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British Telecommunications Engineering

EDITORIAL

Communication is a vital ingredient for the development of industry and commerce. Telecommunications, since its first tentative steps were taken 150 years ago when Cooke and Wheatstone took out the first patents for the electric telegraph, has been the catalyst for even greater economic and social development than ever before. Telecommunications has insinuated itself into most aspects of everyday life, but the perception by the majority of the public of telecommunications as the payphone and the plain old telephone service, despite their ability in the UK to dial directly to some 550 million telephones world-wide, is only the tip of the iceberg: instantaneous communication is no longer the miracle of the age, for it is assumed to be the norm; television news coverage from every corner of the globe is commonplace, yet it was only 25 years ago that the first fleeting satellite pictures crossed the Atlantic Ocean. In the banking sector alone, telecommunications is the key to electronic funds transfer and automated teller machines, but world-wide it is an important element in the national interbank clearing operations which exceed $2000 billion per day. The importance of telecommunications has long been recognised. Indeed, the International Telecommunications Union (ITU) was founded in 1865, before even the invention of the telephone, to provide a forum for the interchange of ideas that has resulted in the creation of man's most costly and complex artefact, the international telephone service. This October, with the theme of 'Communications Age: Networks and Services for a World of Nations', the ITU has organised the fifth in a series of world telecommunications exhibitions — TELECOM 87 — to demonstrate the new technologies and emerging applications in telecommunications. But are these services what the customer wants, or even needs? In an article on p. 154, Iain Vallance argues that developments in technology are not enough: human relationships, both personal and public, must grow apace with technology for telecommunications to be a better servant of its customers.

Growing Up in an Information Age

Address to IBTE Martlesham Heath Centre

I. D. T. VALLANCE, M.SC., B.A.†

UDC 654 : 681.3

This article is based on the address given by Mr. I. D. T. Vallance, Chairman (then Chief Executive) of British Telecom, to the Martlesham Heath Centre of the Institution of British Telecommunication Engineers (IBTE) on 11 June 1987. In his address, Mr Vallance discussed how changes in technology were having a profound influence on the scope of personal and public relationships in everyday business and the importance of developing these relationships for better service to the customer.

INTRODUCTION

I am delighted to be invited to address the Martlesham Centre of the Institution of British Telecommunications Engineers (IBTE) and to see so many of you here. I do visit Martlesham from time to time, but usually for a specific presentation or meeting with a particular group, and I am glad to have this opportunity of widening my contact with you.

A week ago, at our *Telecom Today* Forum, when we focussed on technology, Colin Browne, the Director of Corporate Relations, opened the session with the motto: *Becoming masters of technology to be better servants of our customers*.

This afternoon, here at Martlesham, amongst you veritable masters of technology, if not Doctors of Philosophy, I would like to lead up to the second part of that motto: **to be better servants of our customers**, by touching on the question: *What does growing up in an information age mean, both for us as individuals, and for the development of our relationships with our customers*?

DEVELOPING RELATIONSHIPS

Growing up as a human being involves developing relationships with other people. To get the best of these relationships, as year succeeds year, we, and our relationships, have to mature. And a maturing relationship, like a good vintage wine, can appreciate in value through our life.

The potential variety of our relationships is increasing rapidly as transport becomes cheaper and faster, as boundaries between nations, cultures and disciplines are weakened and as our own information age gathers pace through technical advances and through the liberalisation of markets.

We have relationships at home, at work and, nowadays, not simply in our immediate neighbourhood, but further afield in this country and overseas. These relationships are being influenced by the new information age, sometimes for good—as in the quality of modern communication—sometimes, I reckon, for ill—in terms of the sheer quantity of trivial information that accompanies the significant data with which we are bombarded daily.

So there are positive sides and problems in the potential of this new information age. We have a new *permissiveness* both in what information technology will permit us to do and in our legal framework. But the new freedoms have to be used sensibly in developing relationships. The moral permissiveness of the last 20 years has not been without its problems, and instances abound of what can happen if such freedom is used irresponsibly.

Indeed, a wise old theologian, asked shortly before he died what he thought of the permissive society, replied: 'there is nothing wrong with permissive society provided you are mature enough to live in it.' [the late Alan Stibbs, speaking at the Law Society.]

In other words, you have to grow up to live in a new age: and we in British Telecom, as a business seeking to prosper in a liberalised market, have to grow up—we have to mature—if we are to make the best of it.

THE SPREAD OF INFORMATION

But ours is not the first information age; there has been a series of them.

The first age required spoken languages that were sufficiently sophisticated for people to organise large-scale architecture—as in the great myth of the Tower of Babel. The storyteller of Genesis could see at once the great advantages which flowed from a common language: messages could be passed by messenger across the world, and stories from one generation to another.

Spoken language has survived, but in such profusion that we have considerable potential for misunderstanding, and we have developed divergent cultures and concepts.

† Chairman, British Telecom

The second age involved writing and dates back at least 5000 years. It became the hallmark of Near Eastern civilisation and progress. Early storage media, tablets or scrolls, were, in our terms, rather inefficient, and the writing and copying processes tended to be expensive in human labour.

Bound books did not appear until the second century AD, yet it was an age whose leading writers are still having a profound influence today. It was an age in which long complex messages could be transmitted; when an empire could organise a large-scale census and associated taxes; when planning and rationing became convenient, and the first message handling systems began to develop.

The third age came with a significant improvement in the production of paper in the fourteenth century; the Italians developed a combination of quality and cost reduction that paved the way for the economic use of the new printing technology.

It is worth reflecting on the vital importance of this unit cost reduction in revolutionising the handling of information. The ability to circulate information in seemingly unlimited quantities had dramatic consequences for life. Demand from the rising literate middle classes saw the classics translated into all the languages of civilised society. New classics emerged such as our own Shakespeare, Hobbes and Locke, and apart from the possibility of catalogue shopping, paper securities and thick legal codes, the postal services could boom.

But information coupled to energy had tremendous power, a disturbing power that led to new laws: publication was controlled, for political as well as economic reasons; regulated monopolies were established, and, with intellectual property law expanding to cover the new possibilities, the seeds were sown of the industrial revolution.

The new information technology opened the way to financial markets of a type which is still familiar. Amsterdam became a leading financial centre with a rapid rise of paper transactions during the first half of the seventeenth century, and the City of London followed in its wake rather later.

However, the main routes of international trade and communication were the sea lanes with a network of European outposts around the globe; ports and their immediate hinterland prospered. Seafaring was hazardous, but so was land travel, and the fastest means of communication was usually by water.

Faster means were sometimes available, but they relied on line of sight to spot the signals sent by beacon, smoke, flashing light, flags or semaphore; then came electricity!

So we come to our own age, the fourth information age, an age that has been gathering pace since the introduction of the electric telegraph opened up the possibility of world-wide telecommunications in virtually real time.

Here in Martlesham you are on the bow wave of the new age as you work on electronics and now optical systems for handling and storing information. Your work has profound implications for the culture, the trade and the politics of our world. To an outside observer, it is fascinating that some of you are working on allowing people to communicate with machines using the speech of the first age whilst others engage in the search for a common sophisticated language so that our machines can communicate efficiently between themselves.

The tools at your disposal, the tools that you are developing, have the potential to be as significant in changing our world as the tools used by scribes, papermakers and printers in previous ages.

In this fourth information age people will be increasingly dependent on the skills which you, here at Martlesham, here in the back room of the business, represent. Yet it is a feature not just of research and development, but of information technology generally, that we are usually unseen servants of our final customers. Being out on the bow wave means that few of us have direct contact with more than a tiny proportion of them.

If we think about it for a moment—most of the time our customers experience our service through our equipment, quite automatically—they are in control, they dial and, on the whole, they get through. In the future, they and their equipment will be able to interact with our network in increasingly sophisticated ways; our place may be to make that interaction so straightforward that they do not have to think about us, as people, at all unless they require training or a new service.

CUSTOMER EXPECTATIONS

At present, many people only speak to someone in British Telecom when something goes wrong and, as I know from the complaints I get, when something goes badly wrong they can sometimes get very uptight with British Telecom staff. This very uptightness is a measure of the importance of our role in their lives.

Understandably so! because people have become so highly dependent on our services. For instance, in the City of London, we feel like victims of the very success of telecommunications: between 30 and 100 times as much trade now goes on over telecommunications links as on all the ships and aircraft going to and fro from the UK. Demand for our services has continued to soar in the City since the Big Bang and, even with hundreds of extra staff and much increased levels of supply, we are having great difficulty keeping up.

And many of our customers need us to have modern technology because they too are trying to improve the quality and value for money they offer; they too are trying to meet even more stringent demands; and often they need our services to get the best from their own investment in new technology. Like us our customers are under pressure. Like us they are having to grow up in a new information age.

What then would the average customer expect from a large telecommunications company, in terms of everyday service?

Well, the relevant BTEC course no doubt provides the answer; as studious readers of the *Supplement* to April's *British Telecommunications Engineering* will recall, the answer (and you can apparently expect three minutes to get this down) is, and I quote:

Typical customer expectations would be:

maximum value for money,
immediate installation of new telephones,
fast and accurate connections to called parties,
satisfactory two-way conversation,
immediate repair of any service breakdown no matter how minor the breakdown.

In other words the **average** customer wants quality and value for money in plain old telephony; fortunately for those of you involved in more sophisticated information technology many customers are now demanding rather more in the way of information services, and we expect that demand to grow in quality and quantity year by year.

As I hope you all know, my personal ambition as Chief Executive is to make British Telecom a telecommunications operator second to none in terms of quality, value for money, technology and in the information services which we are able to offer our customers; in the catch phrase **Top Telco**.

Discussing what that means at one of our *Telecom Today* fora, I was delighted when one of your number spelt it out as putting the Top Telco theme into practice in his own job here at Martlesham. It is self-evident that people like me at Board level have to find new ways of handling relations with our customers and their expectations. It is less evident, but equally true, that every one of us in British Telecom needs to be involved if we are to live up to that initial motto of becoming masters of technology to be better servants of our customers.

And this is where the complications arise in terms of relationships because, as I said just now, most of us have little contact with our ultimate customers. But we have to consider our internal customers; for our business involves tremendous interdependence.

Imagine cutting over a single System X and you soon begin to appreciate the need for effective vertical integration from specification through development and procurement, design and assembly, software and data building, routing and wiring, all the work that needs to have gone on before the exchange is cut over. And again, if one thinks about the number of people who may be involved in handling a single customer order from the initial contact through to installation, one soon realises that becoming better servants means recognising our part in a chain of internal customer relationships.

PERSONAL ROLES AND RESPONSIBILITIES

Growing up means growing into relationships with each other in that chain. Those of us who are in management have a vital task not only in helping each person who is in a link in that chain to have the skills and the tools needed to be dependable, but also in helping individuals and teams to grow into relationships within the chain that are effective in serving the ultimate customer.

I would like to look at some of the essentially human aspects of those relationships. Let us start with trust; trust is fundamental to human relationships: from the earliest we trust that the sustenance which our mother provides is safe; poisoning, whether negligent or deliberate, is seen as a rather serious breach of that trust.

I hope each of us has valued relationships of mutual trust and respect at work, but I fear that each of us has also known the downside of mistrust and suspicion in a relationship that has not matured properly. In mentioning hope and fear, we move to the expectations that are associated with any relationship. In a relationship of trust and respect we have good grounds for hoping that our best expectations will be fulfilled; in one of mistrust, we fear that our worst expectations will be fulfilled.

But we ourselves are the other side of each relationship, and mutual trust demands of each of **us** that **we** are trustworthy and deserving respect. Whilst, on one hand, that means trying to avoid building expectations that we or others in the chain simply cannot meet, it also means being ready to do our level best to meet the high expectations which others are trusting us to fulfil.

I recognise that in going for high expectations means taking risks; it means that we have to rely on each other to use our initiative. It means being clear about the direction in which a project is going and the purpose that underlies it. In the sponsored work at Martlesham that direction and purpose needs to be decided by the appropriate Divisional staff in light of their own customer relationships.

It also means thinking through the selection and management of our *blue sky* projects. These are important, but our *blue sky* pilots, flying above and beyond the bow wave, are even further away from the final customer than most of us are. I am sure that your new Director, Alan Rudge, will bring a fresh perspective to this work.

In the relationships in which we are involved, we have to strike our own balances between our autonomy and the need to consult; it's not always an easy balance—we may make mistakes—it's a bit like riding a bicycle, with experience our instability is less likely to result in a fall. We learn self-control even if some doubts remain. Rules may be set down to govern overall (or even particular) situations, but within them personal initiative and responsibility are essential.

Again, part of growing up is taking responsibility; the old Post Office was not too good either at expecting personal responsibility or shouldering corporate responsibility; the TIs often watered down the former and the Act specifically exempted us from the latter. I have no doubt that an important part of growing up in our relationships, whether inside British Telecom or at the interface with our customers, is going to be how we accept responsibility and how we cope when we have failed.

I mention failure, not because we should tolerate it as we strive towards a *Total Quality* approach, but because, without establishing good ways of dealing with failure or indeed success, we may remain reluctant to take risks or to give or accept responsibility. I intend that we shall develop firm and fair relationships both with staff and customers. Indeed, we are already re-examining our contractual terms to see whether they fit this particular bill.

I mentioned skills, I mentioned tools and the need for each of us to be equipped to be dependable. In this each of us is a customer for training and development. But the fact that we are customers does not exempt us from responsibility. I expect each of you to accept that part of your own personal responsibility in your particular job, and for the future, is to think about and be committed to your own continued development, your own mental and physical fitness for the tasks you undertake.

It is a personal responsibility but it is also one element in the management chain as part of each manager's responsibility. The resources of the personnel function are there to support you, but the fundamental responsibility is with you. You should have an input to the annual appraisal cycle and to your own development plan and you should expect to put your commitment into your future and not simply to rely on the business as happened all too often in the past.

BUSINESS MISSION

I am in no doubt that British Telecom has a good deal of the cream of Britain's work force, we have tremendous potential, but it does need to be harnessed; we need to be clear about our mission, what it is we are about, and our values; how it is that we go about our business.

My colleagues in the Operations Executive Committee and I have been devoting a good deal of attention to this recently and we shall be setting out the results of our labours in the coming months. We have seen the need to clarify roles and relationships so that each of us knows who our immediate customers are and so that their requirements can be spelt out and met in a professional and helpful way—ideally *right first time* though I appreciate that on the research side that is not easy.

British Telecom's Mission

British Telecom's mission, our central purpose, is:

- to provide world class telecommunications and information products and services; and
- to develop and exploit our networks at home and overseas—so that we can:

  meet the needs of our customers;

  sustain growth in the earnings of the group on behalf of our shareholders; and

  make a fitting contribution to the community in which we conduct our business.

British Telecom's Values

in conducting the business to fulfil that mission:

- we will make sure we understand our customers' needs and give increasing value for money;
- we will constantly improve the quality and capability of our products and services;
- we will compete strongly but fairly in the market place; we will keep our business by looking after our customers in an expert and helpful way and by meeting their requirements first time, every time;
- we will make sure we understand and meet the needs of our colleagues, to enable us to operate as an effective team;
- we will ensure that British Telecom people—our most valuable asset—know what is expected of them;
- we will encourage them to express their views and give them the means to make a real contribution to British Telecom's success; we will treat them fairly and firmly and reward them justly;
- we will foster pride and integrity in the organisation and trust amongst each other; and
- we will make sure we understand and improve the effectiveness of our suppliers so that they can meet our needs first time.

We are also working on a statement of how the group operates; this statement will go on from the mission and values to setting out the structure of the organisation, the role and responsibilities of the constituent parts; the checks and balances by which the group is controlled and the relationship and interdependencies that we must manage if we are to ensure our long-term success.

Amongst the detail, we shall be working on the role of account and product managers, each of whom has a place in the *chain of service* as a surrogate for the ultimate customer and as a vital link in communication between people like yourselves and our markets.

Account managers—that is, individuals who look after specific customers--have a particular role in fostering loyalty between customers and the business. Our old organisation was strong on loyalty (though not always with customers) and it is a quality that we should retain. Of course it needs to be updated to take account of the changes that have taken place: competition, for one instance, and changing career patterns for another. Nonetheless it is worth sustaining—particularly in the face of our own, all too common, cynicism. If we are to grow into mature relationships, then there will be a place for humour, but it needs to be a healthy humour rather than a sour one. We do not attract credit to ourselves or to British Telecom when we run it down. Let us be self-critical, but in ways that put things right.

EXTERNAL RELATIONSHIPS

We are not an island; each of us has to depend on others, inside and outside business; we shall need to mature in our relationships with contractors who are at once suppliers, customers, competitors and potential collaborators; we shall have to mature as an international player, and we have much to learn—including languages and about other people's cultures and their ways of doing business.

In this area, Martlesham has already taken part in our exchange arrangements with NTT. When I was in Tokyo in April, Dr Shinto and I signed a fresh agreement to extend the scope of our exchanges and I am sure that we can use our long-standing relationship with NTT to gain a better understanding of each other. NTT (like ourselves) were a statutory monopoly; they (like ourselves) now face competition and they too have their shares listed on the Tokyo Stock Exchange, albeit at a much higher Price/Earnings ratio.

As statutory monopolies we, the old operators, could have stagnated and just about survived. But as we are privatised and our markets liberalised so stagnation must mean eventual extinction. We have no realistic choice. I believe that we, in British Telecom, and our equivalents around the world, have to grow up, we have to develop better relationships with our immediate customers and our ultimate customers.

In a word, we need **integrity**.

- Integrity in our technology—our strength has lain in being operators of the network; we have had to see that international communications worked smoothly; now we need to develop our skills **and to use coherent architecture** so that our information services can be built on integrated networks, products and equipment that work properly together.
- Integrity in our organisation—in providing information services to our customers, it is not simply the technology that needs to work together: individuals, teams and units need to work together effectively; and this means
- Integrity in our dealings with others —honest work and wholehearted workmanship, and an
- Integrity in facing the world as it is; it is an uncertain world, we have an uncertain future. Some react to this uncertainty by hoping for stability and then despairing of finding it. I hope that we can acknowledge and face up to uncertainty, integrating ourselves with the world as it is so that we can make the best of it.

CHANGING WORLD

Our world is, in its very nature, dynamic. The natural world is a place of constant changes, some faster, some slower, and it is the same with technology and human relationships. When I started work 20 years ago, Kao and Hockham were just publishing their seminal paper on optical fibres and we were still civil servants working in a Government department.

Ten years ago, (when we still had Dollis Hill and this place was just beginning to appear above the trees) millimetric waveguide was still in favour. A decade after Kao and Hockham, there was still no full-scale production of optical fibre cable in the UK. System X was coming along and for most people in Post Office Telecommunications, I guess, the future seemed certain and secure.

But the seeds of change had already been sown, not just technically, but socially and politically—as can be seen in the Carter Committee's report and in some Conservative writings of the period; uncertainty and change were in the air, but most people carried on oblivious behind closed windows.

It was possible for innocence, or was it ignorance, of the underlying process to keep people from adapting while they basked in an illfounded sense of security.

Now we have learnt that the future is uncertain; today's General Election is unlikely to be the last (at least I hope not!) Yesterday's technological breakthrough is but just another step towards the prospect of a fifth information age.

Integrity is an asset that we should grasp as we face the future; it can outlast particular technologies. And if we build it up in British Telecom it will stand us, and our successors, in good stead.

CONCLUSION

As I conclude I realise that some things have turned full circle; like the Egyptians before us we are back to communicating with flashing lights; like the users of clay tablets, people are looking for flatter and flatter displays, we might call it electronic paper; and, in the sophistication of our architectural development and software engineering, we are searching for a common language holding the key to communication and organisation. Speaking as a language graduate not as an engineer, I assume that such a language might help you to be masters of technology. But I believe that its **real** importance for all of us in British Telecom would lie in enabling us all to be better servants of our customers.

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Biography

Iain Vallance received his B.A. degree from Brasenose College, Oxford, and then joined the North West Region of the Post Office in Manchester as an Assistant Postal Controller. Two years later, he moved to Postal Headquarters in London. In 1970, he became a post graduate of the London Business School. After being awarded an M.Sc. in 1972, he joined the Financial Policy Division and, a year later, was appointed Personal Assistant to the Chairman of the Post Office. He was made Head of the Financial Policy Division in 1975; and, in the following year, at the age of 32, became Director of Central Finance. He became Director of Telecommunications Financial Planning in 1978, and Director of Procurement Executive's Materials Department in 1979. He joined the Board of British Telecom in 1981, and, after a brief spell as Assistant Managing Director of the then Inland Division, was appointed Managing Director of Local Communications Services. He became Chief of Operations in 1985 and Chief Executive in October 1986. He took up his present post of Chairman of British Telecom on 1 October 1987 on the retirement of Sir George Jefferson.

CCITT Signalling System No. 7 In British Telecom's Network

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UDC 621.395.34

This article is an overview of CCITT Signalling System No. 7 and its application to BT's evolving network. The structure of BT's current version of CCITT No. 7 signalling is described together with indications of proposed enhancements expected to take place in the late-1980s and early-1990s. Later articles will describe in detail the various component parts which make up BT's CCITT No. 7 signalling and how it is tested within BT's network.

INTRODUCTION

The CCITT Signalling System No. 7 (CCITT No. 7) is a common-channel signalling system in which information can be transported between two stored-program controlled (SPC) exchanges over a single high-speed communications channel (64 kbit/s) by means of labelled messages. The signalling information relates to a large number of circuits and provides the capability to implement a variety of new services, including many that are based on the integrated services digital network (ISDN). BT regards CCITT No. 7 signalling as one of the key elements in the development of its telecommunications network and as a result has been implementing this standard over the last three years on all its digital exchanges (System X *et al*).

This article gives an overview of the structure of CCITT No. 7 signalling, the national specifications currently being adopted in BT's network and gives an insight into likely future evolution in relation to ongoing CCITT studies during the 1984-88 period.

STRUCTURE OF THE SIGNALLING SYSTEM

When CCITT No. 7 signalling was first specified, its main purpose was to set up and release physical circuits between digital exchanges for telephony-type services.

To take account of the wide range of applications that were foreseen for the signalling system, it was designed on a very modular functional basis. The transport mechanism is application independent, and it is this feature that is one of the principal strengths of CCITT No. 7 signalling.

Figure 1 shows schematically the structure of CCITT No. 7 signalling.

BT's version currently comprises two main parts:

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- *Message transfer part* (MTP) this is common for all applications. It transfers signalling messages over the network and performs subsidiary functions such as error control.

The MTP has a three-level hierarchical structure:

(*a*) Level 1—encompasses the physical signalling data link, which in a digital network consists of a 64 kbit/s time-slot in a PCM system. In most cases time-slot 16 is used, however there is nothing that prevents any time-slot except time-slot 0 from being used.

(*b*) Level 2—encompasses the signalling terminal together with functions for adaption between the processor software signals and the bit stream of the signalling data link. Fields for error detection and correction are added by the signalling terminal to ensure error-free transmission. These fields are analysed in the receiving signalling terminal, and repetition is requested if an error is detected.

