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# British Telecommunications Engineering



## EDITORIAL

Each year, on the 17 May, the International Telecommunications Union (ITU) celebrates World Telecommunications Day to commemorate the founding of the ITU in 1865. This year the theme is 'The transfer of technical know-how in the age of electronics'. Such transfer of technology is accomplished in a number of ways; for example, by participation in international standards committees, major exhibitions, and vocational training. Technical publications also play an important role in this respect and this *Journal* and its *Supplement* is no exception. The continuing advances in technology must be mirrored by the reappraisal and development of teaching methods and syllabi to better prepare the technician and the engineer of the future. These changes must, in turn, have a direct influence on the *Journal* and the *Supplement* so that they too continue to provide the most appropriate material. In this respect, feedback from the readership is important in ensuring that these needs are met. In this issue of the *Journal*, an article explains how the Business and Technician Education Council (BTEC) training scheme will be developed over the next few years, and a questionnaire is included which readers are urged to spend a few moments to complete and return so that we may continue to provide you with the best possible service.

# British Telecom's Future Network

## Presidential Address to the Institution of British Telecommunications Engineers

R. E. G. BACK, C.B.E., C.ENG., F.I.E.E.†

UDC 621.39

*This article is based on the Presidential Address given by Mr. R. E. G. Back, the then President of the Institution of British Telecommunications Engineers, to the London Centre on 21 September 1987. Mr. Back first discusses the present state of the telecommunications market and future prospects, and then sets out the network objective, which is to provide a high-quality low-cost and high-functionality network for the benefit of customers. He follows this by reviewing current plans and programmes by which this objective is being pursued, and how it will be advanced in the future.*

### INTRODUCTION

The primary function of a public telecommunication network is to enable people or machines to communicate efficiently and effectively at a distance. When, at the turn of the century, the UK network was unified and put under the control of a Government Department, it was a manual (operator-dependent) telephone system. Since then it has evolved to a fully automated system with direct dialling to most nations and offering a range of services.

During the financial year 1986/87, British Telecom's revenue was £9·4 billion, of which 80% was directly attributable to the network and the services which utilise it. It follows that, in an increasingly competitive environment, the evaluation of the choices available and the decisions made about the future structure and functionality of the network are crucial to the users, the shareholders, the telecommunication industry, and to those who work in BT.

The evolution of the network is dependent upon two major interactive factors: the market and technology. Under competition, the totality of BT's offerings to its customers must be driven by market demand. Without the advances in technology, however, it would not have been possible to improve quality and keep costs down nor to offer the range of services that are available today. This trend is expected to continue.

This article will briefly consider the market place, and the objectives for the network that have been adopted from a consideration of the requirements and characteristics of the market. The treatment of the market analysis is necessarily superficial in this article, but there is extensive analysis available to support the main conclusions. The article will then outline the existing and developing plans intended to fulfil the network objectives. Finally, it will offer a brief insight into the network of the future.

### MARKET

The UK market for telecommunication services is diverse, ranging from low-usage residential customers who only want a basic telephone service to major business customers with requirements for a wide range of speech and data services. To serve this market, BT must first understand it. In recent years, understanding has been improved by undertaking a substantial programme of market research. As a result, the picture is now much clearer, but there are, of course, still areas where further research is needed to give greater clarity.

Of the various market segments, large business customers (defined here as those with more than 10 exchange lines) are of particular interest to BT for a number of reasons. In 1986/87, although they accounted for less than a million connections out of the total of 22 million, large business customers contributed 20% of the revenue and an even larger percentage of the profit. As leaders in the market-place, most of them require access to a wide range of telecommunication services and many provide a ready partner for the evaluation and introduction of new services. A major characteristic of these companies is that information and, therefore, communication is the life blood of their business, and they demand reliability and quality above all other characteristics. They also look to their suppliers to provide an evolutionary path so that they can take advantage of more advanced services as their requirements and the available technology alter, without having to make wholesale changes to their entire installations.

At the other end of the spectrum, the residential market with 18 million connections presents a different challenge. The sub-seg-

† Corporate Director, British Telecom

ments range from businessmen running their businesses from home, to households originating only a few calls, although some of them may well be recipients of a large number of calls. The residential market as a whole represents an opportunity for growth. International comparisons indicate that residential customers in some countries use the telephone much more than their counterparts in the UK, and many have a second line. Although much of this can be attributed to differences in attitude to the telephone, greater usage could be encouraged by BT undertaking a range of actions such as improving quality, adjusting tariffs and providing new services.

Many sectors of our business (for example, *customer premises equipment* (CPE), *value added data services* (VADS)) are now subject to competition from a variety of suppliers. Competition in the network is provided principally by Mercury Communications Ltd. (MCL), which is currently focusing on the most profitable areas; for example, providing services to major business customers, trunk by-pass via interconnect, and international services. Noting that our licence is due for review in 1989, BT can expect to face greater competition in the future from 'resale'; a third operator; or the possibility of the local network being fragmented into self-contained geographical units. Of these possible sources of further competition, resale seems the most likely. This would clearly be a threat if our tariffs for private circuits and the PSTN remain unbalanced. However, the intense marketing which normally accompanies a resale operation is likely to stimulate and enlarge the market place to the benefit of both reseller and BT.

Besides meeting competition from within the UK, BT may also encounter competition on a more global scale; that is, from overseas telephone companies penetrating the UK market by offering end-to-end services to multinational companies. On the other hand, the relaxation of the regulatory environments overseas may well provide opportunities for BT.

To compete successfully and serve the whole spectrum of the market, BT's first priority must be to provide high-quality and low-cost basic services. Because BT has an obligation under its licence to provide a universal service within the UK, BT's average operating costs, and hence its prices, are likely to be higher than its competitors. Nevertheless, costs must be reduced to the minimum consistent with high quality, whilst competing primarily on a basis of quality and customer satisfaction. In addition, BT must provide up-to-date advanced services to meet the requirements of large business customers.

The challenge is, therefore, to provide advanced services for those customers who require them in a way that is not at the expense of a high-quality and low-cost basic telephony service. It is to meet this challenge that the network objective is: *To provide a high-quality low-cost and high-functionality network.*

## CURRENT PLANS AND PROGRAMMES

### Cost and Quality

To assess the modernisation plans and programmes currently being undertaken to fulfil BT's network objectives, it is necessary to examine them against the issues of cost and quality.

When the modernisation programmes were presented to the Post Office Board† in the 1970s, the prime objective was to improve quality for customers. This priority has not changed even though cost reduction is now, as then, an important element. Neither a breakdown of network costs (see Figure 1) nor the total give any indication of competitiveness unless the costs are compared with some recognised benchmarks such as the equivalent costs of other telephone companies.

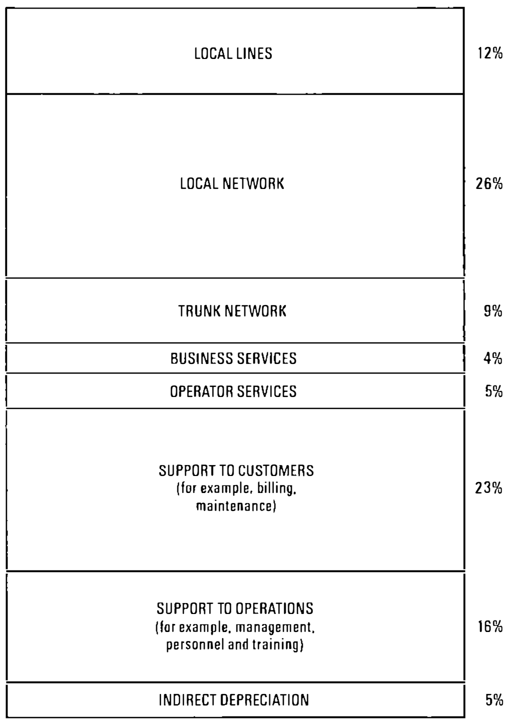



**Figure 1—Distribution of costs of the UK public telecommunication network**

Because of the difficulty in obtaining and using cost data, competitiveness may conveniently be compared by using an indirect measure such as the number of connections per employee. Although meaningful data is

† In 1969, the British Post Office (BPO) ceased to be a Department of State and became a Public Corporation. In 1981, the telecommunications business of the BPO was split from the Post Office to become a separate corporation trading under the name British Telecom (BT), and in July 1984 it became a public company, British Telecommunications plc.

still difficult to obtain because of the different ways telephone companies operate, Figure 2 demonstrates that there is a significant gap for BT to make up when compared with the best. In order for BT to become more competitive, there must be programmes to reduce costs and, bearing in mind the size of the gap, the solutions will have to be radical.

## Trunk and Local Exchange Restructuring and Modernisation

The initial programmes undertaken by BT to improve quality and reduce costs were the modernisation and restructuring of the trunk and local networks. These programmes were not designed just to replace analogue exchanges (Strowger) with digital exchanges (System X or, later, AXE 10). At the same time, as a result of our evaluation of the different economic characteristics of digital transmission and switching systems compared with their analogue counterparts, the programmes were also designed to obtain an overall reduction in the numbers of exchanges.

Reducing the number of exchanges has three effects. First, exchanges will be larger. These are more economical, for whereas a modern digital exchange has a high central-processing cost, the incremental costs associated with an increased size to cope with more traffic are only marginal (see Figure 3). Secondly, most calls are local to the area in which they are generated. Therefore, increasing the geographical coverage of an exchange to concentrate more traffic into one switch will not only eliminate junction plant, but also reduce the consequential costs of double switching. Thirdly, concentrating exchanges will also result in a lower cost for exchange maintenance. Other benefits gained from digitalisation will be dealt with later under 'Quality and Value'.

The total number of trunk exchanges (group switching centres) is currently being reduced from 400 to 53 with complete interlinking between them. Most of the digital transmission systems between trunk exchanges run over optical-fibre cable or microwave links using CCITT Signalling System No. 7 as the communication protocol. The coaxial cables carrying digital systems will be replaced by optical-fibre cables in the near future.

The local exchange modernisation programme is advancing rapidly with, on average, two analogue exchanges being replaced by digital each working day. Although the network will retain its basic hierarchical structure, processors will be concentrated into fewer centres with the extended use of remote concentrators.

## Local Network

Restructuring the local network involves completely reassessing all of its components,

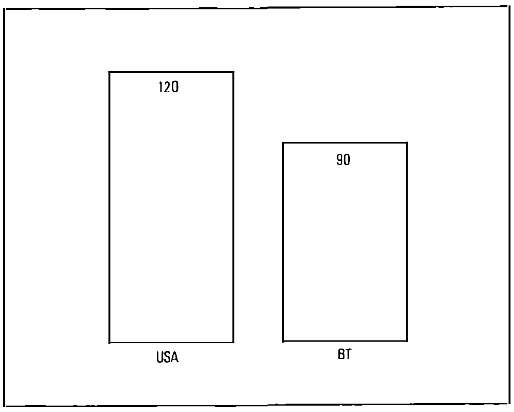



**Figure 2**
**Number of connections per employee**

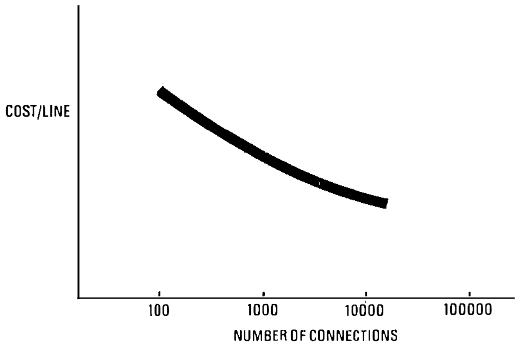



**Figure 3**
**Graph illustrating the relationship between cost and exchange size**

including switching, main distribution frames (MDFs), cabinets, cabling, distribution points (DPs), repair centres, etc. One of the options available to BT is to connect major customers by using a broadband medium such as optical-fibre cable through the associated *flexible access system* (FAS). This has many advantages. To the customer, fibre offers a significant improvement in quality and, with blocks of circuits and multiple services being provided over one link, a reduction in costs. Flexible access allows any type of customers' equipment to be connected to the appropriate range of services over any link, and enables customers to gain access to additional services at short notice. Improved reliability is achieved from automatic circuit monitoring and network management facilities, with further protection being obtained by duplicating cables over different routes.

The use of optical fibre also offers a number of advantages to BT. First, exchanges may cover larger geographical areas. The consequential benefits from installing larger exchanges include reducing the costs of switching, junction and other plant. Secondly, with flexible access, customers' lines are terminated on a 2 Mbit/s frame at an exchange. The considerable reduction in the number of physical connections will do much to alleviate the serious problems of congestion on MDFs that have existed for years in major exchanges in many city centres. This same reduction in numbers gives opportunity for cross-connection to be automated. Because of economies of scale, the advantages of fibre access are particularly marked in areas with significant numbers of large business customers. However, with reducing costs, which we can confidently expect, it would be possible to serve the smaller business customers and eventually residential customers by fibre. There may be an intermediate stage when multiplexors are provided at convenient sites (including street furniture) close to these customers, possibly retaining copper for the final drop.

The first group of local networks that were studied to see how restructuring could best be achieved and to evaluate the benefits were those of Central London and the adjacent areas to the west: the 'Western Corridor'. It was found that, with exchange modernisation, restructuring the local network would enable the exchanges in those areas to be reduced from 55 to 22. As well as savings in equipment and line costs, it has been estimated that when the programme has been completed, the operating costs for these areas will also have been drastically reduced.

### Network Management and Copper Uplift

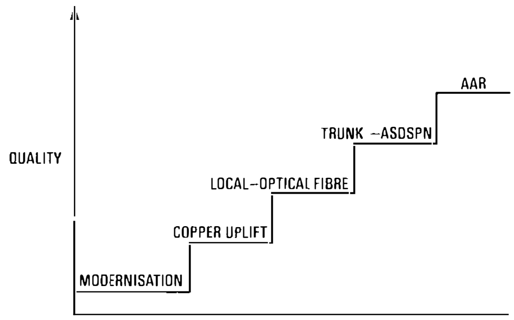
Network management and copper uplift are further programmes that are playing an increasing role in BT's modernisation strategy.

BT is now offering its customers, particularly large businesses, a wide variety of complex network services over a network carrying increasingly heavy volumes of traffic. To maintain good quality and reliability under these circumstances, it is essential to monitor and control the operation of the network continuously. A special programme is under way to install new types of network management systems to identify and by-pass faulty lines and equipment throughout the network, and to direct traffic flows over the most efficient routings. The eventual aim is to provide an integrated network control system to control the operation of multiple services from a central point. This will be dealt with later under 'Future Technology and Network: Control'.

A large amount of local underground cable is 50–60 years old creating numerous difficulties in maintaining an acceptable quality of service, in locating and clearing faults, and in providing service to new customers. These old cables need to be replaced, but it will be many years before it will be possible for optical fibre to be the main type of underground cable. The copper uplift programme to upgrade inferior cables in the local access network is, therefore, an important interim solution to improving the quality of local line plant.

### Quality and Value

A number of programmes have been specifically developed and planned to improve the quality of service. Some of these programmes are presented in Figure 4 as steps on a quality staircase, the purpose of which is to illustrate




ASDSPN: Automatically-switched digital service protection network
AAR: Automatic alternative routing

**Figure 4—Quality staircase**

BT's intention to continuously move its customers up to new levels of improved quality.

Modernisation, which has already been discussed in terms of cost reduction and from which substantial quality benefits have already been achieved, has been shown to be the starting-off point. Currently, some 2% of local calls and 4% of trunk calls are being lost on existing systems because of equipment being engaged in processing other calls, or because of plant defects.

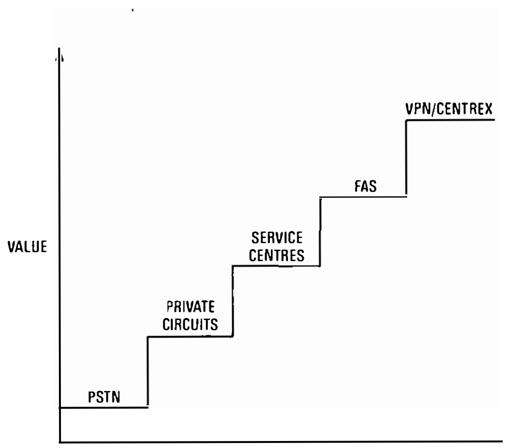
A ten-fold improvement has already been experienced in the fault rates at System X and AXE 10 exchanges compared with Strowger, and this will be increasingly reflected in the overall quality of the network.

Besides these improvements in the fault rates of exchanges resulting from modernisation, it should be noted that there have also been improvements in the fault rates of underground plant, which have halved over the past ten years.

At a higher level on the staircase, the *automatically-switched digital service protection network* (ASDSPN) is a circuit protection system for 140 Mbit/s trunk routes. A special feature is its use of artificial intelligence for making a succession of choices to restore service rapidly if a 140 Mbit/s link goes down. It is a prime example of systems which are being deployed to protect the network. More programmes are being planned as BT considers quality improvement to be both a vital and a continuous activity in providing service to all of its customers.

Besides providing high-quality services, business customers must also be provided with the range of advanced services they require to improve their own efficiency and so maintain their competitiveness in national and world markets. Although customers will be able to obtain many advanced services from the facilities provided by their CPE, they would obtain a major advantage from these services being provided through functionality in the network. The services would be available as required; always be the latest version; and, as the complication would be in the network, customers would have a lower capital outlay for simpler and cheaper CPE. Here too, because of progressive advancements, functionality may also be conveniently illustrated as steps on a value staircase (Figure 5).

Highly-automated service centres have recently been introduced throughout the UK to oversee the maintenance, repair and installation of business customers' lines and equipment. These service centres, with their interconnecting messaging systems based on the X.400 protocol, offer a single point of contact within BT to large business customers regardless of the complexity and locations of their installations, and have been very well received by customers. The service centres also have built-in alarm programmes to detect and flag key issues (for example, potential slippage of work) so that they can be speedily resolved.




FAS: Flexible access system
PSTN: Public switched telephone network
VPN: Virtual private network

**Figure 5**
**Value staircase**

## FUTURE TECHNOLOGY AND NETWORK

### Switching

An analysis of the cost structure and cost trends of modern digital switches show that larger units give lower costs per line, and it is expected that over a period the network will evolve to larger units. These may well be multi-processor units on a single site. Remote concentrator units and multiplexors will be used to increase the geographical coverage whilst keeping costs down by efficient use of the large central processors. For the longer term, exchange systems will be capable of variable bandwidth and wide bandwidth switching and so enable much more complex and varied services to be offered to all segments of the market. Optical switching will probably enter the network as a means of switching large blocks of traffic between centres.

### Transmission

Recent advances in radio technology suggest that in some circumstances there may be attractive alternatives to the current methods of providing fixed local access distribution using copper cables. However, available bandwidth in those parts of the radio frequency spectrum appropriate to present developments is very limited, and this scarce resource is likely to be reserved to meet an increased demand from mobile radiocommunications. This said, there are now some very interesting developments in cordless telephone technology which should certainly be investigated.

Based on present knowledge, optical fibre is likely to remain the main transmission medium of the network because of its almost limitless capacity and reliability. Over the next few years, optical-fibre cables will be increasingly used in the local access network, first, to provide service for major business sites, but extending progressively to residential services which might involve the siting of multiplexors as street furniture. Ultimately, if cost and design problems can be overcome, an all-fibre local network is a distinct possibility with the timing of introduction influenced by regulatory decisions on the ability to carry entertainment TV as well as telecommunication services.

As now, optical-fibre systems will be single-mode, but with an increasing use of passive optical components. The wide bandwidths available will make possible the use of wave-division multiplexing. At present, the main transmission routes between trunk nodes operate at 140 Mbit/s, and incoming and outgoing traffic in 2 Mbit/s blocks has to be multiplexed through several intermediate steps to the 140 Mbit/s transmission level. Synchronisation occurs at the 2 Mbit/s level, but above this the current network operates in a plesiochronous mode; that is, there are some surplus bits in the structure which allow for minor differences in the timing. The future proposal is to synchronise at the 140 Mbit/s level, or possibly to adopt a new international standard of 155 Mbit/s, which will allow insertion or extraction of 2 Mbit/s blocks from the higher level bit stream directly without requiring a chain of multiplexors.

The synchronous network (illustrated in Figure 6) will be protected by a hierarchy of remotely-controlled *higher-order automatic cross-connect equipment* (HACE) nodes for the provision and re-arrangement of digital paths, including automatic diversion to standby paths on failure. Besides its ability to reroute traffic, HACE will also be able to accept inputs directly from synchronous multiplexors and so eliminate the need for electronic frames.

### Control

As mentioned previously, much attention is being given to developing and introducing new and improved network management facilities, for both traffic and event management, to enable the network to tolerate localised traffic congestion and fault conditions without affecting service to customers. One of the main keys to future network control is the implementation of *integrated network man-*

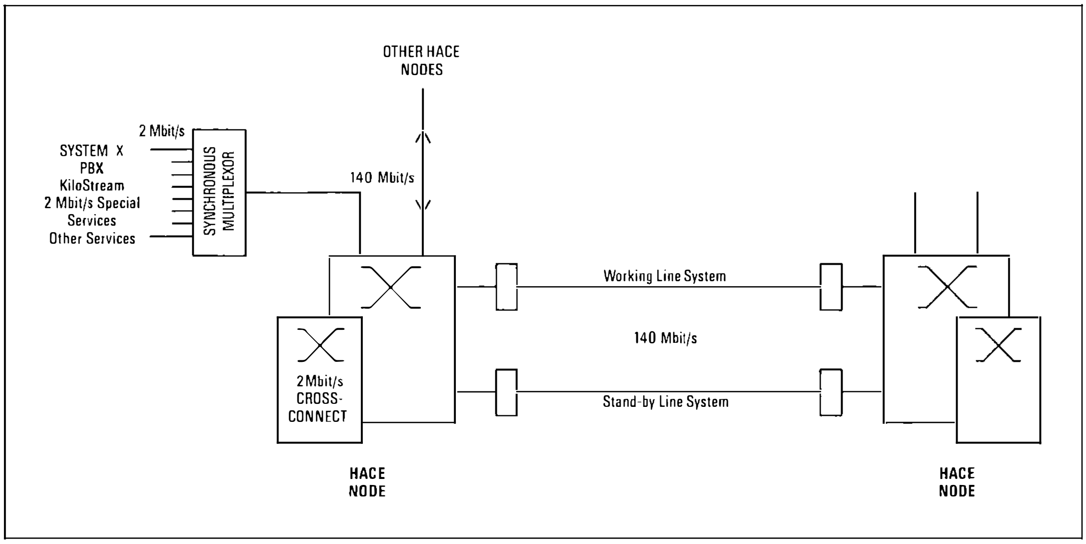



**Figure 6**
**Outline of higher-order automatic cross-connect equipment (HACE)**

*Note*: Synchronous optical network (SONET) STS 3 rate (155 Mbit/s) may be adopted instead of 140 Mbit/s for optical-fibre links, and the SONET virtual tributary rate (VTR) instead of 2 Mbit/s to cross-connect in the HACE node

*agement*, in which all network functions and services are brought under a common hierarchy of controls (Figure 7). Besides offering central control, this allows information interchange between different control points (plant controllers) and customer interfaces; for example, CSS, service centres. As in so many areas of telecommunications, it is crucial to adopt well-defined interface standards both to allow evolution of the network and to facilitate competitive procurement. Integrated network management is important as it will enable customers to implement interrelated changes to their network services directly as they are required without having to apply for changes to be made on a piecemeal basis.

A further question is whether the additional intelligence for controlling advanced services should be located in the local switch or if it should be provided centrally within the network at a limited number of centres. Centralising intelligence has the advantages of achieving greater control, flexibility in providing services, and lower costs. At the extreme, all of the intelligence could be built into the network with the local exchange processor merely being used to interconnect input and output ports under the control of this external network intelligence.

One new facility that will make use of separate control is the *intelligent network database* (INDB). The schematic layout of

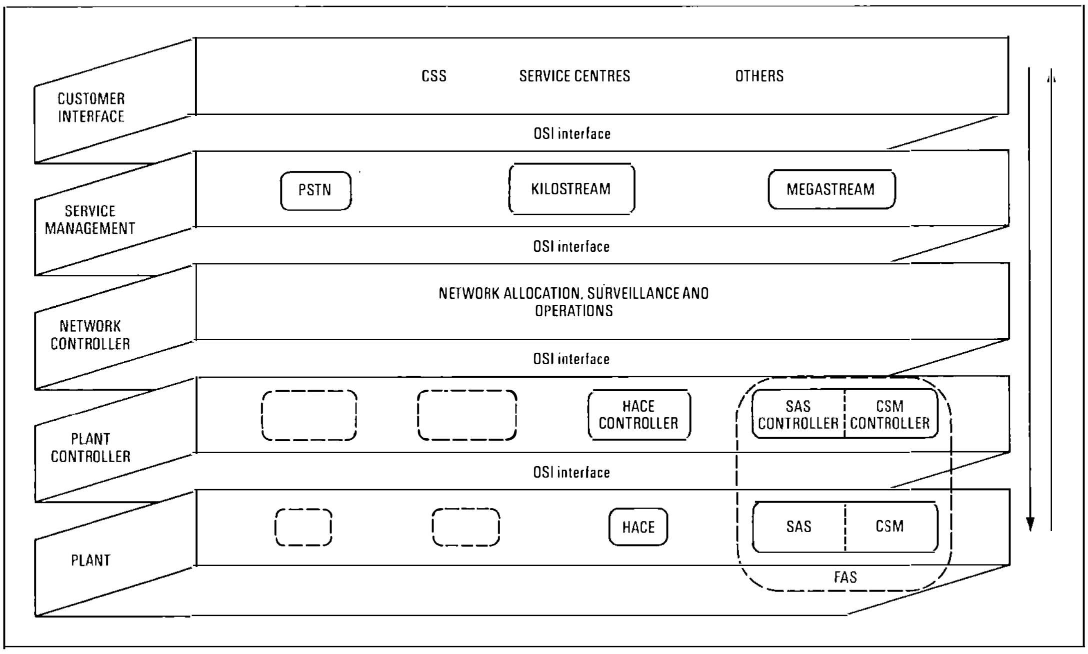



**Figure 7**
**Network management functional layered model showing, as examples, the management of HACE and FAS**

CSS: Customer service system
CSM: Customer service module
FAS: Flexible access system
HACE: Higher-order automatic cross-connect equipment
OSI: Open system interconnection
SAS: Service access switch

such a system is illustrated in Figure 8, In essence, the database receives, stores and continuously updates information from the network management infrastructure and then releases specific service instructions to exchanges when requested. INDB will initially be used to provided advanced services such as call diversion, premium charging or reverse charging, etc.

## CONCLUSIONS

Under the twin pressures of technology and market forces, the future network must be constructed with flexibility in mind so as to react quickly to change. In consequence, the basic network will be relatively simple with few switching points and containing just sufficient intelligence to connect calls from input port to the correct output. Higher network functions will depend upon separated intelligence systems and associated control. Currently, the latter systems are targeted on large central processors and this may well be the best solution, but it must be noted that the highly centralised commercial computer systems of the recent past are now threatened by the development of networks with distributed intelligence. This trend may assume great importance in the development of the future multi-purpose telecommunication network.

There can be no doubt that the future network will be very different from that of today, though reached by evolution rather than by today's revolutionary change to digital. Despite an almost continuous process of change the objective throughout will be constant: *To provide a high-quality low-cost and high-functionality network.*

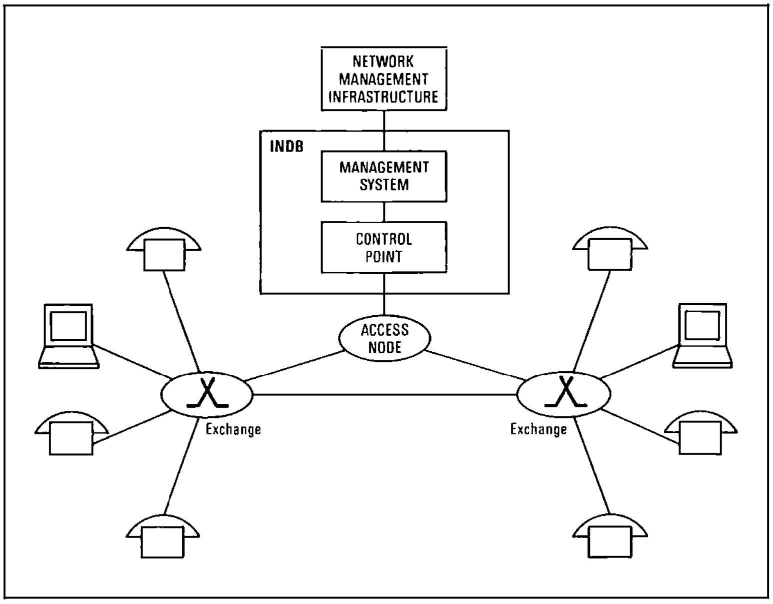



**Figure 8**
**Intelligent network database (INDB)**

## Biography

Ron Back joined the BPO in 1942 as a Youth-in-Training. After working on various aspects of microwave radio systems and the provision of satellite earth stations at Goonhilly Downs, he was appointed Deputy Director in Network Planning responsible for transmission planning and submarine cable systems. In 1975, he moved to the Service Department, and in 1979 became Senior Director responsible for Networks. This was followed in 1982 by appointment as Assistant Managing Director, and in September 1983 as Managing Director, National Networks. In November 1983, he was appointed to the Board of BT. Mr Back was President of the Institution of British Telecommunications Engineers from May 1984 until May 1988.

# Service Protection in the Trunk Network

## Part 1—Basic Principles

M. J. SCHICKNER, C.ENG., M.I.E.E.†

UDC 621.395.74 : 621.395.12

*British Telecom provides service protection facilities in its trunk network to ensure an adequate availability of service. These facilities are now being enhanced by automatic switching. This, the first part of a three-part article, gives the basic principles of service protection, while Parts 2 and 3 describe automatically-switched systems respectively providing 'route' and 'network' protection.*

### INTRODUCTION

For many years, British Telecom (BT) has used manually-patched stand-by line systems, in a service protection network (SPN), to improve the availability of its analogue trunk network. This network mainly comprised 4 and 12 MHz coaxial line systems together with microwave radio systems with integral 1-for-$N$ channel protection switching.

On the introduction of the high-capacity digital trunk network (DTN), an equivalent 140 Mbit/s digital service protection network (DSPN) was provided. The acronym DTN is used in this article to distinguish 'worker' digital sections (DSs) from 'stand-by' DSPN DSs. Figure 1 is given in order to clarify certain other terminology.

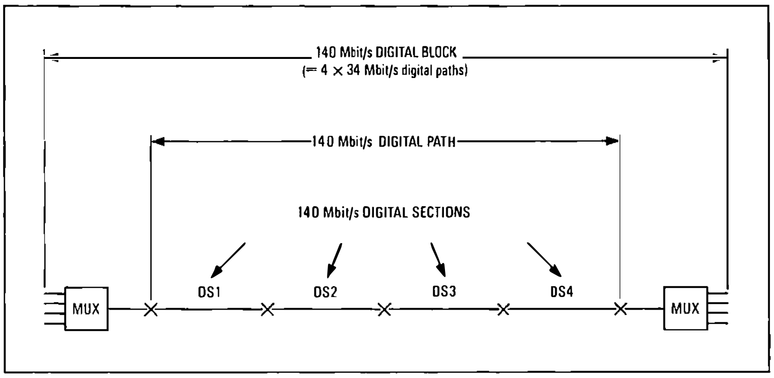



**Figure 1**
**Terminology**

### GLOSSARY OF TERMS

| | |
|---|---|
| ASDSPN | Automatically-switched digital service protection network |
| ASPE | Automatic service protection equipment |
| BT | British Telecom |
| CCITT | International Telegraph and Telephone Consultative Committee |
| DS | Digital section |
| DSPN (or SPN) | Digital service protection network |
| DTN | Digital trunk network |
| LTE | Line terminal equipment |
| MTBF | Mean time between failures |
| MTTR | Mean time to restore |
| MUX | Multiplex equipment |
| PSE | Protection switching equipment (a general term) |
| SPN | Service protection network |

A 140 Mbit/s digital block consists of a 140 Mbit/s digital path comprising one or more DSs connected in tandem and terminated at each end by a 34/140 Mbit/s multiplex equipment (MUX). Each DS interfaces at 140 Mbit/s and may be on a coaxial, optical fibre or radio system operating at 140 Mbit/s, or at a higher rate with integral multiplexing. Protection switching is provided for DSs but, at some stage, reports of switching events need to be related to digital blocks for the purpose of network management.

The BT public switched telephone network (PSTN) and the private KiloStream and MegaStream services use a trunk network that will be fully digital by 1989. This trunk network comprises a complex mesh of, approximately, 400 terminal stations interconnected by 3000 DSs with a mean length of about 50 km. Other private circuits are conveyed on existing analogue transmission equipment retained with the digital trunk network.

In 1979, BT considered that processor and data communication systems were sufficiently developed to make an automatically-switched DSPN (ASDSPN) practicable. After a feasibility study, a contract was competitively placed in 1983, for the design, supply and installation of equipment for an ASDSPN, which will be fully brought into service during 1989. (To provide an acronym that is easier to remember, this network is often referred to as *ASPRIN*, meaning *A*utomatically *S*witched *P*rotection and *R*e-routing for the *I*nland *N*etwork).

Because of increased concern over the availability and performance of the trunk network, especially for business/data customers, it was decided that the dependence of automatic switching on the rather lengthy development period required for the ASDSPN system was not acceptable. It was therefore decided to procure and install a limited amount of a relatively-simple automatic service protection equipment (ASPE), which provided protec-

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tion on a route basis rather than a network basis. By adapting an existing design, ASPE was ordered in 1985 and installed, within a year, on the most sensitive routes. The intention being that when the ASDSPN was installed, the ASPE would be moved to certain fringe or isolated areas where the former was not appropriate or economic. The ASPE and ASDSPN systems will be described in Parts 2 and 3 of this article, respectively.

## NEED FOR A SERVICE PROTECTION NETWORK

### Without an SPN

If no SPN facilities are available, restoration of traffic after failure of a piece of equipment could take anything from a few minutes to several days and is influenced by the following factors:

(*a*) If a maintenance person is on site, has the appropriate spares and the fault is in that station, the offending unit can be located and replaced within a few minutes.

(*b*) If the site originating an alarm is unattended, it can take on average two hours for maintenance staff to get there and commence location of the trouble.

(*c*) If the fault is located to a dependent repeater/regenerator in a line system, it could take several hours for the appropriate maintenance person to collect transport and a spare unit, drive to the site, open up and if necessary pump water out of the appropriate manhole or footway box, before changing the faulty unit.

(*d*) If the fault is the result of a cable defect, it could take several days to call out the appropriate cable crew, obtain spare cable of the correct type from a store and replace the faulty section. This is complicated if some of the cable pairs are still serviceable and carrying traffic, or if there is no space in the cable duct to insert the replacement cable section before withdrawing the faulty section.

### Manually-Patched SPN

The manually-patched SPN scheme used by BT ensures that about 90% of system failures are 'made good' within a time of 20 minutes to three hours and with a mean time of less than one hour. This relies on some of the large terminal stations being staffed 24 hours a day and many stations for the normal business day. Factors (*a*) and (*b*), above, still apply, but, by manually patching the traffic on to stand-by systems, the effects of (*c*) and (*d*) are avoided.

### Automatically-Switched SPN

The development of automatically-switched service protection systems was considered necessary in order to provide the quality of service expected of a modern telecommunications network. BT has, therefore, set performance and availability targets based on CCITT Recommendation G.821[1] and developed a network management policy which includes:

(*a*) automatic protection switching, with the objective of making good 90% of failures within 10 s,

(*b*) control by a national/regional/local management hierarchy, and

(*c*) general use of network rather than route protection switching.

## AVAILABILITY REQUIREMENTS

The *availability* of a transmission path is normally expressed as the percentage of time that the path is available for use by a customer at a specified level of performance. A circuit is deemed to be unavailable when there is a break in transmission for greater than 10 s, or the error ratio exceeds 1 in $10^3$ for more than 10 consecutive seconds. Any period containing impairments, but not deemed to be *unavailable*, is said to have *degraded performance*[2].

The published target for availability of BT's KiloStream and 2 Mbit/s MegaStream services is 99·85%, which approximates to an unavailability of 13 hours a year; in most cases the service will be better. This target is first apportioned for the trunk and the local parts of the network, taking account of the type of plant used and based on a realistic worse-case connection. Such a connection might contain 30 multiplex equipments and 10 transmission systems in the trunk portion alone. From this, it can be seen that an average of only a few minutes of unavailable time per year is acceptable for a single multiplex equipment or a single transmission system.

The availability (Av) and unavailability (UAv) of equipment or a system is related to the mean time between failures (MTBF) and the mean time to restore (MTTR) service, in the following ways:

$$\text{Av} = 1 - \text{UAv}$$

$$\text{UAv} = \frac{\text{MTTR}}{\text{MTBF}}$$

$$\text{Av} = \frac{\text{MTBF} - \text{MTTR}}{\text{MTBF}}$$

Conventionally, Av and UAv are expressed as a percentage, MTBF in years and MTTR in hours or minutes. Obviously, the same units of time must be used for MTBF and MTTR when making the calculations.

### Line System Availability

The prime factors affecting the MTTR of a line system have been mentioned above, under the heading 'Need for a Service Protection Network'. This, together with the actual MTBF of coaxial line systems, gave an availability figure which indicated the need for automatic protection switching.

Several BT digital coaxial systems display a rather unsatisfactory MTBF and, hence, require protection. The reason is twofold:

(*a*) They use regenerators with a nominal spacing of 2·0 km, on 1·2/4·4 mm air-spaced coaxial cable pairs. These regenerators were developed before suitable large-scale integrated circuits were commercially available and resulted in component counts and fail rates approximately twice that of the earlier 12 MHz analogue coaxial systems.

(*b*) BT's coaxial cable network is normally run under or alongside roads and, hence, there is a significant risk of cable damage due to road works.

The introduction of 140 Mbit/s single-mode optical line systems having a regenerator spacing greater than 30 km has avoided the need for underground regenerators and power feeding facilities and hence improved the system MTBF. However, the risk of cable damage and faulty terminal equipment still exists.

