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EDITORIAL

Telecommunications play an important part in the social and economic development of today's world. However, international telecommunications can be achieved only by the mutual co-operation of the administrations involved. Several articles in this issue of the *Journal* highlight the role played by the International Telecommunications Union (ITU) in the fields of regulation, planning, co-operation and standardisation of telecommunications world-wide. The formation of international standards is often a long and difficult process as many differing engineering solutions may be feasible and equally valid. Although a single rigid standard might be advantageous in terms of reduced manufacturing costs through volume production, such a standard might impose unacceptable constraints on the network's ability to accommodate new technology and customers' requirements. For the integrated services digital network (ISDN), the International Telegraph and Telephone Consultative Committee (CCITT) has adopted a concept of modular interfaces as the basic framework on which the ISDN can evolve. An article on p. 202 of this issue of the *Journal* reviews the I-series Recommendations for the ISDN, and on p. 212 reviews the standards for packet data networks. Radiocommunications also play an important part in international communications and considerable progress on standards has been made by the International Radio Consultative Committee (CCIR), much of it concerning the introduction of digital techniques. A report of the decisions reached at the XVIth Plenary Assembly of the CCIR is given on p. 237.

Recorded information services were introduced in the UK in 1936 with the inauguration of the speaking clock service in London. The article on p. 192 marks the fiftieth anniversary of the service by reviewing developments that have taken place in the provision of recorded information services.

Fifty Years of Recorded Information Services

C. E. DORE†

UDC 621.395.91

On 24 July 1936, the speaking clock recorded information service was inaugurated in the London area. This article celebrates the golden jubilee of the speaking clock by reviewing the developments that have taken place in the provision of recorded information services over the past 50 years.

INTRODUCTION

This year, British Telecom's (BT's) recorded information services (RIS) celebrate their golden jubilee anniversary. The speaking clock, or as it is now called *Accurist Timeline*, is 50 years of age this year. The service, which was initially restricted to London, opened in 1936 and was developed into a nation-wide service in 1942 with the installation of a second pair of clocks in Liverpool. It is still the most popular of British Telecom's RIS and attracts around 220 million calls per year. In addition to the public information services (Guidelines), recording machines have been used for many years to provide service messages for operators and, latterly, for the customer.

ORIGINAL CLOCK

The Mark 1 clock[1] (see Fig. 1), designed in 1936, used optical techniques to store and reproduce the announcements and tones. The words and phrases were recorded photographically as concentric circular tracks on four flat glass discs. To reproduce the sound, beams of light were passed through the rotating glass discs and focussed onto photo-electric cells (Fig. 2). Mechanical shutters were used to interrupt the beams of light so that the outputs from the photo-electric cells were assembled in the correct sequence to form a complete announcement every 10 seconds. The appropriate phrases were selected mechanically by using a series of shafts and cams to move the optical systems to different tracks on the discs. The clock, which was driven by a single motor, was controlled by comparison with a pendulum swinging freely in a temperature-controlled cabinet and was accurate to within 0·1 s (see Fig. 3). Hourly corrections

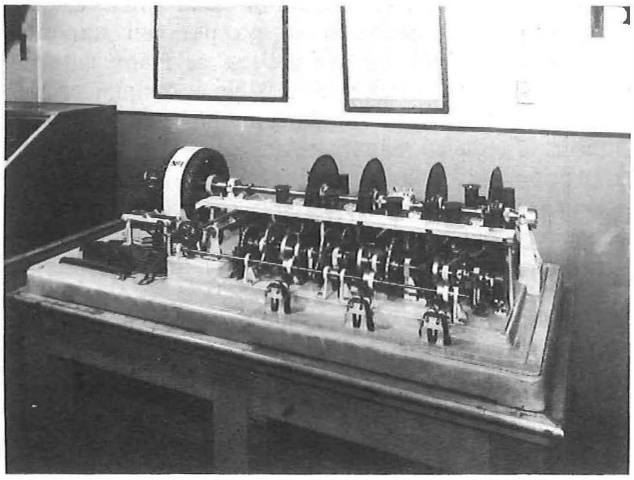

Fig. 1—The 1936 speaking clock

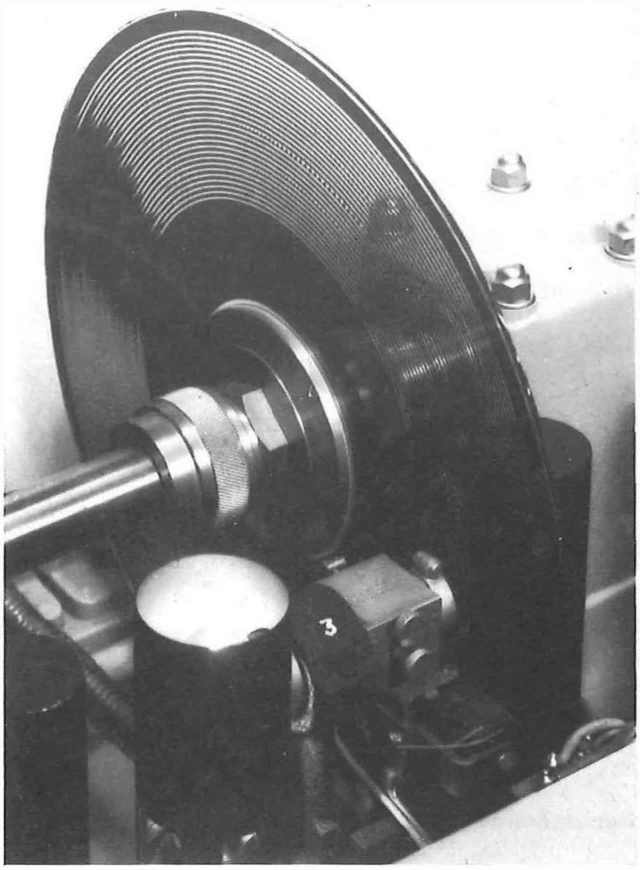

Fig. 2—Glass disc with recorded phrases

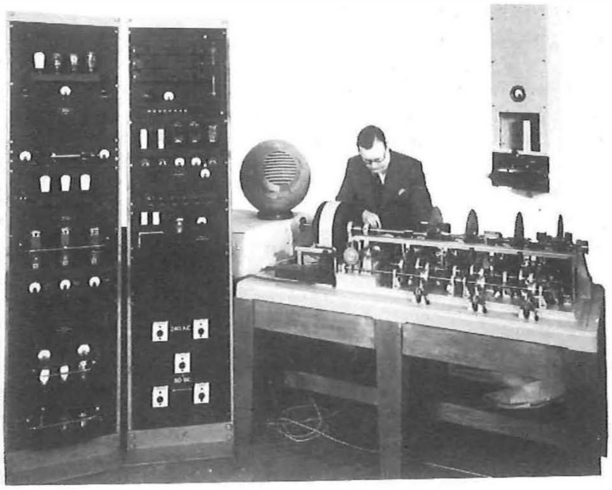

Fig. 3—Amplifier panels and control pendulum

† Analogue Exchange Systems, British Telecom Inland Communications

were made by referencing the clock to a time signal from the Royal Observatory.

Australian Speaking Clock

In 1954, a modified version of the speaking clock was built for use by the Australian Post Office[2]. This clock had three discs and an auxiliary motor to move the optical system. As the new clock was required to be accurate to within 0·05 s with correction once every 24 hours, a crystal-controlled oscillator was used rather than a pendulum.

REPLACEMENT CLOCK

After 27 years service, the 1936 machines were replaced, in 1963, by the Mark 2 speaking clock[3], Fig. 4. One of the main features of the new clock was the use of a spinning drum with a magnetically-loaded coating of neoprene, which was the technology of the era, as the recording medium. The announcements (and pilot tones for monitoring purposes) were recorded onto this magnetic layer and read off by magnetically-sensitive heads, which were lightly sprung against the surface of the drum and lubricated by a thin film of silicone oil. A total of 79 separate tracks was required to store the various phrases needed to make up the speaking clock. The remainder of the machine consisted of high-precision gears and cams which built up a composite announcement in the correct sequence. The pips were controlled in a slightly different manner from the rest of the announcement. An optical arrangement with a shutter mounted on the end of the main drive shaft interrupting a beam of light was used to give a series of 1 s pulses. These pulses were used not only to control an oscillator for the pips, but also as part of the time-correction circuit. The Mark 2 machines maintained an accuracy to within 0·01s by synchronising their motors with a quartz-crystal-controlled oscillator with a daily correction referenced from the Rugby time signal.

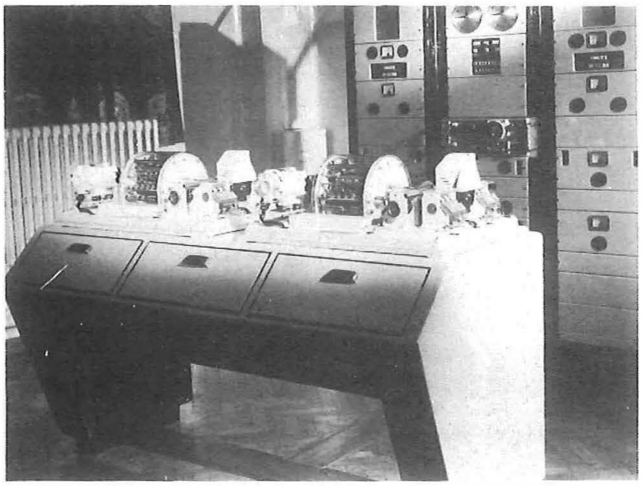

Fig. 4—Mark 2 speaking clock

PRESENT CLOCK

In 1984, the Mark 2 machines, which required regular maintenance, came to the end of their useful life and were replaced by the current Mark 3 clock[4], Fig. 5. The Mark 3 machine, known as *Chronocal*, was designed by engineers at BT Headquarters, and uses microprocessor control and digital speech recording. The speech and tones are encoded by using pulse-code modulation (PCM) techniques and then stored digitally in read-only memory (ROM). The composition of the announcement in the correct sequence is controlled by a microprocessor. These clocks maintain an accuracy to within 0·005 s, each clock being controlled by a high-accuracy temperature-controlled oscillator. The accuracy of the clock is checked once a day by reference to the National Physical Laboratories atomic clock via a feed from Rugby, as for the Mark 2 machines. Because the atomic clock is more accurate than the Earth's rotation round the sun, it is sometimes necessary to re-adjust the speaking clock to take account of this. If the Earth's rotation slows down by 1 s, the clock can be programmed to add a fourth stroke of tone to adjust for this. Conversely, should the Earth's rotation speed up by 1 s, the clock can be programmed to output only two strokes of tone. The instruction to implement this comes from the Home Office and is subject to international agreement.

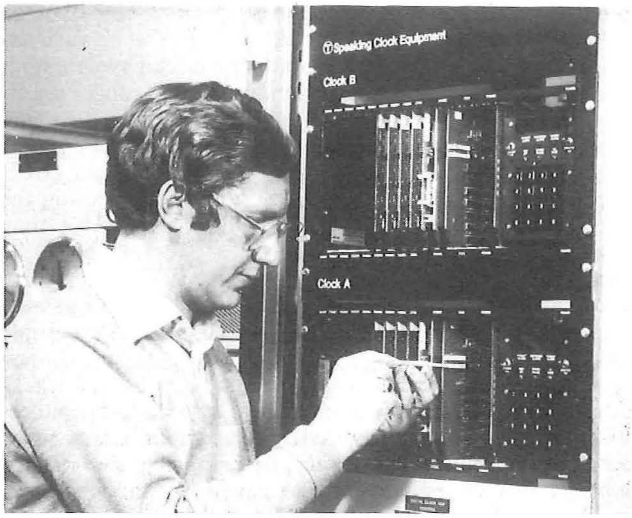

Fig. 5—Present speaking clock

In 1985, the speaking clock broke with tradition when Brian Coby became the new voice for the clock. Both the previous voices were those of women, Miss Jane Cain, in 1936, and Miss Pat Simmons, in 1963*. In 1986, yet another change for the clock was brought about when Accurist Watches Ltd. joined with BT in advertising, for a trial period, their company's name on the Timeline service.

SERVICE ANNOUNCEMENTS

Experimental Verbal Announcement

In April 1935, an experimental system to replace the busy tone by a verbal announcement from a 'robot operator' was tested in the Folkstone exchange area[5]. The word 'engaged' was recorded optically on the sound track of ordinary motion picture film, which was then clamped to a circular drum to give a continuous loop 54 inches long.

Congestion and Delay Announcements

As the telephone system in the UK expanded, it became necessary to introduce a different type of RIS. Prior to the introduction of subscriber trunk dialling (STD) in the late-1950s and early-1960s, all trunk and international calls were originated and controlled by operators. When 'demand working' was introduced for the trunk service, there was a

* The voices of all three clocks can be heard at Telecom Technology Showcase, 135 Queen Victoria Street, London EC4V 4AT, where the Mark 1 clock (in working order) and examples of the other clocks are housed.

requirement for the operators to be advised of the expected delay if particular routes were congested[6]. Later, with the introduction of mechanisation for trunk circuit switching, it was necessary to advise the operator of any congestion at intermediate switching points so that alternative routing could be attempted[7]. Typically, operators were given, via a special switchboard jack or the automatic switch train, either the length of delay expected or information concerning the progress of the call on any particular route. This took the form of a recorded announcement; for example, the announcement for a route delay would say, 'One hour, one hour', and for switching congestion, 'No lines from London'. These announcements used a single glass disc with multiple tracks. Unlike the speaking clock, however, a fixed optical system was arranged to make outputs from all the tracks available simultaneously so that the appropriate announcement could be selected by means of a switch. Later, when STD was introduced, a new machine using magnetic recordings was introduced to make the congestion announcement available to the customer in the form, 'Lines from London are engaged, please try later'[8].

Changed-Number Announcers

With the introduction of STD and the growth of the telephone system in the UK, the need for a third type of RIS arose. For instance, as exchanges grew in size, it became necessary to cater for bulk number changes. These announcements, known as *changed number announcements* (CNAs), inform the calling customer of bulk number changes at the destination exchange. Typically, it might inform the customer to add '8' in front of the number dialled. These announcements were originally reproduced from a variety of commercially available disc machines, tape-recording machines with endless loops of tape or specially-developed machines produced by the Research Branch[9, 10].

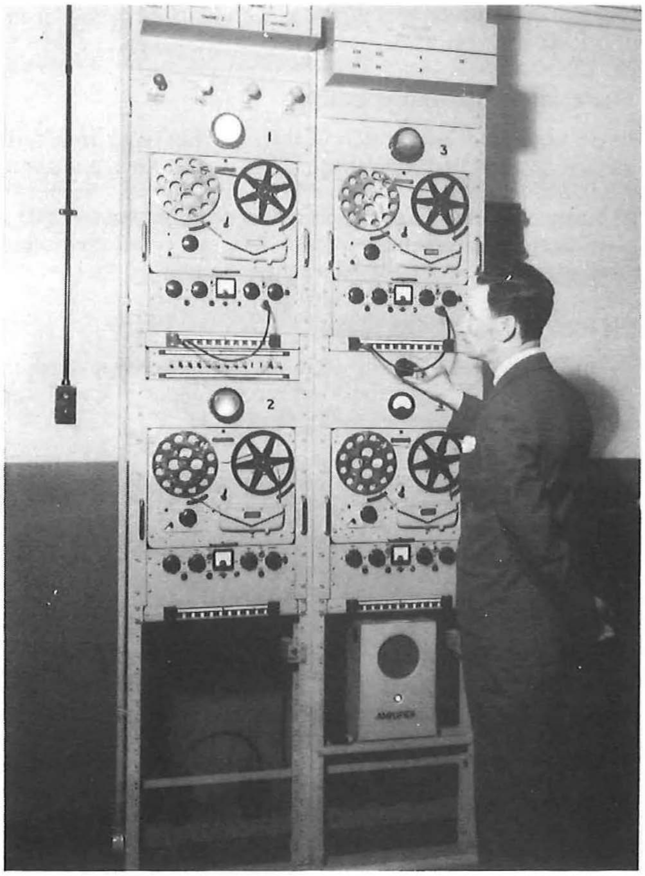

Fig. 6—Reel-to-reel recorded announcement rack

PUBLIC INFORMATION SERVICES

March 1956 saw the introduction of a new recorded information service, the weather forecast[11]. From then, the RIS was steadily expanded by adding such services as test cricket scores, state of the roads[12] and the tele-tourist services. The machines used to provide these types of service are not fixed-message machines, as used by Timeline, but are similar to the CNA machines, since the information needs to be updated at regular intervals (see Fig. 6). The service nowadays includes over 20 Guidelines, many with seasonal or regional variations with such information as the state of the ski slopes in Scotland and local coastal yachting conditions.

RECORDED INFORMATION CENTRES

In the early-1960s, purpose-built recorded information service centres (RISCs) were introduced[13]. They were generally located close to a group switching centre (GSC) with a nearby local manual board so that operating staff were always available to make recordings. The RISCs were semi-automated with specially-designed recording control and distribution circuits to ensure a consistently high-quality announcement, see Fig. 7. There are now some 80 RISCs around the UK providing recording facilities and distributing Guideline announcements to their dependent GSCs.

In the late-1960s and early-1970s, two purpose-built machines were introduced as service standard machines. The Equipment Announcer No. 9 (EA No. 9)[14] was designed to provide a long-term CNA type service, and the Equipment Announcer No. 11 (EA No. 11) to provide the quick-update type announcement.

Fig. 7—RISC control panel used at small recording centres

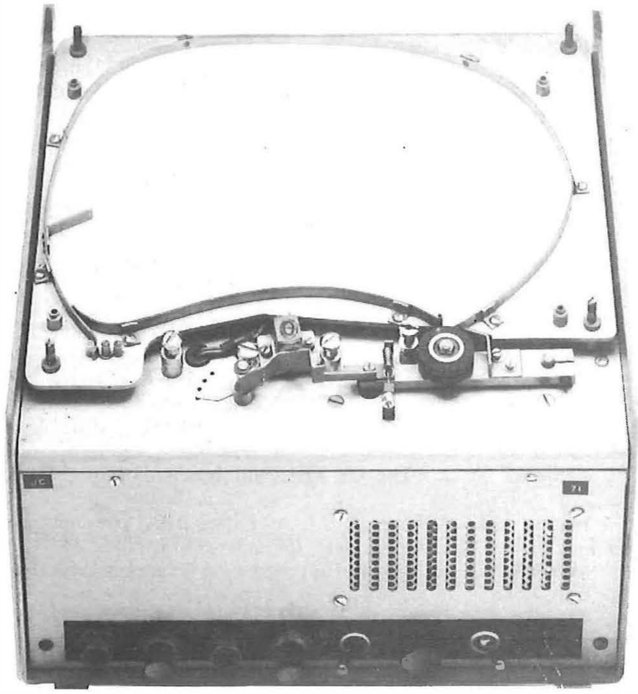

Fig. 8—Equipment Announcer No. 9

The EA No. 9, Fig. 8, uses a pre-recorded endless tape similar to that used in domestic reel-to-reel tape recorders and is generally co-located with the exchange that it is serving. Each tape has a twin track that enables the EA No. 9 to play two simultaneous messages. The tapes are normally prepared by an RISC and fitted by local exchange staff.

The EA No. 11, Fig. 9, uses a cylinder covered in magnetically-loaded neoprene material similar to that used by the Mark 2 speaking clock. The announcement is recorded as a circular helix on the cylinder and is read by a magnetically-sensitive head moving along the cylinder. A new announcement can be recorded on the cylinder at the same time as the equipment plays back the original announcement, thus providing a very fast updating facility.

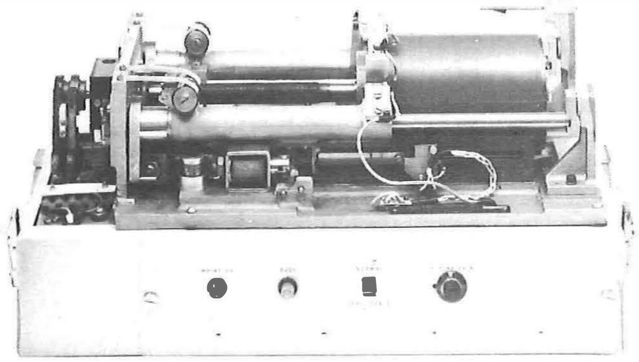

Fig. 9—Equipment Announcer No. 11

Because the EA No. 9 and the EA No. 11 recording medium is a form of magnetic recording and the machines are basically mechanical, they require considerable maintenance to keep them serviceable. There are currently several off-the-shelf solid-state equipments available which are being used to supersede the EA No. 11. These equipments use a form of PCM technique similar to, but not the same as, that used on the Mark 3 speaking clock and provide an excellent quality of reproduction. These new machines are usually capable of providing up to 30 different messages of up to several hours in length if required. A standard vocabulary, once digitised and stored, can be accessed and manipulated via a man–machine interface (MMI), typically a visual display unit or teletype. The announcement is formed by using the MMI to construct phrases and sentences and to direct them to the required output port. This can be done whilst any or all of the other ports are outputting their various announcements without disrupting or corrupting these announcements. The announcement, once formed and checked, can be distributed by the RISC in the normal manner.

REMOTE CALL FORWARDING

The early-1980s saw the introduction of the remote call forwarding (RCF) service, which also provides a form of RIS. To prevent the calling party clearing down during the 10–15 s required to re-route a call, an announcement is connected to the caller. The standard announcement tells the caller that the call is being forwarded at no extra cost to the caller. For an extra fee, the service provider can have a customised announcement made by the RISC and fitted by the local exchange staff. The source of the announcement is a simple cassette, similar to a domestic cassette, but with an endless loop of tape containing the message. This equipment is fitted at the local exchange and is suitable for connection to all types of analogue exchange in BT's network.

AUTOMATIC CHANGED NUMBER INTERCEPTION

The latest recorded information service to be introduced is the automatic changed number interception equipment (ACNIE). The ACNIE is connected to the ceased customer's pair of wires, intercepts the call, trips the ringing after allowing at least one ring cadence to be heard by the caller and connects the announcement to the caller.

Fig. 10—Automatic changed number interception equipment

'Ceptel' shown above is a version of ANCIE by Telspec Ltd. The upper part of the equipment houses the exchange control unit ECU which is used to assemble messages and direct them to an individual line via a central processor unit (CPU). The lower part of the equipment contains 5 × 16 line interface circuits and their associated CPUs. Each CPU holds its own vocabulary, down loaded from the ECU disc, and assembles the message for its associated 16 line interface circuits.

There are currently three different off-the-shelf designs accepted as suitable for connection to all types of BT's analogue exchanges. These ACNIE all use a form of compressed PCM, known as *delta slope modulation*, or *adaptive PCM*, to digitise and store a limited fixed-speech vocabulary onto RAM, ROMs or discs. The total vocabulary stored is in the order of 60 s, which is considered sufficient for this type of service. Typically, the announcement would be 'The number you have dialled has been changed to 123 4567. I repeat, 123 4567, you have not been charged for this call'. The announcement starts at the beginning for each call.

This equipment can serve between 8 and 2000 lines (ports), built up in groups of 8 or 16 ports, depending on the manufacturer and configuration ordered (see Fig. 10). In all cases, the content of the announcement can be changed by the exchange staff, within the limitations of the vocabulary, via an MMI and directed to any port without the operation of any other port being affected.

The calling party, at present, is not charged for the call, but should this policy change the facility exists to charge for the call.

PREMIUM RATE SERVICE

One of the most recent developments in the RIS field is the introduction of a revenue-sharing service called *Premium Rate Service*. Any company licensed by the Department of Trade and Industry can set up an information service sharing any revenue created with BT. This service can be either exchange-based and managed by BT for the licensed company, or simply managed and run from the company's premises. These value-added network services (VANS) are accessed via the 00 code and, at present, are charged at the Irish Republic rate. The equipment used to provide this service varies from analogue recordings on simple endless tape cassettes to machines using adaptive PCM encoding techniques.

CONCLUSION

RISs are now an accepted way of life; customers have come to expect to be provided with clear, concise information. BT has, over the past 50 years, always endeavoured to provide and expand such a service and will continue to do so over the next 50 years.

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Biography

Colin Dore joined BT in 1955 as a Youth-in-Training with the Long Distance Area in Faraday Building. He spent some time on exchange construction and continental semi-auto, later to become international auto with the introduction of IDD. In 1965, he was promoted to the Headquarters Development Department and worked on the design of international registers. He was promoted in 1972 to work on the design of national and international signalling systems and on special investigations. Since 1981, he has been Head of Group with responsibility for technical support for Strowger and TXE2 systems, exchange common services, the speaking clock, automatic changed number interception and star services.

IMTRAN Image Transfer System

J. T. LING†, and M. W. REDSTALL, B.SC.*

UDC 621.397.6 : 621.395.3

This article discusses the IMTRAN system for transferring still television pictures via the public telephone network. The article outlines the background to the development of IMTRAN, highlights the particular benefits that it brings to the medical world for transferring images from diagnostic equipment, for example, X-ray equipment and body-scanners, and briefly describes its features and operation.

INTRODUCTION

For several years, neurosurgery and neuroradiology specialists, particularly at Frenchay Hospital, Bristol, had lamented the lack of equipment which would enable them to transfer medical information speedily and accurately between distant locations, especially since approximately 50% of medical information produced by the new high technology equipment found in many hospitals today is visual; for example, X-ray, body-scan and ultrasound images. Cost effectiveness, efficient patient management and clinical results could be improved considerably if these video images could be conveniently transferred.

Meanwhile, British Telecom (BT) Research Laboratories at Martlesham Heath had been developing an image transfer system for use in the security surveillance field which, although not suitable as a dedicated medical imager, had potential which was recognised by personnel in the health service.

At a meeting organised by Frenchay Hospital in January 1984, BT and several major manufacturers of computer tomography (CT) scanners presented details of how each of their companies was approaching the problem of transferring diagnostic images between hospitals. The CT scanner manufacturers could transfer images between their own equipment or dedicated viewing stations of their own manufacture, but none of the equipment was cheap, portable or suitable for connection to standard voice communication telephone lines. In contrast, BT's system, which was purely an image transfer system that used a standard 625-line format with a 1 V peak-to-peak signal as its input, was, in effect, independent of the diagnostic equipment. It was portable, having its own carrying case and weighing approximately 5½ kg, and it was simple to use, reliable, used ordinary telephone lines and could be operated for the cost of a telephone call.

SYSTEM OUTLINE

The system, known as *IMTRAN*, which has emerged as a result of consultations between BT and medical experts is manufactured by Fulcrum Communications Ltd. The basic system consists of two portable transceiver units (see Fig. 1), each costing about £4500, which can be used in any location where they can be connected to a power supply and to a telephone line via a standard BT socket. Various accessories, including monitor, video camera and stereo cassette recorder, are also available. In a hospital, the transmitting unit can be connected directly to a CT scanner, ultrasound machine, video camera or any other standard video source. The signals from this source are stored digitally, but transmitted as analogue signals over the telephone network. At the distant end, another IMTRAN terminal reconverts the analogue signals to digital signals, and the images are displayed on a television monitor. Speech facilities are also available over the same circuit, and IMTRAN's digital store enables the received picture to remain on the monitor while it is being discussed. This facility is very important as it enables medical staff, wherever they may be, to consult one another over the telephone connection while studying the transferred image.

Three picture resolutions are available:

low:	128 pixels × 128 lines × 64 grey levels
normal:	256 pixels × 256 lines × 64 grey levels
high:	512 pixels × 256 lines × 64 grey levels

pixels—picture elements per line

The update rates for a single complete picture are 8 s, 32 s and 64 s, respectively. There is little or no degradation from the original picture at the highest resolution and the images can be recorded on stereo audio cassette tape if required.

APPLICATIONS

The advantages of IMTRAN both to medical practitioners and patients are considerable. IMTRAN enables images from diagnostic equipment, or patients' notes, to be quickly transferred to other locations (see Fig. 2); for example, to a consultant in a specialist unit or even at home. Thus expert interpretation can be obtained immediately. Transportation costs can be greatly reduced if the need to move a patient to a central referral unit can be avoided. For example, the consultant may decide that movement is unnecessary or may

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* Technology Applications Department, British Telecom Development and Procurement

Fig. 1—IMTRAN transceiver

Fig. 2—IMTRAN in use

be dangerous for the patient. Conversely, the consultant may decide that an immediate operation is essential; the patient can then be prepared for the operating theatre by the time the surgeon arrives at the hospital. IMTRAN is also of great benefit where hospitals share a work-load or facility such as body-scanning equipment. A major hospital may have several satellite hospitals and visual communication may be essential to obtain an expert's opinion, a second opinion or for teaching purposes.

Encouraged by successful trials of IMTRAN at Frenchay Hospital, many health authorities and hospitals have now installed units, including Bristol Royal Infirmary, Gloucester, Cheltenham, Bath, Truro, Plymouth, Christchurch, Poole, Southampton, York and Wakefield. An example of the benefits that IMTRAN is bringing is in the way in which scarce hospital resources in Cornwall and the Isles of Scilly are being helped by the installation of this equipment. Three hospitals—The Royal Cornwall (City) in Truro, the West Cornwall in Penzance and St. Mary's Hospital in the Isles of Scilly are linked by IMTRAN. The main casualty unit is at Truro, but doctors will be able to consult each other even though they are based at different hospitals at considerable distances away. Two-thirds of the casualty patients are seen in places other than the central unit in Truro. There are casualty units at Penzance and Falmouth and six other departments run by general practitioners. If a doctor in Penzance or on the Isles of Scilly wanted a second opinion on a patient, or a decision on whether the patient should be transferred to the specialist unit, this could be done immediately even though the doctor was at another location. This could avoid the cost of moving a patient by ambulance from, say, Penzance to Truro, or, in the case of the Isles of Scilly, by helicopter to the mainland.

Because IMTRAN uses ordinary telephone lines, its range is virtually unlimited and it can communicate with another unit virtually anywhere in the world. The first international use was during the MECOM exhibition in Bahrain, when pictures were received there via satellite from Howland Street, London. In October 1985, IMTRAN was used to send medical images from the CT scanner at Frenchay Hospital direct to the Royal Australian College of Radiologists Conference in Brisbane. The demonstration was a huge success and an eminent radiologist at the conference was able to make a diagnosis from the pictures he received. As a result, six units were sold and further orders are anticipated.

Attention has so far been concentrated upon the medical applications of IMTRAN, but several possibilities exist in the commercial world. For example, aeronautical engineers could examine engines or airframes with the aid of a borescope and video camera, and transmit pictures of suspect parts to experts anywhere in the world; a graphic designer could respond much more quickly to his or her client's instructions. However, these possibilities have yet to be fully explored.

PRINCIPLES OF OPERATION

A real-time image, as generated by a television camera, requires a bandwidth of about 5 MHz for transmission. If one attempts to restrict this bandwidth without changing any other of the television system parameters, such as line standard or refresh rate, then the picture loses resolution and becomes progressively more blurred.

In the case of a still picture television (SPTV) system such as IMTRAN, the bandwidth available for transmission is a mere 3 kHz over the public switched telephone network (PSTN). Clearly, some parameters of the television system have to be changed in order to transmit well-defined pictures in this bandwidth.

In an SPTV system, as the name implies, the system parameter that is changed to reduce the bandwidth required is the refresh rate. In broadcast television, the complete picture is refreshed every 40 ms, whereas in a typical SPTV system over the PSTN, this figure is 32 s. This change alone scales the bandwidth required by a factor of 800, and reduces it to about 6 kHz. By using only every other line of information in the picture and allowing some loss of horizontal resolution, the transmission bandwidth requirement can be brought well within the 3 kHz available over the PSTN.

The slowing down of the refresh rate is achieved by using a system of picture storage and slow transfer from transmitter to receiver. At the transmitting end of the connection, a single television frame is captured into a solid-state store. Once stored, it is a simple matter to transfer the picture to an identical store at the receiver at a speed appropriate to the bandwidth available for transmission.

A block diagram of IMTRAN is shown in Fig. 3. One of two video inputs can be selected by a solid-state video switch in the video interface. Once the source is selected, then the signal from the source is passed to the frame store, where it is digitised, at a sample rate of 10 MHz, to 6 bit accuracy.

Only one field of the video input is digitised and stored and this results in a display having 256 active lines each with 512 pixels. This requires 768 Kbit of storage, which

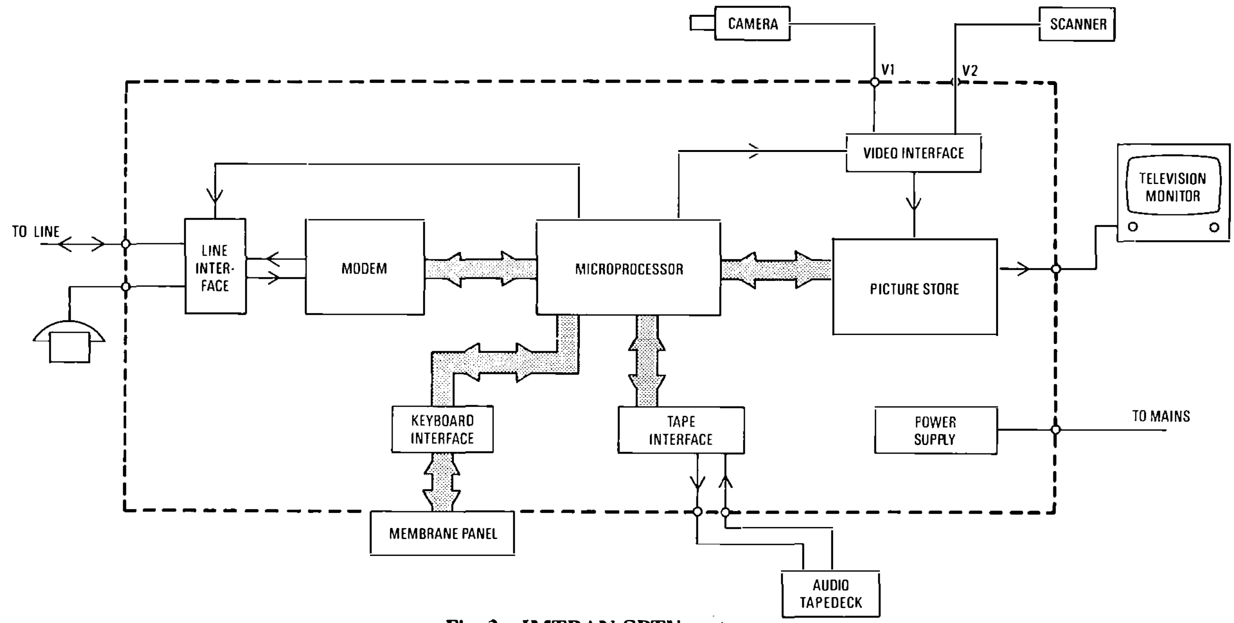

Fig. 3—IMTRAN SPTV system

is implemented by using 64 Kbit dynamic random-access memory chips. In fact, the store has a capacity for two pictures of this resolution which gives the equipment a single-picture 'store and retrieve' facility.

Once in the store, the picture can be accessed by the microprocessor, one picture element or pixel at a time, and passed to the modem for transmission. The user has a choice of the picture resolution that is sent and this is accomplished by subsampling pixels during transmission, and repeating pixels during reception.

The choice of the means of transmission was made with the requirements of high throughput and low cost in mind. The transmission technique chosen is that used for Group 2 facsimile transmission; that is, vestigial sideband amplitude modulation of a 2·1 kHz carrier. This gives a data throughput equivalent to about 12 kbit/s at far less cost than a 9·6 kbit/s modem for example.

Also incorporated in the modem is a dual-tone multi-frequency (DTMF) chip set, which allows end-to-end signalling of parameters such as picture resolution, and an interrupt signalling generator and detector, which enables the units to alternate easily between speech and picture transmission. Since the picture transmission is analogue and the picture is stored digitally, the microprocessor incorporates a digital-to-analogue converter which converts each pixel to an analogue value as it is passed to the modem.

Picture reception is the reverse of transmission. The incoming signal from the PSTN passes first through the line interface and then to a digital attenuator. During the start sequence of the picture, the loss in this attenuator is adjusted by the microprocessor to compensate for the line attenuation. The signal is synchronously demodulated, filtered and passed through an analogue-to-digital converter to the microprocessor. Each pixel value is then placed into the store in exactly the same place that it occupied in the transmitting store.

In this way, a complete picture is built up and can then be displayed by reading the stored values at a high rate, converting back to analogue and feeding to a television monitor. The transmitting and receiving functions are kept in step by an accurate crystal in each unit.

Since during transmission and reception the picture occupies a very limited bandwidth, the result can also be recorded on a conventional stereo audio tape recorder. To overcome the problem of amplitude fluctuations due to variations in contact between the tape and the head, the signal is recorded in frequency-modulated form. At the same time as the picture information is recorded on one track, a clock signal is recorded on the other. When the picture is replayed, the clock is used to track any tape 'wow' that may be present.

Because every element of the equipment is under the control of a microprocessor, a high degree of flexibility is achieved. All depressions of the keys on the front panel are communicated through the keyboard interface to the microprocessor, which carries out the task requested. For example, depression of the TRANSMIT AUTO button initiates a routine in which the microprocessor first switches the line interface from speech to picture transmission. It then instructs the modem to send an automatic-gain-control set-up tone and then a series of tones to indicate the resolution of the picture being transmitted. The microprocessor then proceeds with the picture transmission. When it has transferred an entire picture, it initiates a fresh picture capture and starts the process over again.

The status of the equipment is indicated by on-screen messages at the top of the display (see Fig. 2). Progress of the picture transmission, which proceeds from left to right, is indicated at the send end by a thermometer-type confidence bar immediately above the picture.

Picture transmission occupies most of the speech bandwidth so the unit cannot be used for simultaneous speech and picture transmission. However, alternation between speech and picture working is easily accomplished. At any time during picture transmission, either user can operate the TALK button on the front panel. This automatically reverts the user's unit to telephone use and signals to the far end, both with an audible alarm and an on-screen message, that TALK mode has been requested. The user at the far end responds by operating his/her TALK button; the two users can then converse.

This freedom to alternate between speech and picture transmission means that, in one compact unit, the user has the means to send and receive good-quality images, discuss in detail aspects of the image, and store the images for later reference if required.

CONCLUSION

This article has briefly described BT's IMTRAN image transfer system. The particular benefits that the system brings to the medical profession have been considered. IMTRAN makes an important contribution to three major areas of the medical service: patient care, efficiency and cost control. It is thus a tool which is leading to more effective use of that expensive and scarce resource—medical expertise. Its applications are to be found wherever diagnosis and treatment depend upon high-quality visual images being located, examined and retained for further use.

The advantages of immediate access to diagnostic pictures will be evident to consultants and practitioners in many fields of medicine: neurology, orthopaedics, obstetrics, gynaecology, dentistry, pathology, and others. IMTRAN will find uses for an ever-broadening variety of applications as its extraordinary benefits become evident in practice.

Biographies

John Ling joined the then Post Office from school in 1957 as a Postal and Telegraph Officer. In 1967, he was promoted to Sales Representative in Bristol covering business and special services customers. He was appointed to Sales Superintendent in Plymouth in 1977 and, in 1983 to Data Marketing Officer in the South West Telecommunications Board. In 1984, he took over the product management of IMTRAN. He is responsible for marketing, further development and selling into medical and industrial markets throughout the UK.

Martin Redstall joined the then Post Office as an apprentice in 1963 in the Reading Telephone Area and attended Portsmouth Polytechnic between 1966 and 1970. After graduating, he joined the Visual Services Division of the Research Department at Dollis Hill and subsequently at Martlesham Heath. He currently heads a group dealing primarily with the development of SPTV equipment for use both on the PSTN and integrated services digital network.

An Introduction to the Work of the CCIR and CCITT

INTRODUCTION

Three articles in this issue of the *Journal* feature the work of the International Radio Consultative Committee (CCIR) and the International Telegraph and Telephone Consultative Committee (CCITT). The CCIR and the CCITT are two of the four permanent organs of the International Telecommunication Union (ITU), which is the specialised agency of the United Nations for the planning, co-ordination, regulation and standardisation of telecommunications world-wide. In addition to the CCIR and CCITT, the ITU, whose headquarters is in Geneva, comprises two other organs: the General Secretariat and the International Frequency Registration Board (IFRB). The ITU was founded in 1865 and has 160 member countries.

DUTIES AND ORGANISATION

The duties of the two International Consultative Committees (CCIs) of the ITU are

(*a*) *CCIR* to study and issue recommendations on technical and operating questions relating to radiocommunications, and

(*b*) *CCITT* to study and issue recommendations on technical, operating and tariff questions relating to telegraphy and telephony.

Each CCI is under a Director, who is assisted by a specialised secretariat. Participation in the work of the CCIs is open to all members of the ITU as well as to private telecommunication operating agencies, scientific and industrial organisations and international organisations which satisfy certain conditions.

Each of the CCIs holds a Plenary Assembly every four years. The Plenary Assembly draws up a list of technical subjects, questions relating to telecommunications, the study of which should lead to improvements in radiotelecommunications, or in the telegraph and telephone, data transmission and telematic services, particularly in international relations. These questions are then referred to a number of Study Groups composed of experts from different countries. In addition to the 11 CCIR Study Groups and the 15 of the CCITT, there are two joint CCIR/CCITT Study Groups—CMTT for television and sound transmission, and CMV for definitions and symbols (vocabulary), both of which are administered by the CCIR.