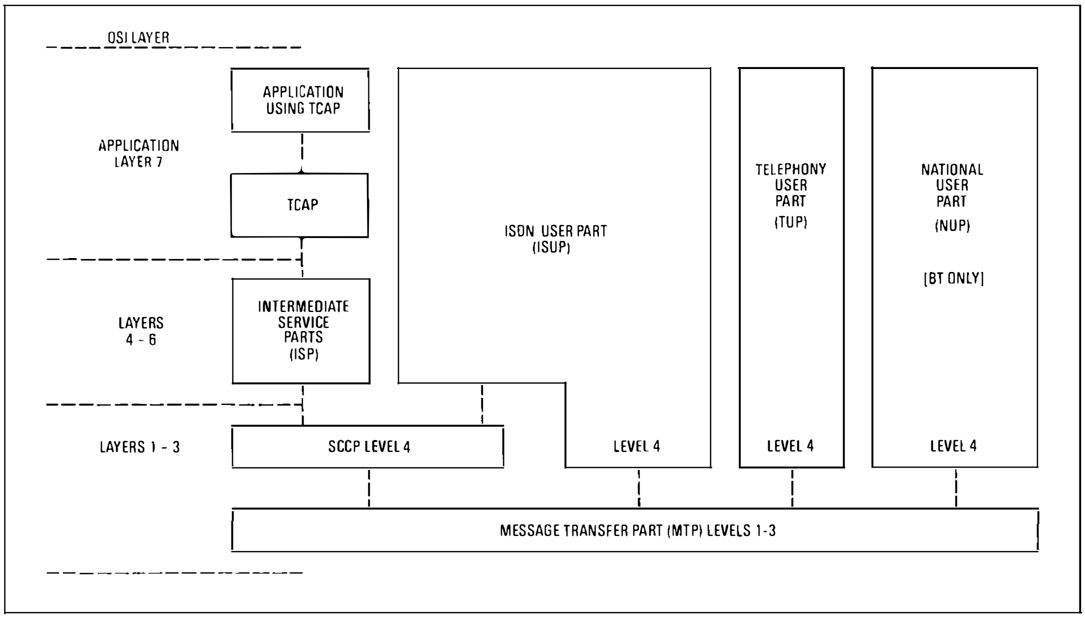
(*c*) Level 3—comprises the signalling network functions, including transfer of messages, reconfiguration of routes after failure, or sending information about abnormal situations in the signalling network.

- *User part* this is application dependent. Within BT this is termed the *national user part* (NUP) and this is known as *Level 4*. The NUP defines the functions and procedures that control both telephone and ISDN-type calls and circuits; for example, the signalling information to be exchanged between the switching centres, and the various signals that should be used.

NATIONAL SPECIFICATIONS FOR CCITT SIGNALLING SYSTEM No. 7

Because of its intended versatility and reliability, the specification for CCITT No. 7 signalling is very complex, and occupies approximately 450 pages of text simply to cover the MTP and user part areas in CCITT

Figure 1
Relationship between CCITT No. 7 Functional Levels and OSI layering



OSI: open systems interconnection
SCCP: signalling connection control part
TCAP: transaction capabilities application part

Recommendations Q.701–Q.707 and Q.721–Q.725.

When BT decided to specify its network requirements for CCITT No. 7 signalling some four to five years ago, the CCITT Recommendations were used as base documents; however, the level of detail and the scope of the information was found to be inadequate for implementation purposes, hence BT produced its own series of specifications.

Message Transfer Part

The BT implementation of the MTP is specified in BTNR 146 (British Telecom Network Requirement) and BTNR 167 Issue 2 and is based very closely on the CCITT Recommendations. Even so, the MTP(BT) differs from that adopted in many other countries for two reasons:

(*a*) The CCITT Recommendations allow for a number of national options. An example of this is that the CCITT Recommendation allows load sharing either within a linkset or between linksets; BT has implemented load sharing with a linkset and requires an even distribution of traffic to available links.

(*b*) In some cases, the CCITT Recommendation is not sufficiently complete to allow implementation in practical networks. An example of this is that a load-sharing algorithm is necessary before implementation can take place; however, this is not specified in the CCITT Recommendations.

National User Part

The BT NUP specification (BTNR 167) differs from that of CCITT in a number of areas. The main reason for these differences is that when BT was specifying the requirements for its digital network in the late-1970s and early-80s, the CCITT was concentrating on the telephony user part (TUP). Hence, whilst using the studies as a basis for the NUP, additional features were added to incorporate ISDN capabilities. Examples of these are:

(*a*) The TUP procedures allowed information to be passed only on a link-by-link basis. In an ISDN environment, it is necessary to provide end-to-end procedures to allow services to be provided on the periphery of the network without changing all nodes in the network. These concepts are now being introduced in the CCITT.

(*b*) CCITT Recommendations do not take account adequately of the existence of more than one version of CCITT No. 7 signalling. BT adopted a 'confusion' message to determine the level of implementation in other nodes of a network. This concept has only recently been addressed in CCITT.

The adventurous decision to aim for an early implementation of the ISDN within BT's network has resulted in BT's MTP and NUP specifications of CCITT No. 7 signalling having to predict the direction CCITT would go in areas that had not been adequately specified.

The BT specifications for CCITT No. 7 signalling have recently been completed for the ISDN Phase 3 development programme of the network, and many sophisticated services have been incorporated. The process of deriving a specification which allows different exchange manufacturers to develop the signalling system independently of each other, whilst ensuring interworking occurs, is enormous. Currently the specification is in excess of 1000 pages of text and drawings.

EVOLUTION OF NO. 7 SIGNALLING AND ASSOCIATED SPECIFICATIONS

During the 1980–1984 study period, the CCITT extended No. 7 signalling by the introduction of three additional parts which were published in the 1984 Red Book:

- the signalling connection control part (SCCP),
- the operations and maintenance application part (OMAP),
- the ISDN user part (ISUP).

During the current CCITT study period 1984–1988, work is continuing on the above topics with the addition of another part called *transaction capabilities applications part* (TCAP).

A brief review of each of the newly specified parts is given below:

Signalling connection control part The SCCP has two basic purposes: it allows information to be exchanged between network nodes that are not connected by telephony circuits, and it provides addressing capabilities between nodes connected to the same or different signalling networks.

Operations and maintenance application part The OMAP defines procedures for supervising, controlling and testing a signalling network. In addition, it may also enable the transfer of bulk data to be undertaken by the signalling network and carry management commands relating to the operation of the main network.

ISDN user part The ISUP is designed basically for the provision of ISDN services within the switched network. It also defines new principles in network signalling, such as symmetrical release of circuits under calling- or called-party control etc. The ISUP is undergoing considerable revision in the current study period ready for publication in the 1988 Blue Book Recommendations.

Transaction capabilities application part The TCAP is somewhat unusual in that, although it is part of the application layer (the layer that provides real applications or services), it does not offer any real services. What it does offer is a standard structuring technique for non circuit-related applications which should simplify the task of defining application protocols.

Evolution of BT's CCITT No. 7 Signalling System

As mentioned earlier, one of the reasons why CCITT No. 7 signalling is such a powerful tool is that it was designed with evolutionary potential as a key objective. From an overall point of view, the circuit-related mode of BT's version of CCITT No. 7 signalling has become stabilised (MTP and NUP). One possible enhancement in the future would be the adoption of the ISUP. This is not foreseen for some time in BT's network since the NUP has greater capabilities than the present proposals for the CCITT Recommendation. The use of the ISDN user part at international gateways will rely on bilateral agreements with other countries and consequential commercial criteria.

The most likely enhancements will be for non-circuit-related transactions to support services expected to be introduced in the early 1990s, for example, access to databases etc. This implies the introduction of SCCP and TCAP protocols in the network.

SUMMARY

With the introduction of its digital exchanges, BT has been implementing CCITT No. 7 signalling as one of the key elements in the development of its telecommunications network. By virtue of this early implementation of the signalling sytem before the appropriate CCITT Recommendations had stabilised, an element of prediction was necessary for those areas that had not been completely specified. Articles detailing each of the parts of BT's CCITT No. 7 signalling system will be included in a later issue of the *Journal*.

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Biographies

Ken Fretten joined the Post Office Research Station at Dollis Hill in 1944 where he was variously employed on acoustics, transmission and magnetic circuit design until 1965. After four years on switching facilities, he headed a group concerned with all national signalling facilities. Since then he has been promoted within this discipline and for the last six months has been Head of Division covering all network-related standards.

Colin Davies joined BT as an apprentice in 1964 in Gloucester Telephone Area. After a period on transmission, he joined Network Planning dealing with the provision of private wideband systems. In 1976, he was promoted to Level 2 on Special Defence Projects, and since 1980 he has been involved in the specification of both public and private network signalling systems. He is currently the Head of BT's CCITT No. 7 Standards Group.

Status Monitoring on Cable TV and Broadband Data Networks

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UDC 621.397.743 : 621.315.2 : 621.394.4

This article presents a history of cable TV networks over the past 20 years and argues the need for some form of monitoring on those using VHF coaxial technology. It describes British Telecom's status monitoring package—a software system enabling certain parameters of the active network components to be measured and displayed at a central location.

Constructional similarities between cable TV and metropolitan area networks mean that the same type of monitoring system can be used in both environments. The article describes enhancements to the basic package to provide a comprehensive supervision system for these broadband data networks.

INTRODUCTION

Cable TV has been available in this country for nearly 20 years and during this time has undergone many changes. In the mid-1960s British Telecom (then part of the British Post Office) undertook technical and economic studies to ascertain the feasibility of installing a network offering fully integrated facilities [1, 2]. Part of this network was to be a coaxial wideband system offering TV, radio and other services.

The trial system was installed in Washington New Town, had a frequency range of 40–225 MHz and was intended to serve a population of about 20 000 homes. The Washington trial was closely followed by installations at Irvine (Ayrshire), Craigavon (Northern Ireland) and Milton Keynes (Buckinghamshire). These early networks were essentially 'relay systems' offering customers the normal 'off-air' channels and, with the exception of Milton Keynes, had no facility for sending information from the customer back to the head end.

In 1981, the Government appointed a committee to investigate and advise on matters relating to information technology. This body, the Information Technology Advisory Panel published its findings[3] in February 1982.

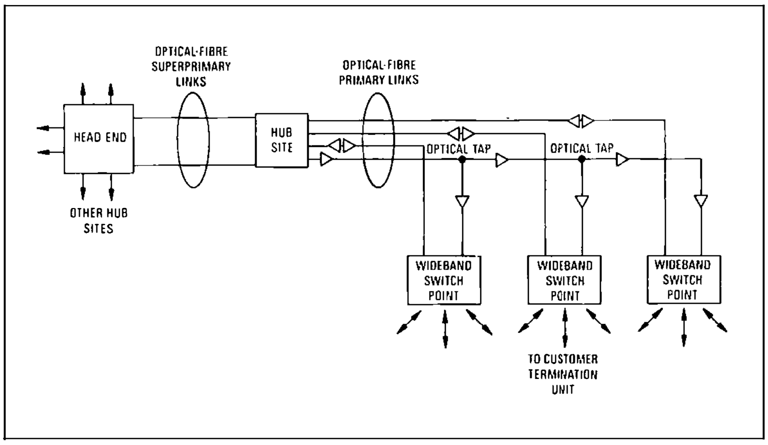
A year later, applications were invited for the provision of a maximum of 12 pilot cable TV projects. These new systems were to cover a maximum of 100 000 homes and preference was to be given to those offering a positive contribution to advanced technology. Thus, the emphasis was shifted from the relaying of television and radio; additional services that would have to be carried on the network included:

- satellite and locally-produced TV channels,
- textual information, and
- interactive services such as home shopping, home banking and opinion polling.

The network would also be expected to act as a data carrier for broadband, local and metropolitan area networks. From this it was obvious that the cable TV networks of the future would need to be of a much higher quality, reliability and versatility than those already existing. On the basis of its proposals, British Telecom was awarded five of the 11 franchises allocated by the Government. Of these, two were VHF coaxial systems and the remaining three were switched-star networks based on optical fibres.

An appreciation of both network types is given below.

Figure 1
Switched-star topology



NETWORK TOPOLOGY—SWITCHED STAR

Figure 1 shows a schematic diagram of the switched-star network. This is an optical-fibre based system with coaxial cable in the secondary link from the wideband switch point (WSP) to the customer. The WSP contains processors which give it considerable intelli-

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gence and error reporting abilities. It is intended in the future to install optical fibres in the secondary links, but the high cost of opto-electrical devices still makes this prohibitive. Figure 2 shows a typical secondary-link frequency plan with current and future services. For further information on this topology see reference 4.

NETWORK TOPOLOGY—VHF COAXIAL

Network Overview

The VHF coaxial system uses a tree-and-branch style topology with a three tier hierarchy, see Figure 3. These three levels, working from the head end outwards ('downstream'), are designated *super trunk*, *trunk* and *distribution*.

TV signals are broadcast from the head end in the 50–450 MHz band because cable loss is lower in this range than at UHF and, as a result, fewer amplifiers are required. The TV signals are returned to the UHF band by means of a small set-top converter at the customer's premises. A reverse path is available, in the 5–30 MHz band, for carrying signals from the customer back to the head end ('upstream'). This is used at present for system commissioning and monitoring, but is available for customer interactive services.

The frequency plan for this system is shown in Figure 4.

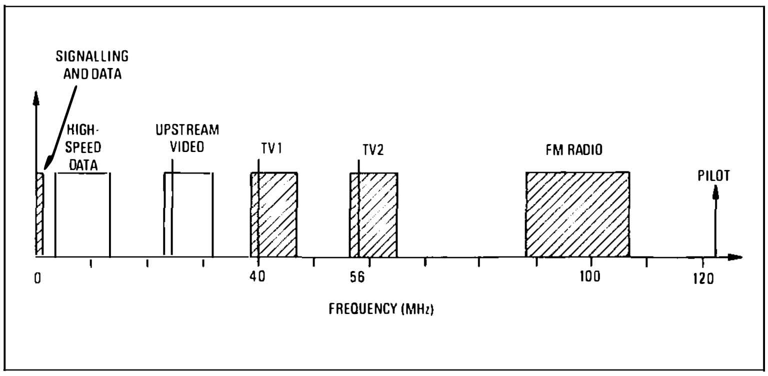


Figure 2
Switched-star secondary link frequency plan

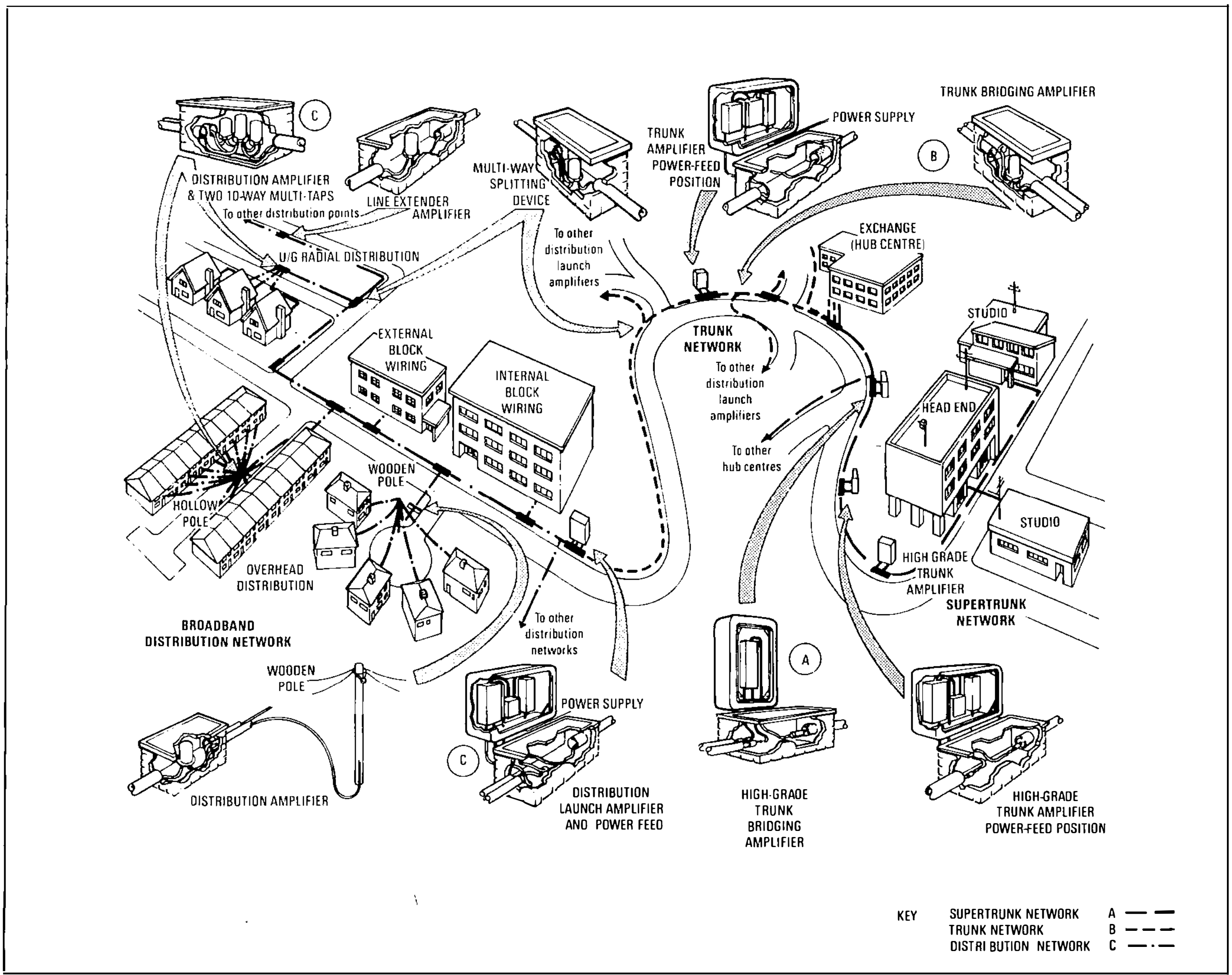
Network Tiers and Amplifiers

As stated above, a VHF coaxial network consists of three tiers:

(*a*) Super trunk routes link the head end with 'hub centres', normally located in telephone exchanges.

Super trunk amplifiers, which use a 'feed-forward' technique, are high-grade low-distortion devices, and are housed in street cabinets

Figure 3
Broadband VHF coaxial system



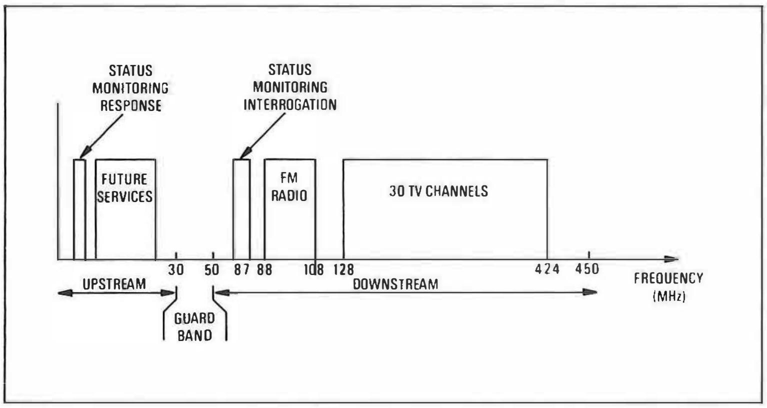


Figure 4—Typical VHF-coaxial frequency plan

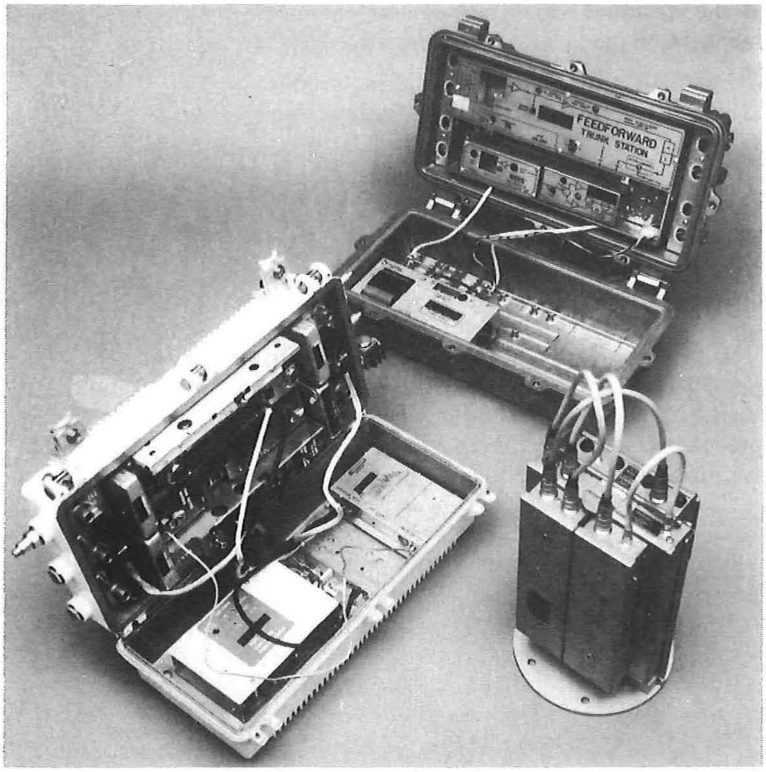


Figure 5—Typical Amplifiers used in VHF-coaxial network

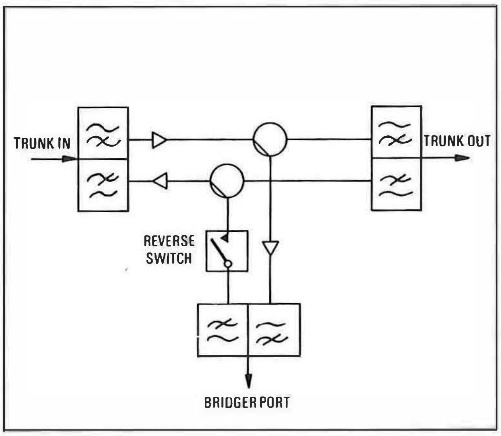


Figure 6
Bridger amplifier

because of their size and heat dissipation.

In a 100 000 customer system there might be typically 10 super trunk routes leaving the head end, each consisting of 20 or fewer amplifiers in cascade.

(*b*) Trunk routes run from the hub-centres to the distribution areas. A maximum of 10 trunk routes branch from a super trunk at the hub-centre, each route consisting of less than 9 amplifiers.Trunk amplifiers may be housed in specially-designed water-tight sleeves in footway boxes or in street cabinets depending on which of a range of amplifiers is installed. The last amplifier in each trunk route, the distribution launch amplifier, is of the feedforward type, ensuring that the distribution area receives a good quality signal.

(*c*) Within the distribution area, signals are relayed to customers by means of line extenders and distribution amplifiers.

It can be seen that a 100 000 customer network could easily contain well in excess of 1000 active devices.

Amplifier Components

Figures 5 and 6 illustrate typical cable TV amplifiers. The major features to note are the main path through the amplifier; the tap points, or 'bridger ports'; the transponder; and the automatic level and slope control module (ALSC). The units are bi-directional; that is, signals travelling in both directions are amplified.

Within the trunk and super trunk tiers of the network, branching is accomplished via the bridger ports. These ports incorporate a three-position reverse-path bridger switch giving NORMAL, OPEN CIRCUIT and 6 dB ATTENUATION conditions. Switching of the reverse path is controlled by the transponder, described in more detail later.

The ALSC makes dynamic adjustments to compensate for variations in the transmission characteristics of the cable. The degree of adjustment is determined from the level of two pilot signals.

NEED FOR A STATUS MONITORING SYSTEM

From the description of the VHF coaxial network, several factors have emerged to justify some form of monitoring:

- the need for a good-quality reliable system,
- the large amount of external plant,
- long cable runs making location of faults difficult and time consuming, and
- the hostile environment in which amplifiers are situated.

However, with the installation of suitable monitoring facilities, the situation can be shifted in favour of the maintenance teams. Provision of a good diagnostic tool makes the following more easily attainable:

(*a*) detection of faults before they affect service,

(*b*) clearance of faults during normal working hours, and

(*c*) reduction of component out-of-service time.

The result is that contractual obligations agreed with franchise operators regarding grade of service can be more easily met.

Having accepted that some form of monitoring is necessary, the scope of the system must be defined.

SELECTION OF ROUTES TO BE MONITORED

Selection of routes requires careful consideration so that the network is neither underprotected nor over-expensive. To assess the benefits of monitoring certain tiers, the following criteria should be used:

(*a*) the number of customers that would be affected by a breakdown, and

(*b*) the degree of difficulty expected in fault location and rectification.

The results of the assessment of each tier are summarised below.

Super trunk Amplifiers in this part of the network could be serving as many as 20 000 customers. Considering the long routes of up to 20 amplifiers in cascade, the inevitable consequence of a breakdown here would be widespread and lengthy disruption.

Trunk Trunk amplifiers and DLAs might be serving between 1000 and 6000 customers. With up to nine amplifiers in cascade, severe disruption would be caused by a breakdown here and, again, difficulty would be experienced in fault location.

