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EDITORIAL

A number of factors are shaping the future of the telecommunications environment in Europe and the UK. The telecommunications industry is in the forefront of plans for the creation of the single European market in 1992. Liberalisation of the market for terminal equipment and a free market for value-added services are two areas in which competition to the existing network operators is growing. An article on p. 226 of this *Journal* outlines these pressures on telecommunications operators and discusses how these factors are shaping the future of the industry. The UK is currently in the vanguard of activity leading to open markets, and a consequence of this is a greatly increased customer awareness and expectation. Service to the customer is critically dependent on the performance of the local loop, or access network. At the recent International Symposium on Subscriber Loops and Services, British Telecom won three of the four awards for papers describing their world leading work on the access network. These three papers are reproduced in this issue of the *Journal* on pages 233–245.

Telecommunications Services in the 1990s

Keynote Address to the Institution of British Telecommunications Engineers

DUNCAN LEWIS†

UDC 621.39

This article is a transcript of the Keynote Address given by Duncan Lewis, Director, Strategy, Products and Services, British Telecom UK Communications, to the London Centre of the Institution of British Telecommunications Engineers on 21 September 1988. In his address, Mr. Lewis outlined the pressures on telecommunications operators resulting from the current changes in the competitive environment and discussed how these factors are shaping the future of the industry.

INTRODUCTION

Rather than present a litany of all the services telecommunications operators are going to offer their customers in the next decade, I thought I would discuss the factors which appear to be shaping our industry. I trained as an historian rather than an engineer, and as you will see from this lecture a lot of what I have to say is about history rather than the future. I think we have to understand the past as well as the present in order to understand the future.

What I want to talk about is the way in which our technology is going to relate to our customers' needs in the next decade. I think we are in for a fascinating period as we give our customers greater and greater opportunity to use the technology we provide in ways we cannot imagine at the moment. Indeed, a lot of our growth and the opportunity for British Telecom lies in actually trusting our customers to use their imagination in using our technology.

There are a number of competitive drivers in our business at the moment, and I want to look at each of them in turn. Firstly, there are changing customers' expectations. Secondly, there is growing competition, not just from Mercury Communications, but from companies that have traditionally not offered telecommunications but are entering our markets as they find a need to add communications to what they do, and they are operating within the same core technology. Thirdly, there is major technological development, and it is from this, or the sudden change in technology, that new companies can very quickly emerge and dislodge very established ones. If you think about IBM and the difficulties it has been in over the last few years, it was actually because it missed an opportunity to exploit its own technologies extremely quickly. Particularly in the personal computer market, but also in the large computer area, it has taken a long time to recover and get back on a growth path.

CUSTOMER EXPECTATIONS

I want to turn to each in detail and start first of all with customer expectations. The first customer expectation is just better price and better performance. The customer quite simply expects a lot more for a lot less, and his or her expectations are continuously fuelled by the experiences of the last 20 years, particularly in the mass consumer market. Fifteen years ago, I bought my first calculator for about £14 and it added, subtracted, multiplied and divided. Today, for a lot less than that, you expect a very high order of scientific functionality.

The standards of such performance and quality have been led largely by what has been achieved in the television industry and in the personal computing sector. The Japanese drove this because they recognised that in order to get their whole technology to take a quantum leap forward they had to produce a product for the mass market, but they also had to produce a product which was inherently reliable, and they chose the television. They simply could not afford the warranty costs if they did not have a reliable product. They also recognised that if you got the colour television industry under control, you have customer loyalty on a mass basis. They did it very simply: if you look at a Japanese television at the end of the 1960s, they began to move towards a single printed-circuit board with about 400 components on it and a failure rate of 1 in 1000 in the first year.

The UK colour television industry was geared towards the so-called rental market: ease of repair, three printed-circuit boards, about 600 components; the engineer could turn up, take the board out, and leave, but it was inherently unreliable with that level of component count and complexity of manufacture. The Japanese moved very quickly to

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automatic insertion; we actually used manual labour, and 1 in 25 TVs went wrong in the first year. Of course the rental companies in Britain realised extremely quickly that they could simply buy the Japanese television and save on their own labour costs because they had a much lower fault rate. And that is exactly what happened in the UK. This virtually wiped out our industry, and progressively across Europe and, of course, in the USA.

Now in our own telecommunications industry we can see the same drive for much, much higher quality standards. From the research that we have done, it is expected that business and residential customers will want dial tone [that is, a new exchange line] instantly in the next decade. They will not wait a week or ten days, or two weeks or six weeks, for the delivery of a line. Major corporations will expect to be able to reconfigure their private circuits and their private services instantly. Current fault rates are simply not going to be acceptable, and security of service will become crucial for major companies which are absolutely dependent upon communications for their own business.

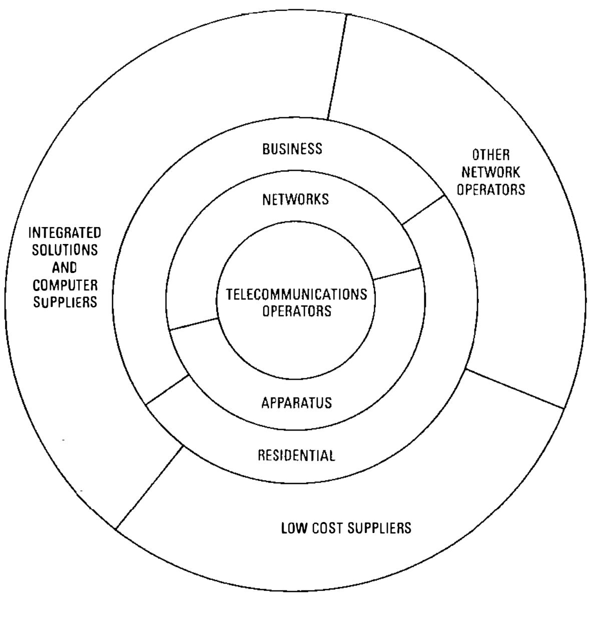
The second thing customers are expecting is solutions and not the technology. They expect the supplier, us, to understand their needs, both at home and at work, and to provide their needs with a technology in a way they can use without difficulty. But there are a number of sub-drivers at work here. The most significant is simply a world-wide shortage of skilled people. If you take the distribution industries in Britain, the big retailers, and we have one of the most sophisticated sectors in the world, they all want the same skilled telecommunications and systems engineers to drive very large networks. It is easier for them if they can off-load that responsibility on to a telecommunications company. But there is a pre-condition, and that is they have got to have visibility of the network we operate on their behalf, and there is a reason for this: if you take one of the large food retail chains, it runs a very large network to ensure efficient provisioning because its whole philosophy is that 'Good food will cost less'. The Managing Director has on his desk every morning a report on distribution the night before and systems operation. He then has the accounts for the entire business of the previous day. The most important thing is whether the distribution system worked overnight. The reason for this is that it turns over its entire inventory in 21 days, and like most businesses, it has a credit line of 35 days. It can fund its entire capital programme on its credit line. If it slips two or three days in that inventory, it starts having to borrow; being a retailer it operates on very small margins, and the interest rates today, for example, it would actually materially affect its profitability. If food arrived late, it would not be fresh, and that too would affect profits. So there is a huge dependency upon the quality of its communications and, although it is a small part of its total assets, it is a very important part of its total infrastructure, and therefore visibility of that network, which we may run, is fundamental to its operation; it wants to know it is secure.

Providing solutions is actually expected by all customer groups, not just the big retail companies—granny really does expect a company to be able to turn up with a pair of wires and a telephone and they should all work. The student expects his personal computer to work and to attach to a local area or a wide area network within his university.

So the third feature is we are expecting the customer to want greater and greater control. Customers will expect to be able to have visibility of what is going on, and although they will expect us to provide services, they will want more and more opportunity to use the intelligence of our network on a selective basis. They will want to choose call barring and who they bar, they will want to choose itemisation, they will want to choose from catalogues of our products, they will want to control and access.

Now companies who can master this ability to meet a higher value in the eyes of the customer, who can offer lower cost, who can provide solutions, who can understand the customers' needs and interpret those in a technological form, and give the customer greater access and control of the technology, will be the winner.

Figure 1
Competition



COMPETITION

If you look where BT is currently positioned (see Figure 1), you can see that we are surrounded by a number of threats. At the centre are the telecommunications operators such as ourselves. Our businesses are conventionally broken into an apparatus business and a network business. In Britain, it is particularly well defined because our Licence says we are not allowed to cross-trade between the apparatus and network business; they have to stand alone in terms of profitability. We have traditionally broken our market into the residential and business market, the famous 'bus/res' split, which is not actually a very meaningful split in terms of how you meet customers' particular requirements, but that is the way it has conventionally been done.

So those three rings are the business, sub-businesses, and the markets we tend to address, and there are three types of competitive threat. I am going to start with what I call the low-cost distributors of products. These are the High Street chain stores and their task is to get boxes and ship them, but they are subject to that cost curve I described earlier; the customer expects to pay a lot less for a lot more, so they constantly feel this margin erosion. A good example is Amstrad. Amstrad took the word processor, found a new way of simply manufacturing it cheaply, put it into volume production and distributed the product through the High Street shops. A product that was originally supplied by the computer companies and office automation companies at very, very high margins suddenly became a low-cost product with quite a slim margin. Fax is going the same way. We were the first company to introduce the £1000 fax, and we have a good margin on it, but now we can see that margin going as others take that market and come in at that price. Those companies are driven to add value to their product by enhancing its value in some way or other by adding modems, by linking them through communications. In the USA, in particular, they are beginning to move into local area networking, and it will not be very long before they will have arrangements with various network operators to distribute their product, so they can control where the value is added.

This is also the case where other network operators operate in our markets. Mercury Communications has simply done that by using basic commodity technology in the form of fibre optics. They have taken fairly standard technology, found a good way of distributing it and, for about an eighth of what we spend in any one year on our network, in terms of capital investment, with a favourable interconnect deal, have created a perfectly viable competitor.

Then there are the large computer suppliers. They are subject to exactly the same performance pressures as the low-cost distributor. Customers expect huge computing power and to pay less for it, so the suppliers have to add some sort of value, either in systems engineering or more particularly in computing and communications combined. IBM has built its international X.25 network and it can offer that service, and it has come to us and other telecommunications operators and leased the lines.

The battle that is going on is about who actually is going to 'control' the customer and provide the added value, and the risk for us is that we are going to be squeezed and marginalised.

There are major differences in our markets, and the problem for a telecommunications operator, which has worked in the residential and business split, is that the split is too unrefined. There is another problem in that telecommunications companies have traditionally grown up as public monopolies, and they have done that not just because of the so-called public good — it is part of the infrastructure of the economy — but because the only way you could actually fund that type of investment up-front, and take the risk to create the physical network, was if somebody was prepared to take the risk in a very large way, and conventionally only the State has been able to do this. The risk is that those companies are inherently inefficient.

There are, therefore, political pressures which are another form of competition, established to make telecommunications operators more efficient. Oftel acts as a proxy for competition on us. So the pressures on telecommunications operators are from competitors who are trying to marginalise them, regulators who try and recognise on the one hand the need to retain the physical network and the importance of that infrastructure, but on the other hand act as a proxy to customers to ensure efficiency in the use of that physical resource.

So if we try and summarise this, competition now falls to these low-cost apparatus distributors, other network operators and computer systems suppliers and integrators. One of the greatest problems we have is that it is the computer supplier that already owns the customer because he has got account management that can understand their needs, and I will come back to that shortly.

TECHNOLOGY

The third area where we see obviously the greatest change is in the technology. This is an absolutely conventional curve (see Figure 2) of what tends to happen in our business, extremely high up-front costs where the cost of production per unit is very high. Conventionally, for every step change in technology, there is a tenfold increase in the costs, and then once you get up the volume curve, the price per unit comes down. But if every time you have got a tenfold increase in costs here, you need a lot more volume to recover those costs. The consequence of that technology effect is that companies are fighting for market share, but it is also affecting increasingly the structure of our whole

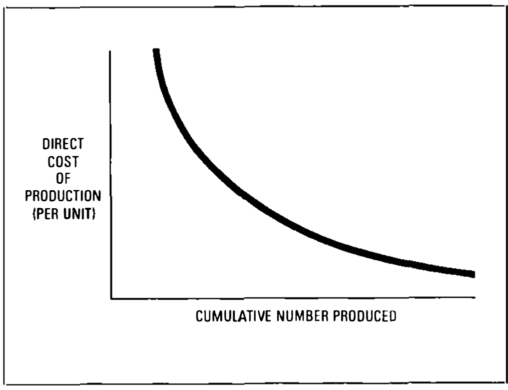


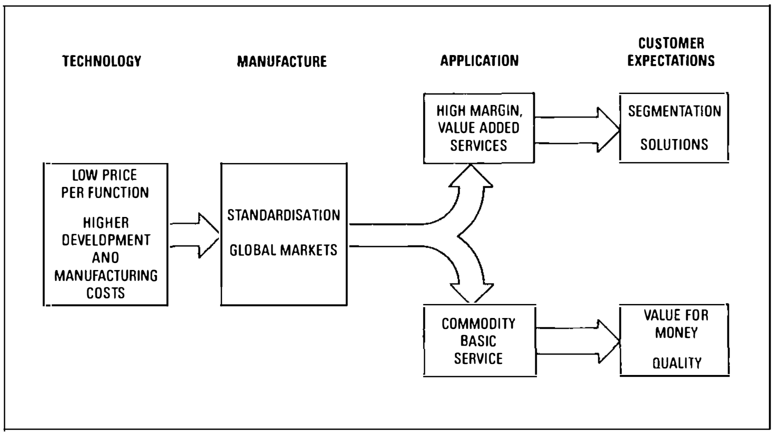
Figure 2
Cost curve

industry, and it is breaking down in a number of ways.

We find technology-based companies, the semiconductor houses, were looking to supply a low-price per function, but are facing higher and higher development and manufacturing costs. Manufacturing requires greater standardisation if you are to get the benefits of economy of scale, and therefore global markets. As those global markets develop we are seeing a split in the way the technology is developed and applied (see Figure 3). On the one hand you get the basic commodity service provider. It is rather like our big switches, the central office switches, System X, today, which are already taking on the characteristics of a fairly commoditised product that you would increasingly buy off-the-shelf from any switching supplier around the world, and what we will be producing is simply, in our case, calls or a value for money product at high quality. So there is a constant theme: as you find silicon becomes 'standardised', you manufacture to a global market, and you provide a commodity product.

The alternative route to market is to add some sort of value to that basic commodity. With the chip you add the software, you design something for a particular market segment, and you have got increasing customer expectation of something dedicated to his particular needs. The problem we face is that what is a one-off or a special today can rapidly be commoditised through the technology and become a standard product. We have it in our own business; it has cost us a huge amount of money to develop the Star Services for System X — almost as soon as they are in the market, we will have to include them in the basic rental. We cannot actually charge more for them because the customer is not prepared to pay, he expects more for the money.

Figure 3
Changing technological/economic dynamics



The technology itself has got a number of features driving it, and a change is going on in the market. The first is what can be termed design on silicon, or application-specific semiconductors. What we are finding is that you can design your entire system increasingly on a dedicated semiconductor. Put another way, the end user can define what he wants and you can realise it in the chip, and it justifies some marginal extra cost: security, or because you want to differentiate yourself powerfully in the market. However, you also find you have to make the same sort of investments as if you were making a standard commodity semiconductor. One European company actually went down the route of going for application-specific semiconductors, but in very high volumes, with the customer being able to design straight on to the silicon and have the final product sent back the next day by post. The customer was prepared to pay a very high margin for that, but there was still the requirement to have a very high volume throughput to recover the investment. So very specific market applications are going on, but you still have to have very large up-front investment.

Quite new marketing techniques again have to emerge to cope with that, and it is exactly the same in software. Advanced software tools, especially those based on intelligent knowledge-based system, will again allow suppliers to design features for customers in particular ways to meet their particular needs. I think it is going to be the ability of telecommunications operators to exploit these technological capabilities, within their networks, which will actually give them the high ground, because if they do not, it will actually go to the computer suppliers and the apparatus distributors. Unless we can find a way of providing products and services to meet the needs of our customers extremely quickly, through the application of these types of technology, we will not be able to compete in the market.

CHALLENGES

How do they go about doing it? I think there are two major challenges we face as a company in the next decade. The first is account management. Who actually controls the customer? Who can serve him fastest? Computer companies have had embedded account management for the last 20-30 years, and they are becoming very sophisticated at being able to work with customers in partnerships and interpret very quickly back into their systems functions the precise requirements of their business. Look at the way ICL survived in the early-1980s. It simply took the view that there was no way ICL could remain a box supplier and develop its own technology; it did not have a big enough market base and it could never take IBM on head-on, so it went and bought Fujitsu technology.

But the other side of the equation was that ICL was re-organised around a number of key market segments, and in each segment you had the account managers, experts in the sector. They hired the people who worked in retailing who understood what a retailer did, and put the systems engineers in there, so they could design together systems that met the customers' requirements to interpret back into the company the requirements of that customer set.

So I think our first challenge, as a telecommunications company, is that unless we continue to develop account management we do not stand very much of a chance of beating the computing companies. And it is a very real problem for us because, unlike a computing company that can choose its customer base, we cannot. We are legally obliged to meet all demand that comes through the door. We have twenty-three million customers, and we have to find techniques for developing account management for each of them. Interestingly, it is our own technology which will allow us to do it, because if we can develop database marketing techniques to allow us to keep information about our customers, to interpret their needs and talk to them about the way their business is developing, or their home lives are developing, we will be able to literally account manage our twenty-three million customers. Indeed, they will expect that as a service from us.

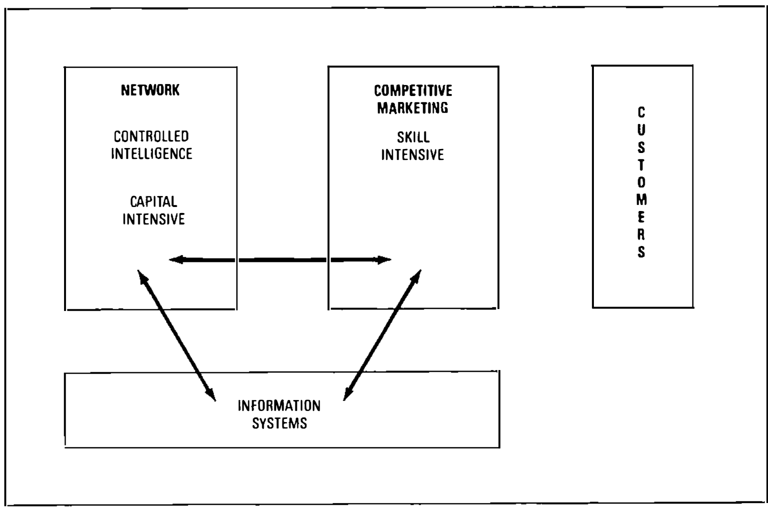
The second major challenge is: who is going to control the intelligence? Put simply, and I guess crudely, it is simply a battle now between the telecommunications operators, who wish to pull facilities towards the heart of the network, and those companies in the computing and related fields who wish the intelligence to go to the periphery. The crucial technological issue for us is how we are going to develop an intelligent network database system — centralised intelligence — so that we can offer competitive services and features that our customers want more cost-effectively than our competitors who are arguing for intelligence at the periphery.

I believe we have to think in terms of an organisational model rather than just a technology model, and the organisational model is something like this. We have to develop a very powerful understanding of our customers' needs, and we are going to require very powerful new management systems to interpret those into the Company (see Figure 4). My own view is that the biggest challenge we face is not the development of central intelligence in the network: the question is, really, who are going to be our partners to develop a framework of intelligence around the central processes. Our challenge is going to be much more the development within our Company of an organisational capability to move towards customer-led operations to exploit the intelligence that is in this network.

What we need is what I call an organisational capability, that is a sum total of all our Organisation's processes so that the whole serves the customer and is greater than its parts. Now an analogy with another industry may help about what I am trying to get at. If you look at Honda, Honda set itself the task of being the world leader in motor engine technology, and has huge capital investment in simply manufacturing technology for engines. It actually writes off its capital about once every two years. We write off Strowger exchanges over forty years. So Honda actually are equipped always to re-capitalise their business every two or three years. They then organise their marketing by a number of sectors: motor cars, motor-cycles, lawn-mowers, boats, and they apply the manufacturing technology they have developed here into those sectors. They retain the technology leadership and at the same time develop competitive positions in a number of markets.

In BT we face exactly the same problem. How do we develop skills to understand our customers' needs and realise them quickly in software features within the network to meet their particular requirements? It is the information systems of our business that will increasingly allow us to do that. I guess the simple analogy today is when somebody can walk into a shop and say, 'I am moving in down the road, I would like dial tone'; and the customer service system (CSS) signals straight to the operations and maintenance centre and it is delivered.

Figure 4
Organisational capability



The focus for us, therefore, has to be on the relationship between people and systems, in developing skills in our people who can use systems to exploit our technology in favour of the customer. Conventional management hierarchies I do not think are going to work in those sort of circumstances. Instead, we are going to have to develop an organisational competence and build our organisation around it directly to serve the customer. If you think about it, centralised intelligence is going to allow customers to develop facilities anywhere around the network to meet their needs, such as dedicated private networks with hierarchical levels of security for different staff, and those are going to be variable, and will have to change every time the staff changes.

We have already begun to establish in the UK an advanced network which provides, for example, the 0800 service and the 0898 services. What customers have quickly realised is that they can use those facilities to enhance the value of their own business. One company, for example, found that it was constantly under pressure to reduce the price of its products to the Department of Health, which was subject to stringent financial controls. On investigation, the supplier found that the Health Department's administration costs were high, and the order processing was complex and represented a large part of these costs. So the supplier actually went back to that customer and said, you could use an 0800 service, we can organise the whole thing on demand, we can do all your billing for you, we can do everything, and actually reduced the administration costs by a very large amount. The consequence of that was that all of a sudden the Health Service begun to take the pressure off the price of the product, and indeed the company supplying this product has made a lot more money. So it tackled a cost problem in its own customer and reduced pressures on itself to reduce its margins. The conditions of achieving this were that the supplier had to understand the customers' costs, and simultaneously had to appreciate how the facilities we offered could be used by the customer. In fact, the first step was that we had to work with the supplier and the Health Department to develop applications for the technology; we became the fulcrum in the see-saw.

There are a number of examples like that. One of the most interesting is the way that a tyre company literally salvaged itself by reducing its distribution costs through the use of the 0800 service.

TELECOMMUNICATIONS OPERATORS

So what have we got? We have a number of competitive advantages. We were State-owned, we were a regulated monopoly. We are no longer State-owned but the monopoly rests, it is regulated, but it is regulated in a way, at least in the UK, which is quite light and we certainly do not have some of the pressures of our overseas equivalents. We own a huge physical network, it is there, and once the customer is attached to it he cannot very easily walk away, and we have a huge customer base.

However, there are a number of disadvantages. Firstly, we have not invested sufficiently in our people, that is people who have got the commercial skills of operating in the sort of environment which is now emerging, and the hardest part of moving the business forward is going to be continuous development by people and investment in their skills. We have to create an entrepreneurism which allows people to exploit the network in the eyes of the customer. A very good example is the impact that CSS is having in certain Districts where the Front Office has been established. Recently in South Wales, I spent a day with CSS and dealing with customers, and the girl who was showing it to me said that the best thing from her point of view was she could now champion the customer because she could get in touch with the engineer directly, she knew where he was, she knew the state of any repair, she could contact the customer and tell the customer what was going on. She could also handle the customer differently because if the customer rang up and challenged her, she had information about what was going on. She gave good examples of where a customer would ring up saying they had rung earlier but nothing had happened. Such a statement can easily be verified and the relationship begins to change with the customer in a very positive way.

The second disadvantage was simply the lack of capital investment. The biggest opportunity we now have in BT is access to capital markets to develop the network infrastructure. The major programme of the next five years will be in the access network. It is great getting System X in, getting the trunk network in, but we have now actually got to get the final pair of the physical infrastructure right, because that is the thing that the customer feels and sees more and more, and if we are to give the quality of service the customer requires — instant dial tone and so on — we have to re-think the way the access network is delivered to the customer. It has been the Aunt Sally of the business for a very long time. It has been the Aunt Sally of the business because in the days of the Treasury, when you were allowed so much cash each year quite regardless of what income came in, the first thing you did was work out the wages bill, the second thing you did was put aside enough money to pay your suppliers for exchange equipment, if you had anything left over you would try and put it into the local loop. It was the first thing that was raided if a squeeze came on from the Treasury. We are very conscious now that that is where we have got to put our money if we are truly to present ourselves to the customer in a way which shows BT to be a quality company.

The third area of concern is the need to develop our account management. We have managed to achieve it for the top 500 customers, but we are very under-resourced still. IBM has over a hundred people working on our account all the time, ICL has the same. I guess we have got one or maybe two working on the IBM account. It is this ability to build up the relationship with the customer, and understand his needs, that I think is the biggest challenge we face, because it is about the development of our people and about the ability of ourselves to take the very fine technology in the Company and put it to the customer in a creative way.

CONCLUSION

So I have not dwelt on a litany of services I think will appear in the 1990s because, frankly, the services are only going to be limited by the customers' imagination. As we provide a network infrastructure, with more and more software embedded within it, and more and more features, the exploitation of that will actually lie with our customers, and that is how we will add value to our entire business. What I think we have to concentrate on now in the Company are the conditions for success in that competitive market rather than just a marketing study of customers' needs, and I think the beauty of our technology is that in many ways the customer can do his own marketing if only we, as the supplier, can find out how to give him access to what we know about the technology.

BIOGRAPHY

Duncan Lewis was educated at the John Fisher School, Purley and Queens' College, Cambridge where he studied history, and subsequently did post graduate research in political theory and international comparative industrial policy. He was adviser to Richard Wainwright MP during the Lib–Lab Pact whilst holding a research fellowship in industrial policy. He joined NEDO, in 1979, as Secretary to the Electronic Economic Development Committee; he became Secretary to the Executive Board of STC plc in 1982, responsible for advising the board on economic and social policy. He became Director, Business Intelligence and Planning in 1984, and a Director of ICL and Director of several other STC subsidiary companies. He joined British Telecom in 1986 and is now Director, Strategy, Products and Services for UK Communications. He has written and lectured on industrial policy and business strategy, he has been a member of the management board of British Schools Technology, of an RSA study on education and is non-executive director of several small companies.

Flexible Access Systems

I. G. DUFOUR, C.ENG., M.I.E.E.†

UDC 621.391.63

British Telecom is treating the introduction of optical fibres into the access network in several phases. The first of these is the provision of direct optical fibres and their associated electronics, known as flexible access systems, *to major customer sites. Investments of over £100M have already been made in London alone and the first systems are operational. One building currently has over 15 000 single-mode fibres terminating in it. It is intended to roll out flexible access systems to cover several million lines over the next six years.*

INTRODUCTION

This article describes a means of providing the normal range of services to business customers through an 'optical pipeline'. The system design, called a *flexible access system*, is currently in service and widespread implementation is expected. This article sets the system design in the context of wider network developments and explains in detail the design features.

NETWORK BACKGROUND

The UK network is already advanced in its use of digital and optical technology. All 53 trunk units are now digital and over 1000 of the 6000 local exchanges (central offices) are wholly or partly digital. Trunk transmission systems will all be digital by 1989 and the junctions (inter-office trunks) linking local exchanges to the trunk units already have a high penetration of digital working and will be substantially digital by 1992. All the digital exchanges are interlinked by high-capability common-channel inter-processor signalling systems (CCITT No. 7).

Within the transmission network, there is already a substantial amount of optical fibre. In September 1987, there were 180 000 fibre-kilometres in the trunk network and 79 000 fibre-km in the junction network compared to only 25 000 fibre-km direct to customers in the access network.

In addition to the switched network, there is already a managed network in place for digital private circuits. This makes use of inter-linked digital cross-connect switches for some tens of thousands of 64 kbit/s digital point-to-point private circuits.

In spite of this advanced technology in the core network, the customer is still buffered from it by the traditional copper local loop. Its lack of capacity, upgrade potential, flexibility and intelligence is now universally recognised as the 'access bottleneck'. Optical fibres provide a potential solution, but the cost and complexity of the associated electronics are acting as a barrier to high-volume implementation. Flexible access systems are a response to this.

NETWORK FUTURES

Several megatrends are unmistakable. One is the continuing progress of optical fibres as a transmission medium. Another is the way that software is now dominating hardware in the complexity of systems and in development effort. Centralised intelligence, and in particular the intelligent network database, is but one manifestation of this: the whole picture includes the increasing range of intelligent systems and their interaction with existing computerised administration systems in order to provide an automated customer service from order handling through provision to ongoing support. Switching trends to incorporate variable bit rate and broadband requirements are less clear, but a general shift towards an overall network broadband capability is clearly discernible. Amidst all of this, the world telecommunication supplier structure is changing such that only a small number of major companies are expected to survive dictated by their ability to invest in research and development and to provide the necessary resources on software development.

Against this background, British Telecom has produced an evolution plan in which optical fibres are first used to provide service to large and medium businesses, then to small businesses and so on leading to the ultimate long-term goal of fibre to the single-line residence. Initially, provision of optical fibres to business customers has been for operational reasons such as an inadequate copper base or shortage of underground duct. However, the aim is for a significant roll-out to provide several million switched lines at all customer sites of 25 lines upwards. To achieve this, the provision of fibre in the loop is viewed as a means of streamlining and simplifying the

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present network both in terms of layout (for example, node consolidation) and operations (for example, reduced copper maintenance costs). A major difference of the British Telecom approach compared to other operators is that volume, and the associated price reduction, is being sought through network replacement where capital cost is counterbalanced by running-cost savings. This compares to the 'loop-growth only' scenarios being pursued elsewhere.

The provision of an 'optical pipeline' firstly to business sites starts with the flexible access system. Several options exist for the progression to other sites including a switched-star architecture, in which British Telecom already has practical experience through its cable-TV subsidiary operating Westminster TV, and a star-bus architecture. The latter has special attractions in a residential environment with low cable-TV take-up rates; a companion article in this *Journal* 'Passive Fibre Local Loop for Telephony with Broadband Upgrade' explains the current work in this area.