The Study Groups draw up Recommendations, which are submitted to the next Plenary Assembly. If the Assembly adopts the recommendations, they are published in what are known as *CCI Books*, which are disseminated by the ITU. These Books also contain a list of the questions under study, study programmes, reports and opinions adopted by the Plenary Assembly of each CCI (CCIR: 14 volumes for the XVth Plenary Assembly, Geneva, 1982; CCITT: 10 volumes for the VIIIth Plenary Assembly, Malaga-Torremolinos, 1984).

The 11 Study Groups of the CCIR are listed in Table 1. The present 15 Study Groups of the CCITT are given in Table 2; the CCITT also has

(*a*) a special Study Group concerned with the future evolution in the structure of the CCITT Study Groups (COM 'S'), and

(*b*) a committee to prepare the 1988 World Administrative Telegraph and Telephone Conference (WATTC) whose objective is to establish a new single set of Regulations for existing and planned international telecommunication services (Preparatory Committee WATTC-88 or PC/WATTC-88).

Further joint CCITT/CCIR activities take place within the framework of a World Plan Committee as stipulated by the International Telecommunication Convention. There are also a number of Regional Plan Committees (for Africa, Latin America, Asia and Oceania, Europe and the Mediterranean Basin). These Committees prepare a General Plan for the international telecommunication network to help in the planning of international telecommunication services. They refer questions to the CCIs, the study of which are of particular interest to developing countries and which are within the terms of reference of the Committees. The Plan Committees are administered by the CCITT.

TABLE 1

CCIR Study Groups

1	Spectrum utilisation monitoring
2	Space research and radioastronomy
3	Fixed service at frequencies below about 30 MHz
4	Fixed satellite service
5	Propagation in non-ionised media
6	Propagation in ionised media
7	Standard frequency and time signals
8	Mobile radiodetermination and amateur services
9	Fixed service using radio-relay systems
10	Broadcasting service (sound)
11	Broadcasting service (television)

TABLE 2

CCITT Study Groups

COM I	Definition, operation and quality of service aspects of telegraph, data transmission and telematic services
COM II	Operation of telephone network and ISDN
COM III	General tariff principles including accounting
COM IV	Transmission maintenance of international lines, circuits and chains of circuits; maintenance of automatic and semi-automatic networks
COM V	Protection against dangers and disturbances of electromagnetic origin
COM VI	Outside plant
COM VII	Data communication networks
COM VIII	Terminal equipment for telematic services
COM IX	Telegraph networks and terminal equipment
COM X	Languages and methods for telecommunications applications
COM XI	ISDN and telephone network switching and signalling
COM XII	Transmission performance of telephone networks and terminals
COM XV	Transmission systems
COM XVII	Data transmission over the telephone network
COM XVIII	Digital networks including ISDN

TABLE 3

Special Autonomous Groups

GAS 3	Economic and technical aspects of the choice of transmission systems
GAS 7	Rural telecommunications
GAS 9	Economic and technical aspects of transmission from an analogue to a digital telecommunication network
GAS 10	Planning data and forecasting methods
GAS 11	Strategy for public data networks

TABLE 4

Handbooks published by the GAS and other Groups during the 1980–84 Study Period

GAS 5/6	Economic studies at the national level in the field of telecommunications
GAS 6	Handbook on economic and technical aspects of the choice of telephone switching systems, 1981
GAS 8	Manual on the economic and technical impact of implementing a regional satellite network
GAS 9	Case study on a rural network, 1983
GAS 9	Case study on an urban network, 1984
GAS 9	Economic and technical aspects of the transition from analogue to digital telecommunication networks
Handbook on quality of service, network management and network maintenance, 1984	
Introduction to CHILL, 1983	
CHILL formal definition	
General network planning	
Rural telecommunications	
Amendments and additions (1983) to the Directives concerning the protection of telecommunications lines against harmful effects from electricity lines	
Jointing of telecommunication cable conductors	
Optical fibres for telecommunications	

In addition, there are *Special Autonomous Groups* (GAS) to deal with questions of particular concern to the developing countries (see Table 3). During the study period 1980–84, the GAS and other groups have published the handbooks listed in Table 4.

RECOMMENDATIONS OF THE INTERNATIONAL CONSULTATIVE COMMITTEES

Suppose that, during a storm on the high seas, a trawler is drifting helplessly. The situation becomes critical and the captain sounds the automatic alarm signal with which his vessel is equipped. A few kilometres away on another ship, a bell rings, having been activated by the distress signal. The alarm has been given, the call has been heard and now help is on its way.

This situation might seem quite ordinary nowadays, but it is in fact the result of lengthy studies and the working out of a way of standardising distress systems so that those who send such signals can be heard and understood.

In a less tragic, and fortunately more familiar, context a telephone subscriber in Europe nowadays has only to pick up a telephone to ask for a call to be put through or to dial directly to San Francisco or to dictate a telegram to be sent to, say, Bangkok. This again is the result of a major effort in international co-operation.

Telecommunications are not in fact possible without the existence of international agreements regulating a whole range of questions: in radio, the frequencies to be used; in telegraphy and telephony, for example, line transmission characteristics, characteristics of equipment to be used on international links, etc. Agreement also has to be reached on how to fix accounting rates and how to carry out international accounting between the network operators involved.

Whereas in the years following the setting up of the ITU these matters could be settled by international conferences, it became clear in the 1920s that international agreements would have to be based on preliminary studies, tests and measurements. International conferences were no longer capable of dealing directly with such complex questions, which require constant co-ordination of studies. It was to provide this co-ordination that the CCIs were created.

These CCIR and CCITT Recommendations, to which reference is made in the Regulations, provide a basis for the international standardisation of telecommunications. They have a great influence on scientific and technical circles concerned with telecommunications, administrations and private operating agencies and designers and manufacturers of equipment throughout the world.

CONCLUSION

The CCIs have a major task to perform in the planning of the world telecommunications network and the regional networks; they also participate in the technical co-operation activities of the ITU for the benefit of the developing countries, in particular by preparing technical handbooks on subjects ranging from cable technology to digital networks and satellite communications.

Review of the CCITT Recommendations for Integrated Services Digital Network

P. J. DAVIDSON, B.SC., C.ENG., M.I.E.E.†

UDC 389.6 : 621.39

The concept of the integrated services digital network (ISDN) was built on the integrated digital network and was seen as the next stage in the evolution of the public switched telephone network to provide digital services and technology down to the customer's premises. This article gives some of the background to the international studies leading to ISDN standardisation, and reviews the ISDN Recommendations (I-series) which were agreed by the Plenary Assembly at the end of the 1980–84 CCITT Study Period. This article is based on a paper which first appeared in British Telecom Technology Journal‡*

INTRODUCTION

Towards the end of the 1976–1980 CCITT Study Period, Study Group XVIII on Digital Networks, having established the principles of an integrated digital network (IDN) for telephony, started considering the next stage of evolution of digital networks. At the same time, Study Group XI on Telephone Switching and Signalling was finalising the specification of a new common-channel signalling system (CCITT Signalling System No. 7) which could be used in an IDN to convey signalling for both telephone and data services.

The 1980 CCITT Plenary Assembly recognised the very strong interest in the concept of the integrated services digital network (ISDN) and gave Study Group XVIII the mandate to produce overall guidelines and Recommendations on ISDN within which the technical studies in a number of areas, for example, user–network interfaces, switching and signalling systems, could proceed. Questions on ISDN studies were also introduced into the work of Study Group VII on Data Communications Networks, which considered the impact of data services in an ISDN, and Study Group XI, which considered digital switching, common-channel signalling and customer access signalling issues. Study Group II also dealt with ISDN numbering issues.

At the end of the 1980–1984 CCITT Study Period, a number of ISDN Recommendations were agreed at the Plenary Assembly. These Recommendations are contained in a new I-series of Recommendations which contain all relevant ISDN Recommendations produced by all the Study Groups.

GENERAL

Background

Much of the time in the earlier studies on ISDN was spent describing future aims. The different and changing regulatory positions of the different countries and the different stages of evolution to digital operation of the many networks made a common understanding of ISDN difficult to reach. The general description of ISDN is contained in the preamble to the I-series Recommendations as follows:

> 'An ISDN is a network, in general evolving from a telephony IDN, that provides end-to-end digital connectivity to support a wide range of services, to which users have access by a limited set of standard multipurpose user–network interfaces.'

This description is of a very general nature and does not give an indication of the elements that characterise an ISDN and distinguish it from any other network capable of supporting different services. There are, however, many features which are specific to the ISDN, such as user–network interfaces, service and network related aspects, which are described later; it is these that characterise the ISDN.

The concept of ISDN was originally built on the evolution, in the various countries, of the IDNs where the term 'integrated' refers to the commonality of digital techniques used in transmission and switching systems. In particular, the telephony IDN, based on the 64 kbit/s adopted for the encoding of speech, was considered to be a powerful means of conveying other services in addition to voice, such as data and video; hence the integration of different services onto a common digital capability. The original idea of a 64 kbit/s circuit-switched ISDN has more recently been expanded. It now includes a more general concept of ISDN so as to allow networks to evolve in a shorter time and, in the longer term, to include packet-switching capabilities and circuit-switching capabilities at rates above and below 64 kbit/s.

Principles of ISDNs

The concepts which form the basic principles of an ISDN and its evolution, and which are included in Recommendation I.120, can be summarised as follows:

(*a*) The main feature of the ISDN concept is the support of a wide range of voice and non-voice services in the same network. A key element of service integration in an ISDN is the provision of a limited set of multipurpose user–network interfaces as well as a limited set of multipurpose network connection types each of which support a wide range of services.

(*b*) An ISDN may support both non-switched and switched connections; switched includes both circuit and packet connections. As far as practical, new services should be compatible with 64 kbit/s switched digital connections.

(*c*) An ISDN will be based on and evolve from a telephony IDN, and may evolve by progressively incorporating additional functions and network features including those of any

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* CCITT—International Telegraph and Telephone Consultative Committee

‡ DAVIDSON, P. J. Review of the CCITT recommendations for integrated services digital network (ISDN). *Br. Telecom Technol. J.*, Oct. 1985, **3**(4), pp. 46–52.

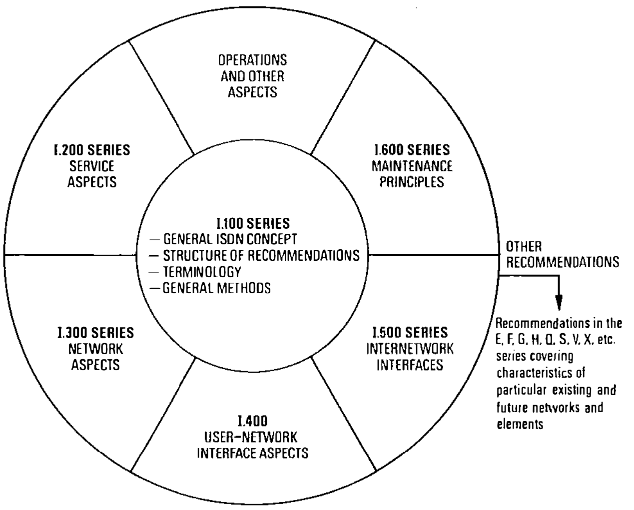
other dedicated networks to provide for existing and new services.

(*d*) The transition from an existing network to a comprehensive ISDN may require in some circumstances one or more decades. During this transition period, arrangements must be developed for the interworking of services on an ISDN and the service on other networks.

(*e*) In the evolution towards an ISDN, digital end-to-end connectivity will be obtained by using plant and equipment in existing networks, such as digital transmission, time-division multiplex switching and/or space-division multiplex switching.

STRUCTURE OF ISDN RECOMMENDATIONS

The ISDN Recommendations are contained in the I-series of Recommendations (Fig. 1) and are structured so that new Recommendations can be easily included in the appropriate sections. Recommendation I.110 describes the structure.



Note: Models, reference configurations, tools and methods are contained in the appropriate I-series Recommendations

Fig. 1—Structure of I-series Recommendations

In the 1980–1984 Study Period, it was agreed that work should be concentrated on those issues relating to the access to the ISDN and, as a consequence, Recommendations were produced on the user–network interface, service aspects, network aspects and, of course, on ISDN general issues. There are currently no Recommendations on ISDN maintenance principles or internetwork interfaces, and work on these has commenced in the present Study Period.

In the present structure of the I-series Recommendations, six parts have been identified and allocated a series number as described in the following sections.

Part I—General

I.110—General structure of the I-series Recommendations

I.111—Relationship with other Recommendations relevant to ISDNs

I.112—Vocabulary of terms for ISDNs

I.120—Integrated services digital networks (ISDNs)

I.130—Attributes for the characterisation by an ISDN and network capabilities of an ISDN

This group of Recommendations covers the concept and principles of an ISDN and lays down a framework of vocabulary and definitions used throughout the ISDN Recommendations. The contents of Recommendations I.110, I.111 and I.120 have already been discussed earlier in the general part of this article. Recommendation I.112 consists primarily of those terms and definitions considered essential to the understanding and appreciation of the principles of an ISDN and are applicable, in so far as they are relevant, to other types of telecommunications networks. The Recommendation covers definitions for services, networks, access arrangements and signalling, and includes a glossary of terms which are in common use in the context of ISDNs and have meanings which are generally understood, but which are not precisely defined as yet.

Recommendation I.130 also contains a list of definitions, but these specifically relate to the attributes used to describe ISDN service and network capabilities. An attribute is defined as *a specified characteristic of an object or element whose values distinguish that object or element from others.* Particular values are assigned to each attribute when a given telecommunications service or network capability is described and specified. Recommendation I.130 has two main sections to its content, one describing some 19 attributes that studies have so far identified and the other describing possible values of those attributes.

Part II—Service Capabilities

I.210—Principles of telecommunications services supported

I.211—Bearer services supported by an ISDN

I.212—Teleservices supported by an ISDN

These three Recommendations cover the results of the work to date in describing the support of services by the ISDN. By definition, ISDN was conceived to support a wide variety of services, from the 'existing' services such as telephony and data communications, to 'new' services for text and graphic communication (Teletex, videotex etc.) and to include, in the longer term, the broadband services for videoconferencing etc.). Some of these services are already defined by CCITT, some are under definition, others are likely to emerge in the future.

The CCITT has defined two broad categories of telecommunications services: bearer services and teleservices.

Bearer Services

Bearer Services supported by an ISDN provide the capability for transferring information between ISDN user–network interfaces and involve only low-layer functions. Customers may choose any set of high-layer protocols for their communications and the ISDN does not ascertain compatibility at these layers between customers. An example of a bearer service is a switched 64 kbit/s circuit mode unrestricted service. A list of bearer services and their characterisation by attributes is contained in Recommendation I.211. This Recommendation also contains a priority scheme for bearer-service provision and a priority rating for those bearer services listed. Bearer services are characterised by a set of low-layer attributes and these are classified into three categories:

(*i*) information transfer attributes;
(*ii*) access attributes; and
(*iii*) general attributes, including operation and commercial attributes.

Teleservices

Teleservices provide the full capability for communication by means of terminals, network functions and possibly functions provided by dedicated centres. Examples of teleservices are telephony, Teletex, videotex and message handling. Teleservices are characterised by a set of low-layer attributes, a set of high-layer attributes and operational and commerical attributes. Recommendation I.212 details the work to date on teleservices, but it is not so complete as Recommendation I.211 on bearer services. Recommendation I.212 contains a framework for describing teleservices and a list of attributes and their characteristics. Specific teleservices and their support by the ISDN have not yet been agreed.

Part III—Overall Network Aspects and Functions

I.310—ISDN network functions and principles
I.320—ISDN protocol reference model
I.330—ISDN numbering and addressing principles
I.331—The numbering plan for the ISDN era
I.340—ISDN connection types

Recommendation I.310 outlines the functional principles of the network aspects of the ISDN as an introduction to the I.300 series of Recommendations (see Fig. 2). Recommendation I.310 provides a common understanding of the ISDN network series of Recommendations by describing the ISDN functional capabilities and their respective relationships.

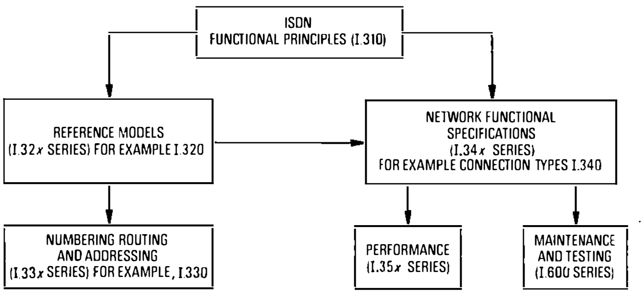


Fig. 2—ISDN network series Recommendations

The ISDN functional description defines a set of network capabilities which enable bearer services and teleservices to be offered to customers. The services require two different levels of ISDN capabilities: low layer which relate to bearer services and high layer which, together with low-layer capabilities, relate to teleservices (Fig. 3).

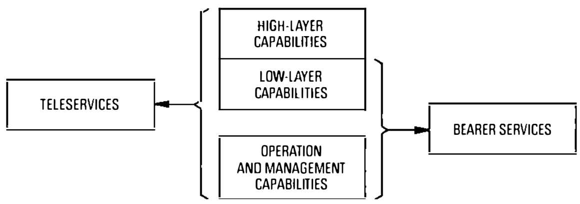


Fig. 3—Relationship between services and ISDN functional capabilities

Recommendation I.320 describes a protocol reference model for ISDN. It is based on the general principles of layering given in the X.200 series of Recommendations and has been developed to model the information flows, including user information and control information flows to and through an ISDN, and to take into account the separate channel signalling nature of the ISDN. In order to construct the ISDN protocol reference model, a fundamental generic protocol block has been identified (Fig. 4).

In particular, the model has been designed so that protocols in an ISDN can be studied in a structured and uniform way with account being taken of the wide range of communication modes and capabilities that can be achieved in the ISDN:

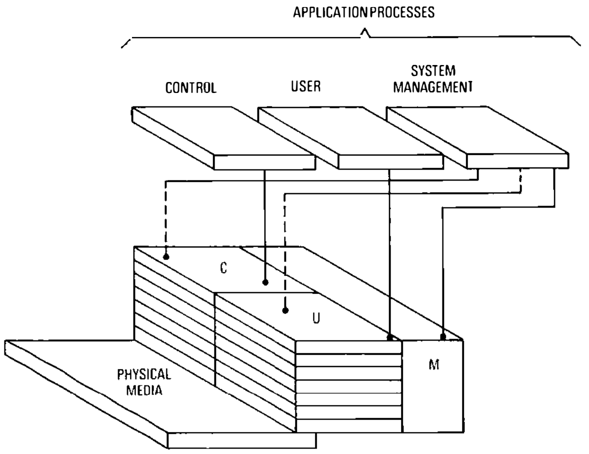


Fig. 4—Generic protocol block

(*a*) circuit-switched connection under the control of common-channel signalling,
(*b*) packet-switched communication via the circuit-switched or packet channel,
(*c*) signalling between users and network-based facilities,
(*d*) end-to-end signalling, and
(*e*) combinations of above in multimedia communications.

ISDN numbering and addressing principles are detailed in Recommendation I.330, and Recommendation I.331 (E.164) describes the numbering plan for the ISDN era. It has been agreed that the ISDN numbering plan should be based on and evolve from the existing telephony numbering plan, and therefore the telephony country code is used to identify a particular country. The principles relating to an ISDN number in relation to the user–network reference configuration are that an ISDN number shall be able unambiguously to identify a particular:

(*a*) physical or virtual interface at reference point T, including multiple interfaces;
(*b*) physical or virtual interfaces at reference point S, including multiple interfaces, for point-to-point configuration; or
(*c*) interfaces at reference point S for multipoint configurations (for example, passive bus).

The ISDN numbering plan, Recommendation I.331, indicates that the international ISDN numbering shall consist of three parts (Fig. 5).

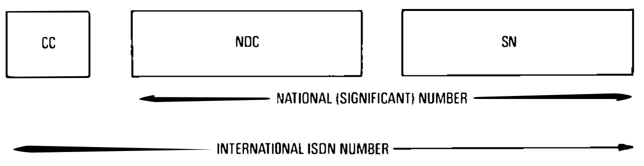


Fig. 5—Number structure

The international ISDN number is composed of a variable length of decimal digits arranged in specific code fields. The international ISDN number code fields are the country code (CC) and the national (significant) number. The country code (CC) is used to select the destination country (or geographical area) and varies in length as outlined in Recommendation E.163. The national (significant) number is used to select the destination subscriber. In selecting the destination subscriber, however, it may be necessary to select the destination network. To accomplish this selection, the national (significant) number code field can be seen as comprising a national destination code (NDC) followed by a subscriber's number (SN).

The NDC code field will be variable in length dependent upon the requirements of the destination address. It can be used to select a destination network serving the destination subscriber or used in a trunk code format to route the call over the destination network in the called country.

An ISDN provides a set of network capabilities which enable telecommunications services to be offered to customers. ISDN connection types are described in Recommendation I.340 as a way of referring to and describing ISDN connections. The attributes of connection types are defined in Recommendation I.130. An ISDN connection is a connection established between reference points; thus, it is the physical or logical realisation of an ISDN connection type. Each ISDN connection can be categorised as belonging to a connection type depending on its attributes of information transfer rate, signalling access protocol and performance which are all examples of ISDN connection type attributes. An ISDN connection is composed of connection elements (see Fig. 6), and these concepts provide the basis of a very powerful tool for defining network capability in a rigorous manner to enable interworking, quality of service and performance and routing studies to continue.

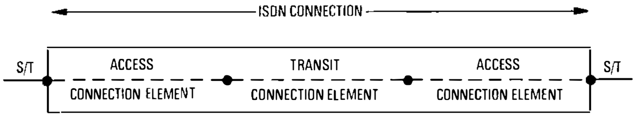


Fig. 6—Example of connection elements forming an ISDN connection

Part IV—User Network Interfaces

Section 1

I.410—General aspects and principles relating to Recommendations on ISDN user–network interfaces

I.411—ISDN user–network interfaces—reference configuration

I.412—ISDN user–network interfaces—channel structures and access capabilities

From a user's perspective, an ISDN is completely characterised by the attributes that can be observed at an ISDN user–network interface, including physical, electromagnetic, protocol, service capability, maintenance and operation and performance characteristics. Recommendation I.410 lists the requirements of the user–network interface and outlines the scope to be covered in defining the interface characteristics and capabilities. A key objective in the definition of ISDN has been that a small set of compatible user–network interfaces can economically support a wide range of user applications, equipment and configurations. To assist the definition of ISDN user–network interfaces, the CCITT has produced a reference model for user-network terminal arrangements (Fig. 7). This is described in Recommendation I.411.

The ISDN user–network interface Recommendations apply to physical interfaces at reference points S and T. At reference point R, physical interfaces in accordance with existing CCITT Recommendations (for example, X- and V-series) or physical interfaces not included in CCITT Recommendations may be used. There is no reference point assigned to the transmission line to the local exchange since an ISDN user–network interface is not envisaged at this location.

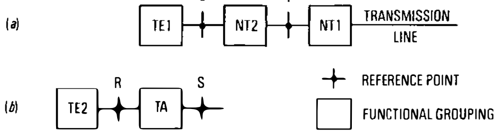


Fig. 7—Reference configurations for the ISDN user–network interface

The NT1 functional grouping includes functions equivalent to layer 1 of the Open Systems Interconnection (OSI) Reference Model and are associated with the proper physical and electromagnetic termination of the network. NT1 functions are:

(*a*) line transmission,
(*b*) maintenance functions and performance,
(*c*) monitoring,
(*d*) timing,
(*e*) power transfer,
(*f*) multiplexing, and
(*g*) interface termination, including the possibility of multidrop termination employing contention resolution.

The NT2 functional group includes functions equivalent to layer 1 and higher layers of the OSI Reference Model. PABXs, local area networks and terminal controllers are examples of equipment or combinations of equipment that provide NT2 functions. The NT2 functional grouping may include:

(*a*) protocol handling,
(*b*) multiplexing,
(*c*) switching,
(*d*) concentration,
(*e*) maintenance functions,
(*f*) interface termination and other layer 1 functions.

The terminal equipment (TE) functional grouping includes functions equivalent to layer 1 and higher layers of the OSI Reference Model. Digital telephones, data terminal equipment and integrated work stations are examples of equipment or combinations of equipment which provide TE functions.

The TE functional grouping may include:

(*a*) protocol handling,
(*b*) maintenance functions,
(*c*) interface functions, and
(*d*) connection functions to other equipment.

Two types of TE have been categorised:

(*a*) TE1 is an ISDN terminal equipment with an interface that complies with the ISDN user–network (interfaces) or interfaces not included in CCITT Recommendations.

(*b*) TE2 is a terminal equipment with an interface that complies with non-ISDN interface Recommendations (for example, the CCITT X- and V-series interfaces) or interfaces not included in CCITT Recommendations.

The terminal adaptor (TA) functional grouping includes functions equivalent to layer 1 and higher layers of the OSI Reference Model that allow a TE2 terminal to be served by an ISDN user–network interface.

Interface structures and access capabilities for ISDN are described in Recommendation I.412. A set of channel types has been defined for the ISDN user–network interface.

Examples of channel types are the 'B-channel', which is a 64 kbit/s channel intended to carry a wide variety of user information streams and provides access to a variety of communication modes within the ISDN (circuit switching, packet switching and semi-permanent connections), and the 'D-channel', which can have the values of 16 kbit/s for the basic access structure or 64 kbit/s for the primary-rate interface structure. The D-channel is primarily intended to carry signalling information for circuit switching in the ISDN, and it may be used to convey packed-switched data services.

The basic interface structure is composed of two B-channels and one D-channel, 2B + D. The B-channels can be used independently; that is, in different connections at the same time. With the basic interface structure, two B-channels and one D-channel are always present at the ISDN user–network interface, but one or both B-channels, however, may not be supported by the network.

The primary-rate interface structures correspond to the primary rate of 1544 kbit/s and 2048 kbit/s. At the 2048 kbit/s primary rate, the interface structure is 30B + D, although one or more of the B-channels may not be supported by the network.

Channel types at rates higher than 64 kbit/s have been defined, and interface structures of these channels described in Recommendation I.412.

Section 2

I.420—Basic user-network interface
I.421—Primary rate user–network interface

Section 3

I.430—Basic user-network interfaces—layer 1 specification
I.431—Primary-rate user–network—layer 1 specification

Section 4

I.440—ISDN user–network interface data link layer—general aspects
I.441—ISDN user–network interface data link layer—specifications

Section 5

I.450—ISDN user–network interface layer 3—general aspects
I.451—ISDN user–network interface layer 3—specifications

The CCITT 'brand' name for the basic access interface is I.420 and for the primary-rate interface, I.421. These Recommendations simply refer to those Recommendations which contain the detailed specification for those interfaces. For example, the basic user–network interface is described in Recommendations I.430 (layer 1); I.440, I.441 (layer 2); and I.450, I.451 (layer 3). To recapitulate, some of the general features of the basic user–network interface that need to be borne in mind when the necessary protocol is being developed are:

(*a*) an access capability of 2B + D plus any necessary housekeeping/local signalling requirements that have to be catered for;
(*b*) an outband signalling channel that needs to cater for circuit-related signalling as well as packet data services;
(*c*) an interface that should be equally applicable at both the T and S reference points;
(*d*) an interface that, when applied at the T reference point, should handle both point-to-point as well as point-to-multipoint configurations; and
(*e*) signalling protocols that should be based on the OSI architecture.

In Recommendation I.430, the layer 1 specifies the services required from the physical medium and the services provided to layer 2. The services required by the layer 1 from the physical medium of this interface are a balanced metallic transmission medium, for each direction of transmission, capable of supporting 192 kbit/s. The services provided to layer 2 are the following:

(*a*) transmission capability by means of appropriate encoded bit streams, for both B- and D-channels and any related timing and synchronisation functions;
(*b*) the signalling capability and necessary procedures to enable customer terminals and/or network terminating equipment to be deactivated when required and reactivated when required;
(*c*) the signalling capability and the necessary procedures to allow terminals to gain access to the common resources of the D-channel in an orderly fashion while meeting the performance requirements of the D-channel signalling system;
(*d*) the signalling capability and procedures and necessary functions at layer 1 to enable maintenance functions to be performed; and
(*e*) an indication to the higher layers of the status of layer 1.

The details of Recommendation I.430 for layer 1 of the basic user–network interface cover frame structures, coding rules, frame alignment, electrical characteristics, D-channel access control, activations/deactivations.

Similarly contained in Recommendations I.440/1 and I.450/1 is the information which defines and describes the layer 2 and layer 3 of the ISDN network access protocol.

Section 6

I.461—Support of X.21 and X.21*bis* data terminal equipment (DTE) by an ISDN
I.462—Support of packet-mode terminal equipment by an ISDN
I.463—Support of V-series type interfaces by an ISDN
I.464—Rate adaption, multiplexing and support of existing interfaces for restricted 64 kbit/s transfer capability

It was recognised in the CCITT that there would be requirements for the ISDN to support terminals operating to existing interface standards and that, in the early years of the ISDN, the majority of terminals connected to the ISDN would be via existing interfaces at the R reference point. To ensure that terminals connected to the ISDN would interwork correctly with each other and with compatible ISDN terminals connected via the ISDN interface at reference point S or T (that is, TE1 terminal), it was necessary to standardise the TA which converts the protocols to be used at the R reference point to those operating at the S and T reference points. These specifications for specific terminals are contained in the I.461/2/3 Recommendations. In addition, to meet the requirements of existing pulse-code modulation transmission equipment which is used in some overseas countries and which restricts the number of contiguous binary zero bits that may be transmitted, Recommendation I.464 was produced. This Recommendation specifies the requirements on the rate adaption procedures when working with such a 'restricted' 64 kbit/s transfer capability.

CONCLUSION

Work in the present CCITT Study Period has already commenced and is aimed at consolidating and expanding the text of the Recommendations discussed here. Proposals for new Recommendations on topics not yet covered have been made and, by the end of the Study Period, significant advancements and definitions of additional ISDN capabilities will have been made. A further article detailing the current status of the work is being prepared and will be published in a forthcoming issue of this *Journal*.

Biography

Phil Davidson graduated from Salford University in 1968 and joined British Telecome to work in the Network Planning Department. In 1977, he was promoted and went into the Systems Strategy Division, where he became involved in various technical support activities for System X; in 1981, again on promotion, he joined the Communications Standards Division. He is currently responsible for standards policy, network and service standards and, for the major part of the past four years, has been primarily concerned with standardisation studies for the ISDN.

Heat Dispersion from Buildings into the Ground

W. G. BROWN, B.SC.(ENG.), C.ENG., M.I.E.E., M.C.I.B.S., C.DIP.A.F.†

UDC 621.395.7 : 697.97

One method of dispersing heat in the cooling system for an electronic exchange or computer centre is to transfer the heat directly into the ground surrounding the building. This article discusses the two methods of achieving this, the closed-loop and open-loop systems.

INTRODUCTION

Modern electronic exchanges and computer centres emit considerable amounts of heat, sometimes as much as several hundred kilowatts. Very little of this heat is put to good use, mainly because the maximum output occurs during the summer, when it cannot be used for heating. The building services engineer is therefore required to dissipate this heat in the cheapest, most reliable and quietest manner possible. One way of doing this is to transfer the heat into the ground surrounding the building, and two methods are available, namely the *open-loop* and *closed-loop* systems. Both systems have been used in the past but mainly in domestic situations, and very little information is recorded about their use for large-scale cooling.

CLOSED-LOOP SYSTEM

A closed-loop system using buried plastic pipes was successfully used in the condenser circuit of a direct expansion (DX) cooling system, similar to that used in the British Telecom (BT) standard cooling unit*, in a BT computer centre built about four years ago. Fig. 1 shows the plastic pipes being laid in a protective concrete screed in the car-park area. Fig. 2 shows a schematic diagram of the water circuit.

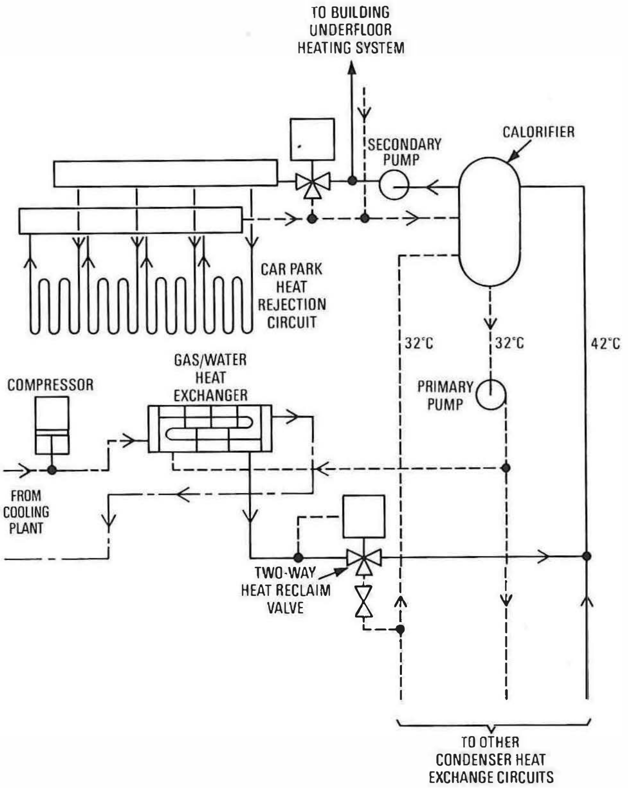


Fig. 2—Arrangements of the water circuit at Sandridge Computer Centre

Fig. 1—Covering plastic pipes with concrete during the installation of the closed-loop heat rejection system at Sandridge Computer System

The whole life cost of such a system is more than twice that of one using air-cooled condensers; the reason for its use was that the local authorities had granted planning permission for the centre on the basis of an extremely low noise level (Noise Rating curve 28) at the boundary of the site.

The design of the heat rejection circuits presented some problems even though a considerable amount of literature existed on the use of buried plastic pipes for underfloor heating. However, from this information, it was possible to calculate the optimum spacing for the pipes, but it was not clear how deep they should be buried below the surface. The closer the plastic pipes are laid to the surface, the more heat they dissipate, but they are also more susceptible to solar radiation and ambient temperatures. At greater depths, say below 1 m, heat dissipation is less but virtually constant and

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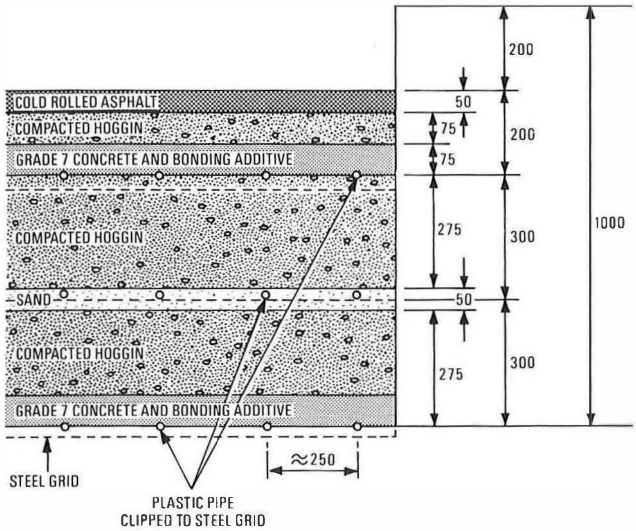
* BROWN, W. G. Equipment Cooling for Modernisation. *Br. Telecommun. Eng.*, Jan. 1984, **2**, p. 246.

there is a large mass of material which allows heat to be stored on hot days and dissipated during the cooler night-time period. The depth at which the plastic pipe is buried is therefore a compromise. In the UK, with a normal maximum daytime temperature of 32°C and an average temperature of 23°C, the optimum depth was found to be approximately 0·5 m. At this depth, heat dissipations range from 150 W/m^2 on the hottest days to 200 W/m^2 on the coldest days with water temperatures of 42°C on and 32°C off.

To obtain some confidence in the theoretical figures, plastic pipe was buried at three levels in a small test area. The surface and various other layers of this test area were identical to that of the car park. Fig. 3 shows a cross-section



Dimensions in millimetres

Fig. 3—Section through test area

through the test site. The tests showed that considerably more heat would be dissipated in practice than that predicted by the theory, because of some of the pessimistic figures that had to be assumed in the theoretical calculations. The main installation has performed well over the last few years and no evidence has been found of the soil drying out or of leaks; nor has there been any requirement for maintenance. In general, it can be said that the closed-loop system is an expensive but satisfactory method of heat dissipation where space is available beside the building and where a low noise level is of overriding importance.

The closed-loop system of cooling, which has proved to be very reliable, is not suitable for direct cooling and where this is being considered an open-loop system must be used.

OPEN-LOOP SYSTEMS

In an open-loop system, water is pumped directly from a borehole, used for cooling the exchange and then discharged either to waste or into a second borehole some distance away. Apart from the fact that discharging the waste into a sewer may be prohibited or may be made financially unattractive, there must be a moral duty to both preserve and make the best possible use of natural resources.

In the UK, the usual temperature of ground water is in the region of 10–11°C, which corresponds to the average rainfall temperature. At this temperature, it is therefore quite possible to cool an exchange by pumping the water directly from the ground and through the coils of air-handling units, and thus obviate the need for much costly chilling plant. Such a system, compared to conventional plant, is virtually silent in operation and has very low maintenance and running costs.

The problems to be solved are associated with

(*a*) the quality of the water,
(*b*) the quantity of the water available,
(*c*) the cost of the borehole installation, and
(*d*) possible recirculation between supply and discharge holes.

Water Quality

Most water in the UK is of a type that is suitable for cooling. The pH of the water is normally about 7·0 and there would seldom be a need for a stainless-steel cooling coil.

Dissolved solids and bacteria exist to some extent in most water and can be a problem unless certain precautions are taken. Calcium carbonate is a fairly common problem particularly since the water is being heated, even though by only some 2–3°C, and therefore can be deposited on the walls of the cooling coil. However, in a field trial carried out over a period of three months, there was a negligible deposit on the cooling coil in water that, when analysed, showed the temporary hardness to be 265 parts per million. This trial was carried out without any restriction on the discharge side so that, in a considerable part of the system, the water was under a negative pressure which would have tended to assist the formation of scale. Where the deposition of calcium carbonate is a problem, the effect is greatly reduced by ensuring that air does not enter the system and that the water is kept under positive pressure all the time.

A not insignificant feature of water quality is its temperature. While rain-water may enter the soil at about 10°C, its temperature is raised as a result of geothermal effects. In the UK, figures vary from 10–50°C per kilometre depth. While such a temperature rise may be a delight to the heat-pump engineer, it means that, for direct cooling, borehole depths must be limited to approximately a hundred metres. A useful approximate rule is 1°C temperature rise per hundred feet.

Quantity of Water Available

The assessment of the quantity of water available is a matter upon which the engineer has to take professional advice. Consulting well records and speaking to well owners near the proposed site will indicate at an early stage the likely yields from boreholes and the depth of the water table. Even water temperatures and analysis can be obtained this way at virtually no cost. The British Geological Survey provides a professional advisory service and, short of drilling a hole, this is about as far as the matter can be taken. However good the pre-drilling investigation, this can be no guarantee of success. Drillers can usually quote cases where they have drilled boreholes yielding thousands of gallons per hour, moved a few yards away to drill a second borehole and found nothing. Whatever one's opinion of water diviners, their advice may sometimes prove to be better than that of the professional geologist. Most drilling companies can recommend a diviner that they have successfully employed over the years.

Fig. 4 shows the performance of a typical cooling unit, and from this can be deduced the rule-of-thumb figures of 70 imperial gallons per hour per kilowatt nett cooling duty required with a supply water temperature of 12°C and room temperature set point of 24°C.