Distribution This part of the network is characterised by large numbers of active devices serving relatively few customers (less than 10 in some cases). With never more than three amplifiers in cascade, fault location should be simpler. Also, the amplifiers used are of small physical size with little space available to house the control electronics.

From this analysis it was concluded that all amplifiers as far as the DLA should be monitored. Beyond this point it would not be economically viable.

Having established the need for a monitoring system and identified those areas where the greatest benefits can be anticipated, it remains to describe the system implemented by British Telecom.

BRITISH TELECOM'S AMPLIFIER STATUS MONITORING SYSTEM

Most amplifier manufacturers market a monitoring package, controlling only one device type. No single package was suitable for the type of network which British Telecom was providing, consisting of amplifiers from several sources. Thus it was decided to develop a new system in-house with the Local Broadband Systems Division providing the network expertise and Technology Executive's Software Development Division designing and implementing the software.

This strategy contained important benefits in that it ensured British Telecom's control over the software quality, supporting documentation and direction of future development.

The following were established as the primary considerations in the design of the system:

- it should embrace all amplifier types,
- the network should be monitored continually (with most other products it was possible inadvertently to suspend the scanning),
- it should be flexible and easy to use, and
- the structure should allow later enhancements to be made without extensive redesign.

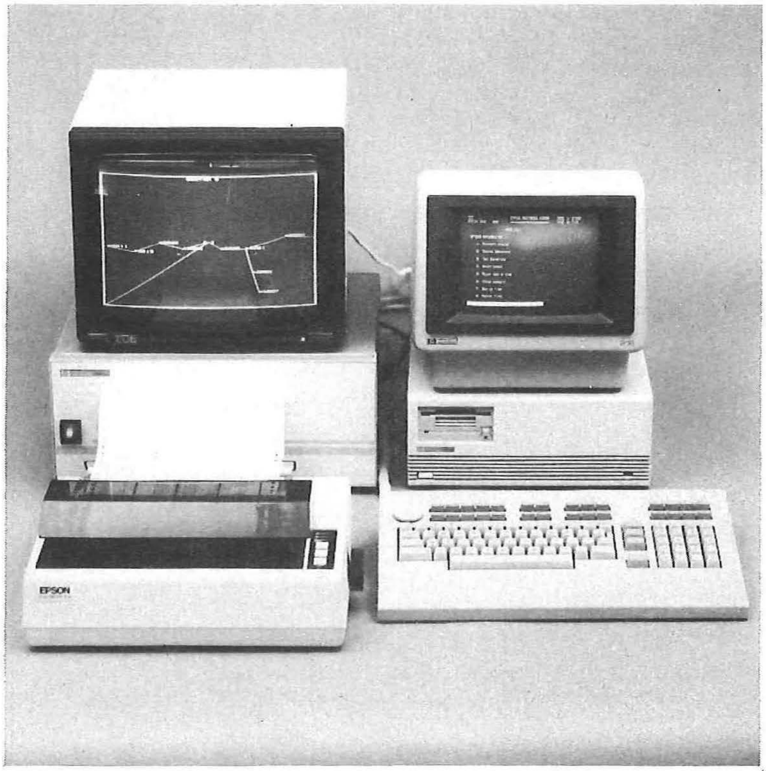
The main features of the resulting product are described below in terms of hardware and software.

HARDWARE

The status monitoring system uses a central control computer, located at the head end, to continually interrogate transponders attached to amplifiers.

A Hewlett Packard 300-series microcomputer was the chosen host machine (Figure 7). Based on a 68000 processor, it satisfied the processing power and memory requirements. Its modular structure also enabled different

Figure 7
Status monitoring computer



configurations to be generated for different franchises.

The control computer communicates with the network via 4800 baud modems; it broadcasts interrogation signals downstream (forward path) and receives replies on the reverse path. The transponders generating these replies are supplied by the amplifier manufacturers. Although there are several types of transponder, one property is common to all—the ability to make voltage measurements and perform switching or status actions. Each transponder performs actions when requested by the monitoring computer. The request identifies the amplifier to be tested and the action required. Typical applications for the measurements might be:

(*a*) measure AC line voltage,
(*b*) measure regulated supply voltage,
(*c*) measure high pilot level,
(*d*) measure low pilot level.

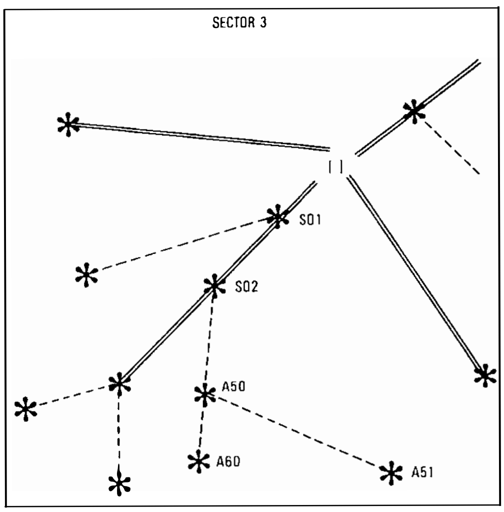
The switching actions allow manipulation of the reverse path at an amplifier:

(*a*) switch reverse path to PAD INSERTED,
(*b*) switch reverse path to OPEN CIRCUIT,
(*c*) switch reverse path to NORMAL CIRCUIT,
(*d*) return state of reverse path at transponder.

Figure 8
Typical station parameters screen

```
                    STATUS MONITORING SYSTEM          DATE 01/01/87
                    ========================          TIME 15:30:00

                    STATION PARAMETERS

STATION NAME      = A001       (A000..A127, R000..R127)
PRECEDING STATION = HEAD       (A000..A127, R000..R127, HEAD)
STATION MODE      = A          (Receive attn, Inactive, Active)
REVERSE PATH      = N          (Pad inserted, Open Cct, Normal cct)
LOCATION          = 500, 500   (0..999,  0..999)
DEVICE TYPE       = LWB-310    (74, 150, 152, 310)
APPLICABLE TESTS  = 12345678   (12345678)

COMMENTS          =
                  AB34 : OUTSIDE 34 WEST AVENUE

                   NORMAL          NON-URGENT %      URGENT %
AC LINE VOLTAGE     50.0 VOLTS        2                3
REG SUPPLY VOLTAGE  24.0 VOLTS        2                5
HI PILOT VOLTAGE     9.5 VOLTS       10               15
LO PILOT VOLTAGE    15.2 VOLTS       10               15
```

Figure 9
Typical schematic sector display



The transponder can also relay information on the state of four pass/fail alarms. Suggested uses of these have been:

(*a*) humidity range exceeded,
(*b*) temperature range exceeded,
(*c*) amplifier case open,
(*d*) pressure loss.

Inclusion of these, or any similar alarm, is a matter of inserting an appropriate transducer into the housing.

SOFTWARE FACILITIES

In the normal course of events, the system runs without operator intervention. It selects one of the set of transponder actions and requests it in turn from all amplifiers in the network, repeating the cycle with the next action required.

The repetition rate of the requests can be altered so that some actions are executed more often than others, or just one device is interrogated repeatedly.

By using the voltage measurements returned from the network as a reference, non-urgent and urgent alarm thresholds may be assigned to individual amplifiers. The operator can thus select the level at which an alarm is triggered.

To allow the status monitoring system to make a judgement concerning the exact location of a fault it requires certain information:

(*a*) the type of device under test,
(*b*) the measurements expected for all parameters,
(*c*) the physical location of the device, and
(*d*) the position of the device relative to all others.

This information is supplied when an amplifier is commissioned and may be changed at any time thereafter. Figure 8 shows a typical amplifier parameter display.

Two fields of particular importance on this display are the 'preceding station' and 'location' fields. By storing the preceding-station information, the system can deduce the position of an amplifier relative to all others. With this knowledge, spurious errors resulting from faults in other parts of the network can be eliminated.

A schematic display of sectors of the network can be obtained by combining this information with the 'location' co-ordinates and connecting a low-cost graphics terminal, see Figure 9. This gives an instant picture of amplifiers which are functioning, failing or receiving attention and provides a visual clue to the problem area. Comments relating to an amplifier may be recorded. In practice, this facility has been used to associate the amplifier with information held on planning maps.

Any unacceptable results are signalled audibly at the computer, dumped onto the printer and may be diverted through to the alarm system of a remote telephone exchange.

As well as detecting faults, the operator may suppress noise on the reverse path by instructing transponders to attenuate or open-circuit the bridger ports.

Amplifiers which have been identified as malfunctioning may be designated as RECEIVING ATTENTION, thus inhibiting further interrogation. A printed report of all stations in this mode may be generated to ensure that these are not overlooked. Reports on faults and several aspects of the network can also be generated.

Security is maintained by forcing the user to specify a password prior to executing any action which will permanently modify the details held in the system. Additionally, all data files may be backed-up onto diskette and taken off-site.

Certain microcomputers in the series include power-fail protection and allow monitoring to continue for up to 1 minute in the event of mains supply interruption.

PLANNED ENHANCEMENTS

The system has already received several upgrades resulting from operational experience gained in the Aberdeen and Coventry networks. New features are added continually, the following being some of those under consideration:

(*a*) trend analysis of historical fault information,

(*b*) linesman control of the system from any point in the network via hand-held terminals,

(*c*) implementation of a link to the system administration centre (where billing and other management functions are performed),

(*d*) monitoring of stand-by power supplies at hub centres, and

(*e*) modification to monitor domestic alarms.

The system has been in use for two years and has undoubtedly simplified the process of fault finding by providing warnings and locations of impending failures. This type of assistance is required in all high-quality networks.

The opportunity of installing the status monitoring system in a different environment came with the development of metropolitan area networks. The factor common to both these networks is the transmission medium—VHF coaxial. Continual monitoring of these networks is just as important if the reliability criteria are to be satisfied. Additional features are necessary for complete supervision of broadband networks and these are explained in subsequent sections.

BROADBAND SUPERVISOR

Broadband data networks use a technology similar to that already described, but for a different purpose. The emphasis is shifted from the broadcasting of information to the exchange of data between two users on a communications channel. As Figure 10 illustrates, a 'mid-split' system is necessary to provide similar bandwidth in the upstream and downstream directions.

All the reasons already stated in favour of monitoring still apply, but the usage of broadband data networks suggests that some extra functions should be provided to permit the detection and elimination of signals corrupting the data carrier. To explain how this may be achieved cost-effectively, it is necessary to describe the method of data exchange between users.

Data Network

The communications network employs a transmission technique known as *carrier sense multiple access/collision detection* (CSMA/CD), a contention system in which a large number of individual network interface units (NIUs) share a common high-speed channel. Terminals or computers connect to the network via NIUs. All NIUs have a unique address and use built-in operating software to enable users to set up and control connections interactively. The NIU builds data for transmission into packets containing source address, destination address and error-control information. The packet is only sent when the NIU detects that no other units are transmitting. Signals from all NIUs are sent upstream to the system head end, where they are translated to a downstream frequency and broadcast over the system. All NIUs continually monitor the network for packets containing their own address, passing any found on to the user.

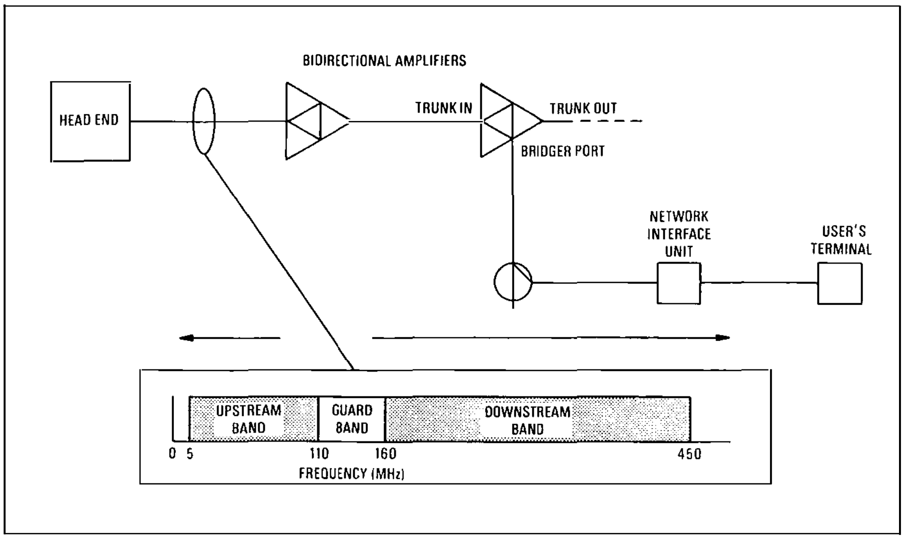
Detection and Elimination of Interfering Signals

Noise or other corruption of the transmission medium may result in several failed calls. To guard against this, test calls are made at regular intervals (or on demand) between two specified NIUs located at the head end. A failed call starts the process of segmentation; that is, the repeated disconnection of smaller and smaller sections of the network by means of reverse path switching. This continues until the source of the problem has been isolated and the call can terminate successfully. The supervisor permits transmission routes to be classified so that they may be disconnected by segmentation:

(*a*) at any time,
(*b*) only as a last resort, or
(*c*) never.

This ensures that vital routes are safeguarded.

Figure 10
Broadband data network frequency plan



Additional Features

By including the above in the status monitoring system, a high degree of protection against network errors is achieved. To obtain even greater reliability, the scope of the package must be widened. This has been done by making the system responsible for the supervision of a stand-by network; this overcomes the problem of equipment which has been damaged in transit or is liable for any other reason to fail soon after installation.

The stand-by network comprises several amplifiers which are interrogated in the same manner as those located in the main network. Several NIUs are also supervised, their status and functional performance being periodically examined. Any unexpected events are immediately flagged and appear on the test history which is printed when an NIU is removed from the network. As a result, a supply of tried and tested components is assured for installation.

Prior to an NIU being attached to the network, it is configured to make it inoperable except when addressed or controlled by a privileged unit. This enforces the scheduled testing and prevents unauthorised release of equipment.

Although this network was designed to test new batches of equipment, it may also be used to diagnose faults in units returned for repair.

CONCLUSION

The modern cable TV network, because of its size and complexity, needs some form of fault monitoring package. British Telecom's system meets a need which could not otherwise be satisfied. Its modular design has enabled it to be used in both television and broadband data networks with minimal changes. During the two years of its deployment in operational environments, it has proved useful and versatile in detecting and localising network problems. It is a symbol of British Telecom's commitment to service, quality and the improvement of its communications networks.

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Biographies

Terry Ockendon joined the Post Office in 1963 as a Youth-in-Training. After spending some time on exchange maintenance, he transferred to the Telecommunications Development Division in Wembley. Here, as a Technical Officer, he was involved in the development of wideband amplifiers for cable television and then development of audio local line transmission equipment. He is now an Executive Engineer responsible for control and computerised test equipment for new cable TV networks.

Jim Laird joined British Telecom in 1982 after graduating from Queen's University of Belfast with a degree in Computer Science. His work at the Belfast Systems and Software Engineering Centre began in a group producing software tools for System X. Since 1983, he has been involved with aspects of cable television including development of monitoring systems and evaluation of third-party software. Currently, he is a team leader concerned with testing software for large data networks.

Steve Hammond joined London City Area in 1972 as a Trainee Technician Apprentice. In 1979, he transferred to Telecommunications Headquarters to work on local line concentration and multiplexing systems, initially as a Technical Officer, then as an Assistant Executive Engineer. During this time, he passed the CEI Part 2 examinations and became an associate member of the IEE. Promoted to Executive Engineer in 1984, he has since been involved in the development of local and metropolitan area networks, and studies into interactivity and advanced local networks. Additionally, he is the System Manager for a new local area network being installed at Local Lines Headquarters, Shaftesbury Avenue.

Events up to TELSTAR, 1962

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UDC 621.396.94

Twenty-five years ago world-wide communications entered a new era. TELSTAR, the world's first commercial communications satellite, was launched on 10 July 1962 and the first live television signals via satellite were received by British Telecom's first earth station at Goonhilly Downs, in Cornwall, in the early hours of the following morning. This article describes some of the events leading up to the establishment of the Goonhilly earth station, and goes on to tell the exciting story of the first TELSTAR experiments. An accompanying article in this issue of the* Journal *gives a personal account, from one of the staff involved at the time, of the search for a suitable site for the station and the construction of the first aerial and building.*

INTRODUCTION

The privilege of being in at the beginning of a new method of communication is offset by the feeling looking back that much of the story was missed at the time. Perhaps this was because those individuals involved were so committed to their particular specialism that the important background information just did not become generally known. However, the strong camaraderie at all levels of staff stationed at Goonhilly in 1962 allowed the dissemination of snippets of information and this chronicle is based on a collection of these.

The story started in 1960, when the Engineer-in-Chief's Office of the British Post Office (BPO) was approached by the National Aeronautics and Space Administration (NASA) on the willingness of the BPO to take part in active communications satellite experiments. Note the word 'active' as there was already an experiment entitled *ECHO*, which was a large plastic sphere, 30 m in diameter with a metallised surface. This was launched in a low orbit and operated at VHF frequencies; it was possible to achieve one voice channel by using very high power transmitters and sensitive receivers. ECHO was the only orbiting satellite easily visible to the naked eye. As a medium for communication, ECHO was limited as its reflective capability was imperfect and rapidly deteriorated as the sphere lost its shape. Nevertheless, General Eisenhower, when President of the USA, broadcast his Christmas message to the US troops throughout the world in December 1961 via ECHO.

The new offer to the BPO from NASA was based on the active satellite RELAY, due for launch in 1962. RELAY was to be solar-powered, operate at 1700 MHz from ground station to satellite, 4000 MHz from satellite to ground and be launched into an elliptical orbit inclined to the equator so as to give about an hour of mutual visibility between the USA and Europe. The bandwidth of the satellite RELAY, some 50 MHz, was capable of carrying television or multi-channel telephony.

SITE SEARCH

The difficulty entailed in this offer was that a very sophisticated ground station would be required to participate in the experiment.

The Senior Engineer nominated to lead the BPO RELAY involvement was Captain C. E. Booth, Deputy Engineer-in-Chief of the Post Office Engineering Department (POED), who had been due to retire in 1962. Captain Booth tackled the project with all the vigour he could muster, together with the support of the Engineer-in-Chief, Albert Mumford (later Sir Albert).

The POED did not let the grass grow under its feet and, since the summer of 1960, a search had been in progress for a suitable location for an experimental aerial. Sir Ronald German†† was quoted in the *Guardian* in an article giving details of the site, as follows: 'We are, I think, absolutely satisfied that although there is still a good deal of practical work to be done, we shall see within the next few years commercial communications by satellite'.

The story of that site search with some touches of humour is told by Brian Oakes himself*, but the actual acquisition of the site was still in doubt despite the drive of Captain Booth. Salvation appeared in the form of Her Majesty's Government White Paper of 1961, which suggested that partial control of the finances of the BPO should be removed from the Treasury and given to the BPO. This new-found freedom allowed the POED to purchase the site in time to confirm the Department's intention to participate in the RELAY experiment.

To meet the now considerable task facing

† Satellite and Lines Executive, British Telecom International

* OAKES, B. A. Operation Skyward. *Br. Telecommun. Eng.*, Oct. 1987 (this issue).

†† Director-General of the British Post Office

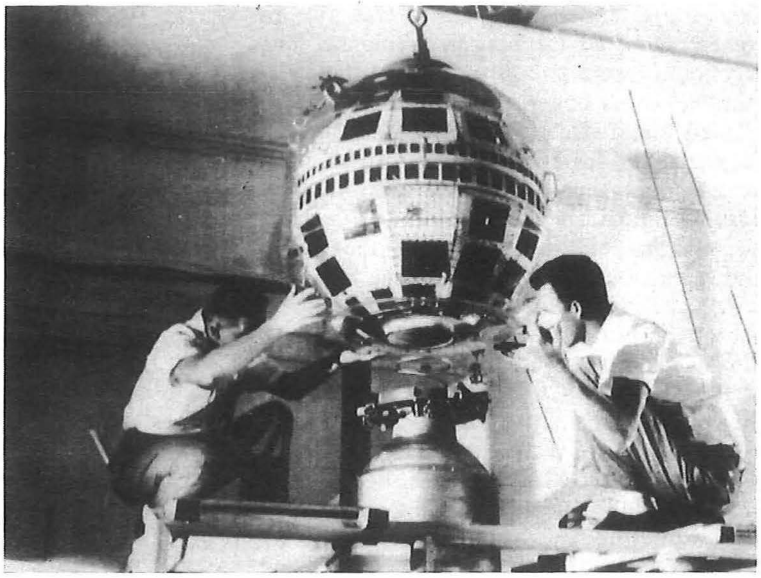


Figure 1
TELSTAR satellite
(this was the first photo-telegraph picture to be transmitted by satellite, New York to London, 14 July 1962)

the POED, Captain Booth (Deputy Engineer-in-Chief) had formed a new branch 'WS' under Mr. W. J. Bray, Staff Engineer, and Mr. F. J. D. Taylor, Staff Engineer in Research, pledged his full support. This trio were to have their culminating success seated at the console at Goonhilly station in July 1962.

TELSTAR

At this point, the question may well be asked, when did TELSTAR appear? A small paragraph in *The Times*, 12 September 1961, mentions that Bell Telephone Laboratories, USA, were designing and constructing an active satellite, designated *TSX*, due for launch in 1962 by NASA. This project TSX was for a satellite capable of handling television and multi-channel telephony signals between the American Telephone and Telegraph Company's (AT&T's) ground station, being constructed at Andover, Maine, USA, and the BPO station in Cornwall, England. As a result of this, the construction of the experimental aerial was being accelerated to meet a possible spring launch. TSX was to become TELSTAR (Figure 1). The RELAY satellite did not become available until later in 1962, and so gave up its historical role to TELSTAR.

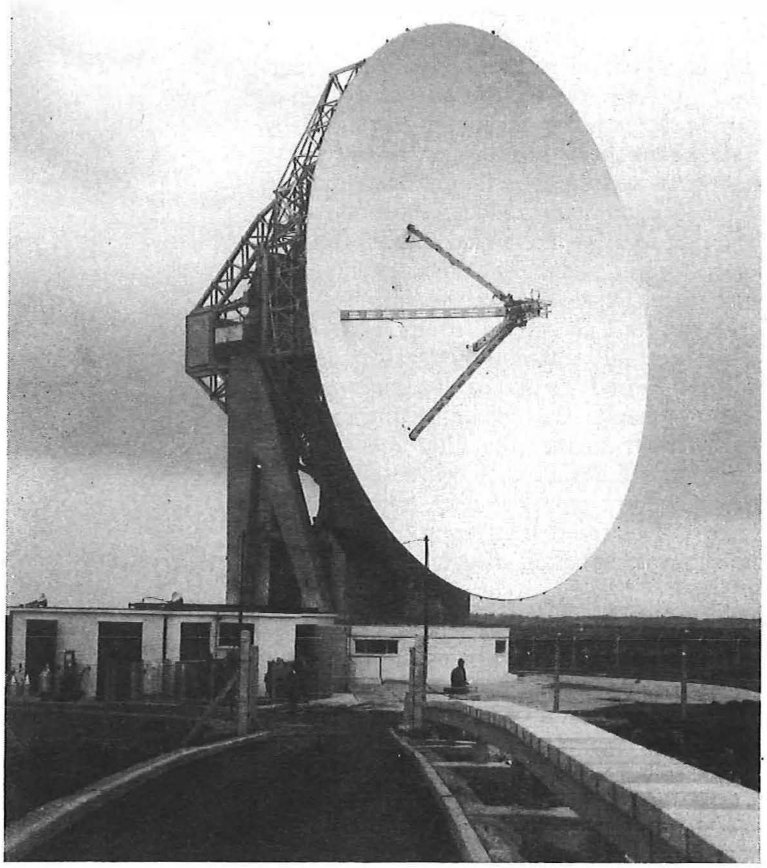


Figure 2
Aerial 1, Goonhilly Downs

AERIAL DESIGN

The aerial (Figure 2) being constructed in Cornwall was totally different from the AT&T aerial in Maine. The latter used a 'horn antenna' about 61 m (200 ft) long and of such delicate and precise construction that it had to be protected from the elements by a huge 76 m (250 ft) hemispherical radome of plastic supported by compressed air.