### Multiplex Availability

The MTTR of a multiplex equipment is determined by:

(*a*) The time taken for maintenance staff to reach the equipment. As most alarms from a multiplex equipment normally indicate a fault elsewhere rather than in itself, the alarm could be indicated in a station remote from the fault, and could necessitate calling out staff at several stations before the offending equipment is located. This could take several hours.

(*b*) The time to identify and replace a faulty unit in the offending multiplex equipment. This usually takes only a few minutes, as BT normally provides sufficient spares, on site, for any traffic-affecting units.

The MTBF of a multiplex equipment is very dependent on the design and technology used and is specified as the MTBF of a bothway tributary path through the equipment. Table 1 gives the target MTBFs set for BT equipments. The actual performance of current designs is significantly better than the target figures given.

**TABLE 1**
**Multiplex MTBF Targets**

| Design Generation | Rate (Mbit/s) | MTBF (years) | |
|---|---|---|---|
| | | Each Bothway Tributary | Total Multiplex |
| Current | 2–8 | 30 | 12 |
| | 8–34 | 20 | 8 |
| | 34–140 | 10 | 4 |
| Next | 2–8 | 35 | 35 |
| | 8–34 | 30 | 30 |
| | 34–140 | 12 | 8 |

As a result of the improved MTBF of optical line systems, the performance of multiplexing becomes more significant, and the question was asked whether BT should provide protection switching for multiplex equipments. A study concluded that, with the improved MTBF expected for the next generation of multiplex equipments, it was not necessary to give a further improvement in performance by using protection switching. The benefit could in fact be negated by the complex cabling and operational practices that would be introduced. The cost of cabling, accommodation and the stand-by multiplexors, was also significant.

## PROTECTION STRATEGY

### Route Protection

Protection can be provided on either a route or a network basis. The former is normally provided as one stand-by for a number of worker DSs (1-for-*N*) on an individual route. Figure 2 gives an example. '1-for-1' and '*N*-for-*N*' are variations that can also be considered.

Route protection is more appropriate for:

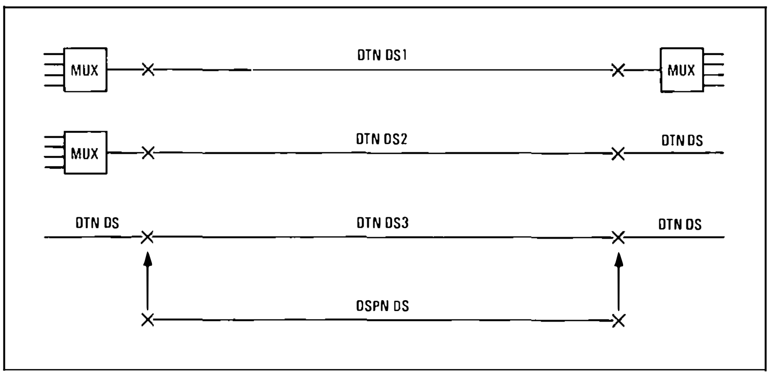
(*a*) High-capacity, fringe and isolated routes; where an adequate protection network cannot be provided around the protected route. In such cases, consideration should be given to providing a more secure transmission medium; for example, a cable buried deeply and avoiding roads, so as to minimise the risk of multiple system failure due to cable damage.

(*b*) Microwave radio systems; which may be subject to a rapid selective-channel-fading phenomena.

### Network Protection

Network protection provides much greater

**Figure 2**
**1-for-*N* route protection**
(In example, *N* = 3)




*Note*: *n*/*x* = DSPN path: choice number *n* comprising *x* DSPN DSs in tandem flexibility and is more appropriate for a complex tightly-meshed network, like the core of BT's trunk network. For any one failure, it provides the option of many make-good paths, each of which comprises one or more DSPN DSs connected in tandem, to bypass one (the failed DS) or more DTN DSs in a digital block. Figure 3 gives examples.

Network protection has advantages over route protection in that it:

(*a*) can protect against the failure of more than one DTN DS on any particular route,

(*b*) can protect transit (but not terminating) 140 Mbit/s paths when a station fails wholly or in part; for example, due to fire damage or power supply failure, and

(*c*) requires significantly fewer DSPN DSs for the same level of overall protection (availability).

### Bothway Make Goods

To minimise the risk of traffic failures due to maintenance operations, BT normally applies the policy of making good both directions of transmission although, in many cases, only one direction has failed.

### Other Uses

In addition to making good the traffic of failed systems, the BT DSPN is used for planned work; for example, making good a DS that:

(*a*) is to be interrupted for construction work; for example, diversion of a cable for road works,

(*b*) requires a unit to be changed, at a convenient time, to remove a low-level fault, or

(*c*) has not failed, but requires investigation because network surveillance indicates that its error performance is jeopardising the overall network performance limits.

### Access for Protection

Two basic methods of providing access for protection switching are possible: serial or parallel.

With serial switching, appropriate switches are introduced between multiplex and line terminal equipment (LTE) or between tandem connected LTEs as shown in Figure 4.

A disadvantage of serial switching is that the switches are permanently in the traffic path and, thus, potentially degrade its reliability. Depending on the design, all protected paths could pass through the protection switching equipment (PSE) and could be lost in the event of a PSE fault.

BT uses a parallel method of providing access as illustrated in Figure 5.

To make this practical, all equipments that interface at 140 Mbit/s are provided, at minimal extra cost, with dual output ports and dual input ports with a remotely-controlled SPN switch. Dual ports are necessary on LTEs for protection of a tandem-connected line system. This method has the additional advantage that the type of protection switching can be changed or temporary patching schemes implemented without interruption to service. A fault in the PSE can only be a hazard to any traffic made good at that time. One disadvantage of parallel access is mentioned in Part 2 of this article, under the heading 'Use of ASPE in a Network'.

### System Fail Condition

With manually-patched systems, the need for a make good is indicated by the normal system alarms. With automatically-switched protection systems, a suitable system fail (SF) condition has to be provided from the LTE to be protected, to trigger the automatic protection switching.

With 140 Mbit/s coaxial systems, the SF condition was provided by retrospective modi-

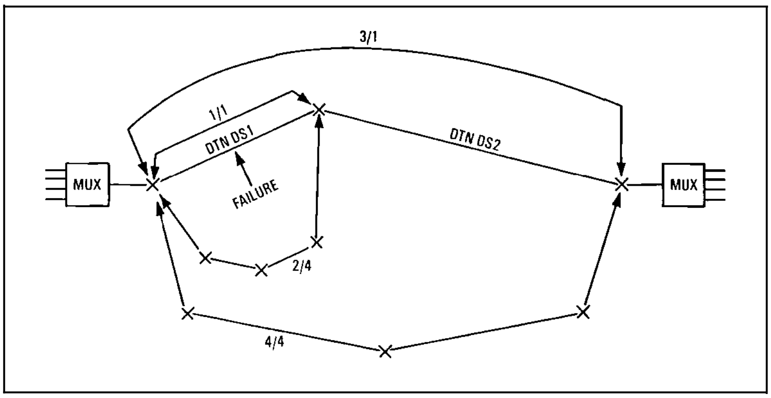



**Figure 3**
**Network protection, showing four possible make good paths**

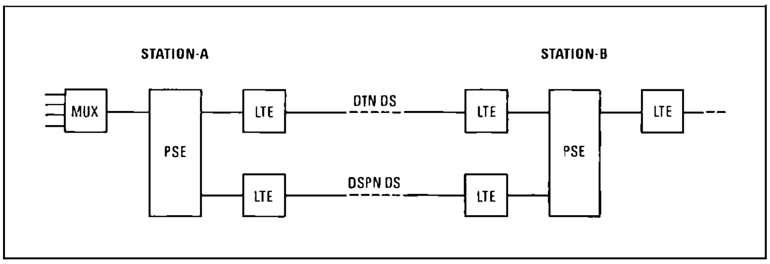
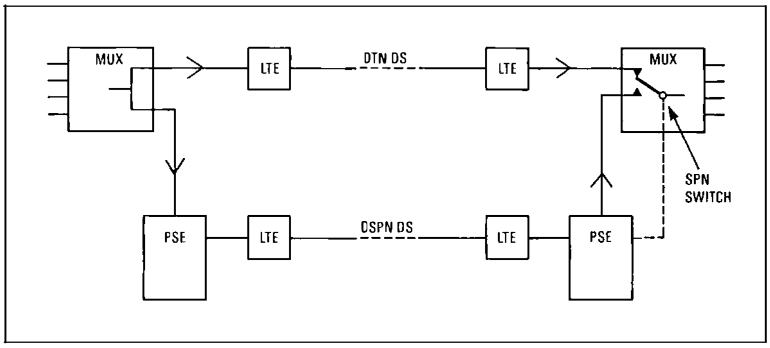



**Figure 4**
**Serial access for protection switching**




*Note*: Only one direction of transmission shown

**Figure 5—Parallel access for protection switching**

fication and hence derived from existing system monitors related to:

(*a*) loss of line signal,
(*b*) error ratio greater than 1 in $10^3$ or $10^4$, and
(*c*) LTE power fail.

Although this approach meant that a significant part of the LTE was not monitored, it was considered acceptable, as most faults were due to intermediate line regenerators, at 2 km spacing, or cable faults. 140 Mbit/s optical line systems were designed initially to provide an SF condition which was derived from similar parameters to the 140 Mbit/s coaxial systems.

However, with the introduction of 565 Mbit/s optical line systems having integral multiplexing, and thus being protected by switching at 140 Mbit/s, this situation has changed. Single-mode optical systems do not require regenerators closer than 30 km. This means that, in addition to the increased amount of traffic carried, the reliability of the terminal equipment is more significant, so that additional monitoring of the terminal equipment, including the multiplexing, is necessary.

### Reliability of Protection Switching Facilities

It is important that the circuitry of protection switching facilities, equipment and cabling, is monitored to ensure that there is a high probability that it will function correctly when required for a make good. Various methods of monitoring are used, dependent on the particular circuitry concerned. Examples are:

(*a*) the SPN control and the SF connections are monitored automatically for open-circuit and short-circuit conditions,

(*b*) DSPN DSs are self monitoring to the same extent that any line system is; that is, it monitors the line signal but not all of the terminal equipment,

(*c*) the ASDSPN equipment automatically routine tests its own switches, the DSPN DSs and the interconnecting cables, by sending and monitoring a 140 Mbit/s test pattern,

(*d*) watch-dog timers are used to check that processes have not locked-up or gone into a closed loop, and

(*e*) an ASDSPN equipment periodically carries out sanity checks, which involve automatically polling (calling) each of its peripheral equipments (VDUs, printer, switching racks, etc.) and other ASDSPN nodes, over the PSTN and the packet switched service (PSS), for a correct response.

To avoid causing any disturbance to a traffic path, none of the routine testing methods must apply an actual make good and restoration.

Examples of other design features that ensure reliable service are:

(*a*) The control input to the SPN switch must be protected against misoperation by noise spikes, as it would not be acceptable for the switch to be operated when a make good path was not present and, hence, disconnect traffic.

(*b*) A permanent command is sent to hold the SPN switch in either its NORMAL or its STAND-BY position, so that the 140 Mbit/s equipment will switch to the correct port after recovering from a power failure. The PSE must have some form of non-volatile memory in case, it, itself, suffers a power failure. In the case of the manually-patched DSPN, the memory is a mechanical toggle switch on the PSE.

## SWITCHING REQUIREMENTS

### Make Good Time

The intention of a protection switching system is to make good the traffic as soon as possible after a failure has been detected. However, it is prudent to apply a persistency check before initiating a make-good sequence as the disturbance to traffic, caused by a make good and the subsequent restoration, could be greater than that caused by a single brief interruption of the normal path; for example, on a coaxial system, an interruption due to a surge in earth currents resulting from a lightning strike. Unless further experience indicates a change is required, BT is using a persistency check period of 500 ms.

An intelligent protection system, such as ASDSPN, can also count breaks that are shorter than the persistency period, but are recurring. Such a system can be programmed to initiate a make good if the count exceeds a predetermined number.

As CCITT Recommendation G.821[1] gives 10 s as the threshold between impaired service and unavailability, BT has set this period as an objective upper limit for the time to complete most automatic make goods.

### Switching Speed

Switching of traffic from one good path to another—that is, restoration or switching for planned work—is specified by BT to cause an interruption of the 140 Mbit/s path of less than 20 μs. This interruption, plus the inevitable phase slip, will cause realignment of subsequent demultiplexing such that the interruption at a 64 kbit/s port is less than 15 ms on 90% of occasions.

### Automatic Restoration

To minimise unnecessary switching due to intermittent faults, it was decided that a fault-clear condition must persist for 30 minutes before an automatic restoration can take place.

### Radio Systems

Microwave radio systems at present used in the BT network, normally have an integral 1-for-*N* automatic protection switching system. This affords useful protection against equipment (component) failures, but more significantly provides a measure of protection against transient and irregular propagation phenomena, such as multipath fading.

Multipath fading results from the combination of propagation paths with slightly different delays, producing short duration narrow-band selective fade events which affect each channel in turn as the cancellation notch traverses the frequency band. The onset of a fade can be detected and the traffic switched to protection before the error ratio degrades to an unacceptable level. The 1-for-*N* switch, therefore, acts as an in-band frequency-diversity arrangement and can produce improvements of the order of 5 to 50 times during the short period in the year affected by fading.

These fade characteristics require very fast switching which is not compatible with the persistency check and delayed restoration provided for cable systems. Consequently, such radio systems are specifically excluded from the ASDSPN.

As the differential transmission delay between two channels of a digital radio system is only a few bits at the traffic signal rate, the switching can be designed to be *slipless*; that is, there is no loss or gain of bits in the traffic signal. In the case of network protection, because of the very different path lengths involved, it is not practical to provide slipless switching.

When, by its specific nature, a radio system does not suffer narrow-band fading; for example, short hops of a 19 GHz system, and where, depending on its location in the network, it is not always necessary or desirable to provide integral protection to cover other failure mechanisms, then it could be protected by the DSPN.

### Jitter Performance

Designers of a protection switching system need to consider the effects of that system on the jitter performance of a long tandem-connected path in which it may be used. In a network protection system, this can be a severe requirement.

### Line System Settling Time

Except in a synchronous network or with a 1-for-1 protection scheme, when a traffic signal is switched on to a stand-by line system, that line system experiences a change in clock rate. Each time the clock rate is changed, that system needs a certain time to settle to error-free transmission. This is an unspecified parameter and a wide spread of settling times has been found in practice, ranging from a few milliseconds up to 2·2 seconds. A few, the slowest systems, have been modified to bring them within an acceptable limit.

To minimise the disturbance to traffic when switching from one good path to another; for example, for planned work, the protection switching system should apply the traffic signal to the new path and allow that path to settle before switching at the receive end.

The design of protection switching systems must also allow for some DSs that, as the result of a clock rate change, not only generate errors, but may also generate a system fail condition and inject an *alarm indication* signal. This can occur on a tandem-connected DTN DS following the DS being made good, as well as on the DSPN DS path about to be used, and could cause an unwanted make good to be initiated, or the make good to be aborted.

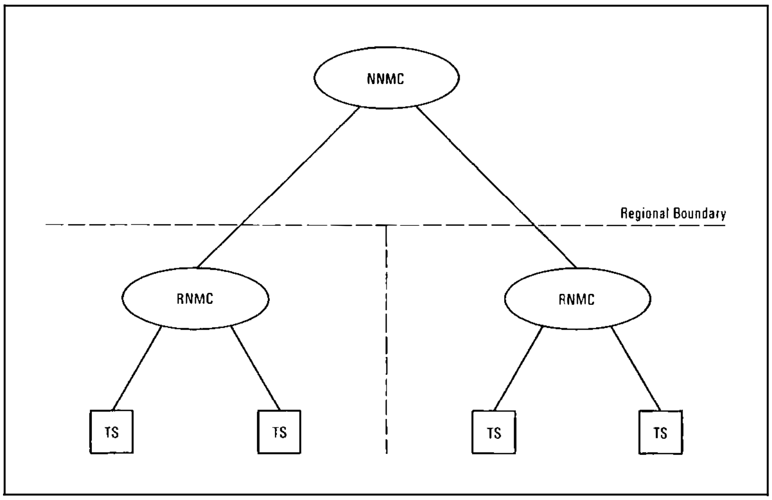
BT is currently introducing a specification requirement to limit settling time for new designs of DS.

## NETWORK MANAGEMENT

### Hierarchy

The automatic protection systems used by BT were designed to be operationally compatible with the management hierarchy of the existing manually-switched analogue and digital service protection networks, so as to permit a phased introduction. Figure 6 shows the management hierarchy used.

**Figure 6**
**Management hierarchy**




NNMC : National network management centre
RNMC : Regional network management centre
TS : Terminal station

Terminal stations (TSs) report to a regional network management centre (RNMC), which is responsible for managing service protection in its own region and liaising with other regions. The RNMCs all report to one national network management centre (NNMC) which is responsible for:

(*a*) overall management of service protection and resolving inter-regional contention,
(*b*) ensuring that make goods for planned

work do not significantly reduce protection of the DTN network against failures, and

(*c*) producing network performance statistics.

### Other Facilities

In addition to providing automatic make goods, a practical system must permit some or all of the following facilities:

- Manually-initiated make goods.
- Inhibition of a particular DTN DS from being made good.
- Inhibition of a particular DSPN DS from being used.
- Automatic restoration, and its inhibition.
- Manually-initiated restoration.
- Forced make good, on to a sub-standard DSPN DS.
- Forced restoration, on to a sub-standard DTN DS.
- Delayed (preprogrammed) make good.
- Delayed restoration.
- Advanced booking of planned-work operations.
- Casual use of the DSPN for *ad hoc* services; for example, occasional TV links.

## THE FUTURE

The hardware realisation of future generations of protection switching will be very much affected by the development of other network management facilities now being introduced or under study, and exemplified by the following.

### Automatic Digital Distribution Frames

BT is now using an automatic cross-connect equipment (ACE)[3] in the KiloStream network. This equipment interfaces with the network at 2 Mbit/s and provides multiplexing to and cross-connect facilities at 64 kbit/s. It is, in effect, an automatic digital distribution frame (ADDF) with facilities for remote (centralised) manual control; its prime function being circuit provision and rearrangement. The use of ADDFs at higher levels in the network is being considered and these are sometimes referred to as *higher-order ACE* (HACE).

### Synchronous Multiplexing

Feasibility studies are now in hand to consider the use of synchronous multiplexing at rates above 2 Mbit/s. This offers a significant reduction in the cost of multiplexing compared to the current plesiochronous hierarchy, and provides an economic way of providing HACE and tributary drop-and-insert facilities.

### Network Surveillance

Development is in hand for a transmission network surveillance (TNS) system that uses a station processor to collect data on alarms and performance from individual multiplex and transmission terminal equipments, and send it to an RNMC for processing and display. Remote-control facilities will also be available.

### Next Generation ASDSPN

Studies have already commenced to determine the feasibility of integrating all of the facilities stated above into one unified system, based on centralised hierarchical management control. It is to be expected that future ASDSPN facilities will also be embodied within this system.

## CONCLUSION

This first part of the article has given the basic principles of protection switching and indicated why BT has followed the particular line it has. It illustrates the importance that BT places on providing a high availability of service in its network. Parts 2 and 3 will, respectively, describe the ASPE and ASDSPN systems.

## ACKNOWLEDGEMENTS

The author would like to thank various colleagues in the planning, works, maintenance and network management divisions, who, over the years, have contributed to the knowledge contained in this article. In particular, George Clark, Jimmy Gipp and Arthur Walker, the now retired members of the original ASDSPN working party.

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# Service Protection in the Trunk Network

## Part 2—Automatically-Switched (1-for-*N*) Route Protection System

M. J. SCHICKNER, C.ENG., M.I.E.E.†

UDC 621.395.74 : 621.395.12

*British Telecom provides service protection facilities in its trunk network to ensure an adequate availability of service. These facilities are now being enhanced by automatic switching. This, the second part of a three-part article, describes an automatically switched system that provides (1-for-*N*) route protection, while Part 1 gives the basic principles and Part 3 describes a more comprehensive automatically-switched network protection system.*

### INTRODUCTION

Part 1 of this article gave the basic principles and the history behind the development of an automatic service protection equipment (ASPE) for the British Telecom (BT) trunk network. This part of the article describes the design and facilities of an ASPE that provides 1-for-*N* route protection at 140 Mbit/s. An explanation is also given for the need to develop a SPN access unit for the trunk network.

### SYSTEM DESIGN

The ASPE provides route protection by using parallel access and the system fail (SF) condition described in Part 1 of this article. It enables a digital section (DS) in the traffic-carrying digital trunk network (DTN) to be made good by transferring its traffic on to a DS which is part of the digital service protection network (DSPN).

#### Basic Operation

The heart of an ASPE is a 1-to-6 switch, controlled by a microprocessor. If any one of six DTN DSs fails, its traffic is switched on to a DSPN DS. An optional mode of operation is to connect casual-user traffic to the sixth input. In this mode, the casual-user traffic is disconnected from the DSPN DS if the latter is required to make good any one of the five DTN DSs connected to the other switch inputs. Casual-user traffic has a lower availability of service provided at a lower rental, and is used for purposes such as transmitting video signals between TV studios in circumstances where the signals can be retransmitted, if necessary.

The following example explains the operation of ASPE by referring to the system block diagram shown in Figure 1.

Assume the line system, DTN DS1, fails in the direction shown and the failure is detected by the line terminal equipment (LTE) at station-B. The LTE generates an SF condition which is detected by the ASPE. A telemetry signal is sent via modems over a suitable path to the ASPE at station-A. The latter operates its TRANSMIT (TX) switch to connect the stand-by port of multiplex equipment, MUX1, to the DSPN DS. Station-B operates its RECEIVE (RX) switch to connect the DSPN DS to RX MUX1, and the SPN switch in MUX1 to complete the make good. Identical operations are carried out at the same time in the opposite direction of transmission.

#### Switching Requirements

Account had to be taken in design of the problem with line system settling time (to be described in Part 3 of this article) and the need to minimise the interruption of traffic when making good a DTN DS to permit planned work. This was achieved by a software time delay of 350 ms, which allows the DSPN DS to settle to the bit rate of the traffic signal, before operating the high-speed (20 $\mu$s) SPN switch at the receive end of a make good. This resulted in a design that gave the required high-speed change-over for a planned-work make good and any restoration, while giving a make-good time, for a failed system, of about 850 ms (500 ms persistency check plus 350 ms settling time).

#### Switching Devices

In view of the make-good times mentioned above, a coaxial relay is fast enough and

### GLOSSARY OF TERMS

| | |
|---|---|
| ASPE | Automatic service protection equipment |
| CMI | Code mark inversion |
| DS | Digital section |
| DSPN (or SPN) | Digital service protection network |
| DTN | Digital trunk network |
| LTE | Line terminal equipment |
| MUX | Multiplex equipment |
| RX | Receive |
| SF | System fail |
| TX | Transmit |

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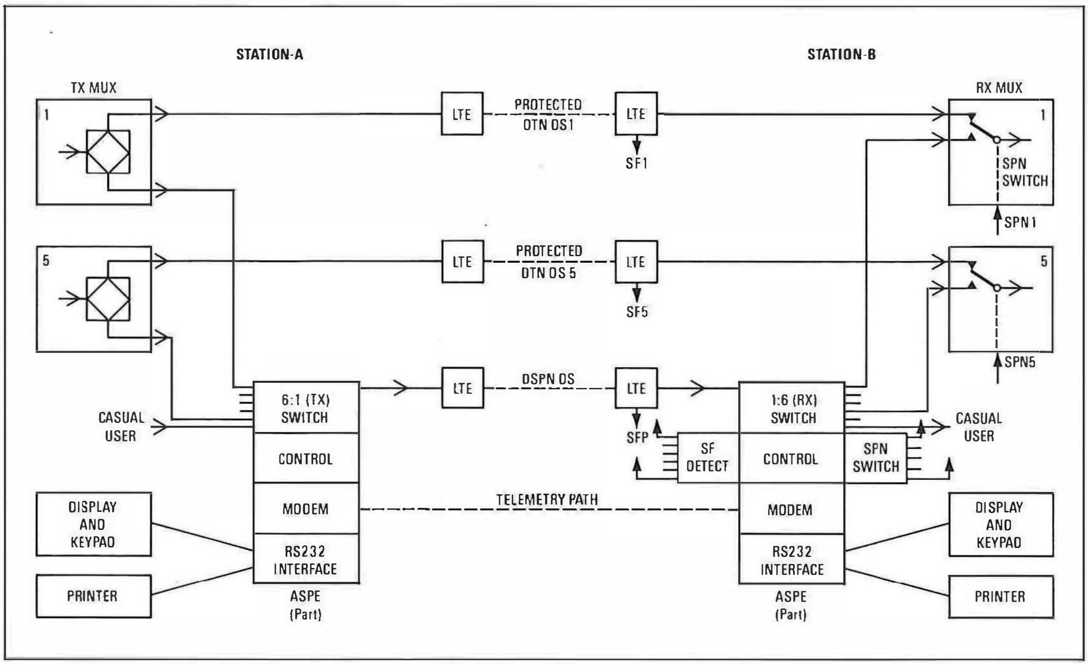



**Figure 1**
**System block diagram**

*Note*: Only one direction of transmission shown

avoids problems with jitter that could occur with electronic switches. Furthermore, relay switches provide a low insertion loss, of less than 1 dB, in the 140 Mbit/s CMI traffic signal path. For planning purposes, the normal maximum cabling loss of 12 dB, at 70 MHz, is reduced to 11 dB, to allow for relay loss, and, as the ASPE is non-regenerative, divided in half to give 5·5 dB on each side of an ASPE switch. This gives a cabling limit of 55 m using the BT standard Cable Coaxial No. 2003.

## Telemetry Path

A 1·2 kbit/s telemetry signal is used to co-ordinate the ASPE switching at the two ends of a route.

In most situations, the engineering speaker circuit of the DSPN DS is used as the telemetry path. In a few cases, where certain line systems do not have a speaker circuit, a telemetry path has to be provided by some other routing, which would normally be a private circuit; for example, the BT Keyline 25B service. Another possibility is to use the auxiliary data path provided over the main optical path by some optical line systems; when such a system is used as a DSPN DS, it is dependent on the auxiliary path having a compatible interface.

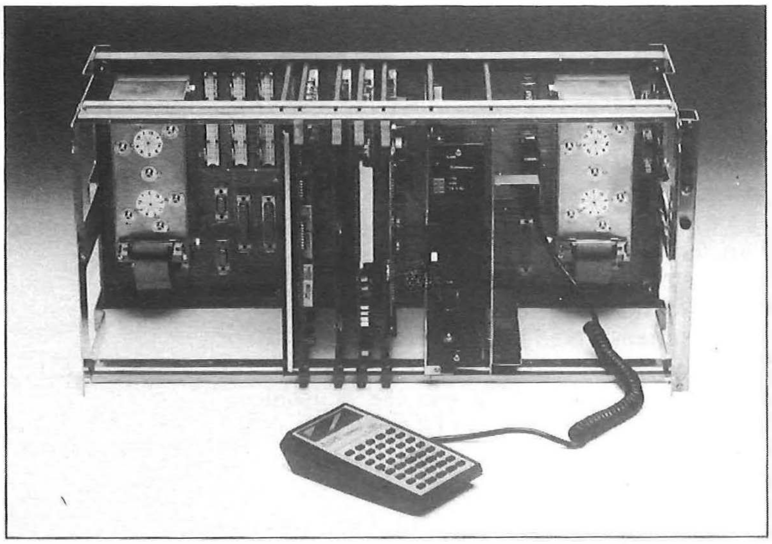
Obviously a telemetry path cannot be routed over one of the transmission paths being protected, otherwise the ASPE would not be able to implement a make good if this path fails. A technique that could be used, if necessary, is to transmit the telemetry over more than one, say three, of the protected paths. This would permit satisfactory operation if any two of the three paths failed. However, this would probably require additional interfacing circuitry, not provided with the current design of ASPE, and access to the spare digits in the transmitted multiplex signal or the auxiliary path of the line system.

To avoid loss of traffic, it is essential that telemetry errors cannot cause incorrect switching. This risk is minimised by specifying that the telemetry will function correctly with a line error ratio of up to 1 in $10^3$. This is achieved by transmitting each command three times, and only accepting a command as valid if it is recognised for two of the three transmissions.

## Hardware

One end of an ASPE system is contained in one shelf of equipment built in BT TEP-1E construction practice, as shown in Figure 2.

**Figure 2**
**ASPE equipment**



The equipment operates off a centralised −28 or −48 V supply. Figure 3 gives an indication of the shelf layout.

The transmit and receive relays are built into screened boxes as illustrated in Figure 4 and mounted on the rear card frame. External 140 Mbit/s cabling terminates on connectors mounted directly on the relay units.

The location of the relay units in the shelf is determined by the TEP-1E practice which requires the cabling to leave the shelf at either or both sides. Connector fields on the shelf backplane are used for terminating other external connections such as the SF and SPN control wires, the telemetry path and a printer, if required. Printed wiring boards (PWBs) containing the remainder of the circuitry are mounted in the centre of the shelf.

The control-circuit firmware† is contained in a plug-in electrically-programmable read-only memory (EPROM) device. This makes it simple to change retrospectively instructions or to provide enhancements by fitting a new EPROM. A separate non-volatile memory is used to store configuration data and thus guard against power failure. The traffic on any DTN DS that is made good is lost for the duration of an ASPE power failure, but will automatically be re-made good when the power supply is restored.

A plug-in hand-held terminal provides a 14-character display and keypad for indication and control purposes. This can permit economy by using the terminal as a portable device which is only plugged in when required. However BT decided, for operational reasons, to provides a hand-held terminal stored in each ASPE shelf.

## FACILITIES

### Automatic Switching

The basic facility, automatically to make good a failed DTN DS, is provided with a 500 ms system fail persistency check to avoid unnecessary make goods, and with automatic restoration 30 minutes after a fault clears, to minimise switching when intermittent faults occur. Automatic restoration can be inhibited and a manually-initiated restoration used instead.

If the DSPN DS gives an SF condition, any automatic make good in operation at that time will be restored, even if the DTN DS is still faulty. No further automatic make goods will occur until the SF from the DSPN DS has cleared.

If operationally beneficial, two levels of priority may be applied to the DTN DSs so that, if a high-priority DTN DS fails, it can be made good by automatically restoring a low-priority DTN DS already using the DSPN DS.

† Firmware is executable code or data held in a read-only memory device.

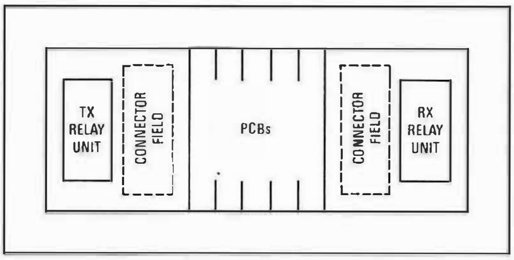



**Figure 3**
**Shelf layout**

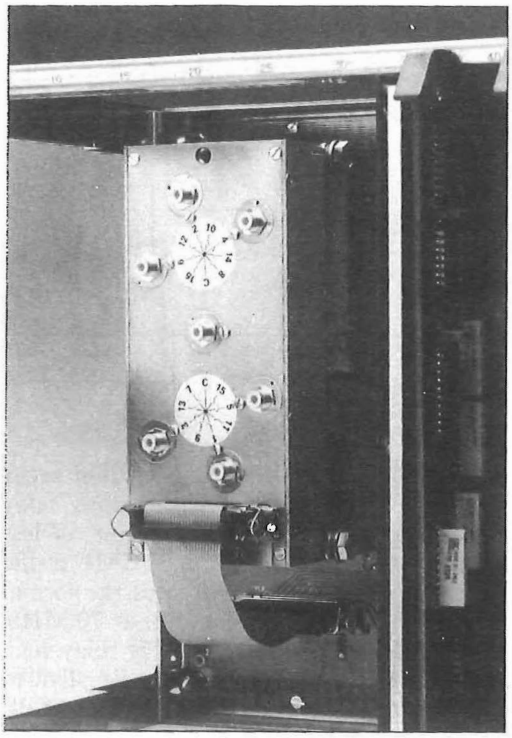


**Figure 4**
**Relay unit**

### Manual Control

Manual control facilities are available via the hand-held terminal and can be used to override any previous automatically-initiated switching. This is to give flexibility in management of the overall trunk network. It is possible to inhibit a particular DTN DS from being made good or the DSPN DS from being used. Also, traffic can be forced on to a sub-standard DSPN DS or a satisfactory make good forced back on to a sub-standard DTN DS.

Any switching event or a fault in the ASPE system will raise an appropriate station alarm, to attract attention, and the condition reported on the hand-held terminal. The terminal is also used to modify certain pre-programmed features; such as level of priority.

By replacing the hand-held terminal by a connection to the BT interim network monitoring system (NETMON), reporting and control can be provided to/from both a central point in the same station and the regional network management centre (RNMC).

### Other Facilities

Self-checking facilities are provided and con-

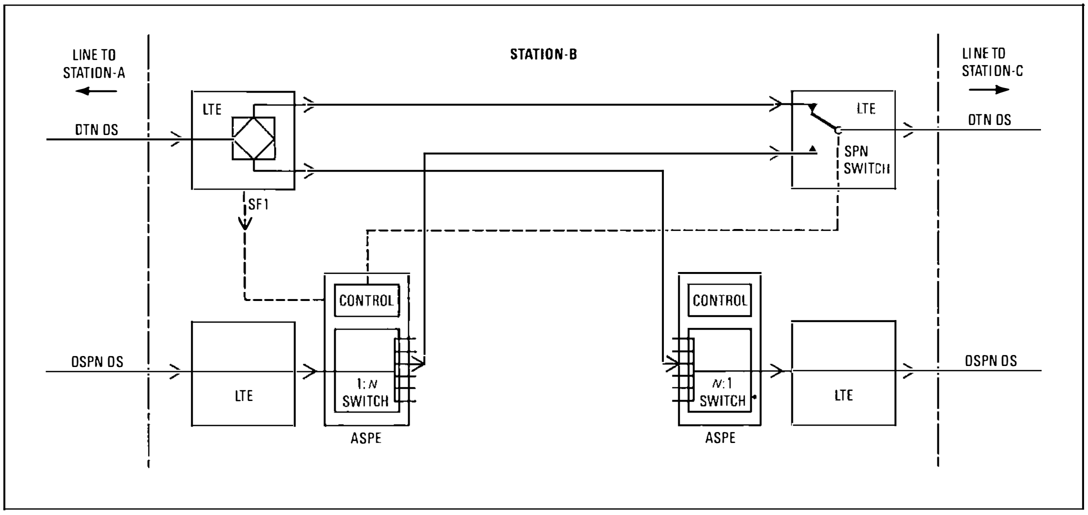



**Figure 5**
**Tandem ASPE systems**

*Note*: Only one direction of transmission shown

trolled by the ASPE microprocessor, which generates a station alarm if any defects are found. Checks are made of:

(*a*) the signalling over the telemetry path to the remote terminal,
(*b*) the hardware: memory operation, relay drivers and other hardware, and
(*c*) the microprocessor itself by a watch-dog timer.

An interface is provided for connecting a data printer which would record date, time and details of any failures and switching events.

## USE OF ASPE IN A NETWORK

During development of ASPE, a problem with the BT method of using parallel rather than serial access for protection switching (as described in Part 1 of this article, under the heading 'Access for Protection') was identified. To illustrate the problem, Figure 5 shows two DTN DSs connected in tandem at station-B, with each protected independently by an ASPE system.

It can be seen from the diagram, that if either of the line systems fails, it can be made good on a DSPN DS. However, if both line systems were made good, the traffic is disconnected as there is no path between the two DSPN DSs.

It would be possible to overcome this problem if the processors in the two ASPEs concerned could communicate with each other and a path was provided between the two ASPE switches. In a practical situation, it becomes much more complicated as there could be three or more ASPE-protected routes into a station, and it would, in reality, require a central intelligence to control all the ASPEs and a switch to route traffic between the ASPEs. This is then becoming more a network-protection system, like the automatically-switched digital service protection network (ASDSPN), rather than a simple route-protection system. Parallel access does not give problems with a manually-patched DSPN or the ASDSPN.

For the above reason, ASPE protection is only considered safe if it is used for a DTN DS that is connected at both ends to multiplex equipment, not another ASPE protected line system. However, the risk to traffic can be minimised if certain operational practices are applied; for example, by inhibiting the ASPE protection of an adjacent tandem-connected line system if and when one line system has been made good by the ASPE. A radio system with an integral protection channel does not cause this problem and can be connected to a ASPE protected line system.

## SPN ACCESS UNIT

Consideration is being given to the introduction of a SPN access unit, which comprises two circuits as illustrated in Figure 6, one for each direction of transmission.

This unit would serve three purposes:

(*a*) It provides switching and branching to overcome the tandem ASPE problem identified above and as illustrated in Figure 7. It also enables ASPE to interwork with ASDSPN. This facility, to provide a unit to isolate the branching for one protected system

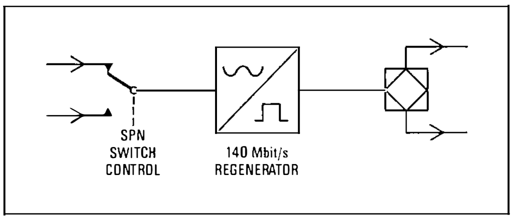



**Figure 6—SPN access unit**

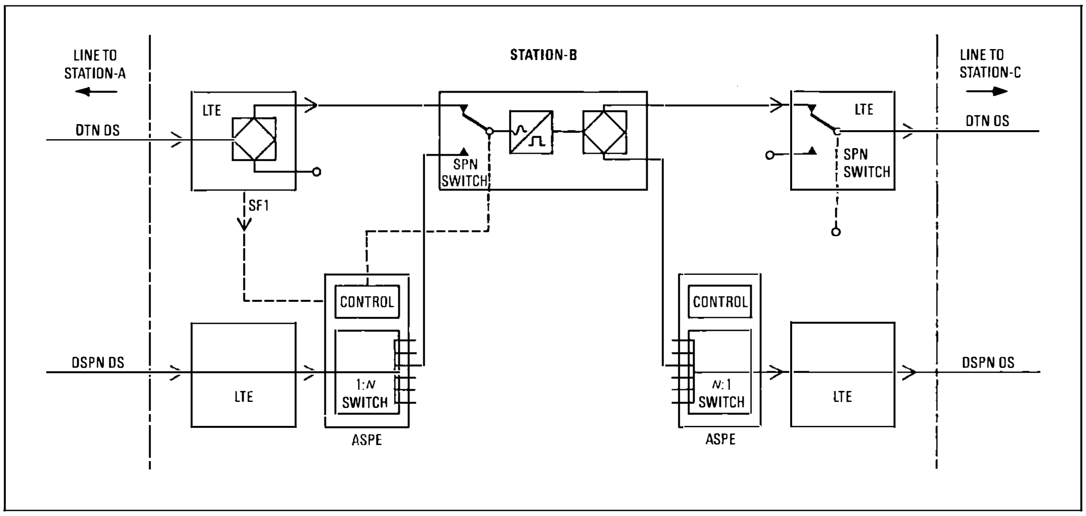



**Figure 7**
**SPN access unit used with ASPE**

*Note*: Only one direction of transmission shown

from another, is called *branching isolation*, or more simply *isolation*.