Cost of Borehole Installation

If the level of noise is not a consideration, the borehole

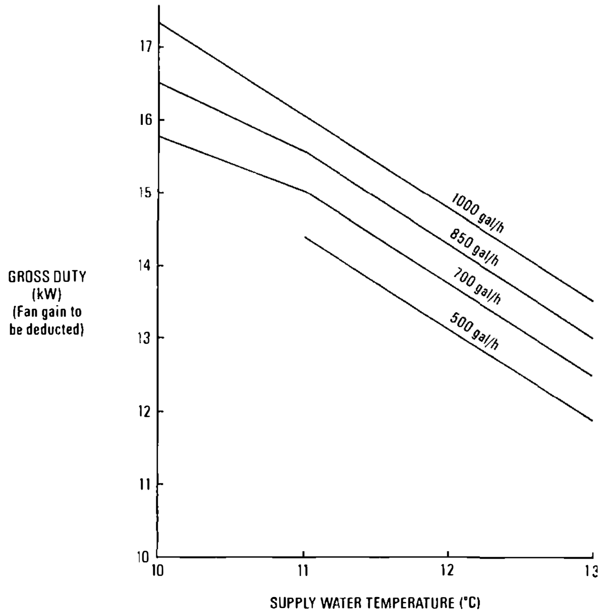


Fig. 4—Performance curves of borehole air-handling unit

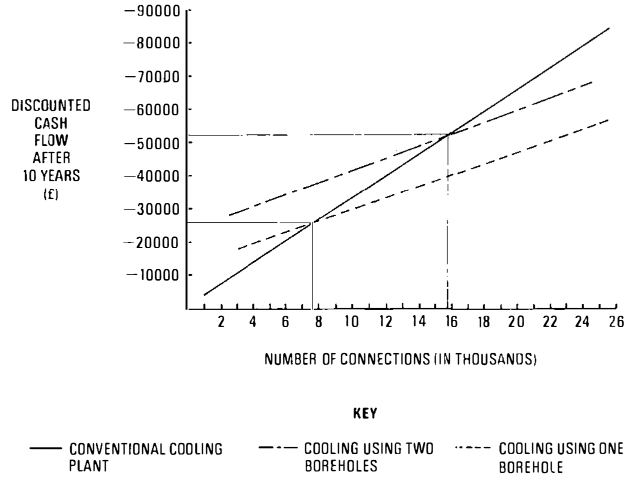


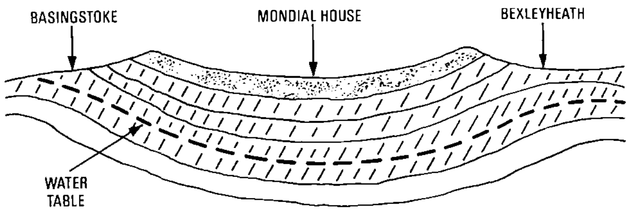
Fig. 6—Discounted cash flow analysis for various sizes of exchange

method of cooling is worthwhile only if the combination of prime cost and running costs is less than that of conventional plant. All building services engineers have their own interpretation of 'conventional plant'. In BT, conventional plant is taken to mean either a central chilling plant with or without a fresh-air option, and individual air handling units or BT standard cooling units which utilise either fresh air or an integral DX cooling system.

The latter, being far more economical and reliable than central plant, was therefore chosen for costing. To obtain a valid comparison, which included both prime costs and running costs, a discounted cash flow exercise was carried out on all systems considered by using a test discount rate of 8%.

It became clear at the start of the investigation that, even under the best possible conditions, it would not be financially viable to cool the smallest rural exchanges by using borehole water. At the other end of the scale, Mondial House was considered; this is BT's largest telephone exchange, is used for international traffic and has a cooling requirement of 700 kW.

Fig. 5 shows a geological cross-section of the London



Not to scale

Fig. 5—London Basin geology

basin and the approximate position of Mondial House. Five supply and discharge holes would have to be drilled through 60 m of London Clay and 30 m of water-bearing chalk at a cost of £125 000. This cost is considerably less than the present-day cost of the existing chilling plant, and the total maintenance and running costs would be less than half.

A major problem with this particular site would be the recharge of the warmed water. It is clear that, if this water were to be injected into the ground on the side of the building opposite to that of the supply borehole, problems with recirculation would be quickly established.

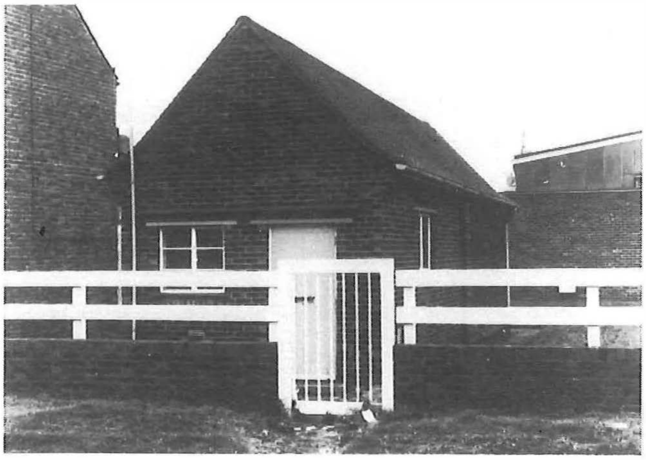
What is of more interest is the medium-to-large exchange where the break-even point can be established (see Fig. 6); for larger exchanges or heat loads, a borehole system would be worth considering. More detailed study was therefore made of Bexleyheath Telephone Exchange, which, as shown in Fig. 5, is towards the edge of the London Basin. The exchange has 26 800 connections and an anticipated peak cooling demand of 47·29 kW. In order to estimate accurately the diameter and depth of borehole required, information was gathered from 18 well records for the area. This information indicated that a 40 m deep borehole was required and that this hole would be capable of supplying the 4000 gal/h required by the exchange. In the subsequent cost analysis, two supply holes and two discharge holes were incorporated for security purposes. A discounted cash flow analysis showed that a borehole system could give a saving of £53 000 over a 10-year period. The borehole system would cost an additional £4000 to install and the break-even point would occur in one year and five months.

A further case study was made of Basingstoke Telephone Exchange, which has over 43 400 connections, a cooling duty of 146 kW and which is situated on the edge of the London Basin. In this case, both the prime cost of £92 000 and running costs of £5100 per annum were less than that for conventional plant (£145 000 and £10 000). This is because the water table at Basingstoke is only 17 m below ground level at the exchange and the boreholes would be used to supply a greater heat load.

In a final analysis, a range of sizes of telephone exchanges, varying from 1000 to 25 000 connections, was considered. These studies were based on boreholes with a constant depth of 40 m and a diameter of 300 mm. A discounted-cash-flow analysis was carried out for one and two boreholes. In the interests of security needed at the larger exchanges, it is probably wise to consider only the two-borehole situation. Fig. 6 shows that, for an exchange with more than 16 000 connections, a borehole cooling system should be considered. This must not be read out of context, since one of the parameters, namely the depth of the borehole, was kept constant in order to make this analysis possible.

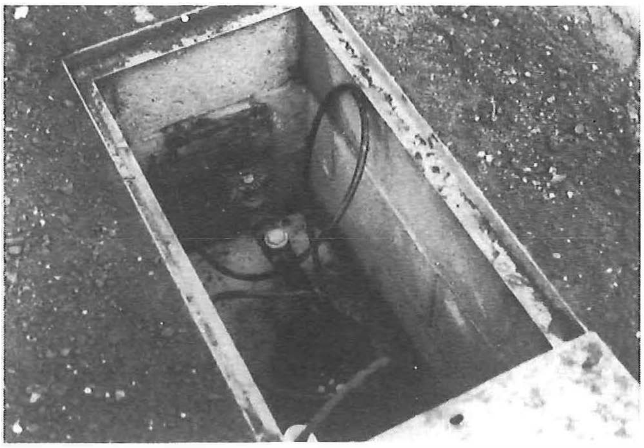
Recirculation between Supply and Discharge Holes

A pilot project was set up at Cliffe, Kent, in a small disused



(*a*) Disused telephone exchange at Cliffe

(*b*) Drilling boreholes



(*c*) Borehole

Fig. 7—Cliffe Telephone Exchange borehole project

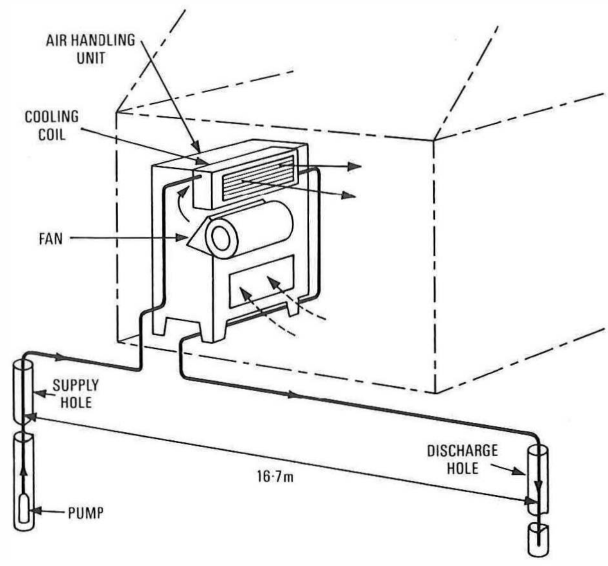


Fig. 8—Diagrammatic layout of the cooling system at Cliffe

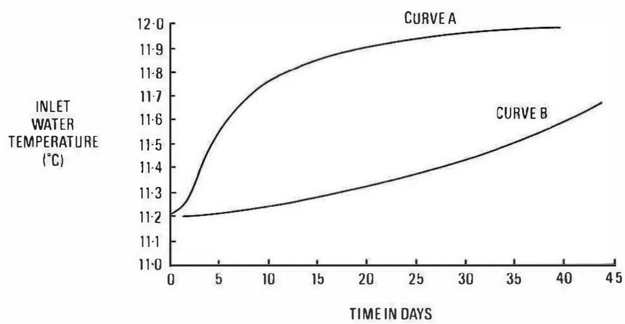


Fig. 9—Variation of supply-water temperature with time for Cliffe experimental borehole system

telephone exchange (see Fig. 7) to investigate the problem of recirculation between supply and discharge holes. Fig. 8 shows the arrangement of the system used. Water at 800 gal/h from the supply holes was pumped through an air handling unit, which was supplied with a 10 kW heat load.

Curve A, Fig. 9, shows how the supply water was affected by the warmed discharge water. After six weeks, the supply temperature had risen by 0·8°C. Tests were continued for a further six weeks, but the inlet water temperature remained constant. This temperature rise was of considerable importance since reference to Fig. 4 shows that there is an 8% drop in available cooling duty for every 1°C rise in temperature.

Various mathematical models were used, unsuccessfully, to try to fit the observed results with theoretical calculations. A computer run on one mathematical model was carried out by using the parameters:

Specific heat capacity = 1000 J/kg/°C.
Thermal conductivity = 2 J/kg/s/°C.

The results of this run are shown in curve B which indicates a disappointing discrepancy between theory and practice. Indeed, the computer model did not show a stabilisation of temperature until about 3–4 years, by which time it was some 2°C higher than that which was actually recorded. This long time constant is not impossible in practice, and a case has been recorded in the UK where warm water has started to return through the supply hole after a period of four years.

Although all theoretical results have proved to be more pessimistic than those achieved in practice, considerable further work will have to be undertaken before it is possible to accurately predict the distance needed between the supply and discharge holes for a given heat load. Only then will it be possible to say with confidence whether such a cooling system can be installed at a BT exchange site.

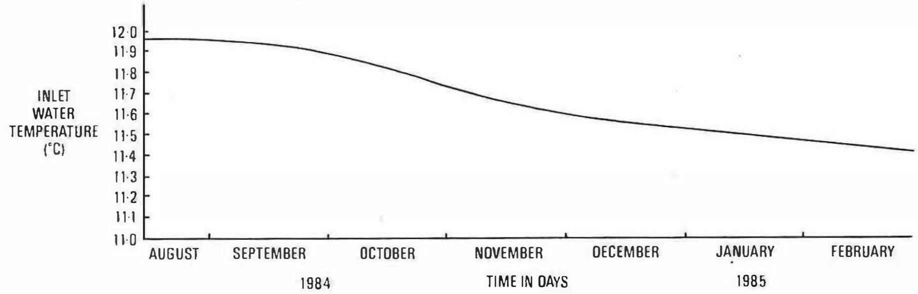


Fig. 10—Variation of supply-water temperature with time for Cliffe system during winter months, when water cooling has ceased

Fig. 10 shows how the water temperature fell over a period of seven months. Rainfall and the slow movement of water underground towards a river or the sea are both aspects which contribute towards this characteristic. This feature is also of significance since cooling other than by fresh air is required by BT for less than 1000 hours per year. At the present time, the problems regarding the calculations for ground cooling are similar to those that apply to ground heating and as such there would be no commitment to a large-scale exchange system where there is a possibility that the available cooling duty will be lost with time. However, this policy extends only to situations where the water is discharged into the ground and does not apply when sewage discharge is possible.

PLYMSTOCK TELEPHONE EXCHANGE

In 1985, BT made a commitment to borehole cooling at Plymstock Telephone Exchange (see Fig. 11), a TXE4 electronic exchange with a cooling requirement of 35 kW. It was known that the exchange was too small and the water table too deep to allow a favourable financial comparison to be made with a system using central plant or BT standard cooling units. However, a borehole cooling unit was manufactured that had similar dimensions and performance to the BT standard cooling unit. The unit was designed so that, if the borehole system proved to be unsuccessful, then the inner section could be removed and a standard inner section with its own integral direct expansion system could be wheeled into its place. Valuable experience was gained from this study and BT now has greater confidence to go on to larger schemes.

Had a single borehole been drilled and the water discharged into the public sewer, the system would have been economically viable. In fact, the water authority was willing to see this happen since it would have provided a means of flushing the sewage system in the summer months. However, BT wished to determine the effects of water recirculation. The separation between the boreholes was 17 m, and the system was used in the summer of 1986. No rise in the water inlet temperature was detected.

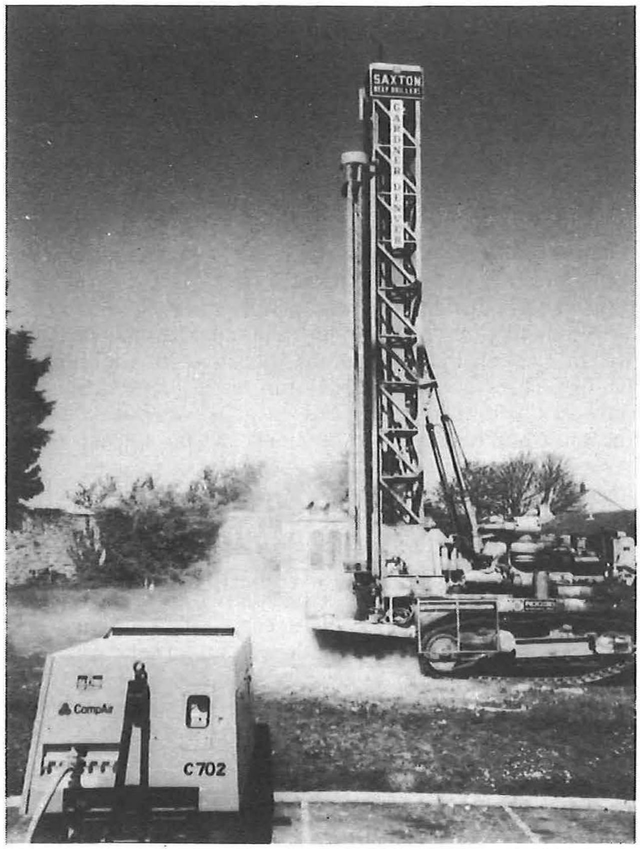


Fig. 11—Drilling at Plymstock Telephone Exchange

THE FUTURE

BT intends to proceed with further borehole cooling installations for both office and exchange purposes but, wherever financially and technically possible, the water will be discharged to waste. A scheme is being planned at the moment to make use of boreholes for both heating and cooling. The heating will make use of a heat pump. Under normal circumstances in the UK, the heat-pump system would not be financially viable but, since the cost of the boreholes would be written off against the cooling system, this would no longer be the case.

Many large cities in the UK now have a rising water table. As industry in the city has declined, old wells and boreholes have become disused, and the water table has risen to such a degree that the foundations of some buildings will soon be in danger. The cheapest way to protect these buildings is to sink a borehole and pump continuously. Several cities, including Manchester and London, are now beginning to suffer from this problem. Therefore, in the not too distant future, it may be necessary to have borehole systems sunk for some buildings and, under these circumstances, it should be well worthwhile to use the water to both heat and cool the building before the water is discharged into the sewer.

Biography

Gordon Brown is head of the Building Engineering Consultancy Group. He joined the then Power Division of the Post Office from industry in 1968. He worked on various DC and AC projects, including Power Plant No. 432, and was particularly involved in the development of the associated high-voltage packaged substations. He moved onto building engineering services work in 1977 and was responsible for the development and introduction of the range of standard BT cooling units. His present work includes investigation into new methods of exchange cooling.

Development of CCITT Standards for Packet Data Networks

G. MOUDIOTIS, B.SC., M.PHIL.(ENG.), M.B.C.S.†

UDC 389.6 : 621.39

The rapid growth of the communications industry has produced the need for a programme of rationalisation of international computing and networking standards. This article reviews the work done by the CCITT in this field since 1980, and particular attention is given to the progress being made in the standards for packet data networks: X.25, X.3, X.28, X.29 and X.32. It also discusses some aspects of the Open Systems Interconnection (OSI) Reference Model that are related to the Network layer and to X.25.*

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INTRODUCTION

The CCITT is the data and telecommunications standards body of the International Telecommunications Union (ITU), which, like the International Standards Organisation (ISO), is an agency of the United Nations.

The CCITT is responsible for producing Recommendations for telecommunications equipment and services to be applied to public communications networks. The published Recommendations have the status of international standards within the telecommunications industry. In addition, the CCITT provides standards for data communications networks and related services such as videotex, Teletex, facsimile and message handling and, in that respect, recognises the need to liaise with the ISO in these areas to achieve and maintain international compatibility. Activities at the CCITT are the responsibility of Study Groups (SGs), and the Recommendations they produce are agreed and ratified at the Plenary Assembly every four years. The X-series Recommendations are the responsibility of SG VII, which is concerned with all aspects of data communications networks including the interchange of data over public networks. Each SG entrusts the work to be carried out during the study period to a number of working parties (WPs) of experts in a particular field.

WORK OF SG VII

The CCITT SG VII was entrusted by the VIIth Plenary Assembly in 1980 with the study of 41 Questions (items of study) related to data communications networks.

SG VII set up five WPs with the following responsibilities:

WP VII/1: network service classes and facilities,
WP VII/2: network access interfaces,
WP VII/3: network interworking, switching and signalling,
WP VII/4: network transmission and maintenance, and
WP VII/5: network aspects.

For each Question, a special rapporteur was appointed to progress the work of the SG.

In the course of the 1981–1984 period, the SG drew up 35 new Recommendations. Recommendation X.200 (Reference model of OSI for CCITT applications) was adopted provisionally in May 1983. Substantial amendments have also been made to 25 existing Recommendations.

With the inclusion of substantial parts of Recommendation X.87 into a new Recommendation X.300 (interworking of networks), this Recommendation was abolished.

In conclusion, a total of 71 Recommendations have been contained in the X-series for data communication networks.

With regard to the proposed study programme for the next study period, 1985–1988, SG VII is retaining a number of existing Questions and adding 22 new Questions, making a total of 48. Most of the new Questions relate to interworking, including the integrated services digital network (ISDN), and to message presentation services including directories, document architectures and message-handling systems.

EVOLUTION OF X.25

The X.25 Recommendation was firmly established in 1980 as a workable interface specification for packet-mode data terminal equipment (DTE). Its adoption internationally by all packet-switched public data networks (PSPDNs) has helped considerably towards its stability as an interface for world-wide communication. The question of stability was also paramount in the minds of the SG VII/WP2 participants collaborating in this work with other standards groups, DTE manufacturers and users, since stability ensures a growing market for the protocol and wider availability of cheaper X.25 terminals.

SG VII/WP2 has been particularly concerned in the last four years with the following main issues:

(*a*) the interworking of private X.25 networks with public packet-data networks;
(*b*) the alignment of X.25 to provide the OSI Network service requirements;
(*c*) new optional user facilities, particularly the on-line registration and network user identification facilities; and
(*d*) the readability of the X.25 text and its accuracy.

In resolving these issues, it has been ensured that the new capabilities do not impact on existing implementations of terminals or networks. Certain facilities have been upgraded from optional to mandatory status. Table 1 lists all the facilities for the switched virtual call service to be made available in all PSPDNs.

Interworking with Private Networks

X.25 in 1986 incorporates a number of enhancements to provide the end-to-end control required when private X.25 networks are interconnected to public networks. Currently, there is no explicit international agreement on interworking protocols for private X.25 networks and for local area networks (LANs) operating in the connection-oriented mode and wishing to access wide area networks. X.25 is naturally

† Public Data Networks, British Telecom Business Network Services

* CCITT—International Telegraph and Telephone Consultative Committee

‡ MOUDIOTIS, G. Development of CCITT standards for packet data networks in the period 1980–1984. *Computer Communications.*, Aug. 1985, 8, 186–192.

TABLE 1

Essential Facilities for Packet Data Networks Applicable to a Virtual Call Service

Facilities Assigned for an Agreed Period of Time	Facilities on a Per-Call Basis
Closed user group Flow control parameters negotiation Throughput class negotiation Fast select acceptance Incoming calls barred Outgoing calls barred One-way logical channel outgoing	Closed user group selection Window size negotiation Packet size negotiation Fast select Throughput class negotiation Transit delay selection and indication

suited for such interworking cases. However, a number of other interworking issues still remain to be resolved: those involving multiple connections, methods of routing when alternative routes are provided in public networks and security aspects.

Enhancements relate to the exchange of accounting information, local charging prevention and closed user groups (CUGs), the latter being extended to a maximum of 10 000 CUGs.

Consideration was also given to the explicit identification of the calling DTE and the PSPDN, the restrictions of X.25 timeouts, the inclusion of *call progress* signals in *call clear*, *reset* and *restart* packets and call redirection within the private network.

The numbering plan for public networks, X.121, has also been extended to allow enhanced addressing and subaddressing capabilities for private networks. As a supplement, and specifically for OSI, the *networks address extension* facility was incorporated in X.25.

Alignment with the OSI Network Service

It has been decided by the CCITT and ISO that the X.25 virtual call service protocol will be used to provide the OSI connection-oriented Network service. Towards this end, certain elements and procedures were added to X.25 and new facilities were introduced.

Optional User Facilities

The *fast select* and *fast select acceptance* facilities were upgraded to essential facilities. These now permit user data of up to 128 octets in *call confirmation* and *clear* packets.

The *transit delay selection and indication* facility was also introduced as an essential facility. This enables a DTE to specify a desired transit delay on a per-call basis, and the network is requested to allocate resources and to route a call in such a manner that the requested transit delay indicated to the DTEs is not exceeded. This facility is necessary for OSI in addition to the *throughput class negotiation* facility introduced in 1980.

CCITT-Specified DTE Facilities

The facilities carried transparently end-to-end between DTEs are contained in the facility field under a new marker, the *CCITT-specified DTE facilities marker*.

The *calling and called address extension* capability, which operates beyond the 14-digit maximum address that identifies a DTE connected to a public network (as defined in X.121), permits calling and called addresses of up to 40 digits each to be transferred in *call set-up* and *clear* packets.

The quality-of-service negotiation facilities are the *end-to-end transit delay* (cumulative, requested, maximum acceptable) *negotiation* facility, the *expedited data negotiation* facility and the *minimum throughput class negotiation* facility.

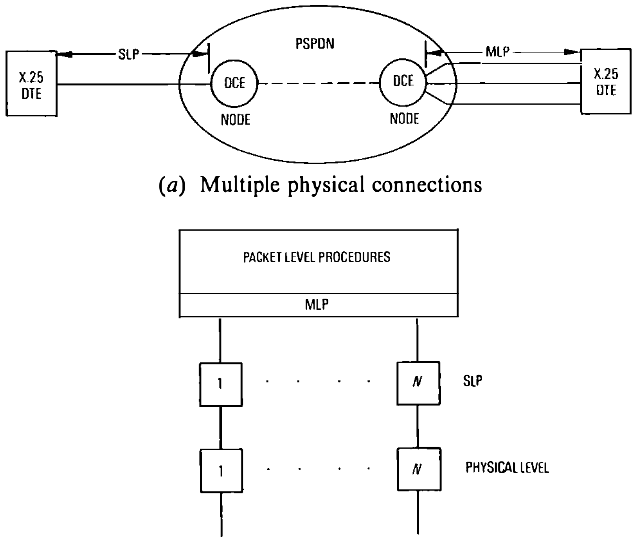
Other changes involve the extension of the user data of the *interrupt* packet from 1 octet to 32 octets maximum required by the expedited service, the agreement that the general format-identifier field will provide the means of protocol identification to be used at the Network layer and the negotiation of the overall availability of the D-bit to support the receipt confirmation Network service.

Changes to the Link Level

The X.21*bis* interface is no longer an interim solution, as in 1980, and it has equal status to the X.21 interface for connections to PSPDNs.

The link-layer access protocol (LAPB) has been aligned with the single-link procedures of X.75. Multilink procedures were also introduced into the LAPB. These operate over multiple physical connections between a single DTE and a node on the PSPDN (see Fig. 1(*a*)). These connections are viewed as a single logical link, and data packets are interchanged independently across these connections. Multilink procedures provide resequencing of frames for optimum load-sharing, and links can be added or removed without the loss of data packets or the need for calls to be cleared. Fig. 1(*b*) illustrates the model for multilink procedures.

The extended numbering option, modulo 128, for frame-sequencing over satellite links, for example, was introduced in LAPB.



(*a*) Multiple physical connections

(*b*) MLP model

SLP: Single link procedures
MLP: Multiple link procedures
N = Number of single links

Fig. 1—Single and multilink connections to X.25 DTEs

Facilities and Enhancement to the Packet Level

The datagram service has been deleted in the X.25 and X.2 Recommendations, since no telecommunications or network administration is currently planning to provide this service. A Question that more accurately reflects the emerging area of interest in connectionless services was set for further study.

An optional facility, *on-line registration*, was introduced to allow a DTE to request registration of facilities or to obtain current values of facilities offered by the PSPDN. Some facilities, such as flow-control parameters, charging information, etc., can be negotiated, while others, for example, CUGs, are not indicated by the network. Dynamic changes of facility options by means of the on-line registration procedure prior to setting up a call are also useful for X.25 switched access (X.32).

An optional security feature, the *local-charging preven-*

tion facility, was introduced which, if subscribed to, authorises the network to prevent a customer from receiving reverse-charge calls or third-party charges, and from making chargeable calls.

The *network user identification* (NUI) facility enables a DTE to provide information for billing, security or management purposes when setting up a call to the PDN.

The *charging information* facility provides call data (duration, segment count) to the subscriber to this facility when the call is cleared.

When subscribed to, the *call redirection* facility permits calls to a busy or out-of-order DTE to be routed to another DTE. In addition, a *call-redirection notification* facility can be used to inform the alternative DTE of the reason for call redirection and the address of the original DTE.

The *hunt-group* facility is used when there are a number of DTEs connected to the same called address. This facility permits the distribution of incoming calls across the designated group of DTE interfaces.

The *called-line address-modified notification* facility is also new, and it is used to inform the calling DTE, within the *call-connected* or *clear-indication* packets, that the call has been redirected and the DTE address to which it has been sent.

The CUG facility now covers an extensive number of variants. A CUG with an *outgoing access-selection* facility, to be used for called DTEs that are connected to large private networks, was also introduced.

The permissible packet sizes were increased to 2048 octets and 4096 octets.

The length of the facility field was also increased to 109 octets (from 64) to accommodate the new facility codes, including those for OSI. Thus, for universal operation, all networks are required to offer a maximum *call request* packet of 259 octets, including the link-level fields.

The *recognised private operating agency* (RPOA) facility was also extended to allow a DTE to select more than one RPOA transit network.

EMERGENCE OF X.32

The need to provide access to packet data networks through other public switched networks and, in particular, the telephone network (PSTN) and the circuit-switched data networks (CSPDNs) was first discussed by the CCITT at the Hague, Netherlands, in March 1982.

By the end of 1984, a new, but incomplete, draft Recommendation X.32 emerged to describe the functional elements of the interface to PSPDN services for dial-up-access (Fig. 2). This interface supports packet-mode DTEs and Teletex terminals. X.32 has now been finalised and is an approved CCITT Recommendation.

PSPDNs can offer two main types of service when accessed by X.25 DTEs via switched networks. These services depend on whether the DTE has been previously registered with the PSPDN. Terminals that have a leased-line connection and have made prior arrangements regarding facilities, number of logical channels, etc., might require to use dial-up access as a back-up service. On the other hand, DTEs unknown to the PSPDN, for example, mobile DTE users for whom a dedicated access line is not economically justified, might require to make temporary use of the PSPDN services via the PSTN or CSPDN. In that case, a PSPDN can offer a limited number of facilities, that is, those optimal user-facilities that govern the direction of virtual-call placement, or even an extended set of user facilities with certain restrictions in the lifetime of the switched-access path.

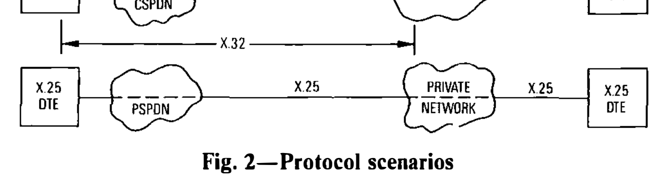


Fig. 2—Protocol scenarios

X.32 is very much concerned with the problem of identification of terminals, the authentication of access to the network in dial-in operations and, conversely, the identification of the network to enable a DTE to operate, for example, with the correct CUG. The identification protocol, therefore, allows the exchange of specific security-related information (for example, encrypted key, signature, etc.) for authentication of access to optional user facilities and services.

X.32 outlines several means of identification, some of which may be complementary:

(*a*) No identification of the caller; therefore, no chargable calls or reverse-charge calls are permitted. This means that limited facilities are offered and methods of charging are arranged otherwise.

(*b*) Identification by means of the PSTN or CSPDN calling-line identification signal: this is a secure method used widely for charging purposes, but it does not guarantee the actual identity of the caller.

(*c*) Identification by means of procedures prior to a virtual call: these involve exchanges of *exchange identification* (XID) frames or *registration* packets.

(*d*) Identification on a per-call basis by means of the NUI facility which may contain information for billing or security purposes.

It is anticipated that dial-up access using X.32 will become an important service in the future. Network providers in France, Canada, Japan and the UK already support some form of switched access to subscribed X.25 DTEs. X.32, as it does not need a dedicated line, would reduce the cost of X.25 access; this would therefore encourage its implementation on smaller systems and on the external gateways of simple LANs that require occasional access to PSPDN services.

FURTHER ENHANCEMENTS OF THE PACKET ASSEMBLY/DISSASSEMBLY FACILITY

Support of interactive asynchronous start-stop mode terminals (DTE-Cs) accessing packet networks is provided by the three CCITT Recommendations X.3, X.28 and X.29, which are known collectively as *Triple X*. The connection of these terminals to PSPDNs is accomplished via a packet assembly/disassembly (PAD) facility which, typically, supports a number of DTE-Cs simultaneously. X.3 specifies the basic PAD functions by means of PAD parameters, and a set of parameters defining the operational characteristics of each DTE-C is maintained in the PAD. X.28 defines the interface and protocol including a set of commands for the terminal user. X.29 defines the procedures for the control of the PAD over an X.25 network by an X.25 DTE or another PAD on the network (Fig. 2).

The demand for advanced facilities in the PAD to support the sophisticated features of intelligent terminals that are available has increased considerably in the past years. Examples of these facilities include editing, line-feed insertion, parity checking and insertion, selective editing and call reselection. Certain features required to enhance the user friendliness of the PAD interface have also been introduced in the signalling protocol.

Four new functions have been introduced in the 1984 Triple X:

(*a*) *Editing PAD service signals (parameter 19)* This controls the format of the editing service signals sent to the DTE-C by the PAD depending on the type of terminals, namely, a printer or visual display unit (VDU).

(*b*) *Echo mask (parameter 20)* If the echo function is enabled, then received characters will be echoed to the DTE-C prior to the transmission of any data waiting at the PAD. Parameter 20 permits the terminal user to control which group of characters are echoed back by the PAD.

(*c*) *Parity treatment by the PAD (parameter 21)* The PAD can now check the parity of the data received from the terminal and/or generate parity of the data transmitted to the terminal. The type of parity (even, odd, mark, space) is indicated by the eighth bit of the character received by the PAD. If there is a parity error, the PAD returns an *error-service* signal and does not echo the character in error.

(*d*) *Page wait (parameter 22)* The PAD can be directed by the DTE-C to suspend the transmission of data to it after a specified number of lines is transmitted. The PAD can resume the transmission of data when, for example, it receives an *X-on* character from the DTE-C. This type of operation is intended for VDU terminals that might be receiving a large volume of data.

An extensive number of minor changes and improvements were also introduced; these, however, will not affect terminal equipment implementations:

(*a*) Reselection: By means of X.29 procedures, the PAD can be requested to clear a call and establish a new virtual call to a reselected X.25 DTE; for this purpose, the packet-mode DTE provides all the information required in the incoming call-packet to the reselected X.25 DTE.

(*b*) New access rates of 1200 bit/s duplex and 1200/75 bit/s were introduced.

(*c*) PAD service signals can now be specified in a network-dependent format.

(*d*) The maximum length of X.29 PAD messages was set to 128 octets, and error reports in X.29 from the PAD were improved.

(*e*) National or local parameters, not standardised in X.3, can be indicated in PAD messages; their use is not recommended for international or internetwork communications.

(*f*) All facilities planned to be supported by the PAD have been allocated a specific code.

(*g*) PAD-to-PAD signalling on receipt of a *break* has been improved.

(*h*) A PAD now provides explicit support of the D-bit; there is no guarantee of data delivery to the DTE-C being implied, however, from the acknowledgement sent by the PAD to the packet-mode DTE.

(*i*) Parameter-indication PAD messages carry error-codes for invalid attempts to adjust parameters.

IMPACT OF OSI

The CCITT and ISO have well-established links of co-operation in many areas. Their co-operative effort to develop a common version of the OSI Reference Model has, however, been unprecedented. This has given extra impetus to the model as an international standard. The technical alignment of the models described in X.200 and ISO 7498 was achieved early in the CCITT cycle.

The description of the OSI Reference Model consists of an abstract hierarchy of seven layers of services/protocols and lists, in broad terms, the principal functions of each layer. The top three layers are concerned with the control of communication once a connection has been established. The lower four layers are concerned with the establishment of a connection having the required characteristics of throughput, transit delay, security, costs, etc. The Transport layer is present in the two end-systems of the connection only and does not exist within OSI networks or any inter-network gateways. The Network layer is responsible for establishing the logical path of the connection.

Table 2 lists the CCITT Recommendations developed for OSI and the equivalent ISO documents. These relate to the connection-oriented services and protocols and to the services offered by telecommunications administrations for Teletex (advanced Telex), videotex (text transmission) and message handling.

TABLE 2

Standards Relating to OSI for Connection-Oriented Services and Protocols

CCITT	ISO	Title
X.200	IS 7498	Basic reference model
X.210	DP 8509	Service definition conventions
X.213	IS 8348	Network layer service
X.214	IS 8072	Transport layer service
X.215	IS 8326	Session layer service
X.224	IS 8073	Transport layer protocol
X.225	IS 8327	Session layer protocol
X.25	IS 7776	Link-layer access protocol (LAPB)
X.25	DIS 7478	Link-layer multilink protocol (MLP)
X.25	IS 8208	Network layer protocol

IS: International standard
DIS: Draft international standard
DP: Draft proposal

Network-Layer Protocols

For PDNs conforming to X.25, the connection-oriented Network service (NS) has achieved complete technical alignment with the switched virtual-circuit service. The OSI NS offers a set of mandatory features that are globally provided, and two optional services of receipt confirmation and expedited data-transfer which are facilitated in X.25 by means of the D-bit and *interrupt* packet, respectively.

The functional characteristics of a connection between two end-users across one or more real networks is expressed by a set of quality-of-service (QOS) parameters, which include throughput, transit delay and network connection priority.

Throughput

Throughput refers to the total bandwidth delivery capability of a network measured in bit/s (that is, routing, flow control, congestion control, etc.) and the requirements for both transmission and switching. In OSI, it enables Transport- and Network-layer entities (that is, functional units in these layers) to choose between alternative ongoing connections and, in the Transport layer, for example, it is used to decide whether to multiplex a new connection over existing Network-layer connections.

Transit Delay

Transit delay or the maximum delivery delay for data is also an important parameter to end systems. It enables them to choose between alternative connections, and to allocate internal resources to satisfy the requirements of the particular application supported (that is, interactive or file transfer).

Network Connections Priority

This parameter relates to the occasional congestion problems that arise in packet networks. It enables a connection that supports several applications to be degraded or discarded as a result of this congestion. Priority is expressed by three subparameters:

(*a*) priority to obtain a network connection (for example, in order to obtain diagnostic information regarding the congestion),

(*b*) priority to hold and keep a connection until the completion of certain data transfers, and

(*c*) priority for certain types of data traffic over (for example, queued data-traffic).

Others

Other parameters such as acceptable cost, residual error rates, etc., are also important considerations related to routing, management and maintenance of the network connection.

Network-Layer Addressing

The subject of global addressing for the unambiguous identification of any terminal in the OSI environment has been the most controversial and difficult to define and resolve. By 1984, certain agreements had been reached between the ISO and CCITT, on the basis of which a Network-layer addressing scheme was progressed. This scheme relies on the concept of the network service access point (NSAP), which is the interface address between the Network layer and the Transport layer of the OSI model. In addition, some progress was made towards establishing an international registration authority to control and administer the allocation of NSAP addresses, in a similar manner to the way in which CCITT administers data network identification codes (DNICs) to public networks.

Existing numbering plans such as X.121, F.69, E.163, etc., as defined by CCITT for public networks, are considered inadequate for OSI addressing. They exclude private networks and LANs that do not attach to public networks and terminals on a private network, which can have more than one address assigned to them if that private network is attached to one or more public networks. Furthermore, current interworking arrangements for the routing of calls through concatenated networks are complex and in most cases undeveloped.

On the basis that any addressing solution agreed to by the CCITT and ISO must utilise existing networks without changing their individual addressing schemes or internal routing implementations, the world-wide OSI numbering plan has set as its main principle the preservation of existing allocations of DNICs, for example, to public packet data networks. In general, NSAPs can be identified only by addressing information offered by the NS user in addition to that required by the point of attachment to a real network. As an example, X.25-based networks would be required to carry across two address fields in the *call request* packet. One would be for the network address of up to 14 digits, in accordance with X.121, and would define the specific DTE/DCE interface at the attachment to the PSPDN, and the other would be for the NSAP address which would appear in a facility field as a separate entity under the CCITT-specified DTE facility marker. This mechanism requires no action to be taken by packet data networks and no directory function to support the OSI systems on such networks is necessary. What is required, is the implementation of enhancement mechanisms by end-users and public or private gateways.

NETWORK STANDARDS AND PACKET SWITCHSTREAM

Packet SwitchStream (PSS), the UK national packet-switched network, has been in commercial service since 1981. It has currently over 40 packet-switching exchanges operating with international connections to over 70 networks in 50 countries. PSS offers a set of services compatible with those defined in CCITT Recommendations X.25, X.28 and X.29 (1980) and a number of complementary services and facilities, known as *MultiStream*, providing quality data communication for non-packet-mode terminals and other terminals using proprietary protocols.

Adherencc to the widely accepted standard X.25 as the method for communication for PSS has resulted in a number of benefits to the user: it allows low error rates, it makes economical use of lines, it is low cost on long-distance use and is efficient for interactive access to databases.

British Telecom's (BT's) overall network strategy is to develop PSS within the framework of an Open Network Architecture in line with the OSI Reference Model. This strategy includes the implementation in 1986/87 of enhanced and additional features of X.25 (1984) which will provide the OSI Network service. In addition, the introduction of an X.32 service will provide the economy of dial-up access to users of intelligent terminals, personal computers and minicomputers.

CONCLUSIONS

This article has reviewed the development of standards related to packet data network interfaces, with particular regard to the progress made in the last CCITT plenary period on the relevant Recommendations. The scope of these Recommendations has been widened in response to the market demand for extra facilities and for the advanced communications services that have been developed in the past years.

The impact of OSI on existing protocols and services has also been considerable. It is expected that the trend towards OSI will continue and that the momentum of the 1980–1984 standards programme at the CCITT will also continue unabated in the next study period.

APPENDIX—CCITT RECOMMENDATIONS

The X-series Recommendations, Volume VIII, are published in the Red Book (they can be ordered from CCITT, Sales Services, ITU, Place des Nations, CH-1211, Geneva 20, Switzerland). Volume VIII consists of the following seven fascicles:

VIII.1—Data communication over the telephone network. Series V Recommendations.

VIII.2—Data communication networks: services and facilities. Recommendations X.1–X.15.

VIII.3—Data communication networks: interfaces. Recommendations X.20–X.32.

VIII.4—Data communication networks: transmission, signalling and switching, network aspects, maintenance and administrative arrangements. Recommendations X.40–X.181.

VIII.5—Data communication networks: Open Systems Interconnection (OSI), system description techniques. Recommendations X.200–X.250.

VIII.6—Data communication networks: interworking between networks, mobile data transmission systems. Recommendations X.300–X.353.

VIII.7—Data communication networks: message handling systems. Recommendations X.400–X.430.

Biography

George Moudiotis graduated in 1960 from London University with a B.Sc. in Electrical Engineering and was awarded a Master of Philosophy degree in Engineering from the same university. He has been involved in data communications for 15 years at ITT and ICL and, since joining BT National Networks' Packet Switching Services in 1982, in the development of standards and protocols for the packet-switched data network. He is currently BT's lead delegate to CCITT SG VII/WPII on network interworking, a member of the British Standards Institution working group on OSI Network and Transport standards and is participating in CEPT's work on the harmonisation of public data networks and the development of European functional standards. He is also responsible for the technical management of an information database to be used in a demonstration network of OSI products.