This design of antenna shortened the connecting waveguide from the aerial to the first amplifier to a few feet. This greatly improved the inherent noise performance of the antenna and made the system probably the most sensitive receiving device of microwaves in the world.

The French PTT was impressed with this design and, as a result, purchased this system. American engineers built almost a carbon copy of the Andover, Maine, antenna at Plumeur Bodou in Britanny, France. This solution was not favoured by the POED, as the Goonhilly site had to contend with high winds and 1270 mm (50 inches) of rain per annum; a plastic radome seemed unlikely to be able to cope with Cornish weather. Instead, WS Branch turned to the engineers who had designed Jodrell Bank. This firm of consulting civil engineers, under H. C. Husband, had demonstrated their civil engineering skill throughout the world, and Jodrell Bank 1, a 76 m (250 ft) diameter dish for radio-astronomy work, was an excellent example of British engineering.

By good fortune, Husband & Co. had on its drawing boards a design for Jodrell Bank 2. A few modifications and the design became Goonhilly 1; the drawings still exist which designate the aerial as a 'Radio Telescope'.

The 26 m (85 ft) 'dish' design for Goonhilly 1 was met with polite interest by the pundits of microwave engineering, but it was obvious that, internationally, the 'horn' aerial concept was considered to be the favoured design. Surprisingly, apart from a truncated 'horn' aerial built at Caernarvon in West Australia, several years later, the two horn antennas at Andover and Plumeur Bodou were the last that the world was to see in regular satellite communication service.

The list of the contractors engaged by the POED's consultant to construct Goonhilly 1 includes many names now almost forgotten:

Concrete work: Cleveland Bridge.
Steel structure: John Brown's Land Boilers, Glasgow.
Electrical drive system: Brush Electrical.
Roller track and elevation screw: Markham, Chesterfield.
Gearboxes: Crofts Limited.
Azimuth chain: Reynolds Limited.
Aerial steering system: Whitworth Gloster Aircraft.

The winter of 1961/62 now became intensely active at Goonhilly to meet the expected launch dates of TSX and RELAY. So many contractor's staff were on Lizard Peninsula that all the guest houses were full. A snow fall which lasted several days in that winter also gave cause for concern, but work was not affected to any great extent. The consultants and the contractors were providing the basic 26 m steerable dish; it was up to the POED to provide the extra items which would turn this into a working satellite earth station.

RADIOCOMMUNICATIONS EQUIPMENT

During the Second World War, the POED had been engaged in research to provide high-capacity radio links across the English Channel as soon as the Normandy invasion was commenced. To simulate this sea crossing, two experimental radio stations had been built on each side of the Bristol Channel: one was at Castleton in South Wales and the other at Backwell in Somerset. The research staff at these two stations were now to play a major part in the Goonhilly story designing and building the radiocommunications equipment for the system. In most instances, no suitable commercial equipment was available, but a 10 kW 1700 MHz water-cooled transmitter had been obtained for the RELAY project. The 6 GHz transmitter for the TSX (soon to be called *TELSTAR*) project had to be designed and built from scratch. The 4 GHz receive system was the responsibility of the BPO Research Station at Dollis Hill, and one group there designed and built the feed which was to be mounted on a quadrapod at the prime focus of the dish. Concern over the capability of steering 850 tons of aerial to point precisely at a low orbiting satellite led to the feed being mounted eventually on gimbals so that fine tuning of the beam pointing could be achieved. A further refinement was mechanical rotation of the feed which, through an ingenious offset in the 4 GHz circular coaxial waveguide, allowed the receive beam to 'wobble'.

By displaying this wobble on a cathode-ray oscilloscope in relation to the received signal from the satellite, the operator was able to correct the feed for best performance. The ergonomics were interesting in that the operator rested his fingertips on the surface of a pivoted metal ball which protruded through the horizontal surface of his control desk while he gazed at the cathode-ray tube, and by pushing the ball in the appropriate direction, he could maintain the symmetry of the display and thus correct the position of the feed.

At the BPO Research Station at Castleton, one of the problems of 'locking' onto a fast-moving satellite beacon was being tackled by Neil White, then a Scientific Officer, now Station Manager at Goonhilly. The highly elliptical orbit of these early satellites meant that the frequencies of their on-board radio beacons exhibited considerable Doppler shift as the satellites moved in from space at an apogee of about 9650 km (6000 miles) and then swept away again from the perigee which could be as low as 805 km (500 miles). This required the design and development of a very elegant beacon receiver with multiple intermediate-frequency (IF) stages, locking oscillators and very narrow bandwidth to cope with the minimal signal-to-noise of the satellite beacon signal. A potential problem with this receiver was that it could not really be tested until the satellite was in orbit and it says much for the design and performance in that it 'locked on' within a few seconds on the first 'pass' allocated to Goonhilly in the first experiment.

Wideband FM television receivers were also being developed with special techniques to improve their performance when operating near threshold. Two main principles were adopted and developed into actual equipment. One type was called the *FM feedback receiver* which processed the wideband FM signal by feeding back the baseband signal in anti-phase to the first-stage local oscillator. Thus, the FM on the local oscillator reduced the modulation deviation to allow the signal to pass through a narrow filter, and thus enhance the signal-to-noise ratio. This early receiver was physically large and took up two full equipment racks.

The second technique operated at the 70 MHz IF and the baseband signal was now used to change the centre frequency of a narrow filter so that the filter followed the incoming FM deviation of the satellite signal. This was much more compact, but setting up these devices could take several hours as all the tuning points and control systems interacted.

The first 4 GHz amplifier in the receive system had to be extremely 'quiet' so as not to introduce any noise into the incoming satellite signal as the typical power levels expected were tenths of a picowatt. The branch of the BPO Research Station at Dollis Hill engaged in this area was already in partnership with Mullard Laboratories in developing a MASER (microwave amplification by stimu-

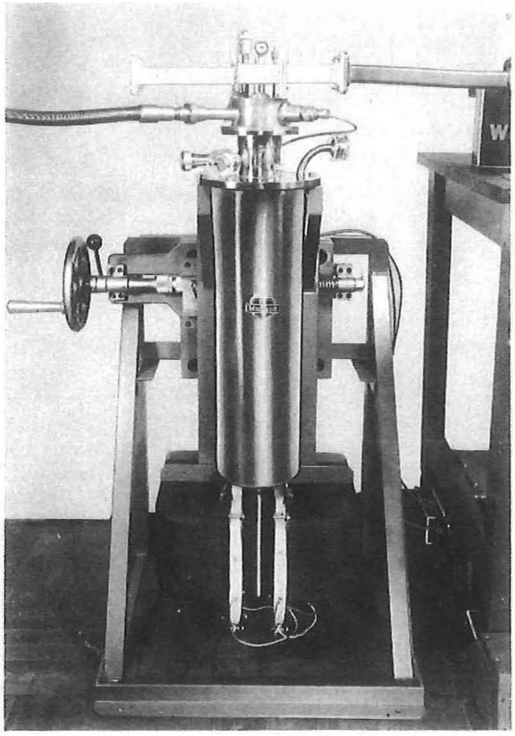


Figure 3
Goonhilly MASER amplifier

lated emission of radiation) for field use on Goonhilly 1. The principles of the MASER (Figure 3) are too involved to explain here but the complications of the device included that the active component, the *comb*, had to be immersed in liquefied helium in an evacuated chamber to lower the temperature to about 4 K (equivalent to −269°C), while, at the same time, being subjected to an intense magnetic field and 'pumped' by a 40 GHz oscillator. To help this inner chamber to maintain its temperature, an outer chamber contained liquid nitrogen at about 67 K. All of this required to be installed in a tiny cabin 16·8 m (55 ft) above ground level with the only access by a vertical ladder and a crane for the vacuum flasks. Later, a Simon hydraulic platform facilitated the movement of the huge vacuum flasks of liquid helium and nitrogen up to the maser's 'eyrie'.

To bring this exotic amplifier to a state of readiness, took four hours of intense work, and it is remarkable how the technicians recruited from Telephone Areas rapidly became familiar with work that had hitherto been the province of advanced physicists. The vacuum flasks of these liquid gases came down to Cornwall by train to the junction at Gwinear Road (now disappeared as a victim of Beeching), and at first these dewars with their wisp of vapour caused consternation among the station staff.

WS Branch had the task of pulling the whole project together as well as the construction and fitting out of the central building. To meet the deadlines, teams of technicians from all over the south-west assembled to carry out the complex communications wiring in the central building which housed the operations consoles, experimental equipment suites and satellite communications equipment.

AERIAL STEERING SYSTEM

The aerial steering system being provided by Whitworth Gloster Aircraft had a design team led by John Marshall now a senior lecturer in Bath University, and they were still modifying the design after arrival on site. These men were some of the first digital experts in the UK and their expertise in hard-wired logic, which they had evolved by using germanium transistors, had been used on two previous projects: a steel rolling mill and a multi-pattern knitting machine.

A policy decision was made, after many meetings, that the Goonhilly aerial would be steered by prediction rather than by attempting to follow the radio signal emitted from the satellite—a very difficult option for fast-moving satellites of the RELAY/TELSTAR type.

The prediction method relied on the interpolation of orbit data supplied by the satellite control centre in the USA. This data, which could give accurate satellite trajectories up to 2 weeks ahead, was processed by an Elliot 803 computer, which, at that time, was the largest computer the POED had available. Only two were in use, one at Dollis Hill and one at Goonhilly, and so Mr. K. Sams and Mr. D. Skerten came down to Cornwall from London to perform this vital function. The output of the computer was a paper tape which was fed to the aerial steering tape reader one second in advance of real time to supply the aerial with tracking angles at 0·02 second intervals. On the structure, were encoders which produced the actual angle of the aerial to an accuracy of 2^{-16} revolutions or 19·77 seconds of arc. The demanded angle from the tape was compared with the actual angle from the encoders and the difference angle was fed to a digital-to-analogue converter which, after processing in the servo amplifier to a first-order integral—that is, proportional to the rate of change of angle—was used to drive the 100 horsepower steering motors. This feedback loop gave accurate tracking to within 1–2 minutes of arc and in service was very satisfactory.

The inclination of the satellite orbit of 65° to the equator ensured that Goonhilly only performed an azimuth slew, and approached the forbidden zone (directly overhead) on only a few occasions. When this did occur, however, it was a spectacular sight as that huge structure accelerated up to 120 degrees per minute as it rotated smoothly around to regain track. This feat could be performed on Goonhilly 1 in about 2 minutes, but the much slower Andover horn aerial took at least 5 minutes.

PROJECT COMPLETION AND PRESS INTEREST

As the whole project approached completion, it required enormous efforts by WS Branch to interface and co-ordinate all the contractors and the many areas of the POED involvement.

Access to the aerial entailed queueing and time schedules for 24 hours were issued on a daily basis.

The aerial was shown to the world press in May with its surface plates tack welded into position and no feed installed on the quadrapod, but no comment was made. Applications were flooding in for access to the station by newspapers and television companies to be present during the initial experiments. Regretfully, because of the cramped facilities, the press were offered only six representative places, but the television cameras were allowed in. Of course the press could not agree on this as hundreds had applied and so eventually they were all barred.

As a result, a scientific reporter on a British newspaper wrote an article on the USA and BPO aerials in particularly scathing tones. The article contained the line: 'the antenna at Andover, Maine, USA, is as fine as a jewelled watch. In comparison, the aerial at Goonhilly Downs in Cornwall is driven by a bicycle chain'. This caused some resentment at the station, although the massive azimuth drive chain (Figure 4) with each link 127 mm (5 inches) in width had indeed been made by Reynolds, who manufactured bicycle chains.

A policy decision had been made by WS Branch that no consultants or contractors were to operate the station for any experiments with the satellites TELSTAR or RELAY. As most of the communications equipment had been supplied through or made by the POED, this was not a difficulty. However, the aerial drive and steering system were still the responsibility of the contractors and the consultants were somewhat reluctant to allow the aerial to be handled by BPO engineering staff. Eventually they relented and the author was chosen to control the aerial on the initial TELSTAR experiments.

There then followed some very intensive training with a great deal of emphasis on the safety of personnel and the safety of the structure. These requirements resulted from the high rotational speeds of which the aerial was capable and its potential capacity for self destruction from the inertia of a moving structure of 850 tons despite multiple interlocks and cut-out switches.

FIRST EXPERIMENTS

July 1962 saw furious activity. The satellite simulator station established at Leswidden near Lands End was immensely important in the pre-experiment phase of each 'pass'. The period during one orbit in which the satellite was to be used for experiments was termed a *pass* and given a number, which was the orbits since launch. The time when the satellite appeared on our horizon was denoted *T* and a run-up to an experiment started at *T* minus 6 hours with preparation of the maser. At *T* minus 3½ hours the aerial had to be on the Leswidden bearing to check out the radio system, and at *T* minus 20 minutes the aerial was brought around to await the appearance of the satellite on the horizon.

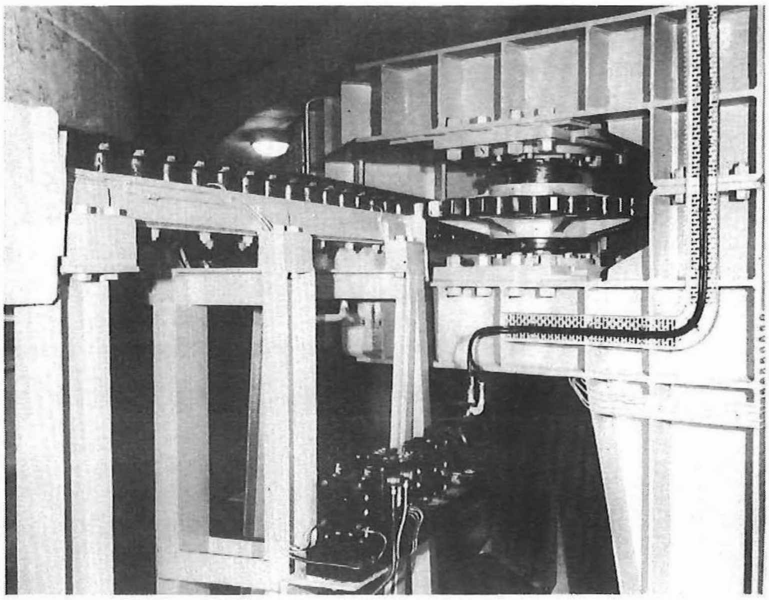


Figure 4
Azimuth drive chain and tension sprocket

A senior engineer of Assistant Staff Engineer (ASE) (level 4) rank was in overall charge of the station as Controller of Experiments, and he had an Assistant Controller of Experiments who ensured that the run-up schedule was adhered to strictly and that every segment of the station and its staff was ready.

Mr. R. W. White, ASE from the BPO Research Station at Castleton, was the designated Controller for the initial experiments on TELSTAR which would commence on pass 6 after launch, with a television transmission from Andover, USA, to Plumeur Bodou, France, and Goonhilly simultaneously. Assessment of the television performance lay with Plumeur Bodou, and so our role as observers would allow us to check out the station.

Tuesday 10 July 1962 was a fine day. The launch of TELSTAR took place on schedule at 08.35 GMT and the orbit was reported as predicted. Initial tests by the US control centre indicated that the satellite was functioning correctly. Precise update information on the actual orbit was sent across from the US control centre to Goonhilly and the Goonhilly computer reprogrammed for pass 6. At about 15.00 hours, the Controller of Experiments gave most of us the afternoon off with strict instructions on our return. As a result, almost the entire operational and experimental staff of the station tried to relax

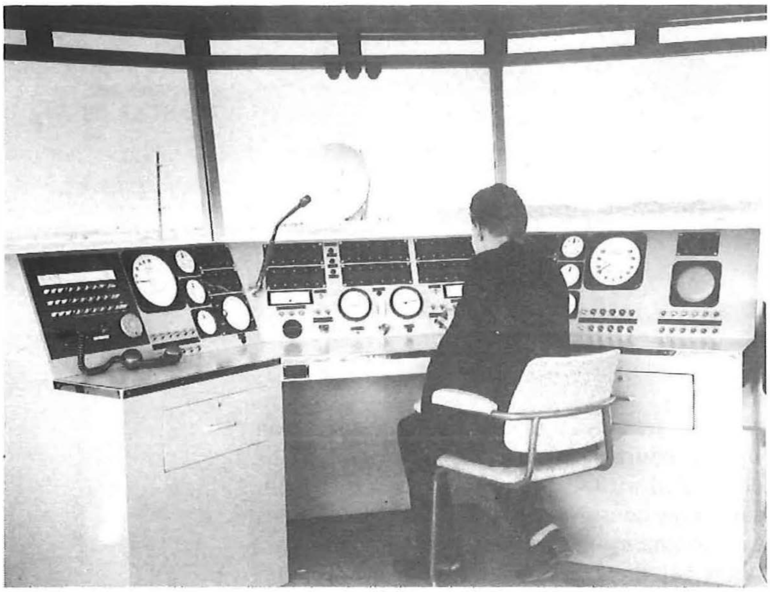


Figure 5
Aerial control tower console

The main television monitors above the console (Figure 6) showed speckled noise. At his left, the triumvirate of Captain Booth, Mr. W. J. Bray and Mr. F. J. D. Taylor sat apparently at ease. At the next console position to the right of Mr. White, sat Norman Williams of WS Branch in charge of television audio and all communications. To his right, hunched Mr. Peter Moore gazing into the green depths of his screen at wild elliptical patterns while he chatted *sotto voce* to the author. At the end of the console sat Neil White at the control position for the transmitters and receivers. In front of the consoles, the racks of experimental equipment were staffed by the design teams from the BPO Research Stations. A similar group were at readiness in the turntable cabin on the aerial. All of the cabins were locked and access up the structure was forbidden once the aerial was in readiness.

Behind the main console downstairs stood a glass screen. All the station staff not operationally involved, but whose contributions had helped to make this moment a reality had chosen to assemble here. Behind them, on a raised platform stood the BBC camera with Raymond Baxter giving the commentary along with Ian Trethowan of the ITV.

Precisely on time, the tape reader gave its first lurch and the aerial started to track upwards. The television monitor showed nothing, and from the main control room one or two voices confirmed only 'weak signals' and then the calm voice of Mr. White cutting in 'let's have a signal level measurement'. The response came almost immediately: '30 dB down on expected'. Then the television monitors locked and a vague figure appeared amongst a lot of noise. Mr. White came on line to the author confirming that 'the signal

by going down to Coverack harbour, strolling about feeling slightly out of place amongst the garishly dressed tourists who stared at these groups of rather soberly attired men. There was great tension in the air and, behind the smiles and the false jokes, everyone was keyed up. It was almost a relief for the staff to get back into the station to commence the pre-acquisition checks.

The time approached. The aerial was brought round to the acquisition angle and all waited. The author sat in darkness in the aerial control tower (Figure 5) with Mr. C. N. Kington, the Senior Consultant from Husband & Co. At his back, an automatic BBC camera looked across at the flood-lit aerial. All the operational staff had headsets on and we could hear the calm voice of Mr. White issuing his final instructions.

Figure 6
Experiment control room

was very weak, and requesting that the track be optimised if possible'. It soon became obvious that the minor corrections being made had little effect and the track continued with only the vague figure of the President of AT&T being seen intermittently.The anti-climax of the failure was disheartening, but even before the aerial was being parked the trouble had been diagnosed. The Controller of Experiments, Mr. R. W. White, announced on the station public address system that the circular polariser installed in the feed was reversed. He did not propose to attempt to correct it because of the hazards involved in working on the feed, 18 m above the ground, in the dark and the station was stood down.

What had gone wrong? The press release PB115 dated 1 August 1962 stated the problem. Only a few comments can be added. A few days before launch, Mr. C. F. Davidson, ASE, BPO Research Station, Dollis Hill, was concerned about the setting of the polariser. He telexed Bell Laboratories in the USA and requested that they confirm the polarisation of the wave as 'emitted by the satellite'. As far as can be ascertained, they sent a statement which defined the signal as seen at our feed and, at this point, confusion arose because of the potential ambiguity. It was not until that first attempt to receive that the error became clear; 3 hours work corrected our system the following day.

Next evening saw the whole station keyed up for the next usable pass, which was allocated to France. An agreement had been made between the three entities of the USA, France and the UK that television would be confined to test signals only, apart from the welcoming address by the AT&T President.

Almost 30 seconds before the satellite was due to transit our horizon, the first signals were noted and those present were treated to the 'chuff-chuff' noise on the sound channel as the radio signal from the satellite was refracted in turn by the lower atmospheric layers. The aerial settled onto track, and before an elevation angle of 0·5° had been reached (0° is a line tangential to the earth's surface from the aerial), the system had locked on solidly and the picture was excellent.

Initial test patterns came from the USA and we saw the 'Indian head' motif (Figure 7) that was to become very familiar. After a few minutes, the USA transmitters were turned off and the French proceeded to transmit. With typical Gallic flair, the French television 'test' signal seemed to consist mainly of the crooner Yves Montande on film.

At the end of that pass, a hurried conference among the project leaders led to a change of plan for the next pass which was allocated to Goonhilly and due to commence in 2 hours. The television test patterns were minimised except that we took delight in sending our GPO caption with the royal cipher. Instead, the USA and French viewers were taken on a conducted tour of the Goonhilly station by the courtesy of the BBC cameras. This concluded with Captain Booth speaking from the main console, introducing his associates and commenting, 'we had a little trouble last night but this has now been resolved. I noted with particular interest the extremely low angles at which communications were established'. He then went on to congratulate the USA design team, our colleagues in AT&T and the builders of TELSTAR.

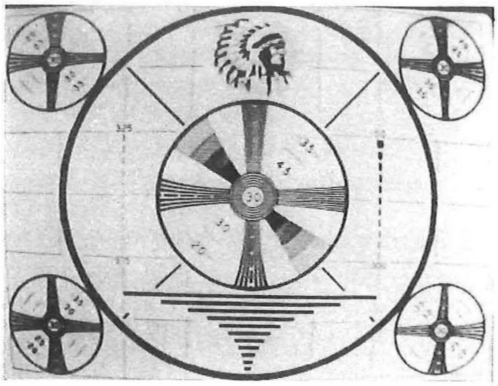


Figure 7
'Indian head' test card received at Goonhilly from Andover, via TELSTAR, 11 July 1962

CONCLUSION

This was the first live television by satellite. Almost in an instant the world was aware of TELSTAR. It was even mentioned in the Queen's Christmas broadcast. The Vatican was also pleased to make a quotation about TELSTAR that referred to it as 'a star that harmed no one but contained the seeds of international understanding'.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the help and assistance given by his colleagues in Satellite Systems Division.

Biography

John Lawson recruited into the Dundee Telephone Area as a Y2YC in 1949. After gaining experience in transmission and microwave systems, he passed the Engineer-in-Chief's board to Assistant Executive Engineer in 1962 and was sent to Goonhilly in March of that year as the first member of the permanent staff with a special responsibility for aerial steering systems. He controlled the No. 1 aerial for the first TELSTAR experiments and subsequently took part in most of the experiments on TELSTAR, RELAY, EARLYBIRD, etc. In 1971, he was promoted to Station Manager (Organisation) at Goonhilly and eventually transferred to British Telecom International (BTI) Headquarters, where he was promoted to Head of Group in 1981. He has carried out studies and training for the International Telecommunications Union in Indonesia on the PALAPA satellite system (50 earth stations) and recently in Sudan (16 earth stations). His site search work culminated in the London Teleport for which he was responsible for all the initial planning, and then demonstrated successfully to the television industry dual-channel television operation via one transponder from the Limehouse Studios by using multiple earth stations and reception on 3·7 m dishes which led to BTI's pre-eminence in this field. Currently, he is responsible for planning at Madeley Earth Station, but also assists Telconsult in overseas studies which have resulted in expanded BTI business.