(*b*) It provides parallel service protection access for certain equipments or systems that do not have these facilities built in; for example, certain radio and submarine cable systems.

(*c*) It can be used as a 140 Mbit/s regenerator, for situations where in-station cabling between equipments has a loss in excess of the normal 12 dB limit.

## CONCLUSION

Although ASPE does not have the network management facilities and flexibility of the more complex ASDSPN, it was developed, supplied and installed in a very short time, to enable BT to provide automatic protection on certain sensitive routes in the trunk network, and is now giving a good and reliable service.

## ACKNOWLEDGEMENTS

The author would like to thank his colleagues in the ASPE Team, who contributed so much to the project. Acknowledgement is also given to STC Telecommunications Ltd, at Basildon, for permission to publish the photographs used in Figures 2 and 4.

# Service Protection in the Trunk Network

## Part 3—Automatically-Switched Digital Service Protection Network

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UDC 621.395.74 : 621.395.2

*British Telecom provides service protection facilities in its trunk network to ensure an adequate availability of service. These facilities are now being enhanced by automatic switching. This, the third part of a three-part article, describes an automatically-switched system that provides network protection. Part 1 outlined the basic principles involved and Part 2 described an automatically-switched route protection system.*

### INTRODUCTION

Part 1 of this article gave the basic principles of service protection and the history behind the development of an automatically-switched digital service protection network (ASDSPN). (To provide an acronym that is easier to remember, this network is often referred to as *ASPRIN*, meaning *A*utomatically *S*witched *P*rotection and *R*e-routing for the *I*nland *N*etwork).

The initial requirements and proposed design approach were published[1] during the early stages of system design, while this part of the article:

(*a*) gives an overview of the system architecture and mentions certain design features,

(*b*) describes the various switching and management facilities provided, and

(*c*) mentions various operational aspects concerned with the introduction of an ASDSPN.

After a feasibility study, one contract was placed competitively for the design, supply and installation of equipment for both a field evaluation network and the full operational network, which would be brought into service by 1989. The field evaluation network comprised three terminal stations (TSs), a regional network management centre (RNMC) and a national network management centre (NNMC).

Because of changes in BT nomenclature, the ASDSPN equipment: hardware, software and documentation, uses the older BT term of district network management centre (DNMC), not the current BT term RNMC, which is used in this article.

### SYSTEM ARCHITECTURE

The ASDSPN provides network protection by using parallel access and the system fail (SF) condition as described in Part 1 of this article. It also meets the switching and network management requirements described therein.

#### Hierarchy

The ASDSPN was designed to be operationally compatible with the network management hierarchy (mentioned in Part 1 of this article) used for the existing manually-switched analogue and digital service protection networks. This would permit the ASDSPN to be phased in under the control of the same network management organisation. Figure 1 shows the ASDSPN hierarchy.

The ASDSPN comprises an NNMC, RNMCs and TSs, together with the digital service protection network (DSPN) of stand-by digital sections (DSs). Each of the nodes is processor controlled and communicates with other nodes via the DSPN and the public switched telephone network (PSTN). Also, for faster communication, any NMC can communicate with any other NMC via the packet switched service (PSS). Each TS has a switch array that can connect any DSPN DS to any other DSPN DS, or to the digital trunk network (DTN).

### GLOSSARY OF TERMS

| | |
|---|---|
| ASDSPN | Automatically-switched digital service protection network |
| BT | British Telecom |
| CCITT | International Telegraph and Telephone Consultative Committee |
| CMI | Code mark inversion |
| DS | Digital section |
| DSPN (or SPN) | Digital service protection network |
| DTN | Digital trunk network |
| FMG | Fast make good |
| LTE | Line terminal equipment |
| MUX | Multiplex equipment |
| NMC | NNMC and/or RNMC |
| NNMC | National network management centre |
| PSS | Packet-switched service |
| PSTN | Public switched telephone network |
| RNMC | Regional network management centre |
| RX | Receive |
| SF | System fail |
| SMG | Slow make good |
| TS | Terminal station |
| TX | Transmit |

† Network Systems Engineering Transmission Division, British Telecom UK Communications

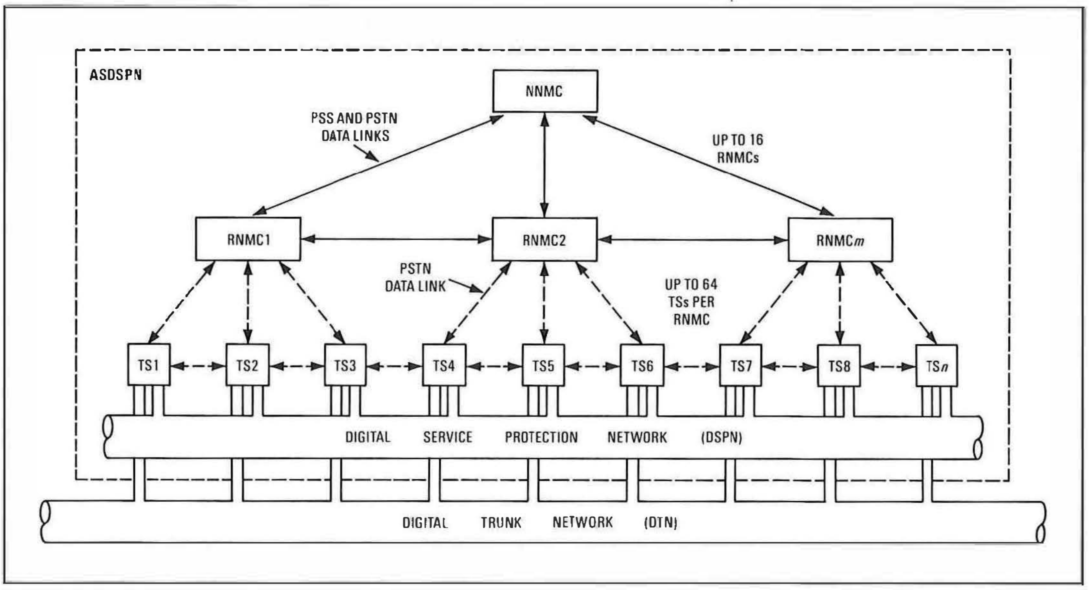
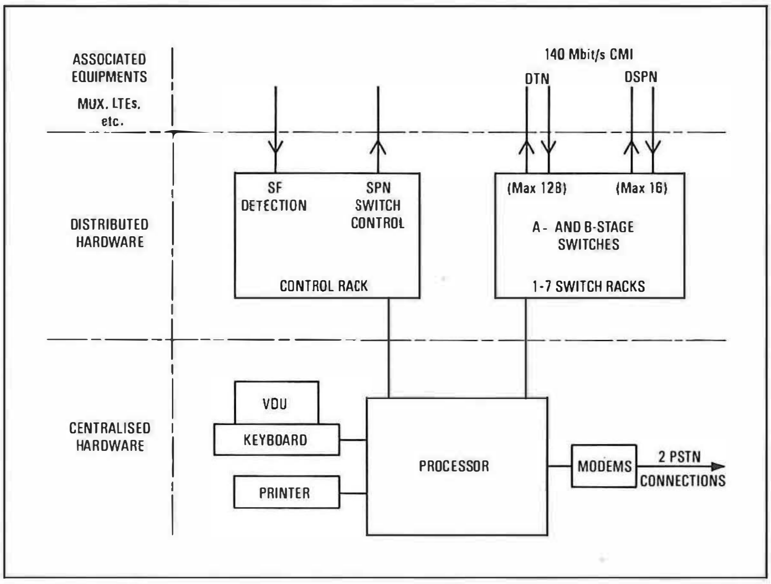



**Figure 1**
**ASDSPN hierarchy**

**Figure 2**
**TS hardware**




## Hardware

The primary contractor designed the system around a bought-in proprietary design of processor and its related VDUs and printers.

This approach resulted in the ASDSPN TS equipment being partitioned, as shown in Figure 2, into:

(*a*) *Centralised hardware*, which is mounted on a dedicated desk (Figure 3) located in the maintenance area of a TS. The desk top holds a VDU and printer, with the processor and PSTN modems mounted in a pedestal. This equipment is mains power operated.

(*b*) *Distributed hardware*, which is built in standard BT TEP-1E construction practice and comprises one control rack and up to seven switching racks. This hardware is located in the main equipment area of the TS and operates off a centralised −28 or −48 V supply.

The NMCs are located in an office-type environment and operate off a mains power supply. The only difference between the NNMC and the RNMCs is the number of VDUs provided, as indicated in Figure 4.

A pseudo-geographic display board, 7 m × 3 m in area, is provided at each NMC, as illustrated in Figure 5. The display board shows the whole DSPN and uses light-emitting diode (LED) indicators to indicate the availability of DSPN DSs on each route. By flashing the LEDs, it also shows a make-good path that has just been implemented, or is being planned.

Consideration was given at the beginning of the project to using either a large-screen VDU or a projection system instead of the LED display board. However, this was rejected on the grounds of cost in development and the unproven technology available at that time.

**Figure 3—TS control desk**

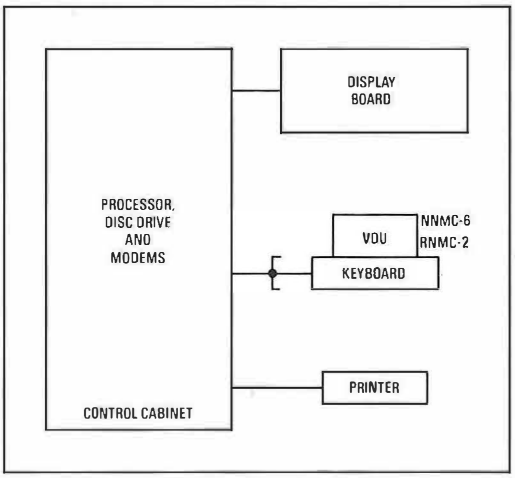



**Figure 4**
**NMC hardware**

**Figure 5**
**NMC display board**

## Basic Operation

The restoration of service by switching traffic from a failed DTN DS on to a stand-by path is called *making good*. To enable the system to make good in the fastest practical time, each TS processor holds a set of pre-programmed make-good plans as well as data on the availability of the DSPN DSs. This enables it to implement a make good without having to refer to a processor higher in the management hierarchy, that is, its RNMC.

Figure 6 illustrates a simple example of the basic operation of a make good.

Consider a DTN line system, terminated at both ends by a multiplex equipment (MUX) at TS3 and TS4. If this system fails in the direction incoming to TS4, the line terminal equipment (LTE) at TS4 detects the failure and generates an SF condition. The SF condition is detected by this TS's ASDSPN equipment, which attempts (initiates) a make good. The TS4 processor selects a make-good plan and signals, at 375 kbit/s, over the 140 Mbit/s DSPN path to be used to the processor at TS3. In this example, as TS4 is the only initiating TS (that is, a uni-directional fault), TS4 now takes the role of a 'leading TS' and asks the TS3 equipment to assist, as a 'co-operating TS', in first testing the path, then diverting traffic on to it from the failed DS.

If the fault was bi-directional, it would be detected at TS3 and TS4 and both would initiate action. When the two processors are in communication, they would apply certain rules to determine which of the two leads the make good and which co-operates.

The make-good path could comprise several DSPN DSs connected in tandem, in which case the leading TS communicates in turn to the processor at each intermediate TS on that path and requests a connection through to the co-operating TS.

In practice, the multiplex equipments shown in Figure 6 could be line terminal equipment or any other equipment (for example, a TV codec) connected to the protected line system.

Once the urgent matter of restoring traffic has been dealt with, follow-up action commences to advise processors and staff at various locations of the switching event.

Referring the example back to Figure 1, it can be seen that TS4 reports to RNMC2 which takes control of that particular switching event. All TS processors concerned with that switching event automatically report their action to RNMC2. Where a TS is controlled by a different RNMC, for example, TS3, it reports over the PSTN to its own RNMC which automatically passes the message on to RNMC2 via the PSS. RNMC2 collects the TS reports and passes a summary up to the NNMC.

If an automatic make good cannot be implemented, a report is sent to the supervising RNMC. RNMC2 will then attempt a make good selected from a second set of make-good plans. If this is not successful, a prompt alarm is raised at TS4 and RNMC2 to enable staff to consider whether a manually-initiated make good can be implemented by any other path. For example, suitable DSPN DSs could be made available either by diverting existing make goods on to other paths, or by stopping planned work on DSPN DSs or DTN DSs previously made good.

## Database and its Dissemination

To enable the ASDSPN processors to function automatically, they require access to certain information or data. This data falls into four classes:

(*a*) *Current network*. This gives details of the following:

- ASDSPN nodes (NMCs and TSs).
- DTN DSs.

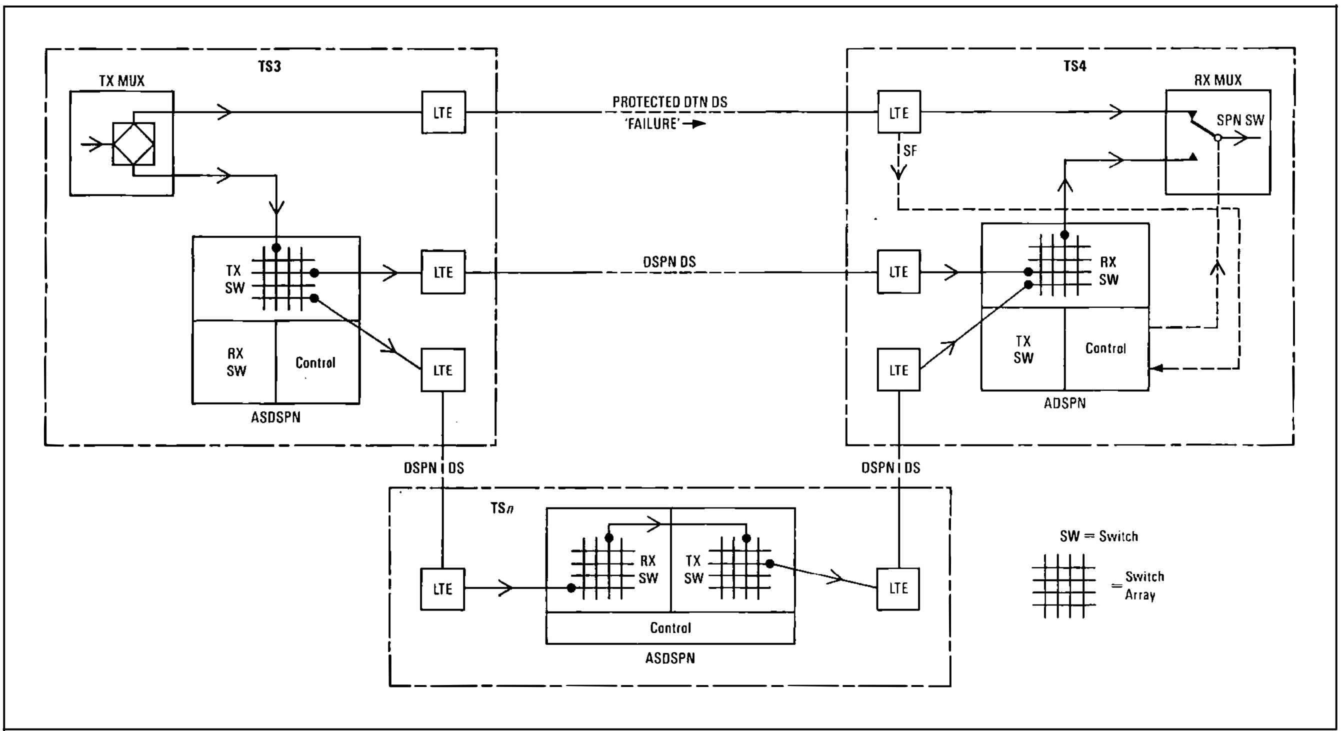



Figure 6
Make-good sequence

● Digital blocks, and the DTN DSs from which they are formed.
● DSPN DSs.
● Make-good plans.

(*b*) *Current Abnormality*. This identifies abnormality in the network; for example:

● DTN DSs made good and the DSPN paths used.
● Unavailable DSPN DSs, in use or faulty.
● ASDSPN nodes out-of-service.

(*c*) *Future Planned Work*. This contains details of switching planned for the next six months; for example:

● DTN DSs to be made good or restored.
● Times.
● DSPN DSs to be used.
● Responsible RNMC and authorisation node.

(*d*) *Local Configuration*. This contains the hardware build of a ASDSPN node; for example:

● Number of switch racks in a TS.
● Connections to the ASDSPN equipment; such as, which DS is connected to which port of the switch.
● Identity of authorised operators and their passwords.

The local configuration is specific to each node and is entered at that node. However, the current network and current abnormality data are common to the whole network and, to avoid mis-operation, it is important that the processors in all TSs, RNMCs and the NNMC have the same data. To achieve this, such data is only entered at the NNMC and then automatically disseminated to all RNMCs and TSs as necessary. In line with this practice, all switching events are automatically reported up, via an RNMC, to the NNMC for entry in a current abnormalities file, then disseminated down to give a non-urgent in-station alarm at all nodes concerned, with a printed summary and a VDU display of the event.

A study of the data communications requirements, other than those for actually implementing a make good, took into account the amount of data to be transferred, the frequency of use, and the reliability of the data paths, especially when multiple failure conditions are present in the DTN. This study concluded that the PSS should normally be used for communication between NMCs, and the PSTN for communication between a TS and its RNMC or other TSs. In the event of a PSS failure, inter-NMC communications is automatically re-routed via the PSTN.

To guard against loss of the database, all RNMCs hold a copy of the NNMC database and each NMC can have two other NMCs nominated so that either one can take over its responsibilities in the event of a failure.

### Limits on Automatic Operation

It is fundamental to the design philosophy that the ASDSPN can only initiate automatic switching within defined limits, so that uncontrolled situations are prevented. As an example, ASDSPN does not generate its own make-good plans, but selects one, when necessary, from a set of plans formulated elsewhere and previously entered at the

NNMC and disseminated to all nodes concerned.

## Switching Requirements

### *Make Good Time*

Problems with DS settling time, described later, dictated that the fastest make-good time should be 4 s. CCITT Recommendation G.821[2], which gives 10 s as the threshold between impaired service and non-availability, determined the upper limit.

### *Switching speed*

Switching of traffic from one good path to another, that is, restoring or switching for planned work, is specified to cause an interruption of less than 20 $\mu$s at 140 Mbit/s. This interruption, plus the inevitable phase slip, will cause realignment of subsequent demultiplexing such that the interruption at a 64 kbit/s port is less than 15 ms on 90% of occasions.

### *Switching Devices*

Coaxial relays are satisfactory for simple 1-for-*N* type route-protection schemes but, because of inherent crosstalk, physical size and power consumption, are not considered suitable for large switch arrays operating at 140 Mbit/s. To permit an adequate length of in-station cabling, the switch array must be regenerative and provide standard CMI interfaces which permit up to 12 dB of cable loss at 70 MHz. This gives a cabling limit of 120 m, using the BT standard Cable Coaxial No. 2003.

### *Switch Array Configuration*

The ASDSPN 140 Mbit/s switch array is illustrated in Figure 7. The array uses space-division switching in two stages and provides non-blocking full-availability to the DSPN DS ports.

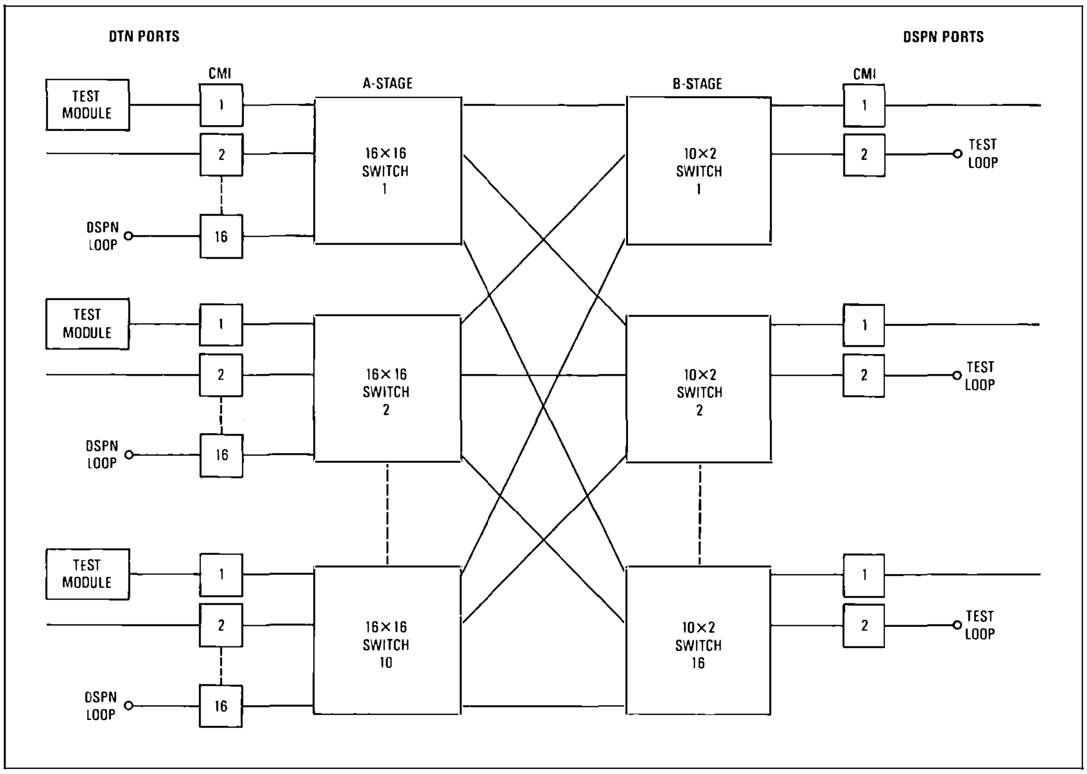
The A-stage switches use 16 × 16 matrices and the B-stage 10 × 2 matrices. This configuration allows a maximum capacity of 160 DTN DS ports and 16 DSPN DS ports. In practice, the full DTN capacity is reduced by the requirements for test-module access and loopbacks, to a working limit of 128 DTN DSs. These loopbacks are used when one DSPN DS is required to be connected to another at an intermediate station on a make-good path. In very large TSs where the maximum capacity of an array is exceeded, two independent ASDSPN TS equipments can be used with DSPN ties between them.

The loopbacks at the DSPN ports permit automatic routine testing of paths through the switch array by test modules. Such testing can be extended over a DSPN DS to a DTN loopback at another TS.

## 120 and 565 Mbit/s Operation

The ASDSPN was designed for protection switching at 140 Mbit/s; however, BT has a number of line systems operating at 120 and 565 Mbit/s.

**Figure 7**
**Maximum switch array**




CMI: Code mark inversion, 140 Mbit/s interface units
*Note*: All connections represent both directions of transmission

With about 100 line systems operating at 120 Mbit/s, it was decided for economic reasons not to provide protection at this rate. Instead, 120-to-140 Mbit/s converters were developed, to enable the 120 Mbit/s line systems to be protected by the 140 Mbit/s DSPN. To enable the 140 Mbit/s path within the 120/140 Mbit/s converters to be self monitoring, these equipments need to be looped, transmit to receive, at their 140 Mbit/s ports when in their normal 120 Mbit/s mode of use. With ASDSPN, this looping facility is provided by looping the interstage side of the A-stage switch, this loop being automatically removed when a protection path is set up.

For economic and technological reasons, current 565 Mbit/s line systems are designed with integral multiplexing and give no access to the 565 Mbit/s signal. Therefore, they are treated as four 140 Mbit/s DSs and protected by switching at this rate.

With the need to augment the DSPN commensurate with the growth of the DTN, some 140 Mbit/s DSs within the 565 Mbit/s systems will normally be used for protection. This has the advantage of reducing the number of 140 Mbit/s DSs that need to be made good when a 565 Mbit/s system fails.

### Reliability

Part of the reliability of ASDSPN equipment is provided by the modularisation into centralised-battery operated distributed hardware (the switching racks), and mains-operated centralised hardware (the processor). If the centralised hardware fails, the current state of the switch array is maintained so that the traffic on any make-good paths in use is not at risk. This means that further automatic switching cannot be implemented, although make goods and restorations can be carried out by manual patching on the switching racks. Most faults on the switching racks will only affect a few of the possible make-good paths. Again, these can be put right by manual patching, or by changing cards.

To meet a general SPN requirement mentioned in Part 1 of this article, under the heading 'Access for Protection', the ASDSPN provides a non-volatile memory of any switching events by holding the database on a hard magnetic disc. If the disc is damaged, the data is recovered from another ASDSPN node when the disc is replaced.

### Problem Areas in Design

#### *Jitter Performance*

BT has calculated that up to 32 digital sections may be connected in tandem before the input jitter tolerance limit of CCITT Recommendation G.823[3] is exceeded. For design purposes, it was assumed that the maximum number of DSs in a digital block is eight, and one DS may be made good by manual initiation with a path comprising 16 DSPN DSs, giving 8−1+16=23 DSs in tandem, as shown in Figure 8. If any one of these DSs fails and is automatically made good with a path comprising eight DSPN DSs, this would give 23−1+8=30 DSs in tandem. Such an arrangement would have 26 ASDSPN switches in the path at various TSs. The above indicates that the 30 DSs in tandem could accumulate sufficient low-frequency jitter to reach the threshold of the terminating multiplex equipment (MUX) and hence a very tight jitter specification must be imposed on each of the 26 ASDSPN switches.

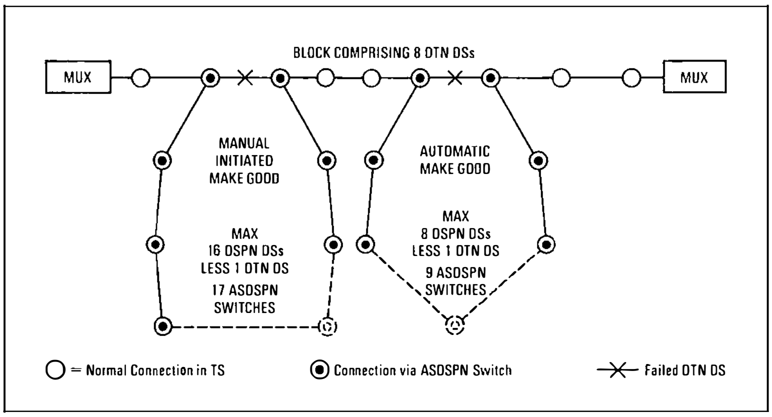



**Figure 8**
**Maximum path length**

#### *Line System Settling Time*

Each DSPN DS in an ASDSPN is normally fed by an idle signal driven from a local clock. When a manually-initiated make-good path of 16 DSs is set up, a DS may, depending on its location in the path, experience up to 19 sequential changes of clock rate.

Each time the clock rate is changed, a DS needs a certain time to settle to error-free transmission. This is an unspecified parameter and, in practice, a wide spread of settling times has been found, ranging from a few milliseconds up to 2·2 s. A tester has been developed so that any line systems taking over 400 ms to settle can be identified and corrected.

When the effects of settling time were realised, the ASDSPN equipment was modified to limit the slew of the bit rate at its DSPN output ports so that the robust ASDSPN signalling would be successful, despite errors occurring in the 140 Mbit/s path. However, software time-outs had to be used to allow the overall make-good path to settle before a 140 Mbit/s error-ratio test was performed and the traffic switched.

In addition to errors, some DSs may generate a system fail (SF) condition and inject an *alarm indication* signal (AIS). The latter would interrupt the ASDSPN signalling and possibly cause the make good to fail while the system fail condition could initiate an unwanted make good of the make-good path.

BT is currently preparing specifications to limit settling time of new designs of DS.

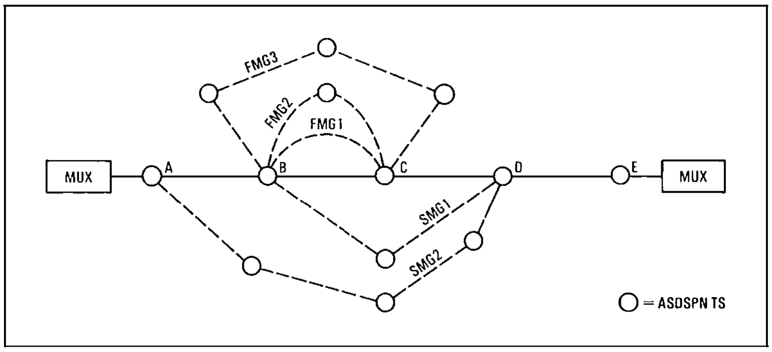
## SWITCHING FACILITIES

The following basic types of switching facility are provided by the ASDSPN.

### Fast Make Good

To expedite make goods and to minimise the effects of multiple system failures when the data links between TSs and RNMCs may be unavailable, it was decided that each TS should be able, automatically, to initiate make goods without referring to an RNMC. To do this, the processor in each TS works to a set of pre-programmed make-good plans. This type of automatic make good is called a *fast make good* (FMG), and some examples are illustrated in Figure 9. For an FMG, the initiating TS is also the lead TS.

**Figure 9**
**Make-good paths**




Example shows four DSs forming a digital block with a failure B to C

A TS database can hold up to eight FMG plans for each route terminating at that TS, a route being one or more DSs connected in parallel between two TSs. Each DS on a route may follow a different geographical path and be provided by different types of transmission media; for example, coaxial cable, optical fibre or radio. Each FMG plan may comprise up to eight DSPN DSs connected in tandem via other TSs in the ASDSPN and may be used for any DS on a particular route; that is, all DSs on any one route have the same set of FMG plans. Note that any DSPN DS may be a member of many FMG plans for different routes.

It is intended that an FMG should be available for about 90% of failures. The precise figure will depend on the number of DSPNs actually provided and whether they are available when required. There is a need, therefore, for the NNMC to limit the amount of non-emergency (planned work) usage of the DSPN at any one time.

### Slow Make Good

If an FMG path is not available, an initiating TS will call its RNMC, via a modem, over the PSTN. The RNMC normally holds a further set of plans, called *slow make good* (SMG) plans, because of the relatively long connect time of the PSTN. A make-good path is selected and passed, if necessary via another PSTN connection, to an appropriate TS (the lead station) for implementation. Except under multiple fault conditions, when congestion may exist in the telephone network, an SMG is generally completed within about 40 s.

Like an FMG, an SMG path may comprise up to eight DSPN DSs connected in tandem. However, an SMG path differs in that it may bypass more than one DTN DS in tandem, as shown in Figure 9. An SMG may also use non-ASDSPN TSs (that is, using manual patching) except at the lead TS. When a manual patch is required, the RNMC processor asks its operator to arrange for the necessary patching to be made. When the operator confirms this has been done, the rest of the make good is implemented automatically.

### Manually-Initiated Make Good

If an automatic FMG or SMG cannot be implemented, a prompt alarm is raised in both the initiating TS and its controlling RNMC. In this case, an operator, in either location, can manually initiate a make good by using a path of up to 16 DSPN DSs connected in tandem and formulated especially for that failure.

Manually-initiated make goods may be required for reasons other than lack of FMG and SMG plans; one example being where unmonitored parts of a line terminal equipment fail and an SF condition is not generated. In this case, a station alarm will be raised at a subsequent equipment to alert staff.

### Restoration

Switching of traffic back on to its normal DTN path is called *restoration*. For any restoration, the lead TS first calls over the PSTN to any intermediate TSs on the protected DTN path to check that the path is good for service before co-ordinating the restoration with the co-operating station.

After restoration, the lead TS calls all TSs on the make-good path, via the PSTN, and instructs them to release the DSPN DSs that were being used.

After an automatically-initiated make good, three modes of restoration are possible:

(*a*) automatic, 30 minutes after the SF condition is removed,

(*b*) automatic as (*a*), but only outside the normal busy periods, or

(*c*) manually-initiated restoration after the SF condition is removed; that is, no automatic restoration.

The restoration mode and the normal busy periods required by (*b*) are pre-programmed, individually, for each route in the network. Automatic restoration as (*a*) or (*b*) above is not available for a manually-initiated make good.

### Traffic Management

Under multiple fail conditions, when all available make-good paths have been used, it is sometimes possible to optimise the use of the DSPN DSs by transferring traffic from one make-good path to another, so as to release certain DSPN DSs for any outstanding failures.

The following facilities are also provided to maximise the flexibility of the system:

(*a*) *Delayed operation* A make good or restoration, programmed for automatic implementation at some future time,

(*b*) *Inhibiting* Preventing the make good of a sub-standard DTN DS, or the use of a DSPN DS, and

(*c*) *Forcing* Switching traffic on to a sub-standard DSPN DS, or back on to a sub-standard DTN DS. This facility requires a confirmatory command to avoid accidental operation.

These facilities are collectively known as *traffic management*. As they can give rise to complex network switching activities, additional software is provided at the RNMCs to prevent an operator unintentionally disconnecting traffic.

### Make Good of a Make Good

If a DSPN DS fails while in use, it will be automatically made good by any available FMG path. The ASDSPN ensures that on restoration, the traffic switches directly back to its normal path, not via the first make-good path.

### Planned Work

Planned work, as mentioned in Part 1 of this article under the heading 'Other Uses', can be formulated by an RNMC up to six months in advance and submitted to the NNMC for approval, before the NNMC equipment automatically enters it into the main database. This means that any RNMC can display approved planned work to assist in formulating other new plans.

A planned-work event is automatically implemented, subject to an operator, at a nominated node, authorising a request to proceed.

### Casual-User Traffic

Facilities are available to use DSPN DSs for casual-user traffic. Such traffic is provided with normal automatic protection and is classed either as *secured* or *unsecured*. In the latter case, if any of the DSPN DSs being used are required to make good other traffic, the service will be automatically disconnected. Such a service could be offered at a lower rental; for example, for transmission of video signals between TV studios, in situations where these signals can be retransmitted, if necessary.

## OPERATIONAL ASPECTS

The following operational points were identified while planning the introduction of the ASDSPN.

### Co-ordination

For smooth operation of an ASDSPN, it is essential to review traditional operational practices and co-ordination between the various departments concerned with installation, commissioning, circuit provision, maintenance and network management. The correct sequence of changing hardware connections and changing network data in the ASDSPN databases is very important; for example, those changes necessary for re-routing a digital block on to different DSs, especially if any concerned DS is made good at that time.

### Database Entry and Dissemination

The ASDSPN was originally designed so that data describing the network and make-good plans would be manually entered at the NNMC. Detailed study indicated that, ideally, for the BT network, 20 or more operators may be required full time over the first two years to enter all the data for ASDSPN. This is because of:

(*a*) the continuous overall growth of the DTN,

(*b*) the progressive installation of ASDSPN equipment, and

(*c*) the desire to frequently optimise pre-programmed make-good plans, as the network changes.

The current network data is already available in a network management database (MANUS: *MA*in *N*etwork *U*tilisation *S*ystem). This data will be periodically processed by a separate program to produce automatically optimised make-good plans. This new network and its optimised make-good plans will then be loaded into the ASDSPN NNMC database.

In order to make this work load more manageable, it could be automated by transferring the data by tape, computer to computer. Alternatively, if manual entry is retained, the work load could be made more manageable by reducing the number of SMG plans being entered, especially at times when there are a large number of changes in the network configuration. This is a reasonable assumption as SMG plans form the largest part of the data, but are normally used only in the occasional event that an FMG plan is not available for a particular failure.

Once network modernisation is completed and ASDSPN is fully installed, there should normally be no difficulty in using manual entry to optimise make-good plans. Adjustment of the data can be made manually, and as necessary, between periodic downloads, whether the downloads are automatically or manually entered.

### Design Control

Because of the complexity of the design, it was recognised that, when the network is brought into service, it will require an efficient support organisation, which BT has based on experience of operating System X exchanges. The purpose of this support will be to control:

(*a*) System build and compatibility. This will be met by a database holding the issue numbers of all items of hardware, firmware† and software, for each node in the network.

(*b*) Investigation of service problems. This will be carried out on an out-of-service network containing current issues of hardware, firmware and software, and controlled by the Operational Support Division.

(*c*) Evaluation of design changes for remedial and enhancement purposes. This will be carried out on a separate test bed containing new issues of hardware, firmware and software, and controlled by the System Engineering Division.

The test networks used in (*b*) and (*c*) would each, typically, contain equipment for one NNMC, one or two RNMCs and a number of TSs.

## CONCLUSION

This article has described the features of what will probably be one of the largest interactive computer networks in the UK for some time. As an indication of its complexity, it has the same order of application software as the central processor of a System X exchange, although the latter has considerably more processing power distributed in the form of firmware.

† Firmware is executable code or data held in a read only memory device.

In common with many other projects which involve a considerable effort in software development, the initial estimates have, with the benefit of hindsight, proved over optimistic. Consideration is now being given to postponing the introduction of some of the more advanced facilities described in this article in order to achieve the prime objective, which is to bring the basic ASDSPN fully into service in 1989.

## ACKNOWLEDGEMENTS

The author would like to thank his colleagues, in the ASPRIN development group, who have contributed so much to the project. Acknowledgement is also given to Plessey Transmission Systems at Beeston, Nottingham, for permission to publish the photographs used in Figures 3 and 5.

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2 CCITT Recommendation G.821 Error Performance of an International Digital Connection forming part of an Integrated Services Digital Network. CCITT Red Book, Fascicle III.3, 1984.

3 CCITT Recommendation G.823 The Control of Jitter and Wander within Digital Networks which are based on the 2048 kbit/s hierarchy. CCITT Red Book, Fascicle III.3, 1984.