FLEXIBLE ACCESS SYSTEMS

Flexible access systems provide a delivery vehicle for the standard portfolio of network services to businesses with potential for new service offerings at later stages. Using the benefits of network rationalisation to justify modernising a proportion of the copper-loop, the approach bridges the gap between short-term cost justification and the longer-term strategic trends. The key elements of flexible access systems are shown in Figures 1 and 2 and are:

- flexible intelligent primary multiplexers located at customers' premises along with the appropriate higher-order multiplex and opto-electronics;
- a single-mode optical-fibre cable network;
- a digital cross-connect switch to handle private circuits, both analogue and digital; and
- software to monitor and control the hardware and to interface with existing operations systems.

Cable

The cable network is dimensioned and laid down at the outset to avoid constant piecemeal addition. As indicated earlier, the target sites are 25 lines upwards. In practice, the cable network is laid down with 96-fibre cables breaking down to 48- and 24-fibre cables. Generally, the 24-fibre cables lead to a joint serving a number of customer sites. Each customer site usually has four fibres, but these may in some cases be fed from two diversely routed spine cables. The customer entry cables are thus of two or four fibres. Generally, these are met by a 4-fibre fixed-count cable or by means of 'blown-fibres' which are also described in another companion article in this *Journal*.

Customer site equipment

The equipment at the customer site includes opto-electronics, higher-order multiplex and the appropriate number of primary multiplex (channel-banks). It also includes protection-switching at the 2 Mbit/s level to duplicate the fibres and transmission equipment, stand-by batteries, line-testing aids and a cabinet. The whole assembly is referred to as the *network service module* and the network boundary is on the customer side of this.

Node Transmission Equipment

At the node, the opto-electronics and higher-order multiplex equipment is installed to bring the systems back to 2 Mbit/s (unless, of

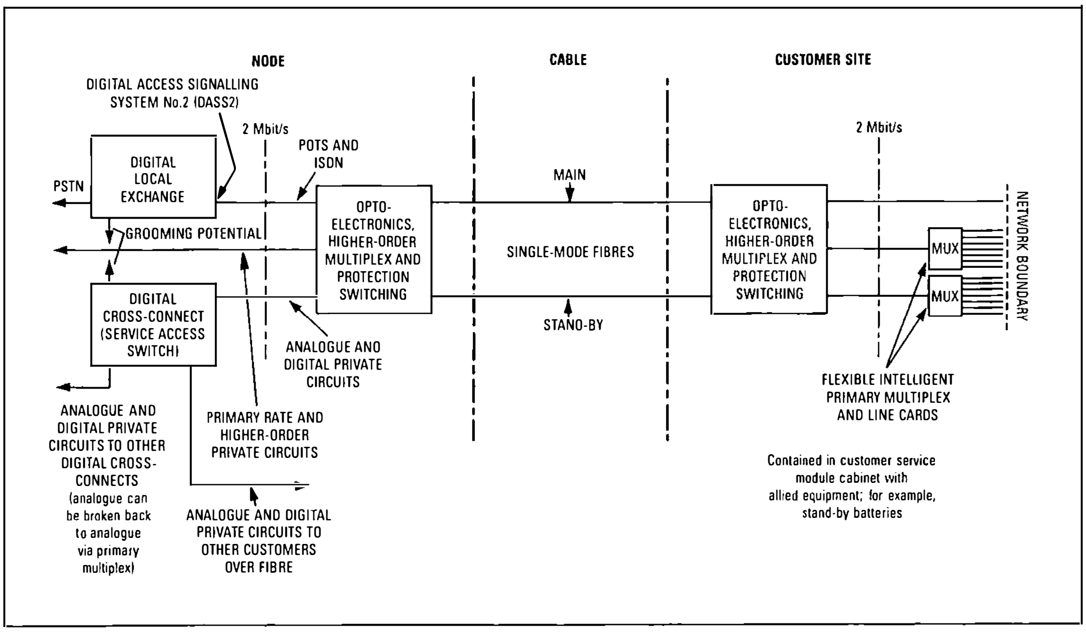
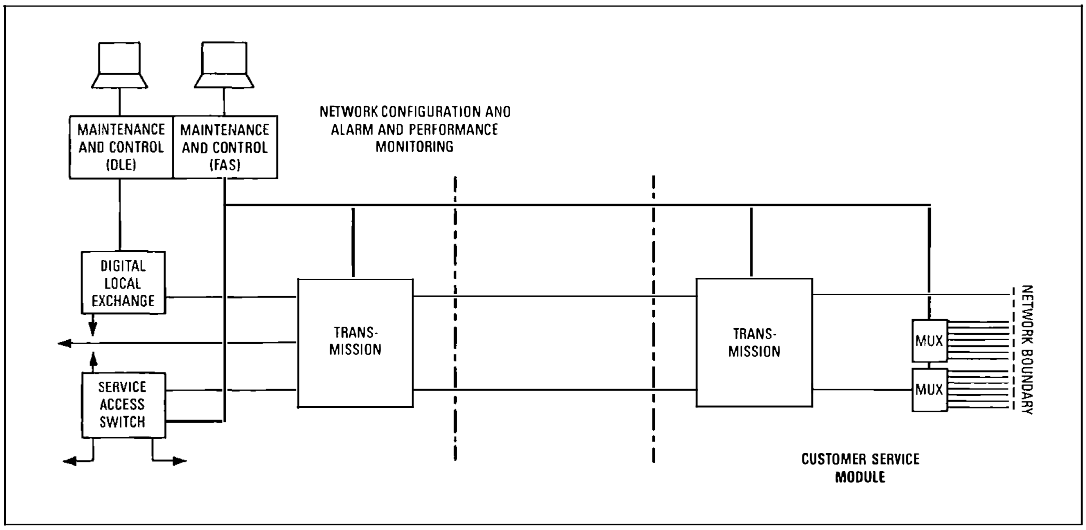


Figure 1
Flexible access system (hardware)

Figure 2
Flexible access system (software)



FAS: Flexible access system

course, there is a private-service demand for a higher bit rate).

Service Access Switch

The service access switch is a digital cross-connect for private circuits. However, as it is dimensioned to handle analogue circuits as well as digital circuits, it can be significantly larger than digital cross-connects hitherto employed. A 2048 2 Mbit/s port switch is the main building block so far.

SERVICE APPLICATIONS

The ways in which the above elements are used differ between switched and private services and some description of each helps to understand the application or the network.

Switched Services

As the flexible access system is a common bearer for all services, it has to interface with a wide range of customer premises equipment. The principal services are analogue telephony (POTS†) serving telephones and PABXs, with a variety of signalling systems including MF4, and digital telephony (ISDN) at both 2B+D and primary rate. The simplest of these to consider (see Figure 1) is a primary-rate ISDN access for an integrated services PBX (ISPBX). Here the service is presented to the customer at 2 Mbit/s, and the 2 Mbit/s stream is routed to a 2 Mbit/s port at a digital local exchange. In the UK, a signalling system is already agreed between British Telecom and ISPBX suppliers, and is known as *Digital Access Signalling System No. 2* (DASS2). The next to consider is analogue POTS. Here the lines are grouped together onto one or more primary multiplex and each 2 Mbit/s stream is again taken to a local exchange 2 Mbit/s port. The signalling interface is again DASS2, although in this case it is a future development of the ISDN version. This interface is critical to the economics of flexible access systems as the cost of a further multiplex and two additional line cards cannot be supported. ISDN (2B+D) lines can be substituted for an appropriate trade-off of POTS lines.

† POTS—'Plain old telephone service'

Private Services

Private services differ from switched services in that the customer-to-node link is only one part of an end-to-end service where the remainder of the circuit may not be on a similar system. The interconnection arrangements and particularly the service management arrangements are thus far more complex. The simplest service to describe (see Figure 1) is for primary-rate digital service. Here the flexible access system acts simply as a transmission bearer. For other private circuits (speech band, 64 kbit/s and $n \times$ 64 kbit/s), they are grouped together on a common primary multiplex and 2 Mbit/s stream and routed to the service access switch. Here they may be routed back to another customer on the same switch, via another switch to another customer, broken back to analogue via a node-located multiplex or, in the case of digital private circuits, sent into the managed private core network.

Grooming

Switched and private traffic are intended to be separated at the 2 Mbit/s level but there is potential, especially for small customers (30–50 lines), for a single 2 Mbit/s path to contain a small number of private circuits as well as switched lines. The best way of achieving this is still being resolved although there are several alternatives (grooming via the service access switch, locked-up time-slots through the local exchange or time-slot agility in the transmission equipment).

SOFTWARE CONTROL

A feature of this sort of network is the need to minimise technician (craft) visits to customer premises and to have a high degree of configuration flexibility and status monitoring from a control centre (Figure 2). The network configuration capability arises through cross-point control of the service access switch and dynamic time-slot allocation to line cards at the primary multiplex. Also, circuit characteristics, such as send and receive gains, are under software control. All the electronics are under continuous surveillance both for faults and error-rate degradation. Some diagnostic features are built in and the protection switching can be controlled via the software as well as automatically. The software is increasingly configured to accord with a network-wide generic structure (see Figure 3) where the plant and the plant control are purchased against specifications requiring an interface, via a defined protocol (Administration Network Interface Standard), to British Telecom supplied network level controller software.

Initial systems have called for a separate access control centre, but eventually the control is likely to be integrated with the local exchange control centre for switched service and with the managed private circuit network centres. These will be brought together and interfaced at the network controller level.

The system described is not just a long-term aim but, for private circuits, a reality today. The first flexible access system was brought into service in December 1987 in the City of London (the financial district of London). It is based on three nodes and is dimensioned to serve several thousand customer sites. The cable network is already largely in place and one node has over 15 000 single-mode fibres terminating within it. The same node has one 2048-port service access switch operational, another in course of installation and several more planned. The other nodes are also for 2048-port switches. The network is currently being extended to an adjacent part of London known as *Docklands*. Both these networks will have switched services added in conjunction with DASS2 developments on the local exchange by early 1990.

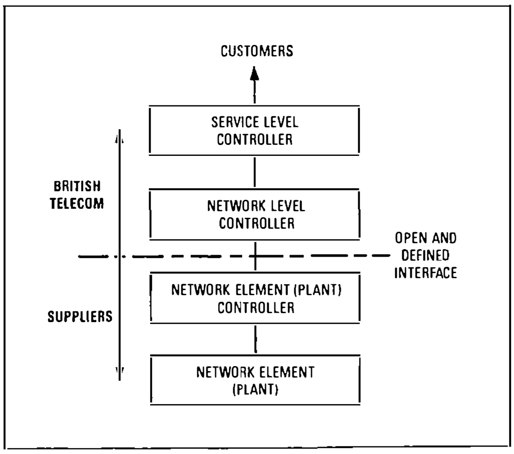


Figure 3
Generic structure for software control

At that time, flexible access systems will also be installed in other parts of London and other major cities.

CONCLUSION

This article has detailed the design features of a system for widespread implementation of optical fibres to business customers of 25-lines upwards. Implementation plans are well advanced and the first systems are in service now.

ACKNOWLEDGEMENTS

The author would like to thank the many people involved in designing and implementing flexible access systems and the General Manager, Network Systems Engineering and Technology, for permission to publish.

Biography

Ian Dufour is Head of the Access Network Evolution Division in UK Communications Headquarters. He has spent over 25 years with BT on a variety of duties concerned with network planning, cable and transmission equipment installation and computer planning-systems design. He has worked in field units as well as at Headquarters. He is now responsible for implementing plans to introduce optical fibres, together with their associated electronics and software systems, into the local network.

Passive Fibre Local Loop for Telephony with Broadband Upgrade

K. A. OAKLEY†, C. G. TAYLOR†, and J. R. STERN*

UDC 621.391.63 : 621.395.3

British Telecom is already taking fibre direct to major business customers using its flexible access systems [1]. BT has now identified a potentially economic method to serve smaller business customers (say less than 20 lines) and eventually the residential market via an all-fibre access network.

The target is to provide a fibre network justified economically solely on the basis of known services such as telephony, whilst laying down a fibre infrastructure that can support a wide range of new services from telemetry to cable television and broadband ISDN (B-ISDN).

The solution lies in sharing one single-mode feeder fibre from the exchange over several customers' premises by using a number of passive optical splitters in the street network. Time-division multiple-access (TDMA) is used initially on one wavelength to support telephony whilst other wavelengths are used later to support future service upgrade including broadband.

INTRODUCTION

Existing Approaches

Several administrations are studying fibre network architecture [2]. Most existing approaches to an all-fibre network have featured an active star approach with one or two fibres to each customer's premises either direct from the exchange or from a remote electronics (RE) site. Studies within BT have revealed a number of problems with this approach:

- Significant broadband penetration is needed for economic justification.
- The cost per line for telephony is considerably higher than via copper.
- The initial fixed costs are high.
- Space requirements at the exchange or RE site are large.
- The fibre-per-premises approach is inflexible and has many of the forecasting problems of the copper network.

The Passive Approach

BT studies show that a network based on passive splitters using time-division multiple-access (TDMA) provides a solution to each of the above problems. Whilst the initial technology is more complex and challenging, the rewards are a significantly more economical and practical network architecture for telephony that can flexibly accommodate future services.

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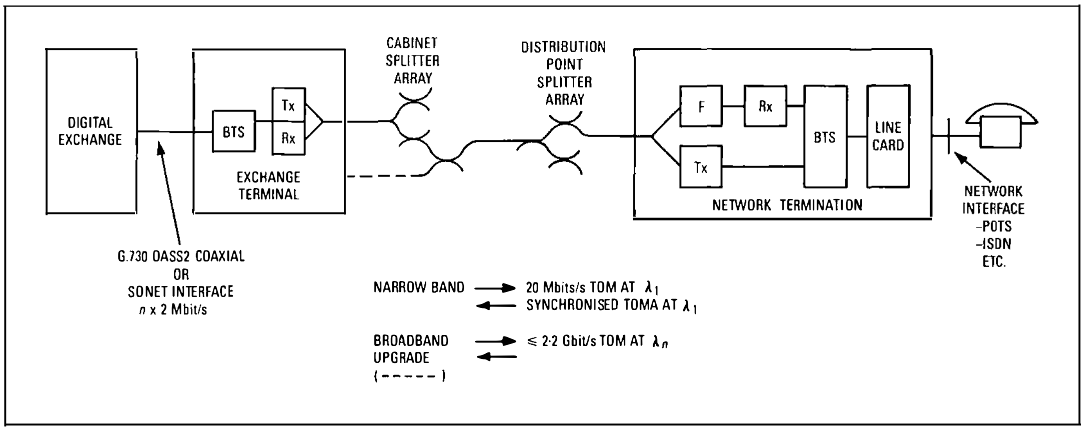
TDM versus WDM

Comparative studies [3] have shown that time-division multiplexing (TDM) is the better option for conventional narrowband services. There are economic benefits in sharing one easily managed exchange transmitter and receiver between many customers, there is flexibility on the amount of capacity available to each customer, and spare bits in the TDM structure can offer maintenance features. TDM can also be implemented earlier, before low-cost distributed feedback (DFB) lasers are available. With a suitable wavelength allocation plan, the full capacity potential of wavelength-division multiplexing (WDM) can be reserved for future broadband upgrades. BT has considerable experience with the TDMA approach used on multipoint radio systems.

TPON TECHNOLOGY

Figure 1 illustrates the telephony on passive optical network (TPON) system. A single-mode fibre is fed from the exchange terminal (ET) and fanned out via passive optical splitters at the cabinet and distribution point (DP) positions to feed a number of individual customers. Each customer receives a fibre from a DP and, via this, a TDM signal broadcast from the exchange. The network termination (NT) accesses the particular time-slots of the TDM intended for that destination plus any associated signalling channels. Line cards provide the detailed services required by the customer; for example, analogue telephony or ISDN services. The NT transmits back to the exchange using TDMA in a low-duty-cycle mode with the converging traffic streams passively interleaving at the DP and cabinet branching points. The NT is synchronised to the



BTS: Bit transport system F: Optical bandpass filter Tx: Transmitter Rx: Receiver

Figure 1
TPON

exchange clock and a ranging protocol is used to set a digital delay line in the NT to ensure that the bursts of data arrive in the correct time sequence at the exchange receiver. The ranging protocol can accommodate customers anywhere from 0–20 km from the exchange on the same system, although current optical power budgets restrict the range to 10 km.

The current system design views favour an optical split of up to 128 ways and a transmission rate of 20 Mbit/s. This is comfortably within the range of low-cost low-power consumption CMOS and allows the provision of a 144 kbit/s ISDN line or equivalent capacity to each customer.

The exchange-to-customer direction is allocated a narrow bandwidth centred on 1300 nm to allow maximum capacity in that direction for future services. The mean output power is about 1 mW. This requires a DFB laser at the exchange end, but its cost is shared and therefore small. The customer's receiver requires an optical filter, but this can be added at very low cost. The customer-to-exchange direction is allocated a wider bandwidth centred on 1300 nm to allow the use of a low-cost Fabry Perot laser at the customer end.

Comparative studies are continuing between duplex and simplex fibre working. There are significant trade offs between power budgets, costs, and operational issues. A duplex single fibre solution is preferred even if necessary at the cost of a lower split than 128 way.

Diverse routing can be economically provided by picking up unused exchange side outlets at the cabinet splitter and running these to stand-by opto-electronics at the ET.

Optical Splitters

The development of low-excess-loss optical splitter arrays at an acceptable price is a critical requirement. Wavelength-flattened devices are essential in order to allow broadband evolution via WDM techniques. Considerable progress has been achieved in recent years via the fused coupler approach. Splitters with wavelength-flattened 2 × 2 devices are now becoming commercially available at low excess losses. Feasibility studies within BT have made considerable progress towards high-yield wavelength-flattened coupler arrays.

Opto-Electronic Technology

The development of low-cost optical transmitters and receivers, particularly for the NT equipment, is crucial to network economics. It is envisaged that the NT transmitter, receiver, optical filter and coupler, together with the drive electronics and TDMA electronics, could be packaged in one low-cost module. To further reduce cost and improve reliability, the module could be supplied pre-fitted with a 200 m blown fibre [4] tail without an optical connector.

The cost of the NT transmitter may be further reduced because it operates in a low-duty-cycle mode thus obviating the need for temperature control. A monitor photodiode is not required because the transmitter power is adjusted via a downstream telemetry path from the exchange.

Bit Transport System

A key feature of TPON is the bit transport system (BTS) which accesses a number of 64 kbit/s channels from the exchange (in the form of 8 × 2 Mbit/s Digital Access Signalling System No. 2 (DASS2) coaxial interfaces or in the future via Sonet interfaces) and converts them to a 20 Mbit/s TDMA signal on the fibre and back to individual 64 kbit/s channels at the customers' end.

The proposed frame structure in the exchange-to-customer direction comprises 82 basic frames of which two are used for multiframe alignment, and the balance to support 2304 8 kbit/s traffic channels and 128 8 kbit/s housekeeping channels, together with other bits for fibre identification and maintenance. One housekeeping channel is allocated to each customer outlet and is used to convey traffic time-slot-assignment information from the exchange end together with ranging, transmit level and status information. The 8 kbit/s traffic channels can be flexibly assigned to a customer outlet; for example,

18 × 8 kbit/s for a 2B+D 144 kbit/s ISDN;
9 × 8 kbit/s for a CCITT format POTS† line (64 kbit/s speech, 8 kbit/s signalling);
8 × 8 kbit/s for a T1-format POTS line.

In the customer-to-exchange direction, the 8 kbit/s traffic and housekeeping channels are transmitted by the customer end as sporadic single bits. To accommodate varying line losses and propagation times, the bursts are synchronised by using a delay line timed from the downstream signal and set continuously by the exchange end over the downstream housekeeping channel. When a NT is initially installed, a ranging pulse is sent to the exchange in a silent period in the upstream frame structure which corresponds to the frame period allocated to multiframe alignment in the downstream. The exchange unit calculates the timing constant from this ranging pulse. Minor corrections, for example, for temperature shift, can be calculated and sent during normal traffic usage.

The BTS electronics can be realised in one VLSI circuit, and thus the cost of the TDMA approach is minimised.

Security

A perceived worry for any users of a broadcast system such as TPON is privacy. The standard system includes the following features:

- There is no physical access either optical or electronic to the 20 Mbit/s BTS signal.
- A secure authentication message interchange between NT and ET based on unique identity codes prevents NT emulation.
- The exchange end BTS detects tapping devices connected to the network.
- There is a very complex 20 Mbit/s frame structure.

These features ensure that the privacy of TPON is considerably higher than the copper network, which can be simply tapped by any easily modified telephone bought at a local shop. They are intrinsic to TPON and add no significant extra cost. For modest extra cost, security can be improved still further by using various forms of encryption.

With the right precautions, security is an attribute of the system not a weakness.

Practical Demonstration

Two early test systems, one built from commercial PMUXs and one from a multipoint radio system have demonstrated the feasibility of the approach [5]. A further demonstrator which actually utilises the 128-way split 20 Mbit/s BTS frame structure has now been built at British Telecom Research Laboratories (BTRL). It is being used to explore both the technical and operational support issues raised by such a network.

† POTS—'Plain old telephone service'

TPON OPERATIONAL ISSUES

The design of a major new access network infrastructure is an opportunity to address many of the operational issues that have plagued the copper network for years.

Planning Features

Telcos need to cope with growth that is often of an infill nature rather than in large greenfield areas, and with the replacement of pockets of the existing copper network that have high maintenance costs. This situation calls for a fibre technology that has a low fixed infrastructure cost with most costs associated with actual take up of service. A passive-splitter-based network, with its lean use of fibres and flexibility to meet service need at any outlet without running new cables back to the exchange, fits this approach very well. For a business customer with four POTS lines, only 25% of the total capital cost of about $500 US per line is associated with up-front risk money spent on the exchange end and fibre infrastructure. The balance is split equally between each fibre outlet and each POTS line provided.

The use of blown fibre [4], particularly in the distribution network, presents another opportunity to fine tune expenditure. The time-consuming work of laying the low-cost empty microduct can be done as an initial risk investment and the fibre itself can be quickly blown in when demand arises.

The basic fibre infrastructure can support a wide variety of remote terminals. Three broad types have been identified:

- *Business TPON* 4–30-line unit mounted in a customer's premises.
- *House TPON* a 1–2-line unit mounted in a customer's residence.
- *Street TPON* a pedestal-, wall-, pole- or underground-sited unit at the distribution point leaving 15–30 subscribers to be served via conventional copper drops into the premises.

Field Practices

Today's copper networks suffer high maintenance costs, much of which can be attributed to the loose linkage between the network itself and the records which describe it, the job given to a field technician, what he/she actually does and what is finally recorded back on the records. The copper network also has limited self-monitoring facilities.

The TPON system is intricate and probably unmaintainable without high technology tools. However, analysis has shown that the capital cost of those tools once developed is low and they can be built into the network design. Up-to-date information on network topology is built into the BTS: losses, distances, fibre fault positioning and status of subscribers' terminals. By using a fibre clip-on test set, which is itself positioned and identified to the exchange control centre, a technician can be given work electronically straight from the system's control records, the work done can be monitored, the technician has access to sophisticated test facilities including fibre identification and finally the work is attributed to him/her for future quality checks. There is thus considerable potential for accurate dependable records, time saved locating faults, quality and responsible workmanship.

Regulatory Aspects

Fibre to customer premises raises a number of regulatory issues. Firstly, the customer must provide local power and the provision of battery stand-by by the Telco is a key cost and space issue. BT is currently providing a 10 hour stand-by on its systems to major businesses. Secondly, is the question of where the network boundary with the customer is positioned. Most of the maintenance and security features of any fibre network are lost if the terminal equipment is not provided as part of the network. The network boundary must therefore be the service interface (for example, POTS 2-wire pair) output from the network terminal.

BROADBAND UPGRADE—BPON

The passive fibre infrastructure laid down for telephony must be flexibly upgradeable to provide future broadband services such as cable television, high-definition television (HDTV) and broadband ISDN (B-ISDN). There are a number of options for a broadband passive optical network (BPON) depending on factors such as broadcast versus switched services, codec bit rate, number of wavelengths available, maximum economic bit rate etc.

Early Cable TV Upgrades

A simple TDM option for 32 TV channels could use a single bit PCM codec to encode each PAL TV signal at 70 Mbit/s. An experimental system has been built using novel techniques [6] which involve scrambling each channel with a unique pseudo-random code sequence. Such a system minimises the amount of NT circuitry that operates at the TDM bit rate of 2·2 Gbit/s and allows most of it to operate at the channel bit rate of 70 Mbit/s thus considerably reducing cost. The 2·2 Gbit/s bandwidth imposes a power budget which limits the split to 32 way. The existing fibre network must therefore be augmented by adding more feeder fibres and connecting them into the existing cabinet splitter (shown dashed in Figure 1).

The 32 channels broadcast to the customer give a similar service mix to that provided on VHF coaxial systems in the UK. Lower-bit-rate codecs are being researched throughout the world, and, when 34 Mbit/s codecs become available, the system could have 64-channel capability, or two channels per home could be provided for switched BPON (see below).

These techniques could offer costs competitive with industry-standard coaxial tree-and-branch Cable TV networks.

Switched BPON

Instead of allowing all customers to receive all channels (broadcast BPON), each of the 32 customers on the BPON split could be allocated a particular channel, which then acts as a transport pipe from a head-end switch to the customer's premises. The customer controls a head-end video switch by means of the TPON signalling system, which then gives access to any number of video sources, including a video library service. Perhaps the most flexible arrangement would be to reserve some channels for the broadcasting of the most popular TV channels, and to use the rest to access the head-end video switch for minority channels.

The availability of inexpensive WDM devices and DFB lasers will, in the future, enable either the number of channels broadcast to be further increased, or give each customer access to two or more switched channels. Work in this area is reported in Reference 7.

B-ISDN and ATM

TPON and BPON provide an early-entry strategy for the provision of fibre in the local loop based on existing services. B-ISDN will come along in the future, capable of carrying any services, but having high-speed two-way capability.

In the longer term, with the availability of WDM devices, BPON will be able to carry 16 or 32 separate wavelengths, one for each customer requiring B-ISDN. Another, possibly more cost-effective method, would be to apply asynchronous transfer mode (ATM) techniques to a two-way 150 Mbit/s or 600 Mbit/s system shared by 32 customers using TPON-like ranging mechanisms. This ATM system could be carried on the passive network on a separate wavelength, and interface to customers' B-ISDN equipment via a user-to-network interface (UNI). Such a system would have more than sufficient capacity for telephony, video-telephony, video-conference or high-speed data transmission for the residential or small business customers and provide compatibility with B-ISDN.

Wavelength Plan

With a sensible wavelength allocation plan, none of the above services need be mutually exclusive. Any mix of the above services can be supported on the same fibre infrastructure. Thus, as a customer requests new service 'x', the simple addition of a new NT on his/her premises and addition of a new DFB laser at the head-end gives the customer a new service at low start-up cost. This could well be the key to the introduction of new broadband services, which can thus be marketed without significant up-front capital investment by the system operator.

CONCLUSION

TPON and BPON represent an interesting early opportunity to deploy an all-fibre network economic for telephony only that also resolves many of the operational problems of the copper network. At the same time, it lays down an infrastructure that allows Telcos to compete aggressively in future new broadband markets.

It is, therefore, a key component of an entry strategy for fibre in the local loop which will enable Telcos economically to make the transition from the telephony world of copper pairs to new broadband fibre.

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Biographies

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Granville Taylor heads a companion section in UKC Network Headquarters concerned with the technology for providing cable TV services via fibre. He is UKC project manager for BPON research at BTRL, Martlesham Heath.

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Blown Fibre Experience in the Local Loop

M. H.HOWARD†

UDC 621.391.63 : 621.395.3

British Telecom is embarking on an installation programme to directly 'fibre' its major business customers. In the years ahead, this will be extended to serve smaller business customers with the ultimate aim of an 'all fibre' network encompassing the residential market also.

In support of this activity, blown fibre has been introduced as a radically new way of installing optical fibres into the local loop. Blown fibre, as the name suggests, is a technique for installing optical fibre by 'blowing' using compressed air into a pre-installed network of small-bore tubing.

A brief review of single-mode fibre performance and effects of the cabling process is followed by a description of blown fibre.

INTRODUCTION

As the benefits of the rapid advances in technology, in particular optical transmission, are pushed closer to the customer, it is of particular importance that great attention is given to the optical-fibre infrastructure necessary to support not only current but future transmission systems.

The local loop, more familiarly being termed the *access network*, poses particular operational problems as opposed to the long-distance trunk network.

Currently, within British Telecom, as elsewhere, the local loop is predominantly copper, having being deliberately planned and constructed, over a period of 100 years, in a piecemeal fashion. That is, the rate of growth has been determined by economic planning rules.

The net result is a physical network in a constant state of evolution and growth. A sad consequence of this activity is the poor performance perceived by the customer as a result of all this 'working party activity'.

Hence a major feature of an access network optical-fibre infrastructure must be that it is enduring both in terms of current required optical performance and perceived future needs.

Clearly, the wholesale replacement of a fibre network to take advantage of new technology is neither desirable nor economic.

FIBRE PERFORMANCE

Current silica-based optical fibres can be made with losses approaching intrinsic limits over a wide wavelength range. Figure 1 shows the spectral attenuation of a typical single-mode optical fibre.

Two major mechanisms are apparent:

- Rayleigh scattering (from fluctuations in the material smaller than the wavelength under consideration) leads to a loss edge at low wavelength.
- Infra-red absorption from bonds in the silica leads to a loss edge at high wavelength.

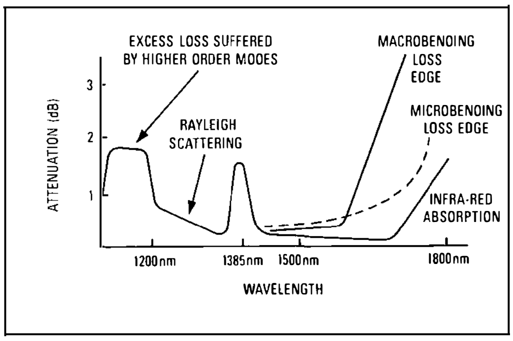

Figure 1
Spectral attenuation of a typical single-mode optical fibre

Between the two edges, peaks due to residual water (OH ions) in the silica are the major non-intrinsic loss contributor. The result of these mechanisms is to leave two major low-loss 'windows' centred on 1300 nm and 1550 nm wavelengths. Typical production losses at these wavelengths would be 0·3 dB/km and 0·2 dB/km respectively, with useful windows of 1275–1325 nm and 1475–1575 nm.