Operation Skyward

B. A. OAKES, C.ENG., M.I.MECH.E.†

UDC 321.396.94

This article is a personal account of the search for the site and the construction of the aerial and buildings for BT's first satellite earth station prior to the launch of TELSTAR in 1962. An accompanying article describes some of the events leading up to the establishment of Goonhilly Downs earth station, and the first TELSTAR experiments.*

INTRODUCTION

Space probes and satellites were in their infancy in the late-1950s: the first artificial satellite (SPUTNIK 1) had only been launched by the USSR in 1957, followed a month later by SPUTNIK 2 containing the first creature in space—the famous dog Laika; and the first man in space—Yuri Gagarin—was not until 1961. There was therefore a ripple of excitement when news that the British Post Office (BPO) was becoming involved in a space project reached me in the summer of 1960. In fact, the BPO had already been approached to participate in 'moon bounce' experiments for overseas communications in 1959 and the Research Branch had assisted other Government Departments in experiments with the first passive communication satellite, known as *ECHO*, a 30·5 m (100 ft) diameter aluminised balloon launched by the USA in 1960.

At that time, I was a member of the external provision group of the 'radio-inland' (WI) branch of the Engineer-in-Chief's office. This branch was responsible for the planning and provision of the growing network of microwave stations, and the responsibility of the group I was in was that of obtaining sites and specifying and supervising the construction of the masts, towers and aerial systems. At that time, these 'line-of-sight' links were operating at 2 GHz and 4 GHz, and as those were the frequency bands to be used by the proposed satellites, the job of finding a suitable site fell to WI Branch. As there was no particular station name, the project was called *Operation Skyward*, and no time was lost in drawing up a list of requirements for a suitable site.

SITE REQUIREMENTS

It was known that the satellite would be in a low orbit and would have only a short period of mutual visibility with the USA as it passed from one horizon to the other. The site therefore needed to be flat and have as low a horizon towards the west as possible. To maintain communication for a commercial system, it would clearly require a second aerial ready to pick-up the following satellite as the first passed out of view. The received signal was also going to be extremely weak and the site had therefore to be free from any additional radio noise such as the interference that can arise near hospitals, industrial premises, or radar installations. The need to be able to connect television and telephony circuits back to London was not overlooked and the proximity to a suitable link taken into account.

The primary requirements for the site began to emerge:

(*a*) large enough to accommodate at least two pairs of aerials,

(*b*) flat with as low a western horizon as possible,

(*c*) as far south as possible,

(*d*) clear of large conurbations and other interference sources,

(*e*) capable of connection into the inland network,

(*f*) geologically stable and suitable for supporting the large aerial structures,

(*g*) site for which planning permission would be forthcoming and, of course, one that could be purchased at a reasonable price.

SITE SEARCH AND ACQUISITION

A map study of the south-western part of the country commenced and the armed services were approached for details of surplus airfields or other redundant establishments in that area.

In August 1960, I set off in my open Lea Francis sports car to survey several potentially usable sites including three unused airfields around Exeter, farmland near Kingsbridge and an ex-radar station at Prawle Point. My brief was to report back to the office on a Monday for a high-level meeting on the following day. In the event, the back axle of the car failed with a disconcerting bang at 16.00 hours on the Friday with further sites unexplored. Although those were the days when a telephone call to the main agents in London brought an immediate response of a crown

† Satellite and Lines Executive, British Telecom International

* LAWSON, J. S. R. Events up to TELSTAR, 1962. *Br. Telecommun. Eng.*, Oct. 1987 (this issue).

wheel and pinion being put on the overnight train, it still required the hotel landlord to lend me a car to complete my mission and report back by telephone.

Difficulties were encountered in obtaining the release of the favoured airfield site and the search continued. Studies were being undertaken to examine the problems of frequency co-ordination with the BPO's microwave links to Bristol and Plymouth. Although the actual frequencies to be used by the satellites had not yet been decided, it was considered that there was a possibility of interference occurring and this pointed to the choice of a site as far south west as possible.

As a result of advice from the local Telephone Area and the County Planning Officer, the area of search moved to the Lizard Peninsula, coincidentally the location selected by Marconi for his experiments 60 years earlier. Three sites were favoured:

(*a*) *Predannack*—an ex-wartime Royal Air Force airfield, deserted but partly used by the Royal Navy for simulated air-sea rescue operations by helicopters from RNAS Culdrose, and used, incidentally, by Barnes Wallis during his swing-wing aircraft experiments;

(*b*) *Croft Pascoe*—a Forestry Commission site, part of which could have been utilised for our purpose; and

(*c*) *Goonhilly Downs*—a large area of open land part of which had been a wartime radar station but then returned to private ownership.

A survey of each of the sites was carried out and, while any of them would have been suitable and were indeed pegged out, the larger and immediately usable Goonhilly (Figure 1) topped the list. Almost all the Lizard has a substrata of a very hard granite-type rock called *serpentine*, and at Goonhilly this appeared outcropped or only about 60 cm down over most of the site, which made it unsuitable for agricultural use. In spite of this, the price exceeded that recommended by the Ministry of Works, but the recent financial independence obtained by the BPO enabled an agreeable settlement to be reached with the owners. The ownership of the 163 acres was in fact divided between two prominent local landowners while others had common site boundaries.

PLANNING

In February 1961, the BPO signed a 'Memorandum of Undertaking' with the National Aeronautical and Space Administration (NASA) to participate in the experiments with active satellites, and work then began in earnest: negotiating for the site, placing the contracts for the aerial, mobilising the Ministry of Works for the construction of the equipment control building and of course the BPO South West Region and local Telephone Area for communications. Planning was already well advanced on the best way of establishing the necessary broadband link back to London and had settled on using the London–Bristol coaxial cable route, expanding the existing Bristol–Plymouth microwave link and extending this by two intermediate stations to Goonhilly by using 2 GHz equipment. Transactions for the land were sufficiently far advanced by March 1961 to enable a detailed survey to be carried out, and this was my first experience of 'Cornish mist'. Carrying out a survey to a 50 ft (15·24 m) grid with the team and the levelling staff disappearing in and out of the mist is an experience for budding surveyors.

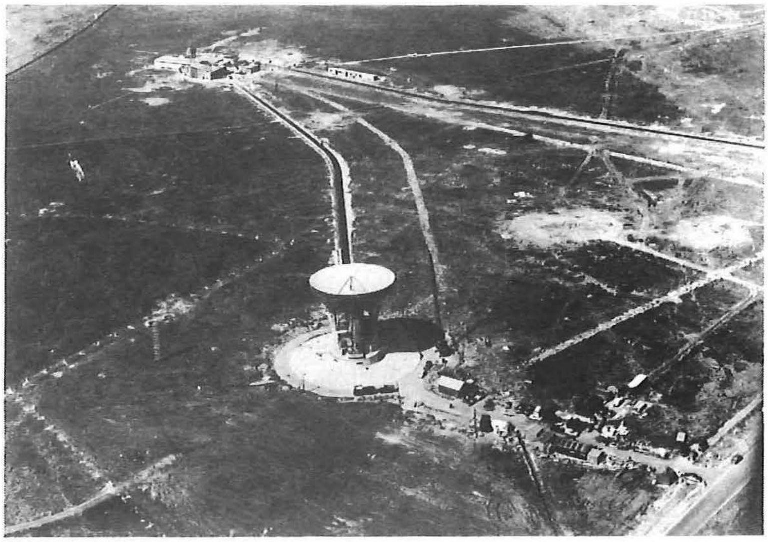
The site included the usual service water tower, three concrete shelters and a number of much older relics—seven ancient burial mounds, called *tumuli*, and a standing stone dating from the Bronze age or earlier, plus a most valuable modern asset—an Ordnance Survey trigonometrical station.

The layout of the site, which was approximately 0·8 km square, was planned to utilise the base of some existing roads; the control building was located roughly in the centre of the site and the aerial in the eastern corner, adjacent to the main road.

The need for aerials to be able to work in pairs was envisaged for any future commercial system and the positions for four further aerials established.

In 1961, the sources of large parabolic aerials were few, but a firm of consulting engineers, Husband & Co. of Sheffield, who had earlier (1957) designed the giant 76 m (250 ft) diameter Jodrell Bank radio telescope, had on the drawing board the design for a smaller 'mark 2' telescope, also for Manchester University. This design, consisting of an elliptical reflector supported on a concrete azimuth structure, was suitable for modification to incorporate the more accurate 26 m (85 ft) diameter parabolic reflector and equipment cabins required for our purpose.

Figure 1
Aerial view of site for Goonhilly Downs satellite earth station, May 1962



Full access to the Goonhilly site was obtained in July 1961 and work commenced promptly with the demolition of two of the three concrete shelters by local units of the armed forces using explosives. Some years later, during site clearance of the site for the second aerial, a contractor brought me a handful of unexploded gelignite that had been discovered in the rubble of one of these shelters. Needless to say, it was handed to the bomb disposal authorities with some alacrity.

To reduce the design time for the central control building, one of a range of standard buildings used by the Ministry of Works for the microwave link stations was selected. The layout was planned to accommodate the remote control suite for each set of equipment in a main console in the apparatus room, which would also include the intermediate frequency and baseband equipment, record and measuring facilities, 24-channel multiplex equipment and the microwave link. Elsewhere in the building were located telecine equipment and a computer room. The control of the aerial was also initially planned to be located in this area by using a submarine-type periscope, but, in the interests of safety and to provide a visitors' viewing position, an airfield-type control tower (Figure 2) with outward sloping windows was added to the design. Interestingly at that time, the nearby naval air-station had vertical windows in their tower but soon borrowed 'our design'.

Figure 2
Aerial 1 control tower and inland-link microwave mast

In order to carry out tests of transmission and reception before the launch of the satellite and to determine the radiation pattern of the aerial, it was necessary to establish a simulated satellite station that was far enough away for the beam to have formed and of course above the horizon from Goonhilly Down.

At that time, telecommunication to the Scilly Isles was by a VHF radio link from a BPO station called *Leswidden*, near Lands End, and an early task was to ensure that a 'line of sight' existed between the sites and to measure the actual bearings. The path length between the sites was approximately 34 km across Mounts Bay, an area frequented by small fishing craft. It was considered that observation by theodolite of a normal target over that range was unlikely to be successful, even in good visibility, and the Department of Overseas Surveys advised the use of either a survey beacon lamp having a very narrow but intense beam or a heliograph. The 1922 heliograph loaned to us proved nostalgic for one of the local technicians assisting me who had used similar signalling devices in India and was fairly expert at the accurate alignment necessary. However, this may have been reliable in the outposts of the Empire where the sun always shone, but we were defeated and had to use the beacon lamp at dusk, night being avoided on the advice of HM Coastguard because of the risk of confusion to shipping. From the height of the centre of the Goonhilly aerial, it was found that a 12·2 m (40 ft) high tower was required at Leswidden for a ½° elevation angle, and three 'stout' poles were recovered from another site near Bodmin to form a structure capable of supporting two 3 m (10 ft) dishes.

WORK COMMENCED

Excavation work for the aerial base and central building commenced in July 1961 and, owing to the serpentine rock, blasting was necessary to achieve adequate depth for the foundations of the circular track and centre pivot. To avoid the time-consuming and expensive work of excavating a cable trench between the two sites, a distance of about 0·4 km, concrete troughs mounted on short pillars were utilised to carry the 4-coaxial-pair signal cable and the equipment control cables.

One of the essentials for accurately tracking the satellite according to a pre-computed program was to have an accurate time reference. The BPO Research Branch was one of the world authorities on the manufacture of quartz crystals for accurate frequency measurement, and so it was natural that such devices should be installed at Goonhilly to provide the necessary universal time clock reference. To ensure the utmost stability, our specification to the builders called for separate foundations down to the bedrock. On a site visit, we found a workman at the bottom of a 12 ft deep hole still digging. We had located the crystal room over one of the few holes in the serpentine and we settled for the hole to be filled with concrete. When explosives were used to demolish the third and final concrete shelter, which had been used by the contractors during construction, observations were made to test the stability of the crystals and they were found to be vibration free.

The aerial consists of a circular concrete turntable carrying two reinforced concrete 'A' fames and a centre portal supporting the elevation bearing cross-beam. The turntable, rotating about a centre-pivot, was carried on a tapered roller track about 12·2 m (40 ft) in diameter. While construction of the concrete work progressed on site by Cleveland Bridge and Engineering Co., the heavy but high-precision machining of the roller track and the 9·1 m (30 ft) long lead screw (Figure 3) for the elevation drive was being carried out by Messrs. Markham of Chesterfield.

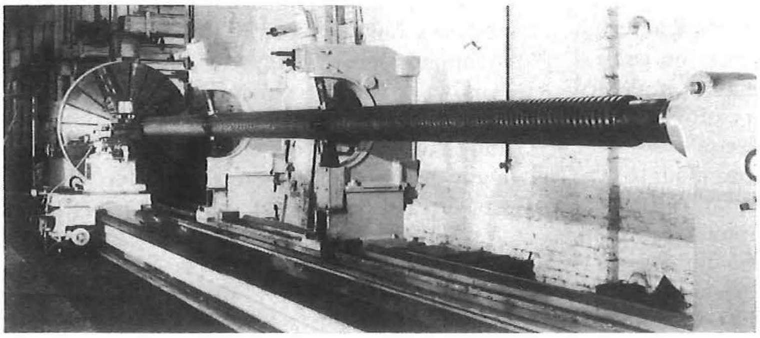


Figure 3 Turning elevation screw

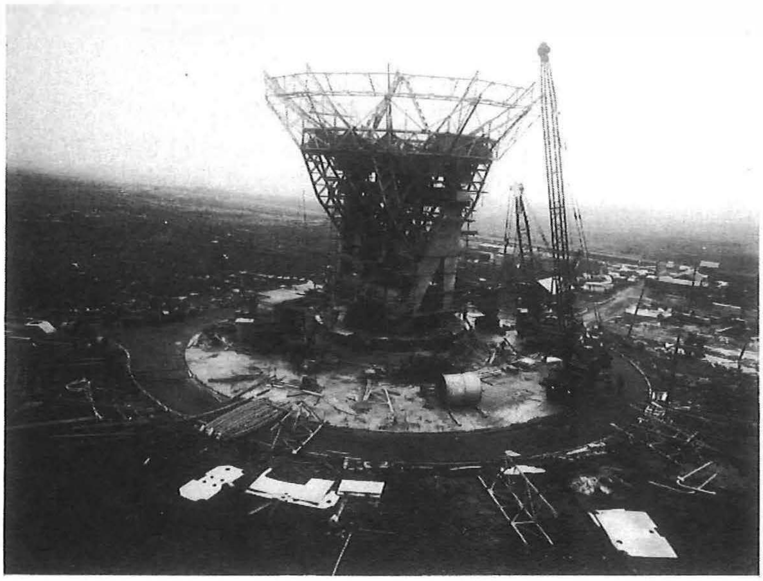


Figure 4 Aerial 1 under construction, March 1962

By the end of 1961, the concrete construction was nearing completion and after a 3-week period of maturing, the elevation cross-beam was ready for stressing. Some 288 steel wires in 24 tubes had been arranged inside the concrete beam and by using hydraulic jacks these were tensioned, the wires being gripped in tapered collets in the end plates. This operation, as were most others, was to be filmed by the BPO cine unit, but came to an abrupt end when failure of some of the wires caused the collets to be fired like bullets in the direction of the cameraman. Erection of the steelwork (Figure 4) for the reflector was the next operation and this was contracted to John Brown Land Boilers, whose crew consisted mainly of shipyard steelworkers from Clydeside. This was also a highly hazardous operation, at least for the Husband and BPO resident engineers and film unit, for whom a ladder had to be provided. This was the era of lightning strikes for increased pay and, frequently, work would cease and the steelmen would descend hurriedly via the structure while their spanners, welding torches etc. would slide down the reflector to cascade around the ladder and any unfortunate on his way up. By using shipbuilding techniques the 10 gauge Corten steel plates were screwed and welded into place on purlins to achieve an accuracy, considered good then, of 3/16 inch (4·8 mm) in the centre area and 3/8 inch (9·5 mm) at the outer panels.

With the completion of the antenna, systematic step-by-step testing of the drive mechanisms was undertaken as well as careful balancing of the reflector by the addition of scrap steel and concrete to the counterweight boxes. Finally, before the aerial could be used to track a satellite, it was necessary to know accurately where it was pointing. Devices called *encoders* were fitted to both azimuth and elevation axes and these were capable of resolving the angle to within approximately 20 seconds of arc, but of course needed to be zeroed. In order to carry this out, one of the cabins behind the reflector was equipped with a telescope similar to those used in gunnery, aimed parallel to the axis of the dish, and it was my task to make observations of the sun and stars while being tipped through 90° to determine the actual mechanical pointing angle of the aerial relative to true north and the horizon.

PROJECT COMPLETION

The aerial was finally completed in time for the launch of the TELSTAR satellite on 10 July 1962 just one year after construction work commenced, and in spite of the international notoriety the aerial received at the time for being driven by a 'bicycle chain', it still continues to perform a valuable service to BT's satellite communications.

Biography

Brian Oakes is Planning and Provision Manager for the Goonhilly Downs earth station. He joined the BPO in 1948 as a draughtsman-in-training. After initial training, he spent some time in various specialist offices of the Engineering Department including Research, Lines, Power and Factories, and then Radio Branch, working on the reconstruction of the main radio stations—Rugby and Ongar and the coastal radio stations. After his success in the 1958 limited competition for Assistant Engineer, he was appointed to the Radio Inland Branch, which involved the structural and external provision of microwave stations. This led to his early involvement in the construction of the Goonhilly earth station; when the Satellite Branch was formed, he was one of the initial station staff with responsibility for the aerial and all mechanical, power and cryogenic activities. This was followed by a period as Executive Engineer supervising the construction of aerials 2 and 3 before transferring back to London in 1971 to join the newly formed overseas satellite consultancy group, which took him to Africa as Chief Resident Engineer for the construction of an earth station for the Republic of Zambia. On his return to Headquarters, he became Head of the earth station planning group, and in 1981 was promoted to his present Head of Section post.

ELECTRA Mark 2—A Codemark Checking Machine

R. VICK, C.ENG., M.I.MECH.E., and J. S. BUTLER, M.I.E.E.E., M.SC., D.I.C., A.C.G.I.†

UDC 656.851

With the advent of more mechanised sorting of letter mail in the British Post Office (BPO), the need to provide a fast and accurate means of checking the quality and accuracy of coding is vital. The ELECTRA machines were designed by the BPO to meet this need.

This article is based on a paper presented at the International Postal Engineering Conference, May 1986, and is reprinted here by permission of the Council of the Institution of Mechanical Engineers.*

INTRODUCTION

In any highly automated process, the need for quality control is paramount; automatic mail processing is no exception.

It is the quality and accuracy of codemarking which the mail receives in the mechanised handling system which will ultimately determine the quality of service that the British Post Office (BPO) can offer to its customers.

The ELECTRA Mark 2 machine was conceived to simplify the present manual and laborious sampling system used in the BPO for monitoring codemarking and sorting accuracy.

The ELECTRA Mark 2 (Figure 1) was designed to read automatically phosphor codemarks printed on mail by either ink jet printer or hot pin transfer methods, and to display the corresponding alphanumeric code, to enable the operator to compare the displayed data with the address information on the mail item.

This article describes the design and construction of the machine, together with giving a résumé of the operational facilities.

† Engineering Department, British Post Office

* VICK, R., and BUTLER, J. S. Electra Mark 2—a code mark checking machine. Postal Engineering, *Proc. I. Mech. E.*, **1986–5**, p. 265.

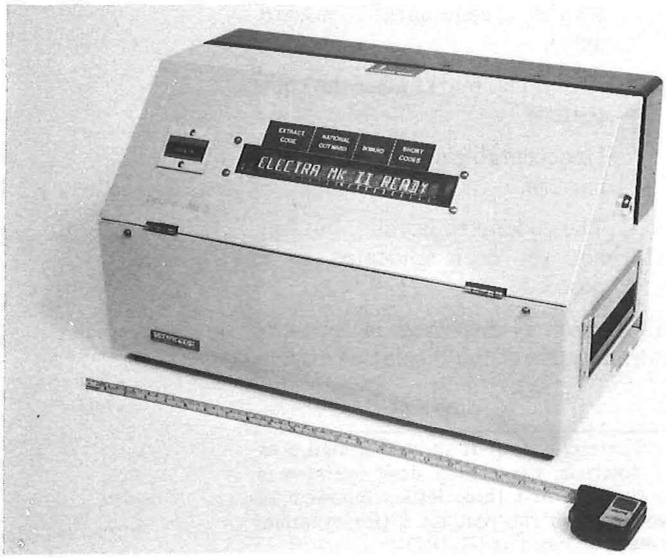
BACKGROUND TO THE DEVELOPMENT

The need to maintain a high quality of service has always been one of the main objectives and traditions of the BPO. This philosophy is as important today in highly mechanised offices as it was in the early days of the business.

In mechanised letter sorting offices (MLOs), mail is coded by either optical character recognition (OCR) machines with ink jet printers or manually by letter coding desks. The vast majority of coded mail in the BPO is produced by letter coding desks. The codemark format for both the OCR machine and the coding desk is the same: one row for the 'outward' (up to 14 bits) and one row, directly above it, for the 'inward' (up to 14 bits) (Figure 2). The codemarks are achieved by a coding desk operator reading the address (or postcode) and pressing the appropriate keys on a keyboard. The quality of service that the item of mail receives thereafter is directly related to:

- how accurately the operator has read the address, and
- how accurately the operator has transcribed the address to the keyboard.

Figure 1
ELECTRA Mark 2



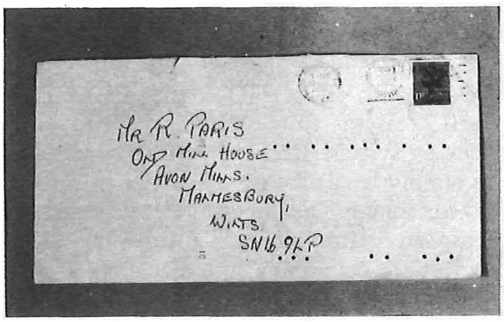


Figure 2—A typical codemarked letter

Prior to the introduction of ELECTRA, MLO supervisors checked coding efficiency by comparing the codemark pattern(s) with the address on the letter. These checks are carried out on a random basis during the coding process. The supervisor placed a plastic gauge over the letter and added together the corresponding denary number for **each** codemark for both the outward and inward codemark patterns. The supervisor referred the sum total for each codemark pattern to a master reference file. The information in the master file should correspond to the address/postcode on the letter. This method of checking operator coding accuracy was laborious, prone to error, very time-consuming, and allowed only a limited number of items to be sampled in any given time.

Consequently, the BPO Engineering Department was asked to devise a method by which the manual process of checking coding accuracy could be replaced by a fully or semi-automatic system. It was from this brief that ELECTRA was born.

THE FIRST ELECTRA

The first ELECTRA, the ELECTRA Mark 1, was a small hand-held device and was incorporated into a proprietary calculator. The inward only part of the codemark pattern was manually entered by the supervisor as a series of '0's and '1's, a '0' being keyed when a codemark was missing and '1' being keyed whenever a codemark was present. The calculator display would then indicate the alphanumeric code corresponding to the information keyed in. Although significantly faster than the then current manual method, the supervisor needed to 'key in' the codemark pattern; unfortunately, owing to the limited size of memory, only the inward part of the code could be checked and it was, of course, also prone to operator error.

THE SECOND ELECTRA

The second ELECTRA, the ELECTRA Mark 2, is a fully automatic codemark checking system. Items of mail to be checked are simply 'posted' through a slot in the top of the machine. The item is then automatically transported through an ultraviolet (UV) irradiation section and into a reading section where both the outward and inward codemark patterns are read simultaneously. The corresponding alphanumerics for the code patterns are then displayed. This operation takes approximately 1½ seconds.

CAPABILITIES OF ELECTRA MARK 2

The ELECTRA Mark 2 can read and decode the following:

(*a*) outward extract† codemarks;

(*b*) national outward and inward codemarks;

(*c*) national short codemarks;

(*d*) local short codemarks; and

(*e*) simultaneous display of options (that is, if any outward codemark pattern corresponds to, say, an extract code and outward code and national short code and local short code, **all** options are displayed).