Measurement in Britain

UDC 389.6

In the UK, some £15 000M is spent each year on making measurements. Metrology, the science or system of weights and measures, therefore, is a valuable tool with which industry can improve its competitiveness. This article reviews the role played by the Metrology and Standards Requirements Committee to promote, sustain and extend an efficient National Measurement System.

INTRODUCTION

In the UK, about 6% of the gross national product (GNP) is spent in making measurements†. These measurements range from the simple and relatively low-accuracy requirements of the high-street trader selling drapery or food to the high precision necessary for the manufacture of advanced aero engines.

The accuracy of all these measurements relies on the calibration of the measuring equipment against a measured standard of higher accuracy. Thus, to ensure that measurements made at different times or at different places agree to within an acceptable degree of accuracy, a national calibration system is required. Similarly, when goods or services are traded overseas, the system needs to agree with similar standards maintained by the trading partners.

NATIONAL MEASUREMENT SYSTEMS

Governments of most industrialised countries have long recognised the need for national measurement standards. Within the last century, much has been done to mould a variety of these standards into a measurement system. Such systems require the following essential components:

(*a*) a central or premier laboratory for maintaining national measurement standards of sufficient accuracy to serve the needs of industry and commerce,

(*b*) a practical system for ensuring that the measurement standards and instruments used in manufacture, trade and commerce are traceable to the national standards, and

(*c*) national specification standards for use in design, production, quality control, product design, health and safety. These specification standards must be compatible with international specification standards for ease of international trading.

The level of dependence on traceability varies according to which sector of society is considered. In particular, where there are regulatory or contractual requirements the dependence is strong. Examples of this are the retail sector regulated by the Weights and Measures Act, the health and safety sector regulated by professional codes of practice, and the supply of defence equipment regulated by the Ministry of Defence Quality Assurance or British Standards requirements.

There are other areas in manufacturing industry where there is less dependence on the National Measurement System, mainly through lack of awareness, with the consequence of unnecessary penalties being paid for the want of better metrological practices; for example, the measurement of colour in textiles and ceramics.

The Department of Trade and Industry (DTI) has responsibility for the UK's National Measurement System which is centred on three major laboratories: the National Physical Laboratory (NPL), the National Engineering Laboratory (NEL), and the National Weights and Measures Laboratory (NWML). However, it is to the Metrology and Standards Requirements Committee (MSRC) that the DTI looks for advice on the research and development (R&D) needed to sustain, improve and promote the National Measurement System.

† Measurement in Britain—a framework for industry. Department of Trade and Industry.

DTI REQUIREMENTS COMMITTEES

The general terms of reference of the DTI's advisory and requirements committees are to advise the Secretary of State for Trade and Industry on:

(*a*) the identification of the R&D and innovation requirements in the relevant areas of industry and technology,

(*b*) the consideration of particular proposals for R&D programmes referred to the committee by the DTI, together with giving further recommendations for longer-term or more speculative programmes,

(*c*) new initiatives to further the application of science and technology to problems within the committee's area of responsibility, and

(*d*) any other topic within the committee's competence or other initiatives within the DTI which have an impact on the committee's interests.

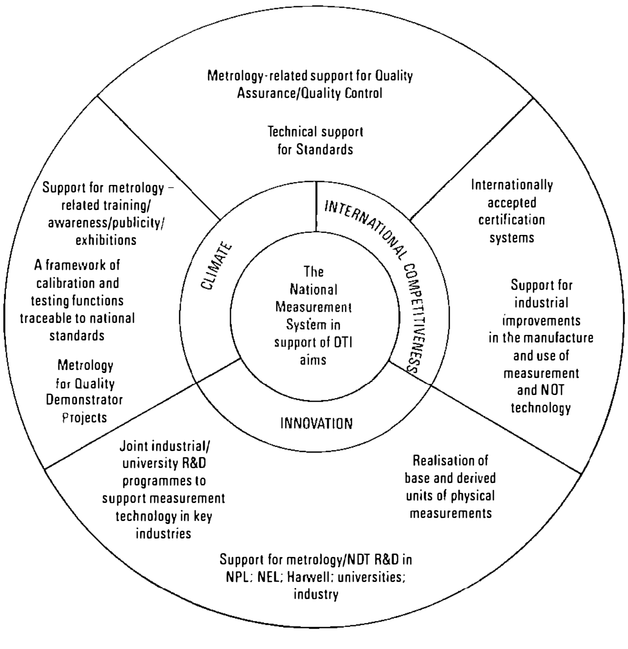
The general strategies developed by the advisory and requirements committees also relate to the overall aims of the DTI. Central to this theme is the aim to encourage, assist, and ensure the proper regulation of British trade, industry and commerce whilst growth in world trade and the national production of wealth is being promoted. In general, this central aim can be fostered by creating the right climate in which to operate, by ensuring international competitiveness and by promoting innovation in science and technology.

METROLOGY AND STANDARDS REQUIREMENTS COMMITTEE

The collective coverage of metrology and standards expertise of the MSRC is wide with members drawn from industry, universities, research councils, research associations, British Standards Institution (BSI) and the Ministry of Defence.

The MSRC defines its own strategic aim as the support and encouragement of R&D, innovation, developments and applications of measurement science to promote, sustain and extend an efficient National Measurements System.

Within this central aim there are three secondary aims and objectives. The first is the MSRC's main task and is the promotion and extension of the National Measurement System. This task includes ensuring that the National Measurement System is properly integrated and related to the systems of other countries. It also encompasses the need to ensure that proper calibration and certification practice is encouraged and carried out throughout industry and commerce. The second aim is to develop the strategy of the Committee in line with the priorities set centrally by the DTI and to provide support where appropriate. The third aim



MRSC aims and activities

is to strengthen the system of British Standard Specifications and to encourage the raising of the demonstrable quality of British goods.

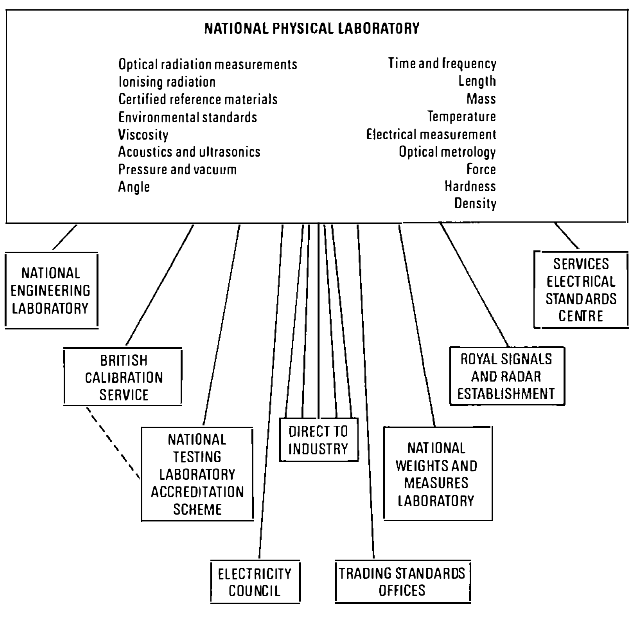
Promotion and Extension of the National Measurement System

The National Measurement System is an extensive framework of technical and administrative arrangements which provides companies and the scientific research community with an opportunity to relate their measurements to each other through calibration against a hierarchy of measurement standards. The primary standards for the UK are held at the NPL which acts as the focus for the UK National Measurement Scheme. As well as holding the national standards, the NPL is responsible for the management of the network of traceable calibration arrangements throughout the UK. It also ensures that British measurement standards are compatible with those of the UK's trading partners overseas through its links with the International Bureau for Weights and Measures (BIPM). The NPL, and NEL in the case of flow standards, undertakes R&D work to improve the standards in line with technological development and user demand.

The NWML has responsibility for maintaining the UK's trading measurement standards in mass, length and capacity and for providing a calibration service which gives authority to these standards when used in trade. In addition, the NWML is responsible for specifying measurement standards and testing equipment to ensure uniform levels of accuracy in Local Government Weights and Measures Offices. The NWML also assesses the design of weighing and measuring equipment to ensure that it is suitable for trade in the UK and the European Community. The laboratory also represents the UK on legal metrology in the European Community and in the International Organisation for Legal Metrology (OIML).

As part of its programme to encourage the adoption of better measurement technology throughout industry, the MSRC has launched a series of demonstration projects (Metrology for Quality) in several sectors of industry. Each project is designed to show the effectiveness of investment in new measurement techniques, especially where these are technically risky, initially expensive or demand new in-house skills. The MSRC also supports a major programme on non-destructive testing at the Atomic Energy Research Establishment, Harwell.

The MSRC has collaborative projects at several industrial research establishments but is keen to encourage more at other centres of metrology expertise at universities, polytechnics and research associations. The Committee's Publicity and Training Working Group has the task of enhancing the awareness of industry of the benefits of improved measurement technology through its contact with trade associations and professional groups. DTI support is available to industry in the form of subsidised consultancies under the Business and Technical Advisory Service, and Support for Innovation grants. The support includes advice on the application of measurement technology and the development of measurement equipment.



The UK National Measurement System depicting main lines of traceability of measurement accuracy from primary standards to ultimate users

Support for DTI Initiatives

The MSRC frequently modifies its work programme to support new initiatives taken on by the DTI or where a high priority has been placed on certain objectives. Current activities in which the committee follows these initiatives are: the National Quality Campaign; initiatives in key priority or enabling technologies; and support for the DTI's initiative to place more emphasis on human skills.

National Quality Campaign

The MSRC undertook several initiatives to reinforce the main messages and objectives of the National Quality Campaign. Improved measurement technology for better standards is an integral component of quality which falls within the direct sphere of responsibility of the Committee and so, in 1983, it supported the launch of a number of schemes which included:

(*a*) the Quality Assurance Advisory Service to provide QA consultancy to small and medium-sized companies,

(*b*) the Financial Assistance for the Implementation of Quality Assurance Schemes which selectively offered grants of up to 25% of eligible costs to companies employing up to 500 people,

(These two activities have since been merged with other DTI advisory and financial services).

(*c*) the commissioning and funding of case studies which demonstrate how improvements in a company's measurement techniques can lead to improved QA management systems—Metrology for Quality Projects, and

(*d*) Publicity and training for measurement technology through exhibitions, seminars, conferences and courses.

Support for Priority Technologies

The DTI has highlighted a number of enabling technologies which have a major impact on a wide number of industrial and commercial sectors and a number of initiatives have been taken to encourage the adoption and exploitation of, for example, micro-electronics, opto-electronics and information technology. The MSRC reflects these priorities in its programme and includes work on microcircuit linewidth measurement, fibre-optic standards, and positional accuracy of co-ordinate measurement machines and programmable robots.

Support and Promotion of Improved Human Skills

The MSRC is supporting this initiative on improving human skills by extending its work in the area of education and training with the aim of increasing the number of qualified and trained metrologists.

Support of Specification Standards

In the Memorandum of Understanding between the Government and the BSI, the DTI has agreed to support proposals for R&D to develop or improve British Standards. The MSRC Secretariat has agreed to act as the main DTI focus and clearing house for proposals from the BSI or other agencies which believe that measurement and test specification standards need improvement. An important criterion for support is that the enhanced standard would be compatible with European standards and, where possible, with international standards.

METROLOGY FOR QUALITY DEMONSTRATION PROJECTS

The 12 Metrology for Quality Demonstration Projects were commissioned by the DTI on the advice of the MSRC. These projects show the commercial benefits derived from the application of modern measuring equipment and measurement control. The projects cover a number of industry sectors ranging from woodworking and footwear to aerospace and fibre-optic industries. For each project, an initial audit of the current measurement and quality-management system was made, recommendations on changes necessary were implemented and a post audit conducted. The changes recommended might include the adoption of statistical process control techniques or the use of improved measuring instruments such as a simple dial angle gauge, for example, in the woodworking industry, or a three-dimensional computerised measuring machine in the aerospace industry. In other cases, it might prove necessary to develop a new measurement device.

Of particular interest to the telecommunication engineer is a project carried out at Standard Telecommunication Laboratories Ltd. on the manufacture of optical fibre. When a fibre is drawn, it is covered immediately with a polymer coating, and it is the uniformity and concentricity of this coating that is an important factor in the ultimate quality of the fibre. The difficulty arises in attempting to measure continuously the concentricity of an item only 125 μm in diameter being made at the rate of 60 m/minute. To solve the problem, a concentricity monitor using a split laser beam was designed. Analysis of the interference pattern detected by arrays of photodiodes enables the concentricity to be monitored and allows automatic feedback to be applied to the process. This new measurement device has enabled the mean concentricity to be reduced and drawing speed increased to 120 m/minute for lengths in excess of 10 km. In addition, other benefits have accrued from improved fibre yield and quality.

ACKNOWLEDGEMENT

Acknowledgement is given to the MSRC Secretariat for permission to publish the information contained in this article.

Copies of leaflets describing the Metrology for Quality Projects and further information can be obtained from the MSRC Secretariat, Department of Trade and Industry, Room 244 Ashdown House, 123 Victoria Street, London SE1E 6RB.

Underground Plant

A Review of the Causes of Damage and the Means of Control

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Damage to underground ducts, cables and jointing chambers during excavation activity causes disruption to telecommunications services and diverts effort from productive work. This article reviews the causes of damage and the various means by which both the number of cases and the extent of damage can be minimised.

INTRODUCTION

About 35% of the total capital assets of British Telecom (BT) is in external plant and much of these assets is in underground plant located mostly in the highway. BT shares these locations with a large amount of plant belonging to the distribution networks of other utilities and organisations. Because the plant is buried in the ground, it is covered up; left alone, the plant is in a secure environment but out of sight and therefore not located readily. Unfortunately, this also makes it vulnerable when the ground is disturbed for whatever reason. Damage is a major hazard for all the utilities' underground plant—water, gas, electricity, and telecommunications. As a result, studies and trials have been carried out to identify the causes of interference damage and the means by which the incidence of damage can be limited. This article draws on the knowledge and experience gained by BT and by the utilities working together through the aegis of the National Joint Utilities Group (NJUG).

As an example of the serious effects of cable damage, in the junction network during 1976, 124 cases of isolation of exchanges which took on average almost 12 hours before service was restored were recorded. These isolations were caused by 79 cases of damage, and 27 were the result of actions taken by BT staff.

Most of the serious breakdowns of telecommunications cables in outside plant result from damage caused by the excavation activities of the utilities, their contractors or other building or civil engineering operations. Such damage is wholly undesirable for the following reasons:

(*a*) The customer is inconvenienced as a result of the loss of service, a factor which is becoming more critical as commerce and industry become more dependent on telecommunications.

(*b*) The cost of repairing the damage can be recovered from the party causing the damage, provided the culprit can be identified. Nevertheless, a repaired cable may be less reliable than the original. It is also difficult to estimate the full impact of the cost to the business especially in lost revenue.

(*c*) Rectifying the damage means that effort has to be diverted from productive and profitable work.

For the purposes of this article, the word 'damage' encompasses 'direct' and 'indirect' damage, and the effects may be either 'immediate' or 'delayed'. Direct damage occurs when, say, a cable is cut by an excavator; indirect damage is associated with failure of other utility plant which, in turn, affects telecommunications plant. In many cases, the impact of the damage is felt immediately through the deterioration or loss of service. However, the effects can be delayed; for example, a punctured cable sheath which allows moisture ingress leading to corrosion and eventual failure, or a duct which may be damaged and which may become apparent only when cabling in the bore is next attempted.

A particular problem for telecommunications is that the results of damage to plant do not impinge directly upon the operatives undertaking the excavation. Striking an electricity cable can lead to burns from molten metal or the possibility of electrocution; fracturing a water main or a gas main produces immediately observable results. When a telecommunications cable is damaged, the operative who causes the damage does not suffer and the real effect upon the employer is delayed until the insurance premium is next reviewed.

PLANT IN THE GROUND

There is a great diversity of plant which can be encountered in the near-surface environment as Table 1 indicates (see Fig. 1).

The items in the list refer to plant which is in current use; in addition, there are likely to be relics of abandoned services which normally would be quite uneconomic to recover when superseded. Apart from those listed, disused hydraulic or pneumatic mains may be found in several cities of the UK; cellars and old building foundations under the streets add further obstructions.

The immense amount of utility plant under the ground is indicated in the 'Horne' Review[1] from which Table 2 is extracted. The figures quoted are exclusive of any service connections from these mains to customers' premises.

† Local Lines Services, British Telecom Inland Communications

From *The National Telephone Engineer*, Nov. 1906:

'The electrification of the tramways by the London County Council and other bodies in the London area is having very serious effects on the company's plant, particularly on the underground portions of it. In spite of careful watching and co-operation with the tramway authorities on the part of the engineering department, frequent breakdowns occur through damage caused by the tramway contractor's men driving their steel wedges and guard rods through ducts and cables..'

From *The New Civil Engineer*, 27 March 1986:

'It very nearly did not happen at all [the Giotto space encounter].. Two days before, as the space vehicle was activated, contact was nearly lost for an hour. Scientists sweated as emergency deep space communications systems were switched on with no effect, and millions of pounds worth of effort seemed doomed. But no ionic solar outbursts caused this. It was a man in an excavator, in Australia, who dug up the cable between the ground reception stations for the signal. Construction strikes again.'

TABLE 1
Buried Plant

Operator	Buried Plant
Telecommunications	Duct, cables in duct, directly-buried cables, buried joints, manholes, joint boxes, shallow-depth duct tunnels
Water industry	Pipes, valves, hydrants, sewers, manholes, meter chambers, service connections, telemetry cables, culverted streams and rivers
Gas industry	Pipes, valves, branch connections, ducts
Electricity supply industry	Cables, ducts, joints, link disconnecting boxes, protective coverings, marking tapes
Cable television	Ducts, cables, amplification points
Local authorities	Street lighting cables, pipes for district heating schemes, highway drains, traffic sign cables, traffic control cables
Private	Drains, sewers, oil distribution pipes
Transport	Cut-and-cover rail and road tunnels, pedestrian subways

TABLE 2
Summary of Utilities' Underground Plant (1983)

Utility	Number of Customers Serviced by Underground Mains	Length of Underground Mains (km)
Electricity	20 million	400 000
Gas	15·9 million	230 000
Telephone	20 million	430 000 (duct-runs exclusive of cables)
Water	21 million	340 000
Public sewers	21 million	250 000
Total	-	1 650 000

Source: PUSWA Review[1]

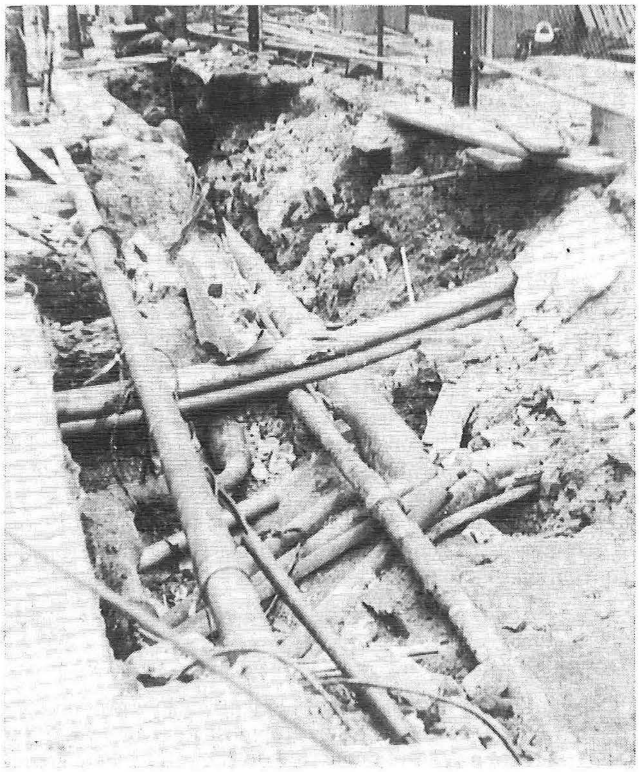

Fig. 1—Typical congestion of plant in a city centre excavation

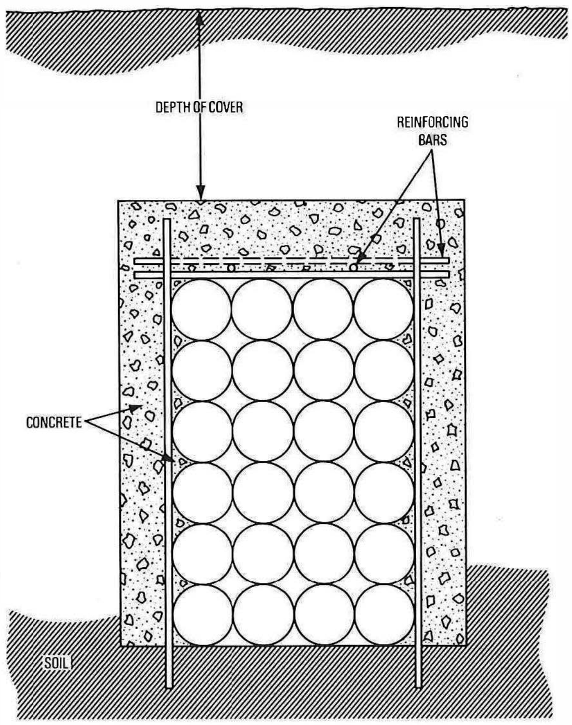

Fig. 2—A typical nest of duct with concrete haunching

VULNERABILITY OF DUCT AND CABLE TO DAMAGE

Of all the components of telecommunications hardware, underground plant has potentially the longest life, and this applies especially to duct. Unless physically damaged, earthenware and plastic ducts have an indefinite life. This characteristic means that duct installed in city centres in the early years of this century is still likely to be in use for the most modern of cables.

Polyethylene-sheathed cable has limited resistance to damage and, although occasionally it has been buried directly in the ground, by far the largest proportion has been either installed in duct or provided with steel-wire armouring for direct burial.

Duct offers varying degrees of protection according to the type and method of installation. All currently-purchased duct is either plastic—polyvinyl chloride (PVC) for the most widely-used 90 mm bore Duct 54D and the 51 mm Duct 56, or polyethylene for small-bore duct—or steel as 102 mm bore pipe. Plastic duct has moderate resilience to damage when laid directly in the ground for up to eight ways; for larger formations, concrete haunching is used (Fig. 2). Although the concrete is provided primarily to impart structural stability to the road formation, it also acts as an effective protection against excavating implements.

Plastic duct has, however, been in use for little over 20 years; most of the duct in the ground is earthenware, the purchase of which was only finally discontinued in 1983. Earthenware is an extremely durable material and has an indefinite life provided it is laid properly and left undisturbed. The material is however brittle and can be cracked fairly easily. Simple cracks are not too serious, but, if pieces of duct come away, then very sharp edges are likely to be present which could cause serious damage to cable sheaths during cabling of the bore. This was the principal reason for the decision to cease the purchase of earthenware duct and standardise on plastic. Mis-aligned joints are another source of difficulty with earthenware duct, especially with older types, and these 'dropped joints' have been a major cause of problems with cabling.

Throughout this century, steel duct has been used where extra protection to the duct route has been necessary; typically, on bridge decks and similar locations where the normal depth of cover cannot be provided.

Various other duct materials have been used—wood, wrought iron, pitch-fibre, asbestos-cement, precast concrete block—but their use has not been sufficiently significant to enter into the present discussion. One final type merits a mention: in effect, a ducted cable but supplied complete as combined cable and duct. Known as *PETAP*, it consisted of a cable loosely contained in an outer tube of polyethylene, and was designed to give a reasonable degree of protection against hand-digging tools in the housing estate situation. It has now been replaced by small-bore duct cabled in the conventional manner.

Depth of Cover

'Depth of cover' is defined as the depth below ground level of the top of the barrel of the topmost duct or, where the duct formation is laid in concrete, to the top of the concrete surround. For many years, the standards adopted were cover depths of 14 inches under footways and 24 inches under carriageways. Current standards are shown in Table 3. In urban areas especially, the congestion of plant beneath the surface often means that variations to the standard depths have to be made. In some cases, nests of ducts have been constructed in headings; these are at greater depth and generally immune from damage.

TABLE 3

Standard Depths of Cover

Type of Duct/Cable	Standard Depth of Cover	
	Footway† (mm)	Carriageway (mm)
Polyvinyl chloride (PVC) Duct No. 54D		
Single way	350	600
Multiway (over two and up to and including 20 ways)	450	600
Multiway leads-in to buildings and over 20 ways for street tracks	600	900
Steel Duct No. 70	350	600
Polyethylene Duct No. 100	350	600
Polyethylene cable laid direct in ground		
(*a*) Other than (*b*)	350	600
(*b*) Customers' gardens or cultivated ground	450	-

† Including grass verges and vehicular crossings over footway

EXCAVATION IN THE HIGHWAY

The utilities are statutorily obliged to provide and maintain a supply or service to the public; to enable them to perform these functions, the utilities were given the right, from the mid-nineteenth century onwards, to break open and reinstate highways in order to lay and maintain their equipment. Other bodies without such statutory rights can be licensed by the highway authorities to carry out street works.

The Public Utilities Street Works Act (PUSWA), 1950, provides a general code which controls the exercise of the statutory powers of the utilities. Two aspects of its provisions bear upon the damage question: firstly, there is the requirement to give due notice in writing to other utilities when excavation of the highway is proposed; secondly, it lays down the basis on which the owning utility can recover costs of making good the damage caused by another utility.

AMOUNT OF EXCAVATION

It has been estimated[1] that the total expenditure by the utilities on work in the highways involving excavation amounts to some £1000M per year. Some two million excavations are made each year by utilities alone; to this number must be added the number of excavations made by local authorities and during civil engineering and building work. Table 4 gives an indication of the size of the utilities' workload. With this high degree of activity, coupled with the problem of congestion of plant in the sub-surface environment, it is not surprising that damage to utilities' plant occurs and constitutes a major element in the disruption of service to customers.

The excavation activity is unevenly spread geographically, as indicated in Table 5. It should be noted that this data was derived from the number of notices issued under the PUSWA notice procedures. As a result, it understates the total number of openings as one notice may cover several separate excavations. The figures for London indicate that, on average, there is at least one opening per year per 75 m length of carriageway!

TABLE 4

Utilities' Annual Workload 1982/83

	Gas	Water†	Sewers†	Electricity	Telecommunications
New and replacement mains (km)	5457	3200	2500	4000	3150
Number of new and replacement services (1000s)	767	230		200	467
Number of small openings (1000s)	544	536		217	74

† England and Wales only
Source: PUSWA Review[1]

TABLE 5

Intensity of Utility Excavations in the Road, 1982/83

	Notices of Works in the Carriageway†		Notices of all Works (Footway and Carriageway)	
	Total Number	Number Per Kilometre of Road	Total Number	Number Per Kilometre of Road
Metropolitan Counties	187 748	5·4	438 016	12·7
English Shire Counties	334 610	1·6	616 211	2·9
London Boroughs	170 555	13·5	362 394	28·7
Welsh Shire Counties	44 366	1·4	55 844	1·7
Scottish Regional Councils	66 387	1·7	106 468	2·9
Totals for Great Britain	767 800	2·3	1 514 808	4·6

Source: PUSWA Review
† Including notices covering works in both the carriageway and the footway

REASONS FOR EXCAVATION

BT has the only underground network which is extensively ducted, and a high proportion of all new cabling work and maintenance can be carried out from jointing chambers without the need to excavate. Obviously, there is need to excavate when new ducts are being installed. Limited excavation is needed to clear blockages in the ducts which may be caused by breakage or displacement of the duct or an accumulation of silt or tree roots. Excavation is also needed when underground feeds are being provided for new customers or to gain access to buried joints which, although obsolete, still exist in some numbers.

Ducted systems are used to a limited extent by the other utilities; for example, road crossings may be provided with ducts through which pipes and cables can subsequently pass without the road surface having to be broken open. Some electricity cables are installed in ducts, but the loss of intimate contact with the ground, which assists heat dissipation, restricts the power-carrying capacity of such cables. For the provision of new cables and pipes, excavation is needed, as was, until recently, the renewal of gas, water and sewage pipes, but renewal techniques are now available which permit an increasing amount of this work to be carried out with a minimum of excavation. For all service connections to new or renewed piped mains or to electricity cables, small excavations are required.

Among the utilities, telecommunications is also unique because emergency openings constitute only a very small proportion of the total. The collapse of a sewer, a burst water or leaking gas main requires immediate attention because of the safety implications. Most routine faults on BT's cable system can be cleared from jointing chambers unless damage has been caused by excavation.

INCIDENCE OF DAMAGE

Statistical data on the circumstances of damage to utility plant in general, and BT's plant in particular, are available from several sources. Those used for this article included:

(*a*) the NJUG study *One Week in March* in which the details for all cases of reported damage to the plant of all utilities occurring in one week in March 1981 were recorded and analysed;

(*b*) the NJUG Bradford Records Trial, where, for a two-year experimental period, the plant map records for a 75 square mile area of Bradford City were exchanged between the utilities by using microfiche;

(*c*) the NJUG-sponsored Lothian Susiephone One-Call Trial which provided a single telephone number contact point for non-utility excavators;

(*d*) the NJUG Digital Records Trial based on the Dudley Metropolitan area with utility as well as local authority participation;

(*e*) various in-house cable fault statistics; and

(*f*) a Health and Safety Executive (HSE) publication on electricity cable damage[2].

These statistics vary considerably in detail because they were collected for different reasons; in spite of this, the overall picture which emerges has been consistent and throws light on the circumstances of damage, who caused it, how it was caused, what implement was involved etc. Analysis of the data provides a valuable guide to actions which are likely to have most effect in reducing the incidence of damage.

The NJUG's 'One Week' survey indicated that the number of damage cases per annum suffered by the utilities was in excess of 70 000. The costs of repair incurred in one week exceeded £250 000 (1981 prices). On this basis, it is to be expected that current annual costs of repair to the utilities exceed £15M a year.

CAUSES OF DAMAGE

Equipment

Several studies have included an analysis of the types of equipment causing damage. The principal implements involved are mechanical excavators, hand-held power tools and hand digging tools. The remaining categories include earth spikes, bar-holing tools and thrustborers. In all cases, there has been a number of incidents where it has not proved possible to identify the implement; it is therefore very likely that the percentages shown in Table 6 understate the attributions.

TABLE 6

Tools Involved in Damage

Source	Utility	Mechanical Excavators %	Power Tools %	Hand Tools %	Total Number of Incidents in Sample
'One Week'	All	55	11	16	1408
'One Week'	BT	31	14	11	266
HSE[2]	ESI	33	23	24	-
Lothian	AU	30	15	33	177
Bradford	BT	25	11	38	157

In practice, the number of damage cases is of less significance than the magnitude of the damage, and it has been shown that, as might be predicted, mechanical excavators and power tools are liable to lead to much more costly damage. For example, a spade may fracture a duct but the chances of damaging a cable in that duct would be fairly low. A mechanical excavator could smash the duct and then snag the cables and perhaps lead to extensive damage over a considerable length of cable. For the 157 cases examined in the Bradford trial, the ratio of costs incurred as a result of damage by various means was:

mechanical excavator—1
power tool—0·93
hand tool—0·26

Human Factors

In all surveys of the causes of damage, carelessness and negligence and, on occasion, malpractice have been shown to be major contributors. Several factors contribute to this. One important issue which applies to much excavation work by contractors is that it is generally undertaken by unskilled casual labour with a low degree of commitment to the work, and where standards can be maintained only by close and competent supervision. Often, productivity incentives are used which further accentuate the problem of careful excavation practices being achieved.

In some cases, damage can only be attributed to blatant and knowing malpractice. An example of this occurred on a major road reconstruction contract; repeated damage was caused to a telecommunications cable, and, the contractor's agent, when taken to task, virtually admitted that, because a penalty clause for delays in the road contract would incur such high cumulative cost penalties, claims resulting from cable damage were of lower priority. Another example of knowing damage was where the route for a large-diameter steel main had been made by deliberately breaking away several ducts in the top layer of a nest. As the ducts were empty, such damage would not have been discovered until cabling had been attempted through the blocked bores. In another instance, a small contractor hired an expensive excavator and claimed that he could not afford to bother about the possibility of damaging underground plant.

Effect of Heavy Lorries

There has been a great deal of discussion about the effect of heavy lorries on the structure of roads since the publication of the Armitage report[3], which recommended an increase in the legal weight of lorries. The piped utilities were especially concerned about the likelihood of damage to their underground plant. It was the view of BT that an increase in lorry weights would have a less serious direct impact on telecommunications plant. As the duct system is not designed to be fluid-tight, there could, however, be secondary effects: if gas or water pipelines were to suffer more failures as a result of increased traffic loading, then BT would be likely to experience more ingress into the underground system with a consequential increase in unproductive time spent in pumping out jointing chambers or in clearing gas.

Experience of the performance of jointing chambers would suggest that heavier traffic loading should not pose a structural problem. The one category of plant which could suffer would be the access covers for jointing chambers in the carriageway. As traffic weights and densities have increased in recent years, the incidence of premature failures of the covers and their mounting frames has increased. This problem has been countered with the new design of cover made from spheroidal graphite cast iron, which has high strength and good ductility compared to the traditional grey cast-iron covers.

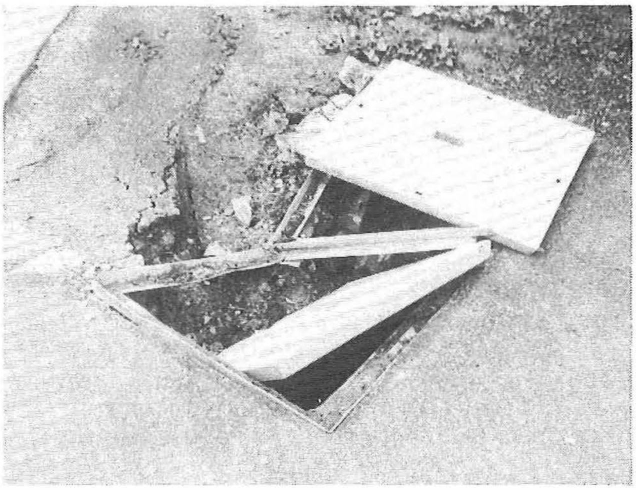

Fig. 3—Joint-box frame and cover damaged by heavy goods vehicle overriding footpath

If heavy vehicles do not cause problems for BT's plant in the carriageway, this cannot be said to be the case when heavy vehicles park or drive over footpaths and grass verges. Again, it is the cover of the jointing chamber which is likely to suffer (Fig. 3) but cable and duct too can be damaged. Some highway authorities try to limit damage to pavings by laying robust concrete footpaths, but such action itself can lead to more utility plant damage, as the only way in which access can be gained to plant is to use powered breakers and the increased risk which they bring. Normal footway surfaces such as paving stones or tarmacadam can be opened up with the more controllable hand implements.

Effect of Subsidence

Subsidence may be the consequence of natural compaction or movement of the ground, the result of tunnelling or mining, or settlement caused by nearby excavations. The effect of such ground movements on piped services can be serious and, in the case of fractured water mains, can lead to further severe ground movement if soil is washed away. BT plant is tolerant of small ground movement as earthenware ducts have some degree of flexibility in the joints and PVC duct in itself is reasonably flexible. Earthenware duct cannot tolerate large movements and joints are liable to be displaced or the duct itself may be fractured.

Ground movement is usually tolerated by jointing chambers constructed in reinforced concrete, but brick-built chambers may develop cracks which weaken the structure.

Trenchless Construction and Renewal Methods

Percussion moling, thrust-boring and pipe-jacking are techniques that are used to obviate the need for trenching apart from the provision of launching and reception pits at the ends of the run. In the past, these methods were notorious for their deviation from the intended line when obstructions were encountered or changes in ground state occurred. Modern techniques are more accurate but a straight drive can still cause damage if insufficient attention has been paid to plant location beforehand.

A recent variant of percussion moling is pipe-bursting. This is one of the new techniques being used for the replacement of gas mains, water mains and sewers. The concept was originally developed in the UK in the early 1980s to replace cast iron gas distribution pipes without the need to excavate except for send and receive pits. The method was originally used for the replacement of pipes size-for-size but, more recently, has been extended to the replacement of pipes with larger diameter pipes.

A pneumatic or hydraulic-powered 'burster' is used which, as it is passed down the pipe, expands and fragments it and

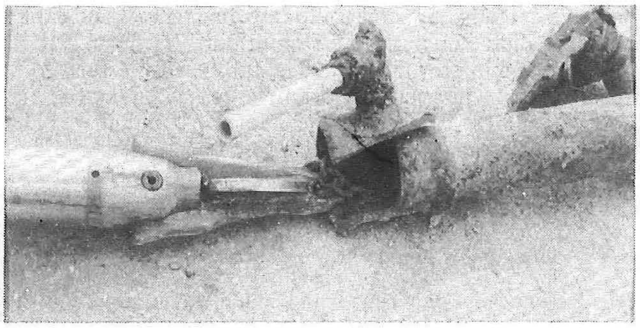

Fig. 4—Pipe burster unit on left, and cast-iron pipe and fractured coupling

forces the fractured pipe material into the surrounding ground (Fig. 4). As the bursting unit proceeds, it tows either a polyethylene liner or the replacement pipe. The liner is used where there is concern that the fragments of the old pipe may physically damage the new pipe as it is drawn in; after the liner has been inserted, the new pipe is pulled in. In addition to the excavations at the sending and receive ends, small pits have to be dug to isolate and reconnect service connections.

Size-for-size replacement has limited effect on the surrounding plant or highway surface as the surrounding soil has only to accommodate the volume of the pipe fragments. More recently, however, the technique is being used as a means of providing a larger replacement pipe. In a pipe-bursting operation, there is inevitably some ground movement, and other utilities have to be alert to the possibility of damage to their buried plant. BT's plant has suffered damage in some instances, but data is not yet available to estimate if a major problem exists. The main problems are more likely to occur when the clearances between the pipe being burst and BT's duct or jointing chamber do not conform to preferred values. Otherwise, the use of this technique could reduce the incidence of damage to BT's plant as a great deal of trenching is obviated.

Miscellaneous Causes

Sometimes, it is difficult to identify BT's ducts when they are similar in appearance to plant of other utilities. For example, a small iron pipe could be a gas pipe, a water pipe or an old-style telephone duct or the pipe could be disused. Often, the only effective way to identify the contents is to drill into the pipe; should it contain a cable, then it may be damaged.

Where difficult ground conditions in civil engineering construction are encountered, it is sometimes necessary to resort to ground treatment. One method is to pressure grout to fill voids and fissures in the ground, but the grout may also enter the duct bore through joints and cause blockages.

Another source of difficulty is where trench excavations have not been back-filled correctly and hard objects bear against the duct wall; this can lead to the duct being damaged during compaction of the back-fill.

DAMAGE—A CASE STUDY

During the course of the Bradford Records Trial, a detailed record was kept of the circumstances surrounding damage to plant. Analysis of the returns of the 157 cases of damage to telecommunications plant indicated the following:

(*a*) As is evident by Fig. 5, which shows the causes of damage to BT plant for the period November 1979–June 1981, insufficient care was the major factor.

(*b*) Eight instances occurred where BT's ducts had been deliberately damaged in the course of tracing gas leaks or in gaining access to seal leaks in either water or gas pipes. As only a very small proportion of the duct network is fluid-tight, gas can permeate into the ducts from leaky gas mains; British Gas personnel may have to break into ducts in order to determine the direction of gas flow in them during localisation of the leak.

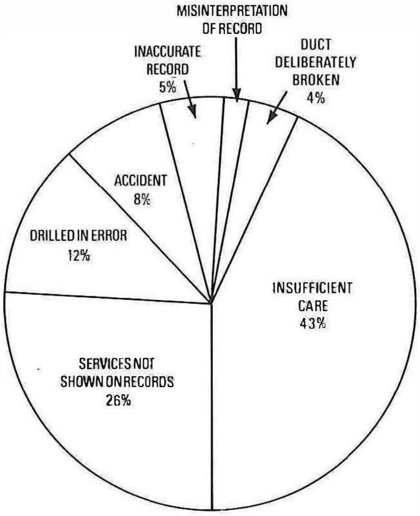

Fig. 5—Causes of damage in the Bradford trial

(*c*) In several cases, the damage could be seen as purely accidental and would have been difficult to avert. For example, the stabiliser leg of a mechanical digger engaged in excavating to locate a burst water main sank into the sodden ground and damaged a duct and its cable. In another case, a spade slipped on a stone and was deflected onto an earthenware duct which then fractured.

(*d*) Mistaken identity was also a problem. In two cases, cast-iron ducts were mistaken for gas pipes and cut through. In another instance, the contractor was aware that BT's ducts were nearby but mistook electricity board ducts for the expected BT ducts and so relaxed his vigilance in subsequent digging.

(*e*) Other damage resulted from excavations taking place in the wrong place or the plans being inaccurate or incomplete. Inadequate records contributed to a quarter of the damage incidents.

(*f*) Of the 157 instances of damage, only the duct and not the cable was damaged in 69 cases. Directly-buried cable suffered frequently; this high incidence of damage to such cables is not untypical and has been one of the reasons for the installation of fully-ducted systems on new estates. There is good evidence from the case study that duct acts as an effective first line of defence for the cables.