The majority of systems currently operate in the 1300 nm window region, where relatively low-cost lasers are readily available. It is clear, however, that the availability of low-cost narrow-linewidth lasers (for example, DFB lasers) operating in the 1550 nm window make wavelength-division multiplexing an increasingly attractive proposition. This being the case, the importance of preserving optical performance, from manufacture, through cabling to installation in the ground, is a major consideration.

OPTICAL-FIBRE CABLE

The structure of the optical-fibre cable is designed to protect the fibres from tensile and radial stresses, provide adequate bend performance during and after installation and

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give environmental protection to the fibres over their design lifetime.

The major factors affecting the optical performance once the cable has been laid are:

- macrobending and microbending loss,
- hydrogen absorption loss, and
- stress corrosion.

These are generated in service owing to interaction of fibre stress with moisture and other contaminants, cable materials and environmental temperature variations.

Macrobending and Microbending Loss

These are two distinct loss mechanisms affecting fibre performance in cables. In both cases, the optical signal couples out of the fibre and this results in a transmission loss. Macrobending loss occurs when a fibre is progressively bent in a pure bend configuration. Microbending loss occurs when small periodic perturbations are introduced into the fibre. Both loss modes can be generated at any stage during cable manufacture, the cable installation process, or during service owing to environmental effects.

Hydrogen Absorption Loss

The effect of hydrogen on optical fibres has been known to cable designers for some time. The presence of hydrogen is known to cause excessive optical loss. The source of this hydrogen is believed to be generated from certain fibre coatings and from electrolytic action of the metallic parts of the cable in the presence of moisture. In practice, this effect is small for single-mode fibre.

Stress Corrosion

Stress corrosion is a mechanism whereby molecular bonds at a fibre surface flaw, under the action of stress and moisture, will grow and eventually fail, and lead to fibre failure.

The aforementioned loss or failure modes are by no means all that the cable designer and manufacturer have to take into account. They should, however, give an indication of the complexity of cable design and therefore cost.

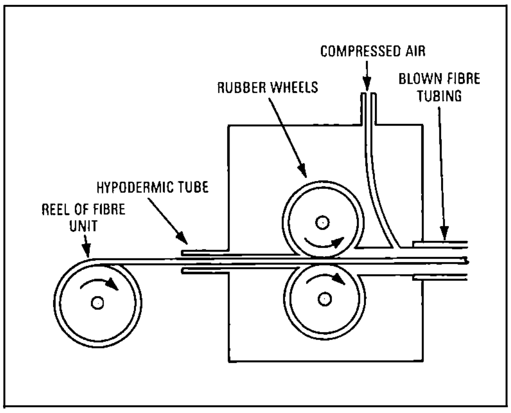


Figure 2
Blowing head

BLOWN FIBRE

In 1983, a paper [1] was presented at the 32nd International Wire and Cable Symposium describing a technique called *blown fibre.* At that time, it was very much a research and development project at British Telecom Research Laboratories, Martlesham Heath. This technique is now currently in use in British Telecom's access network.

The principle of blown fibre is that a composite unit of optical fibre is installed into a small-bore tube by the viscous flow of air.

The essential components of the system are three-fold: microduct, fibre unit and blowing head.

Microduct

The microduct is a small diameter tube, currently 6 mm bore, extruded from low-density polyethylene specially doped to provide a low-friction static-free bore. Several of the tubes are bundled together (current sizes are 2, 4, and 7) and given an overall sheath of polyethylene for use externally or PVC for use when fire resistance is required, as in buildings. The sheath incorporates an aluminium foil, not as a moisture barrier but to facilitate stripping of the sheath from the microduct bundle, and, as in the case of conventional optical-fibre cable, to act as a heat-sink when shrinkdown closures are used.

Tube bundles are pulled into ducts using conventional cabling techniques, but of course are far easier to handle and manipulate than cable. The individual micro-duct tubes are joined together very simply with readily available push-on fittings, to provide a continuous leak-free path. Individual tubes can be extracted from the bundle as required to provide a customer feed.

Fibre Unit

The second component is the fibre unit. Various unit sizes are being developed, the most widely used currently being of 4 fibres. The four individually coloured and buffered fibres are held in a symmetrical unit, together with a ripcord to aid stripping, with a coating of foamed polyethylene. The unit has an overall diameter of 2 mm and weighs 2 g/m.

Blowing Head

The final component is the blowing head, which can best be described by reference to Figure 2. The fibre unit is fed into the blowing head via the hypodermic tube and is then taken up by the rubber drive wheels. The rubber wheels are driven under a constant torque just high enough to overcome the effect of the pressure drop along the air-sealing hypodermic tube, and to feed the fibre unit off the drum.

As the fibre unit enters the microduct tube, it comes under the influence of the air-flow from the compressed-air source. The fibre unit is carried along by aerodynamic drag and hydrostatic forces distributed along the whole of its length as it travels through the microduct. Rates of 0·5m/s are typical.

BLOWING DISTANCES

The maximum length that can be cabled with a single head is directly related to tube friction, tube and fibre unit diameter, system operating pressure and, to a lesser extent, the number of bends in the route. Theoretically-derived relationships between these parameters supported by practical experiment led to a planning limit being imposed of 600 m at a maximum pressure of 150 psi in the 6 mm bore tube. There are, in fact, many situations where 1000 m is achievable (generally substantially straight runs) but applying a planning limit of 600 m caters for all practical field environments.

ADVANTAGES

Perhaps the most novel feature of the blown fibre technique is the packaging of fibres into a rugged but extremely light bundle (2 g/m) and then distributing the installation forces along its total length.

The resultant strain imposed on the fibres upon installation is negligible. The virtual elimination of fibre strain as a result of the installation technique obviates the requirement for a strength member (generally metallic) or the need to exclude moisture (usually achieved by metallic moisture barrier).

Removing the need for metallic elements eliminates the major contributor to hydrogen generation, and hence significantly reduces any remaining concern over hydrogen absorption loss.

Design and careful selection of materials greatly reduces the effects of microbending and macrobending in the fibre unit.

A significant advantage of blown fibre is the ability to defer fibre provision. Whilst the inexpensive microduct tubing can be installed at an early stage, the fibre itself need only be installed when required.

EXTENDING BLOW LENGTHS

No sooner had the problems of consistent blowing over 600 m been solved than techniques were investigated to extend the use of blown fibre in the access network. Currently three methods have been devised [2]:

Method I—Mid-Point Blowing

Quite simply, in this method, the equipment is placed somewhere near the centre of the route to be installed and the fibre unit is blown first in one direction and, by inverting the fibre dispenser, the remainder is blown in the other direction, to give a consistent end-to-end planning limit of 1200 m.

In order to achieve this, it is necessary to store the fibre torsionally in a pan, with one twist per turn built in. In this way, fibre unit can be dispensed from both ends of the pan as necessary without rotation of the pan, the in-built torsion falling out during the dispensing process. This technique is used further in method III.

Method II—Tandem Blowing

The second method is called *tandem blowing*, and, as the name suggests, consists of inserting another blowing head some 600 m along the route. With single-head blowing, the operator must observe and adjust the installation rate to ensure that the fibre unit is not forced into the microduct tube causing undesirable buckling.

The tandem blowing process has been automated to avoid the need for operator coordination. This is achieved by the use of a fibre-unit 'buckle detector' either side of each blowing head. The 'detector' incorporates an optical detector to sense the relative position of the fibre unit within the microduct tube and, as part of a feedback loop, controls the installation speed at each blowing position.

In theory, there is no limit to the number of blowing heads that can be placed in series.

Method III—End-Loop Feeding

The third method is by a technique called *end-loop feeding* (ELF). It is based on single-head installation and relies on the ability to rewind excess fibre at the end of a 600 m blow, and blow a further 600 m distance, if necessary rewinding yet again for further blowing. The ELF machine contains a rotating arm device which loads constant-diameter loops of fibre unit into toroidal pans. As the fibre unit is coiled in the pans, torsion is stored in each loop whose notional centre is incremented eccentrically around the pan centre, creating a rosetted format. This enables fibre unit to be pulled from the stationary pan without tangles or lifted turns.

OPTICAL PERFORMANCE

Most of the trials of blown fibre were carried out in the city of Leeds. Initial trials were based on multimode fibre units, but in 1986 British Telecom standardised on single-mode fibre for its access network.

Measurements of optical performance were made on the fibre units before and after installation. The comparisons are shown in Figures 3 and 4 for a sample of seven fibres at 1300 nm and 1500 nm. The route length of fibres was 3·2 km.

It can be seen from these results that the blowing technique does not adversely affect fibre performance. These same routes were revisited 9 months after the original installation and demonstrated no discernible increase in loss.

Figure 3
Fibre performance at 1300 nm

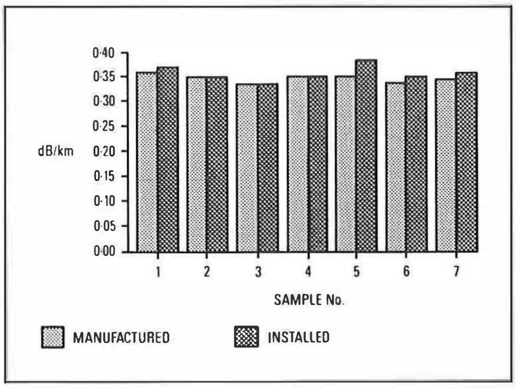
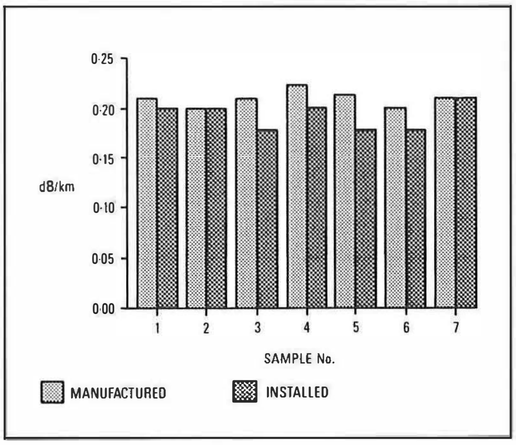


Figure 4
Fibre performance at 1550 nm



NETWORK VISION

It is clear that blown fibre as a technique, used in concert with other more conventional fibring methods, has a significant role to play.

Currently within British Telecom, the access network being planned consists of a number of different cable types ranging from 96 fibre external cable through the fibre count range to 4 fibre internal cable designs (or even blown fibre bundle). A typical route might involve four or more cables all requiring splicing activity. Regardless of the splicing technique employed, be it fusion, mechanical, elastomeric or connector, the same degree of precise fibre preparation is required implying costly and time-consuming operations. It is likely that splicing losses will approach or exceed that of the fibre itself. In addition, some splicing techniques will introduce reflection points into the network. These may prevent the use of the fibre for future bi-directional working or coherent transmission, both processes being sensitive to a level of back reflection. Clearly, it is worth reducing the number of splices.

Given that the processes outlined for extended blow length could achieve the whole of the access route, the vision of central office-to-customer links becomes a possibility.

A network could be constructed of blown fibre tubing interconnected by using simple pressure connectors. It could extend from the central office equipment room directly into the customers' premises. This network can of course be planned and installed well in advance of requirement using the simplest cheapest components. Optical-fibre provision is then installed, almost on demand, from central office to customer without intermediate splicing. Not only has the optical performance of the fibre been preserved, but intermediate splicing degradations have been eliminated.

Whilst not having been studied in detail, it is clear that the ability to defer fibre provision, coupled with cost savings associated with the elimination of splicing, splice housings etc., is an attractive economic package.

CONCLUSIONS

All networks, based upon optical fibre as the transmission medium, must comprehend future transmission performance requirements to avoid wholesale replacement of a significant investment.

The blown-fibre technique has demonstrated how single-mode optical fibre can be installed and its optical performance preserved. Within British Telecom, blown fibre has been used to provide an optical network at Heathrow Airport, is being installed in the City Fibre Network, and is planned for installation in the dockland development areas of London.

Further developments of blown fibre will be aimed at achieving the vision of spliceless networks.

ACKNOWLEDGEMENTS

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Biography

Mike Howard is currently a Section Head responsible for access network operations within Network Systems Engineering Department, British Telecom UK Communications. He joined the, then, GPO in August 1959 as a Youth-in-Training and for much of his early career was involved in the development of carrier systems for use in the local network. He became one of the founder members of BT's cable TV development group involving the introduction of the first system in Washington, County Durham. His current duties include responsibility for the specification and approval of optical fibre and cable for use in the core and access networks.

Human Factors—An Overview

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UDC 658.3.04

Human factors is a multi-disciplinary applied science which has relevance to all human activities in a technological world. It has contributed significantly to the usability and acceptability of many equipments and systems and is of great importance to telecommunications, in all its spheres. The article seeks to explain the concepts and basis of human factors to high-technology systems. The idea of user-centred approach to design is clearly to the fore. It is the key to success in the increasingly complex world which telecommunication researchers are helping to evolve.

This article is based on a paper first published in British Telecom Technology Journal's special issue on Human Factors.*

INTRODUCTION

The aim of this article is specifically to introduce communications specialists to an important allied field with which it is anticipated they may be unfamiliar. Some attempt at a definition would seem appropriate right from the outset. Human factors is the applied science which aims to match the demands of products, tasks, systems and environments to the physical and mental characteristics and limitations of the people who use them.

A synonymous term is ergonomics, derived from the Greek *ergon*, meaning work. In earlier days, ergonomics, which came from Europe, was seen as having a narrow meaning associated with hardware design, whereas human factors, originating in the USA, had wider connotations, from good equipment practice, through man and his working environment, to more psychological concepts of motivation and job satisfaction. It is interesting to note that, of late, much American literature now refers to ergonomics, rather than to human factors.

When the pace of technological change was more leisurely and the impact of the change in the design of a familiar tool or way of working was limited to a small part of the population or a restricted geographical area, there was no need for a scientific discipline such as human factors. In keeping with a very fundamental law, when a need is identified, there are those who seek to fill it. Thus, human factors specialists are being trained to meet the increasing needs presented by the rapidly developing technological age in which we find ourselves.

Fundamental to the understanding of human factors, and a prerequisite for its acceptance, is the acknowledgement that no matter how brilliant the technical concept and execution of a system, it is doomed to failure if the users for whom it is intended cannot or will not use it. Thus, the needs and abilities of the user must be understood, and must be allowed to influence the design, however much this may compromise an elegant technical solution or incur short-term financial penalties.

HUMAN FACTORS CONCEPTS

Communication is a fundamental need of all but a very few and is the 'reason for', or 'means by which', of practically every human activity. The development of communications between people, from the earliest constraints of limited travel to the present electronic age, where distance at least is no obstacle, has been the subject of much study, particularly as a social science. Not only has distance been conquered, but the nature of the information itself has expanded enormously. One has only to consider the transmission of vast amounts of data to and from, or between computers to appreciate this.

The introduction of a transmission medium between respondents, be it some form of transport or a telecommunications system (to name but two), produces an intriguing balance between gains and losses. On the credit side there is the saving of time and/or increase in range and there can be an increase in the amount of information per unit time transmitted. Against this must be set loss of visual image (in some systems), lack of privacy, and a degree of impersonality. Also, all systems need some form of access and control which can represent a further disadvantage even before the transfer of information is considered.

There have been extensive studies of the relationships between travel and telecommunications, detailing the gains and losses which can be assigned to the alternatives[1]. The human factors element in such considerations are important since there are numerous behavioural issues to be addressed. For example, it is likely that comparisons of their

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success would depend upon whether the meetings are routine and non-controversial or, possibly, contentious or confrontational. Also, many individuals enjoy a degree of travel and see it as part of their job satisfaction.

Considerations of the impact of telecommunications upon travel leads to the broader issue of energy conservation where, for example, the ability to control, as well as converse, at a distance can save considerably upon expenditure of effort. If, however, the saving is meant to be of real significance in the long term, then true account of all of the input costs must be taken. There is little point in producing a telecommunications or telemetry system which saves one man-year of operational effort if the manufacturing and maintenance effort over the life time of the system exceeds this.

Having introduced the notion of human effort as being the major expense incurred, which is probably true for all but the most ambitious undertakings (space flight?), it follows that maximising this effort is a sensible and worthwhile pursuit. This can only be achieved in the meaningful long term through the application of sound human factors principles embracing, as this does, full involvement from the outset of those persons whose effort is being maximised. In this context, monetary and other material rewards are seen as short-term methods of raising output, or whatever the goal might be, since we all operate on a system of rising expectations and it takes but a short time for the increased pay to become the 'norm', with life-style adjusted accordingly, and the old dissatisfactions creeping in again.

Industrial relations, management/union consultations, bargaining for rewards, etc., are all areas very close to the expanding boundaries of human factors. For the human factors worker, considerable satisfaction derives from the assurance that human factors knowledge is biased neither to managers nor the managed, but is rather a total statement of all the factors existing in a workplace, and that the mutual consideration of these factors will lead to maximum benefit for all. Thus, the communications specialist referred to in the opening sentence is as much the worker with human resources as with systems and equipments.

The foregoing paragraphs have shown the breadth of human factors as a concept and as a discipline impinging upon many facets of life. The same is true geographically, particularly in relationship to telecommunications, where the dedicated pursuit of technical and operational standardisation has brought about the present situation where national and geographical barriers have been effectively removed. Moreover, the growing cheapness of message storage and manipulation is bringing time constraints substantially under control.

BASIC ERGONOMICS

An understanding of the nature of the science which lies behind the application of sound human factors principles can be gained from a consideration of four main areas: basic disciplines, techniques, facilities and dissemination of findings.

Disciplines

As human factors is introduced into a new area of application, or is met for the first time by a designer, supplier, or user, it must be geared to the needs of the recipient. Thus the human factors consultant must have good interpersonal and communication skills to enable him to determine the client's needs, to explain how human factors can be of great value in meeting them and to secure agreement that the work can be carried out and the recommendations implemented. The basic disciplines involved in human factors, or ergonomics, are anatomy, physiology and psychology. The elements of anatomy of most concern are anthropometry (the dimensions of the body) (see Figure 1) and biomechanics (the application of forces), whereas physiology provides information on the functions of the body. Important contributions from psychology are skill, that is, information processing and decision making, and occupational aspects such as training, effort and individual differences. To draw a distinction from the medical or clinical, these elements are viewed from the unique standpoint of the user in his environment seeking to perform a task, and therefore constitute a discipline in their own right.

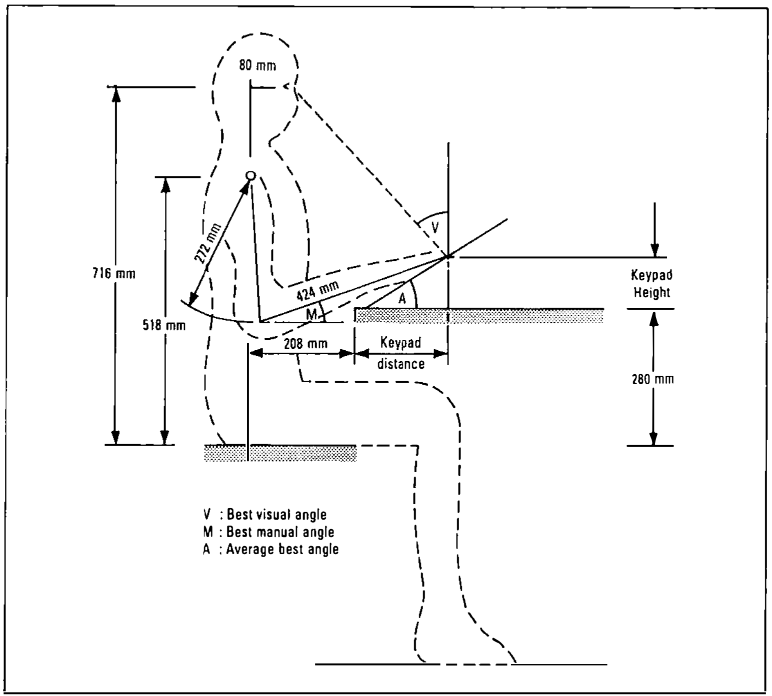

Figure 1
Examples of anthropometric measurements

Thus, human factors has wide applications, but to maximise its benefits, the practitioner must have an understanding of the equipment, system or process to which the techniques are to be applied. This demands knowledge of electrical, electronic and communications engineering and familiarity with computer systems. The latter are particularly important since they are met both as 'tools' in the study of human factors problems, and increasingly as the subjects of the study.

Consideration of the users' environment calls for the measurement and specification of lighting, heating, ambient noise levels and air flows, together with the knowledge of the effects they have upon the user and the means of environmental control.

Any study or investigation involving people can produce very dispersive results which are either meaningless or amenable to unlimited interpretation. Techniques are available both for the design of the study and the analysis of the results which go some way towards limiting the variability and facilitating the interpretation of the outcomes. The human factors practitioner must be proficient in these statistical methods.

The foregoing skills have been sufficient for most tasks to date, but there are additional requirements to meet the challenges of the information society. Principal among these is the need for a clear understanding of the nature of information, its creation, handling, storage, processing and value, and the impact which these elements have upon the user and the workplace. Management services may best describe this concept.

In an enlightened world, it becomes less acceptable to look upon the user as an important factor in a task or process, working more less mechanically in a sociological vacuum. It is becoming more readily accepted that a user is subject to many external influences, both physical and psychological, which affect attitudes, motivation and performance. A contribution from these, the social sciences, will become increasingly important.

The range of skills offered by the human factors specialist is potentially very wide, although an individual will have his or her specialisms. The sphere of operation (for example, industry, domestic, government, military) of the human factors group or consultancy will determine the optimum balance of skills.

Techniques

Human factors has existed for a sufficient time for a body of knowledge and expertise to have been built up such that proposals for a course of action to meet a particular problem can be made which, allowing flexibility for any unknown factors, will nevertheless ensure progress towards a solution. The strategy for human factors support to a project includes determination of the optimum time for entry, definition of the problems, proposals for solutions and identification of the resources which can be provided. As current problems have appeared increasingly in the realms of larger complex systems, so human factors has kept pace, progressing from design of single elements to the consideration of complete tasks. It is this 'systems' approach to thinking which characterises good human factors work. Hence professional judgement is brought to bear on the choice of techniques to achieve the solution. The range of techniques available can be ordered in terms of approximately ascending cost and complexity (Figure 2), although this, and the following paragraphs are a generalisation. Clearly, there are circumstances where field observations or trials could be more expensive or complex than controlled experiments. This is particularly true where errors, or poor design, have reached the field-trial stage because earlier controlled experiments had not been conducted.

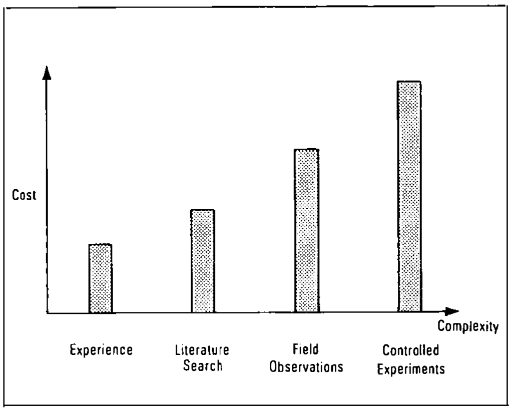

Figure 2
Relationship between cost and complexity

Past Experience

The growth of new systems is as much in terms of numbers of installations as it in increasing sophistication. Thus the same, or similar solutions may be applied to recurring problems, drawing directly upon experience from earlier exercises. For the simpler jobs, the human factors worker will know instinctively what to do, but the more complicated situations are best served through the use of check lists or guidelines. The production of such documentation demands care and expertise and must allow sufficient flexibility of use to cope with the unexpected and to leave a degree of responsibility in the hands of the user. There are, however, dangers in their use by untrained personnel.

Literature Search

This is the means by which the experience of others may be invoked to solve a particular problem. It is not unusual, particularly in the newer fields where information may be sparse, for related but not identical problems and solutions to be described. This calls for varying degrees of interpretation on the part of the human factors expert to relate the published material to the specific circumstance. Nevertheless, a comprehensive survey can provide sufficient pieces of information to be combined into a new solution.

Field Trials

The next phase is to establish what information can be obtained from a live situation. This will involve monitoring the use and performance of an equipment or system under specified conditions, perhaps with early- or pre-production equipment and/or a limited or selected user population. Care must be taken to ensure that the effects of any constraints are recognised and that the monitoring process does not influence the parameters under observation. If circumstances permit a realistic trial, then extrapolation to the normal situation should be straightforward. Similar benefits can be derived from assessments of fully-operational systems where opportunities exist for modification, or for influencing the design of future related systems. Field trials or pilot studies can also be of great value to the human factors worker in providing 'hands-on experience' in what may otherwise be a rather theoretical study.

Controlled Experimentation

Human factors experiments can be expensive and time-consuming to mount, run and analyse, yet they are the only recourse when the previous stages have failed to produce a solution. By definition, this must be the situation which obtains when new solutions are proposed or when new applications are being sought. It is through this means that the quantitative, basic data for human factors recommendations has been assembled.

A human factors experiment consists, essentially, of inviting subjects to carry out a clearly defined task under closely-controlled conditions such that the effects of varying one or a number of parameters can be established.

Figure 3
Latin Square

A	B	C	D
B	C	D	A
C	D	A	B
D	A	B	C

To conduct a rigorous and successful experiment a number of issues must be addressed.

Experimental design needs to take account of learning effects by presenting the 'conditions' to be measured in pseudo-random order to subjects. A Latin Square design is one such method, in which the conditions (A, B, C and D) are presented to subjects in the order dictated by the rows of a matrix (Figure 3). The design can be developed to accommodate additional variables, but if allowed to become too large, the experiment will be difficult to administer.

Other, more sophisticated experimental designs exist. An example is the balanced group design in which the conditions are experienced once only by a number of matched groups, the matching parameters being determined by the nature of the experiment. Also, dependent and independent variables need to be identified and controlled. Objective measures, such as errors and time to complete a task, must be chosen. Subjective opinions may be of interest and an appropriate means of collecting them must be designed.

Statistical techniques must be chosen such that results can be tested for significance. If the underlying distribution of results is known, or can be assumed, then standard measures and analyses of variance can provide statements of confidence, in terms of the probability of a chance result. Where subjective measures are concerned, for example, opinions or rankings, mathematical definition of the behaviour of measures may be difficult to determine. In these circumstances, recourse is made to non-parametric tests.

Facilities

From the foregoing it will be realised that a number of important facilities are essential for the conduct of human factors experiments. The first problem is that of finding suitable subjects. Having noted that subjects must be representative of the user population, a degree of selection is allowable yet care must be taken to avoid bias, perhaps by employing people who are over-familiar with the detailed working of a system. Equally, an over-reliance on volunteers can produce a sample population already disposed to being helpful, and capable of giving answers they believe are expected of them. Moderately persuasive recruitment of passers-by may suffice for short, one-off tests, but for longer sessions, access to a panel of subjects (generally recruited for experimental work but tasks not specified) from whom a test population is selected according to agreed criteria, is to be preferred.

To operate an effective selection process, data must be available on the total population, the user and ultimately the subjects. Anthropometric data has been a mainstay in this area, but increasingly there is a need to have knowledge of cognitive skills as well.

Naturally one needs access to the equipment or systems to be assessed together with any supporting material which is proposed for instructional, training or maintenance purposes. An evaluation of the support data may form part of the complete exercise; if not, an opportunity may arise for comment upon it. If some form of modelling or simulation of an experimental system is called for, then appropriate computer hardware and software will be needed. Computing will almost certainly feature in the statistical analysis of the raw data.

Control of the environment in which the subjects operate may demand extensive provision if factors such as temperature, noise levels, workflow between stations, are of interest. Complete test rooms may be necessary for the more comprehensive investigations.

Dissemination of Information

While statistical significance can be determined with precision, the same cannot be said of the determination of its importance, or of the relationship between the two. The short-term costs of implementing human factors recommendations can be readily calculated, yet the benefits, being essentially longer term, are difficult to demonstrate and quantify. Such benefits include job satisfaction, safety, health, productivity, reduced training, reduced labour turn-over, improved quality of work. The systematic collection of data over a period can reveal some of the benefits, but others, for example, the spirit with which tasks are undertaken, are as subjective to the observer as to the observed, yet they represent a positive contribution to the undertaking.

As human factors principles become more widely known and accepted, the concept of ease of use will become a more dominant factor. Notwithstanding the host of problems already confronting the equipment or system designer, no apology is made for insisting that the needs of the user should feature in his deliberations, either as an additional task or preferably as a new way of looking at existing tasks. Human factors should be allowed to influence all stages of the design process, with decisions being exposed to ergonomic scrutiny and being amenable to modification as necessary. The task should be fitted to the man.

Feedback, or constructive reaction, is important at all stages of a project, not least when the results are presented to the implementer or user. If an effective two-way exchange can be established, this can greatly aid the assessment of recommendations, and the measurement of 'improvements' and cost effectiveness. It is also a valuable check on the quality of the human factors work.

On a broader front, experiment findings (usually from a number of sources) may be presented as human factors recommendations for a particular type of equipment or method of working. They will include statements of what is desirable, typically a range of dimensions or a preferred order of execution, and what the penalties are for deviating from the norm. Acceptance of recommendations leads to standardisation which, if implemented sensibly, can greatly aid universal application without stifling invention. The ultimate step to international standardisation is particularly important and significant at this time.

The reader's attention is drawn to other sources[2–6] for further information on basic ergonomics/human factors.

BACKGROUND TO CURRENT HUMAN FACTORS

Technological Change

The conduct of human factors research and applications at the present time is subject to a number of significant pressures and constraints. Principal among these, particularly where the provision of telecommunications services to other professionals is concerned, is the rapid rate of technological change. Substantial powers of computation and data manipulation, storage and display are readily to hand. Cheapness and physical compactness contribute to this availability, putting huge information-handling resources literally on every desk.

The drive to use this power is irresistible, and rightly so since the potential benefits flowing from its successful management are considerable. However, unless the user interface, both physical and conceptual, is appropriate to the user population, then the power will remain unavailable to all but the few seeking an intellectual challenge. As an aside, determining the right balance between transparency and arousal is, itself, an interesting human factors issue.

Availability of High Technology

The spread of high technology products is by no means limited to the professions. Again, due to lower cost and smaller size of computing and control elements, more general office and domestic products are appearing which have facilities and features unattainable even a few years ago. These features can present genuine problems to users if, for example, the controls are too small or have complex actions or interactions. Again, displays may not be clear, legible and stable, the screen layouts may be inconsistent and navigation through a database extremely difficult.