### Biography

Mike Schickner is Head of Group in Network Systems Engineering Transmission Division of BT UK Communications. He joined BT, in 1948, as a Youth-in-Training in the London South West Area, mainly employed on internal construction. After serving two years National Service in the Royal Signals Regiment, he returned to Long Distance Area in London. As a Technician he spent some time in trunk test and on repeater station maintenance before assisting in the commissioning and operation of the transatlantic test terminal and TASI equipment. During this period, he studied to obtain a City and Guilds Full Technological Certificate in Telecommunications. Promoted, in 1960, to Assistant Executive Engineer at HQ Lines Branch, he was involved in the development of test and FDM multiplex equipment and studied by day release to obtain a HNC and endorsements. Promoted to Executive Engineer in 1967, he commenced development of 24-channel PCM systems before moving on to higher-rate equipments and systems; development of 120 Mbit/s coaxial line systems and the associated multiplex equipment. On promotion to head the same group, he became responsible for development of all coaxial line systems, digital multiplexing above 2 Mbit/s and service protection systems.

# Martlesham Medal for Cable Television Pioneer

Mr. Bill Ritchie, a British Telecom research engineer whose ideas were vital to the development of a world-leading switched-star cable-television network, has been awarded the Martlesham Medal. Mr Ritchie, who has spent almost two decades developing and improving telecommunications transmission systems, was presented with the medal at a ceremony at the London Telecom Tower.

Mr Iain Vallance, Chairman of British Telecom, said: 'Mr Ritchie's work in recognising the potential of wideband networks, and heading the team which developed and designed the switched-star system, is a prime example of applying leading edge research techniques to practical problems.'

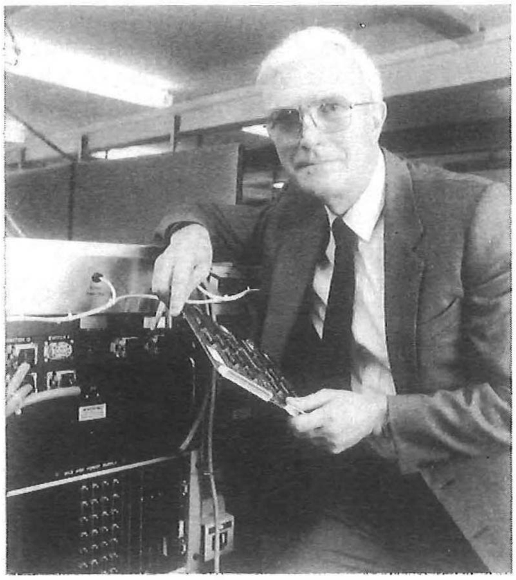
The switched-star multiservice network developed by Mr. Ritchie is the most advanced of its kind in the world, making extensive use of optical fibre. It is now being installed for, and operated by, Westminster Cable TV Ltd., and provides a level of cable television, interactive services and data transmission with otherwise unachievable economy.

'The work was carried out to a very tight timescale—little more than two years from preliminary study to practical operation,' commented Mr. Vallance. 'It is a further tribute to the skill of the team that equipment costs—on which the viability of the system depends—were kept to the original targets.

'Technically, the switched-star system is the most advanced in operation in the world. Our British Telecom research establishment at Martlesham has a high reputation for forward-looking research and development. But in the final analysis, it is the application of research to meet customer needs that is of real importance. And that is what Bill Ritchie has achieved.'

Mr. Ritchie joined British Telecom in 1949 as a Youth-in-Training in Glasgow. While working as a technician, he studied at Strathclyde University between 1956 and 1959, qualifying in Electrical Engineering. He then realised his long-standing ambition to work in research and development by moving to the company's research department, at that time based in Dollis Hill, London. He began the development of wideband systems in 1980 and, from 1982, worked specifically on the switched-star system. In a two-year period, Mr. Ritchie built up a multi-disciplined team; designed and specified equipment prototypes; identified commercial manufacturers; and supervised the installation and commissioning of the system.

Trial transmissions were made over the system in 1984, and British Telecom began installing the Westminster Cable TV system in April 1985. The problem Mr. Ritchie and his team faced was to reach a compromise between the relatively cheap but inflexible tree-and-branch network architecture and the prohibitively expensive star configuration. At this time, cable TV had almost exclusively used a coaxial tree-and-branch network. It is an economical method of distributing TV and an effective means of controlling customer access. However, when it comes to handling the very large numbers of individually routed signals required for a comprehensive interactive service package, problems of congestion, delay, addressability, and security become severe. Also, since all information is delivered to every part of the network, increase in capacity can only be achieved by augmenting the whole network, including the final customer link which involves most of the cost.



**Bill Ritchie, 1988 Martlesham Medal winner**

A star network largely overcomes these problems but the cost and engineering complexity of broadband links from the head-end to each customer is prohibitively expensive at the moment. In a switched-star network, communication between the head-end and a switch point located near to the customer is by shared trunk circuits. Communication between switch points and the customer is by individual links which carry only the information requested by the customer. The switch point acts as a common access point and message concentrator, effectively utilising the head-end-to-switch-point transmission capacity. This network can approach the cost of the tree-and-branch network, and has all the advantages of the star network. There is a capacity limitation in the head-end-switch-point communications, but this can readily be augmented when traffic growth demands it.

# In the Beginning There Was . .

## Memoirs of a Telecommunications Engineer

W. J. BRAY, C.B.E, M.SC., C.ENG., F.I.E.E., F.C.G.I.†

UDC 621.39 (091)

*This article is based on the address given by Mr. W. J. Bray, Director of Research of the British Post Office from 1966 until his retirement in 1975, to the Martlesham Heath Centre of the Institution of British Telecommunications Engineers (IBTE) on 4 January 1988. In his address, Mr. Bray reviewed some of the highlights in the history of telecommunications from the 1920s to 1975 in which he was involved directly or observed at close hand*.*

### INTRODUCTION

It has been my good fortune to have been involved in, or to have seen at close range, one of the most exciting and significant periods in the history of telecommunications—the half century from 1925 to 1975.

This period saw telegraph and telephone communications develop from systems spanning a few miles to a global network of cables under the oceans and satellites poised 22 300 miles above the equator. It saw inter-city links grow from single telephone circuits on pole-mounted copper wires to coaxial cables, microwave links and glass-fibre cables providing thousands of telephone circuits and many television channels. It saw the switching systems that connect communication users develop from primitive manual exchanges linking a few subscribers to computer-controlled exchanges capable of connecting any one user to the 500 million or more in the world network.

The period 1925 to 1975 includes the development of broadcasting from its crystal-set-and-headphone beginning to stereophonic sound broadcasting and colour television from distant planets.

It saw too the birth of a new phase of the telecommunications art—the evolution of data communication systems and information access, visual display systems such as the British Post Office's (BPO's) *Viewdata* (now British Telecom's *Prestel*) and the teletext services of the British Broadcasting Corporation (BBC) and Independent Broadcasting Authority (IBA), and the beginning of conference television (BPO's *Confravision*).

These developments in system concepts were accompanied by an evolving technology in which the thermionic valve was replaced by the transistor, individually-wired components by the microchip, bulky and slow-moving electromechanical switches by fast solid-state electronic switching, analogue transmission and switching by digital methods, and copper wires bearing relatively low-frequency electromagnetic waves by glass fibres carrying light waves generated by lasers.

The expanding range and scale of services provided by telecommunications and broadcasting clearly have a major impact on the way people live, work and use their leisure, and on the business and social worlds, an influence that will extend into the future with even greater effect.

The stage is so wide that it will only be possible in this article to touch on a few highlights in which I happened to become involved. (An authoritative and detailed account of BPO telecommunications and postal engineering contributions in the years 1906 to 1981 is given in references 1 and 2.) However, to set the stage, perhaps a few personal reminiscences are permissible.

### EARLY DAYS

To a schoolboy in the 1920s, the advent of sound radio broadcasting opened up a fascinating new world to explore. Notwithstanding the constraints of limited pocket money, a crystal receiver could be made at home. And what could match the thrill of acquiring one's first thermionic valve and building an amplifier that really worked? A rewarding discovery in a local library was a remarkable book called *The Boy Electrician* by Morgan—remarkable because it taught the aspiring young electrician not only how to make simple electric motors, telephones, batteries and the like, but also instructed him in the quantitative aspects by showing him how to make, calibrate and use voltmeters, hot-wire ammeters, standard cells and resistors, and a Wheatstone bridge, all from the simplest of materials within range of a schoolboy's pocket.

This early interest in things electrical led to an apprenticeship in the Royal Naval Dockyard, Portsmouth, where the excellent, if severely competitive, Dockyard School and thorough training in workshops and on ships

† Former Director of Research, British Post Office
* Mr Bray's memoirs are available in book form: *Memoirs of a Telecommunications Engineer*. See p. 80 of the April 1988 issue of this *Journal*.

provided first-class training in electrical engineering.

The Dockyard electrical scrap heap provided, although unknown to my charge-hand, means for constructing a high-quality moving-coil loudspeaker at a time when most domestic radio receivers had to be content with the tinny sounds of a horn and moving iron diaphragm. Another unauthorised construction from Dockyard scrap was a Baird-type spinning-disc 30-line television receiver that actually received crude flickering postage-stamp size television pictures from 2LO, the BBC medium-wave transmitter in London.

The Dockyard training led in 1932 to a Royal scholarship and a degree course in electrical engineering at the City and Guilds Engineering College in Kensington under the stimulating leadership of Professor C. L. Portescue, former President of the Institution of Electrical Engineers. As Secretary of the College Radio Society, I am proud to have invited Robert Watson-Watt (later Sir Robert and master-mind of wartime radar) to lecture, his subject then being the location of thunderstorms by radio direction-finding.

In these days when research is supported by almost unlimited laboratory equipment and massive computer power, one's higher degree research at Guilds in the 1930s involved the purchase of a few pounds worth of resistors, capacitors etc. in the London radio junk shops and biscuit tins for screens!

By 1935, the time had come to find a job—not easy because unemployment, then as now, was high and competition for work was severe. I applied, via the Open Competition, for a job as a BPO Assistant Engineer. The selection was by interview, the Chairman of the interview board then being A. J. Gill who later became Engineer-in-Chief of the BPO. A key question at the interview was 'did I believe in the objective existence of the sidebands of a modulated radio carrier wave?'

It may seem strange today that there should have been any doubt about the existence of sidebands but at that time there were two schools of thought, one attributed to Professor Fleming of University College holding that they were no more than a convenient mathematical fiction, whereas Professor Fortescue at City and Guilds College had shown by a convincing experiment that they were real, see Figure 1. Having seen this demonstration, I replied with a confident 'Yes!' and the job was mine.

After the usual induction course at Dollis Hill and a short period of training in a BPO Region, I joined the Radio Experimental Branch of the BPO at the Dollis Hill Research Station. And so began a career in telecommunications that proved to be full of interest and immensely rewarding. Since much of it was initially in the field of radio, it is perhaps appropriate briefly to review the radio services of the BPO in the pre-War years.

## PRE-WAR RADIO SERVICES OF THE BPO

Radio played an important part in the services provided by the BPO, ranging from world-wide radio telegraph and telephone communication between fixed stations and to ships, to shorter range communication and security services to coastal shipping via the BPO network of coastal radio stations. In addition, the BPO was also responsible to Parliament for the regulation and control of radio broadcasting, the use of the radio frequency spectrum, the licensing of—and detection of unlicensed—transmitters and receivers, and the suppression of radio interference.

These radio services were managed by the BPO Administration, with support from the BPO Engineering Department at Headquarters and in the Regions, and the Radio Experimental Branch at Dollis Hill.

The scale and scope of BPO radio engineering projects were impressive by any standards. The long-wave radio telegraph transmitter GBR at Rugby, operating at 16 kHz, was, and is, one of the most powerful in the world. It provided broadcast telegraph press and news services and standard time signals from the Royal Observatory at Greenwich to ships at sea and land stations throughout the globe. Its vast aerial array, Figure 2, mounted on twelve 820 ft high masts and extending

**Figure 1**
**Demonstration of the objective existence of sidebands of a modulated radio carrier wave (c. 1930)**

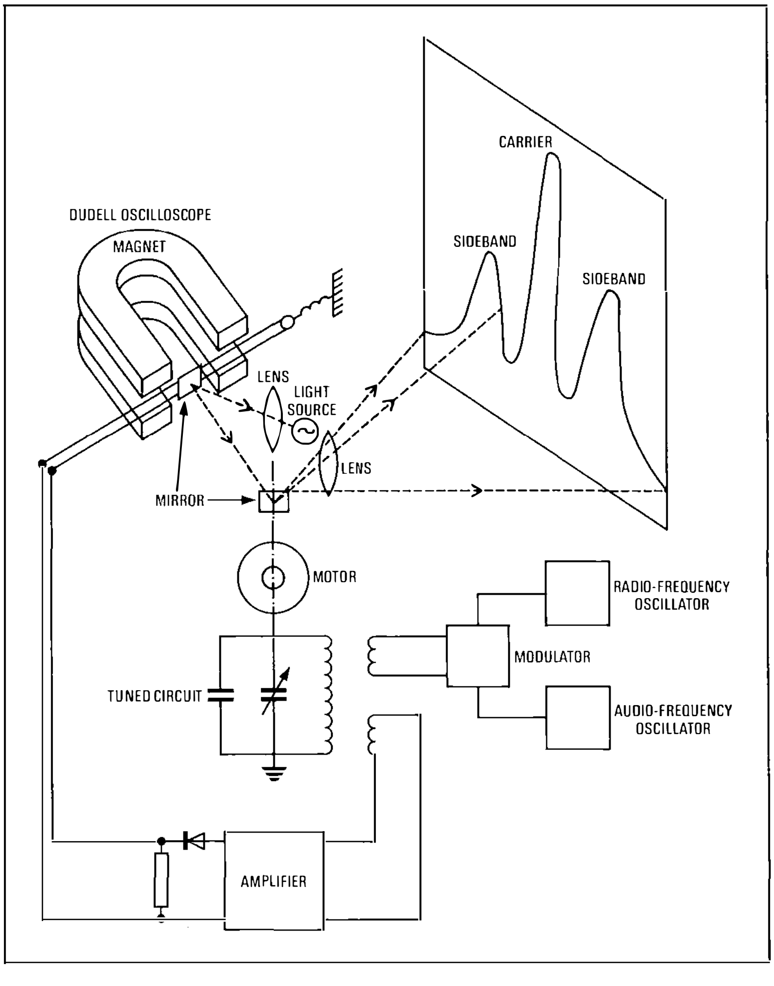
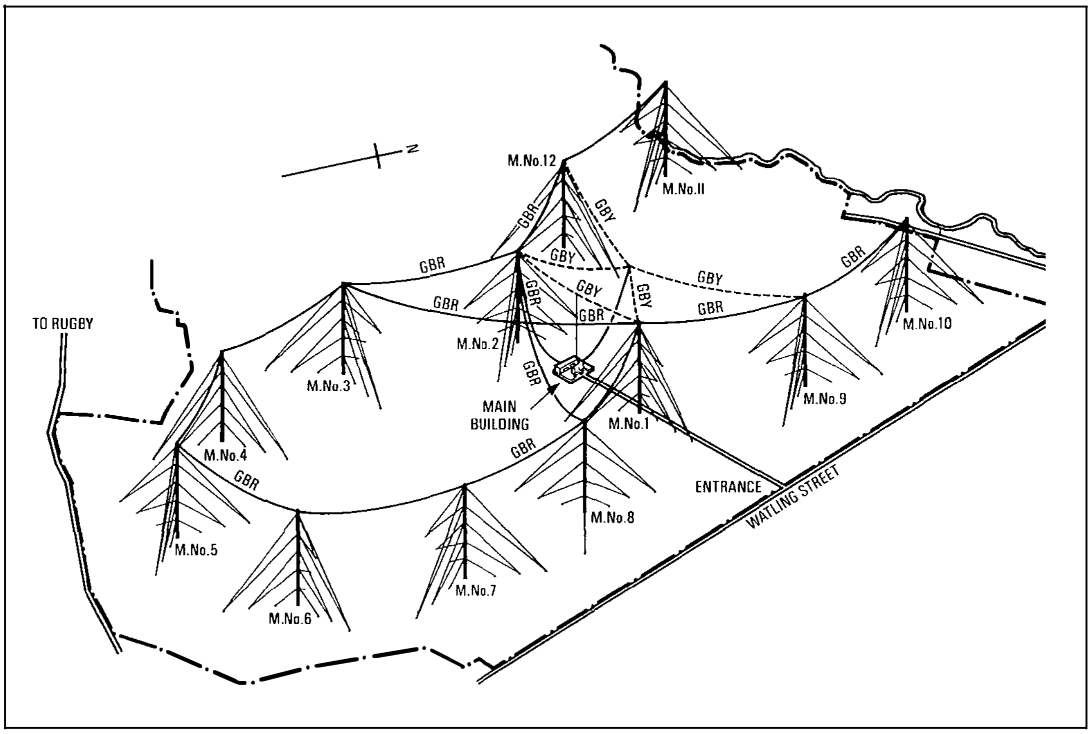


**Figure 2**
**Rugby Radio Station**




*Note*: The GBR (16 kHz) long-wave aerial system is supported on 12 masts, each 820 ft high and weighing 200 tons. It occupies a site about 1·25 miles long and 0·75 miles wide

over a mile, radiates radio waves of 18 750 m wavelength. These very long radio waves propagate freely, by diffraction and guidance between the ionosphere and the earth, from Rugby to its antipodes on the far side of the globe. They also penetrate into sea water and thus provide a means of communication with submerged submarines.

One of my first tasks after joining the Radio Experimental Branch was to measure the impedance of the GBR aerial—the sight of the huge up-lead, several feet in diameter, carrying 1000 A or so of 16 kHz radio-frequency current into space was itself daunting to a young engineer used only to small-scale laboratory equipment. Even more so was the realisation that the aerial was an efficient collector of lethal voltages from thunderstorms anywhere in the Western hemisphere!

Another long-wave transmitter, GBY operating on a frequency of 50 kHz, 6000 m wavelength, provided a single telephone circuit to North America, known as the *Transatlantic Telephone* (TAT). Because of the large aerials and high-power transmitters involved, this was a costly communication channel and call charges were correspondingly high. Furthermore, because of the low frequencies involved, there was little frequency space available for more telephone channels in this part of the spectrum and this had to be shared with several countries. Radio transmission on long waves was relatively stable and the TAT often continued to be usable when the short-wave services were disrupted by ionospheric storms.

Until the advent of the first transatlantic submarine telephone cable in 1956, and apart from the long-wave TAT, all long-distance intercontinental telephone traffic had to be carried on short radio waves; that is, between about 10 and 30 m wavelength or 30 to 10 MHz frequency. The wider spectrum offered scope for many more telephone channels and the engineering costs were appreciably less than for long waves since the transmitter powers required and aerial sizes involved were much smaller. The quality and reliability of the short-wave radio-telephone services were, however, limited by the imperfections of wave propagation by reflection from the E and F layers of the ionosphere and the dependence of these layers on the vagaries of sunspot activity. Even so, the world-wide short-wave radio-telephone services of the BPO were much valued by the public and business world, since they provided a more personal and direct mode of communication than the impersonal telegram.

Initially, the short-wave radio services were operated on an amplitude-modulation double-sideband basis and a first step was to convert them to single-sideband with a partially-suppressed carrier. This conversion yielded an improvement in signal-to-noise ratio of some 9 dB, equivalent to a transmitter power increase of eight times, together with a quality improvement due to the reduction of non-linear distortion arising from multi-path transmission. It also enabled the numbers of channels in a given frequency space to be doubled; a later development, called *independent sideband working*, enabled four telephone channels to be provided on each double-sideband frequency allocation.

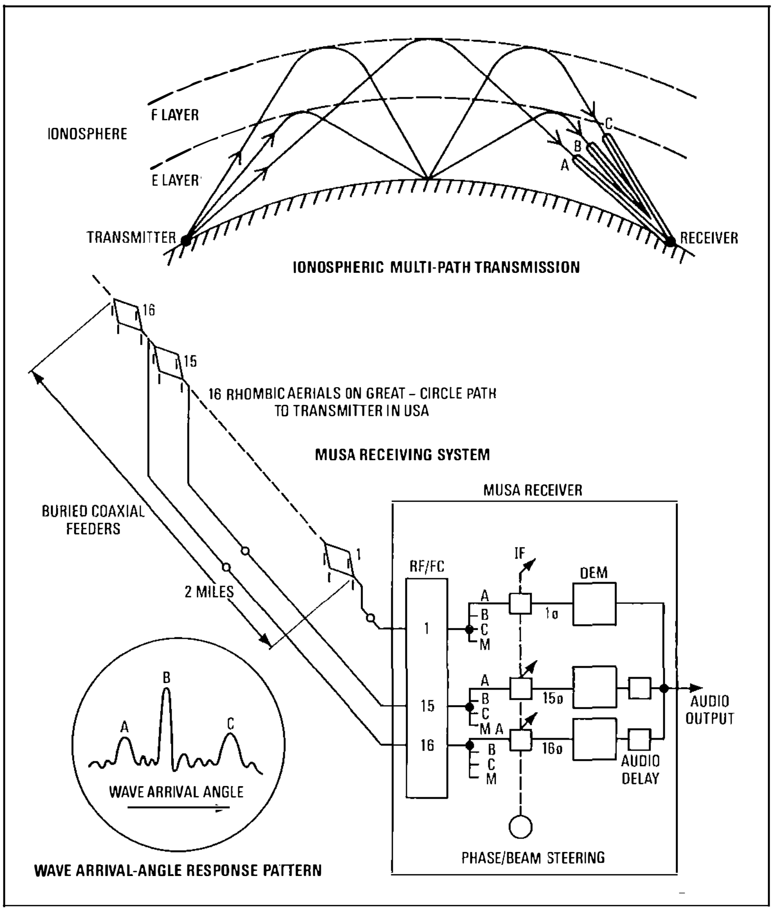
Another of my tasks as a young engineer at Dollis Hill was to design single-sideband receivers and transmitter drives—clearly my confidence in the objective existence of sidebands was being put to the test! This work leaned heavily on the techniques of quartz crystal filter design and construction already developed by my colleagues at Dollis Hill for use in the first coaxial cable frequency-division multiplex systems. These designs of single-sideband radio equipment, which contributed significantly to the growth of intercontinental telephone traffic, were taken up by the Marconi Company on a commercial basis and later used by the armed forces in the War years.

In the late-1930s, the BPO, in a last, almost desperate, bid to improve the quality and reliability of the transatlantic radio-telephone service, designed and built on Cooling Marshes in Kent the most complex and extensive short-wave receiving system ever constructed for commercial use—the multiple-unit steerable short-wave antenna system (MUSA), see Figure 3. Its American counterpart, designed and built by the American Telephone and Telegraph Company (AT&T) and the Bell Telephone Laboratories (BTL), was erected at Manahawkin, New Jersey, USA.

The BPO MUSA involved an in-line array of 16 horizontal rhombic wire aerials extending over 2 miles and connected to the receiver system by low-loss coaxial cables. There the individual signals, after conversion to intermediate frequency, were adjusted in phase and combined, giving a signal-to-noise improvement of 12 dB, equivalent to increasing the distant transmitter power by an impracticable 16 times. Furthermore, the very sharp vertical-plane directivity of the array enabled individual components of the arriving wave-bundle, corresponding to different numbers of 'hops' and ionospheric reflection layers, to be selected in separate branches of the receiving system. There, after demodulation to audio frequency and correction for transmission delay differences of up to 1 or 2 ms, the signals could again be combined.

An interesting feature of the BPO MUSA was the use of a wholly electronic intermediate-frequency phase-correction system, as compared with the American mechanical phasing system. The BPO phasing system was based on the use of a band-pass network equivalent to a long line with 16 tappings, the phase at each tapping being dependent on the frequency. It was perhaps the first practical use of a principle that later was used in radar steerable arrays.

Although the BPO MUSA was substantially complete by August 1939, it was not put into operational use until late-1940. Nevertheless, during the War years, the MUSA served a most valuable purpose, enabling Prime Minister Winston Churchill and President Roosevelt with their Chiefs of Staff to carry out conversations of vital importance to the outcome of the War, special speech privacy equipment being used to ensure their conversations were not overheard.




RF/FC: Radio-frequency amplifiers and frequency changers
IF: Intermediate-frequency amplifiers
DEM: Demodulators

**Figure 3**
**BPO multiple-unit steerable antenna (MUSA) at Cooling, Kent (1940–1960)**

## WAR YEARS

In a highly scientific and technological War, the skills and knowledge of the scientists and engineers of the BPO had a special value, and there is no doubt that they made a significant contribution to the final victory over Nazi Germany and Japan. These contributions were many and varied, and in this article I can touch on only a few in which there was some personal involvement.

My activities in the first year of the War were centred initially on radio direction-finding (DF)—a technique of great importance to the Admiralty for tracing the movements of ships of the German Navy—and the calibration of the BPO short-wave DF stations.

It was also thought that, at the outbreak of War, German agents would set up radio beacons in major cities for the guidance of Luftwaffe bombers and I was given the task of setting up three DF stations around London to locate these beacons—a task solved by commandeering from the Marconi Company

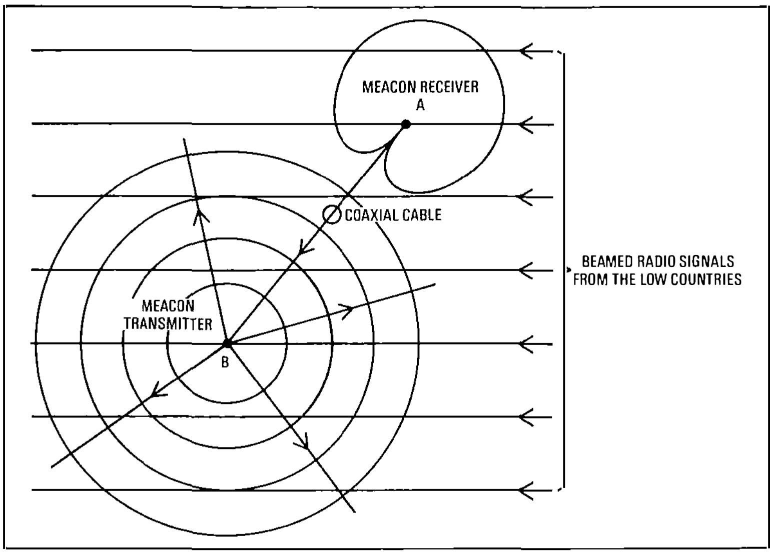



**Figure 4**
**Principles of Meacon system (anti-bomber guidance) (1941–1945)**

three direction finders initially destined for the Russian Navy!

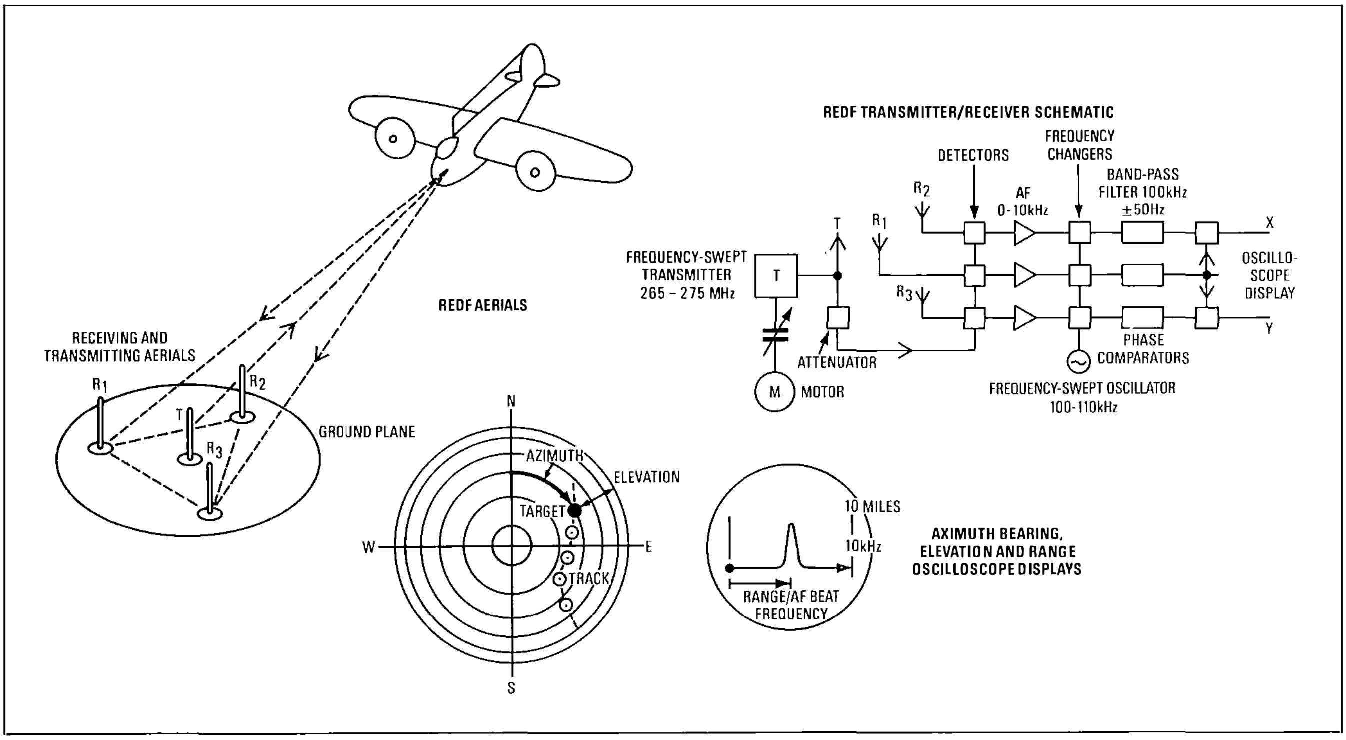
The radio systems developed by the Germans for the guidance of Luftwaffe bombers to targets in the UK have been described by Professor R. V. Jones in his fascinating book *The Secret War*—suffice to say here that they comprised a network of medium-wave transmitters in the Low Countries of Europe, the transmissions from which were beamed over the UK.

It fell to the Radio Experimental Branch of the BPO to devise means for rendering these guidance techniques ineffective, a task in which my chief, J. H. H. Merriman, later Senior Director and BPO Board Member for Technology, became closely involved. The technique evolved, known as the *Meacon* system (for 'mock beacon'), was to pick up the radio guidance signals, send them over some miles of coaxial cable and re-transmit them on the same frequency from a distant location, see Figure 4. By so doing, the guidance system was confused and the bombers found it difficult, at any rate in night-time, to find their targets.

As a light relief from these more serious occupations, I fell to examining, in 1940, the possibility of using the moon as a passive communication satellite; that is, by scattering the energy of a beamed microwave transmission from the earth and so enabling communication to be established between points on earth from which the moon was mutually visible. My calculations predicted that, with the then available microwave transmission powers and low-noise receivers, it would be possible to establish at least a voice channel capability, albeit with a time delay of some 2·5 s. My memorandum on the proposal received a dusty answer from the higher levels of the BPO and a reminder 'that there was a war on, and this was no time to indulge in moonshine!' It is interesting to recall that, in 1946, when Sir Edward Appleton gave his IEE paper on the 'Scientific Principles of Radio-Location', he noted that the US Army Signal Corps had in 1945 detected radio echoes from the moon!

Like other radio engineers of the time who had been at the receiving end of German bombing, I had given some consideration to possibilities of using radio for detecting aircraft, both from the ground and from other aircraft. Unaware, because of wartime secrecy, of the high-power pulse system which Watson-Watt and colleagues were developing, my thoughts had turned to a low-power continuous-wave (CW) system with a linear frequency sweep, see Figure 5. By mixing the

**Figure 5**
**A radio wave echo range and direction finder (REDF) (1942)**



returned echo signal with the transmitted signal, an audio beat was generated, the beat frequency being proportional to the distance of the reflecting object. By comparing the phases of the audio beats from echoes picked up on three aerials, a cathode-ray tube display giving both azimuth and elevation could be generated.

A prototype was made at Dollis Hill, mounted in a BPO van and tried out at Northolt airfield. However, the high-power pulse system was by then under way with full Ministry of Defence support and the low-power CW system had to be abandoned.

## POST-WAR YEARS

### Radio-Relay Systems

Wartime radar development had resulted in the creation, largely through the Inter-Services Co-ordination of Valve Development Committee, of valves, waveguides and other devices for use at frequencies up to at least 10 000 MHz, and it was the availability of these components that gave a strong impetus to the development of radio-relay systems for the inter-city transmission of multi-channel telephony and television signals in the post-War years.

Prior to the War, the BPO had made considerable use of VHF (30–300 MHz) radio-relay systems for providing groups of 6, 12 or 24 frequency-division multiplex telephony channels between the mainland and off-shore islands and across sea channels. These earlier systems had used amplitude modulation of the VHF radio carrier; however, an advance of considerable significance took place in the immediate post-War years with the introduction of frequency modulation which gave a substantial signal-to-noise improvement over amplitude modulation. This advance—the first use of frequency modulation in such applications—was largely due to the initiative of J. H. H. Merriman, R. W. White and their colleagues at the BPO Laboratories, Castleton, South Wales and Backwell, Somerset, who used the new technique as a means for overcoming power-line interference on the Holyhead–Douglas, Isle of Man, VHF multi-channel telephony link. It was undoubtedly the success of this VHF initiative that subsequently paved the way for the use of frequency modulation on microwave radio-relay systems carrying a thousand or more telephony channels.

With the resumption of television transmissions from Alexandra Palace after the war, there came a demand to extend the service to provincial cities, and the BPO became heavily involved in the design and provision of coaxial cable links for this purpose [3]. At the same time, studies were initiated to explore the possibilities of television radio-relay systems. However, there was initially a lack of suitable microwave amplifiers and attention was first directed to the use of frequencies around 200 MHz for which triode valve amplifiers were available. An experimental radio-relay system operating at about 200 MHz was set up between Dollis Hill and the BPO Laboratory at Castleton, South Wales, and was used for a time to provide a link for the opening in 1952 of the BBC television transmitter at Wenvoe, near Cardiff. It was unique in that it was designed to use a single frequency throughout, with rhombic wire aerials on opposite sides of hill-top sites. It also represented a first use of frequency modulation for television relaying. In practice, the experimental link was not without its problems—not the least from interference due to RAF aircraft-borne direction measuring equipment. Later, some sections of the link were converted to microwaves by using frequency-modulated klystron valve oscillators in order to gain experience in this region of the spectrum.

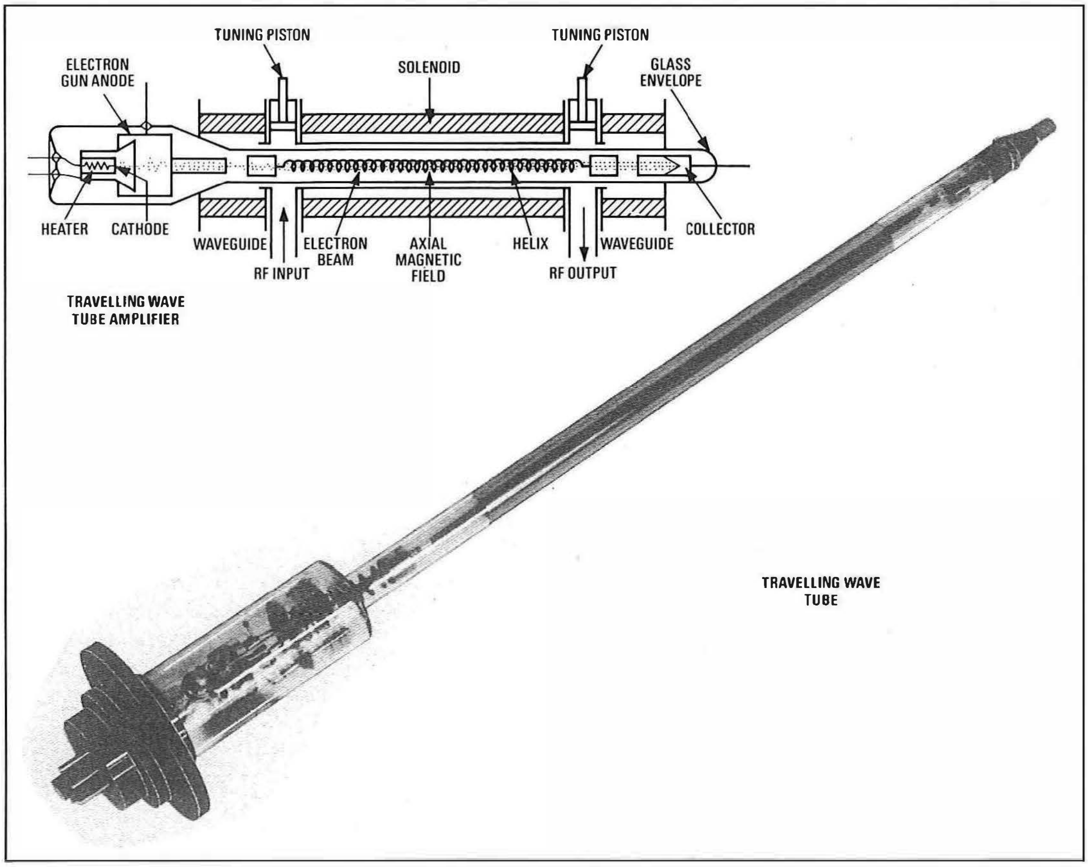
Meanwhile in the USA, the need of the AT&T to meet the urgent need for a nationwide television relaying network gave a strong impetus to the development of microwave radio-relay systems, based on research by the Bell Telephone Laboratories. Initially, the network was provided by the pioneering TD2 microwave system, using the horn-reflector aerial developed by H. T. Friis and the 4000 MHz triode amplifier developed by J. Morton. This triode, which approached the upper frequency limit of valve design, required remarkably close manufacturing tolerances and severely stretched the skill and resources of Western Electric in production.