ELECTRA MARK 2 DISPLAY

The ELECTRA machine incorporates a vacuum fluorescent display which has twenty 12 mm characters. The display is divided into four sections, with each section separated by a blank character: extract codes are shown in the first section (five characters), outward codes appear in the next section (four characters), inward codes appear in the third section (three characters) and the last section (up to five characters) is used to display national or local short codes. The position of the information on the display therefore depends upon what type of code was keyed on the item.

It is possible for more than one code to be shown at any time (item (*e*) in the previous section refers). If a codemark pattern is shared by more than one outward code, each of these possibilities is flashed alternately on the outward part of the display. For example, IP32 and IP33 share the same outward code and so when keyed produce the same codemark pattern. IP32 and IP33 will then be shown alternately on the display. This would also occur if an outward code shared a binary with a local short code. In this instance, a code is shown in the outward code section of the display, and another in the part reserved for national or local short codes.

If the codemark information on the letter is incorrect, the following characters will be shown on the display.

⋆P	Parity fail. This normally means that a mark is missing from the codemark pattern.
⋆I	Incomplete codemark.
⋆INV	Invalid codemark (inward only).
⋆A	Additional marks after the code pattern.
⋆U	Unacceptable marks in the code pattern.
SPARE	The codemark is valid, but has not yet been allocated to a postcode.

This information is displayed in the outward or inward parts of the display as appropriate.

† Outward extract codes—If an item of mail does not have a postcode, the coding desk operator is required to type the first three letters followed by the last two letters of the post town (for example, Guildford would be typed as GUIRD).

DESIGN, CONSTRUCTION AND MODE OF OPERATION OF ELECTRA MARK 2

General Description

The machine is 540 mm long, 305 mm high and 305 mm wide, and weighs 17·2 kg. The machine is portable and is powered from a standard single-phase (240 V AC) 13 A socket outlet.

Casework/Cover Design

Figure 3 shows the hinged top rear cover design which is required for operator access should a letter fail to drive through the transport system. The cover is interlocked to ensure that the complete transport system is switched off, and made safe, whenever the cover is opened.

Engineering maintenance access is provided via lockable panels (Figure 4).

Mechanical Drive and Transport System

The drive arrangement (see Figure 5) consists of a 25 mm elasticated drive belt powered by a 40 W drive motor. The driven roller incorporates a shaft encoder for the generation of shift pulses required during the reading process. The elasticated transport belt is conveyed around the driver and driven rollers and constrained longitudinally within a recess in a vertical plate which contains:

(*a*) Two UV lamps (365 nm) mounted one above the other to coincide with the outward and inward rows of codemarks.

(*b*) A reader entry beam which incorporates an optical-fibre cable 'receiver' to detect the presence of a letter prior to 'reading'. (The other end of the optical-fibre cable is terminated on the solid-state reader board.)

(*c*) Two optical-fibre reader windows to coincide with the outward and inward rows of codemarks. (The end of each optical-fibre cable is terminated on the solid-state reader board.)

The mechanical drive arrangement also contains a rotary solenoid with roller, activated by a photo-reflective sensor, which is used to detect items of mail within the machine immediately after entry into the UV irradiation section.

When a letter is dropped into the UV section, the letter initiates a one second delay. The delay is to ensure that the letter has settled down on its long edge and to allow the codemarks to be irradiated. After the one second delay, the solenoid-activated roller pushes the letter against the continuously running drive belt which then conveys the letter past the reader windows.

Electronics System

The electronics crate is contained in the base of the machine. The crate contains the following printed-wiring board assemblies:

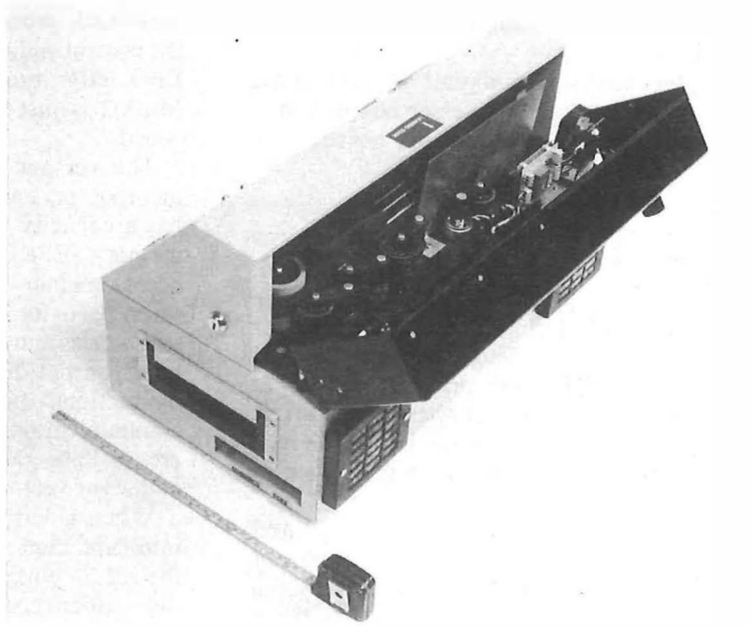


Figure 3—Hinged top cover for operator access to letter transport path

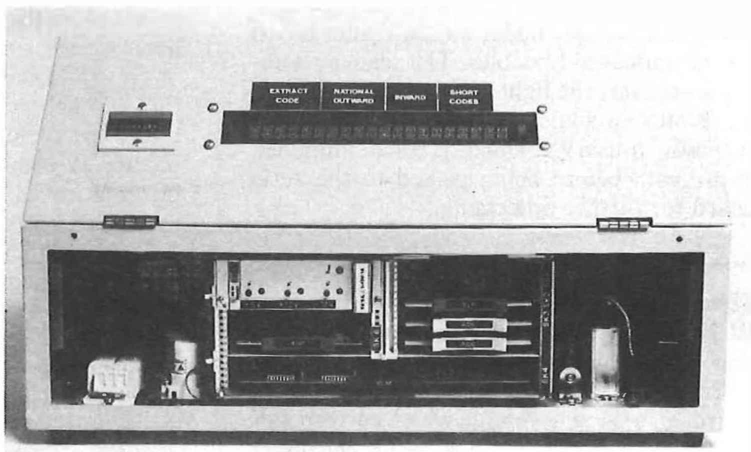


Figure 4—Removable front cover gives engineering access to electronics control system and printed circuit boards

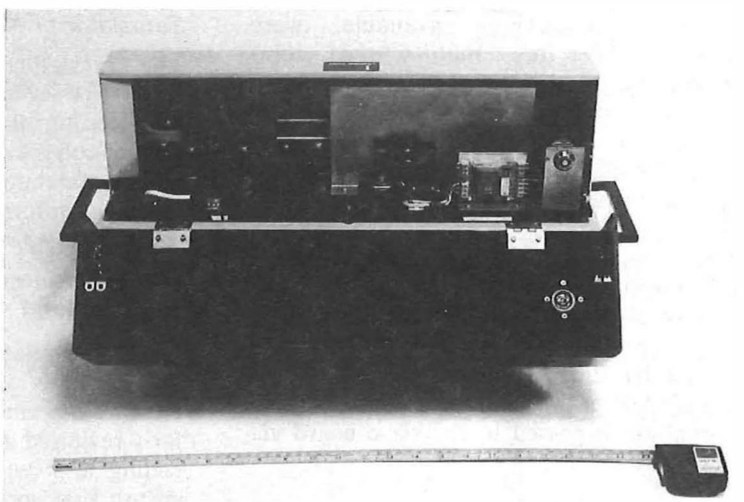


Figure 5—Mechanical drive arrangement for letter transport path incorporating UV irradiation section and reader area

(*a*) one dual-channel solid-state reader board,
(*b*) two analogue-to-digital (A/D) boards,
(*c*) one slave microprocessor board, and
(*d*) one translator or memory board.

Solid-State Reader Board

The solid-state reader board, which was designed by BPO Research and Development, contains three photodiodes, two of which have their own built-in amplifier and are used for codemark detection. The third photodiode is used to detect a letter prior to entry into the reader area. Each of these detectors is connected to the reader entry beam, the outward window and inward window by its own optical-fibre cable.

When a letter enters the reader area and breaks the reader entry beam, an interrupt signal is sent via the reader board to the slave board (see item (*c*) above). The letter containing 'glowing' codemarks in either or both the outward and inward rows is transported across the two reader windows. Photons of light emitted by the marks are conveyed to the photodiodes on the reader board by the optical-fibre cables. The reader photodiodes convert the light emitted by each codemark into an analogue voltage (amplified to typically 0·1 mV) which is then amplified once again before being passed to the A/D board for further processing.

Analogue-to-Digital Boards

There are two A/D boards in each ELECTRA: one for the inward row of codemarks and one for the outward row.

Each A/D board receives, from the reader board, an analogue voltage which corresponds to the light level emitted by each codemark as it is transported past the reader window.

The A/D board is a 6 bit 'flash' converter designed and developed by BPO Research Department. (At the time of the ELECTRA development, single-chip flash converters, although commercially available, were expensive. Therefore, multi-sourced components were used in the design to minimise costs and to maximise maintainability.) The conversion is performed in 0·5 μs by using two ladder networks of resistors (coarse and fine) and two associated sets of comparators. The analogue voltage is fed from the 'coarse' ladder comparators (which decode the three high-order bits) to the 'fine' ladder comparators (which decode the low-order bits). The range over which the 'fine' ladder operates is selected by diode gates connected to the 'coarse' ladder comparators. This digital information is passed to the slave board via one of its parallel ports.

Slave Microprocessor Board

The slave board was designed and developed by BPO Research and Development as a multi-task processor specifically designed for the control and monitoring functions on future BPO letter processing systems. ELECTRA Mark 2 is just one application for the slave board.

The version used in ELECTRA Mark 2 incorporates an Intel 8085 microprocessor. It has a capacity for up to 2 Kbyte of program memory (EPROM) and 1 Kbyte of random-access memory (RAM). It has two RS232 serial ports for communication with the 'outside world' and/or other processors. It has 48 input/output lines (configured as 6 × 8 bit bidirectional ports) which can be used for communication, operation of lamps or relays etc. or data gathering, and contains a timer and eight vectored levels of interrupt.

When a letter enters the reader area, an interrupt signal is sent to the slave board via the reader entry beam optical-fibre cable and the reader board. The slave then samples readings from the port which is linked to the corresponding A/D board for every 1/64 inch of letter travel. (The shift pulses which correspond to each 1/64 inch of letter travel are provided by the shaft encoder mentioned earlier.)

This information is built into a digital picture of each codemark and a digital picture of the complete codemark pattern. When the picture is complete, the slave analyses the information to determine whether the codemark pattern is valid or not.

If the codemark pattern is incorrect (that is, parity fail, incomplete code, additional marks after the code pattern, unacceptable marks in the code pattern), the appropriate error message is passed to the memory board. If the codemark pattern is valid, the slave accesses the memory board and, using the memory board as a look-up table, determines the appropriate alphanumeric characters. The required information is then passed to the display by the memory board.

Translator or Memory Board

The translator or memory board has nine EPROMs, seven of which contain information for decoding all national outward, all outward extract codes and all national short codes.

The remaining two EPROMs contain the necessary information for decoding all local short codes which relate to a particular MLO.

(*Note*: The inward codes are decoded by using an algorithm.)

All data relating to BPO sorting plans are held centrally on the VAX computer at BPO Research, Swindon. This data bank is regularly reviewed and changes are made to both coding and sorting plans (programmes) to ensure that sortations in mechanised offices meet the needs of the customer and reflect changes in mail flow patterns. Clearly the ELECTRA machine was required to have a facility by which its own memory could easily be updated in the event of either a national change or a local change in coding being made. BPO Research proposed a system whereby the VAX computer would be able to down-load specific coding data directly to an EPROM burner and so produce a 'master' EPROM. This could be copied and distributed nationally as and when required. Upon receipt of an updated EPROM, the local maintenance engineer at the MLO would replace one, or more, of the designated EPROMs on the memory board with the updated version(s).

CONCLUSIONS

ELECTRA machines have been supplied to all operational MLOs throughout the UK. A total of 118 machines have been manufactured at a cost of £3500 per machine. This is clearly evidence of the BPO's commitment to improving the quality of service of its business and, at the same time, improving the service to its customers.

ACKNOWLEDGEMENTS

Acknowledgement is made to the Director of Engineering for permission to publish this article and to A. D. Pratt (BPO) for his assistance and advice to the authors.

AUTHOR'S UPDATE

Since the first publication of this article in May 1986, development in both hardware and software has been undertaken to improve the performance of the machines following their introduction to, and feedback from, MLOs throughout the UK. In addition, experimental work has demonstrated the feasibility of reading ink jet printer phosphor codes, on varying backgrounds, containing both the routing code and management data, and down-loading this data directly to an IBM (or compatible) PC. Field trials of the latest design of machine are scheduled for the latter part of this year.

Advances in High-Speed Phosphor Printing

D. EVANS, B.SC.(ENG.), and C. J. SPICER, B.SC.†

UDC 655.2 : 535.37

The development of the optical character reading machine for high-speed codemarking and sortation of letter mail has led to the need for a high-speed method of printing the phosphorescent codemarks used by the mechanised letter sorting machine. This article considers the requirements for the printing system, the method adopted and the results achieved.

This article is an abridged version based on a paper presented at the International Postal Engineering Conference, May 1986, and is reprinted here by permission of the Council of the Institution of Mechanical Engineers.*

HISTORY

Early in the development of the automatic letter sorting system, the British Post Office (BPO) adopted a system of codemarking letter mail with phosphorescent machine-readable codes. Phosphorescent encoding was chosen in preference to fluorescent, magnetic, or passive optical encoding because envelopes have no natural phosphorescence, thus simplifying the detection of the coded information. Fluorescent and magnetic encoding systems are more likely to suffer from background interference: background fluorescence from optical brightening agents added to the paper during manufacture, and background magnetism from enclosures within envelopes. A passive optical system (black and white bars) places a constraint on the customer to leave a set area of the envelope blank and is unacceptable.

The method of coding currently in use on coding desks is hot-melt transfer which, whilst highly effective on all envelope materials at coding desk rates, is an inherently slow process having a maximum throughput speed of two items per second. Optical character reading (OCR) machines are cost effective only at high throughput rates, of the order of ten items per second, and so a new method of printing was required to match the higher speed.

Enclosures within envelopes can be irregular in shape, raising some parts of the envelope surface and leaving cavities elsewhere, and can thus render the envelope vulnerable to damage by high pressures from an impact type of printer. An ink jet printer imposes almost zero impact pressure on the printed item and also has the capability of high printing speed. It thus became the first-choice solution to the printing problem, even though no suitable phosphorescent ink was available at the time[1].

INK JET PRINTING METHOD

Ink jet printing technology covers a diversity of methods ranging from the physical movement of a small glass nozzle from which ink is ejected in a continuous stream, to droplet-on-demand printers from which individual ink droplets can be expelled as required. The method chosen for development uses a continuous stream of droplets each of which can be individually charged to a prescribed level. The droplet stream then passes through a fixed electrostatic field where the charged droplets are deflected by an amount dependent upon their charge. The system outline is shown in Figure 1. A mail item travelling along the line at right angles to both the direction of the ink stream and the line of the deflection can therefore be scanned by a raster of droplets.

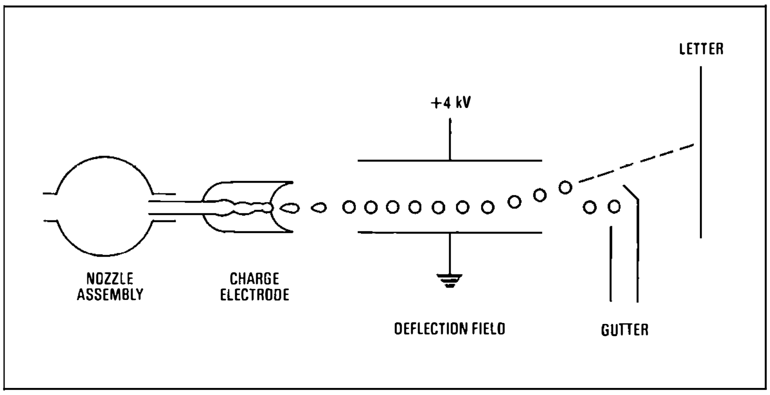


Figure 1
Printer schematic

Good quality ink jet printing depends on uniform droplets, and a critical part of the system is the nozzle from which the jet issues. Any stream of liquid will, after travelling a short distance, break into droplets under the influence of surface tension forces and random vibrations. This phenomenon can be observed by turning a tap to allow a thin thread of water to emerge: a few centimetres downstream the smooth-sided stream becomes ragged and breaks into droplets. It will be noticed that

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* EVANS, D., and SPICER, C. J. Advances in high speed phosphor printing. Postal Engineering, *Proc. I. Mech. E.*, **1986-5**, p. 23.

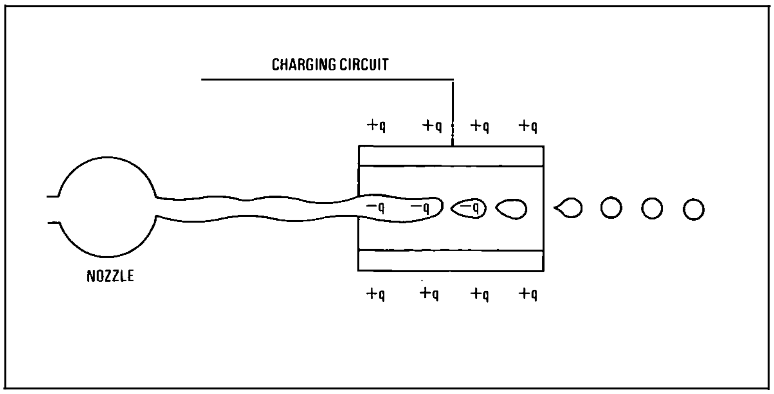
the point of breakup is not fixed, but will dance up and down in an erratic fashion.

In the ink jet printer, it is essential both that the break-up point is contained within the droplet charging zone and that the droplets produced are of identical size. To achieve this, the ink stream is vibrated by a piezo-electric transducer mounted in the nozzle assembly. The imposed disturbance forces the rapid formation of uniform-size droplets at a rate determined by the imposed frequency.

With the ink stream break-up point firmly fixed in relation to the nozzle, accurate charging of individual droplets can be achieved by induction from an adjacent charging electrode.

A positive charge applied to the electrode (Figure 2) induces an equal negative charge on the ink stream. When the droplet breaks off, the charge is trapped until such time as the droplet strikes a conducting surface. By this means, droplets can be charged to any prescribed level determined by the voltage on the electrode and the capacitance of the system (C). For consecutive droplets to be charged to different levels, the charging time must be less than $1/f$, where f is the droplet frequency. The charging time is influenced by the capacitance C and the resistance of the charging circuit, a factor of which is the resistance of the ink stream. A high-conductivity ink is therefore necessary.

Figure 2
Droplet charging schematic



One aspect of the printer which is of particular interest is that the stream of charged droplets issuing from the charging system represents a flow of electrical current and yet there is no DC flow from the power supply feeding the charge electrodes. The printer is in actuality a small generator directly converting the kinetic energy of the ink stream into electrical energy. (A small AC flow (i) occurs in the charge electrode circuit; this is as a result of the change in the capacitance of the system as droplets break from the parent stream: $i = V\mathrm{d}C/\mathrm{d}t$).

The deflection field is produced between a high-voltage electrode maintained at 4 kV (Figure 3) and an earthed electrode. If parallel plates are used, a linear electrostatic field is developed and the deflection of the droplets is along parabolic paths. For ease of maintenance, however, the deflection electrodes have been constructed from rods (Figure 4) which produce a non-linear but stable field. The initial flow of ink on switch-on may produce splutter on the lower electrodes which will flow to the underside of the electrodes and not distort the field. Splutter is less likely to affect the upper electrode, but, if it does, it can be easily seen and cleared by the maintenance engineer.

During the time taken for a letter to pass in front of the printer, some 1400 droplets are produced by a single nozzle, but only 30 droplets will be used on the average letter, the remainder being available for recycling. The recycling process commences at the gutter where uncharged droplets are caught and allowed to flow under gravity to a collection tank.

Figure 3
Linear deflection field

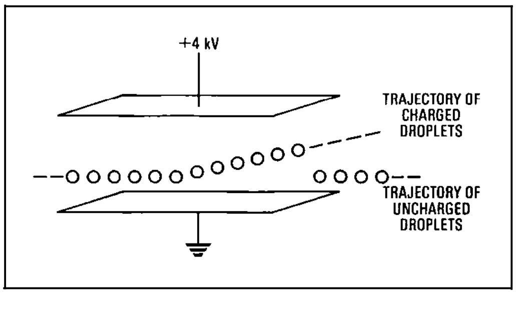
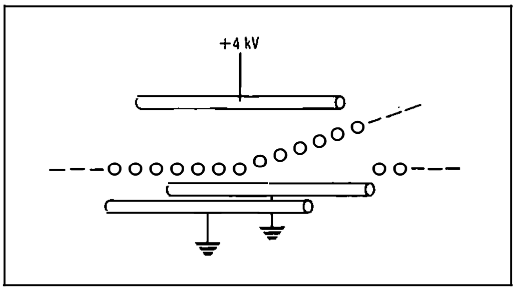


Figure 4
Rod deflection electrodes



A feedback system is used to control the charging of droplets. Feedback is necessary because variations in ambient temperature conditions cause the physical parameters of the ink to change (in particular, in viscosity and surface tension), with a resultant change in the droplet break-off position and timing. The nozzle drive signal is used as the reference time frame for the system and it is important to know in which half cycle droplet break-off occurs so that changes in charging levels are not attempted at the same time as droplets break-off. In the periods between printing bars on envelopes, a small charge is placed on the droplets at a level insufficient to cause deflection of the droplet stream above the gutter. This charge, when detected at the electrically isolated gutter, is sufficient to enable the charging process to be maintained in phase with droplet break-off. If a charge is not detected at the gutter, then the phase relationship between the droplet charging signal and the nozzle drive signal is changed.

PHOSPHORESCENT INK

The jet printer requires an ink that is essentially free from solid suspended matter in order to prevent blockage of jets or filters. The fact that phosphors are normally solid materials at room temperatures posed to the BPO's chemists a fundamental problem which was approached from a number of directions.

The BPO has developed organic phosphors[2, 3, 4, 5] which are a much cheaper alternative to their inorganic counterparts. It is known that certain organic compounds will exhibit phosphorescence when dispersed in a suitable solid matrix such as a resin or a glass system. The matrices used by the BPO are based on urea, cyanuric acid or melamine formaldehyde resins. Phosphorescence, in this case, is a manifestation of the radiative decay of a triplet excited state to a singlet ground state. This electronic transition is said to be forbidden by quantum mechanical methodology ensuring that the triplet has a long lifetime and, hence, afterglow occurs. Unfortunately, in the liquid state, molecular collisions will favour a non-radiative decay by dispersing thermally the energy of the excited triplet state. Phosphorescence of liquids at liquid nitrogen temperatures (77 K) is well known; here the chance of deactivation by collision is very much reduced. Harrison and Wicken reported[1] a few cases of phosphorescence in solutions at room temperature (for example, protein enmeshed molecular systems), but indicated that none were suitable for postal coding and that the probability of finding suitable materials was highly remote.

The search for a jet-printable phosphor ink has been concentrated in four areas: suspensions of finely-ground BPO phosphor, suspensions of microsphere phosphor, ultraviolet (UV)-curable resin systems, and aqueous solutions of BPO phosphor pre-polymer.

Fine-Ground Phosphor Powder

Various attempts were made at suspending a finely ground urea formaldehyde phosphor in a medium consisting of 1,1,1-trichloroethane plus proprietary suspension agents to form a jet printer ink. The smallest particle size that could be achieved without damaging the optical properties of the phosphor was about 5 micron. However, the phosphor powder could only be realistically manufactured with a particle size distribution of 90% of the particles within the range 5–10 micron. Of course, even one large particle could block the jet and the fitting of filters merely moves the problem from the jet to the filter. Although a system using particulate ink was tested, the reliability was insufficient for operational use.