Equally, there is a temptation to provide increasingly complex services through simple terminals, giving rise to unnatural dialogues between user and machine, using unfamiliar and irrational protocols.

As the population of users expands, the majority are likely to be naive and unsophisticated. This is meant in the kindest sense; that is, they lack necessary skill and experience in a particular domain or application. Moreover, an individual user can be skilled in some ways and naive in others. This is likely to be so where there is a lack of transfer or even negative transfer between equipments and services which exhibit dissimilar behaviour when performing similar functions.

British Telecom, itself, is a provider of high technology 'goods' to an ever-widening audience. Their ready acceptance by the mass-users is heavily dependent upon the incorporation of sound human factors principles in their design.

Introduction of High Technology

The study of working conditions has taken much time and effort over recent decades. Some of the findings, for example, those attributable to Herzberg, have become well-known outside work-study, occupational health and human factors circles. Herzberg[7] proposed a two-factor theory of motivation and job satisfaction. One set of factors are those, known as hygiene factors, which, if absent, cause dissatisfaction. The others are related to the content of the work itself and which, if present, motivate the individual to better performance.

The corollary to the understanding of what motivates workers is to realise what discourages them. Case histories abound concerning poor work practices which have demotivated staff. The present situation is exacerbated not so much by change, which, after all, is always with us, but rather by the rate of change which modern technology makes possible. To describe some of the more extreme effects as alienation is not to overstate the case.

The introduction of high technology can change the whole social structure within an organisation. Highly skilled and widely experienced staff can find that their unique contribution has been taken over by, for example, a computer-based system needing a different set of skills to operate, and for which they are ill-prepared. Without appropriate re-training such staff quickly become down-graded, breeding resentment and unrest.

User Expectations

For a variety of reasons, users tend to expect more from telecommunications and other high-technology systems. For example, press and television stress leading-edge achievements without due regard for the problems associated with their introduction on a large scale. Also, users observe developments at their place of work and in other professions whereby they anticipate the availability of more advanced equipments and services. If they have the opportunity to become very familiar with a particular facility, users see its limitations and, again, expect that a new version will become available with improved performance.

Against these expectations, users' abilities are comparatively static, at least within the timescales considered here. Physical abilities such as strength, size, dexterity and endurance are substantially unchanged, but it could be argued that there is an improvement in cognitive capability. This results from continuing education and training and an increasing familiarity with the domain of computers and multi-function terminals.

Appropriate Technology

Even within an advanced society there are abundant opportunities for the application of sound, basic human factors practices. Users still have a need to reach and manipulate controls without strain, or even injury; they need to see status indicators and displays without discomfort; they need suitable environments in terms of lighting, heating, ventilation and decor. There will always be demand for these unspectacular, appropriate solutions.

HUMAN FACTORS IN BRITISH TELECOM

Early Developments

In common with the development of human factors as a recognisable discipline, human factors in British Telecom has grown steadily over the years. However, it should be noted that specialised and circumscribed forms of human factors studies have been conducted over a long period in telecommunications administrations, without necessarily attracting the description 'human factors'. Examples of this are the subjective assessment of telephone speech links, as described by Richards[8] and the determination of user tolerance of impairment occurring with television transmission[9].

Within the field of telephony, there was, in the 1950s, a steady move away from operator-controlled services towards a more automated telephone system. Thus, more and more people (customers and staff) were required to interact with a 'machine' rather than another person, giving rise to one of the earliest, mass man–machine interfaces in telecommunications. Recognition of this important development and the realisation that new and urgent problems needed solutions were the spurs to the establishment of human factors units in telephone administrations.

From the mid-1960s, there was increasing activity in BT directed towards upgrading all the customers' equipment with the twin aims of improving further the quality of service to the customer and providing the customer with an enhanced range of facilities. The need to maintain BT's position as a front runner in the telecommunications world (that is, responding positively to increasing demands from the home market and aiding the British telecommunications industry with their exports) was a further element in this quickening pace of change.

A major decision at this time was to introduce press-button telephones, to replace the dial version which had served for many years. This one change had a significant effect on the direction of human factors research in BT. It heralded the commencement of an important series of studies aimed at determining, for example, the relative performances of keypad telephones versus dial telephones in terms of speed of operation and error rates. In addition to the straight comparison, work was also undertaken to determine optimum size and spacing of the keys and the angle of the keypad (Figure 4). This latter complemented earlier work on dial angle and was extended to determine the preferred height and angle of the keypad associated with a wall-mounted telephone. Results from these studies formed an essential contribution to international standardisation [10].

Concurrently, studies aimed at understanding the difficulties customers were having in controlling the national network were started in concert with applied psychology and services interests. Information collected from market surveys and through controlled observations highlighted those areas in need of particular attention and subsequent experimentation gave guidance on how the improvements could be achieved. Aspects which received specific attention were customers' dialling instructions, the presentation of directory and dialling-code information, the relative advantages and disadvantages between audible tones and recorded announcements, and customer education facilities.

Progressively, computerised techniques were being introduced into industry generally and there were the early signs of an 'office revolution' as well. These developments were of particular significance since they were to have a major impact on both their customers and their staff. Thus the man–machine interface took on a new importance.

Another essential development was the establishment of a public subject panel to provide a ready-pool of subjects for the experimental studies. This was in addition to the willing band of volunteers drawn from the staff of Research Department who had participated as subjects, and continue to do so, since the earliest days of subjective assessment. The need to go public was dictated by a desire to involve subjects more representative of the population at large. The public panel was drawn from the local community and attempted to embrace all identifiable groups within that community.

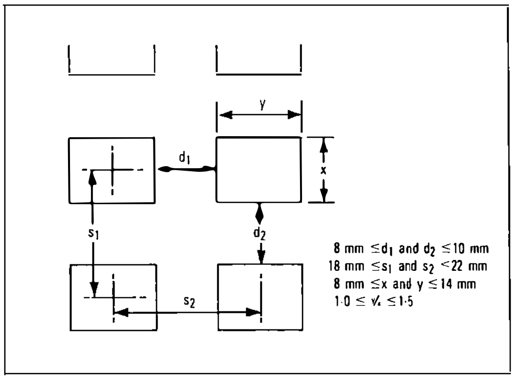

Figure 4
Button size and spacing recommendations

Work in recent years has included studies on management information and process control systems embracing terminal and equipment design (in particular visual display terminals), workstation design and environment and work-flow analysis. Man–machine language (MML), the descriptor of a group of activities which facilitate interaction with a computer system, constituted another important area of study embracing, *inter alia*, input and output modes, data editing, displays, indexing and, for viewdata systems, page location and memory aids.

Instructions, whether written, pictorial or verbal, are essential. Each has been the subject of extensive studies to determine the best methods of production and presentation to secure optimum performance and to establish their relative effectiveness for specific tasks.

Work was also beginning on 'voice' as a means of controlling both the input to, and output from computer-based systems. This involved the study of voice synthesis and recognition and the operational protocols which would ensure usability and acceptability. The move away from traditional keyboard and screen/printer arrangements was prompted, for example, by the desirability for accessing enhanced services from an ordinary telephone.

The Present Situation

Since privatisation in 1984, BT has operated as a public limited company, being subject to the terms and conditions of an operating licence issued by the Government and overseen by the Office of Telecommunications. Under these changed circumstances, BT has been faced with significantly different goals. Their attainment has demanded, in essence, a cultural change, which is itself of considerable human factors interest.

In meeting the combined challenges of reduced development life-cycle, reduced costs and increased efficiency, it is clear that any human factors intervention in the design process must be pre-planned, timely and not threatening to the critical path. Nevertheless, it is possible to pursue a user-centred approach to the design process, as evidenced in the special issue of *British Telecommunications Technology Journal* on Human Factors[11].

To derive maximum benefit from skilled staff, they need appropriate support facilities. Typical of these are advanced computer workstations, supporting high-level languages, for the development of software used in advanced user interfaces. Such workstations are also invaluable for rapid prototyping whereby the features of an interface can be demonstrated to the target user population and, more importantly, can be the source of user-feedback which is used to enhance the original design.

Specialist laboratories also have their place; two are presented as examples. A vision laboratory can provide advanced display facilities and precision measuring instruments for a range of vision research activities, leading to a better understanding of human visual processing related to, for example, colour displays. The specification of vision-based equipment, from the stand-point of user needs, is also facilitated. Typical investigations would concern colour perception, text legibility and colour deficiency. Colour perception is important where colour is used to identify items belonging to the same set or family. Items having the same 'physical' colour can appear to be of differing hue, depending upon size and background. An understanding of this process is essential.

Indiscriminate use of colour, particularly in some combinations, can adversely affect text legibility. It is necessary to develop approved colour sets which give good legibility, whilst avoiding unpleasant side effects. Also, colour deficiency can be found in about 5% of the population; that is, a significant number of customers and staff. Current work on colour deficiency has used printed matter or monochromatic light as test material, whereas emissive displays exhibit very different characteristics. Hence there is a need to develop CRT-based screening tests.

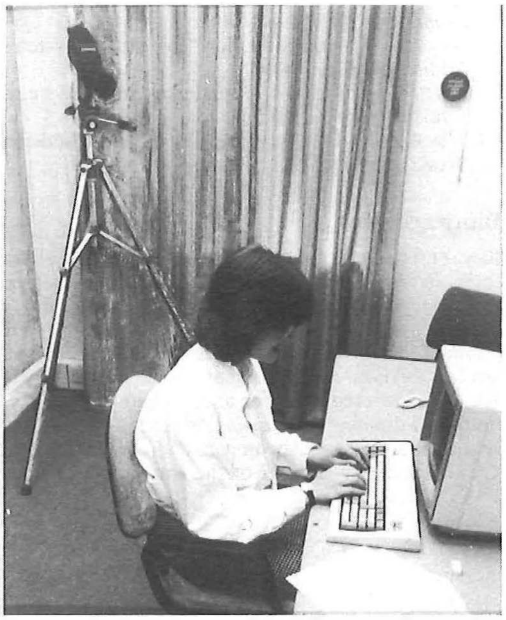

Figure 5
Observation of user performance

A usability laboratory is invaluable for the prototyping and evaluation of user interfaces. Essentially, it provides the opportunity to observe user performance in a non-intrusive way, yet yielding hard data for feedback into the design process (Figure 5). The laboratory has high-quality video recording equipment and associated control console, and a range of monitoring equipments which can be easily connected to the system or product under test. Such equipment would typically be able to make performance measures of the subjects. The laboratory also needs access to a range of prototyping tools to facilitate the simulation of user interfaces and their subsequent modification in the light of experimental data.

The telecommunications field presents increasingly complex application areas, each having significant human factors problems. Examples are: the collection, manipulation and distribution of large amounts of data; the synergy of disparate activities and functions; the operation of large organisational structures. To address these problems, recourse is necessary to more powerful methods and tools. These are used to help in the understanding of the problem; to facilitate the development of the user interfaces for interaction with the application area; to possibly be embodied in the interface itself.

Such tools are typically ascribed to the discipline of artificial intelligence (AI)[12–14]. Examples from within our natural-language program include machine translation, text summarisation, text generation and natural-language interfaces. No attempt is made to mimic human intelligence, but rather, from an understanding of it, to produce more effective user interfaces, systems and products.

An important sub-set of AI is the family of knowledge-based systems or expert systems, characterised by a set of knowledge derived from an expert in the domain, and operated upon by software developed by using high-level languages. Much work has been conducted on the usability of expert systems, including dialogue design and the nature of explanations.

The work has also examined fundamental issues such as tools and languages, knowledge acquisition and knowledge representation.

Thus, current studies seek to establish an understanding of the principles and potential of AI, to assess its capabilities and to demonstrate specific applications. It should be noted that expert systems, *per se*, have their human factors and user-interface concerns, but the thrust of our current activity is towards the use of AI and expert systems as enabling technologies in the solution of human factors problems.

THE FUTURE

In assessing the directions which human factors research and applications may take in the future it is worth considering the following non-exhaustive listing of developments which will continue to influence the evolution of telecommunications:

- convergence of telecommunications/computing/micro-electronics leading to the information society,
- rapid growth in voice control,
- impact on users of introduction of new technology,
- centralisation of control of functions, resulting from the increased use of computer-based systems and data communications,
- introduction of microprocessors into consumer goods, bringing local 'intelligence' into the control function.
- expansion of electronic mail, to encompass computer-supported co-operative work.

Experience suggests that there will be a continuing need for the application of sound human factors or ergonomics principles to a wide range of low-technology problems. Also, there will be steady demand for more natural ways of communicating with advanced systems, using natural language understanding and techniques, both speech and text. Allied to this, visual displays and graphics will be harnessed to provide broad-band information exchange between user and system.

The cognitive processes of dialogue between individuals and groups will need further study if the effective integration of user and system is to be achieved. It is from an understanding of these human attributes, that significant user-interface developments will come.

For larger groupings, the knowledge of the design, growth and development of organisations, and their reaction to change and outside forces, will be of increasing significance. Advanced technological systems constitute one of the major agents for change; their successful introduction will bring many benefits.

CONCLUSIONS

This article has presented the underlying concepts of human factors/ergonomics and explained some of the basic elements of this applied science. The background against which human factors has developed is one of increasing technological complexity and increasing expectations, presenting opportunities and challenges over a broad spectrum. The role of human factors in British Telecom has been described in some detail, showing the ways in which these challenges have been met. It should be clear, also, that there is much still to be done, even to produce usable and acceptable systems using current technology. Some future trends have been identified which will depend, equally, upon sound human factors practices for their successful development and use.

ACKNOWLEDGEMENT

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Biography

Roy Yates joined British Telecom Research Laboratories in 1952, as an apprentice. His principal career interests have been electro-acoustics, telephone set design, telephone transmission performance and human factors. He was appointed to head the Human Factors Division at BTRL upon its formation in 1979. He is a chartered engineer and a Fellow of the IEE, holding a diploma of electrical engineering from that Institution. He has just completed a four-year term as Chairman of the Council of the Ergonomics Society.

A New Generation of Signalling Converters

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This article describes a digital signalling converter, which operates at the 2 Mbit/s level, to convert CCITT No. 4 signalling to CCITT R2D‡ signalling. The signalling converters are being used by British Telecom International in order to provide a CCITT No. 4 signalling capability on one of its international gateway exchanges.

INTRODUCTION

CCITT Signalling System No. 4 (CCITT No. 4) was introduced in the late-1950s, and was specified to allow both automatic (customer direct-dialled calls) and semi-automatic (operator-dialled calls) working. The signalling system was designed for the international analogue networks of the time, and has been used widely throughout Europe over a number of years.

Although the signalling system has served the telecommunications networks of Europe well, other signalling systems have been introduced for international working. These signalling systems are, briefly:

CCITT R1
: An in-band channel-associated signalling system defined for national and international use (this system is intended for regional working and is mainly used in North America).

CCITT R2
: A channel-associated signalling system defined for regional working for both national and international use [1].

CCITT No. 5
: A channel-associated signalling system defined primarily for intercontinental international use.

CCITT No. 6
: A common-channel signalling system defined for national and international use (the signalling channel can operate over an analogue or a digital bearer).

CCITT No. 7
: A fully-digital common-channel signalling system defined for national and international use [2].

The CCITT R2 signalling system effectively superseded CCITT No. 4 for use over continental circuits within the analogue networks of Europe. However, because of the slowness of some Administrations within Europe to modernise their networks, British Telecom International (BTI) will need to interwork with a small number of CCITT No. 4 circuits for some considerable time.

As the CCITT No. 4 signalling system is obsolescent, new digital international gateway exchanges do not provide this signalling system. The cost of developing the CCITT No. 4 signalling system on a digital international exchange would not be economic, because of

- the high cost of introducing any additional signalling system onto an international exchange (a significant element of the cost is the software for interworking with the other signalling systems residing on the switch),
- the limited market for the CCITT No. 4 signalling system, and
- the opportunity cost aspects to a switch manufacturer in devoting valuable, and often limited, development resources to a signalling system with a limited penetration.

Hence, it was necessary for BTI to identify a suitable signalling converter to provide the CCITT No. 4 signalling system capability without any adaptive engineering being necessary on the parent international gateway exchange. After careful evaluation of the proprietary signalling converters available at the time, BTI chose the Delta Communications digital trunk translator (DTT). (The concept of the DTT is based upon Delta Communications T1-to-CEPT** converter. The DTT consists of a family of converters, the designation of the version chosen for BTI's application is the *C4/R2D*. Further information on

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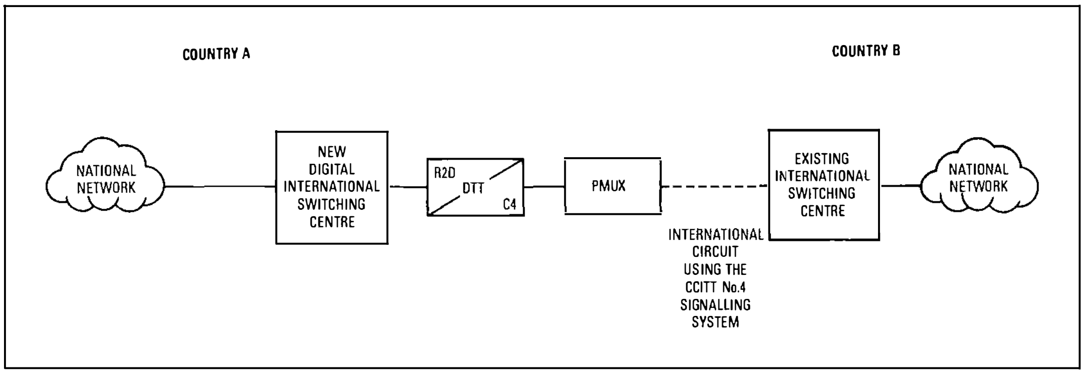
* Delta Communications plc

‡ The term *CCITT R2D* is used throughout this article to refer to the version of CCITT R2 signalling system which uses the digital line signal code described in CCITT Recommendations Q.421–Q.424, and is carried over a digital bearer. The CCITT does not use the term CCITT R2D, but it is commonly used by telecommunications engineers to describe this specific version of the signalling system. A further description of the signalling system is given in a later part of this article.

** T1—T1 Committee of the USA Exchange Standards Association
CEPT—Conference of European Postal and Telecommunications Administrations



DTT: Digital trunk translator PMUX: Primary multiplex

Figure 1 Direct digital interworking of the CCITT specified signalling systems

the other members of the DTT family is given in a later part of this article.) BTI is the first customer for the DTT signalling converter; therefore, BTI and Delta Communications have worked together closely to ensure that BTI's considerable operational experience with the CCITT No. 4 and CCITT R2 signalling systems was used to the benefit of the project.

The main attraction of the DTT to BTI was its capability to provide the translation fully digitally at the 2 Mbit/s level. Hence, digital transmission paths to the distant Administration could be used, if required, for the circuits employing CCITT No. 4 signalling, and digital-to-analogue conversion could be carried out by either primary multiplex (PMUX) or trans-multiplex (TMUX) devices (these features would not be available from signalling converters which operated at the per-channel analogue level). Figure 1 depicts a typical configuration.

OVERVIEW OF THE CCITT No. 4 AND CCITT R2D SIGNALLING SYSTEMS AND OF THE CONVERSION REQUIREMENTS

Principles of the CCITT No. 4 Signalling System

The CCITT No. 4 signalling system (which is defined in CCITT Recommendations Q.120–Q.136) is a channel-associated signalling system which employs two in-band signalling frequencies of 2040 Hz and 2400 Hz. These frequencies are used for both line signals and register signals. Line signals are produced by using these frequencies in a singular and combinatory manner as follows:

X signal	2040 Hz
Y signal	2400 Hz
P signal	2040 Hz + 2400 Hz

The line signals are sent in a non-compelled pulse form in accordance with the protocols given in Tables 1 and 2.

The register signals are sent in binary code by using the single frequencies sent as short pulses as follows:

x signal	2040 Hz for a nominal 35 ms
y signal	2400 Hz for a nominal 35 ms

Each of the above pulses is followed by a nominal 35 ms silent period.

The binary code used for the register signals is given in Table 3.

TABLE 1

CCITT No. 4 Forward Line Signal Codes

Signal	Code
Terminal seizure	PX
Transit seizure	PY
Forward transfer	PYY
Clear-forward	PXX

TABLE 2

CCITT No. 4 Backward Line Signal Codes

Signal	Code
Terminal proceed to send	X
Transit proceed to send	Y
Number received	P
Busy flash	PX
Answer	PY
Clearback	PX
Release guard	PYY
Blocking	PX
Unblocking	PYY

TABLE 3

CCITT No. 4 Register Signal Codes

Signals		Binary Code			
Digit values	1	y	y	y	x
	2	y	y	x	y
	3	y	y	x	x
	4	y	x	y	y
	5	y	x	y	x
	6	y	x	x	y
	7	y	x	x	x
	8	x	y	y	y
	9	x	y	y	x
	10	x	y	x	y
Call operator Code 11	11	x	y	x	x
Call operator Code 12	12	x	x	y	y
Automatic test call	13	x	x	y	x
Note 1	14	x	x	x	y
End of pulsing	15	x	x	x	x
Spare	16	y	y	y	y

Note 1: Signal code 14 is available for use on multi-lateral or bilateral agreement for echo suppressor control.

Each register signal forward digit is acknowledged by a backward 'x' or 'y' signal depending upon the type of call sequence. The signal durations and recognition times used for the CCITT No. 4 signalling system are described in Table 4.

TABLE 4

CCITT No. 4 Signal Durations and Recognition Times

Signal Element	Signal Duration (ms)	Recognition Time (ms)
P	150 ± 30	80 ± 20
X or Y	100 ± 20	40 ± 10
XX or YY	350 ± 70	200 ± 40
x or y	35 ± 7	10 ± 5

Principles of the CCITT R2D Signalling System

The CCITT R2D signalling system was chosen as the means of interfacing with the international gateway exchange for the following reasons:

- all of BTI's international digital gateway exchanges have the CCITT R2D signalling capability;
- the repertoire of signals within the CCITT R2D signalling system is greater than that of the CCITT No. 4 signalling system, thus facilitating interworking between the two signalling systems; and
- as the need for CCITT No. 4 gradually diminishes, the CCITT R2D signalling system ports could be used for other European circuit requirements.

The CCITT R2D is a channel-associated signalling system, which employs different techniques for the line and register signalling. The line signals (which are defined in CCITT Recommendations Q.421–Q.424) are sent in code, on a per-channel basis, in time-slot 16 (TS16) of the PCM system (the analogue version of CCITT R2 uses a single 'out-band' line frequency of 3825 Hz).

TABLE 5

CCITT R2D Line Signal Codes

State of Circuit	Signalling Code			
	Forward		Backward	
	a_f	b_f	a_b	b_b
Idle/Released	1	0	1	0
Seized	0	0	1	0
Seizure acknowledged	0	0	1	1
Answered	0	0	0	1
Clear-back	0	0	1	1
Clear-forward	1	0	0	1
			or	
			1	1
Blocked	1	0	1	1

The line signalling codes use two bits for signalling in the forward direction and two bits for signalling in the backward direction. Under normal conditions the codes used are given in Table 5.

The register signals (which are defined in CCITT Recommendations Q.440–Q.458), which operate in the compelled mode, are sent as in-band two-out-of-six frequencies in the forward direction, with a different set of two-out-of-six frequencies in the backward direction. The same method of register signalling is used for the digital version of CCITT R2 as for the analogue version. A full description of the analogue version is given in Reference 1.

Conversion Requirements

The DTT signalling converter is required to provide the following basic features:

- conversion for calls originating on the CCITT R2D interface into the appropriate CCITT No. 4 protocols,
- the conversion for calls originating on the CCITT No. 4 interface into the appropriate CCITT R2D protocols,
- the processing of both terminal and transit call sequences,
- the processing, or prevention of processing (as determined by command from the maintenance position), of echo-control device signal protocols,
- the conversion of test calls, conforming to CCITT Recommendation O.11, received on one signalling interface into the appropriate sequence for the other signalling interface, and
- the acceptance of national network synchronisation signals.

The signalling interworking between CCITT No. 4 and CCITT R2D is done in accordance with CCITT Recommendations Q.601–Q.608, and Q.611, Q.616, Q.621, Q.626, Q.634, Q.681 and Q.460–Q.480.

It is possible to configure the DTT for unidirectional working (that is, all CCITT No. 4 circuits would be either incoming or outgoing), with a resultant saving in circuitry. However, for operational reasons, BTI has purchased DTTs which are capable of handling both incoming and outgoing CCITT No. 4 circuits (that is, individual circuits are designated incoming or outgoing by command from a VDT, but there can be a mixture of such circuits, as required, within a given DTT system).

BASIC ARCHITECTURAL AND TRUNKING FEATURES OF A DIGITAL TRUNK TRANSLATOR (DTT)

DTT Architecture

Each DTT system deals with one 2 Mbit/s (2048 kbit/s) interface carrying CCITT No. 4 signalling, and one 2 Mbit/s interface dealing with CCITT R2D signalling. Both 2 Mbit/s interfaces are to CCITT Recommendation G.703, and each can carry 30 traffic circuits. Synchronisation with the national network can be achieved by either an external 2048 kHz clock, or from one of the PCM trunks. (In the unlikely event that a digital transmission medium is used for the international CCITT No. 4 circuits, then plesiochronous working would be done, in accordance with CCITT Recommendations, thus obviating the need for synchronisation of the international circuits.)

Three additional interfaces are provided for each DTT, namely:

(*a*) a −48 V power supply,

(*b*) a port to CCITT Recommendation V.24 for connection to a maintenance position VDT, and

(*c*) relay loop conditions for alarm outputs.

The basic configuration of a DTT is illustrated in Figure 2.

Trunking Configuration

BTI has purchased 16 DTT systems for connection to one of its international gateway exchanges. The basic trunking configuration is shown in Figure 3. Interconnection of three VDTs with the sixteen systems is achieved by use of 'intelligent switches'. Each of the two signalling interfaces connected to a DTT goes via a digital distribution frame, thus facilitating maintenance action should the need arise.

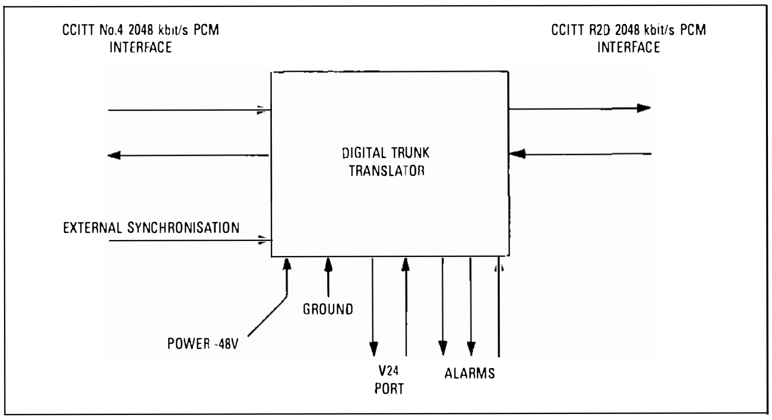


Figure 2
Basic configuration of a DTT

DTT DESIGN

Eleven slide-in units (SIUs) are used within each DTT. A block diagram is shown in Figure 4. The functions of each SIU are briefly described below:

System Timing Unit (STU)

The system timing unit (STU) is essentially a combined trunk interface and timing unit, containing two trunk interface modules (one for each of the two 2 Mbit/s interfaces). Synchronisation of the DTT is provided from this unit via special circuitry which either phase locks to an incoming PCM stream or to an external reference source.

Digital Control Unit (DCU)

The digital control unit (DCU), which is controlled from an on-board Z80B Zilog 8 bit

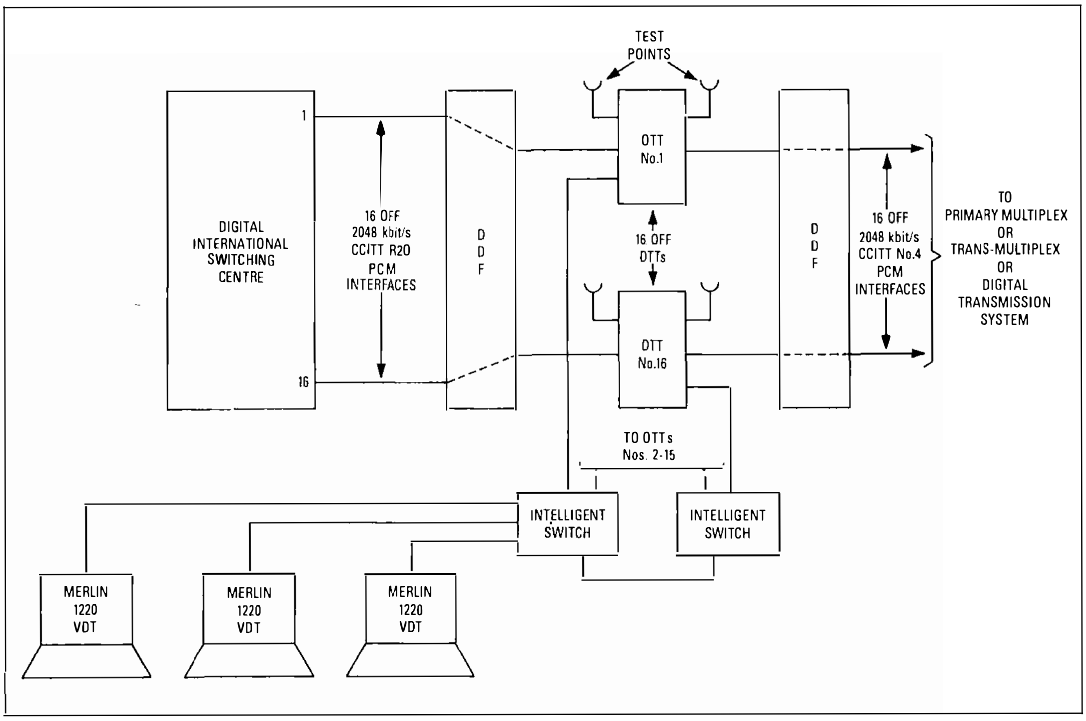


Figure 3
Trunking arrangement

DDF: Digital distribution frame   DTT: Digital trunk translator

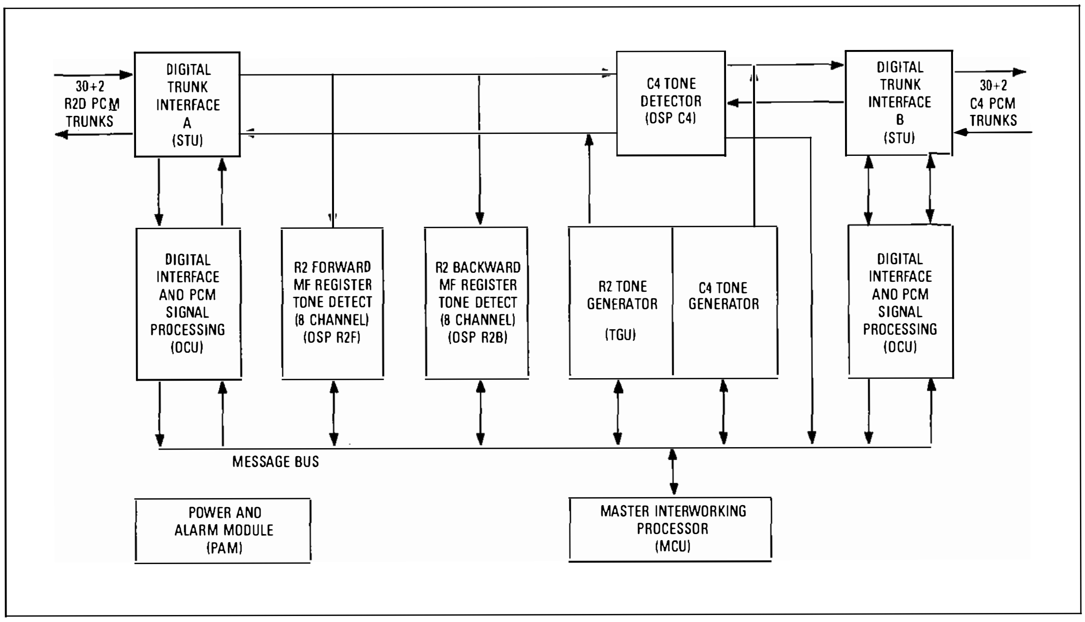


Figure 4
DTT block diagram

microprocessor, acts as a PCM signal processor for the CCITT R2D interface. It has the following main functions:

(*a*) to control the STU,

(*b*) to process the TS16 line signalling information arriving on the time/space switches from the STU, and

(*c*) detects transmission alarms on the two 2 Mbit/s interfaces.