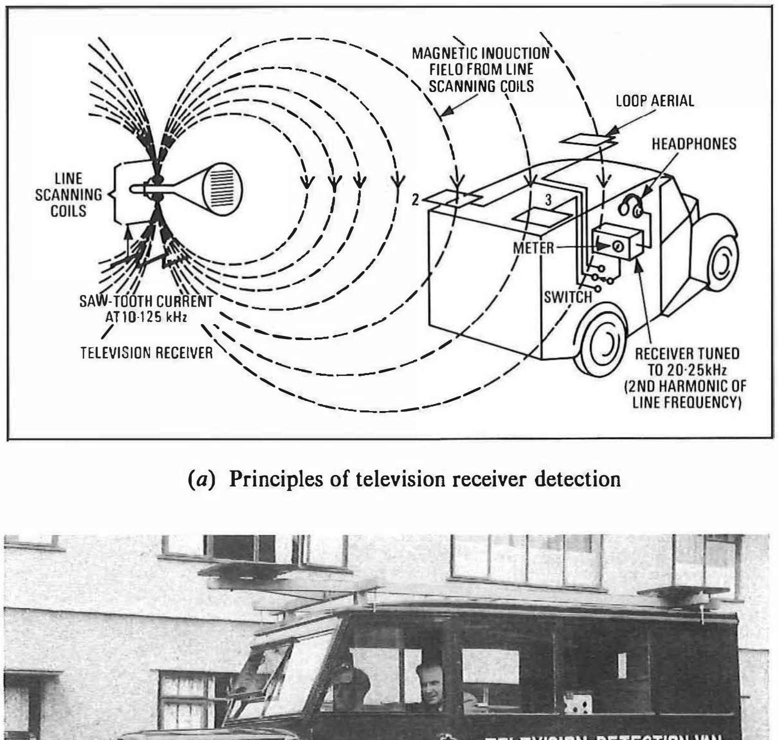
Recognising that a more readily manufactured device, preferably capable of working at even higher frequencies than the triode, was desirable, my thoughts turned to the travelling-wave tube microwave amplifier invented by R. Kompfner at the Clarendon Laboratory, Oxford, during the War. This device was not only easier to manufacture, it was also capable of amplification up to at least 10 000 MHz. I accordingly arranged with the Co-ordination of Valve Development Committee for a contract to be placed with Standard Telephones and Cables for the development of a travelling-wave tube suitable for use in microwave radio-relay systems, Figure 6. This was first used in the BPO 4000 MHz Manchester–Edinburgh (Kirk O'Shotts) radio-relay system for television in 1949—the first radio-relay system in the world to use travelling-wave tubes operationally. It is significant that BTL later used travelling-wave tubes in their higher-frequency microwave radio-relay systems, and important applications also followed in satellite communication and military surveillance systems.

### Television Receiver Detection (1952)

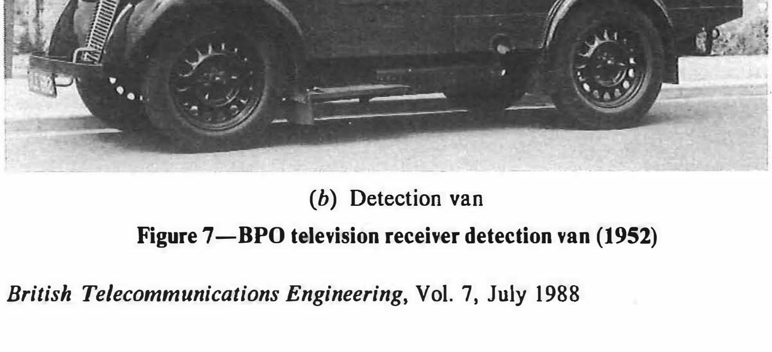
As the numbers of television receivers in use by the public grew into millions, a serious

**Figure 6**
**Travelling wave tube amplifier (Standard Telephones and Cables Ltd.)—output stage amplifier for microwave radio-relay systems**




(*a*) Principles of television receiver detection




(*b*) Detection van

**Figure 7—BPO television receiver detection van (1952)**

problem arose from the substantial proportion of receivers that were unlicensed and the loss to the Exchequer and BBC of income from licence fees. Since the BPO was responsible for licensing and the collection of fees, it fell to that organisation to find a means for reducing the numbers of unlicensed receivers in use. The then Postmaster General (Earl-de-la-Warr) had been challenged in a Parliamentary debate on television licences to show that the BPO had such a means of detection — which, at the time, did not exist. Faced with this dilemma, he turned to the Radio Branch at Dollis Hill for assistance.

It occurred to me that the line scanning coils of a working television receiver produced a strong magnetic induction field which could not readily be screened and which was rich in harmonics of the 10 kHz line frequency. With a loop aerial and a sensitive narrow-band radio receiver, we were able to demonstrate to the Postmaster General during his visit that the second harmonic could be detected up to some 75 ft from the television set. Within a few days, a BPO van had been equipped with three horizontal loop aerials and receiving equipment enabling the signals from the three aerials to be compared and giving a direct indication whether the television receiver was to right or left, in front of or behind the van, Figure 7.

It was with some pride that we gave the Postmaster General a further demonstration, in the BPO van around the streets of Dollis Hill of the detection of domestic television receivers.

The fact that an effective television receiver detection technique existed, backed by extensive publicity from the BBC, the BPO and the press, undoubtedly had a powerful effect in reducing the numbers of unlicensed television receivers and augmenting the Exchequer and BBC income by many millions of pounds over the years—I only wish I had settled for a mere 5% commission!

## INLAND RADIO BRANCH (BPO ENGINEERING DEPARTMENT HEADQUARTERS) (1954–1960)

I was moved from Dollis Hill in 1954 to become Head of the Inland Radio Branch at the BPO Engineering Department Headquarters in the City of London. I knew I would at first miss the contacts with experimental equipment and the 'hands on' experience of designing equipment and making it function. But the work at Headquarters opened the door to a much wider experience of the BPO, the economic and political realities that governed its activities, and the telecommunications industry. It also introduced me to the work of the International Telecommunication Union and active participation in the International Radio Consultative Committee (CCIR).

The work of the Inland Radio Branch covered a very wide field, ranging from the planning and provision of the microwave radio-relay trunk network, the inland and maritime VHF radio services, engineering aspects involved in the regulation of sound and television broadcasting, the control of radio interference, and CCIR studies. Space and time do not permit a more detailed account of these activities but perhaps a few 'highlights' that gave particular satisfaction are worthy of mention:

- seeing the microwave radio-relay trunk system evolve and take its rightful and valuable place in the hierarchy of transmission systems;
- contributing to the international standardisation of the technical characteristics of radio-relay systems and seeing these put into use on the first cross-Channel microwave link in 1959;
- planning the radio aspects of the Post Office Tower—now the British Telecom Tower—the focal point of the microwave trunk network, and its opening in 1965.

## COMMONWEALTH FUND FELLOWSHIP IN THE USA (1955/6)

In 1955, it was my good fortune to be awarded a Commonwealth Fund Fellowship (CFF)—an American foundation for advanced studies and travel in the USA. The CFF awards covered many fields of activity including science, engineering, medicine, the law, business studies, journalism and literature.

Some notable CFF awards in the UK were to Sir William Penney and the journalist Alistair Cook, now resident in the USA; former BPO recipients included the late C. Calveley, Director of Development, and E. A. Mayne, TM.

I had persuaded the CFF managers to let me make my own pattern of study to include periods of a month or so with BTL, the Radio Corporation of America, the Federal Communications Commission in Washington, the National Bureau of Standards and other organisations involved in various technological and regulatory aspects of telecommunications and broadcasting. The period with BTL, mainly at their Murray Hill and Holmdel Laboratories, was especially interesting and valuable. In retrospect, it is remarkable, and perhaps indicative of the good relationship between the BPO and BTL, that a lone Englishman, after having been 'vetted' by the top level of AT&T, was left free to move around BTL, ask questions and acquire information with very little formality or constraint.

My recompense to the BPO for paying my salary during this period was to write a series of confidential reports on what I had learned—but perhaps more important were the personal contacts, especially with BTL people, which later proved especially valuable in establishing a BPO involvement in satellite communications.

## BEGINNINGS OF SATELLITE COMMUNICATION (1960–1963)

My personal involvement in satellite communication was mainly during the period 1960–63 as Head of the newly formed Space Communication Systems Branch at Engineering Department Headquarters—an interesting development from those theoretical speculations during the War years on the possibility of using the moon as a passive communication satellite.

The key events that led to satellite communication being taken seriously were:

- the publication in the *Wireless World* in 1945 of A. C. Clarke's classic proposals for three synchronous-orbit satellites providing global coverage point-to-point communication links and broadcasting (although at the time Clarke's proposals were largely ignored);
- the successful launching in 1957 by the USSR of the world's first artificial satellite — SPUTNIK 1; and
- the launch by NASA in 1960 of the 100 ft diameter balloon satellite ECHO 1—which all could see in orbit—and the demonstration that it could provide long-distance voice channel links by the passive reflection of microwaves.

Up to the early-1960s, the rockets available were not powerful enough to achieve the synchronous orbit with any significant payload and the problems of accurate station-keeping in this orbit—22 300 miles above the earth's surface—had not been resolved. There was, too, uncertainty about the effect on telephone conversation of the 0·3 s time delay inherent in the synchronous orbit. These considerations led to the first communication satellites being launched in relatively low orbits —some 800 to 5000 miles height—with periods of up to 2·5 hours, and having to be tracked across the sky.

In 1960, the BPO and Ministry of Defence sent a joint civil/military team to the USA to study at first hand satellite system development in that country. The civil team was headed by Captain C. F. Booth, Assistant Engineer-in-Chief, BPO Engineering Department, with F. J. D. Taylor, then Head of the Radio Branch at Dollis Hill and myself as members of the team. An important outcome of the visit was an agreement with the US National Aeronautics and Space Administration (NASA) to conduct satellite communication tests across the North Atlantic, the BPO agreeing to build a satellite earth station in the UK at its own expense for this purpose.

From this agreement, events flowed with remarkable speed—they have been reported in detail in an excellent account by J. S. R. Lawson in reference 4.

There is no doubt that the main technological thrust came from BTL who designed and built the TELSTAR satellites and the large radome-protected horn aerial at Andover, Maine. The French PTT, the other participants in these first tests, took the easy, and expensive, way by buying the BTL earth station design and equipment from AT&T and erecting it at Pleumeur Bodou, Brittany.

The British, that is, the BPO, 'did their own thing' in building the satellite earth station at Goonhilly, relying on their own engineering skills and enthusiastic support from other UK Government organisations such as the Services Electronic Research Laboratory, and from UK Industry. We were fortunate in having the help of Sir H. C. Husband, the designer of the Jodrell Bank Radio Telescope, who became responsible for the civil engineering design and construction of the 85 ft diameter open parabolic-reflector steerable aerial at Goonhilly. Incidentally, the co-ordination of these activities within the BPO was greatly helped by the fact that F. J. D. Taylor and I were, by pure chance, next-door neighbours at our homes at Wembley Park!

The first Goonhilly earth station was built in just one year from a virgin site on the Lizard Peninsula, Cornwall, from the start in July 1961 to readiness for the launch of TELSTAR on 10 July 1962. That this complex of hitherto untried equipment functioned so well was a tribute to all concerned. True there was a minor hiatus on the first pass of TELSTAR because of uncertainty about what was meant by right- or left-hand circular polarisation, but this was soon resolved and all was well.

The tests and demonstrations of television, including the first colour television transmissions across the Atlantic from the UK, multi-channel telephony and high-speed data transmissions that followed showed beyond a shadow of doubt that the era of world-wide satellite communications had begun. Furthermore, the results fully justified the Goonhilly design of open-dish aerial as compared with the more expensive radome-protected horn aerials at Andover and Pleumeur Bodou—notably in the avoidance of outages due to heavy rain.

Today, Goonhilly, with its seven open-dish aerials, handles more traffic than any other earth station in the world, and aerial No. 1 is still giving good service!

## DOLLIS HILL AND MARTLESHAM HEATH (1963–1975)

With my return to Dollis Hill in 1963, first as Deputy Director and later as Director, and from being very much a 'radio' engineer, I became to some extent responsible for a wide programme of research, including:

- higher capacity submarine cable systems incorporating long-life transistors;
- advanced switching systems incorporating computer technology and concepts;
- pulse-code modulation digital transmission and switching;
- conference television (Confravision) and Viewdata;
- millimetric waveguide and optical-fibre systems;
- active device research; and
- human factors studies.

Although my role in much of this had to be that of the interested and supportive onlooker, I became very proud of BPO Research Branch achievements especially in the field of transoceanic submarine cable systems and long-life transistor development and production.

## SUBMARINE CABLE SYSTEMS AND LONG-LIFE TRANSISTORS

In this field, my colleagues Dr. J. R. Tillman, N. F. Holmes and Dr. F. H. Reynolds made notable contributions. In this they were continuing the tradition established by their predecessors, stemming from the invention of the light-weight submarine cable by Dr. R. A. Brockbank and the long-life thermionic valve development at Dollis Hill under the direction of Dr. G. Metson (former Director of Research). It was good to see their work on long-life transistors rewarded by the Queen's Award to Industry in 1972.

However, I could not but help feel that they were tackling the job the hard way! For example, the 3000-mile long UK–Canada submarine cable system CANTAT 2 has a total attenuation at the highest working frequency of some 20 000 dB, which has to be cancelled by 500 repeaters each of 40 dB gain, and the whole of this stupendous amplification has to be stabilised to within 1 dB year in and year out. By contrast, the attenuation over the 22 300 miles to a synchronous orbit satellite via the 85 ft dish aerial at Goonhilly was a mere 150 dB, and there was only one repeater!

### Digital Switching

It ill becomes a mere transmission engineer—and a radio one at that!—to comment on the pioneering work on digital switching systems that was in progress at Dollis Hill in the 1960s under the guidance of H. B. Law, L. R. F. Harris, W. B. Duerdoth and N. Martin. However, I did have the privilege of assisting the last Postmaster General—the Right Hon. John Stonehouse—to open the PCM digital exchange at Empress, London in 1968. This exchange, designed and built in Research Department, was the first exchange of this type to go into operational use anywhere in the world.

From this work, and the parallel work on digital transmission, has grown the digital revolution that has transformed the world's communication networks, greatly improving their quality, reliability, flexibility and economic viability.

### Waveguide and Optical-Fibre Systems

Another highlight concerns the work on millimetric waveguide and optical-fibre systems carried out at Dollis Hill and Martlesham Heath. The waveguide was a classic example of a promising technology for high-capacity inter-city routes that was overtaken by a competitor offering greater flexibility in capacity and ease of installation.

The lightweight 5 cm diameter wire helix waveguide evolved by a Research Department team led by R. W. White had by 1970 achieved an attenuation of less than 3 dB/km and a working band from 30–110 GHz. When this wide bandwidth was fully exploited by using high-bit-rate (100/500 Mbit/s) repeaters, a capacity of some 300 000 telephone channels or 200 television channels, or a mix of these, would have been possible. By 1974, a field trial over a 14 km route along the A12 road was in train and showed that the design was effective and practicable. However, by then, the attenuation of optical fibres had come down to a similar value to that of the millimetric waveguide and it was clearly advantageous to concentrate resources on the optical system.

When Kao and Hockham of the Standard Telecommunication Laboratories published in 1966 their classic paper on the propagation of laser light in a glass fibre with a fine inner core of slightly different refractive index, the attenuation probably approached 100 dB/km. So high in fact that only an optimist or a visionary would have sponsored research aimed at a practicable transmission system. It says much for the scientists at STL, and F. F. Roberts and his colleagues in the BPO Research Department, that they had both the scientific skill and the vision to strive for lower attenuation in the face of apparently insuperable difficulties. Their confidence and success are now fully demonstrated by the fact that optical-fibre cables are now fulfilling major roles throughout the national telecommunication network and across the oceans.

### Viewdata (Prestel)

By the early-1970s, the information technology revolution was beginning to take off, and the ability of telecommunications to provide access to remote sources of information in data and video formats was beginning to be realised.

BPO involvement in this revolution at first began almost fortuitously in 1970 with a memorandum from the then Managing Director, E. Fennessy, to all Departments seeking ways of making greater use of the existing telephone network. It occurred to me that there were then some 20 million telephones and 20 million television receivers in use, mostly in the same homes—could not these be linked to provide visual display in letter/figure form of a wide variety of information from data banks at telephone exchanges? A preliminary study of this suggestion was carried out in Research Department by S. Fedida and his colleagues, under the direction of E. Ayers, and a laboratory model demonstrated in 1971. This was followed by a demonstration to the BPO Board in 1974 that led to a decision to proceed with further development and exploitation. In presenting this to the Board, I observed that:

> 'Viewdata is not limited to providing visual information services. It can also store and display messages, for example, telegrams, to await the return of a customer. It can provide a means of communication between the deaf; it offers computer facilities and data files for business and other professional users. It has potential application to education and training in the home. And doubtless many other uses, especially those that exploit its two-way interactive capability, will appear in the future.
>
> 'This is a development of far-reaching importance that could mark the transition of the business from an almost totally telephone-centred one to broad-based telecommunications with an expanding visual service content.'

In the early stages of development of Viewdata, we were not aware of the BBC's *Ceefax* and IBA's *Oracle* teletext systems; however, when these were known, steps were taken, as far as possible, to harmonise the displays.

There are, of course, marked differences in the services that can be provided, notably the virtually unlimited page capacity of Viewdata, its two-way interactive capability and the possibility of charging customers for the facilities provided.

Viewdata—now BT's Prestel—is a growing service, especially in the business field, but has yet to make the penetration into the home that its creators had envisaged.

It is a pleasure to record that S. Fedida and BT were awarded the prestigious MacRobert Award for the innovation and development of the Viewdata/Prestel concept by the Council of Engineering Institutions.

## FINALE

I am very conscious of the fact that this review of some of the telecommunication highlights in the period 1925–1975 is only one person's view; it has left many gaps and the contributions of many colleagues unacknowledged.

Looking back at this period—one hopes without too rose-coloured spectacles—it does appear that there was a strong feeling of dedication to the public service among scientists and engineers of the BPO Engineering Department, that there was a determination to achieve the highest possible standards of engineering excellence, and that innovation and creativity were welcomed and supported.

There is no doubt that these qualities and aspirations also exist in full measure in British Telecom staff today, but in a different and more commercially competitive world. My colleagues and I of the retired staff wish you every success in the future and careers in the fascinating business of telecommunications engineering at least as rewarding as ours have been.

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## Biography

John Bray joined the BPO as an Assistant Engineer in 1935. His early career in the BPO was concerned with the development of short-wave long-distance radio communication in the 1930s and the introduction of microwave radio-relay systems for inter-city communication in the 1940s, which later led to the building of the Post Office (now British Telecom) Tower in London as the focal point of the network. He studied telecommunications in the USA on a Commonwealth Fund (Harkness Foundation) Fellowship, 1955–56. He was responsible for the planning and building of the BPO satellite communication earth station at Goonhilly Downs, Cornwall, and the first television transmissions to the USA via the TELSTAR satellite in 1962. He became Director of Research at Dollis Hill, London, in 1966, and later at the British Telecom Research Laboratories at Martlesham Heath, from where he retired in 1975. He was awarded an honorary doctorate by the University of Essex. He is a former visiting professor at University College, London, and external examiner for the M.SC. (Electrical Engineering) at Imperial College. He is a former consultant to the Council for Educational Technology.

# Technical Education for British Telecom Engineers

I. S. WAYMENT†

UDC 331.862

*This article provides a review of technical education, past and present, describes the latest developments in the BTEC and SCOTVEC National Certificate engineering programmes and considers the current opportunities and methods by which BT technicians can undertake technical education.*

*Technical education is undertaken at some time by most BT technicians and certainly by all those who progress to Technical Officer or managerial grades. This article therefore deals with a topic to which most readers can relate to personally and which will bring back memories that may be long past or very recent if they are currently studying.*

## TECHNICAL EDUCATION 1970–1988

Within the UK, the three main validating and examining bodies for engineering studies are the Business and Technician Education Council (BTEC), the Scottish Vocational Educational Council (SCOTVEC) and the City and Guilds of London Institute (CGLI).

The CGLI is by far the oldest of these three bodies. Until the mid-1970s, the CGLI, and the joint committees that were responsible for setting the National course syllabi, were the two main examining bodies in the field of technician education.

In the early-1960s, there was growing concern in the educational world that the CGLI courses were moving more and more toward specialist vocational training at the cost of the general education and theory content. It was also felt that the National courses were going the opposite way; that is, they were becoming more and more theory based at the cost of relevant vocational knowledge. In 1967, the Secretary of State for Education and Science instigated a survey and report into technician courses and examinations.

As a result of the recommendations in the report, it was decided that all technician training in England, Wales and Northern Ireland should be rationalised into one system that would be overseen by a new body called the *Technician Education Council* (TEC).

In 1973, the TEC was created and from 1976 colleges started offering courses that covered syllabi set by this body. At the same time, the Business Education Council (BEC) was created to fulfil the same role as TEC but in the field of business/management education. 1973 also saw the creation in Scotland of the Scottish Technical Education Council (SCOTEC).

Once the new TEC National courses came on stream, the old National certificate programmes ceased. While the CGLI continued to offer examinations to their technician course syllabi, the numbers using this route for qualification shrank rapidly as TEC became the nationally recognised course.

The role and market of the CGLI has therefore altered considerably since that time and it has adapted to meet these changes.

While the CGLI still offers examinations and qualifications covering a wide area of vocational skills, it has also diversified into other areas of training. One of its major successes has been to establish itself as an expert and consultant in the field of assessment of work-based training. This is an area of great and growing importance within the UK vocational training sector as it is fundamental to the Youth Training Scheme and the new National Vocational Qualification that will be emerging in the next five years. By moving into this field, the CGLI has created an additional new role for itself in the educational field.

In 1983, BEC and TEC merged to become the Business and Technician Education Council (BTEC) and, in 1985, SCOTEC became the Scottish Vocational Educational Council (SCOTVEC).

The CGLI and SCOTVEC are both examining bodies whereas BTEC allows colleges to set their own assessments.

SCOTVEC and BTEC both require that students must enrole with a college and undertake a course of study with a college if they want to be assessed and awarded a certificate. The CGLI, however, allows students to sit examinations without the need for college attendance.

BTEC and SCOTVEC use moderators to visit colleges regularly to ensure that all courses, and locally-set assessments in the case of BTEC, stay within and conform to the syllabus guidelines and standards they recommend.

As the CGLI does not insist on students

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attending a course of study at college before sitting their examinations, it does not moderate colleges to the same level as BTEC and SCOTVEC.

National assessment provides a common and easily understood standard that many people argue is often missing with the BTEC local assessment system although this does remove the flexibility for colleges to vary their programme content according to the needs of local industry.

## SCOTVEC NATIONAL CERTIFICATE PROGRAMME STRUCTURE

Until 1984/85, SCOTVEC National and Higher National Certificate programmes were of three- and two-year duration, respectively.

In 1983, the Government published a document '16–18s in Scotland—An Action Plan'. The result of this, within Scotland, was a major change from the old unit-based programme to a more flexible system made up of 40-hour modules that could be mixed and matched into combinations most suitable to the needs of the students and employers. This system has now been fully implemented at the National level, although the Higher National programme has been retained in its original form.

The advantage of the modular system is the flexibility it allows students, in theory, to study the exact units they need for their particular job. The major disadvantage is that employers in Scotland will soon be faced with employees all offering unique combinations of units rather than a standard certificate made up of set combinations.

## BTEC NATIONAL CERTIFICATE PROGRAMME STRUCTURE

Typical programmes of study for the three-year BTEC National Certificate programme in Telecommunications are shown in Figure 1. Each subject unit was a nominal 60 hours of study time. The complete programme of study was made up of 15 units thus comprising a total of 900 hours of work.

Around 1985/6, BTEC also decided to change the structure of this programme but, as is often the case with the English and Scottish educational systems, it decided to choose a totally different route to that taken by SCOTVEC.

The 60-hour module concept was still maintained but the three-year programme was split into a one-year First (F) level programme, of five units study time, and a two-year National (N) level programme of ten units study time.

The rationale behind this decision was to provide a self-contained one-year programme, F level, of basic general engineering principles for school leavers with minimal qualifications followed by an N level programme for school leavers with 4 GCSEs or successful F level students. A diagram of entry and progression routes is shown in Figure 2.

The core (mandatory) units that make up the F Certificate consist of:

| | |
|---|---|
| Engineering Fundamentals | 2 units study time |
| Mathematics | 1 unit study time |
| Science | 1 unit study time |
| Information technology studies | 1 unit study time |

Total study time = 5 units

There are four preferred N level engineering programmes of study in the following specialisms:

- Communications Engineering
- Electrical and Electronics Engineering
- Electronics Engineering
- Computer Engineering

Each programme is made up of a number

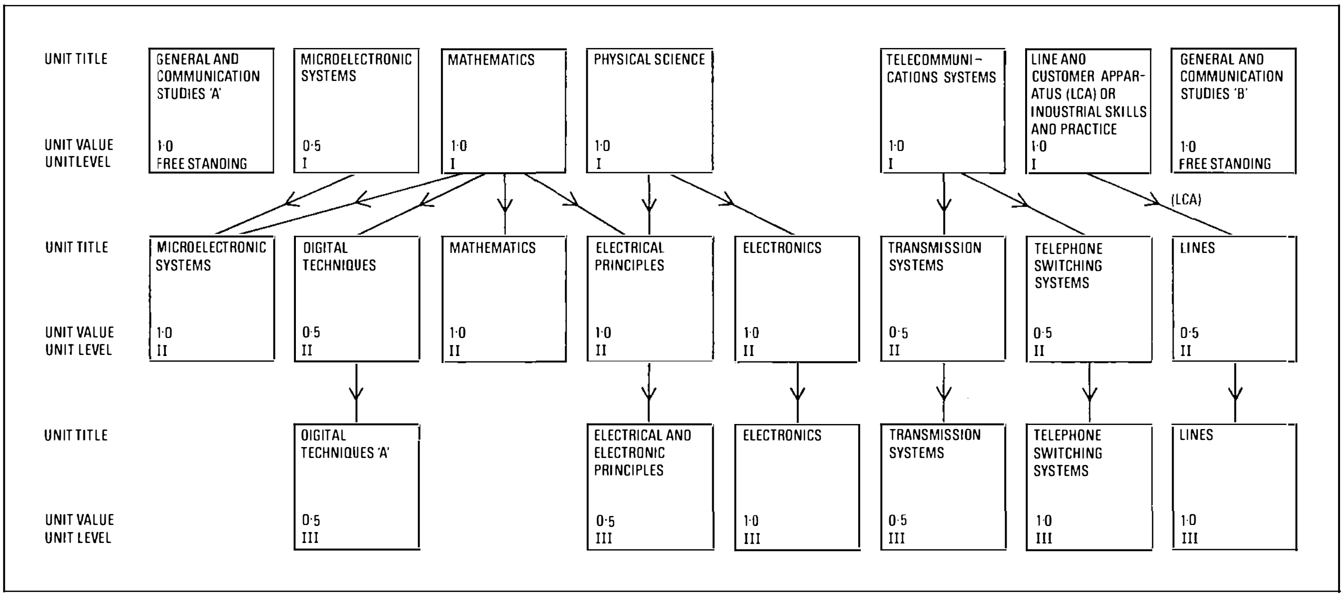

**Figure 1—Typical programmes of study for the BTEC three-year National Certificate programme in Telecommunications**

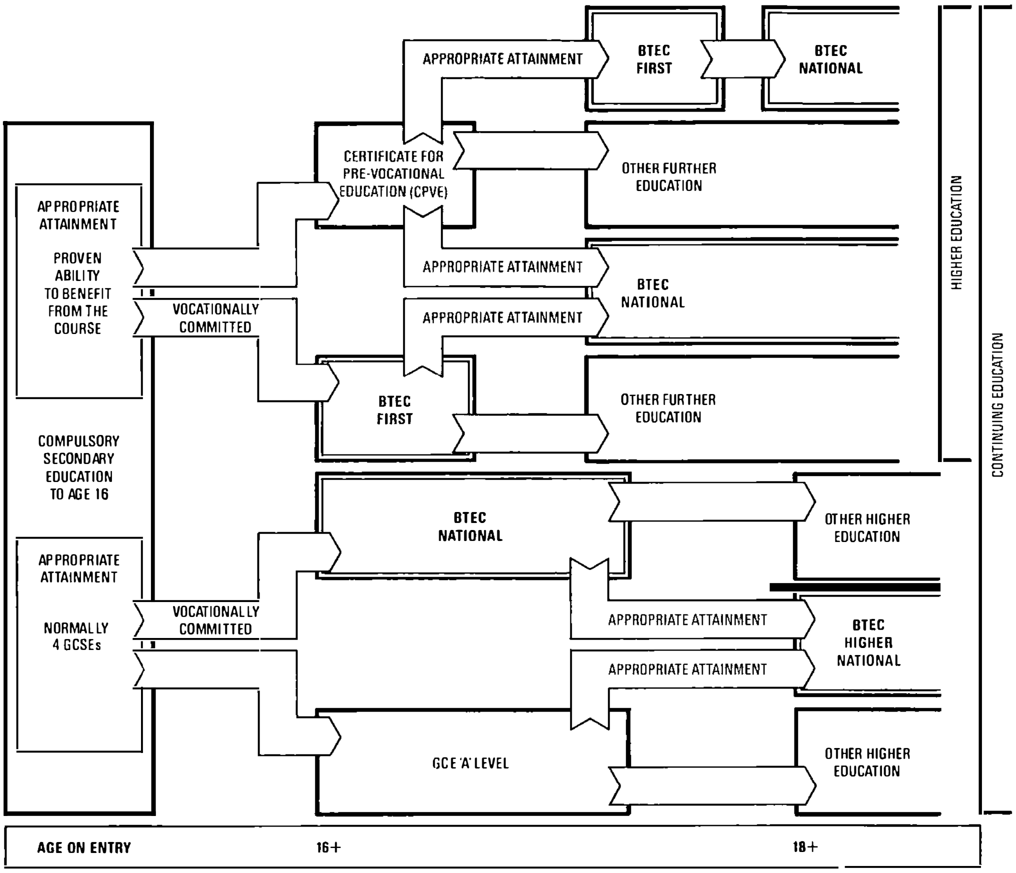


**Figure 2—Entry and progression routes for new BTEC F and N level Certificate programmes**

of mandatory (core) units supplemented by a number of optional units which, together, must total 10 units. Typical combinations of units for the N level programmes are shown in Table 1.

The F level programme was introduced in September 1987 and the new N level programme will commence in September 1988.

Apart from the change in the structure of the programme, there have also been changes in the way the subjects are taught and assessed. BTEC has always advocated that, wherever possible, objectives should be taught or reinforced with practical work and experimentation. However, these requirements are much more explicit and mandatory in the new programme. For most subjects, BTEC has now issued standard sets of objectives which colleges are expected to use. Besides setting objectives, BTEC also gives specific directions as to which of these objectives must be taught by hands-on practical activity and how much teaching time this should take. This means that in future there will be greater time and emphasis placed on practical work.

To ensure and assess that students can apply their knowledge in the workplace, 'integrative assignments' have been included as mandatory elements of the programme. These are 'cross modular' projects that can only be completed by applying the knowledge gained from a number of subjects studied. This element of the course is mandatory and without it a programme certificate will not be gained.

BTEC has attempted, through introducing these requirements, to overcome the problem of students becoming 'paper qualified' but unable to apply their knowledge in practical work-based situations.

## HOW DOES THE STUDENT CHOOSE WHAT TO STUDY?

For students in Scotland, the choice of units that will be studied depends in practice upon three things:

(*a*) what the student wants,
(*b*) what the employer (that is, the training manager), wants, and
(*c*) what the college can offer.

For new students commencing BTEC studies, the choice from now on is whether to enter at F or N level. At N level, the decision becomes what programme and combination of units to take and again depends upon the same three factors as given for Scottish students.

Traditionally, BT has supplied colleges with sufficient numbers of students to ensure that classes in BT-specialist subjects were viable to run. However, with the decline in student numbers over the last few years, it frequently happens that these specialist subjects can no longer be offered.

This problem, caused by the fall in adult recruitment, will exist for the foreseeable future. It has to be accepted that the high

## TABLE 1

**Typical Unit Combinations for the BTEC N Level Certificate Programme in Engineering**

| CORE (MANDATORY) STUDY AREAS | | | | | |
|---|---|---|---|---|---|
| Study Areas | Levels | Electrical and Electronic Engineering | Electronic Engineering | Communications Engineering | Computer Engineering |
| Mathematics | NII | 1·0 | 1·0 | 1·0 | 1·0 |
| Engineering Applications of Computers | NII | 0·5 | 0·5 | 0·5 | 0·5 |
| Industry and Society | N | 0·5 | 0·5 | 0·5 | 0·5 |
| Electrical and Electronic Principles | NII<br>NIII | 1·0<br>1·0 | 1·0<br>1·0 | 1·0<br>1·0 | 0·5<br>0·5 |
| Electronics | NII<br>NIII | 1·0<br>1·0 | 1·0<br>1·0 | 1·0<br>0·5 | 0·5<br>0·5 |
| Micro-electronic Systems | NII | 1·0 | 1·0 | 1·0 | 2·0 |
| Electrical Applications | NII<br>NIII | 0·5<br>1·0 | | | |
| Transmission Principles | NII<br>NIII | | | 0·5<br>0·5 | |
| Software Design Methods | N | | | | 2·0 |
| Microprocessor Interfacing | NIII | | | | 1·0 |
| TOTAL CORE UNIT VALUE | | 8·5 | 7·0 | 7·5 | 9·0 |
| OPTIONAL STUDY AREAS (in addition to core units, to make up 10-unit programme) | | | | | |
| Digital System Fault Finding | NII | 1·0 | 1·0 | 1·0 | 1·0 |
| Electronics (A) | NIII | 1·0 | 1·0 | 0·5 | 0·5 |
| Micro-electronic Systems | NIII | 1·0 | 1·0 | 1·0 | 1·0 |
| Mathematics | NIII | 1·0 | 1·0 | 1·0 | 1·0 |
| Switching Systems | NII<br>NIII | | | 0·5<br>1·0 | |
| Peripheral Devices | NII | 1·0 | 1·0 | | 1·0 |
| Computer Applications in Control | NII | 1·0 | | | 1·0 |
| Data Communications | NIII | | 1·0 | 1·0 | 1·0 |
| Semiconductor Manufacturing Processes | NII | 0·5 | 0·5 | 0·5 | 0·5 |
| Electrical Properties of Materials | NII | 0·5 | 0·5 | 0·5 | 0·5 |
| TV | NIII | 1·0 | 1·0 | 1·0 | |
| Radio | N | 1·0 | 1·0 | 1·0 | |
| Industrial Control and Instrumentation | NIII | 1·0 | 1·0 | | |
| Information Handling Systems | N | 1·0 | 1·0 | 1·0 | 1·0 |

student numbers of the past are gone forever and BT's ability to dictate its wishes to colleges is also a thing of the past. This has caused BT's Training Department (TD) and local training managers to accept that, while the study of specialist units is desirable, it is not essential. If the main objective of technical education is seen as providing BT technicians with sufficient knowledge to cope with their job and the content of the BT vocational courses they will have to attend, it has to be accepted that general electrical/electronic engineering subjects are acceptable alternatives to specialist communications subjects. By adopting this flexible attitude to subjects that can be studied, the problem of class sizes is eased, as most colleges will have sufficient students from local industry to make up one engineering course provided they will all accept a common programme.

## DISTANCE LEARNING AS A STUDY METHOD

For many years, distance learning packages, previously known as *correspondence courses*, were available for BT students wishing to study CGLI subjects but who could not get to college. With the change-over to BTEC/SCOTVEC, new packages were produced by TD to support these programmes. The writing, printing and distribution of these packages was a massive and very expensive exercise. By 1985, sufficient packages had been produced for students to be able to study a complete SCOTVEC or BTEC Certificate programme. Once the scheme had matured, the decision was then taken to license an outside company to administer it on behalf of TD and allow it to charge users a commercial rate for the packages. In return, the outside company would keep the packages updated, write new ones as required and pay a royalty to TD on sales. There were a number of reasons for this decision:

(*a*) While TD was running the scheme, training managers were not charged for the packages; this artificially stimulated the market and, at its peak, over 6000 packages were being issued each year.

(*b*) The true cost of distance learning was not being recognised by training managers and, instead of using it only as a last resort when study by attendance at college was not available, it was often used as a cheap first choice.

(*c*) TD was bearing the full cost of running the scheme.

The National Extension College (NEC), Cambridge, was chosen as the most suitable educational company in the UK to run the scheme. It has a long and distinguished history in the field of open/distance learning and has pioneered many standards and practices which have been copied by the Open University and, more recently, the Open College.

Since taking on the scheme, the NEC has updated many of the units, extended the network of colleges that participate in the scheme and developed a very efficient computerised student administration system. However, the fact that the packages were no longer free to training managers and the drop in recruitment of adult technicians combined to produce a slump in sales. By 1986, sales were such that financially the NEC was only just breaking even on the scheme, and TD was faced with the option of either subsidising the scheme to keep down the cost of packages or letting the NEC increase the prices, which would have further depressed sales.

At the same time that this problem was emerging, BTEC was introducing its new programme, which meant that most of the packages would need to be replaced. Because of the size of this exercise, the NEC could not contain this expense as part of the normal running of the scheme and therefore required additional funding, on top of the subsidy for administrating the scheme, to produce this material.

Faced with financial demands of this size, TD had to reappraise the whole way the scheme was administered and financed.

It was recognised that the volume of sales of packages was never likely to return to former levels and was probably still shrinking, and that only a limited number of choices about the future of the scheme were available, these being:

(*a*) for TD to accept an ongoing subsidy of the scheme,

(*b*) to close the scheme down, or

(*c*) for TD to pay, on a once-and-for-all basis, the development costs of new packages but set up a system whereby unit costs, and thus selling costs, of packages were independent of the volume of sales.

The first two options were definitely rejected, although it was recognised that it would be difficult to achieve and implement all parts of the third option.

It was quickly realised that the complete F level Certificate programme would be impossible to support by distance learning packages because of the amount of practical work in many of the subjects. However, BTEC agreed that the existing packages supporting the old level 1 units could still be studied and certain combinations of these will allow access to N level studies. This will give students who want to study for entry to N level a method of achieving this through the distance learning scheme.

The N level programme also contains large elements of practical work but, by the use of practical kits, it has been possible to get BTEC approval to deliver it by distance learning.

Rather than automatically put the development work of the new packages with the NEC, other leading UK bodies in the distance learning field were invited to tender for the work of producing the new packages. This resulted in the discovery that two open learning centres, those attached to Plymouth and North Manchester colleges, were between them already producing most of the packages required, thus saving any development costs having to be invested.