Microsphere Phosphor

This approach was developed jointly by the BPO and the London College of Printing. It was believed that it would be possible to produce much smaller particles of approximately equal size by polymerisation of the BPO phosphor as an aerosol. Initial work with urea-formaldehyde phosphor was disappointing since aggregates were formed as the particles were collected. Melamine-formaldehyde proved to be more successful and 2 micron spheres were produced which were slightly brighter than the 5 micron ground phosphor. The suspension ink made with the microsphere phosphor was not a significant improvement over the ink made from the fine phosphor powder and, because of the much higher production costs, the microsphere development work was discontinued.

UV-Curable Inks

Advances have been made in recent years in the development of UV-cured resins with many applications in the field of printing on paper and board. Unfortunately, there are a number of drawbacks in engineering a suitable ink for phosphorescent jet printing of codemarks:

(*a*) health and safety clearance of materials,
(*b*) such inks tend to be of high viscosity,
(*c*) cured resins will absorb UV radiation thus shielding the phosphor activator, and
(*d*) precursors may react with phosphor activator.

If a suitable UV-curable system could be found meeting both engineering and health and safety requirements, then it would offer the attractive prospect of being able to print on non-absorbent mail.

Phosphor Pre-Polymer

The phosphorescent ink used in the BPO jet printer is based on the melamine-formaldehyde resin system. The resinification can be split into two stages, (I) an addition stage between melamine and formaldehyde (which forms a mixture of methylol melamine derivatives) and (II) a subsequent condensation stage. The ink is a modified aqueous precondensate which is formed by halting the reaction at stage I prior to precipitation. The ink in the liquid phase is not phosphorescent, but when applied to an envelope the absorption of water into the paper and the rapid solvent evaporation restart the halted polymerisation. It is also thought that the slight acidity of the paper may contribute to the reaction.

Ink Manufacture

The manufacture of BPO phosphors has been documented in references 4 and 5. The jet printer ink is based on molar quantities of melamine and formaldehyde in the ratio of 1:2. The reaction is buffered to pH 8–9 since the condensation stage (II) is known to be accelerated under acidic conditions. The reaction can be monitored in a number of ways since during polymerisation various physical and chemical properties of the reaction mixture change. The proportion of reactive end-groups and/or unsaturation decreases, whilst both viscosity and refractive index increase as the average molecular weight increases. The number of free –OH groups decreases as the condensation proceeds, which will, in turn, cause a decrease in water solubility. Measurement of refractive indices is of little value since changes are small and highly temperature dependent. Viscosity measurement is more worthwhile, but again is temperature dependent. The water solubility is only slightly affected by temperature and is currently the most satisfactory method of reaction monitoring. A small volume of the mix is withdrawn and successive aliquots of water added, with shaking, until opalescence occurs. The ratio of the volume of added water to volume of the mix is the water tolerance. The ink is manufactured to a tolerance of 1:5. The ink is then stabilised by adding alcohol at the end of the reaction. This alcohol also serves to improve the drying properties of the ink. The properties of the ink are given in the Appendix.

PRINTER SELF-CHECKING FACILITY

The phosphorescent ink used in the printer is sufficiently dry to be smudge free within 500 ms of printing on most mail items, although the property of phosphorescence is not developed until the printed mark is totally dry, usually some 1 or 2 seconds after printing. It is not possible, therefore, to check-read the code pattern immediately after printing. This failing is not a major impediment. Check-reading is a process which is used on other OCR systems to confirm that the code-pattern printed on the envelope agrees with the address read from the envelope by the address reader. There is no attempt to re-read the address for this correlation process and so its value is limited to little more than confirming that the printer has printed correctly the information presented to it. The majority of error modes that such a system can detect (it cannot correct error modes) can be accommodated by a printer self-checking facility.

In Figure 5, a secondary gutter is shown on the opposite side of the letter transport path to the printer. Prior to each letter reaching the printer, ink droplets are charged so that their trajectories take them into the secondary gutter. The detection of the charge on these droplets gives an indication that the printer is in correct working condition and that codemarks will be printed as requested.

PHOSPHORESCENT OUTPUT FROM INK JET PRINTED CODEMARKS

A trial of the ink jet printer at Guildford mechanised letter office (MLO) in March 1980 revealed that the phosphorescent output from the codemarks was highly dependent on the background colour of the envelope; bright white envelopes gave a strong signal whilst dark manilas gave a much weaker signal. It was essential that mail coded by ink jet should be readable by the same reading system as hot-transfer printed mail, but providing that this condition was met there was no constraint on the shape of the ink jet printed codemark. Whilst it would have been possible to produce a codemark similar to the round dot of the hot-transfer printer, it was more convenient to produce a vertical codebar comprised of a number of smaller droplets. Moreover, because the phosphorescing codemarks are detected through a tall narrow slit, the level of the phosphorescent signal perceived by the automatic sorting machine could be adjusted by varying the number of droplets per bar. During the course of the Guildford trial, it became apparent that with the current sorting equipment, there was no level for the number of droplets per bar which would give the best achievable performance on both white and dark manila envelopes. Consequently, it was decided that a scanning system should be used prior to the printer unit and that the number of droplets per codebar should be modulated according to the background colour of the

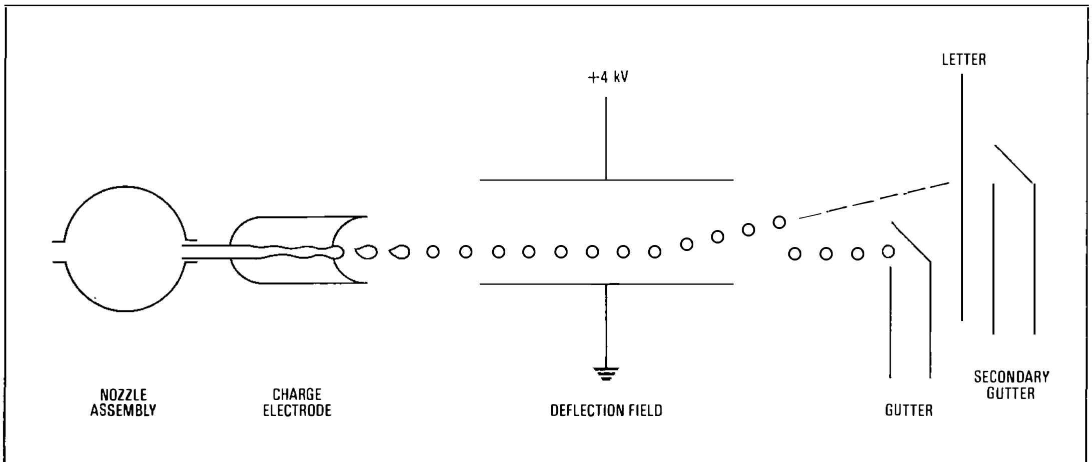


Figure 5
Printer with secondary gutter

envelope. Although it would be possible to discriminate between several levels of colour density and print bars containing from one to eight droplets, adequate system enhancement was considered attainable by the use of a single threshold level and two types of printed bar: three droplet and seven droplet.

BACKGROUND SCANNER

Although a simple single sample system could have been used to detect whether an item of letter mail was white or manila, it was decided that a sufficiently large percentage of mail items vary in colour density along their length, owing to logos, overprinting etc., to warrant a higher-definition scanning system. Solid-state emitter/detector pair devices as, for example, used in optical bar-code scanning wands did not prove adequate for the task. The cause of their downfall was the inability to maintain a constant device-to-envelope-surface distance on irregular items moving at 3 m/s; the output from these scanners proved to be more sensitive to distance than to colour density. It was decided, therefore, that a focussed scanner rather than a close or contacting scanner would be more tolerant of envelope surface irregularities. Figure 6 depicts the structure incorporated in the OCR machine. The envelope surface is illuminated by a parallel beam of light deflected by a prism. The reflected light also passes through the prism and is focussed onto a narrow slit behind which is a solid-state detector. Both the incident ray and the reflected ray are angled to the face of the letter to avoid specular reflection from shiny items. The slit in front of the detector is such as to enable dark areas as small as $0 \cdot 6$ mm^2 to be monitored.

Although a separate scanner is required for each codemark row, a common light source is used, the light being guided by optical fibres to the independent projection systems. A third fibre is used to feed a monitoring diode which is used to set up the threshold levels for the scanner system and to compensate automatically for variations in lamp output. In particular, long-term variations due to lamp ageing as well as short-term variations due to supply ripple (the lamp is fed by low alternating voltage) can both be accommodated.

LETTER TRACKING

The background colour information from the scanner is stored in a shift register incremented by the synchronising pulse wheel of the OCR transport system. The information is accessed from the system when the printer is instructed by the OCR to print a codebar, The response to a print instruction is rapid, and droplets are charged to levels sufficient to print the bar. These droplets then continue on their trajectory until they strike the envelope surface. The flight time of a droplet is of the order of 12 ms and is naturally dependent on its initial velocity, which is proportional to the square root of the nozzle pressure. The ink jet printer is tolerant of some variation in nozzle pressure and so the flight time of droplets cannot be considered to be a constant. Also the letter transport speed of the OCR machine is subject to some variation as a result of changing load and mains supply conditions, and so it too is not constant. As a consequence, some additional processing is required immediately prior to printing a bar to determine where the droplets will strike the envelope, so that the background information can be retrieved and used to control the height of the bar. Fortunately the printer self-checking facility provides the key to the solution of this problem.

The printer self-check facility fires test bars across the letter path prior to the the arrival of every item at the printer end so the time of flight for a test bar can easily be determined. If the time of flight is measured not in real time but in synchronising shift pulse time, then the value of the count, N, gives a direct indication of the distance the item travels during the flight of the droplets. N is used to compensate automatically for variations in both nozzle pressure and transport speed.

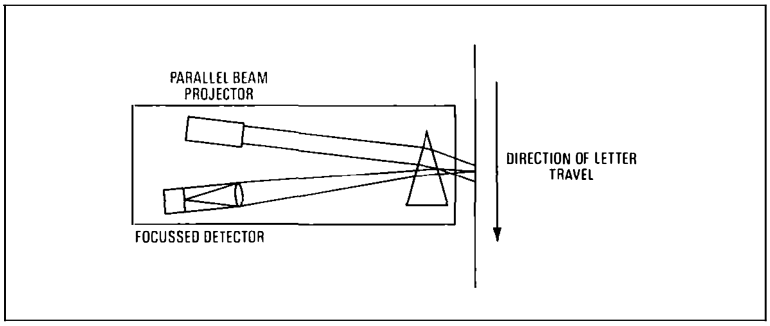


Figure 6
Optical scanner

INK DRYING

Printed codemarks dry by the dual processes of absorption into, and evaporation from, the surface of the envelope. Attempts were made to enhance the rate of evaporation to speed drying on non-absorbent items; calculations showed that the amount of energy required was small, but practical trials revealed a difficulty in providing an efficient energy-transfer process. As attempts at check reading had been abandoned in favour of checking the printer, the requirement for rapid drying rested on the need not to smudge the printed codemarks when the items entered the letter stacks. Tests soon indicated that internal stack pressure played a major part in the smudging of codemarks and, indeed, in exceedingly low pressure stacks, wet items could be stacked with impunity. The results of these tests have so far not influenced the design of the OCR stacking module. No auxiliary drying equipment has been added to the machine apart from a length of letter path to give 800 ms natural drying time between printing and stacking. Drying has recently been improved by reducing the size of the printed droplet.

FLUID SYSTEM

The codemarks produced by the printer are destined to be read only by machine and so there is no need to produce codemarks of a high visual quality. This means that pressure regulation of the ink stream at the nozzle does not need to be too refined and a simple pump with some elementary pressure regulation can be adopted.

The fluid system used is contained almost entirely within plastic piping to reduce the risk of ink/metal corrosion problems. Ink is pumped from the reservoir through a pressure regulating system comprising a simple pressure relief valve, a large-bore plastic pipe (which acts as a smoothing capacitor), a small-bore plastic pipe (a resistive element), a further large-bore plastic pipe and a final regulator. This system controls the ink velocity to within 0·5%. Commercial ink jet printer inks are normally dyes in a solvent of either water or a volatile base so that dried ink can be cleaned by the use of a solvent. The BPO phosphorescent ink does not share this property, but forms an essentially insoluble solid on drying. To ensure that the printer does not clog during periods of non-operation, a solution of alcohol and water is flushed through the nozzle on switch-off. The automatic flushing process takes place both on normal switch-off and under emergency-stop conditions.

RESULTS

The OCR equipment commenced field trials on 13 September 1983. From January 1984, the equipment has been in continuous operation with mail being sorted by the standard automatic sorting machines. In August 1985, a lower-cost printer was installed which produces smaller codemarks to improve the drying time.

FUTURE FOR INK JET

Ink is a very cheap encoding medium and slower-speed droplet-on-demand printers may well soon become an economic replacement for the current hot-transfer printers used on the coding desks. Ink jet has other advantages as well; in particular, there is no constraint on the pitch of the codemarks produced, and compression of the current space-consuming two-line code would be possible: also, there would be an opportunity to place machine-readable management data on the item, thus enabling rapid gathering of system performance and traffic routing information.

The current OCR machine is the first step for ink jet in the BPO; a slow-speed phosphor ink jet for use on coding desks is in its final development stage and in the near future ink jet will be used in a variety of letter-handling machines.

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3 British Patent 870504
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5 British Patent 149103
6 WALKER, A. D. Optical Coding Materials. Symposium on Newer Optical Materials, London College of Printing, 28 March 1979.

APPENDIX

BPO Phosphor Ink Properties

Colour	Normally colourless, but blue dye added for operational reasons	
Luminescence	Bright yellow/green afterglow (see Figure 7)	
Physical	Viscosity	3–6 cP @ 23 °C
	Surface Tension	30–40 mN/m
	Resistivity	6–10 Ω m
	Specific Gravity	1050–1060 @ 23 °C
	pH	8–11
Storage	Six months	
Health and Safety	All components of the ink including the activator have been health cleared	
Drying Time	Smudge free on paper mail in 800 ms	
Humidity	After crosslinking, the codemarks are impervious to water	
Dissolved Solids	30%	

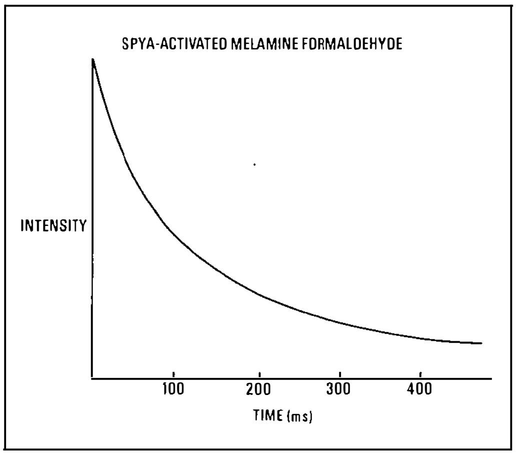

Figure 7—Phosphorescent decay characteristics for BPO jet printer ink. Intensity scale is arbitrary

Connection-Control Protocols in a Fast Packet-Switching Multi-Service Network Based on ATD Techniques

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UDC 621.394.4 : 681.327.8

*This article discusses the requirements for a standardised internal connection-control protocol for use in fast packet multi-service networks. It suggests how a suitable protocol might be derived from existing internationally agreed signalling protocols. This article is an updated version of one which first appeared in Br. Telecom Technol. J.**

INTRODUCTION

In current telecommunications systems, voice and video services use circuit-switched networks whilst data services use both circuit- and packet-switched networks.

Recent advancements in technology make the integration of voice, video and data in a fast packet-switched network a practical possibility. The potential economic advantages of sharing communication resources, coupled with users' requirements to integrate the various services into one terminal equipment, point to the possibility of future multi-service networks using packet-switching principles.

One scenario for such a network[1] is the combination in a single packet switching network of voice, data and a full range of visual services offered by the integrated services digital network, but at reduced cost. Such networks have been labelled multi-service networks (MSNs).

The addition of connection-control capability required for MSN exchanges, over the present generation of systems, could be considerable in the 1990s and beyond, as the demand for services and facilities expands. One approach, for such connection-control capabilities to be achievable with reasonable development and lifecycle costs, could be to simplify and standardise software solutions so as to make the software insensitive to its geographical location and independent of its system hardware. Standard communication protocols between geographically dispersed connection-control elements would allow this structure to be fully exploited.

In this article, only fast packet-switching MSNs which are based on asynchronous time division (ATD) techniques are discussed; ATD switching refers to short fixed-length packets which are carried by the hardware along the communications medium operating at high bit rates[1]. The article also describes the important MSN characteristics of the required connection control protocol and matches them to the existing standard protocols to show which protocol is likely to be the most useful for connection control in an MSN.

CONNECTION CONTROL PRINCIPLES FOR MSN

Any conclusion about the suitability of a connection-control protocol must only be reached having given due consideration to the impact of all the important implementation criteria. The following important principles have been used in this study.

Standards

In recent years, open systems interconnection (OSI) has become an objective for the computer industry to achieve. An OSI 7-layer model has already been defined[2]. The concept of a layered functional model for handling communications protocols is a good one. There is considerable commonality in the protocols either explicitly or implicitly in most communications systems. Much debate and research have already gone into the OSI model and it is felt that it is unlikely that a better compromise will be found. MSNs will inevitably be required to work in an international environment, large parts of which will be working to internationally agreed protocols. It will therefore be good engineering practice for the MSN connection control to make use of the OSI layered model where it is feasible.

There is a strong case for using CCITT I-series[3, 4], X-series, Q-series and G-series standards for the MSN software architecture framework. The main benefits of using these standards are that they are available and well defined and provide a reference architecture which can be used as a model for the information flows within a system.

System Software Independence

In the past, control software has been very

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* KEY, M., and KARIMZADEH, M. Connection control protocols in a fast packet switching multi-service network based on ATD techniques. *Br. Telecom Technol. J.*, Jan. 1987. **5**, p. 49.

hardware dependent and fully integrated with its hardware. Hardware technology is changing very rapidly. It is changing too rapidly for the software to be re-written for every hardware generation. For an MSN, the view has been taken that the connection control functions should be concerned with 'logical calls', not the hardware. A method, therefore, is desirable that decouples the connection control operation from the current processor and switching equipment hardware. This hardware independence would give connection control software an enduring quality significantly reducing the software lifecycle costs. The OSI model is likely to offer a basis for such independence to the connection control system software.

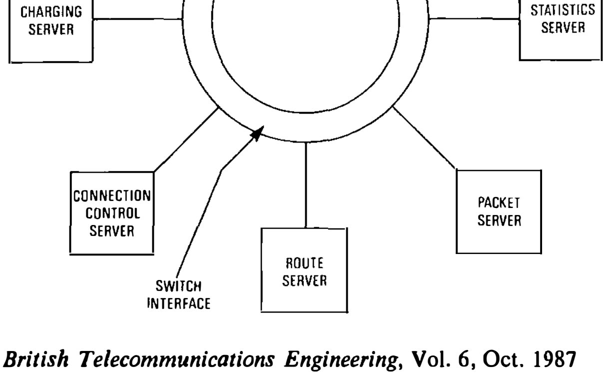
Software Supplier Independence

As hardware costs fall, software is becoming the major contributor to the total cost of a switching system. For economic, political and other reasons, network operators may prefer not to be tied to a single software supplier. For the software to be produced by a number of suppliers, it must be financially rewarding to all suppliers. The OSI standards offer such an environment. Software suppliers do not have to produce software for only one end user, as their software can be used for a number of communications systems (with minor changes). On the other hand, the network operators will be able to buy the software needed from a number of different sources at competitive prices.

Control Distribution and Flexibility

It may be desirable to distribute the control functions of the call. This is expected to produce smaller and more practical software packages, which in time should reduce the development and maintenance costs and improve performance and reliability. In Figure 1, a connection control server, line handler, trunk handler and route server are shown as separate functional units. Each unit can communicate with other units via the internal protocol with no restrictions on its physical location. In some applications, it would be possible to remove the connection control unit and distribute its functions to the periphery of the network; that is, incorporate its facilities in the line handlers. The use of an internal generic connection control architecture offers flexibility for distribution of control functions. Flexibility is also required if MSNs are to be able to provide any 'new' services in a fully integrated and efficient way.

Figure 1
Multi-service network control distribution



THE MULTI-SERVICE NETWORK

The example MSN shown in Figure 1 is used to illustrate how an internal connection-control protocol can allow a number of functional units to communicate with each other and with functional units of other nodes in the network. All functional units must have the same interfaces with the switching entity. Depending on the protocol used and the implementation method, some functional units may be merged.

Connection Control

An MSN implementation amalgamates asynchronous 'bursty' information, like the Packet SwitchStream (X.25) service [5], with synchronous telephony 'stream' services. The system architectures required to support these two radically different service types have traditionally been different. The connection control for an MSN requires the integration of synchronous and asynchronous connection controls into a single control mechanism.

Some of the functions of the connection control in this system are given in Table 1.

In the OSI 7-layer model, the switch entity occupies Layer 1 (Physical) and Layer 2 (Link). Connection-control functions are generally defined by OSI Layer 3 (Network). A number of supplementary facilities may be available from the switch hardware; for example, broadcasting of data packets. These functions are not available in the general

TABLE 1

Connection Control

Set up/clear down of virtual calls
Multiplexing and transfer of asynchronous data over virtual circuits
Data flow control
Handling of interrupts, priorities and expedited control messages
Good error-free transmissions
Reset/restart virtual circuits
Routing of transit packets
Multimedia calls
Broadcast/multicast of data packets
Handling of signalling messages for synchronous data

OSI Layer 3, but have to be addressed by connection control for a more efficient system. Other more complex facilities, for example, multimedia calls, may require control from higher layers. Additionally, Layer 3 has to interface and supply data to the management entity.

In an ideal network, all services would make use of the Layer 3 protocol; that is, they would all access Layer 3 at the intermediate and end nodes. But as this involves delays due to the Layer 3 access (which may be unacceptable to synchronous data), it is more practicable to relay the synchronous data at Layer 2. This is done by first setting up the call using Layer 3 messages. Once this has been done, data is transferred by using Layer 2 data relays; that is, at each intermediate node, Layer 2 is able to route synchronous data packets by referring to their connection numbers (which are assigned during the call set-up and appear in the header of every packet). This method separates the signalling for synchronous data from the data itself. Figure 2 shows the path taken by signalling and data packets in the network.

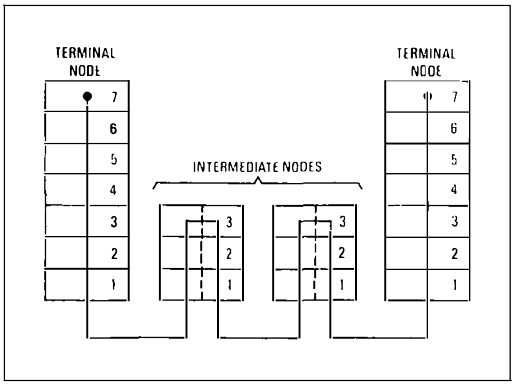
Interworking

It is believed that a large number of ISDN and X.25 users will in future require connection to a multi-service network. Interworking with ISDN is therefore an important facility to be provided by a multi-service network. The various ISDN protocols are defined in the CCITT I-series of documents[3]. Figure 3 shows how an exchange with MSN protocol can be used with the present ISDN. Line handlers, interfacing the ISDN users, act as a type of gateway converting the ISDN protocols to the MSN internal generic protocol. Similarly, line handlers attached to the X.25 users connect the X.25 protocol to the internal protocol. Messages are sent between exchanges by trunk handlers with CCITT Signalling System No. 7 (Q-series) interfaces. The MSN protocol set forms the first three layers of the internal protocol. Connection control is shown as a separate functional unit, but in fact can mostly be absorbed within Layer 3 of the MSN protocol set.