C4 Digital Signalling Processor (DSP C4)

There are four of these units within each DTT. Each DSP C4 can detect CCITT No. 4 signalling tones simultaneously on eight PCM trunks. As the CCITT No. 4 signalling system uses pulsed line signals, the arrival rate of signals cannot be controlled by the DTT in the same way as can be done for the signals of CCITT R2D. Hence, it is necessary for a signalling processor element to be provided per CCITT No. 4 trunk to ensure that signals, which can arrive in an unsolicited manner, are not lost. The DSP C4 uses the MS 2014 digital filter-and-detect (FAD) chip designed by British Telecom Research Laboratories for detection of signalling tones. Outputs from the FAD chips are read and interpreted by an on-board Z80 microprocessor which also uses a time/space switch for communications with the master control unit (MCU).

R2 Digital Signalling Processor (DSP R2)

The purpose of the DSP R2 is to detect the CCITT R2D register signals. Because different frequencies are used for the forward and backward direction register signals, two types of unit exist:

(*a*) DSP R2F for detection of forward direction register signals, and

(*b*) DSP R2B for detection of backward direction register signals.

Both designs of DSP use the FAD chips, and an on-board Z80 microprocessor interprets the digital filter outputs. As the register signals operate in a compelled mode, some control over the speed of register signalling is possible. This, coupled with a very low probability that all 30 CCITT R2D trunks are likely to need register-signal processing at the same time, means that only 8 channels need to be provided for each type of DSP R2 within a DTT.

Tone Generator Unit (TGU)

The functions of the tone generator unit (TGU) are:

(*a*) to provide the coefficients for the CCITT R2D register tones and for the CCITT No. 4 signalling tones, which are held in EPROM;

(*b*) to provide hardware and software reset circuitry, and a hardware watch-dog timer; and

(*c*) to act as a slave processor, by use of the on-board Z80 microprocessor, communicating with the rest of the DTT via the ST-bus.

Master Control Unit (MCU)

The MCU contains an 80C88 microprocessor which operates at 8 MHz. The MCU contains the main signalling protocol translation and interface software for the V.24 interface to the VDT. An ST-bus interface and battery-backed real-time clock are also available on this SIU.

Power and Alarm Module (PAM)

The power supplies for the DTT are generated from a −48 V DC/DC converter provided within this module (the DC/DC converter has been modified by Delta Communications specifically to meet BT Specification BTR2511). All power supplies derived from the DC/DC converter are monitored continuously by special circuitry within this module.

Alarm circuitry within this module monitors various conditions within the DTT, and certain conditions on the PCM interfaces, and raises an alarm condition via the relay loop contacts to alarm circuitry within the international gateway exchange.

SOFTWARE ASPECTS

The software for the DTT is produced by the use of Delta Communications PROTRAN (protocol translation) system. PROTRAN accepts a textual representation of the signalling SDL (CCITT specification and description language) diagram and generates, directly, the necessary program for running on the MCU. The PROTRAN also supports the partitioning of the software into three sections (that is, incoming, outgoing and interworking) as recommended by the CCITT in Recommendations Q.601–Q.685. Hence, any modifications required to the software as a result of revised requirements, or because of experience gained during field trial tests, can be accommodated in an expeditious manner.

BASIC METHOD OF OPERATION OF A DTT

The conversion between signalling systems is controlled by the master interworking processor on the MCU unit. This processor receives messages from the modules which detect the signals of one signalling system and converts them to appropriate signals in the protocol of the second signalling system.

Figure 5 depicts the progress of a call. The diagram is partly incomplete in this instance, to help make the description of operation more straightforward.

EQUIPMENT PRACTICE

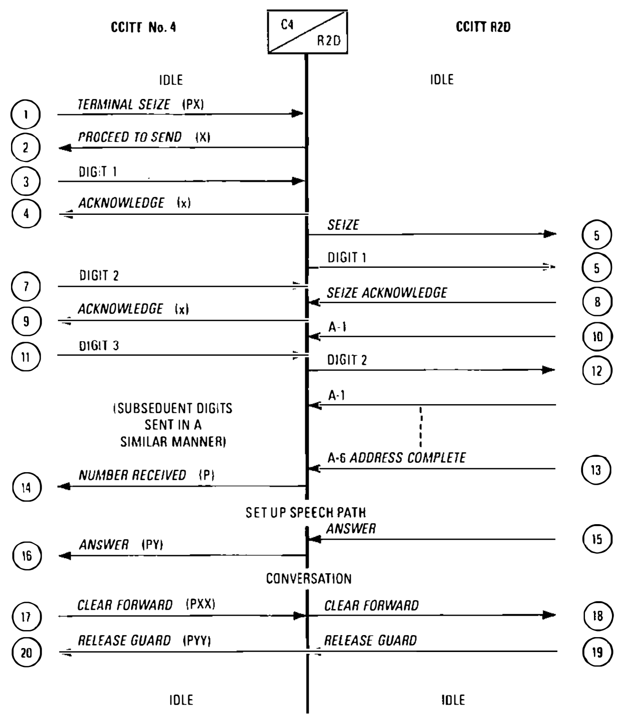
The DTT is housed in TEP-1E equipment practice. Figure 6 shows a typical layout for a DTT. Each DTT is accommodated on one

Figure 5
Call sequence diagram for incoming CCITT No. 4 terminating call

1. DSP C4 SIU detects the beginning of the P signal and splits the speech path. It then validates the complete PX *seize* signal. The DSP C4 sends a message to the MCU indicating the detection of the *seize* signal.
2. The MCU allocates an available CCITT R2 backward receiver for the call, sets the DSP C4 to REGISTER mode and commands the TGU to send the CCITT No. 4 *proceed-to-send* signal.
3. The DSP C4 detects the first digit and sends it to the MCU.
4. The MCU stores digit 1 in its buffer and commands the TGU to send the CCITT No. 4 *acknowledgement* (x) signal.
5. The MCU commands the DCU to send an CCITT R2 *seize* signal in TS16 to the exchange with which the DTT is associated.
6. The MCU commands the TGU to transmit the CCITT R2 digit 1.
7. The DSP C4 detects the second digit and sends it to the MCU.
8. The DCU detects the CCITT R2 *seize acknowledgement* signal and informs the MCU.
9. The MCU commands the TGU to acknowledge the second CCITT No. 4 digit.
10. The DSP R2 detects the A–1 backward register signal and informs the MCU. The TGU is commanded to stop sending the first digit.
11. The DSP C4 detects the next CCITT No. 4 digit.
12. The DSP R2 detects removal of the CCITT R2 backward register signal. The MCU sends the next CCITT R2 digit to the TGU.

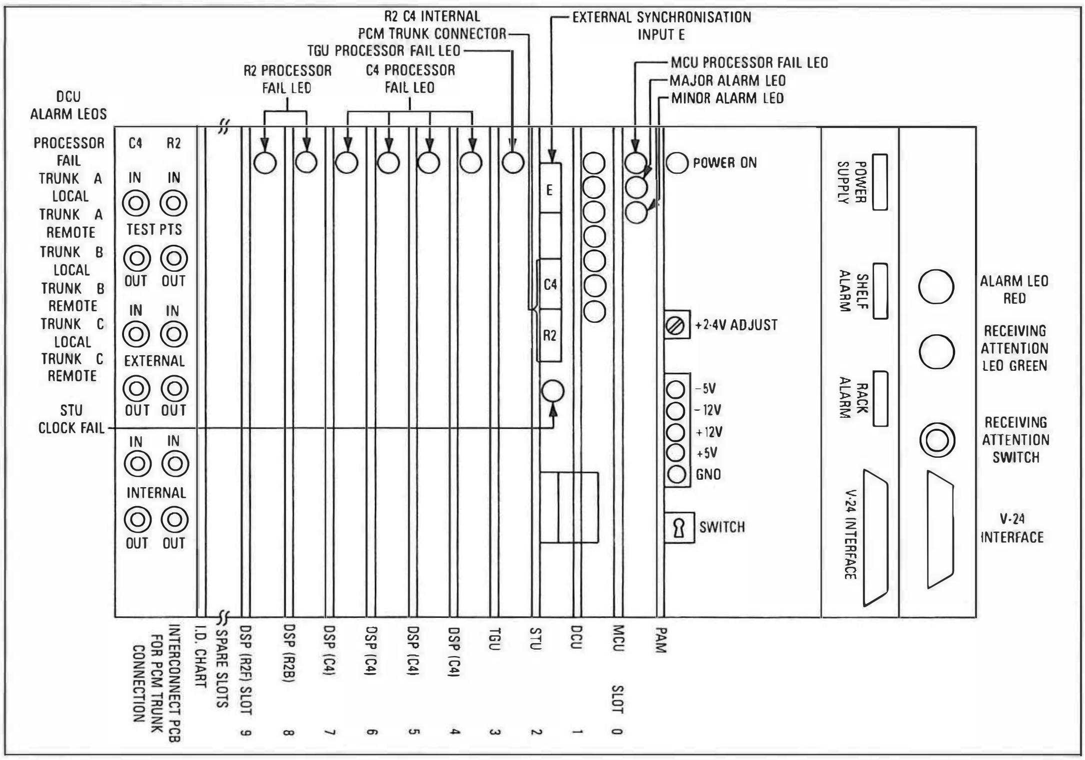
This sequence continues on both interfaces of the signalling converter as required.

13. The DSP R2 detects the A–6 *address-complete* signal.
14. The MCU commands the TGU to send a CCITT No. 4 *number-received* signal (P). The DSP R2 receiver is released by the MCU and the DSP C4 receiver returns to the LINE SIGNALLING mode. The speech path is completed.
15. The DCU detects the *answer line* signal and informs the MCU.
16. The MCU commands the TGU to send a CCITT No. 4 *answer* signal. The TGU also automatically splits and restores the speech path.



17. After conversation, the DSP C4 detects a *clear forward* (PXX) signal.
18. The MCU commands the DCU to send an CCITT R2 *clear forward* line signal. The system then waits for a *release guard* signal.
19. When the DCU detects the *release guard/idle* signal on the CCITT R2 interface, it informs the MCU.
20. The MCU commands the TGU to send a CCITT No. 4 *release guard* signal (PYY), and the DSP C4 to connect a test loop between the GO and RETURN sides of the incoming channel.

Figure 6
DTT shelf configuration



shelf of a standard TEP-1E rack. The equipment configuration being used by BTI is housed in three racks, and is shown in Figure 7.

MAINTENANCE FEATURES

General

The main maintenance feature of the DTT is its ability to interwork with a VDT. The work station for the VDT is shown in Figure 8. A range of features are available, via the VDT, which can be classified as follows:

(*a*) display of system status,
(*b*) monitoring of the signalling performance of calls,
(*c*) the setting of various user options,
(*d*) the running of built-in diagnostics, and
(*e*) control of the VDT passwords.

The other maintenance features are:

(*a*) alarm outputs with associated LED fault indications, and
(*b*) test points on the PCM interfaces.

Diagnostics

Two levels of built-in diagnostics are provided by the DTT, as described below.

Background Diagnostics

During normal operation, diagnostic routines continuously check the entire system as follows:

(*a*) the MCU polls all other SIUs to ensure that they are operating correctly,
(*b*) the operation of RAM and ROM on all processor-based units is verified, and
(*c*) when a PCM or signalling problem is detected, its occurrence is stored in the alarm log (from where it is available to aid fault finding).

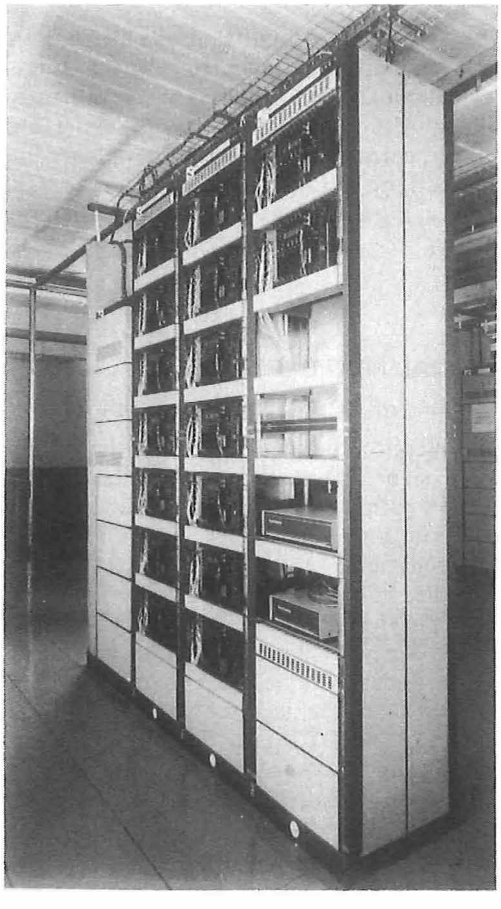


Figure 7—Three racks of signalling converter equipment (shown with covers removed)

Off-Line Diagnostics

When the DTT is 'off-line', a complete set of diagnostics can be executed via the VDT. The diagnostics menu displayed on the VDT offers the following:

1 Converter In/Out of Service
2 Self Test
3 Loopback
4 Remove Loopback
5 System Test
6 Initialise Non-volatile RAM
7 Return to previous Menu

The kernel of the off-line diagnostics is the comprehensive self-test feature, which performs the following actions:

(*a*) the MCU runs internal ROM and RAM checks,
(*b*) the MCU verifies that it can communicate successfully with all other processor units, and that they have run successful individual self-tests,
(*c*) the system checks the PCM trunks of both interfaces via internal 'loopback relays', and
(*d*) with the loopback relays operated, the TGU sends signalling tones on each channel and the system verifies that these tones are detected by the appropriate DSP receivers.

Call Monitor

The call monitor facility allows the user to monitor a channel for current status. Either an incoming or an outgoing channel can be chosen. All signals for the chosen channel (and for the corresponding incoming or outgoing channel) are shown in 'real time' on the VDT display. Figure 9 shows a typical call monitor display.

SPECIAL FEATURES

Looping of CCITT No. 4 Circuits

One of the special requirements of the CCITT No. 4 signalling system is that the GO and RETURN paths of a circuit are looped together, at the incoming end (reference CCITT Recommendation Q.136) when the circuit is in the idle state. This requirement facilitates testing of the circuit at the outgoing end, since a tone sent by a maintenance technician on the GO path should be received on the RETURN path (without the need for a signalling interchange). The DTT provides this feature by connecting the GO and RETURN paths together via a digital cross-point switch located in the DSP C4. The cross-point switch is also responsible for splitting the normal forward speech path between the CCITT No. 4 and CCITT R2D interfaces for the channel in question.

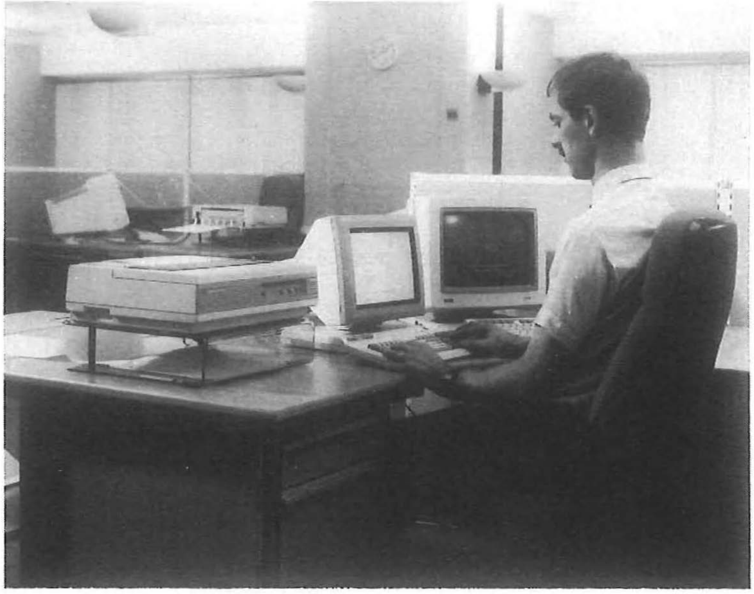


Figure 8
VDT work station

CCITT No. 4 Signalling Interworking Problems

The majority of CCITT No. 4 circuits used in Europe terminate on electromechanical international gateway exchanges. If one electromechanical exchange interworks with another using CCITT No. 4 signalling, any minor departures from the CCITT No. 4 signalling system Recommendations may not be detected (or at least may not cause service difficulties). However, electronic equipment at one end of a CCITT No. 4 circuit, interworking with electromechanical equipment at the other end, may cause service difficulties, since the electronic equipment works at greater speed and with more accuracy. BTI has encountered such interworking difficulties in the past. Because of lack of expertise and financial resources, it may not be practicable for an Administration, who has electromechanical equipment which does cause interworking difficulties (and does not meet the CCITT No. 4 signalling Recommendations), to rectify such deficiencies.

Hence, special consideration was given to the aforementioned aspects during the design

Figure 9
Call monitor display

```
ENTER CHANNEL NUMBER TO BE MONITORED :
USE CONTROL <S> TO START AND STOP DISPLAY
ESC KEY TO INTERRUPT DISPLAY.

R2 INCOMING SIGNALS   STATE   C4 OUTGOING SIGNAL
     IN         OUT                  IN       OUT

   SEIZE        ---      IDLE        ---      ---
   ---          ---      SEIZED      ---      ---
   ---        SEIZACK    SEIZED      ---      ---
   I-5          ---      SEIZED      ---      ---
   ---          A1       SEIZED      ---      ---

<INTERRUPTED> SEND[SEIZE,CLEARFORWARD,BLOCK,UNBLOCK]
OR PRESS RETURN TO REDISPLAY, SPACE BAR TO
EXIT ?
```

of the CCITT No. 4 signalling system software for the DTT. Provision has been made to insert timers and software filters, as necessary, to circumvent such problems should they arise. Such changes to the software are facilitated by the flexibility of the PROTRAN language.

Conversion to Interworking with CCITT No. 5

The modular structure of both the hardware and the software of the C4/R2D DTT mean that its function could be changed should the need arise. By the replacement of a number of the SIUs and of some of the software, the DTT can be re-configured to provide a CCITT R2D/CCITT No. 5 signalling capability. Hence, as the need for CCITT No. 4 signalling diminishes, the signalling system can be replaced with either CCITT No. 5 or CCITT R2D signalling systems (the later, of course, not requiring the use of the DTT).

OTHER MEMBERS OF THE DTT FAMILY

Earlier in this article, it was mentioned that a family of DTT devices exists. Various other members of the family can provide conversion, in different combinations, between the following types of signalling:

(*a*) various versions of decadic signalling,
(*b*) CCITT R1,
(*c*) CCITT R2, and
(*d*) CCITT No. 5.

Complete signalling protocol conversion can be provided for the above signalling systems, together with conversion between T1-format 24-channel 1544 kbit/s PCM systems and the CEPT-format 30-channel 2048 kbit/s PCM system if required.

Plans are also underway for a CCITT No. 7 signalling system interface to be added to the aforementioned family.

CONCLUSIONS

BTI has had a considerable amount of experience in using signalling converters in analogue networks for various special applications. The DTT is the first of a new generation of signalling converters designed to meet the interworking needs of digital networks.

For special low-penetration signalling requirements, the use of a DTT is a cost effective and expeditious method of provision, in comparison with providing a new signalling system on a digital international gateway exchange.

ACKNOWLEDGEMENTS

The authors would like to thank their colleagues, both within British Telecom and Delta Communications plc, for their assistance throughout the project, and in the preparation of this article.

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Biographies

David Johnson was responsible for specifying BTI's technical requirements for the DTT, and for the technical contractual discussions with Delta Communications plc. He is currently a Head of Section within the Materials Services department of BT.

John Rowe is the Marketing Director of Delta Communications plc, a company based in Ireland, which specialises in the development of signalling conversion techniques for national and international telecommunications networks. He has been responsible for liaison with BTI over the DTT project since its inception.

Mini-COSMIC: A Small Modular Main Distribution Frame

J. H. BOWEN, C.ENG, M.I.E.E.†

UDC 621.395.72

The introduction of large common-control exchanges and the need to provide rapid customer service with a low fault rate has enabled British Telecom to introduce a range of proprietary modular main distribution frames for use in the public switched telephone network. In the first of a series of articles, the Mini-COSMIC®, a small single-sided main distribution frame, is described. It is for use generally in the range of 1000 to 12 000 external plant pairs. Future articles will describe the larger frame systems, which can be installed for over 400 000 lines, and outline BT's frame modernisation strategy.

INTRODUCTION

The main distribution frame (MDF) is the interface between external plant and the telephone exchange equipment in a traditional metallic telephone circuit. It provides:

(*a*) a cross-connection flexibility point,
(*b*) a termination capability for cables,
(*c*) protection against lightning and high voltage/current,
(*d*) an interface between external and internal systems,
(*e*) test access, and
(*f*) a reference point.

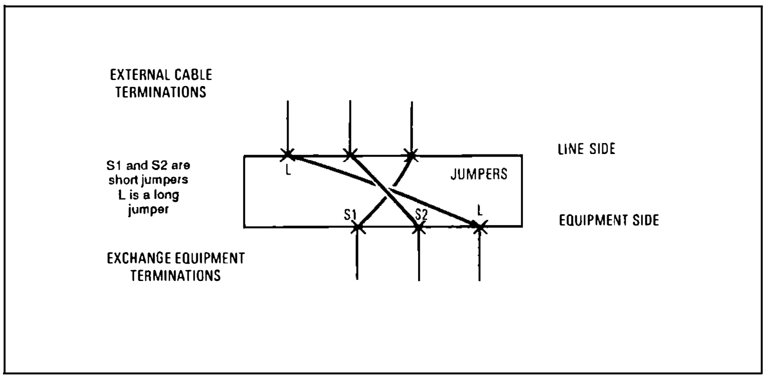


Figure 1
Conventional MDF jumpering principles

CONVENTIONAL MDF PRINCIPLES

The conventional MDF has changed little from its original design in 1893 to the frameworks installed today[1]. The external plant (cable pair) is terminated on the *line side*, the exchange equipment terminated on the opposite *exchange side*, the connection between being made with a *jumper*, see Figure 1. Total cross-connect flexibility is possible, but at the risk of congestion in the jumper bed or jumper rings when a concentration of jumpers changes direction or exceeds the design capacity of the framework.

Two persons are required for efficient running of jumpers, although recent techniques involving computer-produced schedules and a scheme known as *jumper installation fast forms* (JIFF)* have improved the speed of bulk jumpering. With conventional MDFs, typical jumper lengths of the order of 25 m cause problems as a result of chafing when the wire is either provided or recovered unless considerable care is taken. Leaving dead jumpers in the MDF speeds frame exhaustion after a brief period of apparent jumpering efficiency. Long jumpers also increase the chance of exhausting the available space.

MODULAR MDF PRINCIPLES

In the 1960s, an alternative to the conventional MDF was developed. The modular MDF (MMDF) comprises alternating *line* and *equipment* bays, separated by *vertical jumper troughs* (VJTs). All termination blocks are positioned such that the jumpers are provided only on one side of the MDF. Short jumpers are achieved when the circuit is completed by interconnecting the termination on the line bay with an exchange line circuit on an adjacent equipment bay, and this is referred to as *optimum assignment*. The VJT houses the slack jumper wire essential when using insulation displacement connections (IDCs), as shown in Figure 2. The blocks on the modular distribution frame are allocated

† Media Products Group, Fulcrum Communications Ltd., a wholly owned subsidiary of British Telecom.

COSMIC® is the trademark of AT&T, Western Electric, USA.

*CO*mmon *S*ystems *M*ain *I*nter-*C*onnecting (COSMIC) frame. Developed and supported by AT&T, Bell Laboratories and with a transfer technology agreement with BT for use in the UK.

* Jumper installation fast forms (JIFF), developed and supported by BT Thameswey District. A schedule is used to produce a harness of jumper wire in a jig remote from the MDF. The harness is transported to site and can be worked on by a number of staff simultaneously so saving installation time.

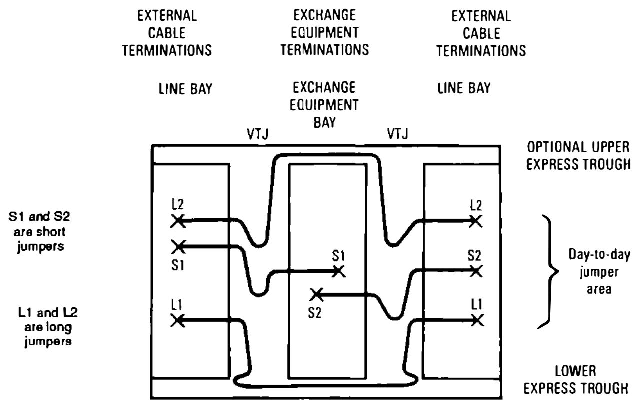


Figure 2
Modular MDF jumpering principles

to allow most of the day-to-day jumpering to be carried out at a convenient working height (without the need to kneel or use a ladder). The short jumper would not have been possible with Strowger telephone exchanges unless both the external cable pair and directory number happened to be on adjacent bays.

BACKGROUND

The fact that the MDF remained substantially unchanged up to the 1960s demonstrated the need for the interface framework, and was a tribute to the foresight of its inventors. During the 1960s, in the USA, very large MDFs were causing such problems that AT&T Bell Laboratories introduced the COSMIC family of single-side-jumpered MDFs. These were examined by visiting staff from BT, but were not considered appropriate at the time as the UK exchanges tended to be smaller and with a lower rate of circuit change (churn).

It was not until 1983 that BT's unit size, circuit turn-over and the time taken to run long jumpers instigated a serious examination of the COSMIC MDFs, and a series of trials was suggested for large modular MDFs. No sites could be obtained since Telephone Areas were reluctant to undertake the installation of such a large new type of framework (which will often remain for the life of the building) for which there was no previous experience in BT. However, this impasse was broken when it was found that Western Electric were producing the Mini-COSMIC. This was constructed from the hardware used for many years in the large COSMIC centres, but configured for a smaller single-sided distribution frame.

A Mini-COSMIC product trial was undertaken to:

- highlight any problems involving:
  (*a*) installation of the framework;
  (*b*) external connections and termination on the MDF;
  (*c*) exchange transfers; and
  (*d*) day-to-day operations;
- provide BT staff with experience,
- enable BT to write installation instructions,
- give confidence to enable other centres to install similar frames, and
- provide the foundation for larger installations.

Trials were organised at two sites in conjunction with the transfer of unit automatic exchanges (UAX13) to an electronic exchange (TXE2) at Roche, near Bodmin, and to a System X remote concentrator unit (RCU) at Long Sutton, near Basingstoke. The Roche MMDF carried traffic to the old exchange for five months prior to the change-over, in March 1986, to one of the last TXE2s to be built. The UAX at Long Sutton caught fire before the RCU was installed and damaged the MMDF. The RCU and a replacement Mini-COSMIC were installed in the refurbished building and entered public service in May 1988.

Sufficient experience was gained with these two installations to prove the hardware and enable BT to give approval for the introduction of the Mini-COSMIC at sites considered suitable by the newly formed Districts.

DESCRIPTION OF THE MINI-COSMIC

The framework consists of combinations of three main parts.

- A *line bay* which terminates up to 1000 external pairs, together with the protector panels and line-side jumper blocks.
- An *equipment bay* which mounts up to twenty 100- or 128-pair jumper blocks. Each bay is 356 mm wide by 380 mm deep and stands 2134 mm high.
- A *vertical jumper trough* (VJT). This is 127 mm wide and of the same depth and height as the bays above.

These are separate, welded steel frameworks and can be erected in many different combinations depending on the requirement.

The frameworks may be erected:

(*a*) free standing in a single suite,
(*b*) free standing back-to-back in a suite,
(*c*) standing a little away from a wall, or
(*d*) close to a wall.

Arrangements (*a*) and (*c*) provide access to aid the addition of cables at a later date while (*b*) and (*d*) satisfy the demand to occupy minimum floor space.

The external and internal cables may enter the framework from:

(*a*) the rear, as in mobile digital telephone exchanges,
(*b*) below, when located on a computer-style raised floor, and
(*c*) the top—this provides maximum flexi-

bility when rearranging an existing exchange building.