Once a source of good distance learning packages for the new units had been assured, it was then necessary to find a way of keeping package costs viable for very low numbers of sales.

To make unit costs independent of volume sales, it was necessary to reduce the fixed element of overhead cost. As most of this consisted of the central administrative costs of the NEC, it was decided that the option of buying packages direct from the producers should be given to colleges and training managers who could then undertake all the organisation of distance learning themselves.

It was recognised that many customers would still want the full NEC service and be willing to pay for it rather than incur the extra work themselves; it was arranged that the NEC will still continue to provide a complete service as long as numbers make it viable and economical to do so.

As from September 1988 therefore, the scheme will no longer be solely administered by the NEC. The new packages from Plymouth and North Manchester colleges will be available for N level units in addition to the old units from the NEC, and colleges and training managers will be able to decide whether they buy direct from the producers or use the full services offered by the NEC.

## CONCLUSION

Over the past twenty years, there have been many changes in technical education courses for technicians. The place of CGLI and the joint National committees has been replaced by BTEC and SCOTVEC. Central examinations have given way to central guidelines on course content to which colleges devise their own courses and set their own examinations. The three-year National Certificate courses have recently changed to the modular system used in Scotland and the F and N level programme used in the rest of the UK.

All of these changes have been introduced to:

- improve the way vocational education is delivered,
- ensure larger numbers of school leavers receive post-school education that enables them to find work,
- equip them with general life skills that will help them cope confidently with the continuous changes they will face in their working life, and
- meet the needs of employers.

There is inevitably argument about the effectiveness and need for some of these measures. It has to be recognised, however, that many of the changes were needed and will ensure that BT technicians have a foundation of technical knowledge that will enable them to meet the present and future requirements of their jobs.

### Biography

Ian Wayment joined the British Post Office in 1963 as an apprentice in London City Telephone Area. Most of his time as a T2A and TO was spent on teleprinter and Telex exchange maintenance. In 1973, he was promoted to Assistant Executive Engineer and worked in the contracts division of what was then the Purchasing and Supply Department. He transferred to UK Communications Training Department in 1979, where he is currently heading the group that deals with technical and educational training schemes and programmes for BT technicians.

*Editors' Note*: Question/answer material covering certain CGLI, BTEC and SCOTEC subjects has traditionally been included in the *Supplement*. Readers' views are being sought on the future role of the *Supplement* in a questionnaire included with this issue of the *Journal*. Readers are urged to complete the questionnaire and return it as soon as possible.

# Application of Bar Coding in Parcel and Bulk Mail Handling

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UDC 656.851

*Bar codes are widely used in the retail industry for an increasing number of materials handling applications. Their application to parcels handling offers potential benefits in productivity, management data and quality of service, but also poses several problems due to the irregular nature of the product being handled. This article is based on a paper* presented at the International Postal Engineering Conference, May 1986.*

## INTRODUCTION

Bar coding is not a new technology. It has been used extensively throughout the retail industry for many years, and its use in materials handling is expanding rapidly. As an accurate source of information for computer databases, it allows tight control of stocks and rapid feedback on market trends or factory performance. This article discusses the developments of the technology and its associated problems which have been investigated by the British Post Office (BPO) and considers the potential applications and benefits to the Business.

## APPLICATION

The BPO realises its need for more information on its own performance; data for costings, billings, quality of service figures and accurate volume statistics to enable efficient running of the Business. Other projects currently under development[1] will solve some of these problems, but bar coding will prove a useful tool to fulfil this need in parcel and bulk mail handling.

The use of bar-coded labels on parcels will allow recording of one or more of the following data:

- parcel origin and destination;
- transit time between offices and possibly to the door; and
- parcel tariff and weight;

as well as making it possible to:

- record parcel delivery;
- automatically sort parcels; and
- track progress of a parcel through the system.

An integrated system embraces a number of existing operational practices; such as, recorded delivery, quality of service and volume monitoring. A bar-coding system will radically alter these practices, which are currently performed manually and independently, so it cannot be introduced without major revision to many operations throughout the Business. It is this that will make the introduction of bar codes in the BPO so difficult.

The bar code itself is one small part of a system comprising printers and readers and, at its heart, a computer database. The sets of data mentioned above impose different requirements on the computer network, and they govern not only the data encoded in the bar codes, but also how, when and where the code is printed and read. Although not all are vital to the running of the service, it would be desirable to generate a system with enough flexibility to accommodate them all. The features of a BPO bar-code system fall into two categories: those which capture and control information (for example, parcel tracking), and automatic sorting. Each of these applications is examined below.

## INFORMATION CAPTURE AND CONTROL

Systems for information capture and control could be developed in two ways: the bar code could hold a unique serial number, or it could contain data encoded directly.

### Unique Serial Number

Tracking parcels and recording delivery of a parcel can only be achieved if each parcel can be uniquely identified. This can be done by encoding a unique serial number in the bar code.

Parcel tracking is the more straightforward application. It comes naturally as a by-product of the bar coding system since each time a code is read, the position of the parcel is known. Obviously, the more places that the code is read as the parcel passes through the system, the greater the resolution of the tracking. The benefit is not just for the customer; data would be available which would

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detect delays and missorts, and indicate where the missorts had occurred.

Obtaining proof of delivery from the system is more difficult, since it requires either the bar-coded label to be returned to a central processing point after the parcel has been delivered or the bar code to be scanned by the postman on the doorstep. Such a scheme will have been introduced before publication of this article and is discussed in more detail below.

Quality of service information will be available once the parcel can be tracked at the posting and delivery points.

The main advantage of choosing to use serial numbered bar codes is that they can be pre-printed centrally and distributed to major customers and Post Office counters. The drawback is that the computer network must extend to every point at which the codes are read, since the data must be matched to the parcel. In a truly integrated system, the network would be linked to the points of origin of the parcels, where the bar codes would be read and other relevant information such as weight, tariff and date of posting recorded.

### Encoded Data

The alternative to a unique serial number in the bar code is to encode information directly. The bar code could carry data which represented:

- date of posting;
- office of posting;
- destination (perhaps in post code form); and
- weight of tariff.

The advantage of encoded data is that much smaller demands are made on a computer network and database. The bar code on the parcel need only be read at the end of its journey to obtain statistics for quality of service, route volumes and cost. Without the serial number, tracking of individual parcels is impossible and it is very difficult to obtain accurate information on transit times.

The amount of data that can be encoded in the bar code is limited by the space available on the label and since label cost is proportional to size, this should be small. The most serious problem with encoded data is label printing. The alternatives are for the labels to be reprinted and then distributed or to be printed locally on demand. If the former option were adopted, rigorous discipline must be imposed on the distribution and use of the labels. To get accurate data, the labels must be sent to the right office, used on the right date and chosen correctly for the parcel's destination. Since the number of different types of label stored by each office would be very large, the full post code could not be contained in the bar codes. The destination would be stored as the outward half of the post code or as a four digit number.

Implementation of the second option, that of local printing, requires major capital expenditure since label printers would have to be installed in many post offices or local sorting offices, though major customers may agree to print bar codes as part of their own address labels. Suitable equipment is already available and retails for £3–4000.

The funding necessary for local printing could be spent more usefully on bar-code reading equipment in the offices and a link to the networked database, especially if some local computer intelligence already existed through the counter automation scheme under consideration by the BPO. This of course implies that the unique serial number system proves more cost effective.

### TRAKBACK

Currently, the BPO intends to introduce a computerised proof of delivery (PoD) system called *TRAKBACK*. The development of this system demonstrates some of the problems encountered.

The customer buys a self-adhesive bar-coded label which is attached to the parcel (Figure 1). Each label carries a unique number—a record of which is given to the customer. When the parcel is delivered, the


*Note*: removable bar code

**Figure 1—TRAKBACK bar-coded label**

bar-coded portion of the label is peeled from the parcel and stuck on a delivery record card which the recipient signs. The card is then posted to the central controlling office, where it is processed. The labels are preprinted centrally and then distributed to post offices and major customers. Because the system offers proof of delivery only, the bar codes contain no other information and are read only in the processing office. To introduce other features, therefore, may be expensive and would certainly require some redesign of the system.

The premium overnight service, Datapost, also intends to introduce a bar-coded PoD system. Despite many similarities, the requirements are sufficiently different to make it difficult to combine these two operations. Whereas proof of delivery within two to three days is satisfactory for the normal parcel service, Datapost would need the information within one or two hours of delivery. It was also decided that the name of the recipient would be required at the same time because there is often a significant delay between delivery of the parcel to a large firm and arrival of the parcel on the addressee's desk. The Datapost system is under development with options being considered. The BPO Engineering Department has suggested that small hand-held terminals each fitted with a bar-code wand, could be used. When the parcel is delivered, the postman would read the code and enter the recipient's name on the keypad. Terminals with built-in acoustic couplers would allow the postman to transmit the data from his deliveries so far, from any convenient telephone on his round.

As the discussion above demonstrates, the different departments within the BPO have widely varying requirements from information retrieval systems. A bar coding standardisation committee has been set up to steer future applications, so that as much harmony as possible between systems is obtained. For the present, however, these small self-contained systems provide valuable experience in the application of these techniques.

## AUTOMATIC SORTING

All the applications of bar coding mentioned above improve the information gathering and management throughout the BPO, but none offer a direct improvement to the service itself. Bar codes, however, have something to offer here too.

In parcel sorting offices, a major bottle neck in the parcel flow is at the induction stations of the sorting machines. Here the postmen face the parcels (turn them so that they can see the address label) and key the destinations into the machines' controllers. The feed rate of parcels onto the sorting machine is considerably less than the machine's capacity, and so any improvement to this would increase productivity. Automatic recognition of the parcel's destination would significantly speed this operation and remove the risk of missorts due to mis-keying This could be achieved by using bar codes in two ways:

(*a*) The more straightforward method would be to have the destination encoded in the bar code, as mentioned above. The data from the reader would then be passed straight to the controller.

(*b*) The alternative is to have a serial number in the bar code which allows the controller to find the destination from a database. This, of course, demands sophisticated hardware links and so is not a viable proposition.

### Reading the Codes

Whichever alternative were chosen, the bar codes on the parcels must be read. Some distributors who use bar codes for outward sorting of goods have installed hand-held readers at the sorting station. The operator must find the code and scan it manually, a task which is no quicker than keying and may prove more tiring. It also means that the operator does not have both hands free to manoeuvre the parcel. It is desirable, therefore, to read the bar codes automatically, with a moving-beam laser scanner mounted over the conveyor belt, as is similar to current practice at many supermarket checkouts, where the cashier moves the goods over a scanner, which reads the code. The PO application, however, must overcome many problems not encountered at checkouts:

#### *Facing*

Unlike supermarket goods, parcels are generally large and heavy, and so to position them below a scanner requires great effort. Whereas a cashier can easily and quickly repeat the pass for any item which fails to read, it would be difficult for a sorter to do so. The postman should, therefore, be asked to face and orientate the parcels onto the conveyor belt, upstream of the scanner. This will also allow multiple injection streaming to one laser unit.

A parcel can be such an irregular shape, that it is not possible to position it with the label level and facing upwards towards the scanner. Installations in warehouses and distribution centres do not encounter this problem, since the goods handled are regular, generally packed in cardboard boxes, and the position and orientation of any code is known. The need to orientate the parcels before passing them beneath the scanner can be removed, if a label comprising two over-square bar codes (height greater than width) at right angles to each other is used. Provided that the label is facing upwards, a single line scanner will successfully read one of the two codes. The alternative is to use an omni-directional scanner, with a laser that scans in many different directions.

#### *Read Rate*

The 'first read' success rate must be very high, since only one pass is available at the induction station. Each failed read, therefore, will reduce the net throughput rate of the machine.

### *Depth of Field*

The depth of field of laser scanners used at checkouts need only be a few centimetres, whereas, because parcels vary widely in shape and size, the depth of field at the induction stations needs to bc approximately 0·75 m. This imposes greater constraints on the scanner and on the quality and size of the bar code.

### *Print Quality*

The bar codes on supermarket goods merely identify the product, and so are printed as part of the packaging. To attract the customer the standard of printing is very high, which means that the code can be very compact. In Post Office applications, the code required on each parcel would be different (or at least one of a number of different types) and would be printed on an adhesive label, the cost of which would be an important consideration. These two factors imply that the BPO bar codes would be of only medium quality.

It has been assumed so far that the labels are already on the parcels. Printing and application of the labels, however, is not straightforward. If a destination code is included in a label applied at source as mentioned above, there is only the problem of size. The label could be applied at some later stage in the parcel's journey at a coding station, similar in concept to the coding desks used in letter sorting. Here an operator would read the address label on a parcel and enter a destination code on a keyboard. A label would be produced and applied to the parcel. The destination code need only be the outward half of the post code, since this would allow sorting at both the despatching and receiving parcel concentration offices.

### Current Work

The Engineering Department is currently evaluating the two types of laser scanner on a test rig which simulates the induction area of a parcel sorting machine. A single line scanner with a depth of field of 0·6 m has been set to scan across the conveyor belt, which runs at 1 m/s. Indications are that on regular parcels, carefully aligned, the read rate will exceed 95%. This particular unit, however, can only read low-density codes; consequently, the bar codes used carried only three characters in CODE 39[2] and yet measured 75 mm in length. Other units will be evaluated which are expected to better this. An omni-directional scanner was also mounted over the belt, and was found to read as reliably as the single line scanner, though it could read codes which were more than twice as dense. The scanning pattern, however, is only 0·25 m in diameter, while the belt is 1 m across. The facer, therefore, must position the parcel so that the bar code passes through the pattern.

No problems are envisaged with any laser reader in reading ideally presented labels. The major part of this study will establish the bar-code readers' tolerance to the angles of pitch and roll of the labels (measures of how level the label is), compactness of code and speed of belt. The study will also compare the engineering and ergonomic benefits of:

(*a*) using a single line scanner so that the facer must face and orientate the parcel (the larger the aspect ratio of the code the less accurate the orientation of the label need be); with

(*b*) using an omni-directional scanner (or an omni-directional label) so that the facer need only face the parcel.

At present, parcels must be fed manually to the scanner, though automatic coding will increase throughput dramatically. In the future, it is envisaged that automatic feeding systems will increase throughput still further.

## CONCLUSIONS

It has been shown that bar coding can assist in many areas of the Busincss. One integrated system, satisfying all requirements throughout the BPO may prove difficult to implement. However, a system built around a bar-coded label which contained a destination code and a serial number would allow all features mentioned in this article to be realised.


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# Role of the ITU in the Transfer of Technological Know-How

UDC 341.1 : 621.39

*The International Telecommunication Union (ITU) has been engaged for many years in the transfer of technology. Today, such transfers are effected chiefly through the Study Groups and specialised autonomous groups of the Union's International Consultative Committees, the International Frequency Registration Board and the Technical Co-operation Department of the ITU General Secretariat. The exhibitions and forums organised by the ITU also constitute a highly efficient instrument for the transfer of technology.*

*This article is based on a press release issued by the ITU to mark the 20th World Telecommunication Day (17 May 1988).*

## ITU CONTRIBUTION TO THE TRANSFER OF TECHNOLOGY

Although the modern concept of technological transfer really took shape in the 1960s, the underlying foundations were laid within the International Telecommunication Union (ITU) at the time of its inception in 1865, more than 120 years ago. Even at that time, the recognition of the need for adequate regulation, standardisation and transfer of know-how to facilitate the introduction of the international telegraph service was paramount. The transfer of technology was thus closely bound up with international co-operation.

## A LOOK AT THE PAST

The establishment of the ITU (then the International Telegraphic Union) in 1865 began what might be termed 'traditional' co-operation for the co-ordination of practices, technical and operating standards, agreed regulatory responsibilities for the acceptance and delivery of messages, the sharing of revenues and the sharing of information concerning new technology.

The subsequent development of technology and the consequences of the many changes inside and outside the traditional telecommunication field have only reinforced the need to widen the scope and depth of this traditional co-operation.

The late-1950s saw the emergence of newly sovereign countries and, in the 1960s, the membership of the Union increased significantly.

There was ready recognition of the mutual interest in widening the scope of co-operation, which was chiefly the ITU's responsibility as the United Nations specialised agency for telecommunications. Special requirements led to new forms of co-operation, a kind of 'tailor-made' co-operation to meet the needs of certain countries as part of the responsibility of the United Nations family and the ITU.

## CO-OPERATION TODAY

The work of the ITU in 1988 covers the activities of regulation, co-ordination and standardisation which underpin the development of the world's network. This form of co-operation also provides an outstanding example of the transfer of technical know-how and skills. It is carried out today in the same spirit as in 1865, through technical co-operation, International Consultative Committee (CCI) Study Group meetings, International Frequency Registration Board (IFRB) seminars, the organisation of TELECOM exhibitions and world forums, and through the numerous publications of the Union's permanent organs.

Thus, each Member country communicates the results of its research and experience and receives in return the information communicated by other Members which is essential to the planning, establishment and operation of world telecommunications. They both contribute to and benefit from shared skills.

## TECHNICAL CO-OPERATION: KEYSTONE TO THE TRANSFER OF TECHNOLOGY

Technical co-operation may be qualified as 'tailor-made' co-operation. It is aimed at improving telecommunication equipment and systems in the developing countries through the dissemination of information, the provision of advisory services, the localised transfer of skills, the establishment of institutes and the strengthening of national self-reliance in those countries. It is unquestionably the most lively vehicle for the transfer of technology.

These activities have primarily been the responsibility of the Technical Co-operation Department of the ITU General Secretariat. Much of the work consists in implementing telecommunication projects within the framework of the United Nations Development Programme (UNDP), although, to an increasing extent, both recipient countries and third-party donors are directly calling upon the services of the Department to execute technical co-operation projects.

A voluntary assistance programme was set up in 1984 to help the developing countries by providing them with the services of experts, training services, equipment and all other forms of assistance for meeting their telecommunication requirements to the fullest possible extent.

In addition, a group of engineers at ITU headquarters is responsible for rendering short-term assistance to the Member countries, either by correspondence or field missions. These engineers provide advice and evaluation to the authorities responsible for the preparation and execution of the Technical Co-operation Department's projects in the following fields: switching and signalling, network planning, traffic engineering, cable networks, line transmission systems, multiplexing, radiocommunication and satellite communications, sound-and-television broadcasting, frequency management and radio propagation.

Lastly, the Department also comprises a Training Division whose activities focus on the establishment of international training standards in telecommunications and the international exchange of training materials.

## A FEW FIGURES

As part of its technical co-operation, the ITU is implementing some 190 projects in about 100 developing countries. The projects are broken-down as follows: 55 in training, 65 in infrastructural development and 70 in planning. In 1987, more than 800 fellows were given training courses either individually or in groups depending on the degree of specialisation. Another policy relating to technological transfers concerns the sending of experts into the field as part of ITU projects. 1987 saw confirmation of the trend which started a few years earlier towards expert missions which, although shorter, called for high-level technical skills.

The Group of Engineers carried out 53 missions, including 21 by external experts. The Training Division, on its part, organised more than 26 training workshops. These missions and workshops gave the local counterpart staff an opportunity to acquire technical skills in all the fields related to the planning, management, operation and expansion of their networks.

However, it is in the field of training that the transfer of technology is most evident and, indeed, it is on training that almost two-thirds of resources are spent.

Every day, some 155 experts share with the local counterparts they are training both their skills and their long-standing experience whenever a technical co-operation project is implemented. Regardless of the field involved, the experts always concentrate on the transfer of technology and human skills in the countries in which they operate so that local people may take over once their mission is over.

It is widely recognised that the development of telecommunication structures and services is dependent upon the professional competence of the staff in service or to be recruited.

## VOCATIONAL TRAINING

Although every country needs experts of its own to ensure its independence in using and exploiting its national network, the spirit of co-operation is indispensable.

The utilisation of human resources for telecommunications is seldom achieved by countries acting in isolation. International co-operation forms an integral part of any harmonious development policy and, through its technical co-operation activities, the ITU plays a major role in helping countries to establish the necessary structures and programmes on the basis of common and complementary staff requirements. Some experts come from technically advanced countries such as France (70 experts seconded for 92 missions in 1987), Sweden (35 experts for 51 missions), the United Kingdom (27 experts for 35 missions), and Australia (23 experts for 25 missions). However, the number of experts sent by countries which themselves receive assistance in the form of expert services is far from negligible.

Thus, India has supplied 26 experts to participate in 26 missions, while itself receiving 52. Egypt and Tunisia, although not receiving assistance themselves, provided 15 experts (8 from Egypt and 7 from Tunisia) for 16 missions. Another example, Brazil, received help from 33 experts and sent out 9 (for 10 missions).

These are striking examples of the 'two-way' exchange of technology at every level of development. Countries have the benefit of much-needed co-operation and, at the same time, share their own technical expertise with other countries.

In applying an expert's specialised knowledge where it is needed, the ITU does not stop at contributing to the solution of particular problems. In so doing, its also fulfils an even more important function; namely, giving staff at every level the opportunity to acquire specialised knowledge from their foreign counterparts and receive an introduction to new technology through both traditional and on-the-job training.

Apart from training carried out within technical co-operation projects, the ITU has, in the past two or three decades,.assisted in the establishment world-wide, within the framework of UNDP projects, of more than 80 national and regional telecommunication training establishments. The ITU has continued this activity at the request of the individual countries, in particular when major investments and changes in technology have been involved.

Training establishments are typically supported by the provision of international experts, fellowships for technical and training staff to study advanced technology abroad and by the provision of training equipment.

In 1975, the ITU started, with the financial support of the UNDP, the inter-regional project for course development in telecommunications (CODEVTEL). At that time, it was a pilot project involving only seven countries chosen to try out a new training development method. In 1982, the Nairobi Plenipotentiary Conference decided to continue funding this project from the ITU's own resources. At present, more than 70 countries are taking part in the project; more than 1000 course developers have been trained world-wide; some 450 courses have been produced following the CODEVTEL method and are available to all participating countries while another 450 courses are under development.

## CODEVTEL

The CODEVTEL project is an example where through a relatively small-scale multilateral effort it has been possible to change significantly attitudes and work habits in the area of training, towards a more professional approach of training development and towards increased self-reliance of the participating countries. Indeed, many developed countries have benefited from the project.

The CODEVTEL project could not have been implemented successfully without a wide consensus regarding training standards and methods. To that purpose, the ITU and Member administrations have been organising a number of international meetings and seminars. These meetings have largely contributed towards promoting the introduction and acceptance of the proposed training standards.

A vital aspect of these meetings since 1980 has been the increased participation of telecommunication equipment manufacturers. Their role is indispensable for training on the most advanced equipment, while mutual understanding between administrations and manufacturers regarding training requirements is essential for the successful introduction of new technologies.

As a result of these meetings, an international sharing system for telecommunication training has evolved in which the ITU acts as the focal point for the exchange of information and training materials. Information is disseminated, in particular, on the state of advancement of the many course development projects, on the objectives and contents of the training courses developed, and on training opportunities in different countries. For this sharing system to function, a computer-based information system has been developed, but in order to cater for the information needs of countries where the necessary equipment is not yet available, the information is presently distributed mainly in printed form. The ITU also encourages an exchange of the training materials developed. They are distributed at the lowest possible cost and hundreds of requests are handled yearly.

Some satisfactory results have been achieved, but much remains to be done. The proper management of human resources requires many actions such as staff selection and training, the establishment of a career policy and provision of a supportive working environment, clear and well-understood organisational goals, as well as regular feedback on individual work and recognition of achievement; it is certainly no easy task to implement such a supportive environment. The ITU has a responsibility and is ready to support and assist those administrations who wish to improve their telecommunications operation in all areas, including the development of human resources, for the social and economic progress of their respective countries.

CODEVTEL is undoubtedly a unique system, an outstandingly useful instrument in the exchange of technical knowledge.

## COMPUTERS AS AN AID TO TECHNOLOGY EXCHANGE

The benefits of electronically designed systems providing users with advanced technology without their needing to undergo lengthy and expensive training are exemplified by PLANITU.

PLANITU is a computer-based system designed to plan, improve and dimension telecommunication networks, and thus facilitates the task of planning engineers. It offers an integrated interactive approach to finding the least expensive solutions to many of the problems arising from network planning.

Engineers do not merely receive training, they also have the benefit of a working tool which, in the space of a few months, gives them the knowledge required for planning their local, national and international networks based on years of experience by engineers and computer experts in this field.

The ITU offers training courses and seminars for future users of the system, transfers programs to administrations and provides software support, including the installation, testing and adaptation of programs to local computers, and any additional training which may be required.

## MAJOR PROJECTS

Another area of international co-operation providing large-scale technology transfers is undoubtedly that of the major projects for the development of national and regional networks, such as the Pan-African Telecommunication Network (PANAFTEL), which was set up to interconnect African countries within the continent itself.

The emphasis of PANAFTEL has now moved from initial network construction to operation and maintenance and network development in terms of capacity and coverage as well as the range of services offered. The introduction of new technologies in these networks is another aspect of the work of project staff and their local counterparts.

Maintenance has in recent years become a priority of the African telecommunication administrations in seeking a return on their major investments in the implementation of PANAFTEL. In support of their efforts, a regional PANAFTEL maintenance project has been set up with the main objective of promoting and advancing the practice of maintenance and maintenance facilities.

Under this project, active co-operation has been established between representatives of all the participating administrations and the international experts. A detailed analysis of the present situation and problems encountered has led to the development of a guide to the preparation of a National Plan for the Improvement of Maintenance (NPIM), the purpose of which is to define an overall strategy for solving maintenance problems (structures, staff, training, budget, logistic and financial facilities, work methodologies, etc.) and propose an appropriate plan of action for implementation by the maintenance authorities of each participating country.

By the end of 1987, 39 countries supporting the strategy were pursuing their efforts to prepare and implement their own NPIM with the skills required to ensure their autonomy in the field of maintenance.

As the foregoing examples show, the transfer of technology through technical co-operation programmes is more than a pious hope. It is a daily reality which properly illustrates the ability of governments and industry to combine their efforts for the greater benefit of all.

## IFRB EFFORTS FOR THE TRANSFER OF TECHNOLOGICAL KNOW-HOW

The main task of the International Frequency Registration Board (IFRB) is to allocate frequency bands and enter notices in a register with a view to having them internationally recognised and protecting them against harmful interferences. The Board consists of five members, each of whom must be technically qualified in the radiocommunication field and individually elected from one of the five regions by the Plenipotentiary Conference in such a way as to ensure equitable distribution among the regions of the world. It acts as a corporate body within which the individual members perform their task not as representatives of their respective countries or of a region but as 'custodians of an international public trust'.

Although the IFRB's tasks have remained virtually unchanged since its inception in 1947, a new dimension has been added to its terms of reference; namely, the transfer of technology. In this connection, several resolutions and recommendations have been adopted by World Administrative Conferences, particularly WARC-79, with a view to increasing technical co-operation in radiocommunication fields and promoting the use of computer technology for facilitating spectrum management by administrations.

The IFRB carries out training activities in its daily activities. Indeed, it trains top-level personnel seconded by interested administrations to ITU headquarters at Geneva in the difficult, painstaking, but essential, process of applying the procedures of the Radio Regulations. Moreover, it can provide administrations with assistance in the co-ordination of frequency assignments; for example, by training the engineers concerned in the complex techniques involved (search for suitable frequencies, determination of the probability of harmful interference or the need for co-ordination, and the determination of incompatibility).

As part of it technical preparations for world or regional administrative radio conferences, the IFRB helps administrations upon request to define their requirements more accurately and, in so doing, is careful to transfer the knowledge needed for improving the skills of the engineers engaged on such work.

The Board also produces explanatory handbooks designed both to inform and to train 'frequency managers'. Moreover, in collaboration with the CCIR, the IFRB organises meetings between developing countries and developed countries, with the purpose of transferring technological know-how in the spectrum management field.

At two-year intervals since 1964, the IFRB has been holding two-week seminars on frequency management and the use of the frequency spectrum. The seminars deal with the practical aspects of organising and establishing radiocommunication services in developing countries, the preparation of national regulations for the operation of such services and the facilities to be implemented for ensuring compliance with the relevant international regulations.

## TRANSFER OF TECHNOLOGY WITHIN THE CCIs

The two ITU International Consultative

Committees (CCIs) are organs responsible for

- studying and issuing recommendations on technical and operating questions relating specifically to radiocommunication (International Radio Consultative Committee (CCIR)), and
- carrying out studies and issuing recommendations on technical, operational and tariff questions in telegraphy and telephony (International Telegraph and Telephone Consultative Committee (CCITT)).

All Member countries of the ITU, and recognised private operating agencies, scientific or industrial organisations and international organisations meeting certain requirements, may take part in these activities.

The Plenary Assembly lists the technical subjects in telecommunications, or questions, the study of which should serve to improve radiocommunications or the telegraph, telephone, data transmission or telematic services, particularly in international relations. These questions are then examined by several Study Groups comprising experts from various countries.

Thus, throughout the year, experts from all countries of the world, at every stage of development, meet and exchange technological knowledge on the questions assigned to them by the Plenary Assembly. At these meetings, the participants familiarise themselves with the various technologies which will be used by new equipment and services to be developed by their administrations and companies; the result of such 'brainstorming' is that a substantial body of technological know-how is shared to spearhead the telecommunications of tomorrow.

The outcome of these discussions is embodied in reports and recommendations which form the basis of the international standards essential to allow the interconnection of equipment designed on a wide variety of principles and techniques.

In 1964, the ITU set up Special Autonomous Study Groups (GAS) to deal with questions of particular concern to developing countries. These groups publish their findings in handbooks on such subjects as the economic and technical aspects of the choice of transmission or switching systems, the economic and technical implications of bringing into operation a regional telecommunication-satellite network, the conversion of an analogue to a digital network or even the strategies for setting up a public data network.

On the question of training, for example, CCITT GAS 9 has analysed the impact of new technology, especially digital technology, on human resources. Chapter 8 of its handbook, dealing with technical and economic aspects of digitisation, will contain references and detailed guidelines established with the help of the Training Division.

The CCIs also participate in the Union's technical co-operation activities for developing countries, notably by producing technical handbooks dealing with problems of particular application to these countries (cable technology, digital networks, satellite communications, etc.).

For example, the CCIR has produced a report entitled 'Spectrum management and computer aided techniques', intended as a guide to modern frequency management, and a 'Handbook for monitoring stations', containing advice on the means of solving new problems encountered on the establishment of a new monitoring service.

The ever-increasing participation of technicians, engineers, mathematicians, artificial-intelligence specialists, researchers and computer specialists throughout the world is a clear indication of the benefits resulting from high-level information exchange as practised in the Study Groups. The truth of this is underlined by a significant increase in the number of participants from developing countries, although attendance of developing countries at CCI meetings is still regarded as inadequate with the result that, in many ways, such administrations are unable to derive the full benefit.

## DISSEMINATION OF INFORMATION THROUGH ITU PUBLICATIONS

The importance of the part played by ITU publications in the field of technology transfer is too often overlooked. The usefulness of the GAS, IFRB and CCIR publications discussed above for disseminating, in the widest sense, technical information is clear.

But one should consider that all the work carried out by the CCIs, the IFRB and the Technical Co-operation Department is issued in the form of specialised publications and made available on request at nearly cost price. The information, assembled at meetings, seminars and conferences is therefore placed at the disposal of all interested parties, whether governments, industry, scientists or universities, whether they are users or suppliers of services or whether they are members of national administrations. Hence, ITU publications play an essential role in disseminating technical information along with the associated transfer of know-how.

A striking example is provided by the *Telecommunication Journal*. Founded in 1869 (with the title *Journal Télégraphique* until 1932), it gives its readers—engineers, economists, teachers at universities and polytechnics, decision-makers—information on the latest technological advances in the Union's Member countries (both private and public sectors). It provides in-depth technical and instructional articles on all aspects of the telecommunication sector, as well as an extremely useful review of new equipment and the latest books on electronics and telecommunications. Finally, it gives an account of Union activities and the main meetings and conferences outside the ITU.

The journal brings out the main economic, technological and general policy trends in telecommunications. Its articles, whether produced by the ITU or by eminent experts in the various telecommunication disciplines are authoritative and soon become works of reference.

### TELECOM EXHIBITIONS

The organisation of world exhibitions is most definitely seen as a means of transferring technological know-how, and, indeed, it was with this in mind that the ITU Plenipotentiaries authorised the organisation of the TELECOM exhibitions. The telecommunication exhibitions are of considerable assistance in keeping the Members of the Union informed of the latest advances in telecommunication techniques and in publicising the possibilities of applying telecommunication science and technology for the benefit of the developing countries.

The exhibition has grown in size from a net surface area of 10 000 $m^2$ at the first event in 1971 to 65 000 $m^2$ in 1987 and attracted nearly 20 times more exhibitors in 1987 than in 1971. TELECOM 87 offered the largest and most comprehensive display of telecommunication equipment and services ever exhibited on an international scale. The exhibitors presented all the aspects of modern telecommunications, from digital transmission and switching technologies to prototypes of integrated services digital networks. A large number of exhibitors also highlighted rural communications, basic services and the fundamental needs of most developing countries.

Finally, the organisation of a forum right from the very first exhibition provides further confirmation of the Union's desire to employ all possible means of achieving the transfer of technology. This technical FORUM, co-sponsored by more than 80 professional technical associations, is a universal event dealing equally well with the aspects of modern technology as with emerging trends in all areas of telecommunications. The proceedings represent several hundreds of pages of information of the highest order placed at the disposal of the international community and constitute an unrivalled source of know-how. To add to the policy, expertise provided in the first part of the forum and the technical experience offered in the second part, both of which have been a feature of the symposium component of TELECOM from its very beginnings, the ITU has endeavoured to extend the range of expertise made available to participants. Thus, as from 1983, a legal part and a special session devoted to regional telecommunications development were instituted. In 1987, two further parts were added: one on economic research and the other on the problems and challenges arising from the development of regional networks.

Thus, TELECOM and the FORUM are agoras in which everyone has a place and can benefit from other people's knowledge. Unique and original, they play a leading role at the forefront of the large-scale transfer of know-how.

# British Telecom Technical College

## Part 1—Training Operations Section

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UDC 331.862

*This article, the first of two parts, describes the Training Operations Section of the British Telecom Technical College. It complements a forthcoming article by Mr. A. W. Bewley which describes the Training Development Section of the College, and the two parts form one cohesive description of the Technical Training Division of British Telecom UK Communications.*

### INTRODUCTION

British Telecom's Technical Training Division, also known as the *British Telecom Technical College* (BTTC), is one of four reporting to the General Manager Training Department (TD), British Telecom UK Communications (UKC). The others are the Training Policy and Commercial Training Division, the Management Training Division and the Organisational Development Support Division.

This article is primarily concerned with the Technical Training Division, and specifically with the Presentation or Training Operations Section. Part 2 will deal with the training development aspects of the work carried out by the Division.

The role of the Technical Training Division is complex, but its function can be summarised simply by defining its responsibilities as being to provide training at the right price, at the right place and at the right time. Thus the Division fits in with BT's main aims, and sees its role in terms of its work-force being sponsored by Headquarters Departments and its supply of services to BT Districts and, on occasions, to non-BT customers.

All training developed and eventually presented by whatever means by TD must receive sponsorship or authorisation that the expenditure incurred in preparing the training is in BT's interest and in line with business policy. Indeed, any provision of capital equipment in support of training is subject to capital authorisation in the same way that District telephone exchanges and other capital projects require authorisation.

TD's sponsors generally come from Headquarters Departments who will be implementing some aspect of network development, including telephone exchanges, transmission systems, customer apparatus or data network facilities. It is rare, but not inconceivable, that Districts themselves would want to sponsor training, although the main avenue of such sponsorship is for District pressure to be brought to bear on Headquarters Departments, thereby justifying widespread sponsor-

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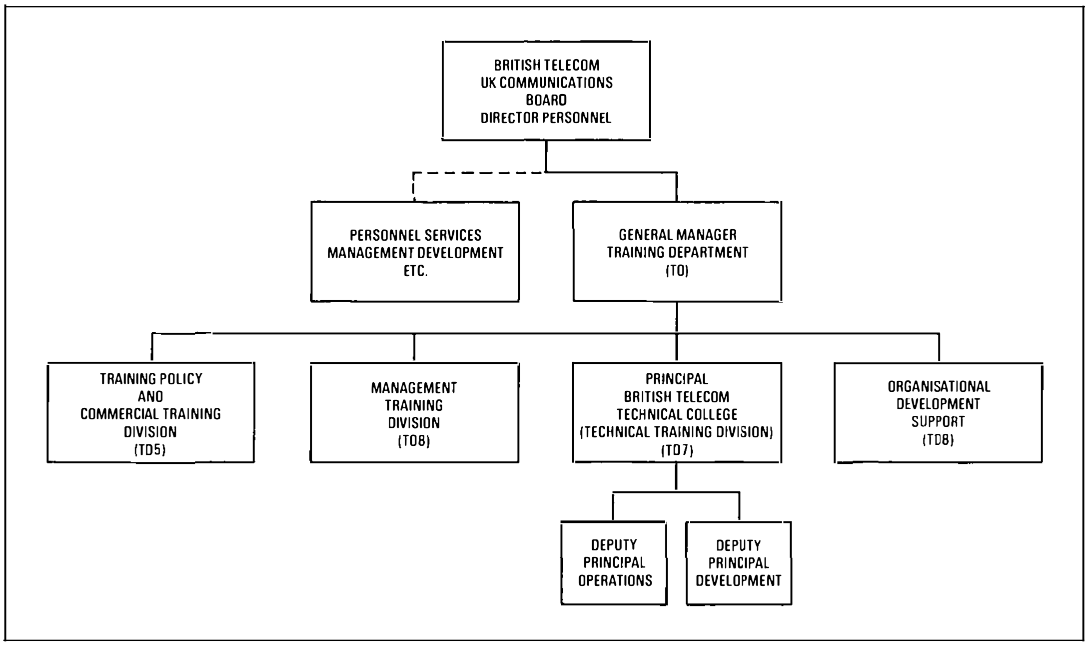



**Training Department organisation**

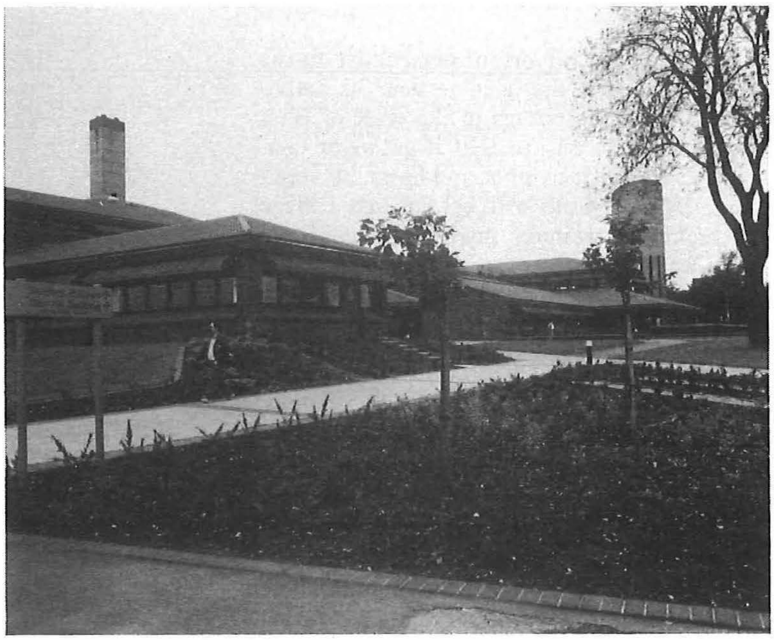
ship for a common training method rather than a piecemeal approach.