(*g*) An analysis of the 117 cases in which the implement causing accidental damage was identified showed that mechanical excavators and powered tools accounted for nearly all the more-expensive repair charges. The use of hand tools caused ducts to be broken, but damage to the cables within the duct was infrequent; the cost of repair was therefore small and averaged about a quarter of the cost of cases where powered equipment had been used.

(*h*) Identification of the origin of the damage showed that nearly half was the result of non-utility operations—local authorities, civil engineering contractors and others. The publicity associated with damage limitation programmes must therefore be extended beyond the confines of the work carried out by utilities.

DAMAGE CONTROL

A strategy for limiting damage to BT's underground plant needs to take into consideration three factors: technical factors such as robustness and location of plant; management factors such as the keeping of records or publicity programmes; and on-site factors such as the training and motivation of operatives who undertake excavation work. Economic constraints are likely to place limitations on what can be achieved, but there is scope for action in all three areas to reduce both the total number of cases and the economic results of such damage.

PHYSICAL PROTECTION

In the urban setting, all BT's cables, with the exception of some cable feeds to customers' premises, are contained in duct. As discussed earlier, earthenware or plastic duct provides a good measure of protection for the cables against damage from hand tools. If it is necessary to resort to machine digging, duct does provide protection provided care is taken during excavation. In general, plastic duct, being more resilient, affords better protection than a brittle material such as earthenware. Large formations of ducts encased in concrete are very resistant to damage.

It has often been argued that BT ought to install its plant at a greater depth, especially when high-value cables are contained in the duct route. There are several arguments against adopting such a policy in most circumstances. The limited amount of underground space which is available could compel other services to go deeper; this would increase the costs to all utilities and give BT little real benefit as access to the piped services would still have to be gained past the cable services. Deeper excavations give rise to more problems of long-term settlement after reinstatement and create a risk of nearby foundations being undermined. As a general principle, the piped services need to be deeper as they are more susceptible to damage from the effects of heavy lorries and, in the case of water, the pipes need to be deep enough to avoid freezing.

The one major exception where greater depth of cover was adopted was for the 60 MHz coaxial cable system[4]. Such a solution was practical as a completely new duct network was constructed for the system. A marker tape of heavy-gauge polyethylene was also placed about 300 mm below the surface of the ground.

In one recent study, in which data on the depth of the plant in the ground was related to the rate of damage, little observable benefit was observed in going to greater depths; the sample size was, however, small.

IDENTIFICATION OF PLANT

The problem of damage due to the wrong identification of utility plant is not serious. An analysis of one water authority's insurance claims showed that between 2% and 4% of interference damage was the result of wrong identification. The Bradford Trial report indicated that only two out of 157 cases of damage to telecommunications plant could be attributed to this cause. There has been nevertheless an important safety impetus in respect of electricity and gas plant to ease the identification problem. The NJUG has agreed, as an aid to the identification of small buried mains and services[5], that new cable ducts and pipes up to 75 mm will be colour-coded as shown in Table 7. This colour coding has been extended by some utilities to ducts, pipes and cables of larger diameters, and the 90 mm bore BT Duct 54D is now supplied in grey material. The full benefit of this aid to identification will apply, for example, to new industrial and housing estates. Elsewhere, the immense amount of older plant in the ground will limit the general usefulness of colour coding.

TABLE 7

Standard Duct and Pipe Markings

Service	Colour
BT	Light grey
Water Industry	Blue
British Gas	Yellow
Electricity Supply Industry	Red or black
Cable television operators	Green

SITE OBSERVATION

The presence of a duct route can be identified in the highway by observing access covers to jointing chambers; there is, however, no guarantee that the duct line between jointing chambers is straight.

PLANT RECORDS

Plant records of the utilities constitute a major data bank of information about the location and type of plant that is beneath the surface of the ground. Unfortunately, the accuracy of the records is very variable. BT is perhaps in a more advantageous position than other utilities because its underground plant throughout the UK has been installed almost entirely within the period during which telecommunications has been a single national organisation. The standards for plant records have been uniform for a long period, but this is not the case for the other utilities which were created by the amalgamation of hundreds of smaller undertakings. The effects of wartime damage in many cities further accentuated the problem of maintaining accurate records.

In the case of the Post Office and BT prior to privatisation, there had been no statutory requirement to maintain records of its telecommunications plant. Nevertheless, detailed records have been kept on the locations of duct route for many decades; for example, the Post Office Technical Instruction XIV of 1921 required the recording of the position of ducts at approximately 10 ft intervals. The recent licence under Section 7 of the Telecommunications Act, 1984, now imposes upon BT a requirement to hold records based on Ordnance Survey maps at scales ranging from 1:625 to 1:10 000 according to the density of development in the area concerned. This statutory requirement does no more than consolidate existing practice. The licence also requires BT to 'provide by means of a telecommunication system free of charge, to any Highway Authority or other person who is intending to undertake works in the vicinity of any telecommunication apparatus it has installed underground, a service furnishing information about the location of that apparatus..'.

A crucial problem to be overcome is to ensure that, when maps are supplied to excavators, they actually reach the operatives on site. For example, in the Lothian trial, when information was supplied to the excavating organisation, this information was passed to the operatives undertaking the work in fewer than half the cases.

DIGITAL MAPPING

A major trial has been established by the NJUG in the Dudley Metropolitan area of the West Midlands with the intention of gaining experience of using digitised mapping systems as an alternative to conventional paper records[6]. At the heart of the system is a computer linked with interactive graphics work stations at various locations in the offices and depots of the local utilities and the Dudley Metropolitan Borough Council. In the context of the present article, it is to be noted that one of the objectives of the trial is to reduce the inter-utility damage by increasing the availability of information about the underground plant of all the utilities.

During the trial, which started in 1982 and is due to finish in 1987, the levels of damage are being monitored as part of the assessment of the financial savings which could result from such systems. One feature of the system is that it can display any small area of any particular map at scales of 1:500, 1:200 or 1:100. The value of such a detailed look of course depends upon the accuracy of the data that is available to input into the data bank.

It is certain that digital mapping will be generally adopted as a cost-effective and efficient method of recording information that has a geographic base. There are however some important constraints:

(*a*) the initial capital cost for computing equipment is high,
(*b*) the Ordnance Survey is not intending to complete the digital mapping of Britain until 2015, and
(*c*) the transfer of utility information from existing paper maps into the digital format represents a major one-off operation. It has been estimated that BT has some 150 000 maps which would need to be converted.

It is not inconceivable that field staff in the future would be able to directly access maps from site. This would ensure that those who need the information for excavation would have ready access to it.

ONE-CALL SERVICES FOR EXCAVATORS

It has been recognised that, if excavators are going to take the trouble voluntarily to find out the buried plant that exists in advance of work starting on site, then a simple means of enabling them to get the requisite information is desirable. If it is necessary to contact four or five separate authorities in order to get information for what might be a small opening, then this is a disincentive. It is known that much of the damage is caused by those who do not take the trouble to check beforehand. One means of encouraging the excavator to ask for assistance is to provide a single source of information on all utilities plant; and so, by making a single telephone call, the excavator can get access to the information required. The idea of a 'One-Call' system originated in the USA in the 1960s, and systems are now functioning in 41 States. The systems have been found to work well and especially so where contractors are licensed by the state; contractors then who fail to use the One-Call system and cause damage run the risk of having their licences revoked.

In Britain, a joint utilities trial took place in 1977 in Blackburn. The former Post Office North West Telecommunications Region, North West Water and North West Gas worked together to establish the service known as *JULIE* (*J*oint-*U*tilities Plant *L*ocation *I*nformation Service for *E*xcavators). In this service, the Freefone 111 service connected the caller to the external plant maintenance centre (EPMC) and the information was entered on special forms which were then forwarded by using facsimile equipment to the other participating utilities.

A more ambitious trial was established under the aegis of the NJUG in the Lothian Region of Scotland[7]. All four utilities and the Lothian Region Highway Authority participated in a trial known as *Susiephone* (*S*cottish *U*nderground *S*ervice *I*nformation for *E*xcavators). The Susiephone system, like the Bradford trial, relied on the use of facsimile equipment which connected the Susiephone Centre to the utilities. The trial ran from March 1980 until September 1983. Non-utility excavators obtained information by using Freefone 8400. Analysis of the results of the Susiephone trial showed that the overall level of damage for most utilities was reduced by 12–17%. However, the scheme was not regarded as cost-effective because of high operational costs and the paper notices required by PUSWA were still needed. However, sufficient confidence in the potential of a one-call system had been generated for NJUG to propose a modified trial in the Lothian Region which would take over from the end of the Susiephone Trial and continue for three years until 1987. This trial, now in operation, replaces the One-Call centre with an electronic message-handling system based on a microprocessor-controlled Telex message switch. The PUSWA notifications are also incorporated into the system and transmitted electronically. The terminals at the utilities are connected to this central switch by private circuits and a modem. Each terminal has a visual display unit (VDU), a keyboard and a printer. In action, the utility operator completes the variable data in the blank proforma notice displayed on the VDU screen and gives details of the intended excavation; the message is then passed automatically to the other utilities and to the Highway Authority. At the receiving end, both a VDU display and a hard-copy are produced. About 20 terminals are connected to the system, which has a capacity for 32 terminals. By the beginning of 1985, the system was handling about 450 messages a day. The Freefone facility is retained for all non-utility excavators.

ELECTRONIC PLANT LOCATORS

Pipe and cable locators used by BT, and widely available commercially, rely on detecting the electromagnetic field radiated by a metallic pipe or cable. These signals can originate from one of three sources:

(*a*) Mains frequency or its harmonics radiated from power cables carrying current can be detected. The so-called *hum detectors* may also detect the fields induced into other cables and pipes by nearby power cables, but their use for this purpose is not reliable. If an electricity cable is carrying only a small current, then these locators may not detect even a live power cable.
(*b*) The source can be a radio-frequency (RF) current induced in metallic pipes and cables and then reradiated. The original sources of the RF field are distant very-low-frequency (VLF) radio transmitters. The efficiency of this approach varies with geographical position and the final 10–15 m of a cable near a termination may not be detected. However, electricity cables which are not radiating any mains-derived hum can be found by this method.
(*c*) The third type also uses a low radio frequency, but this time it is induced into the cable by a small transmitter which is part of the locator package. A related method relies on the signal being injected by direct or close coupling into the cable.

Many types of locator can be used in more than one mode and so provide a useful increase in the likelihood of tracing cables successfully. There is certainly no one type of locator which can be relied upon to give, with confidence, the position of a buried cable and the use of more than one technique is often necessary. The skill of the operator is also an important factor especially where the situation underground is cluttered, as is often the case in urban areas.

All BT's cables have a substantial metallic content which permits the use of conventional cable locators. This statement is equally valid for optical-fibre cables which may have up to three sources of metal in their construction: steel strength member, aluminium foil moisture barrier, and copper pairs.

In the Susiephone trial, locators had been used in only 15 of the 157 cases of damage; there is evidently considerable scope for encouraging the use of such equipment.

THE PLANT PROTECTION OFFICER SERVICE

Plant protection officers (PPOs) are the Statutory Notice field force of the EPMC. The duties of a PPO are

(*a*) to minimise damage to BT's external plant,
(*b*) to make those who have cause to dig in the highway

aware of the need for, and the method of, requesting assistance in locating or identifying BT's plant;

(*c*) to ensure that authorities and undertakers obtain this assistance with a minimum of delay when they request it; and

(*d*) to ensure that all activities of BT's staff in connection with the works of authorities and undertakers are accurately documented for reference should damage occur.

The service provided by the PPOs to excavators can be accessed via Freefone 111 and consists of giving advice free-of-charge over the telephone, marking up maps or marking plant positions on site before excavation starts. The site visit is the most effective as direct contact can be made with the site operatives. The PPO is also likely to be more skilled in the use of locators than contractors' staff. The PPO service has been extensively publicised by advertisements, calendars, stickers and handbills aimed specifically at site operatives and their supervisors (Fig. 6). The requirement of the BT

Fig. 6—Typical publicity material

Licence to provide an information service is met by the existing PPO service.

The 'One-Week' survey showed that excavators who did request information on BT's plant nevertheless still caused damage. In BT's case, out of a total of 62 requests where damage resulted, 33 responses had involved a site visit, and, in 27 cases, records were sent. However, this is not to belittle the information services provided as another study showed clearly that, where the services of the plant protection officer were employed, the consequences of damage were greatly reduced.

DISCIPLINE AT THE WORK PLACE

In most cases, contractors have insurance to cover claims from the utilities for damage and the effect of damage does not accrue until premiums are renegotiated. It is probable that the utilities' most effective allies in damage limitation are the insurance companies. This aspect may become more effective with the greater penetration of optical-fibre cables because the cost of repair in the present stage of technical development is likely to be somewhat higher than for metallic conductor cables.

COMMON SERVICE TUNNELS

The problem of damage to buried cables and pipes would be greatly alleviated by the use of common service tunnels or subways where access to the plant of all the utilities would be gained through a man-entry sized tunnel where each utility was allocated space. This solution has been used, notably in London and some other cities, but there are severe practical problems which limit the adoption of such tunnels. The tunnels involve major civil engineering construction works and could be implemented only on 'green field' sites or where they can be constructed as part of major highway works. Of necessity, the tunnels require a large cross-section to provide adequate working space and clearances between the different main services, which, in a number of ways, are mutually incompatible.

STANDARD PLANT LAYOUTS

The risks of damage to pipes and cables in the highly-reticulated local distribution networks of the utilities would be reduced if it were possible for the utilities and local authorities to work to a standard layout. The NJUG has produced such agreed layouts for use in residential estates[8]. These layouts are suited only for new developments where certain minimum standards of space have been provided as part of the estate road system. The concept has been extended for more general use in a later NJUG document[9]. Of necessity, these ideal layouts apply only to services under the footpath or in a specially-provided service strip, which is a feature of some developments.

An extension of the agreed layout concept, known as the *common trench*, is again applicable only to new developments. With the common trench, a single excavation is made and the individual services are installed as the trench is backfilled. This solution requires considerable co-ordination on the part of the estate developer and each utility, but, where this problem can be overcome, the common trench is an attractive solution and avoids mutual damage of plant which occurs during estate construction. For practical reasons, the utilities' mains are placed closer together in the common trench. This is not a problem during construction, but greater care must be taken in later excavation for repair or reinforcement.

REPAIR OF DAMAGED PLANT

Repair kits are available for the *in situ* repair of damaged ducts. The repair of cable can take many forms according to the circumstances and the type of cable damaged. Because of the loss in the splices in an optical fibre, it is usual to replace the damaged length of an optical-fibre cable between the existing splices in order to avoid eroding the loss budget of the system. With metallic cables, several options are available. Sometimes, if the damage is very localised and water has not penetrated the cable, an *in situ* repair is possible by constructing a joint in the cable; however, it is then necessary to build a jointing chamber at the joint location for future access. In other circumstances, it may be necessary to replace the damaged length with new cable. This may not be a simple task in view of the wide variety of cables which are in use in BT and spare lengths of a suitable cable may not be to hand. In addition to the costs involved in repairing the damage, many other factors have to be taken into account when the total cost of repair is evaluated; these are indicated in Table 8.

TABLE 8

Cost Factors in Damage Repair

Setting up and closing down costs
Duct repair
Normal or out-of-hours working
Cost of replacement cable
Working party size and skills
Temporary restoration and service
Cable diversions
Telecommunications traffic diversions
Conductor splicing costs
Sheath closure costs
Cable testing
Pressurisation and pressure testing
Administration and supervision

COMPENSATION FOR DAMAGE

BT has several means available in law to recover the cost of making good damage to its plant from those causing the damage. Before the Telecommunications Act, 1984, repealed the Telegraph Acts, almost all claims were pursued under Section 8 of the Telegraph Act, 1878. This section protected the apparatus of telecommunications undertakers and imposed absolute liability on any person who destroyed or injured 'telegraphic' plant. No such provision now exists and it is necessary to rely on the provisions of the PUSWA or pursue claims through Common Law; the PUSWA however does not apply to Northern Ireland or the Isle of Man.

Under Section 26 of the PUSWA, undertakers who damage BT's plant are required to pay the reasonable costs incurred in making good the damaged plant; it is unnecessary for BT to have to prove that those who had caused the damage had been negligent. If the works were not executed in accordance with the provisions of the PUSWA, or if the works were not in the highway, then BT has to seek Common Law remedies. However, in the case of Common Law claims, BT must be able to prove negligence on the part of the damager. For the special case of subsidence caused by coal mining operations, the Coal Mining (Subsidence) Act, 1957, enables BT to recover the cost of repairs from British Coal.

It should be noted that claims under PUSWA Section 26 permit recovery of only the costs incurred in making good the damage and not reimbursement for loss of service or other consequential effects.

CONCLUSIONS

This article has shown that, during the course of a year, an immense amount of excavation takes place in the highway, ranging from jobs planned years in advance to emergency openings, and from long lengths of deep trenching to openings with surface areas of less than 1 m^2. The underground environment, especially in urban areas, is frequently severely congested and careful digging is essential if damage to buried plant is to be avoided. A high proportion of the damage sustained to BT's plant could be avoided if some basic steps were taken by excavators: visual survey of the above-ground setting, obtaining marked-up maps from the utility, the use of plant locators, and, finally, cautious digging with only hand tools in the immediate vicinity of plant. The plant protection officer service via Freefone 111 has been shown to reduce substantially the number of cases of damage, their extent and the cost of rectification should damage still occur.

It is very much in the interest of the business to try to minimise the risk of damage and this article has shown how this is being undertaken, often in close co-operation with the other utilities. Damage to plant loses revenue and causes inconvenience and irritation to customers, it diverts resources from productive work in maintaining and expanding the network, and constitutes a waste of national resources.

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Biography

Don Clow joined the Post Office in 1948 as a Draughtsman-in-Training. He became an Assistant Engineer in 1957 and was engaged in the design and provision of antennas and external equipment for high-power high-frequency transmitting stations. In 1969, he moved to his present division as Head of the Structural Engineering Group involved in design and consultancy work for masts, towers and satellite earth station antennas. He is currently Head of the Civil and Mechanical Engineering Section in the External Plant and Transmission Systems Division of BT Inland Communications and is responsible for civil-engineering plant and practices, cabling equipment and practices, cable pressurisation and general mechanical aids and tools. He is also the BT representative on the Executive Committee of the National Joint Utilities Group (NJUG). He has an honours degree from the Open University and specialised in geology and materials technology.

Silicon Micro-Electronics at British Telecom Research Laboratories

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British Telecom, at its research laboratories at Martlesham Heath, maintains facilities for designing, fabricating and testing advanced integrated circuits. This article reviews some aspects of the work carried out on silicon micro-electronics by British Telecom Research Laboratories (BTRL). The article is based on material produced for BTRL's Martlesham '84 exhibition.

INTRODUCTION

Semiconductor integrated circuits, based on silicon device technology, play an important role in the telecommunications network. Digital communication systems, the provision of wide-bandwidth facilities and the introduction of new customer services have been possible only through the availability and application of integrated circuits. Although in many applications use can be made of commercially available standard circuits, the need for more-specialised circuits is increasing steadily. Such circuits offer advantages by enhanced performance, cost savings and increased reliability. In order to ensure the timely availability of such components, British Telecom (BT) maintains facilities at British Telecom Research Laboratories (BTRL), Martlesham Heath, for designing, fabricating and testing advanced custom circuits.

Circuits

Integrated circuits have been developed at Martlesham Heath by using both metal-oxide-semiconductor (MOS) and bipolar silicon technologies. MOS devices are field-effect transistors used in applications requiring high complexity, low power and moderate speed. Particular importance is currently given to n-channel MOS (NMOS) and complementary MOS (CMOS) technologies, and recent examples of circuits that have been developed for system applications include filters for digital transmission systems, high-bit-rate modems, speech coding circuits, digital crosspoint switches and echo cancellers for loudspeaking telephones.

Bipolar circuits are used for those applications requiring the highest operating frequencies: the terrestrial and submarine trunk transmission systems. In these particular applications, BT places considerable emphasis not only on performance but also on long-term reliability. A family of gate arrays has been produced by using emitter-coupled logic (ECL) technology, which is used for high-speed amplifiers, regenerators and timing circuits. This technology has been developed from BT's early transistor technology, which has a long-established reliability record from many device-years of operation. These circuits have been installed in the UK–Belgium No. 5 submarine cable system and will be used in the TAT-8 submarine cable system.

Design

As the size and complexity of integrated circuits increase, it is essential to minimise design costs and time-scales. For this reason, integrated-circuit designers at Martlesham Heath make extensive use of computer-aided design (CAD), and employ not only computers and interactive graphics facilities, but also some of the latest generation of engineering workstations. CAD relieves designers of the tedious but essential checking and verification tasks. In addition, new ways are being developed to use the power of the computer to give even more assistance in the design activity.

These facilities have been used for designing a wide range of circuits for both in-house and external fabrication, including both bipolar and MOS, semi-custom and full-custom circuits. The design of semi-custom circuits is now highly automated with very fast turnaround from logic concept to the chips themselves. The design phase for a full-custom chip is longer, more detailed and hence more costly than for a semi-custom chip; however, the result is a more densely packed and smaller chip, which is thus cheaper in volume production.

Fabrication

Complete clean-room facilities at Martlesham Heath enable every stage in the wafer-fabrication process to be undertaken, and prototype integrated circuits produced for systems evaluation. Data from the CAD facilities is used to make the chrome-on-glass mask and reticule plates used in the wafer printing process. The mask shop is equipped with an optical pattern generator and all of the associated processing and inspection equipment to enable high-quality industrial standard mask sets to be produced. Facilities for electron-beam lithography are co-located within this clean-room complex to allow specialised mask sets and submicron direct-on-wafer writing to be produced.

In the wafer fabrication facility, a wide range of devices and circuits is developed by using many of the latest technological developments. For example, techniques for optical lithography include the use of projection printers and wafer steppers; 'dry' or plasma processing techniques are used in several etching stages; and hybrid assembly methods are employed to make use of various device technologies in system applications. Advanced techniques are in use for the evaluation of materials, processes and circuits to maintain developments to the highest standards.

SEMI-CUSTOM MICRO-ELECTRONICS DESIGN

The traditional custom-designed integrated circuit is characterised by a long development time because of the need to design a full mask set to fabricate the integrated circuit. The resultant chip is, however, a very densely packed circuit which makes the best use of the available silicon. By simplifying the design process, the semi-custom approach trades this optimum use of silicon for shorter development time and lower development cost. This approach is particularly applicable to new equipment development, or where relatively small total quantities of integrated circuits are required. Although several cell-based semi-custom designs have been carried out by BT, most of these designs have used the gate-array technique.

Gate Arrays

In this approach, the semiconductor manufacturer produces silicon wafers of 'uncommitted' chips, which are then 'personalised' with one or more metal layers for each application. Costs are thus kept down by the mass production of identical wafers, and time-scales are reduced because only the metal layers have to be designed and added.

Applications

Gate arrays have been designed at BTRL for a wide variety of applications including System X, the Monarch PABX, integrated services digital network (ISDN), etc. Both bipolar and CMOS technologies have been used in arrays ranging in size from a few hundred to over 5000 gates. The choice of which array to use is complex, and many factors must be taken into account before a final decision can be made.

Design Automation

One of the reasons for the exploding popularity of gate arrays has been the rapid increase in sophistication and availability of computer aids for the design of the metal interconnect layers. Most gate array suppliers now have computer simulators which aid the electrical circuit design, and computer programs which automate or aid the physical design of the metal interconnect patterns. In conventional gate arrays, the main problem is now often the development of the test program.

Summary

Gate arrays can provide a cheap and quick route for the implementation of circuits in silicon. The aim at BTRL is to encourage more system designers to implement their circuit ideas directly in silicon. To make this easier, by further increasing the level of design automation, the UK5000 project was conceived. This, for the first time, also brings guaranteed automatic test-pattern generation to a gate array.

UK5000 Project

The UK5000 project, instigated by the Department of Industry in 1981, was a collaborative project between seven UK organisations: BT, GEC, ICL, RSRE, SERC, STC, and TMC. The aim was to produce a CMOS gate array with at least 5000 usable gates (20 000 transistors), and an associated suite of software which would enable users to produce their required circuits automatically from a logic description.

Chip Architecture

A unique chip architecture was designed which allows all circuit latches to be connected to form a scan-path. This technique is used during testing of the manufactured chips to enable fully automatic test-pattern generation to be employed. All latches are driven by a single gated clock. This results in a completely synchronous circuit, which can be fully checked by the software to eliminate timing hazards.

Software

The software suite was written specifically for the UK5000, and thus is optimised for this array. After the logic description has been entered, the simulator and timing analysis programs are used to ensure that the circuit is logically correct and free from timing hazards. Further programs are then used to 'place and route' automatically the functions on the chip, to generate automatically a test pattern, and perform a final post-layout simulation.

Summary

The UK5000 project was one of the first large collaborative projects in micro-electronics. BT's contribution was to manage the project, design the uncommitted chip, and produce the prototype devices. However, in addition to the collaborative aspects, each participant now has one of the most advanced gate-array design systems available. Within BT, small-volume silicon processing is available, in addition to the design automation software, to allow designs to be taken from logic description through to working prototype chips within just a few weeks.

MICRO-ELECTRONICS DESIGN—FULL CUSTOM

The traditional advantage of full custom design has always been its ability to achieve the maximum functional complexity in the smallest silicon area and thus at the lowest unit production cost. However, this has always been associated with a long design cycle and the probability of reworks due to errors in the very complex design. Over the last few years, however, advances in hardware and software to aid designers, and new design methodologies have enabled ever more complex circuits to be designed more quickly. In many cases, the need for reworks has been eliminated by the use of these computer aids.

Within BTRL, two approaches to full custom design are being pursued. The first is a conventional approach which uses sophisticated computer tools to assist designers and then to check thoroughly their work for any errors. The second is a more innovative approach using an integrated suite of computer programs which uses a hierarchical design methodology to implement 'systems on silicon' and to ensure that the design is 'correct by construction'.

Conventional Full Custom Design

Current BTRL designs primarily use 2·5 μm design rule CMOS technology. Design commences with the transfer of the logic description to a Daisy workstation which is connected to a VAX 11/780 computer; the latter is used for full logic simulation. When the logic design is correct, the designer prepares a chip layout by using a graphics workstation, and the VAX is employed to check that the layout conforms with the design rules. Finally, further programs are run to verify that the layout and logic descriptions of the circuit are identical. These checks ensure that the circuit should operate correctly first time. Normally, prototype devices are fabricated within BTRL and this gives the tightest control of time-scales and costs from design concept to prototype devices for system evaluation.

Full custom circuits ranging in size up to 30 000 transistors have been designed in BTRL for a wide range of applications including System X, transmission systems, 9·6 kbit/s modems, loudspeaking telephones etc.

The ASTRA VLSI Design System

As systems grow in size and complexity, it is no longer sensible to design the system in discrete logic such as transistor-transistor logic (TTL) and then to translate this into a large MOS integrated circuit. In order to make the most efficient use of the silicon area, it has always been necessary to use the unique properties of MOS transistors; for example, storage of charge on a transistor. With very-large-scale integration (VLSI) systems, it has become essential to design from the start with a view to eventual implementation in silicon.

The ASTRA design system being developed by BT encourages system designers to 'think silicon' from the start. The first step in a design using ASTRA is to partition the overall design into blocks which are then implemented in silicon. Each of these large blocks is subdivided into a hierarchy of smaller blocks until transistor level is reached. Each block is thus not only a logic function, but also a physical entity on the silicon chip.

Having planned the layout and logic from the 'top down', the designer then works 'bottom up' by using a shorthand design style, known as *symbolic layout*, to design rapidly the circuit elements in each of the lowest level blocks. The software ensures that no design rules are violated and enables them to be rapidly changed for different silicon processes. Simulation also takes place on single or multiple blocks to ensure that the circuit correctly implements the desired function. Once the detailed layout of the blocks is complete, they are assembled according to the designer's original 'floor plan'.

Chips with up to 30 000 transistors have been successfully fabricated from designs using the ASTRA system and two further chips with about 40 000 transistors each are currently being designed.

Summary

The increasing availability of powerful computer aids to assist in the design and checking of full custom designs is enabling larger and more complex circuits to be implemented in shorter time-scales as silicon chips and with increased confidence of first-time success. Together with rapid prototyping, this enables BT's system designers to achieve the maximum benefits of current VLSI technology in their equipment developments. However, to ensure that maximum benefit is obtained from advances in technology and for increasing chip complexity, the most efficient design methodology should be used. For this reason, the ASTRA system is being developed to give designers a software suite enabling them to achieve the highest functional complexity in VLSI.

CMOS TECHNOLOGY

CMOS is a technology which provides both n- and p-channel MOS transistors on the same chip. This allows circuits to be designed so that current flows only during the switching cycle, with no power required to hold a fixed state. It is this characteristic of CMOS that makes it very attractive as a low-power technology which finds a wide range of applications within BT's network. Current technology provides operation at up to 20 Mbit/s, while technology developments are aimed at 140 Mbit/s.

Emphasis on reducing power dissipation has become an increasingly important issue over the past few years because, as processing and handling techniques improve, chips increase in size, complexity and speed. These improvements all cause increases in the power dissipation of the chips. This can cause problems in packaging and reliability of the chips and may lead to serious consequences in the thermal design of circuits. Thus CMOS, which is inherently a low-power technology, has a great deal to offer, particularly for modern BT systems applications where advances in assembly and interconnection technology aimed at higher packing density of active elements are often limited by power dissipation requirements.

Much of the technology for CMOS has evolved in common with other MOS processes and includes techniques such as local oxidation of silicon by using nitride as an oxidation masking layer, low-pressure chemical vapour deposition of polysilicon, ion implantation for dopant control, plasma etching for accurate linewidth control, metal alloys for on-chip interconnections, and both projection and direct step on wafer alignment for accurate photolithographic pattern definition.

Several variants are possible in a CMOS process. The main ones are p-well, n-well or twin well. The wells are formed by ion implantation and diffusion of appropriate dopants. In the case of the p-well process, this involves selectively implanting boron into an n-type silicon wafer. The n-channel transistors are formed in the p wells and the p-channel transistors are formed in the bulk n-type silicon. A typical device cross-section is shown in Fig. 1. The choice of which option to use is determined usually by whether the circuit is to be used for memory random logic or uncommitted logic arrays (ULAs).

Currently, BT is using a p-well process with critical dimensions of 2·5 μm for the UK5000 ULA. A plan view of part of the UK5000 logic array can be seen in Fig. 2.

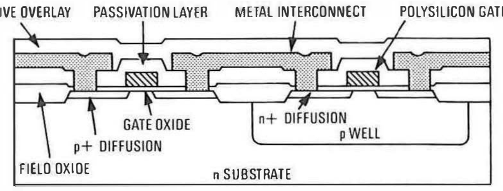


Fig. 1—CMOS device cross-section

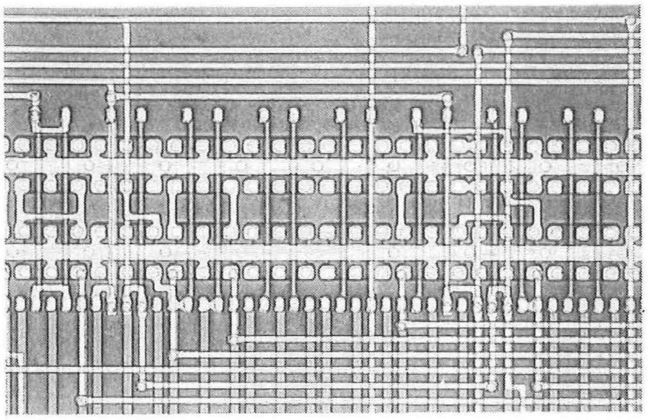


Fig. 2—Plan view of part of the UK5000 logic array

One of the problems with CMOS not experienced in other technologies is that of latch-up. This is due to the pnpn structure which is inherent in the process. This appears across the supply lines and can act as a switch. In the event of this switch becoming turned on, for example, by a pulse on the power lines, excessive current flows into the chip and normally causes failure. The usual method of controlling this is in the design of the input and output stages. Alternatively, a technological solution is to make use of epitaxial layers on low resistivity substrates. This increases the cost of wafers but is very effective; however, it does rely on having a good quality source of epitaxial wafers otherwise the yield is affected, and this adds further to the cost.

As geometries get smaller, latch-up becomes even more difficult to control and it is likely that epitaxy will be more widely used. However, there are other techniques which can be used. One of these is to use an insulator to provide isolation between the n-channel and p-channel transistors. This looks particularly promising for the future because, as well as eliminating latch-up, it results in a lower node capacitance. This reduces power dissipation and allows a higher operating frequency.

BTRL is currently involved in running CMOS processes with minimum feature sizes of 3 and 2·5 μm, setting up a 1·00 μm process and developing insulator isolation technology for CMOS.

EMITTER-COUPLED LOGIC GATE ARRAYS

For over 40 years, BTRL has developed and manufactured innovative high-quality highly-reliable components for the telecommunications network. For undersea communications, the long-life thermionic valve was developed and to date has provided greater than 20 years trouble-free life in submarine systems world-wide. In the quest for devices with wide bandwidth, high reliability and low installed cost per circuit kilometre, a lead was taken to produce the long-life silicon transistor. Three generations of analogue systems using devices designed and manufactured by BTRL have provided millions of trouble-free hours of operation on the major international routes. The most recent of this family, the Type 40 transistor, was manufactured at Martlesham Heath and has accumulated in excess of one million device hours without failure in systems installed since 1977.

With the increase in international calling, the demand for greater circuit capacity has expanded and new technologies now provide the means of offering digital interconnections through the use of optical-fibre transmission systems. To provide the necessary electronics for signal regeneration, a range of integrated circuits has been developed from the Type 40 transistor so that the high reliability of that device is retained in the new designs. All circuits use ECL; the range extends from a simple 8-cell array (see Fig. 3) to a

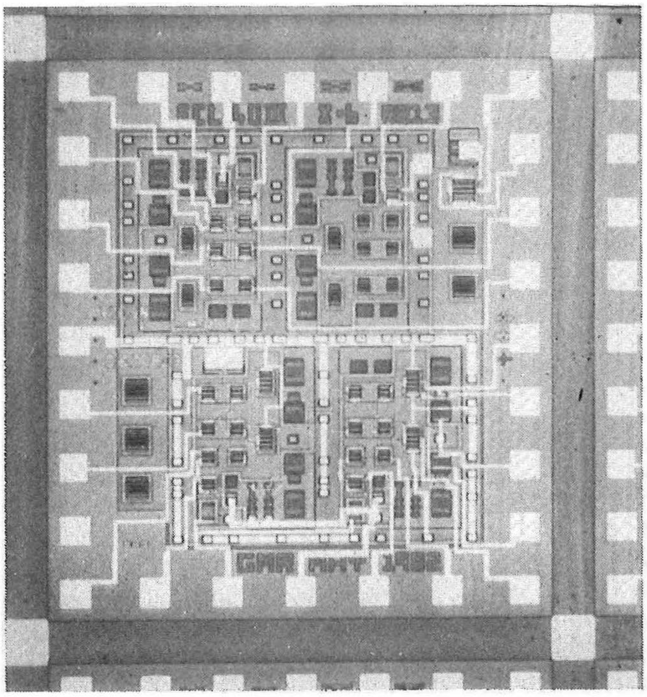


Fig. 3—An 8-cell array similar to those supplied for the UK–Belgium No. 5 system

complex 128-cell array which uses multilevel metal interconnections. A ULA architecture is used to enable a range of applications to be served by customising the final metallisation layers to interconnect a matrix of standard cell elements. The circuits offer high-speed digital operation, good analogue performance and the flexibility to support a wide range of circuit designs.

Current interest in systems is for integrated circuits operating at 320 Mbit/s, but 565 Mbit/s will be required, with operation to 1 Gbit/s and beyond predicted (Fig. 4). All of these can be met by using BTRL's silicon bipolar processes. Applications for the circuits are also foreseen outside trunk transmission systems in, for example, terminals and local area networks, where circuit complexity as well as speed is important.

The time between design and product availability is critical; hence design aids are used which enable a range of fully-evaluated and frequently-used standard library elements to be included in the design structure. These elements or building blocks include high-speed D-type flip-flops and shift registers. The design time is also minimised by the use of extensive modelling and circuit simulation. Finally, an extensive range of software is used to link the design data with the silicon wafer testing area to enable the completed circuit to be validated against the design data.

BTRL can design, manufacture, package and test circuits to stringent manufacturing controls and demands for quality assurance.

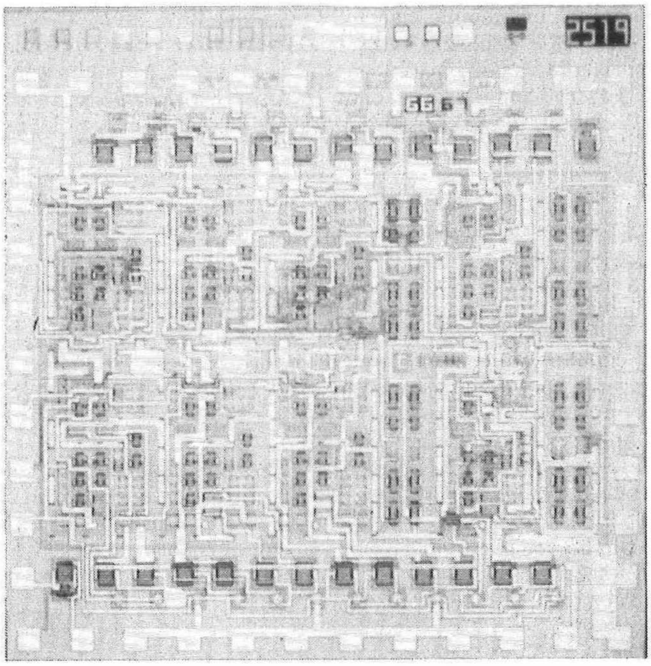


Fig. 4—A 1·2 Gbit/s circuit using advanced ECL 40 processing

SILICON TECHNOLOGY DEVELOPMENT

In addition to the facilities for silicon integrated circuit design and fabrication at Martlesham Heath, development programmes are undertaken to ensure that new fabrication techniques are assessed, qualified and available for introduction into device programmes as required. A few examples of some of the current programmes are given below to highlight the wide scope of the work.

Advanced MOS Technology

Shrinking dimensions of semiconductor devices lead to faster operating speeds, reduced power consumption and increased numbers of components that can be packed on a chip. Unfortunately, at the same time, silicon processing becomes more critical and device operation more complicated. Hence, increasing use of computer simulation is being made at the design stage of a new process both to model the behaviour of devices and the fabrication steps. By linking operating and processing models, device performances may be related directly to processing variables and allow optimised devices to be fabricated within a minimum number of process cycles.

During fabrication, advanced lithographic tools, such as electron beam techniques, are used to achieve good dimensional control, and advanced analytical techniques are used to check the processing and provide information for the process models. High-speed operation is critically affected by the presence of unwanted stray capacitances and parasitic resistances, which become increasingly more important as device dimensions are reduced. New materials such as silicides (metal/silicon alloys) and improved device structures are under development to extend the operating frequency of MOS devices for possible use in advanced transmission systems.

Silicon-on-Insulator Research

The development of high-quality silicon-on-insulator (SOI) substrates enables the speed-power performance of circuits in CMOS technology to be increased by at least a factor of two over similar circuits fabricated on normal bulk silicon substrates. Until recently, silicon-on-sapphire was the only SOI substrate, but was so expensive that it had a minimal impact on commercial telecommunications applications. New SOI processes with potentially lower cost are now becoming available, and BTRL is taking a leading role in the development of two of the most promising of these processes. The first is the formation of the insulating layer by using very-high-dose oxygen implantation to produce a buried oxide layer.

The second process is by the regrowth of polysilicon after its chemical vapour deposition on an oxide layer. In this application, a beam of electrons is focused into a line-beam which sweeps a localised molten zone through a polycrystalline silicon film deposited on top of an oxide. The silicon recrystallises into device-quality single crystal material which may be used as the basis for the development of the very-high-performance SOI circuit described above. The recrystallisation is performed at the Microcircuits Laboratory of Cambridge University.

High-quality CMOS devices have been produced on these substrates at Martlesham Heath. Together with BTRL's partners in this work in the UK SOI Consortium, BTRL will be well placed to develop very-high-performance CMOS circuits for telecommunications applications as commercial substrates become available.

Molecular Beam Epitaxy

Epitaxy, the growth of a perfect crystal layer onto an existing crystalline substrate plays an important part in the fabrication of many silicon device structures. The techniques available for this at BTRL are being extended by the addition of molecular beam epitaxy equipment. In this growth technique, silicon and its dopant atoms are evaporated onto silicon substrates in ultra-high-vacuum conditions. Growth rates, layer thickness, and the sharpness of the doping profile can all be controlled efficiently. Developments of the technique should enable epitaxial insulating and conducting layers to be deposited, and this should extend the range of layer combinations that can be produced, and lead to new device structures.