Separate access or cable runways are provided for external cables in all cases. The use of Unistrut/Airedale or similar cable trays is gaining popularity. Growth may be in either direction, sufficient frameworks being provided for the short-term planning period only, typically 3/5 years, and 2/3 years for blocks.

Subscriber Distribution Frame

The basic subscriber distribution frame (SDF) consists of two line bays, one equipment bay and two VJTs and can terminate a total of 2000 external pairs and a maximum of 2560 exchange/equipment pairs (see Figure 3). The SDF is usually provided in centres where there is a minimum of non-switched circuits; for example, audio transmission equipment for private circuits. Typical installations include the System X RCU mobile telephone exchanges currently used by BT, and RCUs with typically 1000 customers in a rural area.

A three-bay SDF stands 2134 mm high and occupies 380 mm × 1320 mm of floor area.

Main Distribution Frame

Where the requirement is for more miscellaneous and through transmission circuits than can be provided on a SDF, two equipment bays may be provided adjacent to each other so doubling the internal capacity (see Figure 4). This is typically provided when a System X RCU or AXE 10 RSS replaces a larger UAX or small automatic exchange (SAX) or happens to be located at a transmission route intersection.

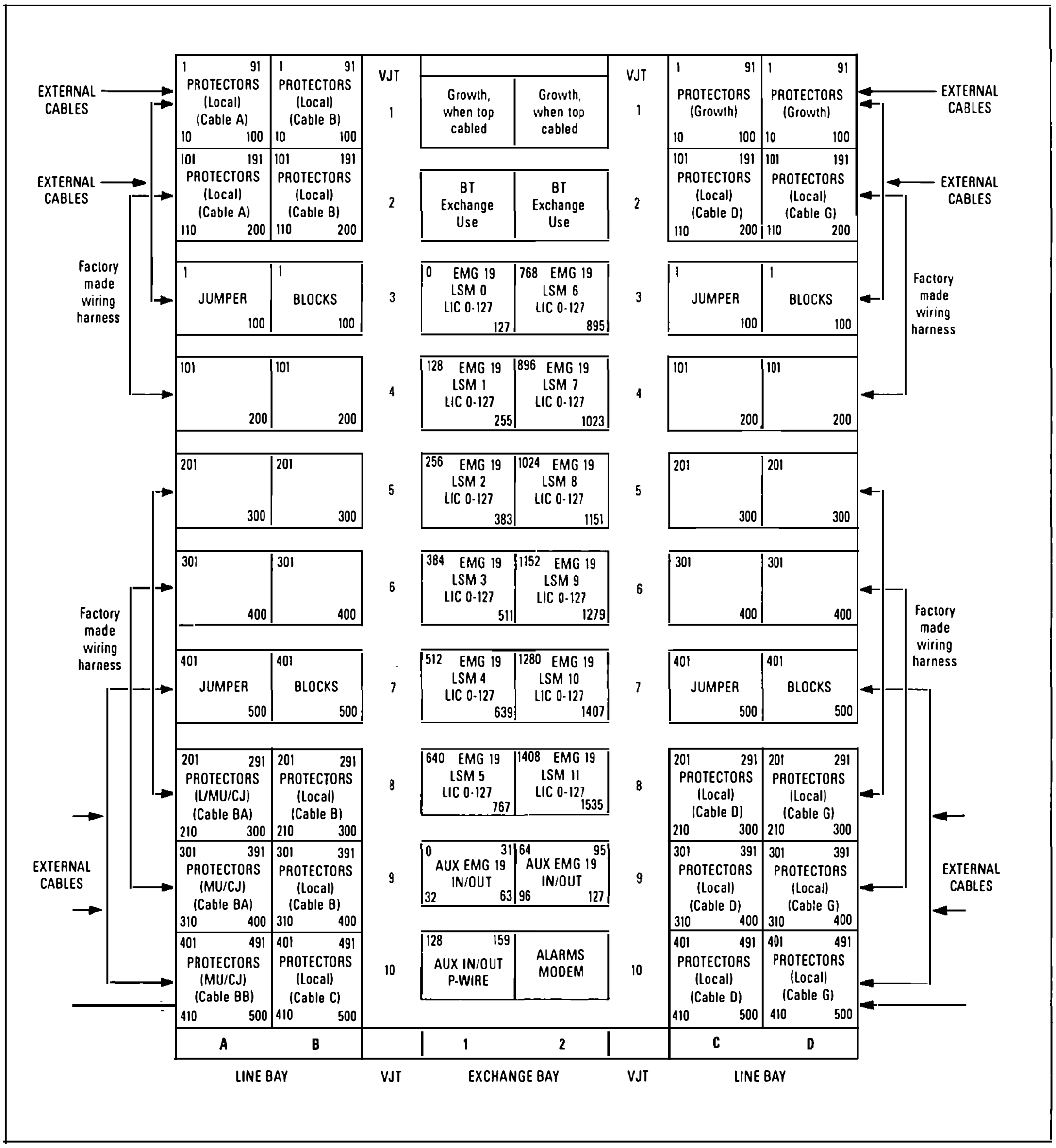
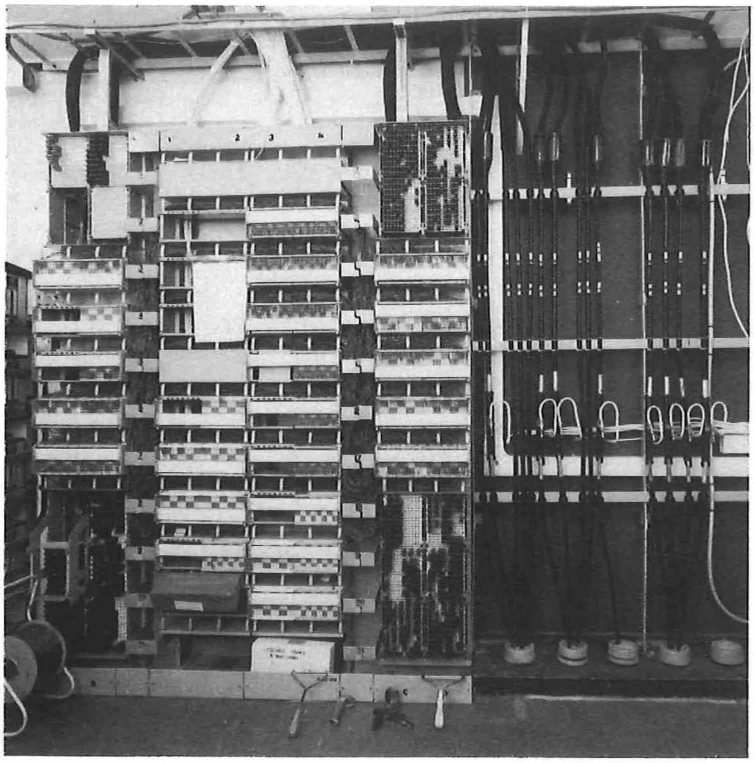


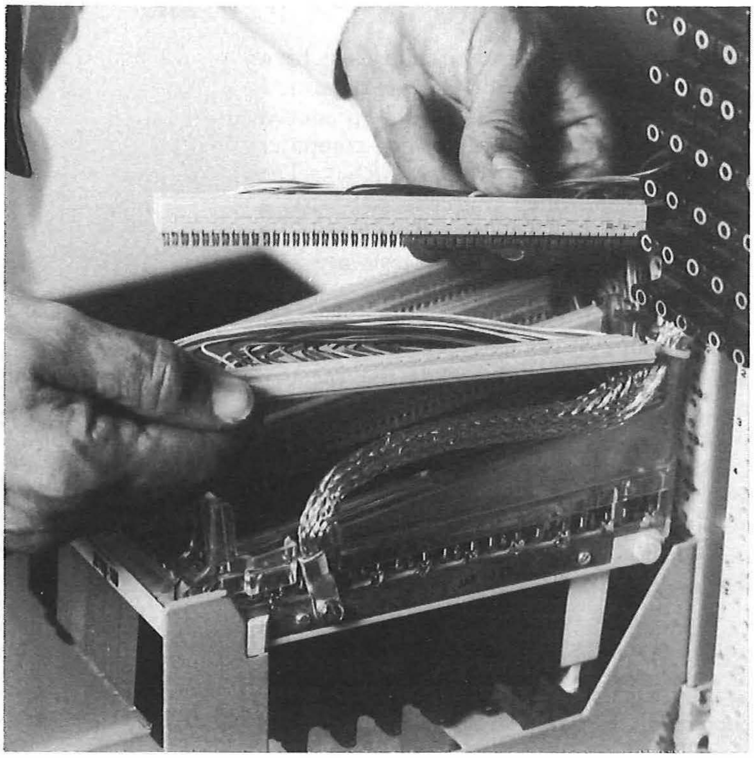
Figure 3
Typical SDF equipped with AXE10 showing the association of protector panels and line-side jumper blocks

Note: The equipment module group (EMG) in this case is 19



Note: Some blanking panels have been omitted to enable unequipped jumper block positions to be seen. Growth in this instance is right to left and equipment bay 3/4 is for non-switched circuits.

Figure 4—2000-pair MMDF cabled to a System X RCU



Note: The connector has been terminated on the external cable ready for connection to the IDC, which is factory wired to reduce installation effort.

Figure 5—25-pair Type 710 insulation displacement connector

A four-bay MDF stands 2134 mm high and occupies 380 mm × 1676 mm of floor area.

Three similar frameworks may be assembled together to serve 6000 external pairs; for larger installations (up to 12 000 pairs), an upper express trough is provided to house some of the long jumpers associated with private circuits etc. Very large installations (up to 18 000 pairs) can be installed using special VJTs.

Trunk, Intermediate and Miscellaneous Distribution Frames

These can be provided by installing appropriate combinations of line, equipment bays and VJTs. Two similar types of bay may be installed adjacent to one another and without a VJT if cross-connection facilities are not required.

CABLING AND MARKING DETAILS

Line Side

The external cable typically enters the building through a gas seal and is attached to an Unistrut/C Type runway support where a gas pressurisation feed point is provided. An air block also enables the sheath to be removed and replaced with flame-retardant convoluted tubing, in keeping with normal practice, see Figure 4. This aids running the cable to the line bays where it is terminated on 25-pair, Type 710, insulation displacement connectors prior to connection to the protector panel, see Figure 5. A factory-wired harness connects the protector panel to the line-side jumper block in multiples of 100 pairs. Plug-in modules provide protection to all cable pairs (including spare plant) and personnel without the need to provide a jumper.

Equipment Side

Equipment jumper blocks (128 pair) are provided for digital exchanges and cabled by using two 64- or four 32-pair cables, which may be either wrap-wired or terminated with IDCs. Normally, 100-pair blocks are used for tie and some miscellaneous circuits. Different colours are used for the fanning strips to aid identification; namely:

blue	external plant cables,
yellow	exchange equipment, and
white	miscellaneous equipment and tie circuits.

Detailed circuit marking is possible down to individual tags or pairs with the provision of an optional designation flip-gate label, Figure 6. Details printed on the lower label refer to the upper half of the block; turning up the flip-gate label exposes information that refers to the lower half. There is space to add local information, if required. Different coloured computer-produced paper labels aid special uses and may be readily changed.

As a result of the product trial, it was found that the Western Electric bay marking schemes needed modification for use with BT cable and MDF records. To enable existing BT practices to be used, the Mini-COSMIC has been coded as follows:

Line bays Alpha characters starting at the non-growing end. Pairs number from the top to replicate 'bar' and 'pair'; typically, A 1–500, B 1–500, the next line bay C 1–500 and D 1–500. Use has been made of the shelf numbering 1 to 10 (from the top) for planning and maintenance purposes.

Equipment bays Numeric characters starting at the non-growing end. The opportunity has been taken to rationalise the marking to ensure all terminated cables are presented to count down in a similar manner (unlike conventional MDFs where the external cable pairs number down from the top and some equipments number up from the bottom).

JUMPERING

The COSMIC jumper tools are designed not to include any cutting action at the insertion of the wire into the insulation displacement tag (which may accommodate two jumpers). This reduces the possibility of a tight jumper and a short circuit across the pair which could cause an acoustic shock or a false calling condition. Typically, 250 mm of slack wire is provided on each jumper and is housed in the VJT. The Mini-COSMIC distribution frames may be unconditionally jumpered; for example, any line pair can be connected to any equipment pair without the framework becoming totally congested, although this would be an extreme jumpering situation.

TESTING AND TEST APPARATUS

The equipment-side jumper blocks do not have a disconnection facility. Testing a jumpered circuit may be carried out in the THROUGH mode, by using a remote line test system or, on the protector panel with the protector module removed, by using a locally mounted Tester AT5422 or equivalent. A range of monitor, test in/out cords, a protector test set and special tools to remove protector panels and jumper blocks complete the system. A 100-pair test shoe enables external staff to use proprietary test equipment for sequential tap-out purposes during the transfer period and later external cable work.

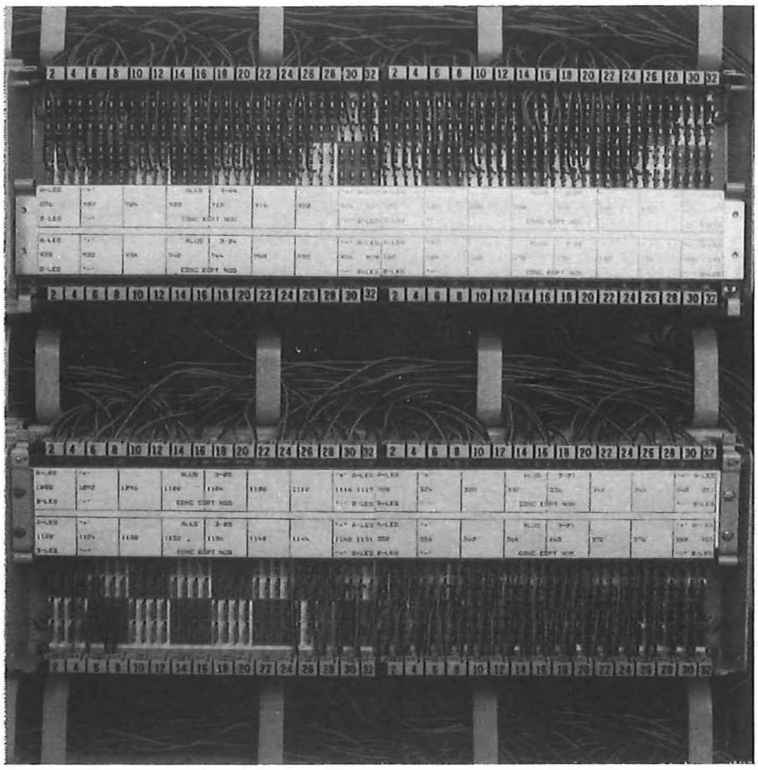
EXCHANGE TRANSFER METHODS

Exchange transfers involving the Mini-COSMIC are usually carried out by using the external-tee method. In many cases, the ducts to the old exchange are often full or contain cables which are beyond their useful life. New ducts are provided from the teeing manhole to the side of the building adjacent to where the MMDF is to be located. Cabling in the exchange is as previously described and shown in Figure 4. The protector modules are not provided at this stage.

Once the tees and the circuits have been verified between the old MDF and the new MMDF, the jumper schedule can be produced (often on-site) by using a personal computer and the frame record system (FRS)†. The jumpers are provided and checked with a Tester 300 or INTEST* and corrected as necessary. Appropriate traffic tests are also carried out.

On the day of transfer, the old exchange is disconnected and the new one introduced by inserting the protector modules on the line bay. The external tees are cut away and the old exchange recovered.

If the new exchange is to be provided in the same building as that at present occupied by the old exchange, the above procedure may be used, but instead of cabling direct to the MMDF from the air block, a cable rearrange-

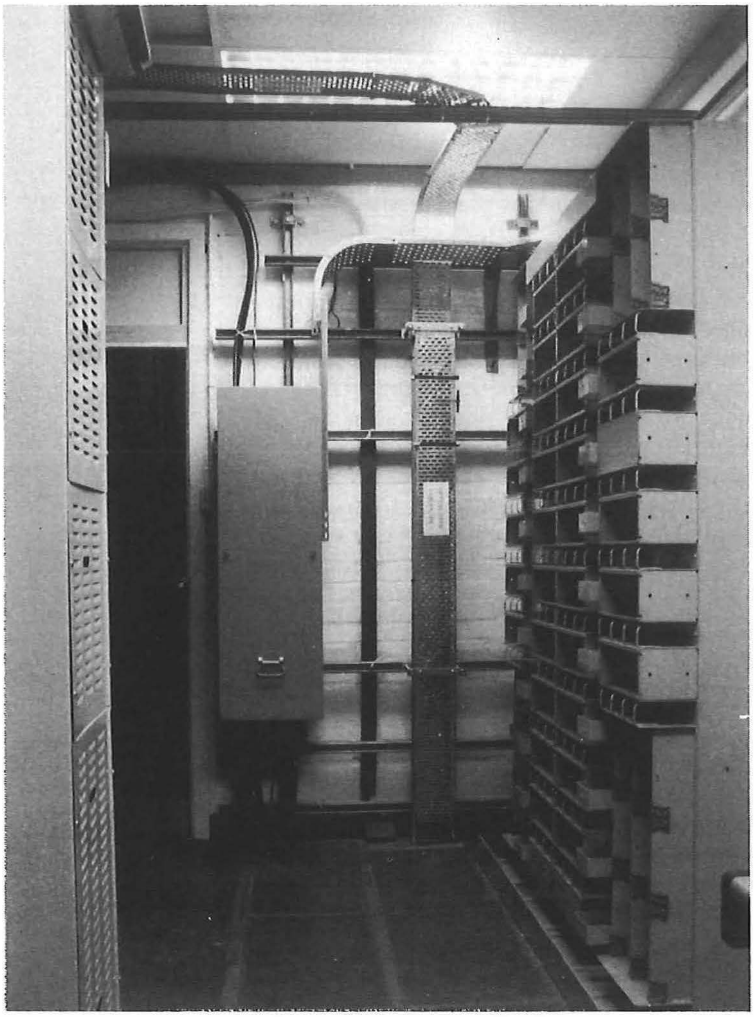


Note: This is a close-up of shelves 3 and 4 from Figure 4 and displays equipment numbers (EN) 128–191; 896–959 and 320–383; 1088–1151. The blocks on shelf 2 contained equipment numbers 0–127 and 768–895.

Figure 6
Examples of typical System X flip-gate labels

† Frame record system (FRS), developed and supported by BT UKC. This is a personal-computer-based allocation-and-record system designed for stand-alone use prior to an exchange transfer.

* Internal Test (INTEST), developed and supported by BT East Anglia District is a computer-controlled tester which compares a telephone circuit on the old exchange with the new exchange prior to transfer to ensure it is provided correctly.



Note: The temporary local cables are fed from below the CRF while in this case the temporary junction cables are visible at the top before entering trunking for security. The MMDF is cabled using the cable tray to the top and right of the CRF. The narrow trunking contains the dry air feeds to the cables in the trench. The small vertical tray contains optical-fibre cables which are not associated with the MMDF.

Figure 7
Cable rearrangement facility cabinet in a building previously occupied by a UAX.

ment facility (CRF) cabinet may be introduced. Up to 2400 external cable pairs may be teed in a CRF and taken to a mobile digital exchange parked nearby. The initial transfer is as above, but to the mobile exchange. The old exchange is recovered, the building is refurbished and the new digital exchange installed and tested. If the MDF in the refurbished building is laid-out similar to the mobile exchange, the same jumper schedules can be used again provided they have been kept up to date. The second transfer is a repeat of the procedure; the temporary cables are removed from the CRF to the mobile exchange and may be kept for use at the next site.

CONCLUSION

The product trials demonstrated that the COSMIC family of distribution frames is suitable for use in BT's network at sites considered appropriate by the BT District's Planning Divisions. The framework system has been incorporated in the exchange documentation for use by BT nationally.

ACKNOWLEDGEMENTS

The author would like to thank the many persons who have contributed to the success of this part of the project. These include Ed Werner and Tim Sargent of AT&T (UK) Ltd, Don Corin, Westward District, and Mick Collins, Thameswey District, for their work with the product trials, Dick Briggs of South Midlands and Chiltern District for Figures 4 and 6 and West Midlands District for Figure 7, Rod Clarke of GPT (formerly Plessey, mobile RCUs), Keith Hayes and colleagues in BT Fulcrum and BT Headquarters, London.

References

1 Patent dated 24 October 1893 by William Ford and Bertram Lenfast in the USA.

Biography

John Bowen joined the then British Post Office (BPO) in 1955 at Gloucester as a Youth-in-Training. National Service was carried out with the Royal Electrical and Mechanical Engineers at Arborfield where he was an Instructor with the rank of T/Capt. On return to the BPO in 1961, he worked on transmission construction and planning prior to passing the Limited Executive Engineer Competition in 1971, when he moved to Telecom Headquarters, Main Line Provision Department. He assisted with the modification of group switching centre equipment used for STD and IDD. In 1979, he was transferred to the Local Lines Department where he was involved with improving exchange transfer techniques. He was initially seconded to BT Fulcrum in 1985 to assist the launch of the COSMIC project and has remained to provide technical support. John is a licensed radio amateur with the call-sign of G8DET.

From Time To Time

A Review of Past Journals

INTRODUCTION

British Telecommunications Engineering was founded in 1908 as *The Post Office Electrical Engineers' Journal*. From time to time, some of the events, innovations and equipment as reported in the *Journal* 25, 50 and 75 years ago will be reviewed. These extracts can present only a brief insight into the wealth of material contained in these early volumes.

75 YEARS AGO
Vol. 6 April 1913–January 1914

Consequent on the unification of the telephone system in the UK in January 1912, some 350 man-years were spent in checking and valuing the inventory for the sale, which culminated in an arbitration hearing lasting 74 days. The National Telephone Company had claimed £20 924 700, but finally settled for £12 470 264.

Telephones

In 1911, prior to the unification of the telephone system, there were 651 936 telephones in the British Isles: 118 995 belonging to the Post Office, 7501 to the municipal systems and the remainder to the National Telephone Company. Growth in London had been dramatic over the previous decade from 39 516 telephones (at a density of 0·6%) to 226 234 (3·3%) and was the third largest in the world, behind Chicago and New York. World-wide, there were 12 318 000 telephones.

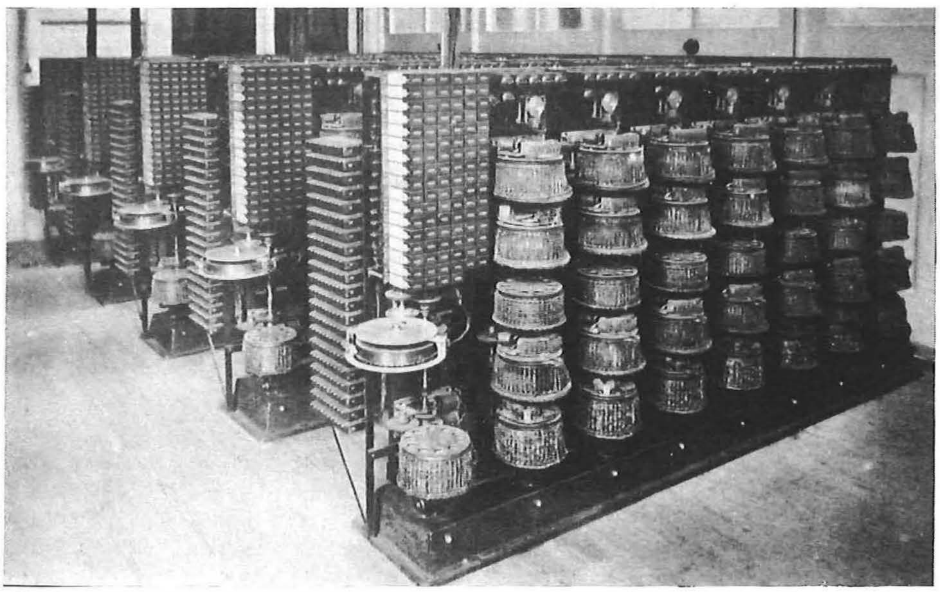
The introduction of automatic working continued with the installation of the Lorimer exchange at Hereford. This system, manufactured in Canada, was powered by a central rotating shaft incorporating gears and clutch arrangements to drive the appropriate cylinder switch. The subscriber selected the required number by a series of levers on his telephone. Once this number was set and the mechanism primed by turning a handle, the handset was lifted to call the exchange. The exchange polled each subscriber's line every 3 s and, on detecting a call, interrogated the telephone to determine the stored number.

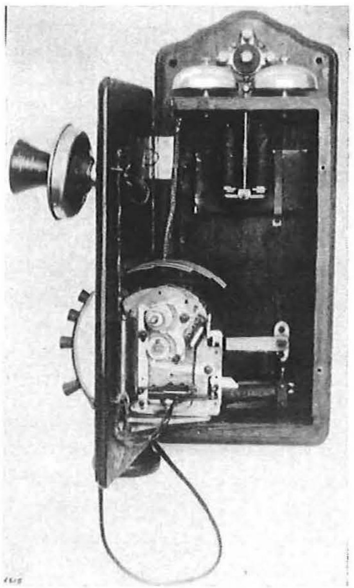
Contracts were placed for automatic exchanges at Leeds, and Darlington, and an experimental compact exchange suitable for small exchanges unattended at night was to be installed at Chepstow.

An illuminating account was given of the arrangements made to provide the American election results to the citizens of Chicago. On the manual system, as each bulletin was prepared, a number of copies were made and some 50 clerks passed these to the distant exchanges by telephone. At the distant exchanges, it was found that one transmitter had sufficient power to serve 20 lines without undue loss. By speaking into five transmitters at once through a system of tubes on a common mouthpiece, 100 lines could be served. Callers were patched up in groups of 20 to the bulletin, a simple switching arrangement enabled the announcer to read the bull-

Figure 1
Lorimer automatic switching equipment

Figure 2
Lorimer wall telephone





etin to one group whilst the subsequent group was being assembled. For those subscribers on the automatic system, the news was provided by the Chicago Examiner. Level 9 was allocated to election traffic, and non-busy trunks from this level were connected through repeaters to a common terminal at which they were bunched into a single trunk to the newspaper office. Here, an attendant continuously read the election news into a loud-speaking transmitter.

Telegraphs

Developments in telegraphy continued to be implemented with the introduction of the Creed equipment on the London–Edinburgh route and quadruple duplex working on the Baudot system on the London–Birmingham route. A new 4-wire submarine cable was laid between England and Germany. Some investigation had been made into the effort required to operate the hand pumps that powered the 1·5 inch pneumatic tubes for dispatch of messages from the counter clerks to the telegraph room. Considerable energy was expended, particularly if the pump was stiff and the feed slide leaky. Staff at the CTO were better served, however, as a new 2·5 inch pneumatic tube working on the Dudley continuous system was being installed.

A brief description of the early days of the telegraph service revealed that the Millstone Lane Office, Leicester, was a model one:

Hours 8 a.m. to 8 p.m., no break, one clerk, Joint C.-in-C. and messengers with railway station office. Counter room led to instrument room, to enter which a string was pulled to lift latch inside. Printer on table under window. Small form for two messengers. Large coal (versus punishment) box capable of holding one ton coal and an unlucky messenger. Battery rack in far corner with its grim row of Daniell 12 plates.

The linesmen of those days were prepared for any emergency: ladder, draw-vice, and wire, with a 'top hat' tool chest, taped inside for the reception of gimlet, bradawl and small screwdriver. The origins of telegraph engineering, albeit visual semaphore signalling, date back to 1794, during the French Revolution, when a military engineer named Chappe devised a method of signalling by means of movable arms mounted on an upright post.

Figure 3
Anglo–German cable

Figure 4—Linesman complete with top hat tool box

External Works

Various external works were in progress in 1913. One major project recently completed was the provision of the Anglo–Irish telephone cable. The four conductors were each formed from 7-strand copper wire and weighed 160 lb per nautical mile. Storm damage of previous years necessitated the replacement of two 130 ft masts to carry trunk circuits across the River Ouse near Hull. Details were given of the arrangements for loading overhead lines by means of pole-mounted coils. An ingenious method of replacing the cables across the docks in Hull used an endless sash line through the duct and back at high level across the

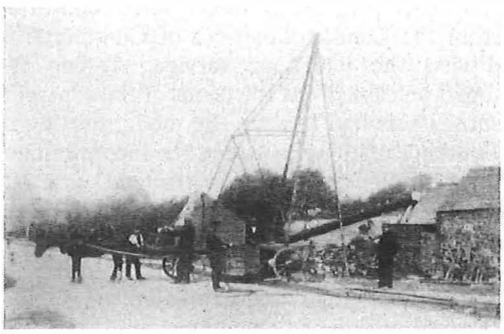


Figure 5—Pole derrick

dock. The draw rope could then be pulled through the duct as required without the danger of it encircling any of the other cables. Fourteen 7-pair 20 lb lead-sheathed cables and one 600-pair 10 lb cable were pulled through the 9 inch cast iron pipe by this method. It was also reported that multiple-way duct was expected to be adopted in preference to cast iron pipes.

The production of plant maps and the difficulties in keeping them up to date was highlighted when it was reported that about 6000 amendments were made each year on the 625 plans that covered the UK. Such was the increase in plant that new maps had to be prepared far more frequently than the planned five year cycle.

Transmission

Measurements in terms of standard cables for transmitters, receivers and PBXs were discussed and the effects of ageing were demonstrated. The difficulties of making quantitative rather than qualitative measurements were discussed and an acoustic bench incorporating a Y-tube to minimise the human element was illustrated.

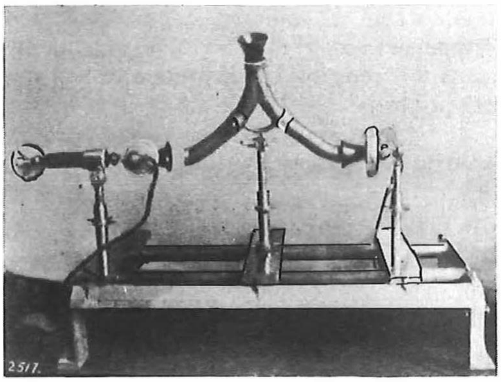


Figure 6—Acoustical bench

Successful experiments were made over the new loaded Anglo-French trunks in the transmission of music from the Paris Grand Opera to London and from Covent Garden to Paris.