From time to time, TD has spare capacity; that is to say, available resources whether in terms of development or presentation skills. These spare resources are available to be used for the training of customers, particularly to meet data-network or overseas-administration needs, or even contractors and perhaps competitors, provided that the training does not compromise BT, or give that competitor an advantage over the Company.

## TECHNICAL TRAINING DIVISION ORGANISATION

The work of the Division is co-ordinated by a management board comprising the Head of Division, two Heads of Section and 11 Group Managers, whose responsibilities range across training design and development, and across the presentational aspects of the Division. Concentrating solely on presentation and leaving other aspects to the forthcoming Part 2, the responsibilities here fall to five Group Managers with responsibilities across all of BT's major engineering activities. Each Group Manager controls four or five training managers, who are located either at BTTC Stone, or at the dispersed training colleges at Paul Street in London, Bletchley Park in Milton Keynes, Shirehampton near Bristol, Shirley in Birmingham and Harrogate in Yorkshire; the latest addition to this string of colleges is the BTTC Muirhouse situated in Edinburgh. The only ex-Regional training college remaining outside the direct control of the Division is that located in Belfast, Northern Ireland. Because of its distinctive organisation at District level, the training school is solely concerned with the training of Northern Ireland students, and it is appropriate and economic for it to remain under District control.

**Dining and recreational areas for students are an important part of the BTTC**



Each BT District also has its training section, and the Division's responsibility is to provide training and/or training material suitable for presentation within the District, perhaps by suitably trained District staff. Indeed, some Districts are considering setting up their own permanent training organisations as more and more training is made suitable for local District delivery. All cases where such training is being considered for local delivery must be examined on its merits. Because of the economics involved, it is generally far cheaper for the Division to provide training either centrally or within District because of the expertise developed across a range of training packages and the economics of scale involved.

## DISTRICT TRAINING

Districts are informed in *Training Letters*, sent to the District training offices, of new training packages suitable for local delivery. The letter gives details of how to obtain the training packages, and the packages give detailed guidance on the presentation of that material to students within the District. Such material, which will be covered in more detail in Part 2 of this article, includes such delivery media as computer-based training, interactive video using computer control, as well as handbooks, which are self-contained booklets covering some training need on some newer types of equipment.

Training guide notes are also issued by TD and these comprise a collection of useful information on new items being launched, and give information summaries as appropriate to installation and maintenance duties within Districts.

The strategies available to the District training staff therefore range from formal college-based courses, training provided within Districts by college staff, to instruction, again within the District, by District staff after they have received briefing at a TD college, the presentation being supported by centrally supported documentation, or other specially produced material such as an audio-visual presentation. Other options include specially prepared training guide notes issued either directly to staff or, again, other specially produced material including audio-visual presentations. The last category would include documentation prepared about a new type of equipment or other product, where the documentation is considered suitable for immediate dissemination to District staff in support of a new and rapidly introduced product national launch. Often timescales for such training are very short because of the amount of secrecy surrounding new products and the need to be in the market-place at the right time and ahead of competitors. The development and provision of such training is therefore usually an urgent job.

It is important that, when in-District training is being carried out, nationally agreed standards concerning the training environment, the accommodation, tutor, media, hand-outs and furniture are appropriate to the function; from time to time, the Technical Training Division issues guidance letters to assist District training staff in carrying out their duties.

Training guide notes and packages are training media which may comprise the printed text, hand-outs, videos, interactive videos or other media suitable for conveying appropriate training information to staff around the Districts, and which can be used at any time that District Training Officers wish. Districts can purchase these and use them as appropriate. The production and dispatch of this material can be very complex since there is a need to make master copies, perhaps involving outside contractors where a video, tape-slide or other audio-visual medium is involved, produce sufficient copies to meet demand, and dispatch them to the customer. Clearly, there is a fairly wide service available to any sponsor requiring to put a message across to staff in which there is a training element to that message.

A Training Letter (TL 8/84), which is a vehicle for the quick dissemination of information on training matters, has been issued to all training groups, and describes the various training strategies available from which any District training need can be met. The changing technology that is found around BT is also very evident in TD. A fuller description of initiatives taken here will be given in Part 2 of this article.

## TRAINING AT BTTC STONE

Training at BTTC Stone has traditionally been for Technical Officer or Technical-Officer-in-Training grades requiring instruction on the more complex equipment such as transmission, data and switching systems, but including external plant, external planning, electric light and power, environmental planning, building engineering services, motor transport skills and a certain amount of drawing office training. Generally, some 1000 students are engaged in training at BTTC Stone at any one time. BTTC Stone also has special facilities with which to support conferences, to provide for senior management technical updates, as well as to play host to a variety of conferences, perhaps initiated by one of the training sponsors or some of the Headquarters Departments; even District management meetings are held there.

The rapid change which characterises BT these days has long since caught up with TD and nowhere less significantly than in the Technical Training Division. In years gone by the rate of change of systems, technology and work methods meant that training once developed would continue unchanged for some years. This is naturally no longer the case in that switching systems, transmission systems, private switches and networks have seen phenomenal developments during the 1970s and 1980s. BTTC Stone has seen much of this equipment, having had to obtain examples for training development purposes and for subsequent training. Even systems purchased have to keep up with developments of the system in the field to maintain relevance, and so college management has to be well acquainted with BT's marketing strategy and particularly the Network Master Plans so that the business operating plans for the Division can properly be made. Often such forward planning involves detailed analysis of the District training needs so that sound assumptions can be made upon which to base training throughput, the corresponding course pricing structure, staff resources and equipment purchases or enhancements to meet changing business needs.

**Conference facilities at BTTC Stone**

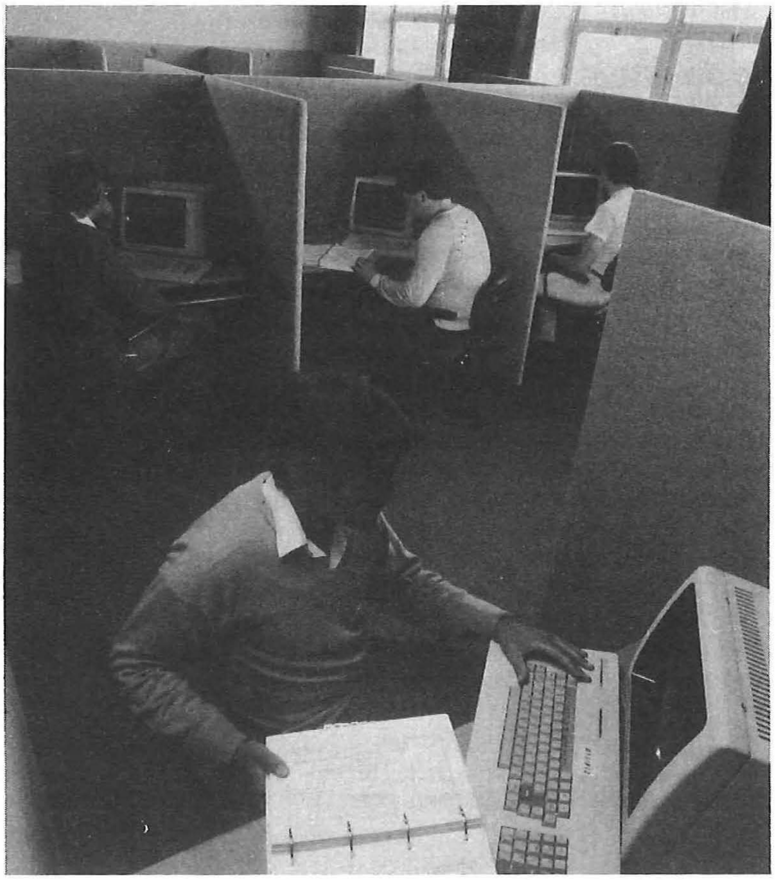
Another most important perspective to the Division's role is the need to gear its seven-site 1400-staff resources to the scale of BT's business and to ensure that it grows or contracts as the business ebbs and flows. Strategically, BTTC Stone will be the last college for technical training provision should the business contract that far, or should sufficient training technology permit the satisfactory provision of vocational training within the District or by 'on the job' methods.

## BTTCs OTHER THAN STONE

The amount of training carried out at other BTTC locations, totalled together, equals that of Stone and has traditionally covered the technician's skills involved in customer apparatus, small business systems, call connect systems, overhead and underground work. An

A class of students training on digital faulting techniques used in District repair centres

important project has been underway for several months now to rationalise all training previously carried out in the old Regions, so that a common national numbering scheme for courses exists; this will ensure that TD's customers need ask only for the course as detailed in the training course prospectus (available at all training officer locations within BT), and that customers are assured of a standard course and one which can be recorded on staff records to assist in staff development.



A typical computer-based training learning centre with students working at a pace to suit themselves

Further rationalisation of training will continue to evolve given the large number of product launches which need to be supported both by sales divisions in terms of products and facilities and by engineering training departments in terms of providing for installation and maintenance staff within Districts to support the products from the outset. The problem for TD here is the inevitable planning difficulties of providing just enough equipment to meet expected demand, and then to support ongoing demand throughout the life of the products; this support needs to be in place both before the products are officially launched and throughout their economic life.

The integration of what were Regional training colleges into the Technical Training Division/BTTC structure is seen from this overall business need to be a most timely event.

## TRAINING TECHNOLOGY

The training technology, as the training courses tend to be described, has varied considerably over the past few years. Everybody is aware of the formal training course involving a lecturer and some instructors, the need to see training equipment, and the more general breaking up of classes into small instructional groups, so that the practical skills can be explained and passed on. However, progress has occurred even in training: the formal course still exists, the within-District training packages of whatever form including video etc. exist, but at the training college students now find some of their training delivered by computer-based training techniques. Although this topic will be dealt with in Part 2, a mention is necessary here to explain how the presentation side of the Division has evolved.

### Computer-Based Training

There are at present, throughout all BTTCs, some 120 computer terminals, each specially adapted to take touch-sensitive messages from the screen, so that students can sense that they have full interaction with the computer system during their tutorial periods. Much has been said about this new and quite challenging training method, used for digital-systems training, transmission principles, and electronics, including logic circuitry and faulting on motor vehicle electrical systems. Students are 'signed' onto the computer system by tutor staff, given a file of student notes which complement the training to be given under the control of the computer. Working at their own pace, students can work their way through various training media, from text on paper, text on screen, video, equipment practicals or other appropriate media. At all stages, students' progress is monitored and, depending upon their responses to questions asked by the computer, students are directed to the next appropriate training module by the computer management package associated with the training.

At any stage, the student's progress might be interrupted so that the services of an instructor can be used to correct any difficulties being experienced after which normal learning can be resumed at the student's normal pace.

The Technical Training Division, as it has gained experience with this new training medium, has experienced problems of a cultural and social nature, and these have had to be resolved. It is believed that a high percentage, in the high 90s, of comments made by Districts have already been addressed, and it is further believed that a very large percentage of students are prepared to accept, and even appreciate and enjoy, training delivered by computer-based training techniques. TD now has a very efficient and most useful alternative when presenting training to large volumes of students for which a consistent, accurate, punchy message is required.

Interactive video is a computer-controlled video in which students can direct their way through the learning material and review, where appropriate, lessons that they have passed through. The power of computer control, and the tremendous impact of video, are combined here to provide a very refreshing training medium for use throughout BT, not just TD.

Developments in the computer area of training delivery are bound, over the next few years, to make use of intelligent databases; that is, computer programs will be delivered with the aim of teaching some appropriate material appropriate to BT's needs, managing the students' reactions and needs as they progress through training material and as they experience, learn and retain information. Their responses to the computer controlling system will afford tutors, looking after the class, valuable information on student progress and achievement, so that BT can be certain that students are going back into the Districts to do their jobs at a proficient level of competence and in a safe manner.

## TRAINING COSTS

The training colleges controlled within the Technical Training Division operate on a cost recoverable basis; that is, they must gauge their level of activity, set their costing strategy to break even and aim at those targets. Generally speaking, this is a more difficult task than that in which a business sets out to make a profit.

TD's income is based on two main sources: one is the recovery of the costs within BT of the design and development of training material; the other is the presentation of training material by whatever means and the charging of Districts the costs of providing that service. Clearly, there needs to be a resolution of the budget setting by Districts for training spend, and the budget setting by TD as it sets out its resources to meet just that level of training required by Districts.

## COURSE COSTING

Course costing is carried out each year and TD has managed to maintain its course costs at a constant level for some years now. Essentially, however, the course costing exercise takes into account the expected number of students requiring that training over the life of the course, the number of staff required for any given number of students, the amount of equipment used and the material which needs to be consumed each time the course runs; for example, cable used for jointing, optical fibre where optical-fibre jointing and testing is involved, or when cable is required to be drawn into ducts and then recovered again. Inevitably, there are wastages, and this can represent a considerable part of training costs.

Where expensive training equipment such as a small call-connect system, transmission system or exchange model is required, TD is charged with purchasing that equipment itself and then recovering the cost of that equipment over the life of that training course; an appropriate charge is apportioned to every student who will make use of the equipment based on the strategy outlined above. On high-volume training courses, even the most expensive training equipment breaks down to a very modest addition to course costs. It is important, however, to recognise that expensive equipment for which only a few students require training will inevitably mean that the premium added to the course cost is considerable.

**An expensive asset—a System X training model**

BTTC plays an important role in support of BT's technological strategies. It is important that it is involved at an early stage so that adequate planning can be made for its activities.

## EFFICIENCY MEASUREMENT

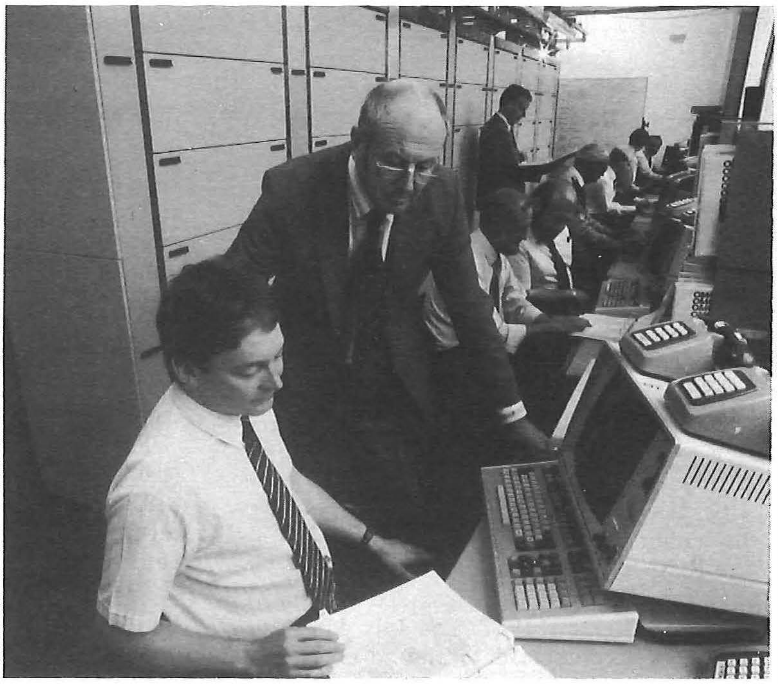
Each part of BT develops its own management indices by which to measure improvements in performance or worsening of performance so that action can be taken. Within TD, there are several measurements taken, but, essentially, these can be considered in terms of the numbers of support staff assisting the training function compared with the level of training produced, or the number of teaching staff for a given number of students. TD measures student throughput in terms of student-weeks, counting part week courses as a percentage of a full week for student-week calculation purposes.

Excluding the large volume of training delivered within Districts using the in-District computer-based training equipment, interactive videos, self-teach packages and other initiatives, the Technical Training Division delivers 80 000 student-weeks of training. Half of this throughput is achieved outside of BTTC Stone, and this sort of figure indicates that some 1500 or 1600 engineers and technicians are being trained or retrained at any one time, representing some 1–1·5% of the technical employees in BT. The policy is to extend the amount of training capable of being delivered effectively and efficiently at the work place or at least within Districts. A balance is always necessary to ensure that business costs are minimised while maximising the economies of scale achieved at central colleges.

A computerised course administration and booking system (CABS) has been developed in conjunction with a software house to record the demand for seats on courses, the allocation of seats to Districts, the call up of students including any special needs for protective clothing, any variation in the course start time as well as providing for the issue of course certificates if appropriate. The computer system caters for all course bookings throughout the Division.

## CONCLUSION

The Technical Training Division is an exciting part of BT at large, seeking as it does to provide for the many technological advances being made throughout the company from optical-fibre to digital switching technology. Demands upon TD are coincident with general business initiatives and it is indeed an important part of the team work needed to ensure success of any one product and the company itself.



**The changing nature of the job of the exchange engineer demands computer terminal skills**

BT is continuing to undergo great change and the Division no less so. TD is likely to develop even closer links with the Districts as it seeks to support far-reaching initiatives being taken to support company thrusts to become Top Telco, an aim only made possible with all staff functioning as a team with the appropriate technical and business skills pulling together with one common aim. The Division will continue to play its part in achieving this goal.

### Biography

David Wrench is Head of the Public Telephony Switching Training group in the Engineering and Vocational Training Division. He joined BT as a TT(A) in the Liverpool Telephone Area in 1965. He transferred as an Assistant Executive Engineer to the then Service Department in Telecommunications Headquarters in 1975, moving in 1979 to the BTTC at Stone to lecture on System X. Promoted via the limited competition to Executive Engineer in 1982, he was employed on training design duties before moving to take responsibility for the System X training sub-group. In 1985, he was promoted to Head of Group with responsibilities for analogue local and trunk switching and signalling, System X, OMC, ISDN and AXE 10.

# Felixstowe Dock Project—First Containerised System X Exchange

C. HAMMOND, and R. J. SQUIRRELL†

## INTRODUCTION

Felixstowe Docks in Suffolk have grown over the last decade to be one of the largest container handling ports in Europe. The development has taken place on the periphery of the existing TXE4 exchange area and has been a constant source of problems because of high growth rates and persistent complaints of poor transmission. A decision was therefore made to provide a System X remote concentrator centre (RCC) in the docks area, and it was aimed to bring the new exchange into service in July 1987.

By December 1986, it was apparent that the building being constructed to house the new RCC would not be completed in time to allow the equipment to be installed and ready for service by July 1987. The July date was the latest acceptable date and so expedient means were sought to keep to the planned time-scale.

Plessey Major Systems Ltd. had been experimenting with methods of containerising System X exchanges, and East Anglia District gave the company an order for a unit to be used as an expedient for Felixstowe Docks. Two concentrators were required to enable some 900 lines to be transferred by July 1987.

## CONTAINER

The 9·1 m container ordered contains seven System X racks, including one power equipment rack, in one suite. The racks are mounted on shock-absorbing pads and the space below is used for under-rack cabling. The container also houses a 'COSMIC' main distribution frame (MDF), spares cabinet, VDT trolley, mains isolation distribution point and has plinths for the possible addition of two reduced-height TEP-1A transmission racks. Constant environment conditions are provided by five air-conditioning units, and the container is protected by a smoke detection/alarm system, as well as an intruder alarm.

## INSTALLATION

By mid-March 1987, after six weeks installation and commissioning at Plessey's Liverpool factory, the mobile digital exchange was ready for demonstration in isolation to BT staff. This was completed by the 27 March and the container was prepared for transportation. Heavy slide-in-units such as power supply unit and subscribers private meter auxiliaries were removed from the racks and packed. The remaining slide-in-units were left in the racks and retained by means of modified shelf covers. Spare units, the VDT and tools etc. were packed in boxes and fixed securely within the container by means of anchorage points and straps.

The container was put onto a low-loader (see Figure 1) and delivered to Felixstowe on 1 April 1987. After the mains supply and earth were connected and the air-conditioning units installed, the demonstration of the concentrators was repeated. The results showed that the container had travelled with minimal ill effects.

From the time that the detailed information was available for the mobile exchange, the exchange data builder had been preparing the hardware data to be loaded onto the Ipswich processor. The subscribers data builder had also been compiling schedules for jumpering and subscribers data for loading onto the Ipswich processor and the operations and maintenance unit (OMU) subscribers record system (SRS) database. Once the data builders had finished their task, the data was loaded onto the Ipswich exchange processor and into the SRS database by the OMU staff; this task took about a week to complete.


**Figure 1—Containerised System X exchange being delivered to Felixstowe Dock site**

† East Anglia District, British Telecom UK Communications

Meanwhile, the installation team was providing tie cables for customers' lines, and PCM links, from the mobile exchange to the MDF and digital distribution frame, respectively, in the main Felixstowe exchange. Integration between the mobile and the Ipswich exchange processor was then carried out, private circuits were set up back to the OMU for the VDT and alarms, and extensive routining, diagnosing and faulting were performed. Customer jumpering and called number announcement jumpering were also carried out during this period.

Final call-sending and amendments were performed, the MDF was wedged up, and meters were zeroed ready for the change-over. The change-over was carried out smoothly at 06.00 hours on 31 July 1987; this allowed some 2 hours in which many frame and exchange tests were performed, and any faults eliminated before they were detected by the customers. The mobile exchange, the first of its kind, was thus brought smoothly into service only 17 weeks after delivery. It should be pointed out that, in the case of the destruction of a digital exchange, a similar container could be brought in and connected in days, as the data would already be provided on the processor.

## CONCLUSION

The containerised System X was eventually taken out of service when the Felixstowe Dock exchange was opened on 26 February 1988, and its performance during this period was entirely satisfactory.

### Biographies

Colin Hammond joined the then British Post Office in 1964 as a Youth-in-Training. His career has included planning and installation of a variety of switching systems. He was responsible for the commissioning of the mobile System X exchange and was then installation team leader for the provision of the Felixstowe Dock RCC. Colin is currently OMU manager at Ipswich.

Bob Squirrell joined the then British Post Office in 1965 as a technician apprentice and was promoted to Technical Officer, converting UAXs to STD working, shortly after completion of his apprenticeship. For most of his career he has been involved with the installation of Strowger, crossbar, TXE4 and System X exchanges. He has also had long spells of temporary promotion to level 1, and was the OMU System X maintenance and internal works manager during the installation of the Felixstowe Docks mobile.

## IBTE LOCAL-CENTRE PROGRAMMES, 1988

### Martlesham Heath Centre

| | | |
|---|---|---|
| 5 October | MEZZA | R. Walters, BT/IPD |
| 19 October | Links Around the World | A. Booth, BT/BTI |
| 8 November | The BT Scene as Viewed by AT&T and Philips Telecommunications UK Ltd. | J. Boag, AT&T/Philips |

### North Wales and Marches Centre

| | | |
|---|---|---|
| 4 October | Tomorrow's External Plant | D. Clow, UKCHQ |
| 8 November | CEGB National Grid and Nuclear Reactors | J. E. Goulding, CEGB |

# THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

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

General Secretary: Mr. J. H. Inchley, NPW2.1.6, 4th Floor, 84–89 Wood Street, London EC2V 7HL; Telephone: 01–250 9816.
(Membership and other enquires should be directed to the appropriate Local-Centre Secretary as listed on p. 211 of the October 1987 issue.)

## IBTE ANNUAL GENERAL MEETING

The Annual General Meeting of the Institution was held on 10 May in the Assembly Rooms, Fleet Building, London, with the President, Mr. R. E. G. Back C.B.E. in the Chair. In the course of the meeting, Mr. Back announced that he was to stand down as President, and that Mr. C. A. P. Foxell C.B.E. (Managing Director Engineering and Procurement) had agreed to replace him. Mr. Back also mentioned the success gained at recent FITCE Congresses, and referred to the 1990 Congress to be held in Glasgow.

After the presentation of the Annual Report of Council by Mr. J. Tippler, there was a formal presentation of Honorary Membership Certificates to:

- Mr. Ray New, who had served with distinction as Treasurer of the Institution for the past four years, during which time he had updated the method of accounting to bring it into line with modern practise. He had managed the finances of the Institution effectively, and made significant contribution to the running of all Institution activities.
- Mr. Short, who had been Assistant Secretary, Finance since 1979. Jack had performed unsung in the background, keeping the books with meticulous attention to detail, and assisting three successive Honorary Treasurers in keeping the Institution on a sound financial footing. He had also, during this period, aided three Secretaries and innumerable Honorary Local Secretaries, who all owed him a great debt of gratitude.
- And finally, to Mr. Back himself, who had been a Vice-President of the IBTE since 1980, and took over as President in 1984. During his term of office, he had unfailingly discharged his duties while maintaining a keen interest in Institution activities. He had also ensured that those at the highest level within BT both were aware of and supported the activities of the Institution. The respect and gratitude of all the Membership were expressed in this well-merited award.

## NEW IBTE PRESIDENT

The new President of the IBTE is Mr. Clive Foxell, C.B.E., B.SC., F.ENG., F.I.E.E., F.INST.P., F.INST.P.S., BT's Board Member and Managing Director Engineering and Procurement. He has responsibility for BT's Research and Development programme, involving some 3500 staff and the £2300M worth of orders placed by BT with industry each year. In addition, he is responsible, through the Chief Scientist, for co-ordination of standards and architectures across BT.

Mr. Foxell was born in 1930 at Harrow and was educated at Harrow High School. He joined the GEC Hirst Research Centre in 1947 as a student assistant and obtained an honours degree at the University of London. After involvement in early research on the transistor and other semiconductor devices, he became manager of GEC's research in

Mr. R. E. G. Back

Mr. C. A. P. Foxell

this field and was appointed Managing Director of GEC Semiconductors Ltd. in 1971.

In 1975, he joined the Post Office as Deputy Director of Research with special responsibility for micro-electronics, materials and optical-fibre systems. After three years, he entered the Procurement Executive responsible for switching equipment, became Director of Purchasing in 1980 and Senior Director Development and Procurement for BT in 1982.

Mr. Foxell is a Fellow of the Institution of Electrical Engineers and the Institute of Physics. He is a Council member of the IEE, a past Chairman of its Electronics Division, and is currently involved in its Qualifications Board and merger with the IERE.

He has published papers and lectured widely on the topic of micro-electronics. A member of several government and university advisory bodies, he is currently a member of the Science and Engineering Research Council, a member of the NEDC Electronics Committee, and DTI Computing, Software and Communications Committee and the Council of the Electronic Engineering Association.

A Liveryman of the Worshipful Company of Engineers, he is married with one daughter, and lives at Chesham, Buckinghamshire. His other interests include photography and railways.

## NORTH WALES AND THE MARCHES LOCAL CENTRE

The Committee of the North Wales and the Marches Local Centre has granted an award for the best presentation by a Local Centre Member during the 1987/88 programme session.

On 16 June 1988, the Local Centre President, District General Manager Mike Marsden, presented Phil Jones, District Exchange Network Design and Service Manager, with an Institution Scroll and a cheque for £25.

The award was in recognition of a presentation given by Mr. Jones in December 1987 entitled 'Cable Pressurisation Monitoring'. The lecture reviewed the history of cable faults, the deployment of junction cable types and the methods employed to protect them. Cable pressurisation practices were shown to be inefficient and the talk developed the options now available and, in particular, the Vaisala processor-controlled surveillance system which includes a software management package. The North Wales District is the first in the UK to install this particular system in its network.

Local Centre presentations have been especially encouraged for the 1988/89 programme in North Wales. On present promises, three such papers are likely.

**Phil Jones (left) receiving the Institution Scroll from Mike Marsden**

## COMPOSITION OF THE COUNCIL FOR 1988–89

Chairman: Mr. J. Tippler.
Vice-Chairmen: Mr. A. B. Wherry, and Mr. A. F. Beardmore.
Honorary Treasurer: Mr. P. A. Allen.
President, Associate Section: Mr. A. G. Bealby.
Secretary: Mr. J. Inchley.

*Representatives*:

Mr. J. H. Mickle, London 1.
Mr. A. P. Oodan, London 2.
Mr. J. M. Griffiths, Martlesham.
Mr. D. B. McMillan, Scotland.
Mr. D. C. Sharp, North East.
Mr. R. J. Slater, North West.
Mr. R. Sutton, Midlands.
Mr. G. W. Adams, Northern Ireland.
Mr. B. Fielder, South West.
Mr. R. W. Henderson, South East.
Mr. W. Carlyle, East.
Mr. R. N. Williams, Wales

## IBTE CENTRAL LIBRARY

The books listed below have been added to the IBTE Library. Copies of the 1982 edition of the library catalogue are available from the Librarian, IBTE, Room GJ, 2–12 Gresham Street, London EC2V 7AG. An abbreviated catalogue was included in the October 1987 issue of the *Journal*. Library requisition forms are available from the Librarian, from Local-Centre and Associate Section Centre Secretaries and representatives. The forms should be sent to the Librarian. A self-addressed label must be enclosed.

Alternatively, the IBTE Library is open on Wednesday mornings between 11.00 and 13.30. Members are advised to telephone the Librarian (01–356 8050) to confirm their visit. Members wishing to reserve books or check availability should contact the Library during opening times on 01–356 7919.

The Library is open to Full, Associate Section and retired Members of the IBTE.

5455 *Fibre Optic Communications*. Joseph C. Palais.

This book introduces the design, operation and capabilities of fibre communications systems. As no previous experience in fibre optics or optical communications is assumed, appropriate background material on optics, electronics and communications is explained. Important theoretical and mathematical results are described in physical terms, and extensive figures and tables are used to make those results readily usable.

5456 *The Essential Darwin*. Edited by Mark Ridley.

Charles Darwin, almost uniquely among the great scientists, wrote for the general reader. Besides the *Origin of Species*, Darwin wrote 18 other books, and ranks among the most broad-ranging as well as the most profoundly influential scientists of modern times. The editor has selected key passages from Darwin's nine most important books. From the *Origin of Species*, there is Darwin's beautifully clear exposition of natural selection and his summary of the case for evolution, and against creationism; from *The Descent of Man*, there is Darwin's explanation of human intelligence and morality, and his theory of sex differences; and from *Coral Reefs*, Darwin's wholly original, and still accepted, theory of the origin of coral atolls.

# Institution of British Telecommunications Engineers

## Associate Section National Committee

### NATIONAL TECHNICAL QUIZ

One of the major events of the Associate Section calendar, the National Technical Quiz Final, took place at the end of April. This year's final was contested between teams from Londonderry and London South West. The winners of the Bray Trophy, which was presented by Dr. A. Rudge, Director, Research and Technology, were the London South West Team.

Besides the trophies already described (see the April 1988 issue of the *Journal*), the National Committee present the following awards at the Quiz Final:

#### Cotswold Trophy

This trophy was presented to the National Committee by the Gloucester Centre in 1974 and is awarded to the Centre or Inter-District Committee who, in the opinion of the National Executive Committee (NEC), has furthered the aims and interests of the Associate Section during the previous year.

In the past, the low number of entries received each year has been disappointing, especially when there are some 10 Inter-District Committees and over 80 Centres, most putting together highly imaginative programmes of events. The number of entries should be much higher and I can only urge all Centres/Inter-District Committees to write a short report on their activities during the year and enter this competition.

This year, there were only three entries, Cardiff, Ayr and Birmingham Centres, with the Cardiff Centre being presented with the Trophy. The programme of visits and talks put together by the Centre was extremely varied and included over 20 events held during the year.

#### Anning Award

After the death of Joe Anning, a member of the NEC for many years, the National Committee agreed that it would be appropriate for an award to be named after him and presented annually to the best apprentice within British Telecom. The old Regional Committees were asked to select suitable candidates for entry into the national competition. The entrants in the national award were judged on the contents of an essay and an interview.

As the number of apprentices within BT decreased, it was decided to change the award to the Young Member of the Year. The award is now open to all members of the IBTE under 25 years of age and selection is based on an interview where the candidates have to discuss a topic, selected from a short list set by the Anning Committee, and an overall assessment of supporting information supplied by the Inter-District Committee and District Liaison Officer.

During my short time on the judging panel, I have been greatly impressed by the very high standard of entrants, both with their knowledge of BT and the wide variety of activities pursued outwith BT. It is encouraging that the award is well supported by the Inter-District Committees.

Entries for the 1988 award were received from Scotland, Wales, South West, Northern Ireland and North East. In a very close contest, the judges declared the winner to be Paul Woolvin from the South West.

### HONORARY MEMBERSHIP

For the first time, Honorary Membership of the Senior Section has been awarded to two Members of the Associate Section, and the Scrolls were presented at the Quiz Final by Mr. A. Beardmore, Vice-President of the Senior Section.

The recipients were:

- Mr. Mervyn Dibden for the work done in furthering the aims of the Associate Section over a great many years. Mervyn has served the IBTE as Secretary of the Salisbury Centre and the South West Regional Committee. As Secretary of the National Committee for a decade, he has made an outstanding contribution to the progress of the Associate Section.
- Mr. John Hannah for his contribution to the Associate Section in Scotland. John has been a long-serving member of the Associate Section and, in 1971, was instrumental in forming the Stirling Centre and served as its secretary for some 17 years. John also served on the NEC, as Chairman, during the formative years of the National Committee.

### NATIONAL CONFERENCE

Several years ago, it was decided that the National Conference would be held in each of the Inter-Districts in turn. This year, the East Inter-District will host the Conference, which will be held in Norwich from 4–5 November 1988.

The National Conference is the only time during the year that Centres, through the two delegates from each Inter-District Committee, have the opportunity to air their views, and instruct the NEC, on the future course the Associate Section should pursue. It is therefore vital that all Centres participate and bring to the attention of the National Committee the changes they would wish to see to enhance the organisation.

### FUTURE ARTICLES

During the coming months, the officers of the NEC will be presenting articles in the IBTE Associate Section *National News Letter* and in *British Telecommunications Engineering* to keep the Membership informed of all matters relating to the Associate Section. Both publications offer an ideal opportunity to Centres to bring items of mutual interest to the attention of Members. Any articles should be submitted to the appropriate editors.

A. JOHNSTONE
*National Secretary*

# Book Reviews

***Electronic Message Systems and Services: An International Handbook.***
Steve Roberts, and Tony Hay.
Comm Ed (Communications Educational Services Ltd.), xii + 304 pp. 16 ills. £48·50.
ISBN 0-94788-724-5.

It is all too difficult to find a quick reference text on messaging services. Too often, information is inaccurate or incomplete. This directory is a rare attempt to document messaging services from a global perspective.

The directory is well presented in a compact quality loose-leaf folder so that the four annual updates can be easily inserted.

The handbook is divided into three sections. The first section gives an explanation, definition and introduction to the technology of each particular messaging service. A summary is also given of international standards. Although the handbook is titled 'International', it gives details of British products in particular. This section thus serves as an introduction to messaging for the general user and indeed the potential user.

The second section gives, by country, a breakdown of public messaging services offered and provides the reader with reliable background information. Although the summary format gives only brief information, an extensive number of countries is covered. (Certainly the range is greater than that in the *Eurodata Foundation Yearbook* if not as thorough.) However, information is often dated. (1984 figures are quoted for the number of Telex subscribers in Austria.) But future updates may well remedy this weakness.

The third and final section provides a company and organisational directory. This gives a quick reference list by product and company information. A personnel listing is also provided. Note the absence of any BT personnel!

For the general user, this directory provides useful summary information on suppliers and products. For UK suppliers and operators alike, it gives an overview of the key players in international markets. If the quarterly updates improve the timeliness of information, this directory is a very worthwhile investment. Even if not, it is certainly a much needed work of reference.

C. SUTTON

***Private Telecommunications Networks. Design and Implementation for Business***
Ron Bell.
Comm Ed (Communications Educational Services Ltd.), x + 180 pp. 65 ills. £35·00.
ISBN 0-94788-725-3.

Private telecommunication networks have been in existence for many years and British Telecom has considerable experience in their provision and maintenance on behalf of its customers.

The advent of digital technology allied to the current competitive environment has seen such networks grow in both numbers and complexity as BT's customers seek to modernise their methods of working while controlling their costs.

Such multivendor networks are not easy to design to meet the high service standards required when equipment from different suppliers is used, and it is important that the customer or the customer's communications managers recognise that, when embarking on a multivendor design, they are in fact the design authority for that network.

The author of *Private Telecommunications Networks*, a manager with considerable private network experience, has produced an informative book that is easy to read and is a very good guide to those who wish to understand the practical issues involved in private network design without getting over-involved in technicalities.

The book covers the various types of private networks and how they might be achieved and indicates how the basic planning information can be obtained. There are chapters covering the financial aspects to be considered, the supply of apparatus and the importance of compatibility is stressed. Network installation covers contractural aspects; through project management to apparatus installation, testing and commissioning.

The final part of the book covers the day-to-day operation of a network and stresses the growing importance of an adequate network management system that monitors performance and assists in rapidly pinning down equipment problems, to permit the rapid restoration of service.

The book is supported by appendices and illustrations which clearly set out the various networks available, how they operate and how they can be justified and controlled.

P. M. GOULD

***Worldwide Telecommunications Guide for the Business Manager***
Walter L. Vignault
John Wiley and Sons Ltd., xvi + 417 pp. 70 ills. £45·85.
ISBN 0-47185-828-5

In these days of rapidly changing communications, this book represented a significant challenge to the author. Covering as it does most aspects of telecommunications, both national and international, it achieves the author's intention of providing a one-stop guide for the business manager.