MULTI-LEVEL INTERCONNECTION ON INTEGRATED CIRCUITS

The interconnection of individual transistors on a silicon chip is produced by a pattern of metal tracks. On relatively coarse geometry circuits, these interconnections can be achieved with a single metal layer. As transistor dimensions are reduced, the routing of metal tracks is more difficult and restricts the number of transistors that can be placed on the chip. Two or more layers of metal separated by insulating layers simplify the track layout and reduce the chip area required for a circuit of given complexity. This feature is essential for the economic design and manufacture of high-density circuits.

A two-level metal process for use on the UK5000 ULA (see earlier), which features a minimum metal track width of 3 μm, has been developed at BTRL. More advanced processes featuring smaller dimensions and up to four layers of metal interconnect are now being developed. Important aspects of the multi-level technology are the choice of materials for the metallisation and dielectric layers, the method of patterning the via within the dielectric, and the surface treatment of the metal contact areas to ensure a high yield of chips with many thousands of vias per chip.

The dielectric chosen for the UK5000 chip was the polymer material polyimide. However, processes using the low-temperature deposition of silicon dioxide are also under development for applications where organic dielectrics may not be suitable. The first and second metal interconnect layers are formed by the deposition of aluminium alloyed with silicon and copper by using the techniques of magnetron sputtering. This technique provides excellent control of the alloy composition and achieves good metal coverage of surface features. The alloy composition has been optimised to prevent interdiffusion with the silicon substrate and to enhance the current carrying capacity of the metal tracks. Advanced etching processes have been used to form the vias in the dielectric (see Figs. 5 and 6) and the complete two-level metal process described above has been shown to give at least 90% yield on circuit structures containing 20 000 vias; this number is more than adequate for the present generation of devices.

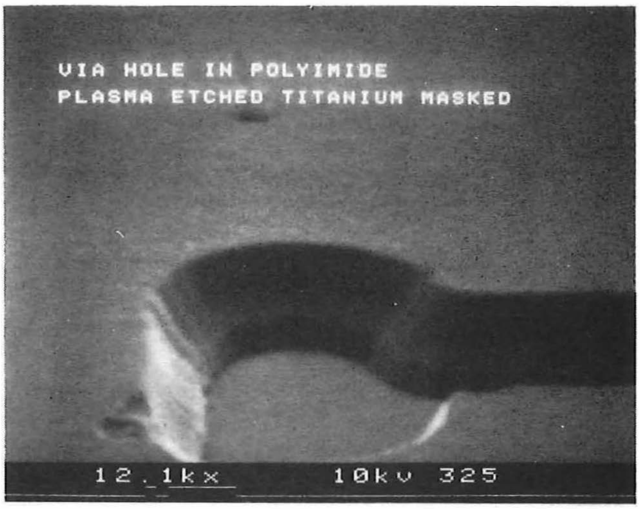


Fig. 5—Scanning electron micrograph of interconnect via

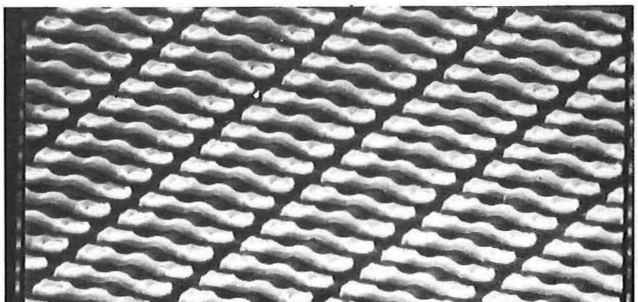


Fig. 6—Metallised interconnection pattern

As the minimum feature size of VLSI circuits decreases to 1 μm and below, it is envisaged that up to four layers of metal interconnect will be required. Collaborative links with chip manufactures and other research laboratories are being established to develop the necessary processes, as this technology will be essential for the exploitation of high-density circuit designs over the next decade.

The formation of vias within the polyimide between the metal layers has to reconcile two conflicting requirements, those of maintaining a maximum via size to retain a fully nested contact and to profile the edge of the via to attain good step coverage of the second layer of metal. A three-stage etching process has been developed at BTRL for the UK5000 to overcome these problems. The via pattern is first defined by conventional photolithography and dry etching in a thin layer of titanium deposited on the polyimide. The polyimide is then etched in two stages in an oxygen plasma to give a sloped sidewalk in the upper half of the via and a steeper sidewalk at the lower end to maintain via size during the overetch period.

ELECTRON BEAM LITHOGRAPHY

Electron beam lithography (EBL) is being developed to provide advanced mask-making facilities for optical photolithography and direct writing of high-resolution device structures. These applications make use of the flexibility and/or resolution of EBL over conventional optical lithography. In this technique, a beam of electrons, 0·1–0·25 μm in diameter, is scanned under computer control over the surface of a substrate, and this exposes the required pattern in a layer of electron sensitive resist. The resist is then developed and used as an etch mask for defining a relief image in the substrate (similar to the use of a photoresist in optical lithography).

The beam is scanned over an area 1–4 mm square with the substrate mechanically stepped under the beam to build a continuous pattern up to the full size of the substrate; for example, a 100 mm wafer. Laser interferometry or registration techniques are used to correct the imprecision of the mechanical workstage, misregistration of previous layers and distortions of the wafer. During registration, special marks on the substrate are located automatically by the electron beam, and are used to align the beam to the substrate with a typical accuracy of 0·1 μm.

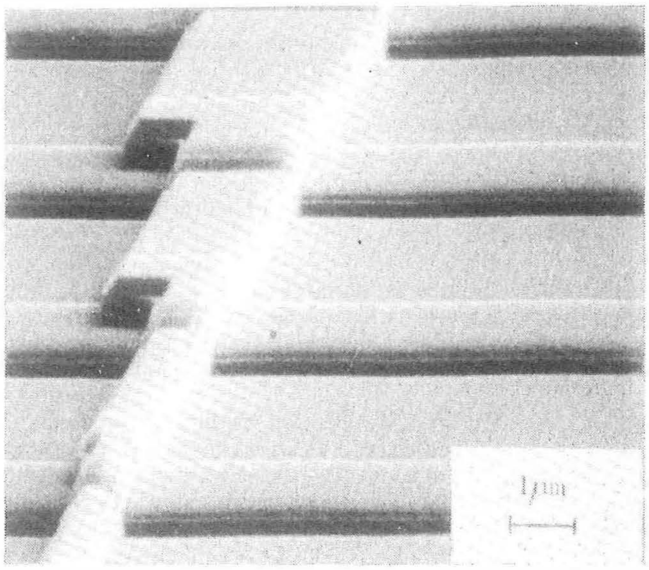
At BTRL, direct writing (no mask) of silicon MOS and bipolar circuits is helping to establish device scaling into the submicrometre region, while its use in the direct commitment of gate arrays for fast development and quick turn round applications is also being investigated. In addition, the high resolution capability has been used to make laser structures (<0·25 μm) on III-V materials and high-frequency surface-acoustic wave (SAW) devices (0·5 μm) on quartz. Some examples of work which have been undertaken are shown in Fig. 7.

Another important and unique application is for the specialised mask-making needed in the development of integrated optics devices on lithium niobate and III-V materials. Conventional optical mask-making equipment is not capable of defining the curved waveguide features needed in this application. EBL pattern generation, however, is enabling complex curves, including sine bends, to be approximated to an accuracy of 0·125 μm or better.

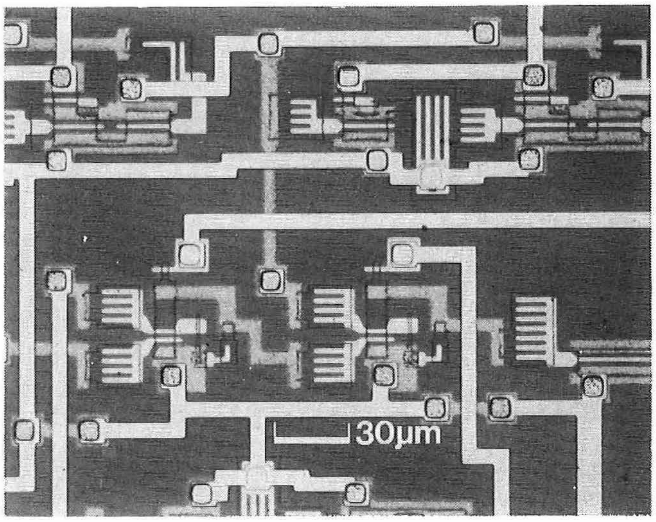
These device activities have required background support in the form of the characterisation of electron resists and processes, and the writing of more software for undertaking direct writing and advanced mask-making. For example, computer-aided design techniques for integrated circuits are not suited to the definition of curved waveguide and SAW devices; hence, a special set of programs was developed to allow efficient design of such components. This has given integrated optics designers a unique facility for the rapid design of sophisticated optical signal processing systems for BT's advanced optical communications projects.

ELECTRON BEAM TESTING OF VLSI CIRCUITS

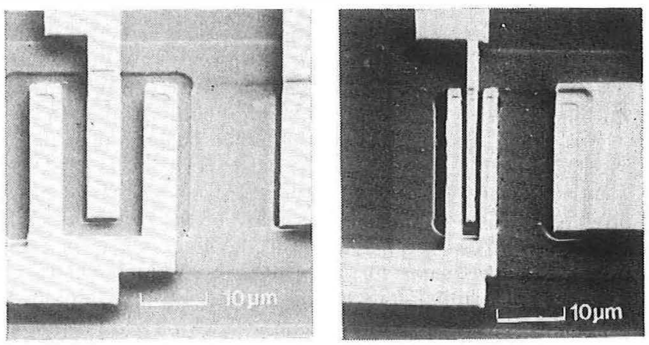
Increased complexity in the VLSI circuits required for advanced communications systems has highlighted severe deficiencies in current test methods. Consequently, design for testability is now receiving considerable attention. The methods under development aim to ensure that each part of the circuit is exercised, and that any fault is reflected by an incorrect output from the circuit. However, since the circuit is accessed only via the primary inputs and outputs, it is not possible to pin-point the exact location of any defect. This is satisfactory where the design is known to be good as in production testing, but is inadequate for the design verification of prototype circuits where the exact nature of a problem



(*a*) Experimental short-channel MOS device with gate lengths of 0·25–3·0 μm



(*b*) Section of a 1 μm gate GaAs digital integrated circuit. All five levels were written directly by electron beam lithography



(*c*) Electron beam lithography has been used to shrink the normal lateral dimensions (left) of an ECL ULA by factors of 0·6, 0·4 and 0·3 on the same wafer. Minimum finished linewidth in the 0·3 × device was 0·6 μm (right)

Fig. 7—Examples of work carried out by using electron beam lithography

must be established. In this case, direct observation of any connection within a logic block may be required.

The mechanical probe, used in the past to examine parts of the circuit, is now of limited use since it can severely damage the contact point, and its associated parasitic capacitance can change the performance of the device under examination. Furthermore, access to subsurface interconnections is not possible unless additional processing is used to open windows at the point of interest. It was for these reasons that BT was one of the first companies to adopt the electron beam probe as the most effective method for fault diagnosis of large-scale integrated circuits.

In electron beam probing, an integrated circuit is mounted in the evacuated specimen chamber of a scanning electron microscope (SEM), and signals applied to the circuit by a drive unit. The primary electron beam generated in the electron gun is focused by a lens system and raster scanned across the circuit. As a result of this electron bombardment, low energy secondary electrons are emitted, whose emission energy and level not only depend on the topography and substrate material, but also on the specimen voltage. As a consequence of this effect, the voltage distribution around the circuit is seen as variations in image intensity, see Fig. 8.

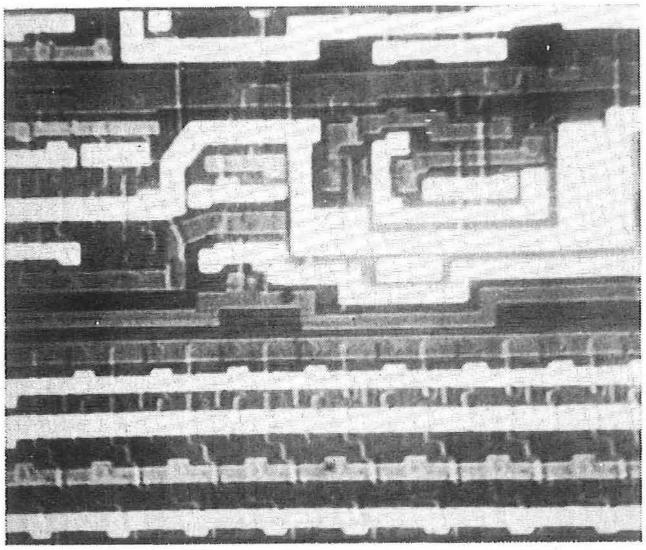


Fig. 8—Electron beam probing of an integrated circuit

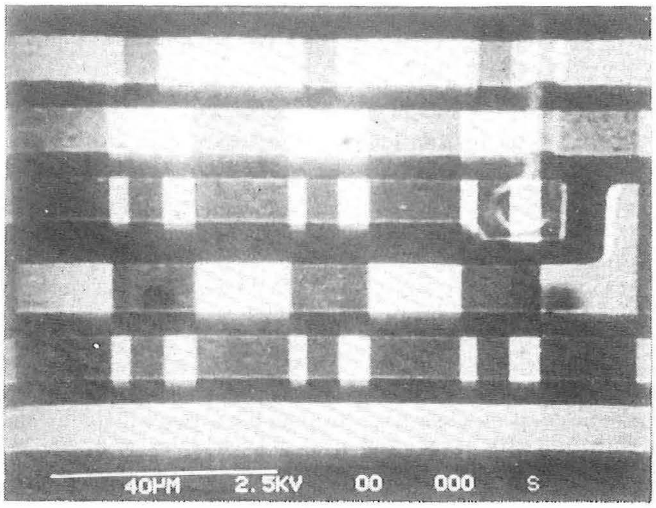


Fig. 9—Mapping of logic states in electron beam probing

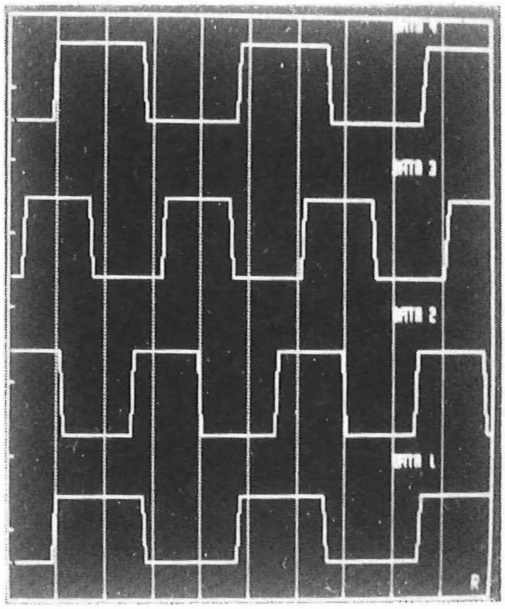


Fig. 10—Waveform reconstruction

If the circuit is clocked slowly, its switching operation can be observed directly. However, as the frequency is increased, the changes become too rapid for the eye to follow, and a stroboscopic method must be adopted. This is achieved either by switching the electron beam across an aperture using electrostatic plates positioned in the SEM column, or by gating the video amplifier chain in synchronism with the circuit clock. A static image is obtained corresponding to a particular instant in time in the clock period. Clearly, this is possible only if the signal is repetitive. An extension to this procedure is to change the phase of the electron-beam pulse by a fixed amount relative to the clock pulse for each line scan of the primary beam. In this way, voltage changes are resolved in time along a frame scan, and light and dark bands are seen according to the logic states. (See Fig. 9). If the electron beam is held on a track and the phase of the electron-beam pulse varied as above, the logic states can be mapped. This information can be stored for several points around the circuit and a timing diagram displayed by a computer.

Finally, it is also possible to use the electron-beam system for quantitative voltage measurement. For this mode, it is necessary to incorporate a device called a *retarding field electrometer*, which provides a measure of the change in energy of the secondary electrons, resulting from a change in specimen voltage, to determine the voltage at a point. If the voltage is measured at different instances in the clock period, the waveform can be reconstructed. (See Fig. 10.)

All of these facilities are available in the BTRL machine, which was the first commercially available system, developed by Lintech Instruments in close collaboration with BTRL. Current work is aimed at enhancing the performance of the system to meet the requirements of new technologies. In particular, the efficiency of the retarding grid spectrometer is being optimised by using computer simulation methods, and the image quality enhanced by the use of frame stores. Additionally, computer control of instrumentation is being introduced to eliminate operator dependence. This is a prelude to a longer-term programme of work aimed at linking the electron-beam tester with emerging CAD software to enable automatic design validation of complex circuits.

Decisions of the XVIth CCIR Plenary Assembly

PROFESSOR I. STOJANOVIĆ†, and R.C. KIRBY*

UDC 621.396 : 061.3

The XVIth Plenary Assembly of the International Radio Consultative Committee (CCIR) was held in Dubrovnick, Yugoslavia, earlier this year. The CCIR is on of the four permanent organs of the International Telecommunications Union (ITU) and its Plenary Assemblies are held every four years to approve new or revised Recommendations dealing with system performance and standards for radiocommunications based on work done by its Study Groups over the previous four years. This article summarises the decisions reached at the XVIth CCIR Plenary Assembly and is reproduced with the permission of the ITU.

INTRODUCTION

The XVIth Plenary Assembly of the International Radio Consultative Committee (CCIR) was held in Dubrovnik, Yugoslavia, from 12–23 May 1986. Participation from 75 countries included more than 400 delegates of administrations and representatives of recognised private operating agencies and international organisations. Professor Dr. Ilja Stojanović, head of the Yugoslavian Delegation, was Chairman of the Assembly. The opening remarks of Professor Stojanović were followed by addresses from: Dr. M. Suković, Deputy Prime Minister of the Federal Government of Yugoslavia; Mr. V. Cagorović, Chairman of the Management Board of the Community of Yugoslavia PTT and Chairman of the Organisation Committee of the XVIth Plenary Assembly; Mr. Th. Milković, Mayor of Dubrovnik; Mr. A. Arai, Head of the Japanese delegation on behalf of visiting delegations; Mr. R. E. Butler, Secretary General, International Telecommunication Union (ITU); Mr. V. Kozlov, Chairman, IFRB‡; Mr T. Irmer, Director, CCITT**; and Mr. R. C. Kirby, Director, CCIR.

The Plenary Assembly approved some 160 new or revised CCIR Recommendations dealing with system performance and standards for radiocommunications, and technical bases for the use of the radio frequency spectrum, based on the work of the Study Groups over the period 1982–86. Highlights included new Recommendations for satellite communications, mobile services, microwave radio-relay systems and television broadcasting. Much of the focus was on digital techniques. During the four-year study period, the CCIR had also prepared the technical bases for eight administrative radio conferences of the ITU. Other new or revised texts included 434 Reports, new Questions for study and Resolutions on technical co-operation and organisation of CCIR work. Significant decisions were also taken concerning the CCIR preparation for forthcoming Administrative Radio Conferences.

The organisation and officers of the XVIth Plenary Assembly are shown in Table 1. The Organisation Committee, and the Technical Co-operation Committee, dealt with the functioning of the CCIR between Plenary Assemblies. It was decided that the present Study Groups would be maintained. Chairmen and Vice-chairmen were appointed.

CCIR work is carried out in 13 Study Groups (see Table 2), two of which are Joint Study Groups with the CCITT. Preparation of technical bases for ITU administrative radio conferences is carried out in CCIR Conference Preparatory Meetings (CPMs), as in the case of the World Administrative Radio Conference on the use of the geostationary-satellite orbit and the planning of the space services using it, or by Study Groups and their Interim Working Parties (IWPs).

In the interval between the XVth Plenary Assembly (Geneva, 1982) and the XVIth Plenary Assembly, some 2450 delegates from 54 countries participated in the Interim and Final Meetings of the CCIR Study Groups. The results adopted by the XVIth Plenary Assembly will appear in 14 Volumes (see Table 3) to be published over the period from August 1986 to June 1987.

Some of the results of the XVIth Plenary Assembly are summarised in the following sections.

TABLE 1
Organisation and Officers of the XVIth Plenary Assembly

Plenary Assembly		
Chairman:	Prof. Dr. I. Stojanović	Yugoslavia
Vice-chairmen	Mr. A. Badalov	USSR
	Mr. Liu Zhongen	China
	Mr. S. Chemai	Kenya
	Mr. J. Durkin	UK
	Mr. R. Shrum	USA
Organisation Committee		
Chairman	Mr. A. R. Bastikar	Canada
Vice-chairman	Mr. A. Arai	Japan
Technical Co-ordination Committee		
Chairman	Mr. E. Kamdem Kamga	Cameroon
Vice-chairman	Mr. M. Okura	Brazil
Budget Control Committee		
Chairman	Mr. S. Al-Basheer	Saudi Arabia
Vice-chairman	Mr. K. Rao	India
Editorial Committee		
Chairman	Mr. M. Thué	France
Vice-chairmen	Mr. R. Bedford	UK
	Mr. F. Molina-Negro	Spain
	Mr. V. Miralles	Spain

† Chairman, XVIth Plenary Assembly
* Director, CCIR

‡ IFRB—International Frequency Registration Board
** CCITT—International Telegraph and Telephone Consultative Committee

TABLE 2
CCIR Study Groups

Designation	Title	Chairman	Vice-Chairmen
Study Group 1	Spectrum utilisation and monitoring	M. J. Hunt (Canada)	R. N. Agarwal (India) T. Boe (Norway) R. Mayher (USA)
Study Group 2	Space research and radioastronomy services	F. Horner (UK)	H.G. Kimball (USA)
Study Group 3	Fixed services at frequencies below about 30 MHz	H. Kaji (Japan)	J. E. Adams (USA)
Study Group 4	Fixed satellite service	S. Hauck (Switzerland)	F. S. Leite (Brazil) T. Muratani (Japan) P. Remedi (Indonesia)
Study Group 5	Propagation in non-ionised media	A. Kalinin (USSR)	F. Fedi (Italy) Y. Hosoya (Japan)
Study Group 6	Propagation in ionised media	L. W. Barclay (UK)	G. L. Mutti (Zambia) Miss G. Pillet (France)
Study Group 7	Standard frequencies and time signals	J. McA. Steele (UK)	S. Leschiutta (Italy)
Study Group 8	Mobile, radiodetermination and amateur services	E. George (FRG)	Y. Hirato (Japan) J. Karjalainen (Finland) R. C. McIntyre (USA) O. Villanyi (Hungary)
Study Group 9	Fixed services using radio-relay services	J. Verree (France)	M. Murotani (Japan) H. Willenberg (FRG)
Study Group 10	Broadcasting service (sound)	C. Terzani (Italy)	A. Keller (France) O. P. Khushu (India) H. Kussmann (FRG)
Study Group 11	Broadcasting services (television)	M. Krivocheev (USSR)	E. Aguerrevere R. (Venezuela) A. Todorović (Yugoslavia) Wu. Xian-Lun (People's Rep.China) R. Zeitoun (Canada)

CCIR/CCITT Joint Study Groups

CMTT	Transmission of sound broadcasting and television signals over long distance	W. G. Simpson (UK)	G. Zedler (FRG)
CMV	Vocabulary and related subjects	M. Thué (France)	M. Ducommun (Switzerland) V. Miralles Mora (Spain) T. Myles (UK)

TABLE 3
Volumes of CCIR Reports and Recommendations Emanating from the XVIth Plenary Assembly

Volume(s) /Part	Title	Volume(s) /Part	Title
I	Spectrum utilisation and monitoring	X-1	Broadcasting service (sound)
II	Space research and radioastronomy	X/XI-2	Broadcasting-satellite service (sound and television)
III	Fixed services at frequencies below about 30 MHz		
IV-1	Fixed-satellite service	X/XI-3	Sound and television recording
IV-2	Frequency sharing and co-ordination between systems in the fixed-satellite service and radio-relay systems	XI-1	Broadcasting service (television)
		XII	Transmission of sound broadcasting and television signals over long distances (CMTT)
V	Propagation in non-ionised media	XIII	Vocabulary (CMV)
VI	Propagation in ionised media	XIV-1	Information concerning the XVIth Plenary Assembly
VII	Standard frequencies and time signals		
VIII-1	Land mobile services		Minutes of Plenary Sessions
	Amateur service		Administrative texts
	Amateur satellite service		Structure of the CCIR
VIII-2	Maritime mobile service		Lists of CCIR texts
VIII-3	Mobile satellite services (aeronautical, land, maritime mobile and radiodetermination)	XIV-2	Alphabetic index of technical terms appearing in Volumes I to XIII
IX-1	Fixed service using radio-relay systems		

RADIOCOMMUNICATION SERVICES

Fixed-Service Satellite Communications

Much work was concentrated in *orbit-spectrum utilisation*, particularly in view of the World Administrative Radio Conference on the use of the geostationary-satellite orbit and the planning of the space services utilising it (WARC-ORB). Technical factors influencing the use of the geostationary-satellite orbit by satellites sharing the same frequency bands have been studied in detail, so that the CCIR work provides virtually all the technical bases for planning and regulation in this field. IWP 4/1 has been the focus for these studies since 1968. The basic Report 453 was revised extensively to reflect the results of recent studies.

Two new Reports point out the technical facts and parameters influencing the efficiency of use of the geostationary-satellite orbit:

(*a*) Flexibility in the positioning of satellites (Report 1002), and

(*b*) Off-axis equivalent isotropically radiated power (EIRP) density limits for fixed-satellite service earth stations (Report 1001).

Report 558, which describes the influence of the satellite antenna pattern on orbit utilisation, was extended by a new Annex IV which contains the elements for a possible new Recommendation to be studied.

New material on methods of improving the efficiency of the geostationary-satellite orbit had been introduced during the final Study Group meetings and is given in Report 1000 describing *spectrum utilisation methodologies*. Another new Report (1003) gives *methods of multi-lateral co-ordination among satellite networks*. A possible means to improve the orbit/spectrum efficiency may be the use of the same frequency band for both the up-link and the down-link. Report 557 dealing with this aspect was revised and new Report 999 provides the necessary calculation methods.

Several existing Recommendations were modified with the intention of improving orbit/spectrum utilisation. Recommendation 580 concerns earth station antenna radiation patterns for use as design objectives. It was revised and a new Report 998, giving explanations of the impact of such requirements, complemented with measurement results, was added. In line with the proposed changes in Recommendation 580, the maximum permissible levels of off-axis EIRP density from earth stations transmitting in the 6 GHz frequency band have been tightened in Recommendation 524 for angles off the main lobe smaller than 9·2°. The maximum levels of permissible interference caused by other satellite networks were increased in Recommendation 466 for frequency-modulated telephone channels and in Recommendation 523 for 8 bit pulse-code modulation (PCM) encoded telephone channels.

With the increasing use of the geostationary-satellite orbit, not only electromagnetic interference but also the possibility of physical interference is considered. A new Question (34/4) and a new Report (1004) deals with this subject.

Aspects of sharing with terrestrial radio-relay systems were studied jointly by Study Groups 4 and 9. New Recommendation 615 specifies acceptable values of interference from the fixed-satellite service into terrestrial radio-relay systems. New Report 1006 gives limits for the EIRP of fixed-service transmitters to protect feeder links of the broadcasting-satellite service sharing the same frequency band.

A great deal of study has been done in co-ordination with the CCITT to ensure that performance standards for satellite systems satisfactorily meet the demands of new digital telecommunication services. New Recommendation 614 formulates the necessary quality requirements for satellite systems forming part of an international connection in an integrated service digital network (ISDN) to meet the overall specifications of CCITT Recommendation G.821. New Report 997 provides supporting material to this Recommendation. Recommendations 522 and 579 were modified to take account of reduced availability of systems operating above 10 GHz, caused by propagation effects.

Concerning maintenance and measurements on earth stations, Recommendations 481 and 482 for noise and performance measurements were extended to be valid also for 372, 492, 552 and 1200 telephone channels.

The CCIR Handbook on *Satellite Communications (Fixed-Satellite service)* was prepared by *ad hoc* group CCIR/MSFS chaired by Mr. J. Salomon (France). The handbook, completed and available in April 1985, summarises fundamental aspects, technology, equipment and planning considerations. Digital communication techniques are emphasised. It is of tutorial character, intended to assist administrations and organisations, especially in developing countries, in the planning and development of satellite communication programmes. It takes into account CCIR Recommendations and the ITU Radio Regulations.

Microwave Radio-Relay

A considerable degree of standardisation has been achieved for analogue radio-relay systems, which are covered by many Recommendations. Current studies emphasise digital techniques, the use of high frequencies (that is, above 10 GHz), increased spectral efficiency, and frequency sharing with other services.

In light of the trend toward digitisation of radio-relay systems, the Plenary Assembly approved the Study Group 9 revision of the framework of study for digital radio-relay systems by splitting the pre-existing Question, which treated all digital subjects, into five Questions covering:

(*a*) hypothetical reference digital paths and performance objectives for digital radio-relay systems,

(*b*) characteristics of digital radio-relay systems,

(*c*) radio-frequency channel arrangements for digital radio-relay systems,

(*d*) interconnection at baseband and intermediate frequencies for digital radio-relay systems, and

(*e*) preferred methods and characteristics for the supervision and protection of digital radio-relay systems.

Concerning digital radio-relay systems which may form higher-grade portions of an ISDN, Recommendation 594, which provides *performance objectives of the hypothetical reference digital path (HRDP)*, was amended in consonance with the work of CCITT Study Group XVIII. A new Recommendation 634, which gives performance objectives for actual operational paths from 280 km to 2500 km long (shorter than the HRDP), was approved. New Reports 1052 and 1053, concerning performance objectives of medium- and local-grade portions of the HRDP, were approved.

The existence of different digital hierarchical levels in three regions complicates the recommendation of unified frequency channel arrangements. However, a sophisticated compromise concept was adopted, as contained in Recommendation 635, which concerns *large-capacity radio-frequency channel arrangements for systems operating in the 4 GHz band*. New Recommendations 636 and 637, concerning *systems with medium and small capacity operating in the 15 GHz and 23 GHz bands*, respectively, were also adopted. Study Group 9 will continue the study of performance objectives and frequency channel arrangements relevant to the digital hierarchy, taking into account the activities of CCITT relating to digital networks.

A new Question was adopted, based on the request of the Plan Committee for Latin America (Paramaribo, 1985), to study the applicability and technical characteristics of cellular-type mobile radiocommunication systems for use as fixed systems.

High-Frequency Fixed Service

High-frequency (HF) radio now provides communications mainly in areas where other means of communication are not available or not economically feasible; for example, in sparsely populated areas. This has been reflected in CCIR work. Automatically-controlled HF radio systems are described in Report 551.

Study Group 3 is examining the impact of new technologies in HF radio. New Report 994 describes requirements for remotely-controlled stations and gives practical examples of implementation of remotely-controlled HF receiving and transmitting stations. New Report 993 discusses the automatic self-test system of remotely-controlled transmitters and receivers. These technologies increase reliability and efficiency, and reduce the need for operators. New Report 992 describes HF networks for relief operations and related equipment characteristics.

Broadcasting Systems

Sound Broadcasting

New Recommendation 643 was adopted on the system studied in the European Broadcasting Union (EBU) for *automatic tuning and other applications in FM receivers*, such as radar data system (RDS).

A new Recommendation was approved on *audio quality parameters for a high-quality sound-programme transmission chain* (Recommendation 644) and another on *digital audio interface for broadcasting studios* (Recommendation 647).

New Recommendation 648 on *digital recording of audio signals*, which provides for a sampling frequency of 48 kHz and linear encoding with at least 16 bits per sample, was adopted as well as a new Recommendation on measuring methods for analogue audio disc and tape recordings (Recommendation 649).

During the 1982–86 study period, several handbooks and microcomputer programs related to broadcasting antennas were prepared by the CCIR Secretariat with the co-operation of Study Group 10:

(*a*) A new edition of the *CCIR Atlas of Antenna Diagrams* was published in 1984 in response to WARC-79 Recommendation No. 500 and in accordance with the detailed provision of CCIR Resolution 76 and Recommendation 414. This new publication is entirely dedicated to HF Antennas, and includes arrays of horizontal half-wave dipoles with or without reflector or imperfect ground (ranging from the single dipole to the more complex HR 4/4/1·5) and arrays of horizontal slewed half-wave dipoles with reflector on imperfect ground (calculated for slew angles of 10, 20 and 30°).

(*b*) *CCIR software for HF antenna diagrams (1984)* is a special publication issued in response to Resolution 81 of the XVth Plenary Assembly and represents a new trend in the dissemination of technical information. The software used for the preparation of *CCIR Antenna Diagrams (1984)* was converted for application to personal computers in order to widen access to these important programs by small and developing countries. The software includes two BASIC language programs (*HFARRAYS* and *HFRHOMBS*) for full pattern calculation of dipole arrays (with or without reflector) and rhombic antennas on imperfect ground. The package is delivered on floppy discs whose size and format can be chosen among more than 310 types for a number of microcomputer operating systems, and is accompanied by a trilingual manual.

(*c*) *CCIR software for LF and MF antenna diagrams (LFMFANT)* was developing in 1985 in response to Resolution 81 of the XVth Plenary Assembly and follows the new trend in the dissemination of technical information initiated in 1984 with the *HFARRAYS* and *HFRHOMBS* packages, specifically designed to be used in microcomputer environments. The *LFMFANT* is aimed at calculating long-wave and medium-wave vertical elements of arbitrary height in any position over perfect or imperfect ground.

Television Broadcasting

The XVIth Plenary Assembly unanimously approved new Recommendations on *digital television interfaces* (Recommendation 656) and on *recording digital television on magnetic tape* (Recommendation 657). Both texts are based on the digital television encoding standard adopted by the CCIR in 1982 as Recommendation 601. The later Recommendation is now enlarged by specification of filter characteristics to limit the frequency spectrum of the coded signal. The new CCIR Recommendations open the door to the realisation of fully-digital television production studios with convenient interconnection of digital studio equipment by means of a single digital video interface standard. The single digital tape recording format greatly facilitates recording, editing and exchange of digital television programmes. These standards provide broadcasting organisations with a great measure of technical freedom in the production of programmes, and lead to an excellent quality of picture. Prof. Krivocheev, Chairman of CCIR Study Group 11, saluted the consensus reached on the digital television Recommendations as a 'historical event in the life of the CCIR'. (See below.)

CCIR DIGITAL TELEVISION RECOMMENDATIONS

The approval of new CCIR Recommendations on digital video interfaces and on recording digital television on magnetic tape is a major milestone in international standardisation of television. They are the result of intensive work carried out in CCIR Interim Working Parties 11/7 under the chairmanship of A. Heightman, UK, and 10-11/4 chaired by P. Zaccarian (NANBA). The two Interim Working Parties were set up by the CCIR in 1983; thanks to close co-operation from the Society of Motion Picture and Television Engineers (SMPTE), the European Broadcasting Union (EBU) and other international broadcasting organisations, they were able to complete this task in time for the meeting of CCIR Study Groups 10 and 11 in October 1985 and to submit to that meeting the text of draft Recommendations that covered in full detail internationally agreed specifications for a single digital video interface and for a single digital television recording format. The texts finalised by the Study Groups were then submitted to the XVIth Plenary Assembly for approval.

Experts world-wide believe that the new digital television standards will open a new era of unequalled recording, editing and post-processing flexibility in the production of television programmes, and in the exchange of superior-quality recorded programmes among broadcasters.

Recommendation 601, adopted by the CCIR in 1982, stipulates the use of digital component signals, sampled at a sampling rate of 13·5 MHz for luminance, and 6·75 MHz for each of the two colour difference signals. Digital coding of component signals, rather than conventional PAL, SECAM or NTSC composite signals, offers great benefits to broadcasters and programme producers since it allows almost unimpaired post-processing capability; special effects, electronic tricks and sophisticated picture manipulations can be performed on recorded signals with the same level of quality that would be achieved if they were performed 'live' on the studio output signal.

The new digital television Recommendations 656 and 657 now adopted by the CCIR Plenary Assembly, together with Recommendation 601, offer the broadcasters, for the first time in history, complete freedom in the production of programmes, and excellent quality in the pictures so produced.

As a result of studies on Teletext systems which started in CCIR in 1978, the XVIth Plenary Assembly adopted Recommendation 653 and recognises standards of four systems which are now in service or are being introduced in different parts of the world.

The Plenary Assembly devoted considerable attention to *high-definition television*, a new technology intended to enable the reception of images either on a television screen or projected, the quality of which will be equivalent to that of 35 mm film on wide screens. Development of high-definition television techniques and CCIR studies in the field have been in progress for more than 10 years, and have been particularly intensive since 1983. The Plenary Assembly, assisted by an Ad Hoc Group, amended Report 801 on *the present state of high-definition television* to reflect the developments which had taken place after the Final Meeting of Study Group 11 in November 1985; that is, progress which has resulted in the availability of high-definition television production equipment from manufacturers in several countries and that such facilities, in various parts of the world, already use certain values of the potential set of parameter values given in a new Annex of Report 801-2. Participants in the CCIR have reaffirmed their objective to achieve a single world standard. The Plenary Assembly unanimously decided to postpone the taking of a decision on a standard at this time, but adopted Resolution 96 foreseeing an extraordinary meeting of Study Group 11 in 1988 to reach a conclusion on a draft Recommendation on high-definition television. Work up to the present time has been devoted to a high-definition television standard for studio production and exchange of programmes. Future studies will also include transmission parameters for broadcasting.

The Plenary Assembly enlarged the technical basis for future work in television frequency planning. A new Recommendation on *radio frequency protection ratios for all AM* [amplitude modulation] *vestigial sideband systems* was approved (Recommendation 655). It merges information formerly given in Recommendation 418 for monochrome systems and collected in former Report 306 for colour television systems. Two new Reports on planning methods for terrestrial television in VHF/UHF bands (Report 1085) and related frequency planning constraints (Report 1086) were also adopted.

The CCIR special publication, *Handbook on sound tape recording, television tape recording and films for international exchange of programmes*, released in 1985, was prepared by the Chairman of JIWP 10-11/4 and is addressed to broadcasting engineers whose responsibility is programmes exchange, and therefore presents a comprehensive collection of CCIR texts particularly selected for relevance to day-to-day operations.

A description is also given of the goals of CCIR activity in this area, of the ways this activity is carried out, and of the scope and weight of the technical provisions adopted by the CCIR and documentation in its publications; in particular, the interplay of CCIR activity with that of other international standardising bodies is also briefly described.

Satellite Broadcasting

Three new Recommendations concerning the broadcasting-satellite service set the stage for future developments on this topic. Recommendation 650, on television standards for satellite broadcasting in the channels defined by WARC-BS-77 and RARC-SAT-83, in association with new Report 1073 and the CCIR special publication *Specification of transmission systems for the broadcasting-satellite service* (to be issued in 1987) give system parameters, examples and detailed specifications for digital sub-carrier and multiplexed analogue component (MAC) transmission formats for satellite broadcasting. New Report 1074 on satellite transmission of MAC vision signals gives details of the parameters to be used in the transmission of MAC-format vision signals. The series is completed with a new Recommendation on digital PCM coding for the emission of high-quality sound signals in satellite broadcasting (15 kHz nominal bandwidth).

New Recommendation 652 and associated Report 810-2 on 12 GHz receiving earth station antenna and satellite transmission antenna reference patterns for the broadcasting-satellite service reflect the parameters used in developing the broadcasting-satellite service Plans in the 12 GHz band in all Regions.

New Report 1075 on high-definition television by satellite outlines how satellite broadcasting can be employed for this new technology, and new Report 1076 on the accommodation of spacecraft service functions within the broadcasting-satellite and feeder-link service bands completes the series of new Reports adopted by Study Groups 10 and 11.

Transmission of Television

Studies on transmission of digital television signals continue both in Study Group 11 and CMTT. First results on bit-rate reduction techniques are given in new Reports 1089 and 1093.

Mobile Communications

Twenty-six new or revised Recommendations and 78 new or revised Reports were approved on the land mobile service; maritime mobile service; aeronautical mobile service; land, maritime and aeronautical mobile satellite services; and mobile-satellite service.

For the land mobile service, new Recommendation 622 on analogue cellular mobile telephone systems has been adopted as well as revised Recommendations on radio-paging (584) and on location registration (624).

In the area of the maritime mobile service, the work on digital selective calling has been completed and two Recommendations (524 and 493) on technical and operational characteristics have reached the final stages so that production of equipment is facilitated. New Recommendation 625 on narrow-band direct printing telegraph equipment has been approved providing rephasing and self-identification. Equipment built in accordance with this Recommendation will be fully compatible with existing equipment.

All texts concerning the Future Global Maritime Distress and Safety System (FGMDSS) were updated and the International Maritime Organisation is now studying the implementation of this system. New Recommendation 628 concerning the performance of the search and rescue transponder (SAR) for locating survivors, and Report 1038 concerning a VHF EPIRB (Emergency Position Indicating Radio Beacon) were also adopted.

New Report 1042 was adopted concerning the protection of the band 406–406·1 MHz used for distress alerting and for determining the position of survivors.

Three further Reports deal with modulation and coding suitable for mobile satellite services (509), future ship earth stations (921) and the radiodetermination-satellite service (1050). Two Recommendations were approved on satellite EPIRB systems using geostationary satellites, one concerning EPIRBs at 1·6 GHz (Recommendation 632) and the other at 406 MHz using low polar-orbiting satellites (Recommendation 633).