Miscellaneous

The Postmaster General received a deputation from the London Chamber of Commerce to discuss the telephone service. Among the topics discussed was the terms of the contracts subscribers had to sign, the modernisation of London's telephone system, the inconvenience of the pillar telephone instrument, and the need for a system of registering calls [subscribers' meters] at both ends of the wire. The committee had been shown the workings of Avenue exchange, and expressed the opinion that all exchanges should be brought up to that standard. During the discussion, the Postmaster General was asked if he would consider the setting up of an advisory committee that could take an independent look at customers' complaints. A suggestion that bills should be submitted twice a year or even quarterly instead of annually was also made. In response, the Postmaster General explained some of the technical difficulties in providing subscribers' meters, particularly in view of the one million calls a day being made in London. The system being used was exactly the same as that used in New York and every other large American city. With regard to modernisation, the Department was currently spending £3M per year on new equipment.

Plans were announced for an electric railway to run in a 9 ft tube beneath the City for postal purposes. The railway would run from Paddington to Whitechapel with future plans to link all the District Offices north and south of the river.

Technical education was provided by detailed notes on AC theory and the establishment of special courses at various technical institutes in London and the Provinces for the rapidly expanding body of workmen employed in the Engineering Department.

An appreciation of the importance of hydrometer readings in secondary cell maintenance was given together with details of a new hydrometer designed to overcome the difficulties experienced when taking measurements on the smaller secondary cells used in some telegraph and telephone systems.

50 YEARS AGO
Vol. 31 April 1938–January 1939

The Post Office Accounts showed that records had been achieved in all directions. Local calls were running at 1882 million and trunk calls at 99 million. There were 2 827 000 telephones and 46 000 public call offices. 5600 exchanges were interconnected by 13 250 000 miles of wire of which 90% were underground. The number of telegrams was still increasing at 49 250 000 inland and 9 250 000 overseas.

Switching

A description was given of the UAX No. 14 that was just being brought into service. The UAX No. 14 was designed to cater for installations serving 200–800 subscribers. A UAX No. 12 achieved fame when mounted on a 6-ton trailer van and, complete with ancillary equipment, it became the first mobile telephone exchange. Exchanges in the Glasgow area were being converted to director working. An article described the problems of providing automatic dialling to all exchanges in the unit fee area; that is, local calls to exchanges outside the linked-numbering scheme. Trials of photographing subscribers' meters were reported as was the development of an electric heater for the beeswax used when terminating

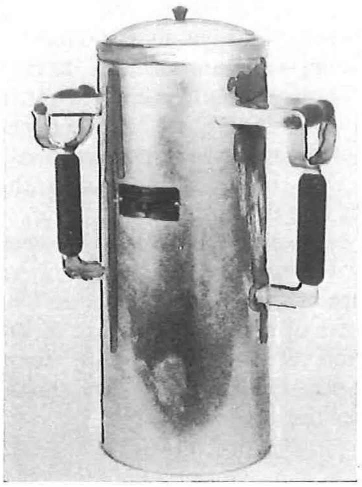


Figure 7
Electric wax heater

Figure 8
Lorry derrick

switchboard cables. The City of London became fully automatic with the opening of Avenue exchange.

External

It was not until 1916 that the Engineering Department made serious use of motor transport when a number of army vehicles were borrowed for work on storm damaged lines. In 1919, surplus army vehicles were added to the fleet which numbered some 600 in all. By 1925, over 950 vehicles were in use, although 736 were motor-cycle combinations. None of the vehicles had any distinctive features other than strengthening for the carriage of poles and cable drums. The 30 cwt utility vehicle was one of the first to be specifically fitted out for working parties rather than general stores carrying. They were first introduced in 1925 and based on an Albion chassis. In 1938, trials were made with a Morris chassis as the number of this type of vehicle had risen to 1305 out of a total fleet of 8818. Trials were made with crane lorries for erecting kiosks, and with ladder derricks clamped to the back of lorries for overhead work, including their use for aerial cabling.

Figure 9
30 cwt utility vehicle

Transmission

A report of the CCIF Rapporteurs' Meeting highlighted three important items which required an early agreement: namely,

(*a*) standardisation of technique of cables for wideband transmission [that is, carrier frequencies and spacing],

(*b*) the application of the idea of 'effective transmission' to replace the older 'volume' basis in assessing the grade of transmission, and

(*c*) the design of a co-ordinated European switching plan.

Agreement was soon forthcoming for transmission systems on carrier and coaxial cables for international purposes: the spacing would be 4 kHz, and the UK agreed to fall into line with all the other countries and transmit the upper sideband on 12-channel carrier routes. The other two points were recommended for further study. Articles in the *Journal* discussed telephone transmission testing by subjective methods, and echo effects in relation to the European switching plan.

The London–Birmingham coaxial cable system was taken into service in 1938. To carry out initial tests over the cable of a complete supergroup, 35 circuits were loaded by conversations between female switchboard operators, the remaining five being used for engineering control. It must be remembered that these initial coaxial systems were designed with 5 kHz channel spacing, hence only 40 channels in the supergroup; 4 kHz working would be adopted when the cable performance had been ascertained. The channel filters used crystal resonators and the

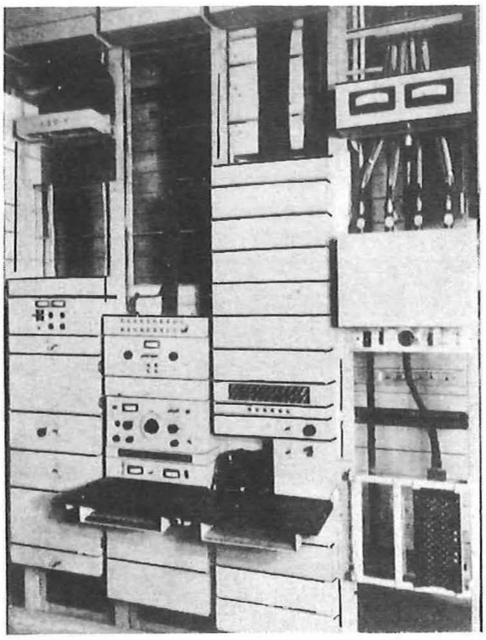


Figure 10—London–Birmingham coaxial system Terminal equipment

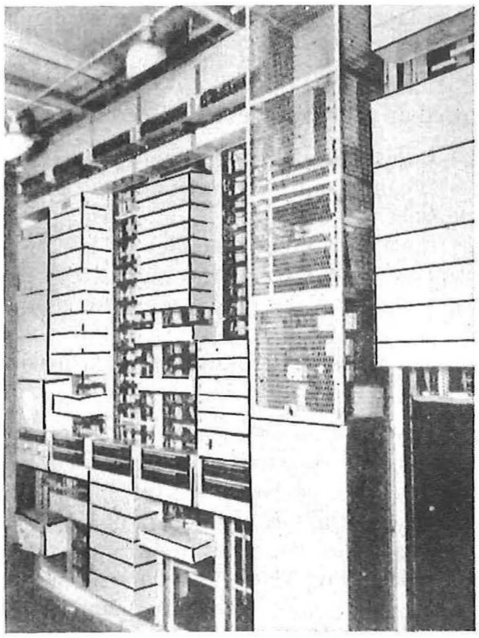


Figure 11—London–Birmingham coaxial system Carrier generating equipment

theory behind their construction and operation was given. Because of the method of mounting the crystals, there was some concern over the effects of vibration on their performance. The effects were checked by packing a number of filters in wooden packing cases and transporting them over a distance of 230 miles in a commercial 2-ton van, the characteristics being checked before and after the journey: no adverse effects were found.

At the same time as the new coaxial cable was being installed, the oldest underground cable in the world, the London–Birmingham No. 1, was being reconditioned for carrier working. The 76-wire cable was laid in 1898 in a star quad configuration using 150 lb copper conductors, but because of the poor crosstalk performance over the first 30 miles, the remainder was laid up in pairs.

A coaxial cable was being laid between Manchester, Leeds and Newcastle. An unusual feature of the route was that at Linthwaite, because of the remote nature of the repeater station, arrangements were being made to provide lighting from the 350 V supply fed over the cable itself.

Radio

A description of the ultra-short-wave radio links being introduced into the telephone network included details of the provision of telephone service to the Scilly Isles.

Customer Apparatus

Details were given of a new telephone instrument and bell set combined in a single moulded case to supersede the Telephone No. 162. This new 300-type telephone could incorporate a number of key units to facilitate simple switching arrangements. Several improvements to the wiring of customer's premises were being introduced with the replacement of lead sheathed or braided covered cables and enamelled conductors. The new cables had tinned copper conductors with vulcanised india rubber insulation and an overall glacé cotton braiding. A lead-sheathed version would be available for damp or deleterious conditions. Moulded plastic terminal blocks in various colours were also introduced together with a new plugging material which, when moistened and compressed into the hole, could take a screw fixing immediately.

Miscellaneous

Time was rapidly spreading over the country with the introduction of the speaking clock at many of the large conurbations, although the opening at Birmingham was marred by a major failure of the public power supply. To guard against mains failures at exchanges that did not have stand-by prime movers, transportable engine-powered battery charging sets were available. However, of the 63 sets currently available, 60 were found to be in poor condition—a replacement programme was embarked upon.

From time to time, reference is made in the *Journal* to the origin of the term 'Butt' — the portable telephone used by exchange maintenance staff. Reminiscences of the conversion of the Portsmouth exchange to automatic working in 1914 suggest that the term derives from 'butt-in-ski', the jargon used by the American installation engineers imported from Chicago to train the local staff.

25 YEARS AGO
Vol. 56 April 1963–January 1964

By 1963, international traffic was growing rapidly. Transatlantic cables were being laid, the first satellites had already been launched, and international direct dialling was born. The transistor was assuming an important role in equipment design, and computing was becoming a fundamental tool of the research engineer.

Switching

Details were given of the equipment required to provide STD facilities at UAXs. On the international scene, details were given of the modifications required to the SSAC No. 9 signalling equipment to interwork with the French 1VF equipment on the London–Paris direct dialling circuits. Details were also given of the theory behind the use of magnetic core in logic and memory circuit. An experimental 3-digit electronic director using these cores was tested in Balham exchange.

Customer Apparatus

For large organisations, a new key-and-lamp desk unit was proving popular, whilst for the small business a simplified house exchange system, the House Exchange No. 3, was introduced.

Transmission

During the previous decade, the size of the trunk network had almost doubled to 34 850 circuits. A growing number of these circuits were being provided on the new small-bore coaxial cable using transistorised amplifiers housed in footway boxes. Special repeater cases had been developed to accommodate this equipment.

A brief description was given of the test facilities and monitoring arrangements for the 405-line television distribution network.

Figure 12 London network switching centre

A new dimension had been added to the transmission engineers' armoury with the introduction of satellite communication. A description is given of the low temperature system at Goonhilly to cool the maser amplifier to less than −271 °C.

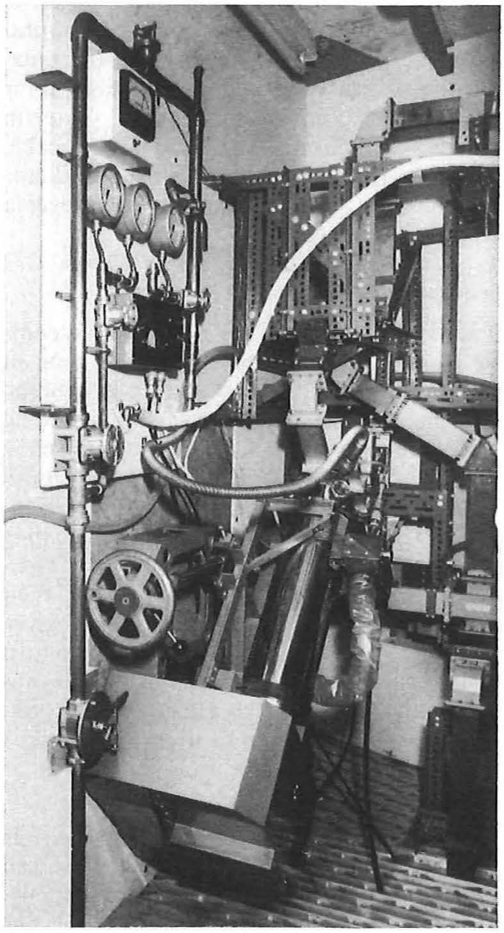


Figure 13—Maser in its operating position

International communications were still primarily in the realm of submarine cables and a description was given of the CANTAT cable system that had formed the first link in the Commonwealth cable network. The second phase, COMPAC, from Vancouver to Sydney using a similar single lightweight cable had just been completed. Additional transatlantic traffic would be served by TAT3, the shore end of which had just been brought ashore from *CS Alert*.

External

To improve service to Barrow-in-Furness, a subaqueous cable was laid across Morecambe Bay.

A report was given on the field trials of large polythene sheathed cables in the local network including some 2000-pair cables with polythene insulated conductors.

Gas pressurisation of underground cables was being progressively introduced and early indications were that a considerable reduction in service-affecting faults was being achieved.

A small hand-operated hydraulic thrust borer was introduced for the installation of plastic-sheathed distribution cable. On a larger scale, thrust boring was used on the M6 motorway to extend the emergency telephone system onto the Preston By-pass.

A gas explosion in Leeds caused structural damage to 1200 yards of 9-way multiple duct, but the cables were undamaged except for some slight flattening of the joints. Water in the steel duct of the Carlisle–Lancaster cable caused severe damage when it froze and crushed three tubes of the coaxial cable over a length of 16 yards.

Training

Details were given of the new arrangements for technical education with the revision of the Ordinary National Certificate courses. Coincident with this change, the training scheme for Youths-in-Training was revised to give a three year course structured to finish with a period of live work under supervision.

The use of the transistor was becoming more and more widespread in telecommunications equipment and an outline of their characteristics and applications was given together with a review of the development of the silicon planar transistor which was confidently predicted to supersede the germanium transistor then in widespread use.

Miscellaneous

The problems of communications in developing areas were discussed with particular reference to the use of radio systems.

Telegraph traffic was on the decline and this, coupled with the advances in teleprinter automatic switching, meant that the pneumatic tube system laid under the streets of London to link telegram reception points with the Central Telegraph Office was now obsolete and was being recovered.

Although the Research Department had been involved in many aspects of computing, indeed had made a major contribution to the COLOSSUS project in 1943, it was not until 1961 that a machine was installed at Dollis Hill for scientific research. The machine, a National-Elliott 803B machine having a 166·5 kHz clock rate and a core store of 4096 words, could be programmed in Autocode. The machine was well used and a survey of its first 18 months of use revealed that it had provided design of low-pass filters, transistor equivalent circuits, frequency characteristics of ladder networks and the design of thermionic valves.

Modern power plant in the shape of high-efficiency semiconductor rectifiers was being brought into service in many exchanges. This new power plant required less space than the existing motor/generator sets thus facilitating provision of the extra equipment required for the introduction of STD.

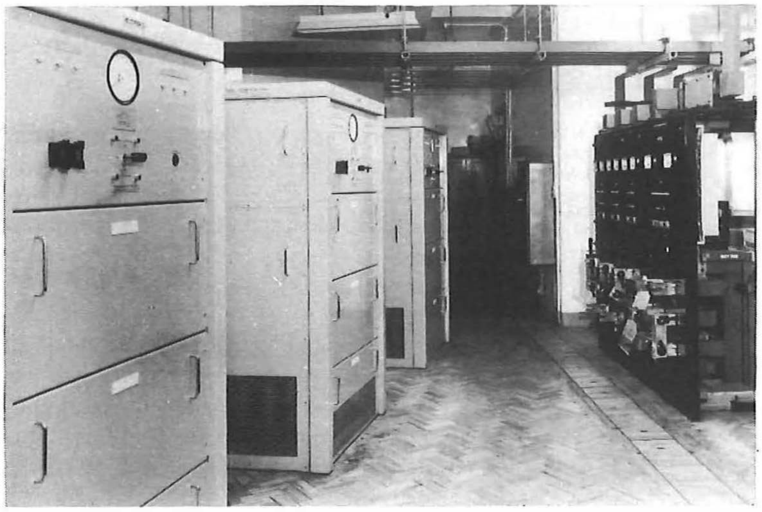


Figure 14
Rectifier power plant

Electronics were also making a timely appearance in the information services with the introduction of the new speaking clock. A less sophisticated machine, but using similar principles, the Equipment Announcer No. 8A, was put to use to announce that 'Lines from ... are engaged, please try later.'

Book Reviews

Expert Systems—An Introduction for Managers
Anna Hart.
North Oxford Academic Publishers Ltd. xi + 208 pp. 71 ills. £18·00.
ISBN 1-85091-368-4.

The book is aimed at managers desiring an overview of expert systems. Understandably, the book does not cover technical issues in detail.

The author attempts to distinguish between expert systems and traditional software and to help assess the suitability of problems for being addressed by expert system techniques. She also tries to point out the likely costs of getting involved in this technology and some of the potential pitfalls. The thinking that should precede projects, the need for clear objectives, and the importance of good project management are covered. The author identifies the necessity of a continuing commitment to the maintenance and support of products beyond the development phase. Also emphasised is the need to consider users early in the project; to be sensitive to their needs, to allay any unfounded fears and address real ones. There is also coverage of some of the tools available and their appropriateness and cost.

The book uses several case histories to help illustrate the points being made. The case histories address issues such as going about project management correctly, assessing the appropriateness of the technology to projects, informing and consulting users and the general need for realism.

Naturally, a book of this size cannot cover all the issues in depth. Readers can only expect to gain a modest technical understanding of expert systems from this book. They can expect to be made aware of some of the central issues, some of the commonly-used terminology, and some of the divergence of views and directions associated with the subject.

D. S. DHALIWAL

Servicing Personal Computers, Second Edition
Michael Tooley.
Heinemann Professional Publishing Ltd., viii + 258 pp. 232 ills. £20·00.
ISBN 0-434-91975-6.

'Repair', very often considered the poor relation of other industrial endeavours, is at last gaining recognition as being both worthwhile and (if correctly managed) profitable. Many and varied are the publications aimed at supporting the more usual repair operations on the domestic electronic front. There is, however, one major exception, the personal computer.

In this book, Michael Tooley identifies the obstacles presented to third-party repair agencies when faced with servicing personal computers and sets about in a methodical fashion addressing the problem. From the outset, the author assumes that the reader does not possess specialist computer knowledge and provides a useful and lucid chapter on the understanding of personal computers at system and circuit levels. He fully discusses the physical aspects of repair, taking into account location, storage, safety, security, useful test equipment and tool kit that would be necessary for a proposed workshop.

Having laid down the ground rules, the author then proceeds on a general level to discuss effective methods of fault location. At this point, the author could be considered to have completed his task, but here the publication becomes a veritable reference book. With the help of excellent illustrations and diagrams, the author describes in detail not only the operation but the recommended approach to all computer durables. Disc and tape drives, printers, monitors and power supplies as well as processor cards themselves are all dealt with in depth.

Particular attention in the latter sections of the book is paid to the IBM PC and its compatibles wherein the author provides useful profiles for many of the latest microprocessors and support devices including the powerful 80286. A further unexpected bonus is the provision of a reference section that, contradictory to its modest 12 pages, contains a wealth of information.

In summation, this is a highly readable book which provides valuable information even for those not directly involved in repair. It represents a significant backstop in the absence of official documentation and provides the reader with the necessary degree of confidence paramount to successful repair.

P. ENNIS

Introduction to Telecommunication Electronics
A. Michael Noll.
Artech House. xvi + 359 pp. 167 ills. £30·00.
ISBN 0-89006-278-5.

This textbook is aimed at, to quote the author, non-technical persons who require a basic understanding of the terminology and concepts used by communication engineers in designing and developing communication systems and products. The material used is taken from courses, taught by the author, and this is reflected in the rather novel style of one page of hand-drawn graphics with each page of text. This works well throughout the book and would help to retain the interest of the audience for which it was written.

The book is organised into six modular chapters and appears in the order: 'Signals and Waves', 'Electricity', 'System Elements', 'Modulation', 'Digital Signals', and 'Computers and Data Communications'. The topics covered in the chapters after 'Signal and Waves' follow the pattern that is common to most introductory books of this type. Whilst I can accept the author's stated reason for the order of the material in the book, I feel that the introduction of such topics as 'Fourier Theorem' and 'Impulse Response' (albeit at a basic level), some 24 pages into the book, may deter the reader. In fact, the whole of the first chapter, on signals and waves, would be more pertinent to the appendices, with reference made to it as required.

Although this is a modern book, some of the material could have been omitted and others expanded; for example, several pages are devoted to thermionic valves and only one page to integrated circuits. More use could have been made of analogies to explain the more difficult issues, and less emphasis on the mathematics, which is not of sufficient depth to be of real value. On the positive side, the narrative given on each of the text pages is generally clear, concise, pitched at the right level, and relates well to the accompanying hand-drawn graphics. Finally, as a college text book and used under the tutorage of the author, it would meet the needs of the non-technical graduates for whom it was intended. However, without assistance, the non-technical reader may find that some areas of the book require further explanation.

D. J. CORRIE

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. 280 of this issue of the *Journal*.)

IBTE LOCAL-CENTRE PROGRAMMES 1989

Aberdeen Centre

9 March 1989:

CITRAC by a speaker from Strathclyde Regional Roads Department. Meeting will be held in Moir Hall, Mitchell Theatre, Kent Road, Glasgow, commencing at 14.00 hours. Joint meeting of Scottish Centres.

Central Midlands Centre

8 March 1989:

Military Fixed Communications by Major J. Shepard, Communications Projects Division, School of Signals, Blandford. Meeting commences at 14.00 hours.

12 April 1989:

Telecommunications: The Next Decade by Dr. D. M. Leakey, Chief Scientist, British Telecom.

Summer 1989:

Proposed visit to Network Operations Unit. Further details to be announced in IBTE information circular.

East Anglia Centre

15 March 1989:

Cellular Radio by Mr. D. Wordley, Director Market and Product Development, Cellnet. Meeting will be held in the Music Room, Assembly House, Theatre Street, Norwich, commencing at 14.00 hours.

19 April 1989:

A presentation by Mr. M. Armitage, Assistant Managing Director (Operations), British Telecom UK Communications. Meeting will be held in the Mumford Theatre, Cambridge College of Arts and Technology, East Road, Cambridge, commencing at 14.00 hours. Joint meeting with South Midlands Centre.

17 May 1989:

The Quality Experience by Mr. R. Pearson, Quality Manager, Hewlett Packard. Meeting will be held at Essex University, Colchester.

14 June 1989:

Developments in Machinery for Producing Philatelic Merchandise by Dr. P. Barton, Head of Philatelic Group, Post Office. Meeting will be held at University Centre, Granta Place, Mill Lane, Cambridge, commencing at 14.00 hours.

12 July 1989:

Telecom Gold by Mr. C. Jones, UKC/Group Director, Dialcom Europe.

East Midlands Centre

All meetings will commence at 14.00 hours.

8 March 1989:

Visit to Derby Computer Centre. Host: M. Bowler, East Midlands District.

12 April 1989:

Marketing Led or Customer Driven? by Mr. D. Simpson and Ms. C. Kelemen, East Midlands District. Meeting will be held at Leicester University.

East of Scotland Centre

9 March 1989:

CITRAC by a speaker from Strathclyde Regional Roads Department. Meeting will be held in Moir Hall, Mitchell Theatre, Kent Road, Glasgow, commencing at 14.00 hours. Joint meeting of Scottish Centres.

29 March 1989 (Dundee):

Remote Maintenance Alarm Handling using the Gateway System by Messrs. E.R. Heatlie and G. M. Neilson, East of Scotland District. Time and venue to be advised.

12 April 1989 (Edinburgh):

Satellite TV: A Practical Approach to Installation by Mr. A. Williams, Special Radio Projects Group, British Telecom. Meeting will be held in Room 340, Telephone House, commencing at 14.00 hours.

Liverpool Centre

15 March 1989:

The Network by Mr. K. E. Ward, Chief Engineer Network Planning and Works, British Telecom UK Communications. Meeting will be held at the Liverpool Museum, William Brown Street, Liverpool, commencing at 14.00 hours.

19 April 1989:

Network Operations and Management—A Customer's Perspective by Mr. R. M. Falconer, Network Services Manager, Imperial Chemical Industries. Location to be advised; contact Brian Stewart 051–229 4444.

London Centre

Details of meetings are notified on a recorded announcement, Tel: 01–587 8258.

Martlesham Heath Centre

Meetings will be held in the John Bray Lecture Theatre, British Telecom Research Laboratories, Martlesham Heath, commencing at 16.00 hours.

7 March 1989:

The Role and Objectives of the Overseas Division by Mr. J. Poston, Marketing Director, British Telecom Overseas Division.

22 March 1989:

Applied Research at Bellcore—The First Five Years by Mr. A. Chynoweth, Vice President, Applied Research, Bellcore.

North and West Midlands Centre

6 March 1989:

Title of lecture to be announced. Presenter: Professor Bryan Carsberg, Director General, OFTEL. Meeting will be held at British Telecom Technical College, Stone, Staffordshire.

North East Centre

March 1989 meeting to be announced.

North Wales and Marches Centre

7 March 1989:

Total Network Management by Mr. J. K. Davidson, Network Operations Centre Manager, British Telecom UK Communications. Meeting will be held at the Beauchamp Hotel, Shrewsbury, commencing at 14.00 hours.

Northern Ireland Centre

Meetings will be held at the BTNI Business Centre, Dial House, 3A Upper Queen Street, Belfast, commencing at 15.30 hours.

8 March 1989:

Future Developments in the Public Network by Dr. D. M. Leakey, Chief Scientist, British Telecom.

5 April 1989:

The Effect of Value Added Service on BT and its Customers by Mr. C. Jones, Director, Dialcom Group Europe.

Severnside Centre

29 March 1989:

Future Trends in Public Telecommunications Networks by Dr. D. M. Leakey, Chief Scientist, British Telecom. Meeting will be held at the Watershed Media Centre, Bristol, commencing at 14.15 hours. Joint meeting with Associate Section.

12 April 1989:

Defence Communications by Lt. Col. P. B. Leonard. Meeting will be held in Gloucester (venue to be advised).

South Downs Centre

14 March 1989:

Telecommunications Networks—Some Possible Developments over the Next Decade by Dr. D. M. Leakey, Chief Scientist, British Telecom. Meeting will be held in the Lecture Theatre, Central Library, Richmond Road, Worthing, commencing at 12 noon.

South Midlands Centre

15 March 1989:

Whatever Happened to the Candlestick by Dr. I. S. Groves, Divisional Manager, Telephony and Data Products Division, British Telecom Engineering and Procurement. Meeting will be held at Wilton Hall, Bletchley, commencing at 14.15 hours.

19 April 1989:

A presentation by Mr. M. Armitage, Assistant Managing Director (Operations), British Telecom UK Communications. Meeting will be held at the Mumford Theatre, Cambridge College of Arts and Technology, commencing at 14.00 hours.

South Wales Centre

Further details and timings will be published in personal invitations circulated prior to each event.

15 March 1989:

Power and Building Engineering Services for the Future by Mr. P. Allen, Head of Power and Building Services Division, British Telecom UK Communications. Meeting will be held in Swansea.

21 April 1989:

Future Optical-Fibre Systems in the Local Loop by Mr. W. K. Ritchie, Chief Engineer, Local Network Projects. Research and Technology Division.

25 May 1989:

Keynote Address *Links Around the World* by Mr. A. J. Booth, Managing Director, British Telecom International. Venue to be confirmed.

Thameswey Centre

29 March 1989:

Turning Points: Engineers Who Changed the Network (recollections of some significant changes and the people who made them) by Mr. J. Tippler, Director Network, British Telecom UK Communications. Meeting will be held at the Berystede Hotel, Ascot, commencing at 14.00 hours.

West of Scotland

9 March 1989:

CITRAC by a speaker from Strathclyde Regional Roads Department. Meeting will be held in Moir Hall, Mitchell Theatre, Kent Road, Glasgow, commencing at 14.00 hours. Joint meeting of Scottish Centres.

Westward Centre

22 March 1989:

The Local Loop—The next 3 Years by Mr. G. Coombes, British Telecom UK Communications. Meeting will be held in Lecture Theatre W4, Workshop Block, Plymouth Polytechnic commencing at 14.15 hours.

Yorkshire and Lincolnshire Centre

8 March 1989:

Active Control Technology: Fly-by-Wire by Mr. T. Smith, Senior Flight Engineer, British Aerospace. Meeting will be held at the Library Theatre, Bradford, commencing at 13.45 hours.

IBTE CENTRAL 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.

LOCAL-CENTRE SECRETARIES

The following is a list of Local-Centre Secretaries, to whom enquiries about the Institution should be addressed.