The book provides an introduction to the many aspects of communications and, in particular, international communications, covering the basics of data communications, comparing the cost effectiveness of various options for information transfer and drawing on the vast range of service types to illustrate what is available. It provides an outline to various transmission modes, satellites and cable, and shows the major international interconnecting modes.

The book introduces digital, voice and data networks and network attachment products. It addresses product acceptance and its level of sophistication in many countries. Touching on standards committees and Open Systems Interconnection (OSI), it provides background on the relevant international telecommunications organisations. Digital, voice and data networks are covered through introduction to X.21, X.25 and OSI, with particular emphasis on international interconnect.

Value-added network services and telematics are covered, as are both global satellite and cable routes, with some useful background on regional and domestic programmes.

Some emphasis in the book is on the US network and its services where carrier options and tariff comparisons are made.

To a student of telecommunications, the book does over-simplify many of the subjects and offers little of the detail required to appreciate fully the engineering complexities associated with the specific areas addressed. Although some emphasis is placed on future communications and efforts have been made to illustrate the effect of known developments, the book could become dated fairly quickly. For anyone on the periphery wishing to have a broad background to the nature and types of services offered in the telecommunications environment, this book is extremely helpful.

The book finds its way onto my shelf through its ability to illustrate simply the options available. As a reference text, it provides a good source of international data on service offerings, including attachment authorisation for modems, etc., and illustrates the countries using the services discussed. Its vast range of tables illustrating anything from the penetration of modems, to videotex and electronic mail users is particularly useful.

The book achieves what it sets out to and proves to be a useful reference text on the structure and type of global communications. One or two minor errors have crept into the text and tables, but these do little to detract from the overall value of this book to those who have a general interest in communications.

D. J. MARSH

***Systems Analysis and Development, Second Edition***
P. J. Layzell, and P. Loucopoulos.
Chartwell-Bratt, 232 pp., 103 ills., £6·95.
ISBN 0-86238-156-8.

If this book was entitled 'Systems Analysis' and did not purport to cover 'Development', I would be happier with it. The language is always uninspired and reading is rather tedious, but perseverance is rewarded with a great deal of useful information. Much of what a modern systems analyst should know is in this book, and it is presented in a logical sequence. There are instances of superficial treatment but in most cases there is adequate detail for the reader not to be frustrated. Not only do the authors present facts, but also they place emphasis where they think it is important. For example, they emphasise the need to invest effort at the beginning of a project so as to maximise the chance of getting the specification right. In the end, however, the strength and main theme of the book is the handling of data. Collection and analysis are well covered and the chapters on system, process and data design provide useful information.

However, there are limitations to the scope of the book. It covers data-processing projects only and the case study, which is developed as the book progresses, is of 'a hotel organisation'. The issues of real-time working are untouched. Indeed, the emphasis is entirely on software, and system aspects are not addressed. The authors' students presumably are not expected to have to consider the thorny subjects of sizing systems to meet requirements without exceeding budget. Thus, while the book provides a good academic treatment of the 'data' analysts's and designer's handling of data, the authors fail to show a practical approach to 'systems' analysis.

My contention that the word 'development' in the title is misleading is further supported by the way the authors treat what are, in their own words, 'a number of issues which can be regarded as less technical than those previously addressed and yet are vital to the successful development of any large system.' Among these 'vital' issues, which are dismissed in a final chapter of ten pages are testing, installation of the system and project management. Verification and validation are not discussed; nor are the collection and use of statistics for project control. This is particularly unfortunate, as the importance of project management in software and system development is now universally recognised. Regrettably, quality assurance is not addressed.

In summary, I recommend this book to anyone who wishes a good logically-presented introduction to handing data at all stages of a project. I cannot recommend it to anyone whose scope extends beyond data to the system as a whole or the project itself.

F. J. REDMILL

***Integrated PBX Systems—An NCC State-of-the-Art Report***
John R. Abrahams.
The National Computing Centre (NCC) Ltd., Manchester. 327 pp. 80 ills. £400·00.
ISBN 0-85012-666-5.

When fully-digital PBXs appeared in the early-1980s (that is, PBXs using digital switches controlled by a computer), they were sold mainly as telephony switches. The possibility that these switches might carry other digital communications was waiting until the late-1980s. Now, the digital PBX is ready to become the central 'office controller' for internal and external voice and data communication, and the data traffic carried by PBXs is expected to double annually for the next few years.

This growth of integrated services communications causes problems for those professionally concerned with PBXs. It is difficult to understand what facilities one needs, or which PBXs meet those needs. An extra complication is the need for 'future-proofing'; that is, to have a product which will offer either now, or through upgrades, facilities needed not now but later. The plethora of standards such as ISDN and DPNSS is an added burden. A major report to explain these issues and survey the market is clearly required, and the NCC is to be congratulated on its timely publication of so comprehensive a report.

The report is aimed towards user and supplier managers concerned with systems having no more than 100 telephones (or terminals) in one location. Its comprehensive brief prevents there being much detail on any one aspect, and in particular anyone hoping to find out in detail how individual PBXs work is likely to be disappointed. Nevertheless, the basic principles are explained, and for those already expert, useful pointers to various PBX designs may be gleaned. Although this is a British publication, the reader will have to cope with some North American concepts and terminology; this should not, however, discourage anyone from using the report.

The opening chapter, 'Terminology and Technology', has a fresh style which is a pleasure to read. Technological sections cover the basic principles of switching, PCM and traffic engineering very well, although sometimes with a simplicity which will fail to satisfy many engineers. Non-technological parts are very clear, with an outstanding critique of CENTREX. The second chapter, 'Features of PBXs', gives a good and comprehensive list of the usual PBX facilities (there are over 100 of them!). Some unexplained acronyms have crept in, and it is here that the reader will be most aware of the North American flavour. A logical organisation ordered by classes of facility would have been more helpful than the alphabetical organisation chosen.

The third chapter, 'Architecture and Cabling', gives a very brief but clear description of the structure of PBXs and pays special attention to comparing decentralised architectures such as the Ericsson MD-110 with more centralised switches. The author is correct to stress that a planned building wiring architecture is both a commercial product and a pre-condition for successful integrated communications. The fourth chapter, 'Applications Programs', is a useful summary of 'add on' services such as voice-mail and electronic text mail. These may be provided inside or outside of a PBX. A significant omission is third-party control of the operations of a PBX by an outside computer, an emerging technology for integrated computer and communications applications.

The fifth chapter on ISDNs is an excellent concise summary. However, it is only a brief introduction to the ISDN, and so will disappoint some readers. The point is correctly made that successful ISDN exploitation will depend on the availability of integrated PBXs and terminals. The reader should note that public ISDN services will grow over time, and that some features such as D-channel packet switching may not be available at the outset. A few standards reference numbers (for example, CCITT I.420) would have been appreciated.

The next two chapters, 'Data Communications Through PBXs' and 'PBX-Based Networks' provide thorough technical overviews. The largest, eighth, chapter reviews 20 PBX systems from 18 different manufacturers. The system descriptions are logically organised under six sections: company background; architecture; telephones supplied; data interfaces; networking capability; and add-on applications available. The reader must be prepared to work on the information supplied to compare systems against one another or with his or her particular requirements. The coverage of technical details is not uniform across systems.

The next largest chapter is the ninth, 'Case Studies'. For many readers, this may well be the most valuable part of the report. It describes 14 PBX implementations (five in the UK), many of which are networked, showing what specific customers wanted, the problems they faced, and what their PBX systems achieved. The final chapter, 'Marketing Information', is unfortunately the weakest. It states in which territories the 20 reviewed PBXs are sold, together with a list of supplier addresses. There is a description of the regulatory regimes of a number of countries in turn; an analytical attempt at classification into regime styles would have been helpful.

In summary, allowing for inevitable limitations in treating so large a field, and for the liability of the report to become dated, the report can be recommended as a valuable and timely source for anyone needing to get a grounding in the complex and changing world of the PBX.

J. F. BUCKLEY

# Product News

## Technology Barrier Broken by British Telecom Datacomms

British Telecom Datacomms has introduced the first modem which meets CCITT standard V.33 and extends V.32 for operation at 14 400 bit/s.

The modem 4142 TCX is the first to transmit full duplex data over the dial-up network, synchronously at 14 400 bit/s. Previously, 9600 bit/s was the fastest full duplex synchronous transmission speed available over the dial-up network. Since the modem conforms to the international CCITT Recommendations, it will communicate with existing V.32 modems and allows users to upgrade current V.32 and V.33 networks, while protecting their original investment.

V.32 and V.33 are the latest CCITT Recommendations, and the 4142 TCX allows a company to expand and upgrade current network capabilities, whilst protecting the investment in V.32 and V.33 technology.

The 4142 TCX is the first intelligent modem in the world with automatic data rate selection. In operation, the 4142 TCX provides not only fall-back capabilities to lower speeds, where the quality of a line is poor, but also automatic fall forward. It is this unique ability to upgrade transmission speeds which will maximise benefits to the user by reducing error rates, improving data throughput and economising on the use of telephone lines.

The breakthrough in transmission speeds is the result of advances in echo-cancellation techniques developed by British Telecom Research Laboratories. It is a refinement of the echo cancellation that BT Datacomms used in developing the world's first V.32 modem operating at 9600 bit/s in 1985. As a further measure to ensure maximum data throughput, Trellis coding, a form of forward error correction, has been used to maximise throughput on marginal telephone lines.

In addition, the 4142 TCX modem includes synchronous V.25*bis* auto dialling for operation on X.25 networks.

**The 4142 TCX modem can be configured as shown with the 4062X six-channel synchronous time-division multiplexer, or as a stand-alone unit**

The sophistication of the modem is ideally suited for use in a variety of network applications. As a gateway between local area networks (LANs), the 4142 TCX modem is up to six times faster than conventional dial-up LAN bridges. It also provides a dial back-up device for LANs linked using 2- or 4-wire leased lines. Conventional back-up facilities for a V.29 or V.33 leased line network need an additional V.22*bis* modem at 2400 bit/s with auto-dial facilities. The 4142 TCX modem enables users to restore networks at a full 14 400 bit/s over a single dial-up line automatically, with no additional equipment, manual dialling or switching between modems being required.

## New Range of Modems for Microcomputer Users

British Telecom Datacomms has announced a new range of modems specifically for microcomputer users; four models are offered, with data transfer rates up to 2400 bit/s, conforming to a variety of CCITT Recommendations.

All models are available as stand-alone units or card-based units for installation in a PC's expansion slots. Full compatibility with the IBM XT, AT and compatibles is provided, complete with support for the Hayes 'AT' auto-calling and configuration commands.

The range is available with Breakout software, under license from PC Communications Ltd. This provides an easy-to-use interface to access facilities such as Telecom Gold, Prestel, Videotex, electronic mail and other bibliographic databases. The software is standard for the integral units and an option for the stand-alone models.

The stand-alone DM 412X and card-based PC412X are V.21/23 modems which work at 1200/75 bit/s asymmetric duplex and 300 bit/s full duplex. Each model has a multiple number store and automatic answering to V.25, with dial-back security protection in the PC 412X.

More advanced facilities are found on the DM 424X and PC424X, which work to V.21/22/23/22*bis* supporting full duplex 2400 bit/s transfer speeds (V.22*bis*). For the more reliable transmission of data as demanded by higher speeds, these modems offer MNP error correction.

BT is also introducing a customer 'Helpdesk' which offers customers fault diagnosis and practical advice on the applications and benefits of the new PC modem range.

## Structured Software Development Route for STEbus Applications

A new approach to fast low-cost STEbus computer system development—with a high resistance to bugs—has been announced by British Telecom Microprocessor Systems. Based around a PC using Kalix design-structure-diagrams, with download and debug software to Martello STEbus hardware, BT believes it offers the most cost-effective means of engineering small-to-medium size control and instrumentation systems on today's market.

The development route is based on a standard IBM PC (or VAX) computer, using C or Pascal compilers, with the addition of the innovative Kalix software tool. Developed at BT's Martlesham Heath Research Centre, Kalix software makes good structured software design practice second nature, since the programmer is obliged to create software with design-structure-diagrams. These British Standard diagrams represent the complex constructs and flows of control in real-time computers, to make it simpler to create a program and very easy to spot and correct errors. In the process, they also allow the project to be split easily between programmers, automatically documenting the design and reducing maintenance costs. When software design is complete, coding is straightforward. If C or Pascal is used, compiler links allow the code to be created automatically on a single command. Furthermore, if the code needs to be modified, only the diagram needs to be changed.

Kalix forms part of BT's Axion group of software tools, which offer a variety of aids to help engineering companies produce effective comprehensible design documents, and take these forward automatically into code. The Kalix package developed for BT's Martello STEbus hardware incorporates a terminal emulator and debug monitor, which allows the code to be downloaded and run on the target STEbus processor, once software creation on the PC is complete.

## New Enhancement to Monarch

BT has launched a further enhancement to the Monarch range of digital PABXs. The new version is the SE220, comprising an enhancement for existing 120A/B Monarch systems.

The SE220 has been developed in order to provide users with a sophisticated telephone system incorporating the latest in telecommunications technology. As a result, existing users are able to enhance instead of having to buy a completely new system.

Enhancement to the SE220 gives existing 120A/B users access to the Monarch's new version 16 range of software, which offers an extensive number of new features. These include fast call set-up, giving quicker connections onto BT's network of modernised public exchanges as well as compatible company private communication networks, and follow-me call diversion, which allows calls to be diverted to follow the user wherever they are located at work.

In addition, a flexible timed change-over of system call-barring operates, restricting the making of long-distance calls after office hours for example. Other features included are repeat last number saved and central console working.

The SE220 has a maximum extension and exchange line capability of 232 and 64, respectively, while up to four consoles are available. The switching capability of the SE220 can be expanded to include not only voice, but also data, with the optional purchase of Datelnet 7000 equipment.

The SE220 also provides additional features from previous versions of software. Such features include enhanced call management, direct dialling in, as well as stand-by power and music on hold.

120A/B customers can easily enhance their existing system, and so derive full benefit from the new version 16 software now available on Monarch. Enhancing is a very cost-effective method of business advancement which avoids the need to re-train staff and console operators. And, in enhancing, a greater return is generated from customers' original Monarch investment.

The new version of Monarch is also subject to a continuing and comprehensive development programme, in which the digital private network signalling system (DPNSS) and integrated services digital network (ISDN) are of prime importance.

The SE220 is the latest in a number of Monarch enhancements made by BT. Previous ones include the 250 C1/C2 enhancement to the SE440 as well as the Monarch Compact enhancement to the SE250. Version 16 software is available now on all new Monarch systems as well as being an optional enhancement to the complete range of existing ones.

# British Telecom Press Notices

## Irish Sea Optical-Fibre Submarine Cables

At the end of March this year, BT successfully laid a £7·2M optical-fibre submarine cable running 126 km between Porth Dafarch, near Holyhead, Anglesey, and Portmarnock in the Irish Republic. The cable, which has no intermediate regeneration, is jointly owned by BT and Telecom Eireann and has been supplied by Submarcom.

The cable was laid by BT's cable ship *CS Alert*, in collaboration with her sister ship, *CS Monarch*. The Holyhead shore end was laid and joined to the land section which was already connected into BT's national network. The *CS Alert* then sailed for Ireland laying the cable behind her. She joined the cable to the Irish shore end, already laid for 6 km out from Portmarnock. At about 34 km out from Holyhead, the *CS Alert* deployed BT's submarine plough to bury the cable about a metre below the sea bed to avoid risk of damage. The plough could not be used for the first 34 km because the sea bed is unsuitable.

Also in March, a £6M 90 km optical-fibre cable between Britain and the Isle of Man was successfully inaugurated by a video call between London and Douglas. The new link was inaugurated by Mr. Miles Walker, Chief Minister of the Manx Government, in a videoconference with Mr. John King, Managing Director of BT's Overseas Division, and the Hon. James Ogilvy, Vice-Chairman, Mercury Assets Management, a member of the Warburg Group.

The new cable is a clear confirmation of BT's determination to provide the Isle of Man with modern communications as quickly as possible. They are essential to the Isle of Man's economic development. They will encourage industry and commerce to extend their presence on the Island, to take advantage of the other benefits that trading on the Isle of Man can bring.

The project has been completed very speedily—the contract was placed just over a year ago and the cable was laid across the Irish Sea only last October. The new cable, which has no submerged regenerators, was supplied by STC Submarine Systems and laid by BT (Marine) Ltd. The new cable will provide islanders with a link to BT's digital trunk network, and is another step towards converting the Isle of Man network to digital operation by 1990.

The cable was buried during laying by using BT's special-purpose sea-bed plough to minimise the risk of damage. The laying was carried out by *MV Flexservice 3*, a multi-purpose twin-screw vessel designed primarily for all kinds of laying work in the North Sea. She is 85·2 m long overall, 19·8 m wide, with an all-seasons draught of 5·12 m. She offers a large deck area free of superstructure for the erection of specialist equipment, and BT Marine has installed on her its advanced subsea technology and engineering services. Her twin screws and four transverse thrusters—two in the bow and two astern—are controlled with the aid of a computer. These enable her to maintain a fixed position over the sea bed irrespective of tidal flow and wind speed and direction—essential for cable laying and jointing.

## Improvements in Packet Switching Data Service

BT is to enhance one of its public data services—Packet SwitchStream (PSS)—by introducing a range of new customer facilities during the year. Further benefits will also come from improvements to be made to the International Packet Switching Service (IPSS), which opened service to its 100th overseas network—in Zimbabwe—on 7 March.

Enhancements to PSS will follow the implementation by BT of the CCITT 1984 Recommendations for expanding the X.25 protocol. These new facilities are being introduced in response to customer demand and demonstrate the continuing evolution and success of BT's managed data network services. They are also a further proof of BT's commitment to Open Systems Interconnection (OSI) through the continuing development of BT's Open Network Architecture (ONA). ONA ensures that BT's information technology products and services are guaranteed to work together and conform to international standards. This brings the benefits of OSI to BT's customers: supplier independence, flexible communications and compatibility with evolving standards.

BT is progressively implementing the 1984 X.25 Recommendations. The principal enhancements being implemented initially include:

- greater facility field length for data terminating equipment (DTE), which means that the length of the facility field in *call set-up* and *call clear* packets can be increased from 63 to 109 bytes, which provides capacity for additional facilities;
- enhancement for fast select calls, which means that user data can be carried in the *call request* packet, even when the call has entered the data transfer phase; and
- notification of call redirection, by which a called DTE is informed that it is chosen as an alternative destination for a call.

Other enhancements include DTE-originated cause codes, expanded interrupt user data field, hunt group address replacement, and called line address replacement.

British Telecom International (BTI) has plans to strengthen IPSS by upgrading the links to data networks in other countries. The plan results in part from a recommendation by the European Conference of Postal and Telecommunications Administrations (CEPT) to enhance internetwork connections in Europe. BTI has already established 56/64 kbit/s IPSS links with the USA, Belgium, France and the Netherlands, and will continue this programme to cover other European, North American and Pacific region routes during 1988.

The provision of higher-speed links on IPSS makes use of new digital transmission paths, such as the optical-fibre cable between the UK and Belgium which came into service last summer. This will reduce transit delay and will result in faster screen filling and file transfer. Operation at higher bit rates will also increase the capacity of international links, and cater for continued growth in the use of IPSS.

BTI also intends to implement other recommendations on some internetwork routes. This will benefit users by enhancing the quality of service on international calls. Automatic alternative routing facilities will be extended to additional destinations. This allows any fault on a single link to be by-passed by routing re-established calls over another circuit.

## Talking Japanese at the Royal Society

BT demonstrated the latest addition to its world-leading computer-based translating system—translation of speech between English and Japanese—at the Royal Society's 'Science into Industry' exhibition in London in May.

Each speaker has a microphone linked to a British Telecom 5200 personal microcomputer. The computers are connected by a telephone circuit capable of handling computer data. The first participant speaks a sentence in English into his/her microphone. The computer repeats what was said on the screen to check that it has understood correctly. When this is confirmed—by hitting a button on the keyboard—the originating computer sends the message to a distant computer, which activates the spoken translation. In Japanese, the characters also appear on a screen which monitors the dialogue. When the Japanese speaker replies, the process is repeated in the reverse direction.

The system is based on a set of several hundred phrases used in connection with booking hotels which are stored in each computer's memory. Although this involves a vocabulary of more than 1000 words, the computers are programmed to recognise only 60 key words. They are used to identify the appropriate phrases, and this reduces the word-recognition task required.

Speech translation was given its first public demonstration in August 1987, when the prototype system was shown translating business phrases between English and French. Since then, other languages have been added—most recently, Japanese. In addition, the recognition and synthesis of speech have been significantly enhanced. In earlier demonstrations, each word had to be spoken separately and in response to a series of audible signals from the computer. The system now accepts connected speech and thus allows faster and more natural communication.

Speech output has also been improved by using digitally recorded and coded speech from native speakers. This permits a much higher quality of speech to be generated without making impractical demands on computer resources. It also allows the system to be applied to virtually any language for which native speakers are available.

## British Telecom at Communications 88

Caring for customers, understanding their needs and offering innovative products and services to improve efficiency were the themes underlining BT's presence at Communications 88 at the National Exhibition Centre in May this year.

The company's 750 m$^2$ stand—its biggest ever—demonstrated its quality and capability as the UK's leading communications company. A strong team of BT's national and international customer account managers and technical specialists supported a presentation of products and services emphasising the company's ability to act as supplier and consultant for all business communications needs.

Major products that made their first UK appearance on the stand included examples of the latest information technology solutions, based on BT's recognition of the long-term trends towards integration of customers' voice, data, and computing requirements and their need for open networked systems.

Products demonstrating this approach included a new small switch for use with integrated digital access (IDA) links to the growing integrated services digital network (ISDN), and the Mezza communication system, based around a Unix multiprocessor unit known as an *information manager*. By using standard telephone wiring, this is linked to a PABX, appearing to become part of it. Also making their debut were the BTeX 600s (a smaller version of the BTeX digital PABX), the Navigator electronic key-and-lamp system for telephone-intensive businesses, and the POET executive/secretary switching unit.

The BT story at Communications 88 was told through five areas:

- *Building and managing the infastructure* modernising a national and international network to serve 23 million customers. Live links from BT's national network management centre showed how its growing 'intelligent' network is able to respond quickly to new situations, and handle peaks of demand and re-routing to avoid faults. An associated display highlighted the City Fibre Network and BT's plans for providing customers with new links over optical fibre.
- *A network for you* featured BT's network management skills and services placed at the disposal of customers to help them manage their own networks. The display introduced the Huntsman fault tracking system, the latest addition to BT's range of network management products.
- *Knowing what you want* a portfolio of solutions to business customers' problems, with products and services covering the whole range of business applications and designed to fulfil requirements simply and cost effectively. The range of value-added business services available from BT's Dialcom Group is now augmented by the Password range of data services covering engineering design, construction and manufacture.
- *Knowing about each other* illustrated BT's two major initiatives to develop a dialogue with its business customers. One is the national network of business service centres offering coherent 'one stop shopping' for major businesses. This was paralleled by Customer Service Systems—the world's largest civil computing project, with which BT is radically transforming its relations with customers at local level.
- *British Telecom consultancy* skills and services at the disposal of businesses to enable them to improve their performance with the help of modern communications. BT's capabilities can help to create networks to meet all current needs, accommodate future developments, and demonstrate new ways of using communications to create business opportunities.

BT managers also made a major contribution to the conference that took place alongside the Communications 88 exhibition. Mr. Duncan Lewis, Director of Strategy Products and Services, UK Communications, gave an overview of the company's drive since privatisation to bring new and improved services to customers. Mr. Keith Ward, Chief Engineer, Network Planning and Works, UK Communications, looked at the way public networks are evolving to carry integrated speech and data services. Mr. Charles Baker, Director of Marketing, Mobile Communications, discussed the future development of terminal equipment for mobile services.

# 5 Million Customers Linked to World's Largest Civil Computing Project

BT's Customer Service Systems (CSS)—one of the world's most challenging computing projects—is now being progressively introduced throughout BT to transform its service to customers. Already more than 5 million telephone customers are benefiting from this multi-million pound development and all 23 million customers will be able to experience its advantages by the end of next year.

CSS is already in use in seven out of BT's 28 Districts: South Wales (Cardiff, Swansea and Newport), Thameswey (Reading, Slough and Guildford), East Midlands (Northampton), Liverpool, Manchester, Sheffield and Lincoln, and the North East (Newcastle, Middlesbrough and Sunderland). During the next few months, it is to be implemented in Severnside (Bath), South Downs (Brighton and Portsmouth), South Midlands (Bedford and Luton) and Northern Ireland.

Describing the project at Cardiff in May, Dr. John Spackman, BT's Director of Computing, UK Communications, said: 'CSS—the world's largest civil computing development—is part of our £2 billion a year investment programme to improve customer service and cater for growth. It is state-of-the-art information technology in action, ensuring customers get the best possible response to their needs. It also raises job satisfaction, because our staff have quickly recognised that CSS enables them to respond quickly and efficiently to customers' calls. The design and development of CSS is an all-British project, executed by BT with assistance from Logica. There is nothing comparable to it anywhere else in the world. Already enquiries from Japan, the USA and Europe indicate that it may well prove to be a significant foreign currency earner.'

Development of the major customer-interface facilities took less than three years—extremely short for a project of this scale. It was started following a detailed study in 1983 headed by Mr. Iain Vallance, now Chairman of BT. This revealed a number of fundamental weaknesses in the computing systems then being used by staff in dealing with customers' enquiries.

The main shortcoming was inaccessibility of information caused by incompatibility between different computer systems. Because of the need to transfer information from one system to another, information about the same customer could be out of date and inconsistent. As a result, customers making enquiries would often have to make several calls to different departments within BT. And if these persons were not available when customers called back later with a follow-up enquiry or to check progress, they often found that staff in other units were unaware of the situation.

With CSS, all staff in each District who deal with customer orders for service or equipment, enquiries about telephone bills, or faults, can have instant access to one integrated database about customers. This database contains information about lines and equipment rented, recent telephone bills, faults, and other service details.

Each time a customer calls with an enquiry, the customer service employee taking the call is able to see at a glance when and why the customer called previously, who dealt with it, and the action taken. If several problems are raised during the same call—such as mentioning an intermittent fault on the line while querying a bill—they can be dealt with by the same individual then and there. If a particular problem proves too complex for first-line staff, it is passed to a specialist who also has access to CSS.

On receipt of an order from a customer, the CSS computer automatically creates a list of the necessary jobs to be undertaken and these are immediately transferred to the appropriate departments for action. No time is wasted in getting the job on the move.

After the first pilot implementation in 1986, introduction of CSS is now fully underway. South Wales was one of the trial sites, and its District General Manager, Mr. Roy Cull, said: 'Our experience has shown CSS is a major benefit to customers and helps our staff to serve them more effectively. They have greatly improved working methods from which almost all paper has been eliminated. Staff know from the reaction they get that customers appreciate the better service we are giving so they get more satisfaction from their work. In short, they have become great enthusiasts for the system. The availability from one computer terminal of all the information on customers' installation, fault history and accounts has enabled us to introduce for the first time in BT's history a single point of contact, able to handle all customer enquiries on line. Previous computing systems made processes such as order handling more efficient. It is only with CSS that we are able to integrate all these systems so that their combined effectiveness is greater than the sum of the individual parts. Without doubt, CSS is the greatest advance in customer service ever made.'

CSS is designed to use the IBM MVS/XA operating system run on 3090 or 3081 mainframe computers (depending on District size), or their equivalents in plug-compatible hardware. These are housed in computer centres set up for each District. These District information system units (DISUs) handle the bulk of the computing activities carried out by a District.

A typical District employs between 4000 and 5000 staff housed in 50 office buildings. It has 300 exchanges serving 750 000 connections. In a year, it sends out about 3 million telephone bills and carries out 500 000 repairs. When fully implemented in such a District, CSS involves 2–2·5 million COBOL statements, 1500 on-line programs, 2000 screen options, 140 million database records, 800 database record types, 50 Gbyte disc storage, 550 000 transactions a day, 600 simultaneous accesses, and 2–2·5 second response time.

Each mainframe is connected through a number of front-end processors to a digital communications network linking it to about 1500 user terminals and 150 user printers. DISUs are connected to a headquarters machine used for processing information and for the migration of software to Districts. They are also linked together in a nation-wide fallback network which includes a central site, equipped as a stand-by against a possible machine failure. Within the system, transaction processing is carried out on CICS and database management on Cullinet's IDMS/R software, using COBOL II application code.

CSS uses an integrated customer database which provides local management with great flexibility in organising work within the District. The scope of organisational opportunity has not been finally determined because some facilities have yet to be implemented. For example, full integration of line test will be available later this year. Some Districts, including South Wales, have evolved an interim solution to provide virtual integration. This enables a customer service employee to conduct a line test from a CSS terminal but the result has to be keyed in to CSS. When CSS and the line test systems are fully integrated, the interface between the systems will be transparent to the user and the response to the customer will be even faster.

CSS is one of an increasing range of computing activities undertaken by BT at both local and national level. Other systems now under development or being implemented will interface with CSS. As part of its commitment to Open Systems Interconnection (OSI), BT is planning the implementation of CSS on an OSI network with a view to implementing such networks throughout all BT Districts over a period of time.

# Notes and Comments

## BT NEWS MISCELLANY

BT has announced an agreement with GEC Plessey Telecommunications (GPT), to work jointly on a major development programme for BT's popular Monarch range of digital telephone systems. The agreement demonstrates BT's continued commitment to Monarch and marks a renewal of the earlier close co-operation between BT and the separate GEC and Plessey companies on the original Monarch product range. After developing separate versions of Monarch (currently sold overseas as Lyric and CDSS), BT and GPT will now combine to develop new advanced versions of Monarch for the UK and overseas markets.

A series of major Monarch product developments are planned for introduction starting from the end of 1988. These will be incorporated both into new Monarch systems and offered as enhancements for existing ones. Among the system facility enhancements planned will be least-cost routing and both private and public digital networking, including the digital private network signalling system (DPNSS).

K. W. KIRK & SONS, the Cambridge-based scientific instrument makers and production engineers, have signed a second major optical-fibre manufacturing and marketing agreement with British Telecom Research Laboratories. The product under licence is an optical-fibre primary-coating stripper, developed at BT's Martlesham Heath laboratories. The primary-coating stripper has been designed to remove the primary coating from a fibre quickly and efficiently, while leaving the core of the fibre intact.

ALL 7000 homes served by the cable television system operated by BT Vision in Irvine and Kilwinning, Scotland, are now being offered a wide range of satellite television channels, in addition to the previous broadcast television and FM radio-relay services. The seven additional channels include films, sport, children's programmes, pop music videos and general entertainment. Customers will have the choice of several different packages of channels on subscription.

BT's latest quality-of-service report reveals that standards of service for its 23 million customers have substantially improved since the difficulties experienced last year. The report, the second in a six-monthly series, confirms that the improvement noted in the first report in September 1987, has continued strongly to March 1988. Compared with March last year (in brackets), the new figures show:

- faults cleared within two working days, now 90·2% (73·9%),
- business orders completed in six days, now 60·0% (28·4%),
- residential orders completed in eight days, now 62·2% (18·0%),
- operator calls answered in 15 seconds, now 86·7% (83·5%),
- directory enquiry calls answered in 15 seconds, now 81·2% (77·0%), and
- public payphones in working order, now 92% (76%, October 1987).

Network reliability also improved in the year, with fewer failed local and national calls.

ORDERS worth more than £100M for digital exchange equipment were announced by BT at the end of March. They comprise over 640 000 lines of System X equipment from GEC and Plessey and over 220 000 lines of AXE 10 exchanges from Thorn Ericsson Telecommunications. They relate to 185 System X exchanges and 36 AXE 10 exchanges. These orders are the 13th in a series placed competitively at approximately quarterly intervals since May 1984. The AXE 10 orders were awarded in January. The System X exchanges will be delivered by the GEC-Plessey joint company.

Also, in May, orders worth more than £100M were announced for a further 800 000 lines of digital exchange capacity, most of which were for System X exchanges after the agreement with GPT reached in March setting out longer-term arrangements for the supply of equipment to BT. BT also announced that it had opened negotiations with Thorn Ericsson Telecommunications with the objective of agreeing appropriate longer-term arrangements for the supply of AXE 10 exchange equipment.

Under its £2000M-a-year investment programme, BT is installing two new digital electronic telephone exchanges on average every working day. There are currently more than 1300 such exchanges in operation.

BT has announced appointments to two new positions in North America and Europe: Denys Bennett has been appointed Regional Director North America, and Mike Morris as Regional Director Europe, both reporting to Graeme Odgers, Group Managing Director. Their role will be to co-ordinate and develop BT's group strategies in these territories, to provide a more effective service to BT's multinational clients, and to establish and enhance marketing outlets for BT's expanding range of information products and services.

BT has also announced a further reinforcement of its management structure in London and the South East of England. Brian Haigh has been appointed Director Operations for London and the South East.

Mike Grabiner has been appointed as General Manger of the City of London District, and David Thomson as General Manager of Northern London District. Charles Williams has been appointed to the post of Director Field Operational Support for UK Communications.

UP to 200 extra jobs are to be created this year at the Cwmcarn, Gwent, factory of BT Consumer Electronics Ltd., to enable this wholly-owned BT subsidiary to cope with growing demand for its products. The factory is investing £1·3M in modern electronics production equipment—a surface-mount facility—to enable it to meet new orders. In consequence, it expects to recruit up to 100 full-time and 200 part-time workers between July and December this year.

IN a major new business initiative, BT's subsidiary the Dialcom Group—a world-wide supplier of value-added data services—is to provide information and messaging services for the engineering industry. This venture, known as the *Password* project, will ultimately cover the entire spectrum of manufacturing and trading in the aeronautical, automotive, civil, construction, marine, mechanical, process, electronics and electrical engineering industries.

A range of databases and associated services is being assembled, in collaboration with manufacturers, distributors, and other organisations, to meet the needs of users at all levels of activity—design, procurement, component and equipment selection, and tendering and contracting. The services are designed to be capable of integration with electronic data interchange—the standardised exchange of trading documents such as orders and invoices.

Dialcom will make Password information available to buyers, designers, and specifiers in the UK through the Telecom Gold electronic mail and information service. Users can search the relevant databases, request further information and order products—all within the same system.

BT has established a network of consumer liaison panels to provide a constant two-way exchange of views between the company and its customers. Panel members are selected from members of the local community who have skills in representing the views of others or particular experience of value to the panel. BT is represented on the panels but they are each chaired by an independent consultant appointed by, and independent of, the company.

Panels have been established in several locations, and the long-term objective is to have one panel in each of BT's 28 Districts. There are also three specialist bodies—a West End of London small business panel, a national consumer liaison panel, and a national information technology panel. Three further specialist panels are planned—a young persons' panel, a consumer leaders' panel, and a products and services panel.

The local panels have been formed to discuss issues of concern to the residential and small business user, and to provide a forum for members of a community to exchange views with BT management. They can act as agents for change by reflecting customer concerns, developing options and suggesting solutions. The panels do not have a role in resolving individual customer complaints, for which other bodies exist, although they will deal with policy issues arising from complaints. They will not replace or mirror existing consumer organisations, such as the Telecom Advisory Committees.

## NEW TITLE OF INCORPORATED ENGINEER

The Engineering Council has announced that the Privy Council has granted the Council's petition to change one of its titles from Technician Engineer (T.ENG.) to Incorporated Engineer (I.ENG.). The Engineering Council's Charter empowers it to confer three titles to individuals admitted to its Register. The other two titles are Chartered Engineer (C.ENG.) and Engineering Technician (ENG.TECH.). The new Incorporated Engineer title comes between these two in standard.

The Engineering Council had felt that the now defunct title Technician Engineer created confusion in the public's mind with the Engineering Technician title. The Council felt that the title Incorporated Engineer more suitably described the professional capabilities of those individuals reaching the standards set by the Council. The change of title is expected to help the Council's aim of linking its titles to job specifications with attendant benefits for individuals and engineering at large. Approximately 60 000 Technician Engineers are affected and will now become Incorporated Engineers.

The standards required for registration for each of the three titles are set out below:

**Professional Engineer Section** (which includes all Chartered Engineers)

| | |
|---|---|
| Stage 1 | Academic standard exemplified by an accredited degree in engineering or a pass in The Engineering Council Part 2 Examination. |
| Stage 2 | A period of approved training. |
| Stage 3 | A period of acceptable experience and professional responsibility. The aggregate of training and experience shall normally be not less than four years. Minimum age 25. |

**Incorporated Engineer Section**

| | |
|---|---|
| Stage 1 | Academic standard exemplified by the BTEC Higher National Certificate in approved programme areas. |
| Stage 2 | A minimum of two years' approved training. |
| Stage 3 | Five years' engineering experience including the period of training shown above. Minimum age 23. |

**Engineering Technician Section**

| | |
|---|---|
| Stage 1 | Academic standard exemplified by the BTEC National Certificate in approved programme areas. |
| Stage 2 | A minimum of two years' approved training. |
| Stage 3 | Three years' engineering experience including the period of training shown above. Minimum age 23. |

## JOURNAL DISTRIBUTION—NOTIFICATION OF CHANGES OF ADDRESS

IBTE Members and *Journal* subscribers who change their home address should ensure that they notify the *Journal* office on the address-label slip provided with every copy of the *Journal*.

All enquires related to distribution of the *Journal* should be directed to The Administration Manager at the address given below.

## EDITORIAL OFFICE — CHANGE OF ADDRESS

The address of the *BTE Journal*/IBTE Administration Office is now

*BTE Journal*/IBTE Administration Office
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# 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):

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*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. 211 of the October 1987 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.

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**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.

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

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of

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

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

Full membership of FITCE in the UK is available only through IBTE. Members and Affiliated Members of IBTE who hold a University science degree or who are Chartered Engineers may join through the FITCE Group of IBTE. The annual subscription for 1988/9 is £5.00; this covers local administration expenses as well as the *per capita* contribution to FITCE funds, and thus ensures that no charge proper to FITCE affairs will fall upon the general membership of IBTE. Membership forms are available from your Local-Centre Secretary or direct from the Assistant Secretary (FITCE), Mr T Ray, Assistant Secretary, IBTE/FITCE Group, UKC/NPW4.1.6, 3rd Floor, D Wing, The Angel Centre, 403 St John Street, London, EC1V 4PL; Tel: 01-239 0810.

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