Report 591 concerning compatibility questions above 108 MHz between the VHF FM broadcasting service and the aeronautical radionavigation and communication service was updated and an initial Report (1057) was approved on a public mobile telephone service with aircraft.

Standard Frequencies and Time Signals

The UTC (universal co-ordinated time) system has been in operation since 1972, and no major changes have been required in the basic Recommendation 460. All other Recommendations were maintained.

A substantially revised Report (1017) on comparative methods for the transfer and dissemination of time and standard frequencies was approved, as were certain supporting Reports giving details of the methods. Two new Reports deal with television methods for the transfer and dissemination of time and frequency and the characterisation of signal delays in antennas (1016 and 1017).

A number of revised Reports were adopted in the field of characterisation of sources and time-scale formation and dealt with, for example, the performance of standard-frequency generators, characterisation of phase and frequency noise, and standard frequency generators in the submillimetre, infra-red and visible-light regions of the spectrum.

Report 898 on the accuracy, stability and reliability of frequency standards and reference clocks, prepared in connection with the studies of CCITT Study Group XVIII on the ISDN, was accepted in its revised form.

Space Research and Radioastronomy

Most studies in the field of space research relate to near-Earth space. Report 548 now presents a summary of the telecommunication requirements for near-Earth space research. The selection of frequencies for transmission to and from manned and unmanned spacecraft and protection criteria for near-Earth space research systems are now in Reports 984 and 985. New Recommendation 609 deals with protection criteria from telecommunication links for manned and unmanned near-Earth space research.

Taking into account that the radioastronomy service is a passive service concerned with the measurement of extremely low power levels, the continuing increased number of satellite transmitters in the geostationary-satellite orbit has brought about the problem of spurious emissions (Reports 697 and 224). The results of the studies were included in new Recommendation 611, *Protection of the Radioastronomy service from spurious emissions.*

SPECTRUM UTILISATION AND RADIO-WAVE PROPAGATION

Spectrum Utilisation and Monitoring

Particular consideration has been given to the studies of interference and electromagnetic compatibility and to the problems of the effective utilisation of the radio spectrum (Reports 662, 664 and 976), including usage of computers for this purpose (Report 841), means against interference (Report 974) methods for monitoring (Reports 979, 976), and measuring emission parameters and spectrum occupancy (Report 977). Most of the texts concerning monitoring have been updated. Extensive revision was made to Report 276 on the monitoring of radio emissions from spacecraft. A new Report (979) deals with the subject of locating sources of interference to emergency position-indicating beacons operating in the 406–406·1 MHz band.

Considerable attention has been paid to the technical elements of frequency management. A revision of the *CCIR handbook on spectrum management and computer-aided techniques* is now ready for publication. The main purpose is to assist the administrations of developing countries in the improvement and automatisation of their spectrum management functions. The *CCIR Handbook for Monitoring Stations* is now being revised. The updated handbook, which provides the essential information for the establishment, staffing and operation of a monitoring system, should be available in 1987. The work on the determination of limits for radiation from ISM equipment was continued and will probably be completed in the present study period.

Radio-Wave Propagation

CCIR Recommendations and Reports on radio-wave propagation are the responsibility of Study Groups 5 and 6, which cover, respectively, propagation in non-ionised and ionised media. The data and information are fundamental in the design, planning and use of radio systems, and frequently represent the bases of technical criteria established at administrative radio conferences to aid the qualification of a required service and for the assessment of interference when frequencies are shared.

During the Study Period significant improvements and additions have been made to the texts, and Recommendations now exist addressing the use of propagation data for most terrestrial and Earth-space communication systems. Notably, 20 of these were new or modified Recommendations adopted by the XVIth Plenary Assembly.

Some useful texts of a general nature have been developed, such as Report 1007 on statistical methods used in propagation, and Recommendation 310 on terminology related to propagation in the neutral atmosphere. Particular attention has been paid to keeping material up-to-date on ionospheric characteristics, and analysis undertaken on the efficacy of various solar and ionospheric indices for long-term ionospheric predictions has led to the adoption of a new ionospheric index, IG, in Recommendation 371. A new Report on artificial modification of the ionosphere by chemical injections has also been adopted.

The short-term and long-term prediction of variation in ionospheric parameters affecting the operation of ionospheric circuits is now more extensively covered in Reports 727 and 888, with the addition of Report 1012 relating particularly to operational problems in high-latitude regions.

Fundamental to determining the behaviour of radio waves in the neutral atmosphere is a knowledge of the meteorological factors which influence propagation. Report 563 contains information on refractivity and hydrometeors, and it is to the second of these that significant improvements have recently been made. Information is provided on the horizontal and vertical structure of rainfall which is needed for the prediction of attenuation and scattering due to rain at gigahertz frequencies on both terrestrial and Earth-space paths. Refinements have been made also to Report 720 which contains data on radio emission (noise) from natural sources and to Report 718 dealing with the behaviour of tropospheric refraction on propagation. The long-established Report on atmospheric radio noise (Report 322) has undergone a major revision. New maps of atmospheric radio noise have been produced, based on an improved analysis of an extended database of noise measurements. The new version, Report 322-3, was adopted at the Plenary Assembly with the desire that further studies be carried out to validate the data contained therein.

At LF and MF frequencies, sky-wave propagation prediction techniques have been developed for use by regional administrative radio conferences concerning broadcasting, maritime and aeronautical navigation services. For ground-wave propagation, a new atlas of ground conductivity has been adopted containing maps of conductivity for MF as well as VLF. The atlas contains LF and MF propagation curves to which the conductivity data can be applied to determine field strength. A new Report on reflection from the surface of the Earth has also been adopted.

Propagation studies at HF have been dominated by the preparation and refinement of a method for predicting sky-wave field strength for use by the WARC on HF broadcasting. The basis of the method adopted by the first session of the Conference was developed by Study Group 6, and studies continued on the refinement of certain aspects of the method. The results of this work are now contained in Recommendation 621 adopted at the Plenary Assembly. Attention has been paid to simple HF sky-wave prediction methods appropriate for use on microcomputers, and this is reflected in a new Study Programme and Report.

Recommendation 370 and its related Report 239, concerning VHF and UHF propagation information for broadcasting services, have undergone revision. Largely in response to information requested by the regional FM sound broadcasting conference, separate propagation curves are now provided for paths over land and over sea, and new information has been added on VHF propagation in areas of extreme super-refractivity. A new Recommendation has been adopted on propagation data for terrestrial maritime mobile services at frequencies above 30 MHz. The method for the calculation of sporadic-E field strength (Recommendation 534) recommended for use at VHF now has wider application and may be applied at low and equatorial latitudes. New information on trans-equatorial propagation has been added to Report 259. Much of the new VHF and UHF propagation information developed during the Study Period has been submitted to the regional African television conference.

At microwave frequencies, Reports 338 and 238 covering methods and propagation data for line-of-sight and trans-horizon radio-relay links have undergone major revision largely due to the comparison that has been made between the prediction methods and available measurement data. Separate Recommendations have now been adopted covering each of these Reports. Similarly, the analysis of available propagation measurement data has allowed useful testing and improvement of Report 564 for Earth-space paths. For example, revision of the general method for rain attenuation prediction has led to closer agreement with available measurement data and covers extended regions of the world. New Recommendation 618 embraces this Report together with three others dealing with propagation information for satellite broadcasting, maritime mobile and land mobile satellite systems. Ionospheric data pertinent to Earth-space paths continues to be contained in Report 263 which *inter alia* has expanded its information on gigahertz scintillation.

Concerning propagation factors in interference, separate (including two new) Recommendations were adopted on:

(*a*) the evaluation of interference between stations on the surface of the Earth,

(*b*) the evaluation of interference between stations in space and those on the surface of the Earth, and

(*c*) the calculation of co-ordination distance.

Ducting and rain scatter are the two principal propagation mechanisms of interference. Techniques have been developed for quantifying the interfering signals from these effects, and the relevant Reports have been updated accordingly. A new Report has been produced on propagation data for bi-directional co-ordination.

Study Groups 5 and 6 have continued to be aware of the need for propagation information relating to developing countries. This typically involves data at low latitudes, in tropical regions and in desert land masses. The texts adopted by the XVIth Plenary Assembly attempt to reflect this need by drawing a more marked distinction than hitherto between regions displaying different propagation characteristics.

ADMINISTRATIVE RADIO CONFERENCES

The XVIth Plenary Assembly reviewed CCIR preparatory work carried out during the 1982–86 Study Period for eight administrative radio conferences. Two Conference Preparatory Meetings (CPMs) were held. Otherwise, the work was carried out by Study Groups through their Interim Working Parties (IWPs). The CPM SAT-R2 prepared the technical bases for the 1983 Region 2 Conference that established Plans for satellite broadcasting in the 12 GHz band and for associated feeder links in the 17 GHz band. The CPM ORB(1) prepared the technical bases for the 1985 Conference on the use of the geostationary-satellite orbit.

The First Session of the Regional Administrative Conference for FM Sound Broadcasting in the VHF Band (Region 1 and certain countries in Region 3), Geneva 1982, adopted Recommendations requesting the CCIR to undertake further studies on propagation, to further investigate the problem of compatibility of VHF broadcasting services and the aeronautical mobile service in the adjacent bands assigned to these services and prepare a report for submission to the Second Session. An IWP in Study Group 5 dealt with the propagation questions, whereas it was eventually necessary to set up a Joint Interim Working Party (JIWP) of Study Groups 8 and 10 to evaluate the possibility of improving compatibility criteria for the two services, and to prepare the CCIR report about the specific compatibility problem. It was taken as a basis for the interference calculations in the planning process at the Second Session of the conference (November–December 1984). The study will continue in the CCIR, with a meeting of the JIWP to be held in the near future.

The preparatory work for the Regional Administrative Conference for the planning of the broadcasting-satellite service in Region 2 (SAT-83), Geneva, June/July 1983, was completed by the CCIR Conference Preparatory Meeting (CPM SAT-R2) in June/July 1982.

CCIR preparatory activities for the Second Session of WARC ORB started during the Final Meeting of CCIR Study Groups, September–November 1985. A JIWP of Study Groups 1, 2, 4, 5, 8, 9, 10 and 11 was established under Resolution 90, adopted by the Plenary Assembly, to consider sharing problems and to consolidate the material from the individual Study Groups into the CCIR report to the Second Session of WARC ORB. This JIWP will hold one meeting following the CCIR Interim Meeting at the end of 1987. IWPs and JIWPs were already set up in the concerned Study Groups to prepare technical material falling within specific areas of responsibility of the Study Groups.

It was reported to the Plenary Assembly that the technical preparation of AFBC(1), the First Session of the Regional Administrative Radio Conference to review and revise the provisions of the African VHF/UHF Broadcasting Conference (Geneva, 1963), was successfully completed by the work of Study Groups 5, 6 and 11. The XVIth Plenary Assembly adopted Resolution 93 to enable any necessary future intersessional work by the CCIR.

Resolution 91 laid out CCIR intersessional studies on sharing criteria for services using the band 1625–1705 kHz as requested by Recommendation COM4/A of the Regional Administrative Radio Conference. The aim was to establish a Plan for the Broadcasting Service in the Band 1605–1705 kHz in Region 2 (First Session, Geneva 1986), and the CCIR were requested to undertake specific studies during the intersessional period. These studies particularly concerned compatibility criteria for the fixed and mobile services which share the 1625–1705 kHz band with the broadcasting service in Region 2.

The XVIth Plenary Assembly noted the completion of CCIR intersessional studies for the World Administrative Radio Conference for Sound Broadcasting in the HF Bands (HFBC), notably the results of the studies on multiband antennas and performance, and those related to the refinement of the propagation prediction method used for planning. The propagation information, approved by the Plenary Assembly as Recommendation 621, had already been made available to the IFRB for use in their intersessional planning activity.

The WARC-79 resolved that a Regional Administrative Radio Conference (Region 3) should be convened to establish the technical criteria for sharing between the fixed, broadcasting and mobile services to which the bands concerned are allocated. As a result of inconclusive consultations concerning the date of this Conference and subsequent action by the 41st Session of the ITU Administrative Council (1986), the date has been delayed until at least 1989. In Resolution 94, the XVIth Plenary Assembly set up a JIWP of Study Groups 1, 5, 6, 8, 9, 10 and 11 to carry out the necessary work. A meeting of the JIWP is to take place during the Block A Interim Study Group meetings in 1987 to prepare a report to be submitted to the interim meeting of Study Group 1 (April/May 1988) for formal approval.

IMPROVEMENTS IN CCIR ORGANIZATION AND WORKING METHODS

One of the most important tasks of the XVIth Plenary Assembly was to consider possible ways to increase the efficiency of CCIR work, and several Administrations submitted specific proposals for consideration. Firstly, the terms of reference and structure of CCIR Study Groups (Resolution 61) were re-examined. The existing structure was retained (see Table 2). Secondly, possible improvements in the organisation of CCIR work (Resolution 24) were discussed. This topic traditionally takes up a great deal of the Organisation Committee's time at each Plenary Assembly. The first item discussed was how to proceed with late contributions which always introduce disorder in the preparation of the meetings. Major changes proposed by one administration were not supported by the majority, but a compromise solution was accepted.

One of the most important issues considered was the problem of the possible acceleration of the procedure for adoption of CCIR Recommendations. There was an in-depth discussion on a proposal for an accelerated provisional adoption of Recommendations analogous to a CCITT provision. Although the proposal enjoyed support from several Administrations, no consensus could be achieved. It was agreed that it should be examined during the next CCIR Study Period.

TECHNICAL CO-OPERATION

The Technical Co-operation Committee of the XVIth Plenary Assembly examined the relevant activities of the CCIR in the 1982–1986 Study Period, reviewed and updated CCIR Resolutions and Opinions relating to technical co-operation and established guidelines for the future CCIR activities in this area. It noted the work carried out in accordance with CCIR Resolution 33-4, particularly the preparation of special publications and handbooks, including material available for use with microprocessors. The work of the CCIR in establishing radio propagation studies in tropical regions, for example, the ITU/CCIR radio propagation programme for Africa, was also recognised.

Resolution 33 on Technical Co-operation was revised based on a proposal from the Administration of Chile. Operational clauses were added concerning the organisation of meetings and seminars in conjunction with IWP meetings in host developing countries and concerning the preparation of microcomputer programs.

The Plenary Assembly took note that the CCIR and its Secretariat had prepared the following handbooks and microcomputer software during the 1982-86 study period:

Broadcasting-satellite systems (1983)
CCIR handbook on spectrum management and computer-aided techniques (1983)
CCIR atlas of antenna diagrams (1984)
CCIR software for HF antenna diagrams (1984)
Fixed-satellite service handbook (1985)
CCIR software for LF and MF antenna diagrams, LFMFAMT (1985)
Handbook on sound tape recording, television tape recording and film for international exchange of programmes (1985).

The increased participation of the developing countries in the work of the CCIR, especially in conference preparatory activities, was noted, as was the number of representatives of developing countries among the Chairmen and Vice-chairmen of CCIR Study Groups (see Table 2).

CONCLUSION

For twelve cloudless days in historic Dubrovnik, leadership in radiocommunication from all continents, reviewed and took decisions on four years of technical studies by the CCIR in nearly every domain of radiocommunications which were intended to foster development of telecommunications world-wide, and to enlarge the benefits of the use of the radio-frequency spectrum and geostationary-satellite orbit.

New Recommendations will strengthen the role of satellite communications in the world's digital network and increase the communications capacity of the geostationary-satellite orbit. The results in terrestrial digital radio-relay systems provide a firm basis for this technology as an integral part of digital telecommunications networks. The future of land mobile communication is enhanced by new Recommendations on cellular mobile radio and radio paging. In the maritime field, advances in digital selective calling and emergency position-indicating radio beacons contribute to the future of maritime commerce.

Radio-wave propagation studies in this period showed important advances at higher frequencies, above 10 GHz. At HF, improved prediction methods adapted to HF broadcasting, and progress in radio noise studies, will make it more practicable to apply such information in future planning. Studies in space science and radioastronomy continue to receive attention in the CCIR. The work in spectrum utilisation and monitoring is becoming a more and more indispensable base for frequency management and for administrative radio conferences.

The CCIR made significant progress in broadcasting. The highlights certainly include digital television, and in this Plenary the digital video recording standard, which will provide a new base for the exchange of programmes. Teletext and satellite broadcasting also now have recommended standards. There was important progress on high-definition television. While many wished and worked for a Recommendation for a world-wide standard to be adopted at this meeting, the broad-based final result maintains the momentum and reaffirms the objective of a single world standard in the next Study Period.

Advances were made in the organisation of studies for administrative radio conferences, an increasingly important element of CCIR studies. The range of mechanisms now formally provided for CCIR work, and the specific plans for the next four-year period, should strengthen CCIR's contributions in this field.

The Assembly reviewed the CCIR position in technical co-operation, noting some progress but adopting new and revised resolutions in an effort to strengthen CCIR's contribution. Progress was mainly in handbooks, computer software, seminars, and propagation studies in tropical regions.

The officers retiring since the XVth Plenary Assembly were: K. Olms (Chairman, Study Group 1), G Hempton (Chairman, Study Group 8), Prof. Y. Angel (Chairman, CMTT), R. Struzak (Vice-chairman, Study Group 1), Assane Gueye (Vice-chairman, Study Group 3), G. Mesias (Vice-chairman, Study Group 4), H. T. Dougherty (Vice-chairman, Study Group 5), K. P. R. Mennon (Vice-chairman, Study Group 8), H. Eden (Vice-chairman, Study Group 10), J. M. Pardo-Horno (Vice-chairman, CMV), J. Garido-Sales (Vice-chairman, CMV), B. A. Duran (Vice-chairman, CMV), J Aries (Vice-chairman, CMV).

Deceased since the XVth Plenary Assembly were: E. R Craig (Chairman, Study Group 4), Dr. C. Siocos (Vice-chairman, Study Group 11) and Prof. I. Ranzi (former Chairman, Study Group 2).

Finally, in accordance with the Nairobi convention (1982), the Plenary Assembly exercised, for the last time, its right to elect the Director. Officals of the ITU will henceforth be elected by the Plenipotentiary Conference, which is next scheduled for mid-1989. The incumbent Director was re-elected to continue until that time.

Progress Achieved Towards the Standardisation of High-Definition Television

PRESS RELEASE ISSUED BY THE INTERNATIONAL TELECOMMUNICATION UNION

The XVIth Plenary Assembly of the International Radio Consultative Committee (CCIR), which met in Dubrovnik (Yugoslavia) from 12 to 23 May 1986, devoted considerable attention to a new high-quality television technique called *high-definition television* (HDTV). HDTV is a subject of intense current interest and activity in the world of television-programme production and broadcasting, and has been a subject of study by the CCIR at the study group level since 1974.

HDTV is intended to enable the reception of images, either on a television screen or by projection, the quality of which will be equivalent to that of a 35 mm film on wide screens.

In November 1985, Study Group 11, under the chairmanship of Professor M. Krivocheev, adopted a report presenting to the Plenary Assembly the results of the four years of work. The report included, in annex, a potential set of technical characteristics (called *parameter values*) for HDTV studio production and the exchange of programmes, based on the developments which had taken place in a number of countries.

One advantage of HDTV is that the quality of the image is significantly higher than in existing television systems as a result of the sharp increase in the number of lines used (nearly twice as many as today's systems) and in the pictorial information carried; another is that it will enable the use of sophisticated television production techniques to be applied to cinema-quality productions. Producers of television programmes and films will thus be given unprecedented possibilities in creating a new realism and enriching the value of their television productions for the benefit of the general public.

The adoption of a single world-wide uniform set of characteristics for HDTV would

(*a*) facilitate the international exchange of programmes (the current situation is that television programmes made in one of the analogue systems (for example, NTSC, PAL, SECAM) often have to go through elaborate conversion processes before they can be replayed in another standard with the resulting loss of quality in the process and costs involved); and

(*b*) provide for lower costs of production equipment because of the economies of scale which a single world-wide standard would create.

The discussions which took place in Dubrovnik on HDTV related to the parameters which HDTV might have at the studio level and did not, at this stage, explicitly include the aspects of transmission and reception. It is obvious, however, that these issues had some impact on the deliberations.

A total of 19 proposals on the subject were made by participating administrations and organisations. To assist the Conference in reconciling the positions expressed through these 19 proposals and with a view to coming to an agreement, an Ad Hoc Group, chaired by Professor Krivocheev, was established.

In the course of its work, the Ad Hoc Group amended report 801, which constitutes the only consolidated CCIR report on HDTV, to include the developments which had taken place after November 1985 so as to reflect the current position regarding the standardisation of HDTV. The amendments took into account that:

(*a*) progress has resulted in the availability of HDTV production equipment from manufacturers in several countries;

(*b*) a number of HDTV production facilities already use, in various parts of the world, certain of the parameter values given in the annex to report 801; and

(*c*) HDTV studio standards need to accommodate future broadcasting systems compatible with existing systems.

Because the views expressed diverged on several issues, many of which were of a fundamental nature, and because of the manifest advantages that the adoption of a single set of parameters for HDTV would bring, the Plenary Assembly unanimously decided to postpone taking a decision on a standard at this time but adopted a Resolution forseeing an extraordinary meeting of Study Group 11 in 1988 to reach a conclusion on a draft Recommendation on HDTV. To accelerate the work of standardising HDTV, the Plenary Assembly also enlarged the scope of the mandate of Interim Working Party 11/6—the sub-group within Study Group 11 responsible for the study of HDTV—and of three study programmes to include (for more detailed information, see Appendix):

(*a*) studies on the requirements of broadcasting including their economic and operational aspects to assist administrations and other corporate users in their decision to introduce HDTV in their television networks;

(*b*) the additional aspects of the recording of HDTV programmes on motion-picture films and the transferability of HDTV programmes to and from motion-picture films; and

(*c*) continuation of the work necessary to define a full set of relevant digital and analogue parameters for a single HDTV standard.

It is expected that, because of the achievements of Study Group 11 in the next study period, and because of the remarkable spirit of co-operation which prevailed on the question of HDTV in Study Group 11 and at Dubrovnik, the 1990 Plenary Assembly will be able to adopt a standard which will be unanimously approved by participants.

APPENDIX

DECISION 58-1 ADOPTED BY THE CCIR ON HDTV

CCIR Study Group 11,

CONSIDERING

(*a*) that high-definition television (HDTV) is a subject of intense current interest and activity in the world;

(*b*) that this work is the subject of Question 27/11 and the Study Programmes which derive from it, and is detailed in Reports 630, 801 and [AC/10-11];

(*c*) that it would be beneficial to HDTV broadcasters and to the public alike if the CCIR could recommend the adoption of a single world-wide studio standard for HDTV;

(*d*) that a step to attain this goal is to define the characteristics of a single HDTV standard to be adopted world-wide for the HDTV studio, and for the international exchange of programmes;

(*e*) that prompt action in this respect is required to avoid the establishment of one of several *de facto* studio standards before all aspects of the problem have been adequately considered;

(*f*) that the proposal for a new Recommendation given in Annex II to Report 801 defines a potential set of basic parameter values for a standard for signal generation in HDTV studios and for the international exchange of HDTV programmes;

DECIDES

1. that the Interim Working Party 11/6 should continue its work within the general terms of reference of CCIR Study Group 11, taking note of Question 27/11 and the Study Programmes which derive from it and with the following specific terms of reference;

1.1 to encourage Administrations to participate in a co-ordinated way in the study of HDTV standard for the studio and for international programme exchange;

1.2 to continue the work necessary to define a full set of relevant digital and analogue parameters for a single world-wide HDTV standard for programme production and for the international exchange of programmes. This should take into account the implications of broadcasting requirements including the economic and operational aspects;

1.3 to study simultaneously, in co-operation with Joint Working Group 10-11S, the methods for emission of HDTV signals and according to those studies to produce the specification of the baseband signal format to be used for emission;

1.4 similarly, in co-operation with the CMTT (the CCIR/CCITT joint Study Group for the transmission of sound broadcasting and television signals over long distance), to prepare a specification for the baseband signal format to be used for the international exchange of HDTV programmes via transmission links;

1.5 to prepare regularly updated draft Reports on the progress of its studies;

1.6 to complete these studies as rapidly as possible and before the CCIR Final meetings in 1989.

Book Review

Management Handbook For Engineers and Technologists. Barry T. Turner, and Michael R. Williams. Hutchinson Education. ix + 413 pp. 133 ills. £10·45.

Many engineers become managers but, unfortunately, too few make this transition easily; this is mainly because they persist in trying to remain good engineers, concentrating on technical details at the expense of the broader range of their new responsibilities. The authors of this book firmly believe in the ability of engineers and technologists to reach the higher levels of management and to perform well in these positions; but they just as firmly believe that the low status of engineers and technologists in this country is largely due to their own attitudes and performance in managerial roles. The arguments used in support of these beliefs are detailed and professionally presented. This book is one of the few on management which is written from the engineer's viewpoint.

The education of engineers lays more emphasis upon the understanding and use of materials and natural phenomena than on manpower and money; therefore, argue the authors, engineers tend to become more interested in mechanisms than meanings, in procedures rather than purposes. This tendency can result in too narrow a focus for managing a business. It is significant that, in the UK, engineers are seen as suitable for supervising engineering work but not for managing the business aspects of that work.

On the positive side, engineers start out with a set of scientific disciplines which stand them in good stead should they wish to learn the techniques underlying a range of business disciplines. They must then go on to study and develop the wider management skills which can create achievement and success from the proper use of those mechanisms.

The contents of the book cover: the industrial scene, knowledge of the business, managing the engineering activity, managing the human aspects, types of technical manager and training and education for management. There is little, if anything, in the body of the book that could be called superfluous; the authors have obviously drawn on years of study and practical experience to distil the essence of critical and useful management issues. Some 78 pages of glossaries (legal, commercial, marketing, computer and stock-exchange terms), check-lists, models, formulae and references are included and these are designed to help the reader rather than to display the erudition of the authors.

There are some recurrent themes that run throughout the book, perhaps the most important of which is change, an issue vital to the survival of businesses in today's environment. On the one hand, several reputable studies indicate that engineers are more conservative as a group than most other groups; on the other hand, the introduction of new technologies and the facilities they allow, resulting from the work of engineers, have caused massive change within and across industries as well as in the very structure of society. The question then arises as to how well equipped is an engineer to become a manager, a large part of whose job is to handle change and motivate people towards it, when so little time and effort has been spent in training him or her in the skills of communicating, motivating and of handling uncertainty.

Linked inextricably to the process of change, therefore, is the issue of how an engineer becomes a manager. There is no doubt in the minds of the authors (nor in the mind of the reviewer) that the responsibility for self-change, that is, learning, is firmly with the individual. People must be prepared to invest their own time, effort and motivation if they want to progress. All others can do is offer opportunities.

This book is aimed at those who wish to learn. It endeavours to set out some of the requirements that engineers will have to meet if they are to become successful managers, and it ends with a hopeful vision of many more engineers on the main boards of companies helping to formulate policies and long-range plans that will not only lead to recovery for the nation, but also to a better-organised profession.

This book is well worth reading and any aspiring manager would be well advised to keep a copy by his or her side for frequent reference. It will not solve all their problems but it will help them clarify what the problems really are.

D. P. O'DONOVAN

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

General Secretary: Mr. J. Bateman, TSD3, Room 304, Williams National House, 11–13 Holborn Viaduct, London EC1A 2AT; Telephone: 01–356 9088.
(Membership and other enquiries should be directed to the appropriate Local-Centre Secretary as listed on p. 251 of this issue of the *Journal*.

IBTE LOCAL-CENTRE PROGRAMMES, 1986–87

Unless otherwise stated, members must obtain prior permission from the Local-Centre Secretary to bring guests.

Anglian Coastal Centre

19 November 1986:

Electronic Mail by K. H. C. Philips, Assistant Director, Mechanised Letter Research, The Post Office. Meeting will be held in LTB5, Essex University, Colchester, commencing at 14.00 hours.

3 December 1986:

Evening lecture by Lynda Chalker MP. Meeting will be held at the Estuary Club, 1386 London Road, Leigh on Sea, Essex, commencing at 19.00 hours. Buffet.

11 February 1987:

Computer Graphics by F. G. Cole, Head of Computer Graphics, Engineering Technical Support Services, British Telecom Inland Communications. Meeting will be held in LTB5, Essex University, Colchester, commencing at 14.00 hours.

11 March 1987:

Local Lines—The Way Ahead by I. G. Dufour, British Telecom Inland Communications. Meeting will be held in the Assembly Rooms, Norwich, commencing at 14.00 hours.

8 April 1987:

Taking Technology to the Market by Mr. M. Bett, Managing Director, British Telecom Inland Communications. Meeting will be held at the Guildhall, Cambridge, commencing at 14.00 hours.

20 May 1987:

Direct Broadcasting by Satellite by D. P. Leggat, Chief Engineer, External Relations, BBC. Meeting will be held in LTB5, Essex University, Colchester, commencing at 14.00 hours.

Bletchley Centre

Members will be advised of locations and times of meetings where they are not shown below.

26 November 1986:

BT's Role in Broadcasting by C. Dorkings.

14 January 1987:

The Changing Role of the Engineer in British Telecom by J. Young.

11 February 1987:

Myths and Legends in Software Engineering by C. Jackson.

8 April 1987:

Taking Technology to the Market by Mr. M. Bett, Managing Director, British Telecom Inland Communications. Meeting will be held at the Guildhall, Cambridge, commencing at 14.00 hours.

Central Midlands Centre

Unless otherwise stated, meetings will be held in UG35, Berkley House, Birmingham, commencing at 14.00 hours.

13 November 1987:

The Wireless Society—Does it Lack Moral Fibre?, by Dr. J. E. Thompson, Technology Applications Department, British Telecom Development and Procurement.

17 November 1987:

Cellular Radio by D. Edwards and P. Isaacs, Motorola Company. Meeting will be held at 18.30 hours, with tea served from 17.30 hours. Joint IEE/IBTE meeting.

4 December 1986:

Telcare by P. Faulkner, Telcare Management Group, British Telecom Inland Communications.

East Midlands Centre

Unless otherwise stated all meetings will commence at 14.00 hours.

12 November 1986:

AXE 10 by D. Colbeck, Thorn Ericsson. Meeting will be held at the Ex-Serviceman's Club, Peterborough.

10 December 1986:

The Technology of Weather Forecasting by A. Brown, Birmingham Airport Meterological Office. Meeting will be held at Leicester University.

14 January 1987:

Analogue to Digital—The East Midlands Districts's Position on Office and Technical Reform by J. Pemberton, Deputy District Manager, East Midlands District. Meeting will be held at Nottingham University.

11 February 1987:

Integrated Circuit Technology and Failure Causes by R. G. Taylor, British Telecom Materials and Components Centre, Birmingham. This will be an all-day visit to the Materials and Components Centre, with a factory tour in the morning and the lecture in the afternoon.

11 March 1987:

The East Midlands District in the Market-Place by P. D. Taylor, Director of Marketing, East Midlands District. Meeting will be held at Nottingham University.

29 April 1987:

Whatever Happened to the Candlestick? by Dr. I. S. Groves, Technology Applications Department, British Telecom Research and Development. Meeting will be held at Leicester University.

Liverpool Centre

Unless stated otherwise, meetings will be held at District Manager's Office, Imperial Buildings, Exchange Street East, Liverpool, commencing at 14.00 hours.

20 November 1986:

Derived Services Network by N. Jefferies, Planning and Works, British Telecom Inland Communications.

22 January 1987:

Direct Broadcasting by Satellite by D. P. Leggatt, Chief Engineer, External Relations, British Broadcasting Corporation.

19 February 1987:

Towards Zero Defects by H. Wilson, Quality Manager, IBM.

18 March 1987:

Regulation of Telecommunications by Professor B. V. Carsberg, Director General of Telecommunications, Office of Telecommunications. Meeting will be held at UMIST, Manchester, commencing at 14.00 hours.

30 April 1987:

The Future of the Local Exchange Network by Dr. C. Brown, General Manager, Network Planning and Digital Exchange, British Telecom Inland Communications.

London Centre

Guests of members and Associate Section members and their guests are welcome to attend. Except for the Annual Family Christmas Lecture, meetings will be held at the Assembly Rooms, 2nd Floor, Fleet Building, 40 Shoe Lane, London EC4A 3DD, and will commence at 17.00 hours with light refreshments being available from 16.30 hours. For security reasons, members and their guests must use the Shoe Lane entrance and be prepared to show a pass card.

11 November 1986:

Have we Got it Right?—The Reflections of a District General Manager by Paddy Doherty, District General Manager, North East District.

22 November 1986:

Annual Family Christmas Lecture *Talking With Nature* by Dr. David Bellamy. Meeting will be held at The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London WC2R 0BL, commencing at 15.00 hours. Admission by ticket only. Meeting is now fully subscribed.

21 January 1987:

High Speed Letter Sorting by Ronald Vick and Ken Willy, Research Engineers at The Post Office Research Centre, Swindon.

17 February 1987:

Corporate Strategy by Angus Walker, Director, British Telecom Corporate Strategy Department.

24 March 1987:

Optical Fibres in the Local Network by John Tippler, Director, Network, and Kevin Shergold, General Manager, Local Line Services, British Telecom Inland Communications.

23 April 1987:

An Inside View of Japan Inc. by Dr. Alec Livingstone, Corporate Information Technology Manager, British Telecom Corporate Services Department.

14 May 1987:

Computer Graphics by F. G. Cole, Head of Computer Graphics, Engineering Technical Support Services, British Telecom Inland Communications. This lecture will be preceeded by the Annual General Meeting of the IBTE Council, starting at 16.30 hours.

Manchester Centre

Meetings will be held in the Renolds Buildings, UMIST, Manchester, commencing at 14.00 hours.

26 November 1986:

Quality Circles by J. Pickup, Eaton Transmissions Ltd.

21 January 1987:

Post Office Packet Sorting Machines by R. Emsley, Post Office Research.

11 February 1987:

Dealing with BT's Major Customers by Dr. S. O'Hara, Director, Business Network Services, British Telecom Business Services.

18 March 1987:

Regulation of Telecommunications by Professor B. V. Carsberg, Director General of Telecommunications, Office of Telecommunications.

15 April 1987:

The Future of the Socket on the Wall: The I.420 Interface and Beyond by M. F. J. De Lapeyre, Technology Applications Department, British Telecom Development and Procurement.

Martlesham Heath Centre

Meetings will be held in the John Bray Lecture Theatre at the British Telecom Research Laboratories, Martlesham Heath, commencing at 14.00 hours.

11 November 1986:

Integrated Optics: Current Status and Future Proposals by Dr. R. C. Booth, and Dr. S. T. D. Ritchie, Research Department, British Telecom Development and Procurement.

3 December 1986:

Operational Communications for Electricity Supply by K. J. Coleman, Eastern Electricity.

15 January 1987:

Whatever Happened to the Candlestick? by Dr. I. S. Groves, Technology Applications Department, British Telecom Development and Procurement.

3 February 1987:

Electronic Technology in Cars. by M. H. Westbrook, Ford Motor Company.

25 February 1987:

EFTPOS: Paying a Bit at a Time by P. G. Marlow-Mann, Tallis Systems, British Telecom Business Services.

12 March 1987:

Data Encryption and Security by S. C. Serpell, Public Data Networks, British Telecom Business Services.

25 March 1987:

The Future of the Socket on the Wall: The I.420 Interface and Beyond by M. F. J. De Lapeyre, Technology Applications Department, British Telecom Development and Procurement.

8 April 1987:

Technology in the International Network by M. Read, Head of Special Engineering and Interconnect, British Telecom International.

Mid Anglia Centre

Unless otherwise stated, meetings will be held at the Mumford Theatre, Cambridge. All lectures commence at 14.00 hours.

12 November 1986:

AXE 10 by D. Colbeck, Marketing Manager, Local Exchange Systems, Thorn Ericsson. Meeting will be held at the Ex-Servicemen's Club, Peterborough.

3 December 1986:

The Technology of Weather Forecasting by A. Brown, Birmingham Airport Meteorological Office.

21 January 1987:

Inside View of Japan Inc. by Dr. A. W. Livingstone, Corporate Information Technology Manager.

25 February 1987:

The Wireless Society. Does it Lack Moral Fibre? by Dr. J. E. Thompson, Deputy Director, Technology Applications Department, British Telecom Development and Procurement.

18 March 1987:

Hardware Techniques for the 90s by Dr. B. A. Boxall, Head of Advanced Hardware Techniques Section.

8 April 1987:

Taking Technology to the Market by M. Bett, Managing Director, British Telecom Inland Communications. Meeting will be held at the Guildhall, Cambridge.

North and West Midlands Centre

Unless otherwise stated, all meetings will commence at 13.45 hours.

3 November 1986:

Information Technology by Dr. A. Livingstone, Head of Information Technology Division. Meeting will be held at the Staff Lounge Conference Room, British Telecom Technical College, Stone.

1 December 1986:

A Consultant's Travels by K. E. Stotesbury. Meeting will be held at the Staff Lounge Conference Room, British Telecom Technical College, Stone.

11 December 1986:

Cellular Radio by Mr. Burrows, Telecom Securicor Cellular Radio Ltd. Joint IEE, IERE and IBTE meeting. Meeting will be held at British Telecom Technical College, Stone. Lecture commences at 19.00 hours, refreshments 18.30 hours.

12 January 1987:

Future Trends in Telecommunications Transmission by Dr. P. Cochran, Technology Applications Department, British Telecom Development and Procurement. Meeting will be held at BBC Training Centre, Evesham, commencing at 19.30 hours. Joint IEE, IERE and IBTE meeting.

12 January 1987:

Computer Based Training Within the District by J. A. M. Smart, Training Resources Manager, British Telecom Technical College. Meeting will be held at the Conference Room, Telecom House, Hanley.

19 January 1987:

Computer Based Training Within the District by J. A. M. Smart. Meeting will be held at S & SC, Devon Road, West Park, Wolverhampton, commencing at 17.30 hours.

26 January 1987:

Computer Based Training Within the District by J. A. M. Smart. Meeting will be held at the Conference Room, Telecom House, Worcester.

9 February 1987:

Network Evolution by R. M. Culshaw, District Engineer, North and West Midlands District. Meeting will be held at the Staff Lounge Conference Room, British Telecom Technical College, Stone.

16 February 1987:

Network Evolution by R. M. Culshaw. Meeting will be held at S & SC, Devon Road, West Park, Wolverhampton.

9 March 1987:

Address by M. Bett, Managing Director, British Telecom Inland Communications. Meeting will be held at S & SC, Devon Road, West Park, Wolverhampton, commencing at 16.00 hours.

North Downs and Weald Centre

19 November 1986:

IT Convergence—The Communications Implications by Dr David Leakey, Chief Scientist, British Telecom. Meeting will be held at The Great Danes Hotel, Hollingbourne, Maidstone, commencing at 14.15 hours.

21 January 1987:

Our Experience Setting up CSS by Mr. L. Butterfield, Deputy District Manager, Thameswey District. Meeting will be held at The Great Danes Hotel, Hollingbourne, Maidstone, commencing at 14.15 hours.

18 February 1987:

The District Materials Centre, Aylesford by Mr. E. Bates, North Downs and Weald District

Northern Ireland Centre

Unless otherwise stated, meetings will be held at the YMCA Minor Hall, Belfast, commencing at 15.30 hours.

12 November 1986:

Interactive Video Network by Dr. J. R. Fox, Technology Applications Department, British Telecom Development and Procurement.

10 December 1986:

STC Products for Business and Home by T. Haynes, STC plc.

14 January 1987:

The Telephone Business by M. Bett, Managing Director, British Telecom Inland Communications. Meeting will be held at Church Hall, Rosemary Street, Belfast, commencing at 15.30 hours.

18 February 1987:
Marketing and BTNI by Mr. A. Thompson, District Marketing Manager, British Telecom Northern Ireland.

11 March 1987:

AXE 10 System Y by D. Colbeck, Thorn Ericsson Telecommunications Ltd., and R. Pine, British Telecom Inland Communications.

8 April 1987:

Tomorrow's External Plant by I. G. Morgan, Head of External Plant Division, British Telecom Inland Communications.

Severnside Centre

Unless otherwise stated, meetings will be held at Nova House, Bristol, commencing at 14.15 hours.

5 November 1986:

Satellite Communication by P. Moss, British Telecom International.

3 December 1986:

See Fibres in a New Light by T. H. Hand, Materials and Components Centre, British Telecom Development and Procurement.

4 February 1987:

The Future of the Local Network by Dr. C. A. Brown, General Manager Network Strategy and Digital Exchange, British Telecom Inland Communications.

4 March 1987:

Progress in Postal Engineering K. H. C. Phillips.

1 April 1987:

Severnside's Materials Warehouse—A Step into the Future. Meeting will be held at The Crest Hotel, Gloucester.

South Downs Centre

Meetings will be held in the Lecture Theatre, Central Library, Worthing, commencing at 14.00 hours.

18 November 1986:

Communications for Air Traffic Control at a Modern Airport by M. Sex, Civil Aviation Authority.