Centre	*Local Secretary*	*Address and Telephone Number*
Aberdeen	Mr. A. T. Mutch	British Telecom, D2.1.6, New Telecom House, 73–77 College Street, Aberdeen AB9 1AR. Tel: (0224) 753343.
Central Midlands	Mr. G. R. Chattaway	British Telecom, BE3.8, Telecom Centre, Little Park Street, Coventry CV1 2JY. Tel: (0203) 228396.
East Anglia	Mr. T. W. Birdseye	East Anglia District PD2.1.5, St. Peters House, 22 St. Peters Street, Colchester CO1 1ET. Tel: (0206) 894041.
East Midlands	Mr. D. H. Bostrom	IO4, 200 Charles Street, Leicester LE1 1BA. Tel: (0533) 534212.
East of Scotland	Mr. B. Currie	British Telecom East of Scotland District, NJ3, Telephone House, 357 Gorgie Road, Edinburgh EH11 2RP. Tel: 031–345 4218.
Liverpool	Mr. B. Stewart	British Telecom Liverpool District, CS63, Lancaster House, Old Hall Street, Liverpool L3 9PY. Tel: 051–229 4444.
London	Mr. C. J. Webb	British Telecom, LSO/PA1.6.4, Room 119B, Camelford House, 87 Albert Embankment, London SE1 7TS. Tel: 01–587 8853. Answerphone: 01–587 8258.
Manchester	Mr. J. M. Asquith	British Telecom, NE20, Telecom House, 91 London Road, Manchester M60 1HQ. Tel: 061–600 5171.
Martlesham Heath	Mr. K. R. Rose	ISP9, Room 241A, 2nd Floor, Trinity Avenue, Felixstowe, Suffolk IP11 8XB. Tel: (0394) 693906.
North and West Midland	Mr. R. J. Piper	c/o Mr. M. N. B. Thompson, BT Technical College, Stone, Staffordshire ST15 0NL. Tel: (0785) 813483.
North Downs and Weald	Mr. N. Smith	British Telecom, NP4, Telephone House, Rheims Way, Canterbury, Kent CT1 3BA. Tel: (0227) 474594.
North East	Mr. P. L. Barrett	British Telecom North East, EP38, Swan House, 157 Pilgrim Street, Newcastle-upon-Tyne NE1 1BA. Tel: 091–261 3178.
North Wales and the Marches	Mr. P. C. Clay	E343, Communication House, Harlescott Lane, Shrewsbury SY1 3AQ. Tel: (0743) 274353.
Northern Ireland	Mr. B. Hume	EI4, RAC House, 79 Chichester Street, Belfast BT1 4JE. Tel: (0232) 227152.
Preston	Mr. A. J. Oxley	BK/CP2, Telephone House, 10 Duke Street, Blackburn BB2 1VA. Tel: (0254) 666390.
Severnside	Mr. P. C. James	NPW/MW4 & 5, Mercury House, Bond Street, Bristol BS1 3TD. Tel: (0272) 230450.
Solent	Mr. D. Henshall	BE33, Solent District Office, 70–75 High Street, Southampton SO9 1BB. Tel: (0703) 823421.
South Downs	Mr. C. J. Mayhew	British Telecom South Downs District Office, ED8, Grenville House, 52 Churchill Square, Brighton, BN1 2ER. Tel: (0273) 225030.
South Midlands	Mr. J. Coley	LL1.4.4, Telephone House, 25–27 St. Johns Street, Bedford MK42 0BA. Tel: (0234) 274849.
South Wales	Mr. P. F. Coleman	NP3, British Telecom South Wales, District Engineering Office, 25 Pendylallt Road, Coryton, Cardiff. Tel: (0222) 691622.
Thameswey	Mr. R. D. Hooker	Thameswey District Head Office, DE4.4, Telecom House, 49 Friar Street, Reading, Berkshire RG1 1BA. Tel: (0734) 501754.
West of Scotland	Mr. L. M. Shand	TNO/S1.4.4, Dial House, Bishop Street, Glasgow G3 8UE. Tel: 041–221 1585.
Westward	Mr. R. Rand	British Telecom, NP2, Exbridge House, Commercial Road, Exeter EX2 4BB. Tel: (0392) 212681.
Yorkshire and Lincolnshire	Mr. R. S. Kirby	UKC/SNE & NI/QO1.3, Netel House, 6 Grace Street, Leeds LS1 1EA. Tel: (0532) 466366.

The Federation of the Telecommunications Engineers of the European Community

27th CONGRESS IN CORK, SEPTEMBER 1988

With the topical theme of 'Business Communications—Customer Requirements and Technical Solutions', the Congress generated over 30 technical presentations from all the participating EEC Countries. This exciting response ranged across such topics as 'The Changing Environment for Business Telecommunications' to 'Digital Cross Connect Systems in the Eireann Network' and 'Business Telecommunications with X.25 on Desk Top Workstations'.

The papers by R. A. Higgins and R. A. Fuller from the strong IBTE team covered 'The Crucial Role of Project Management' and 'Making Light Work in the City', respectively, and, once again, set a high standard attracting a number of complimentary comments from European colleagues.

The concluding 'Round Table Discussion' proved to be one of the most stimulating events. Mr. Derek Nicholas of the International Telecommunications Users Group opened the debate during which it was said that some public telephone administrations in Europe were having a deal of difficulty in meeting the network requirements of major customers. It was no surprise, therefore, that some disappointed customers were looking for other means of satisfying their vital communication requirements. Not unexpectedly, the response was spirited and vigorous.

Overall, the Congress, which included visits to a number of local manufacturing installations, research establishments and operational units, proved to be a success by any standard and well satisfied the 500 delegates. It well justified the generous support received from many local organisations as well as from several manufacturers in the telecommunications and computing fields.

28th CONGRESS IN LISBON, SEPTEMBER 1989

Planning for the 28th Congress, to be held in Lisbon, Portugal, is well in hand, with further announcements expected shortly. As hitherto, details will be given, together with necessary registration forms, in a forthcoming issue to FITCE members of the FITCE quarterly *Revue* journal.

29th CONGRESS IN GLASGOW, AUGUST 1990

For the first time since its formation, the Federation has agreed to hold the prestigious Congress occasion in the UK. Early indications suggest that the total number of delegates drawn from professional telecommunications engineers in the EEC countries will exceed 600—with at least 200 from the Federal Republic of Germany. A deal of carefully co-ordinated planning is therefore needed. Clearly, the IBTE group of FITCE members will be taking the lead in this respect with the support of BT, local government authorities, telecommunications equipment manufacturers and suppliers, as well as such national authorities as the Scottish Development Agency and the Scottish Tourist Board.

The fact that Glasgow will be celebrating in 1990 its award of European City of Culture will not be missed by our European colleagues, who are becoming particularly keen to learn about BT and its management of change into the competitive environment as well as about the modernisation of its telecommunications network.

The Congress, built around a technical core of over 30 papers and presentations by professional telecommunications engineers is already being arranged to give delegates an opportunity also of visiting BT operational units with technical visits to UK manufacturers and educational establishments.

The newly-built Forum Hotel complex centre across the River Clyde from the Garden Festival site has been chosen as the attractive focal point of the event and provides space for the exploitation of a number of useful technical display facilities.

A. B. Wherry
Vice President of FITCE, and
Vice-Chairman, IBTE Council

International Switching Symposium, 1990

The International Switching Symposium (ISS) is held once every three years at various locations throughout the world. It is the world's premier telecommunications switching event that brings together leading experts in this field of study and representatives from operating companies world-wide.

The Symposium embraces all aspects of switching systems from their conception, through design to field experience. ISS '90 will cover both today's operational experiences and future network and key technology trends for the 1990s and beyond.

ISS '90 will be held from 27 May–1 June 1990, in Stockholm, Sweden. Papers in the following broad areas of interest are invited for consideration by the ISS Technical Committees:

Advanced switching concepts
Network architecture innovations
Operating experiences
Advances in control architectures
Computerised operations systems
Forward-looking principles and architectures
Impact of new service needs on switching
Reliability and quality
Novel hardware technology
Advances in software development

Complete papers must be received by the Secretariat by 1 August 1989. Further information can be obtained from the UK member of the ISS International Scientific Committee—Dr. Dave Newman, British Telecom Research Laboratories, Martlesham Heath, Ipswich IP5 7RE.

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

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

MEMBERSHIP

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.

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

The European Telecommunications Standards Institute

2nd Technical Assembly, October 1988, Nice

The 2nd Technical Assembly of the European Telecommunications Standards Institute (ETSI) took place in Nice in France on 25/26 October 1988.

The Chairman of the Technical Assembly, Mr. Stephen Temple, noted with satisfaction the unanimous adoption of the 1989 costed work programme for ETSI. New project teams are to be established for the specification for the pan European digital paging system and digital mobile radio products such as the digital cordless telephones. This adds to the eight project teams established earlier in 1988 on subjects ranging from ISPBX interconnection matters to ISDN terminal adapters.

The Technical Assembly debated the future structure of its Technical Committees once the last of the CEPT Working Groups had moved across to ETSI in March 1989. The division of activities that CEPT had used is likely to be the basis of the future ETSI organisation with more smaller Technical Committees to make the larger participation in ETSI more manageable. In addition, new Technical Committees will be established for satellite earth stations, human factors and advanced testing methods. The Human Factors Technical Committee will also deal with any work arising in the standardisation of facilities to help the disabled telephone user. A plan for the new Technical Committees will now be prepared by the Chairman and presented to the third Technical Assembly in March 1989.

A strategic Review Committee will be established to ensure that ETSI is alerted in good time to new technology or market developments so that appropriate priorities for resources can be applied. The first mission of the Strategic Review Committee is to examine urgently the standardisation priorities for the ISDN. At present, the work is being based on a plan drawn up in Brussels some three years ago. Since then, the world-wide standardisation activities in the CCITT have moved on and a number of European public network operators are implementing ISDN networks.

The Technical Assembly agreed how the indicative voting rules based on individual members will be applied in its Technical Committees. This should greatly speed up decision processes where experts are unable to agree in a timely way.

Mr. Huber from the European Commission services addressed the Technical Assembly on the EC's research and development programme called *RACE*. He stressed the importance of the task ETSI will face in respect of new standards based on the innovative technology likely to emerge from RACE.

The Technical Assembly agreed to a proposal to mount two workshops in 1989, one dealing with advances in Videotex and the other with ISPBXs. Moreover, the Technical Assembly felt that the need to expose the technical work of ETSI would most efficiently be carried out in the future using the wide range of conferences which take place anyway in the countries of ETSI members. However, ETSI would need to choose from amongst the large number of conferences the most appropriate ones. Towards this end, the Technical Assembly agreed that it should be prepared to lend its name as co-sponsor of relevant conferences.

The European Telecommunications Standards Institute (ETSI) is a body which will gradually take over the standardisation activities hitherto carried out by the Conférence Européenne des Postes et Télécommunications (CEPT). The new aspects of ETSI are as follows:

- The principle of consensus which was governing the decision making in the CEPT has been replaced by the principle of national-weighted voting corresponding to that of the EEC Council of Ministers. In this way, the standards within the field of telecommunications are now being agreed upon according to the same principle as other European technical standards. In other words, the telecommunications sector is preparing for 1992.
- All bodies dealing with telecommunications can now take active part in the standardisation activities. The following bodies may become members of the Institute:

  PTTs
  Public network operators
  Manufacturers
  Users, including private service providers
  Research institutes

The EEC Commission and the EFTA Secretariat have a special status as counsellor.

ETSI was founded in June 1988 and is situated near Nice in France.

Telecommunications Heritage Group

The Telecommunications Heritage Group was formed about three years ago as an independent non-profit making organisation devoted to the study and preservation of the heritage of telecommunications (telephones and telegraphs).

The 400 members keep in touch and co-ordinate their research through the Group's quarterly magazine *Telecom Heritage*.

In the long-term, the Group hopes to establish an independent museum of telecommunications, specialising in the areas not covered by existing collections.

Membership of the Group costs £8 per annum and further details can be obtained by sending an s.a.e to:

The Telecommunications Heritage Group
PO Box 499
Bishopbriggs
Glasgow
G64 3JR

British Telecom Press Notices

TAT-8 Goes Live

The world's first transatlantic optical-fibre cable, TAT-8, capable of carrying 40 000 simultaneous telephone conversations, was opened for service between Europe and North America on 14 December 1988 by BT, AT&T and France Telecom.

TAT-8 effectively doubles the existing cable capacity across the Atlantic Ocean. The cable will be used for transmitting data, voice and video and it will have four times the capacity of the previous transatlantic cable installed in 1983.

During a three-way videoconference held between London, Paris and New York to mark the opening of service on TAT-8, the first words to travel over the cable were spoken by author Isaac Asimov. 'Advances in communications technology have always led to advances in human understanding' he said.

The main cable consists of six fibres. Two pairs carry messages, the third pair is used for back-up. TAT-8 provides one fibre pair direct UK–USA, one fibre pair direct USA–France, together with one fibre pair UK–France, via the branching unit. To protect against damage, TAT-8 is buried 1 m below the ocean floor until the water is at least 1 km deep. For additional protection, the cable is steel-clad to a depth of 2·6 km.

AT&T owns 34·1% of TAT-8, BT owns 15·5% and France Telecom, 9·8%. The remaining capacity is owned by 26 other telecommunications administrations and companies. The total cost of the project was some £220M.

From its landing point in Tuckerton, New Jersey, TAT-8 extends 5830 km to an ocean bed branching point off the coasts of the UK and France. From the branching point, located on the European Shelf on a plateau known as the *Meriadzek Terrace* at a depth of around 2 000 m, the UK and French sections of the cable travel 540 km and 330 km, respectively, to their destinations at Widemouth in North Cornwall and Penmarche in Britanny. Specially equipped cable ships were used by each country to complete the work.

TAT-8 will be an important part of a global network linking the major cities of the world by optical fibre. Additional new cables due for service by 1991, TPC3 and HAW4, will provide the first optical-fibre link from the UK to Japan via Hawaii. These will play a vital part in the world-wide intelligent network's service for Anglo-Japanese trade and the global financial community. Plans are well advanced for a sister transatlantic cable, TAT-9, due to be completed during 1991.

[*Editors' Note*: The July 1986 issue of the *Journal* is a special issue on optical-fibre submarine cable systems, and features TAT-8.]

International Extension for IBM-Compatible Data Services

IBM system users can now make transatlantic data calls over BT's international packet switched network in a new service which also offers them the benefit of 'one-stop-shopping'. This new managed data communications network service will give them one point of contact with British Telecom International (BTI) for all queries—ordering, fault reporting or billing.

BTI's international MultiStream synchronous service (IMSS) is specifically designed for users of IBM and IBM plug-compatible equipment implementing IBM's protocols for SNA/SDLC links. It is an international extension of the IBM-compatible MultiStream synchronous services introduced a year ago on BT's public data network (PDN) in the UK. As such, it renews the company's continuing commitment both to SNA and to its growing number of customers using IBM standard protocols.

Using switches already supporting BTI's international packet switched service (IPSS), IMSS provides an immediately-available packet-switched link initially between the UK and the Telenet global multidrop service in the USA. Extensions to other networks in North America, Europe and the Far East are planned for 1989.

IMSS provides a communications path, transparent to users, which will enable remote terminal clusters and systems to be connected to a single port on a front-end processor (FEP). This will offer maximum network resilience while minimising demand on expensive FEP resources.

Customers access IMSS using a MultiStream synchronous packet assembler/disassembler (SPAD) link over a dedicated Dataline to BT's inland PDN. This allows SDLC host computers and controls to be directly connected. The PDN then routes data packets through BTI's gateway into IMSS. Links between customers' equipment and packet switching exchanges are provided and managed wholly by BT. Host Datalines operate at 9600 bit/s; terminal Datalines at 2400 or 9600 bit/s.

Under its one-stop-shopping facility, IMSS offers customers the freedom to choose either BT or Telenet as the service co-ordinator. The chosen operator then provides the total end-to-end international service, passing to the other organisation all the information needed to provide service as the distant end. This avoids the need for customers having to deal with both operators. The co-ordinator also produces a composite invoice—in the local currency—encompassing the charges generated in each part of an international datalink end-to-end.

In the same way, customers may also nominate one operator for fault reporting, irrespective of fault location. The selected operator will act as the customer's agent in resolving any problems occurring anywhere in the entire link.

IMSS introduces low capital investment needs for customers, and minimises their commercial risks. Its software control enables customers' networks to be selected or reconfigured quickly and efficiently. Error protection inherent in packet-switched networks ensures accuracy of transmission.

Distributing TV by Millimetre-Wave Radio

British Telecom's Research Laboratories have successfully demonstrated the use of short-range millimetre-wave radio for delivering programmes into viewers' homes. If the system were licensed by the Government, it could prove a quick and economic supplement to broadband cable networks. It could bring multichannel TV to millions of homes which are unlikely to be cabled before the year 2000.

The demonstration, being carried out at Saxmundham, Suffolk, is of a millimetre-wave multichannel multipoint video distribution service (M3VDS). It is using radio with a wavelength of about 1 mm (corresponding to a frequency of about 30 GHz) to beam four satellite TV programmes plus the four broadcast services to 10 homes in the town fitted with special antennas capable of receiving the transmissions. A commercial system operating in the region above 30 GHz would be capable of carrying between 15 and 25 channels.

BT's system is made economically possible by using gallium arsenide integrated circuits, designed at the Martlesham laboratories. These microchips allow the receiving equipment to be built at a cost many people could afford. Martlesham already has an established world-wide reputation for the fabrication of opto-electronic components from gallium arsenide and is now pioneering the design and fabrication of circuits operating at the more challenging millimetre-wave frequencies. Martlesham has produced monolithic millimetre-wave integrated circuits (MMWICs) on a single semiconductor wafer, which in production can contain hundreds of individual microcircuits. It has also harnessed the properties of high-dielectric-constant ceramic resonators to achieve cost-effective stabilisation of the millimetre-wave oscillators.

Martlesham research workers estimate that, with the economies of large-scale production, receivers would be produced for about a few hundred pounds. These receivers use a dish only 15 cm (6 in) in diameter, much smaller and more environmentally acceptable than the 30–100 cm dishes needed to receive TV programmes direct from satellites. They are capable of receiving a mix of programmes drawn from:

- TV receive-only or direct broadcasting satellites at several orbiting positions;
- off-air UHF broadcast channels;
- cable TV programmes, as extensions of an adjacent network;
- taped programmes injected at the head end;
- high-definition or extended-definition TV when available;
- local interest and community programmes.

In addition, the system may be easily configured for either PAL or MAC formats. And it would allow different satellite programmes to be viewed on different sets.

The system is ideal for use in country towns and suburban areas. It is also of value as a fill-in for cable systems, especially in fringe areas. Because expensive and time-consuming cable work is avoided, quick start-up is achieved at a more predictable cost. Systems can be established rapidly with service available to all potential customers at the outset.

M3VDS offers the programme base of cable at a receiver cost comparable with the equipment required for home reception from just a single satellite. By increasing overall customer base, it could encourage programme production, benefitting the broadcasting industry as a whole.

The system's transmitter consists of small individual units each carrying one TV channel and radiating from a high building. This could serve an area about 2 km in diameter, covering from 5000 to 10 000 homes.

Racenet London Extension

Racenet, the world's largest private satellite network, set up by BT, has been extended to over 2000 London betting shops, to bring the total live television coverage of race meetings throughout the country to more than 6000 betting shops nation-wide.

The satellite network has been installed, maintained and operated by BT on behalf of Satellite Information Services (SIS). Live television pictures from up to three race meetings daily are transmitted from mobile BT outside broadcast vehicles, via the Telecom Tower and its satellite earth station in London's Docklands to a satellite 23 000 miles over the Atlantic Ocean, and finally to small receiving dishes installed by BT at betting shops throughout the UK.

Under the terms of the overall contract, worth £45M, BT has provided a total solution for SIS:

- over 8500 sites have been individually surveyed;
- over 4400 separate planning permission applications and site drawings have been prepared;
- over 8500 landlords' consents have been processed;
- over 7000 sites have been installed;
- in excess of 600 km of cabling has been laid;
- all sites installed are provided with full operations and maintenance cover;
- 150 people working from nine regional centres have been dedicated to site surveys and installation;
- 170 people, based at 58 centres have been specially trained to handle all maintenance aspects of the network;
- a project management team of 30 has been responsible for day-to-day management and co-ordination.

BT engineers installing and pre-testing satellite receiving dish equipment at a betting office site

The whole Racenet project has been a formidable logistical exercise, the scale of which demonstrates clearly BT's impressive depth of technical expertise, versatility and project management skills. The London switch-on was by far the largest and most complex aspect of the overall service. The service is to be further extended early in 1989.

Notes and Comments

BT NEWS MISCELLANY

IN October last year, BT announced a new digital communications service, *multi-line IDA*, providing business customers with high-speed PBX connections to System X electronic local exchanges. The connections will support the new generation of digital electronic switchboards known as *integrated services private branch exchanges* (ISPBXs), now becoming available from all major suppliers in the UK. They will link ISPBXs into BT's integrated services digital network (ISDN).

The multi-line IDA service follows trials which have been running for several months. About 18 000 multi-line IDA ports operating at 2 Mbit/s are ready for use [October] on System X exchanges and the number will progressively increase with the advance of BT's modernisation programme.

Coincident with the launch of multi-line IDA, BT's IDA customers with terminal equipment complying with the international standard X.21 interface are able to access British Telecom International's first international 64 kbit/s circuit-switched digital data service which connects IDA customers with users of France Telecom's 64 kbit/s circuit-switched digital data network *Transcom*. This service heralds the first step on the evolutionary path towards the interconnection of national ISDNs to other countries.

PRIME Computer Inc. and BT, through its US subsidiary Dialcom Inc., has announced a world-wide co-operative effort to develop, market and support communications systems for electronic messaging and information systems for major enterprises.

BT has announced that it is to spend a further £15·8M to complete the modernisation of its inland Telex network. This latest phase will bring BT's investment in the Telex network to more than £100M in the past five years and will lead to an all-digital network within three years. The investment will be used to extend the nine existing provincial digital exchanges and provide a new exchange in Cambridge. These ten exchanges will then absorb customers connected to remaining analogue exchanges.

BT has announed the formation of a Japanese subsidiary company, British Telecom (Japan) K.K. The new company consolidates BT's growing involvement with the Japanese market and follows the formation of a Representative Office in 1986. The new company will actively reinforce BT's telecommunications business with Japan. It will also enable BT to develop its existing businesses for Japan, including its Integrated Trading System for the finance sector, and to seek new markets for its wide range of products, systems and applications. British Telecom (Japan) K.K. will be headed by Dr. George Newns, formerly one of BT's General Managers for Overseas Business Development.

AS a further development in its long-term strategy to establish the company as major world-wide communications and information technology player, BT announced in October last year the consolidation of a number of its activities into a new division called the *Communications Systems Division* (CSD). Operating divisions British Telecom Enterprises (BTE) and the International Products Division (IPD) were amalgamated into the new division. In addition to the operation and management of the units within the two divisions, CSD is also responsible for the product management of customer premises equipment and for a new unit to focus on systems integration.

Managing Director of the new division is David Dey, formerly Deputy Managing Director of BT's UK Communications Division. Sydney O'Hara (formerly Managing Director of BTE) and John McMonigall (formerly Managing Director of IPD) will report to him as Managing Directors of Operations in the new division. All three remain members of the BT Management Board.

Operating units within CSD include British Telecom Applied Technology (BTAT), BT Vision, Dialcom, Information Technology Systems, Marketing Information Services, Mobile Communications, Network Products, Telecom Systems and Yellow Pages. In addition, CSD is responsible for handling BT's interests in Mitel.

BT has also announced a further consolidation of its divisional management. British Telecom International has taken on the responsibilities formerly held by Overseas Division. The Managing Director of BTI is Mr. Anthony Booth. This rationalisation of the company's international activities completes the process of establishing three strong operating divisions covering the company's main activities:

- UK Communications Division—the core telecomunnications activity in the UK,
- British Telecom International—international telecommunications and overseas operations, and
- Communications Systems Division—a portfolio of products, systems and applications for world-wide sales.

MR. Geoffrey Mulcahy has been appointed as a non-executive Director of British Telecom. He fills one of two positions reserved for Government Directors.

BT has awarded STC plc a series of orders worth £65M, including further enhancements to BT's directory assistance service, 30-channel PCM and 2 Mbit/s line equipment, software for STC's programmable digital multiplexer to be deployed in the city fibre network together with optical line systems and multiplexers, and for the provision of MF4 signalling at all TXE4 exchanges throughout the UK.

THE world's first public demonstration of the revolutionary Phonepoint mobile telephone service was carried out by BT on 14 November 1988. The demonstration took place using a BT Phonepoint in Euston Square, London. Phonepoint is BT's version of the public telepoint service being pioneered in Britain and based on a new generation of cordless telephones known as *CT2*. It will allow users to make calls from a network of Phonepoints situated in public places—bus and railway stations, shopping centres, airports, garages and motorway service stations. A consortium of leading international telecommunications companies, including British Telecom, STC, Nynex International and France Telecom, has applied for one of the Government's licences to run a telepoint service. If successful, it will use the Phonepoint system.

BT is developing new videoconferencing equipment which should result in substantial cost reductions in its conference-by-TV service and lead to wider use of the facility. The decision follows the adoption by the CCITT of a new international standard for codecs. BT has made a major contribution to the new standard and plans to implement it as quickly as possible. Existing codecs, to H.120, operate between 768 kbit/s and 2 Mbit/s. The new standard, H.261, allows codecs to operate at rates down to 384 kbit/s, reducing transmission costs significantly. It can even be extended down to 64 kbit/s, the basic rate for switched links on public ISDNs. The CCITT also proposes transcoders to allow systems meeting the H.261 recommendation to interconnect with services operating to the existing H.120 standard. BT is the only UK videoconferencing provider to have established a track record for supplying services capable of interworking with earlier systems.

A MEMORANDUM of understanding establishing a framework for co-operation has been signed by British Telecommunications plc and STET—Societa Finanzaria p.a., the Italian State telecommunications group, covering diverse telecommunications businesses from network operations to manufacturing. BT and STET have agreed to collaborate on the development of business into the 1990s in preparation for the unified European market after 1992. Discussions have already focused on, and will continue between the two companies, exploring the scope for co-operation in specific areas of business, developing further and enhancing the companies' international communications services and harmonising their positions on matters of mutual interest. Specific areas for collaboration include standards, network modernisation and services, mobile communications, value-added services, network services, 'one-stop' shopping, and the use and planning of international networks.

BRITISH Telecommunications plc has also signed a collaborative agreement with Telefonica de Espana S.A., the Spanish telecommunications operator with interests in most telecommunications business sectors. BT and Telefonica have agreed to update, redefine and give greater substance to their common traditional commercial relationships. Specific areas where collaboration is being pursued include international networks, 'one-stop' shopping, a number of value-added services, co-operation in the marketing of products, temporary exchanges of staff, optical-fibre applications, and computerised management support systems.

BT has announced an agreement to provide Telefonica of Spain with a complete telecommunications network management system. The system, the largest and most up-to-date of its type in the world, will control Spain's international and domestic networks. It will be located at a new network management centre near Madrid which will support the rapid development of Telefonica's digital network. The new system will be based on BT's own network management facilities in the UK.

JOURNAL DISTRIBUTION

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 following address: *BTE Journal/IBTE Administration Office*, 3rd Floor, 84–89 Wood Street, London EC2V 7HL. (Telephone: 01–356 8050; Fax: 01–356 8051; Gold Mailbox: 73:TAI009.)

British Telecom
Fulcrum
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Mini-COSMIC(TM)

A new, small, single-sided, main distribution frame

The Mini-COSMIC distributing frame is breaking new ground by providing a modular distribution frame which has been designed specifically with the end user in mind. By alternating Line Bays and Exchange/Equipment Bays it provides for short jumpers and easy installation of service. As a proven system the Mini-COSMIC has been derived from the highly successful COSMIC range of distributing frames which can cater for up to 400,000 lines.

BT Fulcrum can supply the Mini-COSMIC in any configuration to suit your specific planning and installation requirements.

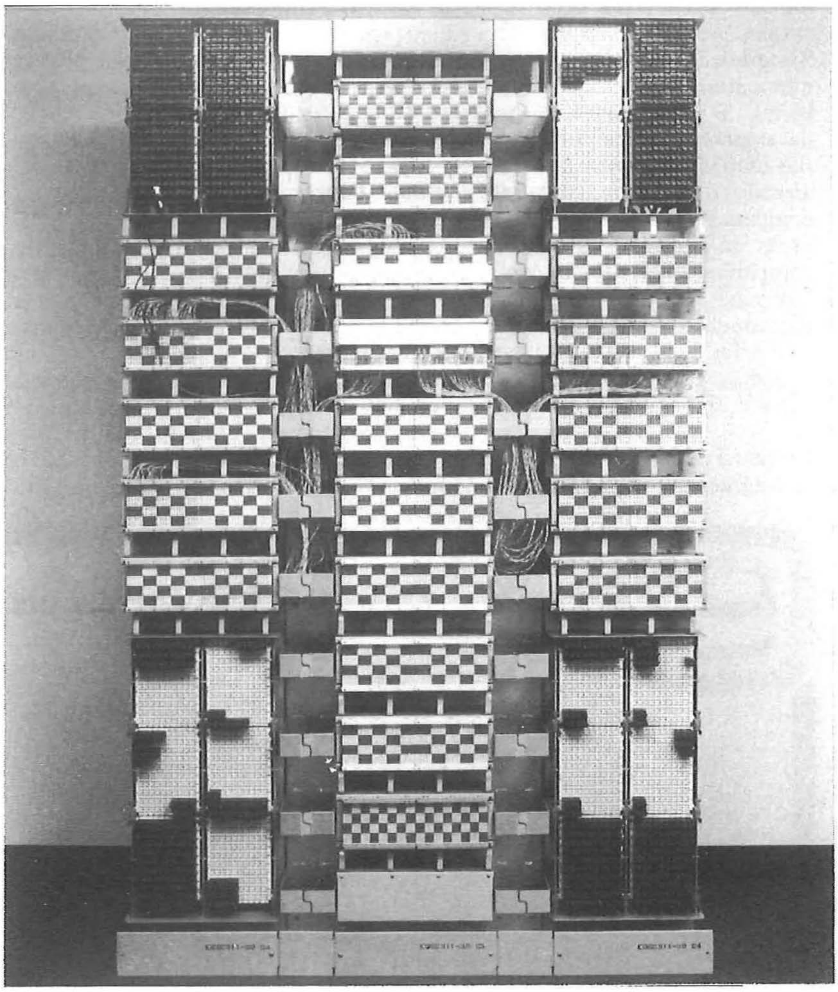
Mini-COSMIC Benefits:

- single sided administration
- may stand directly against a wall or may be free standing
- designed for digital exchanges
- ideal for public or private exchanges, repeater stations, trailers, containers or even ships
- efficient termination using Insulation Displacement Tags
- 3 or 5 point protection is available to protect staff, exchange/equipment and spare external cable pairs against lightning surges and mains power
- ideal for System X or Y RCC's and the larger UXD5 s
- totally single-sided and low height
- eliminates the need for travelling ladders
- modular design allows growth as required
- cabled from above or below
- comprehensive range of tools and accessories are available

The Mini-COSMIC dimensions:

Dimensions relate to the configuration illustrated.
2134 mm (7ft) : high
1320 mm (4ft 4in) : wide
380 mm (1ft 3in) : deep

The two outer bays terminate a maximum of 1000 outside plant pairs each and the centre bay terminates a maximum of 2560 exchange/equipment pairs. The above installation can be extended to serve 12000 outside plant pairs and 15000 exchange/equipment pairs – still occupying only 7925 mm (26ft).



Description

Mini-COSMIC comprises framework and equipment modules. The framework is made up from line bays, equipment bays and vertical jumper troughs. For large capacity installations additional upper express troughs are available. External cables are terminated on connector/protector units and jumpering is between either 128 or 100-pair termination blocks fitted with insulation displacement tags.

Service & Support

Fulcrum provide comprehensive support at the configuration and pre-installation stages as well as during and post-installation.

For further information please contact:

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