9 December 1986:

Accountants and Accounts—Do Engineers Need Them? by J. D. Habberfield, Finance Manager, South Downs District.

20 January 1987:

AXE 10—An Introduction by D. Colbeck, Thorn Ericsson Telecommunications Ltd.; and Network Strategy and Digital Exchange Department, British Telcom Inland Communications.

17 February 1987:

Electronic Funds Transfer at Point of Sale by B. Hingston, Business Network Services, British Telecom Business Services.

17 March 1987:

Marketing—The Missing Link by Mr. P. Benstead, Marketing Manager, South Downs District.

MEMBERS ABOUT TO RETIRE

Members about to retire are reminded that they may secure life membership of the Institution at a once-and-for-all cost of £10·00. Retired members may 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 on local activities.

ASSOCIATE SECTION REGIONAL CONTACT POINTS

The following is a list of Associate Section regional secretaries to whom enquiries about the Associate Section should be addressed.

Region	*Local Secretary*	*Telephone Number*
East	Mr. T. Turner	(0582) 573301 (evenings only)
London	Mr. P. Lendon	01–829 3180
Midlands	Mr. M. P. Melbourne	(0623) 650276
North East	Mr. K. Whalley	(0642) 327777
North West	Mr. R. Craig	(0772) 267236
Northern Ireland	Mr. S. Heraghty	(0504) 261029
Scotland	Mr. A. Johnstone	031–447 8490 Extn. 41
South East	Mr. R. P. Coveney	(0634) 45500
South West	Mr. J. R. Dymott	(0202) 522336
Wales North	Mr. M. L. Thomas	(0492) 632411
Wales South	Mr. H. P. Duggan	(0222) 379732

LOCAL-CENTRE SECRETARIES

The following is a list of Local-Centre Secretaries, to whom enquiries about the Institution should be addressed.

Centre	*Local Secretary*	*Address and Telephone Number*
Aberdeen	Mr. A. T. Mutch	British Telecom, D261, Caledonian House, 232 Union Street, Aberdeen AB9 2BB. Tel: (0224) 753343.
Anglian Coastal	Mr. T. W. Birdseye	Anglian Coastal District PD2.1.5, Telephone House, 45 Victoria Avenue, Southend-on-Sea, Essex SS2 6BA. Tel: (0702) 373723.
Bletchley/South Midlands	Mr. D. R. Norman	British Telcom, ES2.3.4, Telecom House, 25–27 St. Johns Street, Bedford MK42 0BA. Tel: (0234) 57829.
Central Midlands	Mr. G. R. Chattaway	British Telecom, BES5.5, Leofric TE, Little Park Street, Coventry CV1 2JY. Tel: (0203) 28396.
East Midlands	Mr. D. W. Sharman	British Telecom East District Training Office, PS1.7, 200 Charles Street, Leicester LE1 1BA. Tel: (0533) 534409.
London	Mr. L. J. Hobson	British Telecom, BSSU3.6, Room 344, Procter House, 100–110 High Holborn, London WC1V 6LD. Tel: 01–432 2940.
Liverpool	Mr. B. Stewart	British Telecom Liverpool District, CP43, Lancaster House, Old Hall Street, Liverpool L3 9PY. Tel: 051–229 4450.
Manchester	Mr. C. W. Jackson	British Telecom Manchester District, BS14, 5th Floor, Telephone House, 55 Portland Street, Manchester M60 1BA. Tel: 061–600 3333.
Martlesham Heath	Mr. G. Popple	British Telecom Research Laboratories, TA1.2.4, Martlesham Heath, Ipswich IP5 7RE. Tel: (0473) 643341.
Mid Anglia	Mr. W. G. Castle	BSE53, British Telecom District Office, Telephone House, Wentworth Street, Peterborough PE1 1BA. Tel: (0205) 67233.
North and West Midland	Mr. R. J. Piper	c/o Mr. M. N. B. Thompson, BT Technical College, Stone, Staffordshire ST1 0NL. Tel: (0785) 813483.
North East	Mr. P. L. Barrett	British Telecom North East, EP38, Swan House, 157 Pilgrim Street, Newcastle-Upon-Tyne NE1 1BA. Tel: (0632) 328304.
North Downs and Weald	Mr. K. T. Bartlett	OM3, ATE, Best Street, Chatham, Kent ME4 4AB. Tel: (0634) 43372.
North Wales and the Marches	Mr. P. D. Jones	E3, Telephone House, Smithfield Road, Shrewsbury SY1 1BA. Tel: (0743) 69807.
Northern Ireland	Mr. B. Hume	EI4, Churchill House, 20 Victoria Square, Belfast BT1 4BA. Tel: (0232) 227152.
Preston	Mr. A. J. Oxley	British Telecom National Networks/TSP3/NW1.2.6., 10th Floor, Guild Centre, Lords Walk, Preston PR1 1RA. Tel: (0772) 22599.
Scotland East	Mr. T. L. McMillan	British Telecom East of Scotland District, NC35, Canning House, 19 Canning Street, Edinburgh EH3 8TH. Tel: 031–229 3296.
Severnside	Mr. P. C. James	British Telecom, ED2, St. Clements House, Marsh Street, Bristol BS1 4AY. Tel: (0272) 296281.
Solent	Mr. G. R. F. Nunes	BE57, Solent District Office, 70–75 High Street, Southampton SO9 1BB. Tel: (0703) 734257.
South Downs	Mr. C. J. Mayhew	British Telecom South Downs District Office, ED7.1.1, Grenville House, 52 Churchill Square, Brighton, BN1 2ER. Tel: (0273) 201598.
South Wales	Mr. D. A. Randles	British Telecom South Wales District, EP1, 25 Pendwyallt Road, Cardiff CF4 7YR. Tel: (0222) 379622.
Thameswey	Mr. R. D. Hooker	Thameswey District Head Office, DE 4.4, Telecom House, 49 Friar Street, Reading, Berks RG1 1BA. Tel: (0734) 501754.
West of Scotland	Mr. L. M. Shand	British Telecom National Networks/TSO/S2.1.6, Dial House, Bishop Street, Glasgow G3 8UE. Tel: 041–221 1585.
Westward	Mr. C. S. Gould	British Telecom, NS3, Exbridge House, Commercial Road, Exeter EX2 4BB. Tel: (0392) 221671.
Yorkshire and Lincolnshire	Mr. R. S. Kirby	British Telecom North, TE1.1.3, Netel House, 6 Grace Street, Leeds LS1 1EA. Tel: (0532) 466366.

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

APPLICATION FOR FULL MEMBERSHIP

The object of the Institution of British Telecommunications Engineers is to advance the electrical and telecommunications sciences and their application, and facilitate the exchange of information on these and allied subjects.

ELIGIBILITY There are two classes of Corporate Membership (full definitions are given in Rules 5 and 6):

Member British Telecom (BT) staff in the Management and Professional Structure (M & PS), and senior management grades, who are or have been directly involved in the engineering, or scientific or technical work of BT, and equivalent Post Office (PO) staff.

Affiliated Member BT staff in the M & PS of Band A and above whose work is associated with that of Members, and equivalent PO staff.

Other engineering staff in BT and the PO may be eligible to join the Associate Section. Further details of the Associate Section can be obtained from local contact points (see p. 251 of the October 1986 issue of the *Journal*.)

MEETINGS keep Members informed on technical and related aspects of the work of BT and the PO and offer the opportunity for discussion. Details are given in the Centre programme. Members are entitled to claim official travel expenses from their headquarters to the meetings. Copies of papers read at the meetings are published locally and in selected instances nationally.

JOURNAL Each Member is supplied with a free copy of the quarterly *British Telecommunications Engineering*, a technical publication which is highly regarded worldwide by postal and telecommunications engineers. The *Journal* is sent to Members' home addresses.

VISITS are arranged to (BT/PO) installations and to outside businesses and other concerns of interest to Members.

LIBRARY The Institution's lending library comprises 2000 books on scientific, technical and administrative subjects which can be borrowed free of charge via the official post. Books can be loaned for a maximum period of three months unless wanted earlier by another Member; the simultaneous loan of two or more books is permitted at the Librarian's discretion.

SUBSCRIPTION The annual subscription, payable from 1 April each year, is £4·92. The preferred method of collection is by monthly deduction from salary, for which both parts of the form printed below must be completed. Subscriptions are allowable against Income Tax — quote reference CI/SUB/459.

THE FEDERATION OF TELECOMMUNICATIONS ENGINEERS OF THE EUROPEAN COMMUNITY (FITCE) Membership of FITCE is open to IBTE Members who have a University Science degree or are Chartered Engineers. Please tick the appropriate box on the form for details.

APPLICATION FORM

To: IBTE Administration Manager,
Room 107, Intel House,
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Please enrol me as a Member/Affiliated Member* and forward to my pay point the signed authorisation for deduction of the subscription from my BT/PO* salary.

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I, ... (name in full, surname first in block capitals), authorise my BT/PO* pay point to deduct from my salary, until further notice, the sum of £0·41 per month in respect of my subscription to the Institution of British Telecommunications Engineers (IBTE). Any deduction currently being made for payment to the IBTE, IBTE Associate Section (ABTE) or to the *British Telecommunications Engineering Journal* (BTEJ) should be ceased.

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Duty reference and official address ....

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Rank .... Pay No. ....

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Your Pay Number and Pay Group Reference are printed on your salary slip

Notes and Comments

CORRESPONDENCE

Nesco Investments Ltd.,
London.

Dear Sir,

I write to let you know, as an ex-patriate working overseas in Nigeria, how much I enjoy your *Journal*. I am not a communication engineer, but concerned with public utility on the distribution and generation aspects, although after 40 years in this business, one picks up a lot outside one's own field.

Perhaps your technical staff could enlighten me on one point.

Frequently, I am in telephone contact with the UK from my office in Jos, Nigeria. The link up is via microwave circuit from Jos Nigerian telephone authority to Kaduna Satellite Earth Station and thence presumably to Goonhilly or Madely in the UK followed by the usual British Telecom network.

Often there is an echo of my transmitted voice received back in my telephone earpiece and, I am wondering whether you could provide a simple explanation.

Yours faithfully,
A. J. Twitchett

Readers may be interested in the following reply from Mr. F. A. Franks, who is Head of Transmission Network and Equipment Standards Group, British Telecom International.

Dear Mr. Twitchett,

Thank you for your letter enquiring about the reason for an echo of your tranmitted voice being received during certain of your telephone calls. The reason for this is as follows.

As you know, your telephone connection starts off as a two-wire circuit and at the final destination is also two-wire. In between, in order to provide for amplification of both the sent and received information, it is split into a four-wire circuit through something called a *hybrid transformer*. The design of this is intended to ensure that there is no coupling between the go and return paths but this does not always happen exactly because of a variety of factors. Whilst we commonly think that communication is instantaneous, it can never be faster than the speed of light even in free space, and the speed of propagation of a telephone call is somewhat less and dependent exactly on the medium employed. Given that it is finite, then it is possible for you to hear the affect of coupling across the hybrid transformer from the destination point of your call and displaced in time by the round-trip delay time. Whilst this would not be noticeable on short-distance calls, those which are transmitted by satellite can by no means be regarded as short distance! The geostationary orbit is some 36 000 km above the earth and this results in a delay time of approximately 0·3 s. By the time this is reflected back again over the satellite path, your voice becomes displaced by about 0·6 s.

This can be quite troublesome to most users of the telephone service, and echo suppressors or echo cancellors are employed which are intended to eliminate this unwanted echo being returned to the sender. It is only when these malfunction that the sort of problem occurs that you refer to.

Yours faithfully,
F. A. Franks

PUBLICATION OF CORRESPONDENCE

A regular correspondence column would make a lively and interesting feature in the *Journal*. Readers are therefore invited to write to the editors on any engineering, technical or other aspects of articles published in the *Journal*, or on related topics. Letters of sufficient interest will be published under 'Notes and Comments'. Letters intended for publication should be sent to the Managing Editor at the address given below.

APOLOGY

The editors apologise for the quality of reproduction of the map on pages 70 and 71 of the July 1986 issue of the *Journal*.

SUBSCRIPTIONS FOR USA AND CANADIAN CUSTOMERS

Customers in the USA and Canada should pay for subscriptions to the *Journal* by sterling drafts drawn on London for £7·00 for a year's subscription. Payment by cheques drawn in US or Canadian dollars will be accepted at the price of $18·00 to cover bank charges.

DISTRIBUTION OF THE JOURNAL

Many IBTE Members and other employees of British Telecom and the Post Office who subscribe to the Journal by deductions from pay have still not yet supplied their home addresses to the IBTE Administration Office so that copies of the *Journal* can be sent directly to their homes. Back issues of the *Journal* since October 1985, when this new method of distribution was started, are being held in store for these Members and readers until this information is received. Members and readers are asked to remind their colleagues to supply this information as soon as possible if they have not already done so; a form for this purpose was included with the April 1985 issue of the *Journal*. These Members and readers will then be sent the back issues and all future issues to their home address. Any enquires about this notice should be directed to The IBTE Administration Manager, Room 107 Intel House, 24 Southwark Bridge Road, London SE1 9HJ; Telephone: 01–928 8686 Extn. 2233.

CONTRIBUTIONS TO THE JOURNAL

Contributions of articles to *British Telecommunications Engineering* are always welcome. Anyone who feels that he or she could contribute an article (either 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.

Educational Papers

The Editors would like to hear from anyone who feels that they could contribute further papers in the series of educational papers published in the *Supplement* (for example, see the paper entitled *Digital Multiplexing*, included with the April 1986 issue of the *Supplement)*. Papers could be revisions of British Telecom's series of *Educational Pamphlets* or, indeed, they could be completely new papers. It is intended that they would deal with telecommunications-related topics at a more basic level than would normally be covered by articles in the *Journal*. They would deal with, for example, established systems and technologies, and would therefore be of particular interest to newcomers to the telecommunications field, and would be useful as a source for revision and reference and for those researching new topics.

Intending authors should write to the Deputy Managing Editor, at the address given below, giving a brief synopsis of the material that they would like to prepare. An honorarium would be offered for suitable papers.

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 the uniformity of presentation, simplify the work of the *Journal's* editors, printers 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 six pages, although shorter articles are welcome. Contributions should preferably be illustrated with 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 slides can be accepted for black-and-white reproduction. Negatives are not required.

It is important that approval for publication is given at organisational level 5, and authors should seek approval, through supervising officers if appropriate, before submitting manuscripts.

EDITORIAL OFFICE

All correspondence relating to editorial matters ('letters to the editor', submissions of articles and educational papers, requests for authors' notes etc.) should be sent to the Managing Editor or Deputy Managing Editor, as appropriate, at the following address: *British Telecommunications Engineering*, Room 107, Intel House, 24 Southwark Bridge Road, London SE1 9HJ. (Telephone: 01–928 8686 Extn. 2233.)

Forthcoming Conferences

Further details can be obtained from the conferences department of the organising body.

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

The History of Television—From Early Days to the Present. 13–15 November 1986. London.

Antennas and Propagation. 'A Hundred Years of Antennas and Propagation.' 30 March–2 April 1987. University of York.

UK Telecommunications Networks—Present and Future. 2–4 June 1987. London.

Online, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE. Telephone: 01–868 4466.

Cellular Communications. 11–13 November 1986. Hyatt, San Francisco.

Paging Systems. 12–13 November 1986. Hyatt, San Francisco.

Computers in the City. 18–20 November 1986. The Barbican Centre, London.

Localnet '86. 18–20 November 1986. Moscone, San Francisco.

The International ISDN Conference. 18–20 November 1986. Moscone, San Francisco.

The International Open Systems Conference. 18–20 November 1986. Moscone, San Francisco.

Satellites Communications. 2–4 December 1986. Tara Hotel, London.

Videotex International. 9–11 December 1986. Wembley Conference Centre, London.

Business Telecom '87. Exhibition. 3–5 March 1987. The Barbican Centre, London.

Telecommunications and the UK Business User—The Next Four Years. 24 November 1986. The Cavendish Conference Centre, London. This conference considers the major factors influencing the UK telecommunications environment between now and 1990 and what this means for the telecommunications user. Politicians, heads of the two UK network providers, OFTEL, industry leaders, industry watchers and a leading consultant have agreed to speak or provide speakers to address a range of issues. Finally, TUA Chairman, Bill Mieran, will present the users' view on what has been said and will set out the direction the TUA would like the Government and the industry to follow towards 1990. Details and reservations: Liz Goodwin, TUA, c/o Quadrilcct, 46 Gray's Inn Road, London WC1X 8PP.

4th European Conference on Integrated Optics. 11–13 May 1987. Hospitality Inn, Glasgow. Papers covering new and previously unpublished work on all technical aspects of integrated optics are invited, including: fundamentals of integrated optics, hybrid integrated optics, monolithic integrated optics and applications of integrated optics. Deadline for abstracts and summaries of papers: 9 January 1987. Further details from: ECIO 87 Secretariat, CEP Consultants Ltd., 26 Albany Street, Edinburgh EH1 3QH.

1987 International Microwave Symposium/Brazil. 27–30 July 1987. Rio Palace Hotel, Rio de Janeiro, Brazil. Papers describing original work on the following topics are invited: antennas and arrays; microwave radio propagation and radiometeorology; terrestrial and satellite communication systems; microwave active/passive devices and components; millimetre wave components, circuits and systems; microwave techniques in radar, ECM, remote sensing and radio-astronomy; microwave measurements; CAD/CAM; scientific, biological, medical and industrial applications of microwaves; optical communications; and field and network theory. The deadline for the receipt of papers is 31 December 1986. Details from: Prof. Álvaro Augusto de Salles, CETUC-PUC/RJ, Rua Marquês de São Vicente 225, Gávea, CEP 22453, Rio de Janeiro, Brasil. Telex: 2131048.

European Conference on Speech Technology. 2–4 September 1987. Edinburgh University. Papers are invited within the outlined themes of the conference. The themes of 'Speech Technologies' and 'Applications Areas' will explore advancements in computer communications, with topical areas of discussion including automatic speech recognition and understanding, automatic text-to-speech synthesis, and machinery translation and ergonomics. Abstracts by 9 January 1987. In association with the conference, there will also be an exhibition of the latest equipment. Further details from: Technical Media Services Ltd., 62 Kelvingrove Street, Glasgow G3 7SA. Telephone: 041-332 6636.

Forum 87. Fifth World Telecommunication Forum, Part 2, Technical Symposium. 22–27 October 1987. Geneva. Details from: Forum 87 Secretariat, International Telecommunication Union, CH11211 Geneva 20. Tel: +41 22 995190.

British Telecom Press Notices

New London Exchange Leads National Speed-Up for System X

On August 29, more than 3500 customers' telephone lines were switched to a new British Telecom (BT) digital System X exchange in Wood Street, in the City of London; Wood Street became the 71st System X local exchange to open. This key development is part of a modernisation programme that will see, on average, one new digital exchange entering service every working day.

At the opening of London's new Wood Street exchange, in the heart of the City's business and financial community, Mr. Iain Vallance, now BT's Chief Executive, said: 'We can truly say that our digital conversion programme has now taken off'.

He continued: 'This month we shall see a five-fold increase in the number of System X exchanges entering service. By next March, we will have provided over one million digital connections for our customers.

'We now have an average of one new digital exchange scheduled to enter service every working day. Moreover, this pace will be maintained for several years, with half of our customers on modern digital exchanges by the end of the decade.

'Our programme runs to 2·5 million digital lines a year, now all purchased on a competitive basis. Despite delayed deliveries, our engineers are pulling out all the stops to maintain the installation schedule.'

Mr. Vallance added that modernisation of the trunk network was also on course, with 45 of the 55 main digital switching centres already in service. They should all be operational by the autumn of next year.

Rural communities also benefit from digital modernisation. Nearly 200 smaller UXD5 exchanges, offering customers in villages and small towns the facilities similar to those of the larger System X units, are already in service, with a further 300 either being installed or on order.

Contract for 'Big Bang' Technology

A £5M contract was signed earlier this year by British Telecom (BT) and Shearson Lehman Brothers International for a comprehensive telecommunications package for Shearson Lehman's new offices in the Broadgate development in the City of London.

The contract was for the supply of three Mitel SX 2000 PABXs, a major dealing system centred on BT's Key Business System, and internal cabling for the 501 position system, which is expected to be expanded to 620 positions by 1990.

This contract is the largest of the 80 contracts concluded by BT since the beginning of 1986 with companies preparing for the deregulation of the London Stock Exchange, known as the *Big Bang*, which begins in October 1986.

Shearson Lehman Brothers International is a major trading house in equities, foreign exchange and commodities, and has 340 offices world-wide. The company is spending more than $10M in workstations alone for its London trading floor, which is expected to be the largest outside the USA.

The senior management of BT is pleased at BT's success in obtaining this contract against strong competition. It was anticipated that the Big Bang would mean a doubling of orders for these systems; in fact, the latest figures have shown a five-fold increase in demand. To meet these new orders for dealing systems and large private switchboards, which are running at more than £10M a month, BT's City District has had to call in extra teams of engineers from other parts of the company to meet the deadlines. As a result, 20 major projects were completed in June of this year—four times above the level for June 1985. The supply of private circuits is also running 65% higher than last year, and that for exchange lines is 39% higher.

BT is offering Shearson Leham not only the hardware and software systems, but also the corporate talent and commitment to back them, to provide the company with the essential communications support which business will require as the City's dealing environment evolves.

Preparation for Big Bang in the City has created an unprecedented demand for specialist equipment and private circuits. Companies are dependent more than ever on fast communications for accurate prices and share dealing information with almost instant detailed audit information to assess performance and profitability of companies in the market-place.

The City's financial dealers need to transfer information rapidly between dealer outlets, offices, business contacts and customers. With its unrivalled experience in merging telephony and computer technology, BT is making all this possible. Most of the contracts now completed by BT involve the interconnection of a complex range of services—PABXs, dealing systems, private circuits, data communications, facsimile and Telex.

Two dealer-board systems from BT—the City Business System and the Key Business System—have been designed to meet the needs of City dealers.

BT launched the City Business System in 1982. The 'touch-screen' communications system, the first of its kind in the world, features a television screen that doubles as a data display and touch keyboard. Telephone calls can be set up by touching the screen.

The City Business System provides at each dealer position two telephone handsets and a visual display unit that can be recessed into a desk or console. This terminal can be used by dealers for consulting company information, and for sending and receiving Telex messages. The built-in telephone provides dedicated lines to link dealers to other dealers, to customers and bankers, besides enabling normal telephone calls to be made. Colour and flat-screen versions of the system are just becoming available.

Users sit at a console in front of the screen of the system and, by touching squares on the display, can make external or internal telephone calls, hold and release them and designate a line as PRIVATE for confidential or security reasons. The top half of the screen can display computer information, which can be updated and edited with the aid of an optional separate typewriter-style keyboard. A major development project to help customers integrate the City Business System with their in-house computer systems is underway.

A significant advantage which the system has over any previous design is its flexibility. Alterations are made electronically; for example, if a telephone circuit is reallocated to a different desk, no new wiring or re-labelling of switches is required.

The Key Business System, a key-based version of the City Business System, is available for customers who find its rapid pre-programmed keys more suited to their needs and who do not require the data integration that is possible via the City Business System.

Dealerinterlink, a network for on-demand interconnection of private circuits, was opened in April this year, and already has about 3000 circuits.

Dealerinterlink enables private circuits, heavily used in the City, to provide fast trading links between two points, to be established within 24 hours. It gives organisations a flexible system around which to arrange their, as yet unpredictable, trading routes. Dealerinterlink is based at BT's Moorgate exchange. Each user rents a block of 30 links, which can be used for voice or low-speed data, and has the option of additional circuits in blocks of ten.

New Cost-Saving World Record for British Telecom in Optical-Fibre Links

A new technical achievement revealed by British Telecom (BT) is that of sending pulses of laser light along long-distance optical fibre both ways at once, and this will help the company keep down the cost of long-distance calls.

BT is the first operating company in the world to accomplish this feat in a commercial cable installed as part of its public network. This break-through by BT Research Laboratories (BTRL) demonstrates conclusively that just one fibre is sufficient to carry telephone calls instead of the pair of fibres used at present, one for each direction.

This promises substantial savings for BT in providing and installing its growing optical communications network. The sending of light both ways at once in fibre not only cuts the cost of new optical systems but also allows the capacity of existing links to be increased quickly and cheaply without the need to invest in the laying of extra cables. Because each direction of transmission may operate at a similar or identical wavelength, the network could be upgraded by using established equipment.

Engineers from BTRL at Martlesham Heath established simultaneous both-way (or duplex) transmission over a 77 km optical-fibre system between Birmingham and Derby. The link had previously featured in 1985 in other record-breaking achievements. The link was one of the first in Britain to support higher-capacity optical transmission at 565 Mbit/s—four times the rate currently being used for long-distance systems and equivalent to nearly 8000 telephone calls at once. It has only one intermediate light regenerator and includes a record-breaking span of 45 km. Part of the link was also used to demonstrate transmission at 16 times the present rate at 2 Gbit/s—equivalent to more than 30 000 simultaneous calls.

Duplex transmission in a single fibre is accomplished by splicing an optical directional coupler to each end. The coupler consists of a short length of two adjacent fibres which have been fused together by heating. The fusing is precisely controlled so that the outer cladding glass of each fibre merges with the other, while the two cores, in which the light ray travels, remain separate. This allows a proportion of the light in one core to transfer to the other, the amount being determined by the dimensions of the fused section. Light in the 'go' direction is transferred from one core to the other without interfering with light in the 'return' direction in the second core.

BTRL has pioneered the development of these directional optical couplers. They will be manufactured and marketed commercially by BT&D Technologies. the new opto-electronics component company jointly owned by BT and Du Pont.

British Telecom Opens Advanced International Packet-Switching Gateway

A £3·7M exchange handling computer data has been opened in London to meet the demand for international information technology services that have doubled annually throughout this decade.

This new international gateway is the second to be brought into use by British Telecom International (BTI) for its international packet-switched service (IPSS). It provides greatly increased call-handling capacity and additional customer and network facilities to provide industry and commerce with fast, reliable and economical data communications. IPSS now operates with 50 countries, and offers access to and from 73 different packet-switched data networks.

The opening of this new gateway reaffirms BT's commitment to enhancing IPSS to keep ahead of rapidly accelerating demand. Since BT opened the original service to the USA in 1978, calls have increased between 50% and 100% each year. This new gateway will enable BT to meet future growth and cater for customers' growing requirements.

The new gateway uses the DPS 1500 packet switch developed and manufactured by Bell Telephone Manufacturing Company, Antwerp, and delivered and installed by STC Telecommunications. Because of its modularity, the DPS 1500 switch is highly reliable. Failures of individual modules, or components, have comparatively little effect on the call-carrying capacity of the switch as a whole. This is of particular importance for international calls.

The commissioning of this international gateway underlines BT's continuing support for developing standards for Open Systems Interconnection.

More Village Exchanges Ordered

More than 160 villages throughout the UK are scheduled to have high-technology digital-electronic telephone exchanges installed because of an order worth approximately £7M placed by BT in July of this year.

These exchanges, known as *UXD5*, harness the power of digital micro-electronics and computer technology to provide advanced cost-effective communications facilities to groups of up to 300 or 600 customers.

The new order, placed with GEC Telecommunications for deliveries in 1987–89, brings the total of UXD5 exchanges ordered by BT to nearly 600, at a total cost approaching £40M. Already 170 are in operation, serving approximately 28 000 customers; a further 170 should be coming into service this autumn.

This demonstrates BT's continuing commitment to provide rural communities with modern telephone services. Eventually, 120 000 lines of UXD5 will be in service in Scotland, Wales and the remoter parts of England.

The design of the exchange stems from BT's research and development. It gives villages many of the up-to-date telephone facilities that BT is providing in urban areas on its large System X and AXE10 electronic exchanges. Exchanges providing these facilities, such as short-code calling, three-way calls, and automatic diversion of calls to another number, are normally most cost-effective in sizes suitable for large communities.

BT's UXD5, which has been specifically designed for rural use, provides these facilities at no greater relative operating cost than that of providing them on a large scale. The UXD5 design has other advantages, both for BT and telephone users:

(*a*) it can be introduced with the minimum of alteration to the existing network;

(*b*) it is compatible with the evolving all-digital network that BT is introducing under its £1 billion a year modernisation programme; and

(*c*) it reduces maintenance costs and gives a superior quality of service compared with the ageing equipment that it is replacing.

Out of a total of 6260 local exchanges, BT has more than 1600 serving fewer than 600 customers. All but a handful of these are automatic electromechanical systems developed before the war for rural applications and now approaching the end of their useful lives. Although the number of small exchanges is being reduced to achieve operating economies, BT estimates that there will still be more than 1500 of 600 lines or less by 1998, serving a total of 500 000 customers. The UXD5 exchange has much in common with the Monarch digital call-connect system for businesses. Both systems are made in Britain by GEC and Plessey, which are exporting UXD5 exchanges to Malawi, Kenya, the Solomon Islands, and Kiribati.

British Telecom to Automate Social Security Offices

Under a government contract announced this summer, British Telecom (BT) is to provide equipment and services to allow the Department of Health and Social Security's (DHSS's) 500 local social security offices, and its central offices at Newcastle-upon-Tyne and North Fylde, to access the various benefit systems being developed under the department's Operational Strategy. This will permit the streamlining of DHSS service to claimants.

The contract, won in the face of strong competition, was announced by the Rt. Hon. Norman Fowler, MP, Secretary of State for Social Services, in a written Parliamentary answer. The project will form part of the plan for the DHSS to implement its 'whole person concept'. This will eventually enable any claimant to discuss and obtain benefits and entitlements from any social security local office or unemployment benefit office in Britain.

Under the contract, BT will provide a complete fully-integrated terminal system, known as the *DHSS Strategy Terminal System* (STS). This will potentially include the supply of up to 1000 minicomputers and 28 000 terminals under a 7-year installation programme. It will also involve extensive software design, implementation, and support for the project into the next century. The first installation, for accessing the retirement pension system at Newcastle, is due to be brought into regular use by the end of this year.

BT fought off strong challenges in open competition to win this contract with all-British equipment and software, and it demonstrates that BT is making the UK a front runner in information technology.

BT, in collaboration with its three subcontractors, was able to offer equipment and services at the right price, to meet the DHSS specification, and installed under demanding deadlines, with long-term technical and maintenance support. BT has been able to marshal its extensive system and network management skills to provide the DHSS with the comprehensive central management it requires for STS. Moreover, BT's equipment conforms to the Department's general requirement that its network and attachments comply with internationally agreed standards and protocols for Open Systems Interconnection.

BT's three subcontractors, and the equipment they will provide, are as follows:

(*a*) Information Technology Ltd. will provide machines adapted to BT's design from its Momentum 9000 family of 32 bit minicomputers, each able to support more than 100 terminals simultaneously;

(*b*) Newbury Data Recording will supply a visual display unit to BT's design, plus three designs of printer; and

(*c*) Real Time Developments will supply a flexible local area network based on standard telephone cable to connect the terminals and printers to the minicomputers.

These components, combined with BT's skills at systems development, form the basis of a fully integrated terminal system providing access to a full OSI network. This system will be offered by BT as a new product range, designated the *M7000 series*.

STS, one of Britain's largest and most ambitious networked terminal systems, is designed to equip each social security local office to meet all its terminal needs, for the whole of the Operational Strategy, providing access over a nationwide data network to the various main-frame computer centres round the country which process benefit claims and enquiries.

British Telecom to Trial Centrex Service Next Year

Centrex, the telecommunications service which provides customers with the facilities of a modern electronic switchboard from a public telephone exchange, is to be introduced by British Telecom (BT) in the City of London next year. A trial of Centrex will be run on a digital-electronic exchange to be supplied by AT&T and Philips Telecommunications.

BT's contacts with business customers have shown that there is increasing demand for Centrex services. These customers would like to take advantage of the advanced facilities of modern PABXs without having to plan, purchase, accommodate and install their own equipment. The trial will enable BT to gauge customer demand more precisely and to determine how best it can be satisfied. The number and range of companies to take part is intended to be as fully representative of the business community as possible.

Centrex increases the range of choice open to customers, for sites of all sizes. It provides features normally found only on large PABXs; at the same time, it frees the customer from the need for a large capital outlay. Centrex can also enable some or all of the customer's responsibilities for system planning and management to be handled by BT if the customer wishes. The size and features of the individual installation can be increased as the company grows. The trial will be mounted on a 10 000-line 5ESS telephone exchange.

In addition to their automatic PBX facilities, customers in the trial can nominate a particular extension on their own premises to be the operator's position. Alternatively, the same facility can be provided by BT from one of its own operator services centres. Initially, extensions will offer only telephone service, but integrated digital access (IDA) may be available later. This will enable customers to use multi-purpose data terminals as well as telephones on their extensions.

Each extension will offer a range of modern PABX-type facilities:

(*a*) line hunting, seeking out the next available free extension in a group;

(*b*) abbreviated dialling, setting up calls in response to a short code of one, two or three digits;

(*c*) three-way calls, for dial-your-own conferences;

(*d*) call forwarding, to ensure that calls to unattended extensions are answered elsewhere;

(*e*) automatic call-back, to get through to a busy extension when it becomes free;

(*f*) call hold, transfer and pick-up;

(*g*) interworking with PABXs already being used by the customer; and

(*h*) direct dialling-in to individual extensions.

Centrex facilities are not limited to customers on a single site. They can be provided to a multiplicity of sites, whether they are located within the catchment area of the exchange or more widely dispersed. Customers will also be able to control moves and changes to individual extensions, and communications managers will be given details of extension messages.

BT's decision to purchase a 5ESS exchange for the Centrex trial brings to ten the number of such switches to be supplied to the company. The original order of nine exchanges will be deployed to meet the growing demand for BT's LinkLine services and support a range of enhancements to those services. A 5ESS exchange was chosen after competitive tendering. It is a system used in North America, where Centrex has been available in a simple form for nearly 20 years. The trial exchange will use hardware and software identical to that being supplied in North America but will be subject to the adaptive engineering necessary for it to provide standard UK customer interfaces and and be integrated into BT's network.

Currently, no switching system developed in Europe can offer proven Centrex facilities. However, BT has now specified the provision of Centrex services in System X and AXE10 switches to be used in its network.

BACK NUMBERS

The price of back numbers of the *Journal* is £1.75 each (75p to staff of British Telecom and the British Post Office), including the *Supplement* and postage and packaging. (The *Supplement* is not sold separately.) Back issues can be ordered by using the form printed below.

Details of the question/answer material and educational papers published in back issues of the *Supplement* are shown below. For each subject, a list of back issues in which that subject appeared is given. Please note that each issue of the *Supplement* contains several subjects. Take care not to order a particular issue twice.

BTEC UNITS

(Question and answer material based on BTEC syllabi)

Digital Techniques II	Apr. 1983, Apr. 1984, Apr. 1985, July 1986
Digital Techniques A III	Oct. 1983, July 1984, Oct. 1985
Electrical and Electronic Principles II	July 1983, Apr. 1984, Oct. 1985
Electrical and Electronic Principles III	Oct. 1983, Oct. 1984, Jan. 1986
Electrical Principles II	Jan. 1980, Jan. 1981, July 1982
Electronics II	Oct. 1980
Electronics III	July 1983, Apr. 1984, July 1985
Line and Customer Apparatus I	Jan. 1979, July 1981, Apr. 1982, Apr. 1983, Apr. 1984
Lines II	Apr. 1981, Oct. 1982, Apr. 1984, Apr. 1985, Apr. 1986
Lines III	July 1983, Apr. 1986
Mathematics I	Jan. 1979, Apr. 1980
Mathematics II	Apr. 1980, Apr. 1982, July 1983, Apr. 1984, July 1985, Apr. 1986
Micro-Electronic Systems I	July 1983, Apr. 1984, Apr. 1985
Micro-Electronic Systems II	Oct. 1983, July 1984, July 1985
Physical Science I	Jan. 1979, Jan. 1980, July 1981
Radio II	Jan. 1983, Jan. 1984, Apr. 1985
Radio III	July 1986
Telecommunications Systems I	July 1981, July 1982, July 1983, Jan. 1984, Jan. 1985, July 1986
Telephone Switching Systems II	Jan. 1980, Oct. 1982, Oct. 1983, July 1984, Oct. 1985
Telephone Switching Systems III	Jan. 1983, Oct. 1984, Apr. 1986
Transmission Systems II	July 1980, Jan. 1982, Jan. 1983, Jan. 1984, Jan. 1985, Jan. 1986
Transmission Systems III	Apr. 1983, Oct. 1985

SCOTEC SUBJECTS

(Question and answer material based on SCOTEC syllabi and answers to examination papers set by SCOTEC)

Introduction to Telecommunications Systems	Jan. 1979, Apr. 1982*
Digital Techniques and Transmission	July 1982*, Jan. 1984*
Electrical and Engineering Principles	Jan. 1979
Electrical Principles II	Jan. 1983
Electrical Principles III	July 1982*, July 1983*, July 1984*
Electronics III	Oct. 1982*
Mathematics I/II	Jan. 1979
Mathematics III	July 1982*, Apr. 1983*
Mathematics IV	Oct. 1984*
Radio III	Oct. 1982*, Jan. 1984*
Switching Systems III	Apr. 1982*, July 1983*
Telecommunications Transmission Systems V	July 1984*
Transmission Systems III	Oct. 1984*

*Answers to examination papers set by SCOTEC

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(Answers to examination papers set by CGLI. Year of paper shown in brackets)

Circuit Theory T4	Apr. 1986 (1985)
Electrical Principles T3	Oct. 1986 (1985)
Electronics T3	Oct. 1986 (1985)
Switching T4 Option	Jan. 1986 (1985)
Switching T5 Option	Apr. 1986 (1985)
Transmission T4 Option	July 1986 (1985)

EDUCATIONAL PAPERS PUBLISHED IN THE SUPPLEMENT

Field-Effect Transistors	Oct. 1982
Microcomputer Systems (Part 1)	Oct. 1984
Microcomputer Systems (Part 2)	Jan. 1985
Digital Multiplexing	Apr. 1986

The January and April 1982, and the January and April 1985 back issues are no longer available, but photocopies of the Supplements can be supplied for the same price.

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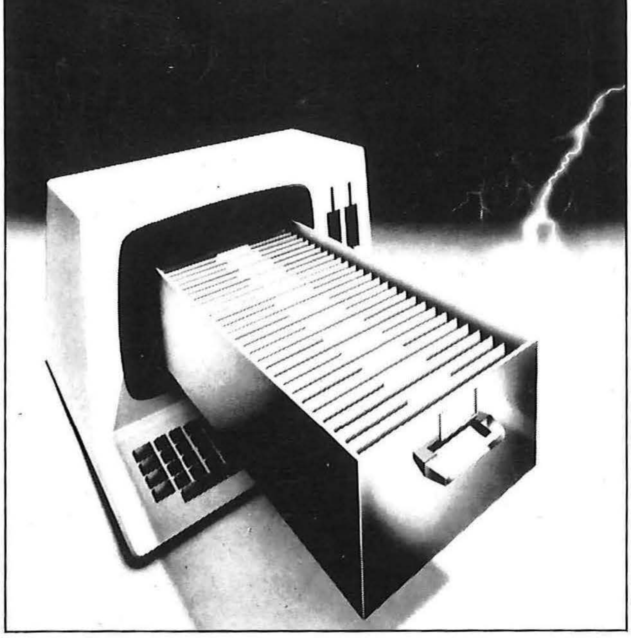

Superfile is a mature, British, multi-user, multi-file, free-form database manager for micros. It allows large text fields and gives automatic keyword extraction. It's extremely fast: a search on 20,000 Records takes a couple of seconds. British Telecom and MoD use Superfile: they do not have to settle for second best. It runs on MS-DOS and many networks, MCCP/M, and Xenix. Superfile can be ported to VAX or IBM 370.

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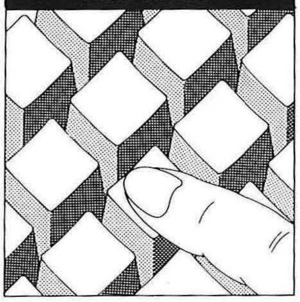

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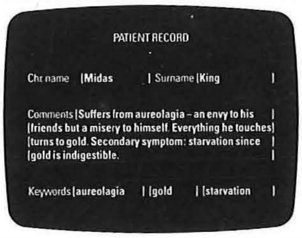

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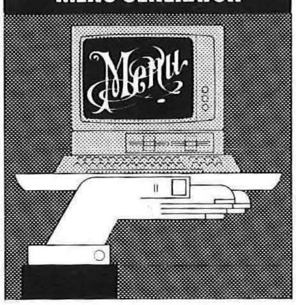

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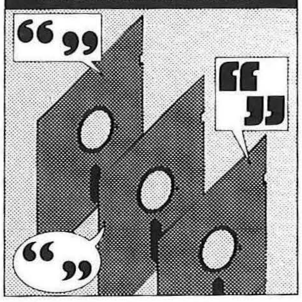

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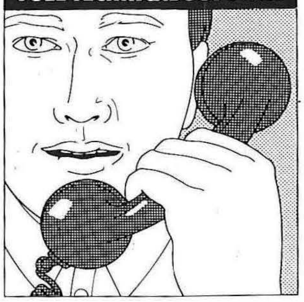

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