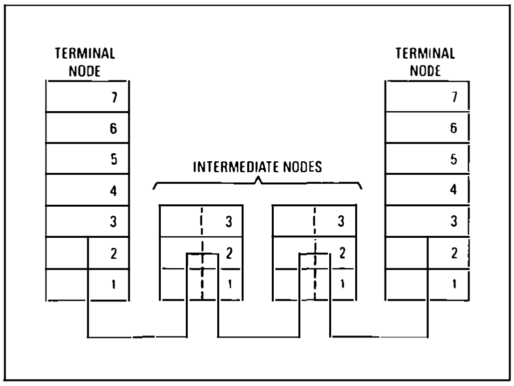
Packet Handling

A packet handler is needed since all traffic is transported across the network in packets. The packet handler functions are generally the same as the connection control functions—to manage the transmission/reception of data packets concerned with virtual calls. The packet handler can either be included in the line handlers or be set up as a separate entity: options A and B respectively show this in Figure 4.

Option A, which provides a distributed packet handling facility, is proposed for use in MSNs. When the packet handler is



(*a*) Asynchronous data flow and signalling for all data



(*b*) Synchronous data flow

Figure 2
The 7-layer model representation for synchronous/asynchronous data flow

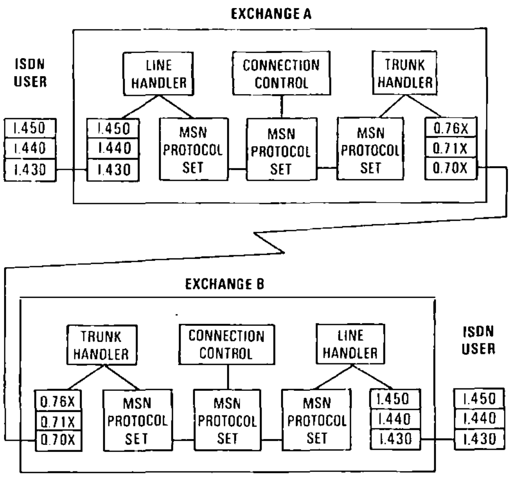
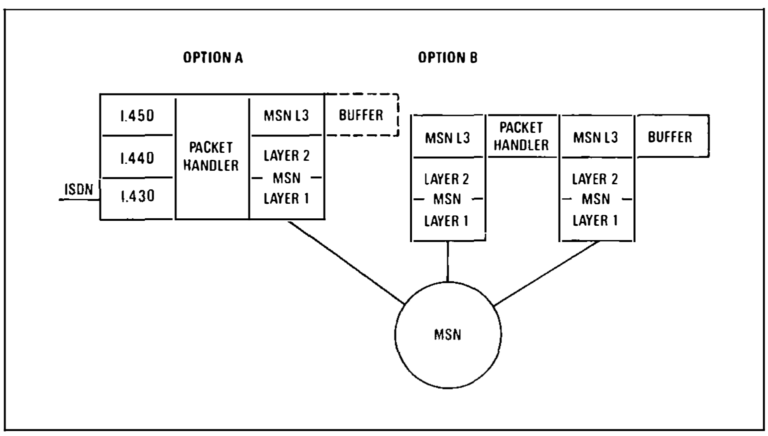


Figure 3
MSN protocol set

Figure 4
Packet handler options



included as part of the line handler, it manages the setting up of virtual circuits and the transfer of of data packets through these virtual circuits. The advantage of this option is that packetisation conversion and virtual circuit set-ups are done at the interface to the network; for example, all traffic inside the MSN can be handled by the same protocol. Another advantage is that in the case of failure, only a limited number of virtual calls will lose services.

LAYER 3 INTERNODAL PROTOCOLS

A number of Layer 3 standards are currently available which may be considered for use as the inter-nodal protocol in MSN systems. Some of these protocols have been found not to be suitable. The reasons for rejecting these are shown in Table 2.

TABLE 2

Disadvantages of Some Protocols for use as MSN Internodal Protocol

Protocol	Disadvantages
Signalling System No. 7	— Layer 3 interface to Layer 2 is not OSI — Routing functions split between message transfer part and signalling connection control part — Use of signalling connection control part to provide logical signalling connections
ISDN—Q.931	— Offers signalling part only without any comprehensive data transfer part — Two-stage call set-up for B-channel asynchronous data — Standards not fully defined — Major changes have been suggested to this standard; for example, one-stage call set-up for B-channel asynchronous data
Q.931 signalling part plus X.25 data transfer part	— Major changes to Q.931 messages and parameters required — Each node must handle both protocols, which may produce non-uniform operation — This protocol needs detailed definition

Layer 2 Service

Ring-based MSN hardware uses a Layer 2 protocol based on local area network (LAN) implementations to control access to the transmission medium. This is called the *media access control* (MAC), the upper sublayer of which is called the *logical link control* (LLC). The LLC is concerned with the establishment and maintenance of individual links and provides communication and support facilities such as flow control, error correction and recovery. There are two methods used for LLC implementation, namely:

- connectionless service, or LLC class 1, and
- connection-orientated service, or LLC class 2.

Depending on which case of LLC has been implemented at Layer 2, a different Layer 3 protocol may be required.

Layer 3 Protocol Over LLC Class 2

LLC class 2 provides negligible rates of packet loss by providing a connection-orientated service. This is similar to the high-level data link control (HDLC) in point-to-point networks for guaranteed packet delivery.

One of the communications standards which is designed as an internodal protocol to work over a connection-orientated Layer 2 is X.75[6].

The CCITT Recommendation X.75 covers the lowest three layers of the OSI model. The first two layers of X.75 (the Physical layer and the Data Link layer) are not required by the MSN connection control, since these are hardware dependent and are covered by protocols such as the Orwell protocol[7] based on the slotted-ring principles of local area networks. It is proposed that Layer 3 of X.75 should be used as the internodal Layer 3 protocol.

In this section, all references to X.75 refer to the Layer 3 of X.75.

The advantages of using X.75 include:

- it is specifically designed as a network protocol,
- it uses established standards,
- the standards conform to the OSI 7-layer model,
- it has integrated call-control and data transfer parts,
- each intermediate node has only to handle X.75 protocol,
- it removes the need for trunk handlers, and
- commercial off-the-shelf packages are available.

X.75 packet types are shown in Table 3 and

TABLE 3

X.75 Packet Types

Call Set-Up and Clearing
Call request *Call connected* *Clear request* *Clear confirmation*
Data and Interrupt
Data *Interrupt* *Interrupt confirmation*
Flow and Control Reset
Receive ready (Modulo 128) *Receive ready* (Modulo 8) *Receive not ready* (Modulo 128) *Receive not ready* (Modulo 8) *Receive request* *Reset confirmation*
Restart
Restart request *Restart confirmation*

are very similar to the X.25 data packets. The distinguishing feature of X.75 is the provision of a network utility field in the *call request*, *call connected* and *clear request* packets. Figure 5 shows the format of these packets. The format of a *call request* packet which includes a network utility field is shown in Figure 6.

The network utility field is a network administrative signalling mechanism which complements the user facility field and serves to separate user service signalling from network administrative signalling. The network utility consists of the utility code field followed by the utility parameter field.

Utility code 11111111 is reserved for the extension of the utility code. Repetition of utility code 11111111 is permitted and thus additional extensions result. This enables X.75 protocol to contain additional facilities if required.

Layer 3 Protocol Over LLC Class 1

LLC class 1 protocol at Layer 2 does not guarantee delivery of packets nor a negligible rate of packet loss. For example, the loss of a Layer 3 signalling packet may be fatal for the operation of the network[8]. This problem can be resolved either by using a special class of protocol for Layer 4 at each end of the system, or by using an error-sensitive protocol for Layer 3.

The first solution requires the use of transport class 4 (TC4) protocol at Layer 4 in each end system. The TC4 will recover lost or erroneous packets by retransmission of those packets. The disadvantages of this method are that:

(*a*) since the retransmissions are done end-to-end, the error recovery delay may be unacceptable, and

(*b*) the end systems (that is, user terminals) have to provide the complex TC4 protocol.

The second solution of providing a different Layer 3 protocol seems to be better suited to solving the MSN protocol problem. There is an OSI protocol called the *network class 4* (NC4) protocol which can tolerate a very poor underlying service. The NC4 protocol[9] was devised from the TC4 procedures and provides a point-to-point error-free OSI network service. With NC4 protocol, any retransmissions are done between Layer 3 of adjacent nodes, with much smaller error-recovery delay times.

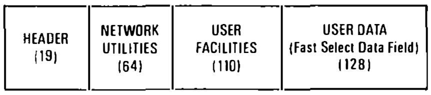
The NC4 packet types are shown in Table 4.

The NC4 protocol makes use of the following procedures to guarantee correct packet delivery:

Retention until acknowledgement This procedure is used to enable and minimise retransmission after possible loss or corruption of packets. Copies of the following packets are retained by the calling node to permit later retransmission if required: *connection request*, *connection confirm*, *disconnection request*, *data*, *reset request*, and *expedited data*. After each packet is acknowledged, it is cleared at the calling side.

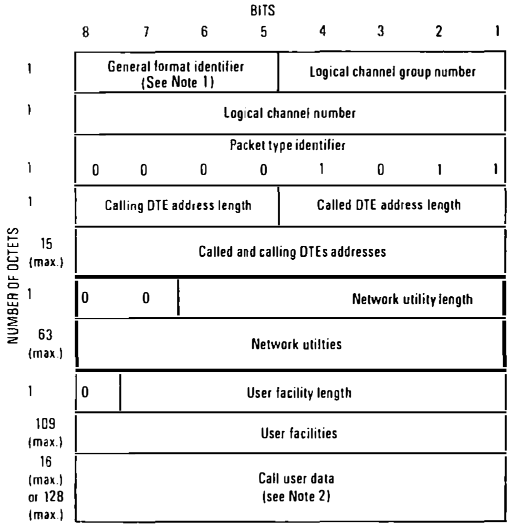
Explicit flow control This procedure is used to regulate the flow of data packets independently of the flow control in the other layers; it is accomplished by using special parameters in the various packets (for example, credit parameter).

Checksum The procedure for checksum is optional and is used to detect corruption of all packets by the lower layers.



Note: maximum number of octets in each field shown

Figure 5
Format of *call request*, *call connected*, and *clear request* packets in X.75



Note 1: Coded 0D01 (modulo 8) or 0D10 (modulo 128). D is the delivery confirmation bit

Note 2: More than 16 octets of call user data will only be present when the FAST SELECT optional user facility is requested

Figure 6
X.75 *call request* packet format with network utility field

TABLE 4
NC4 Packet Types

Call Set-Up and Clearing
Connection request *Connection confirm* *Disconnect request* *Disconnect confirm*
Data and Interrupt
Data *Data acknowledgement* *Expidited data* *Expidited data acknowledgement*
Reset and Error
Network packet data unit error *Reset request* *Reset confirm*

Frozen references This procedure is used in order to prevent re-use of a reference while packets associated with the old use of the reference may still exist. The need for this procedure arises because of possible duplication or recording of packets by Layer 2 or retransmission of packets by Layer 3.

Retransmission on time-out This procedure is used to cope with loss of packets by Layer 2 or discarding of packets because of corruption. Packet types named above plus *data acknowledgement* packets are retransmitted on time-outs.

Resequencing This procedure is used to cope with misordering of packets by Layer 2, and to provide prompt delivery of packets after reception of a retransmitted data packet.

Inactivity control This procedure is used to cope with unsignalled failures of the lower layers and with failures of the Layer 3 entity.

Treatment of protocol errors This procedure is used for the treatment of protocol errors due to invalid packets. One of the following steps is taken depending on the type of error detected:

(*a*) the packet is ignored,
(*b*) the error packet is retransmitted, or
(*c*) the release procedure is invoked.

Figure 7 shows the format for a *connection request* packet in the NC4 protocol. The variable part of the packet structure contains a number of mandatory and optional parameters. These parameters are used to provide the Layer 3 process with enough information for it to perform the eight procedures listed above. The variable part may contain the CCITT user facilities. This enables the NC4 protocol, used over LLC class 1 protocols, to offer end users a service equivalent to the service offered by the X.75 protocol used over LLC class 2 protocol.

Figure 7
Format of *connection request* packet in NC4 protocol

OCTET NO	1	2	3	4 5	6 7	8	9 P	P + 1	P + 128 max 384 octets
	PI	LI	CR	DESTINATION REFERENCE	SOURCE REFERENCE	CLASS	VARIABLE PART	USER DATA	

PI: Protocol identifier LI: Length indicator CR: Credit parameter

ENHANCEMENTS TO LAYER 3 PROTOCOLS

To gain full benefit of the broadcast and multicast facilities offered by the fast packet-switching systems and by the ISDN interfaces, a number of enhancements to the Layer 3 protocols would be required. These enhancements would incorporate the current known requirements and must be designed to allow any future needs to be accommodated. At the same time, it is desirable to keep as close to the original standards as possible. This is to ensure that commercially available software can be used in MSNs with the smallest amount of rework.

In both X.75 and NC4, up to 128 octets of user data can be carried by the *call/connection request* packets. This is the preferred method of enhancing Layer 3 protocol capabilities.

The user data field method of extending the protocol facilities allows the existing protocol field formats and contents to remain intact. The broadcast and multicast facilities can be provided in this way. With this method, it is also possible to carry user–user messages across the network transparently without the establishment of a virtual call by using the fast-select facility.

There is a need for the data in the user field to be structured, since a number of different users require this facility. One method of structuring the user data fields is to encode the first two bytes of the field. The first byte indicates the type of user, for example ISDN, the second byte is coded by the user to indicate what type of message is following the coded byte; for example, *alerting*. Table 5 shows the format for the first two bytes.

TABLE 5
User Data Field Control Bytes

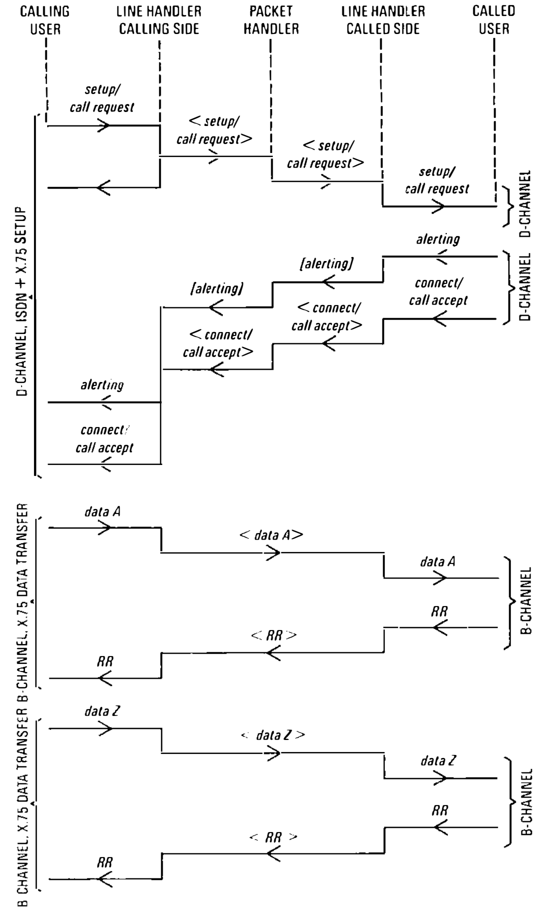
User Data Field		
First Byte	Second Byte	Comments
ISDN	Message type Parameter type Others	Complete message; for example, *alerting* Parameters not found in X.75 or NC4; for example, lower layer capability
MSN	Broadcast Multicast Others	Followed by destination address ranges Followed by destination addresses
Future requirements	For example, charging	

A Message Sequence Chart

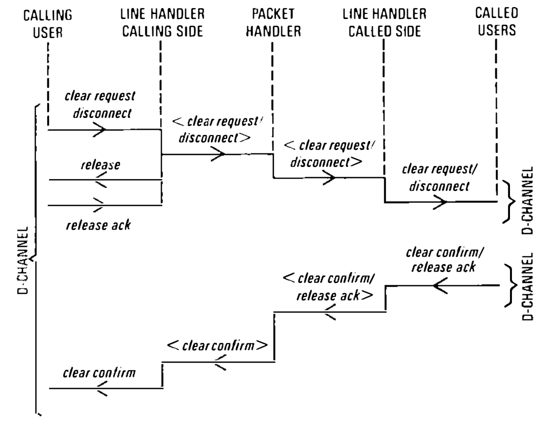
To show the type of interactions in the Layer 3 of a real network, X.75 is used as the MSN internal Layer 3 protocol for an ISDN user–network interface.

The message sequence chart in Figure 8(*a*) shows the sequence of events for an ISDN calling user sending a number of packets (A through Z) to a called user. A separate packet handler is provided which is used to set up and clear virtual calls only. Once the virtual call is established, the calling line handler sends data packets directly to the called line handler.

The ISDN interface signalling messages are on the D-channel and the X.25 packets on the B-channel. Note that the *alerting* message is carried across the network without any change in the fast-select facility data field. At the end of the session, the virtual circuit is cleared by the packet handler. This is shown in Figure 8(*b*).



(*a*) *Call request* and *data*



(*b*) *Clear request*

< > = Internal Layer 3 packets
[ ] = Information carried transparently by internal Layer 3 packets
RR = Receive only

Figure 8—Message sequence chart for MSN Layer 3

CONCLUSION

This article discusses the need for a Layer 3 protocol for multi-service networks. The required protocol must be well defined and standardised, but with enough flexibility to be able to handle the extra facilities required by the MSN. Having compared the advantages of each choice, the most suitable protocols appear to be an X.75-like protocol for working over a connection-orientated Layer 2 service, and NC4 protocol for use over a connectionless Layer 2 service.

The amount of effort required to enhance these standard protocols to that required in an MSN is relatively small. The majority of additions are incorporated in the user data fields. This has little effect on the standard protocols; that is, by adding the user data structures to an X.75 or NC4 protocol, it can be used in an MSN. The same user data structure can be used to carry data transparently by using the fast-select facility.

Both of the protocols described above offer the network user an OSI Layer 3 interface with guaranteed packet delivery. Other solutions have been suggested[10] for the implementation of an internal packet protocol for digital exchanges. These proposals require specification of a new set of protocols for Layer 3, and do not consider working with an LLC type protocol at Layer 2.

A number of subjects require further study, the most important being all aspects of management and how connection control can communicate with different management entities. Provision of supplementary facilities, such as multimedia calls, needs further study too, as it is not clear how many of these supplementary facilities fall within the tasks of the connection control.

ACKNOWLEDGEMENTS

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Telecommunications and Users

This article discusses the changing needs of telecommunications users and the changing environment in which telecommunications providers are meeting these needs. The article is based on a feature published by the Public Relations Division of the International Telecommunication Union in connection with TELECOM 87.

INTRODUCTION

Until the 1960s, telecommunication networks built and maintained by the common carriers (both public and private) had not fundamentally changed; they were designed to carry telephone and telegraph traffic. The basic system had been tailored to the transmission of the human voice and was analogue in nature with space-division switching and frequency-division multiplexing. Initiated at the end of the 1920s and 1930s with the advent of television, more so at the beginning of the 1960s, new types of users began to appear. Until the early-1960s, there had been noticeable separation between the bulk of telecommunications research and development on the one hand and the activities of the computer and related industries on the other. The growing need to merge the two technologies, properly harnessed for the good of mankind, had led to intensified efforts of co-operation between telecommunication administrations and private carriers on the one hand and industry on the other to assure the most effective services at acceptable cost to the end user.

THE EXPLOSION OF NEW TELECOMMUNICATIONS DEMANDS

With the introduction of radio broadcasting, television services, meteorology, marine communication, internal and various governmental services, common carriers began to be exposed to increasing pressure to adapt their networks and services to new communications media.

More recently, electronic processing, space and lunar explorations, earth resource assessments and direct satellite and cable television have put additional pressure on private and public telecommunication carriers.

One example of the colossal explosion of telecommunications demands in the financial sector was quoted by Dr. Alfred Hartmann, chairman of the Commission on Computing, Telecommunications and Information Policies of the International Chamber of Commerce (ICC) at the 1987 Forum of Users Conference (USERCOM) when he said: 'The performance of financial services is to a large extent due to the rapid development of computing, information and communications techniques. Further progress will depend to a large extent on innovation and improvements in the telecommunications sector. Banks today,' he continued, 'belong to the most important user group of telecommunications. 5–10% of their business expenses are spent on telecommunications. The astonishing development in this sector (increases of 15–20% annually) has only been possible thanks to the progress in computing information and communication technology.'

Another example, today still in the developmental phase, may grow above average in the years to come: it is not so much the computing and on-line transmission of corporate management data, but of design data, computer aided design (CAD) and computer aided engineering (CAE) systems linking on-line world-spanning oil, automotive or manufacturing corporations, which have become heavy users of telecommunications services.

Rounding off the random sampling of new users leading the telecommunications carriers into new directions are data banks which store highly specialised knowledge covering financial and company information just as readily as chemical hazards in industry, medical and pharmaceutical research data, biomedical or drug information, and thousands of other specialised areas. The Data Star system, spanning all of Europe, North America and Japan via telecommunications, permits access to over 150 data banks for quick reference. It allows vital information for research and development to be obtained within minutes, for which otherwise man-years would be needed.

WHY THE NEW NEEDS?

Asked what should be done to help one of the major cities to become a financial centre, a specialist answered simply: 'Without a first-class telecommunications system, all other efforts are in vain.' Just as modern financial services would be unthinkable without telecommunications, so would weather-forecasting, space research, traffic safety by air, land or sea, drug safety or hazard control.

Since the beginning of telecommunications, the initiative for the planning and provision of new services and new investments had been in the hands of administrations and private operating agencies. They were the clients of equipment providers. Since the late-1960s, however, this pattern has begun to change. The initial spark which triggers new investment by administrations is coming more and more frequently from industry which tries to satisfy, with the assistance of services provided by administrations and operators, its own needs of telecommunications services.

It was this trend which also prompted the International Telecommunication Union (ITU) in Geneva to organise the first TELECOM as a forum/exhibition where industry and administration carriers meet to discuss the future.

It was certainly this development which led, in 1985, to the first USERCOM in which telecommunications administrations, private operating companies and users met to discuss mutual interests and problems. In such an environment, 'telecommunications has to find a middle-of-the-road answer which allows modern economies to offer users, at the right price, the transmission facilities necessary for economic growth and development,' as Mr. Richard E. Butler, Secretary-General of the ITU puts it.

It would be as illogical to expect the telecommunications administrations to offer every single service requested by the user, as for a normal department store to carry every saleable item of merchandise.

But it is only logical that an intergovernmental organisation provides the regulatory framework for over-the-border telecommunications structures. The ITU has a distinguished record in advancing the cause of telecommunications and is the governing body of international telecommunications regulatory structures. Mr. Butler therefore stresses: 'Account will have to be taken of future evolution of the telecommunications environment as a result of the development and application of new technologies'. And he continued: 'If regulatory provisions were to stand the test of time in a rapid evolving industry, flexibility would be a built-in requirement.'

BALANCED FLEXIBILITY

Regulations must not necessarily have the effect of restricting user choice. A proper balance needs to be maintained between regulation and liberalisation that will be in the interest of all parties.

In this respect, the International Telecommunications User Group (INTUG) sees a place for both regulation and liberalisation, and for private and public networks. Bernard Overeynder, Vice-Chairman, Strategic Planning of INTUG, emphasises: 'By accommodating business telecommunications needs with flexible and realistic policies, PTTs (public and private carriers) will make an important contribution to their country's economic health while optimising the use of their own resources.'

At the more recent USERCOM-87, Mr. George McKendick of INTUG sees that changes in regulation will come in an environment in which users demand more of telecommunications than simple voice transmission.

In such a balanced flexibility, costs have to remain reasonable and accessible to as many users as possible. It is therefore only logical that smaller organisations expect to have access to public networks as advanced as those now created for internal use by larger companies. And as technology advances, new methods are needed to ensure that smaller users can have the advanced and effective communications system they require and can afford.

REGULATION VERSUS LIBERALISATION

In his opening address to the USERCOM 87 Conference in London in March 1987, ITU Secretary-General, R. E. Butler, noted that in view of the changing importance of telecommunications in social and economic development and of the fact that information and information exchange has become the key factor in the progress of world economies, the World Administrative Telegraph and Telephone Conference (WATTC) in 1988 is facing a major challenge. WATTC is charged with the responsibility to provide the background rules for the future which should be sufficient to lead or guide countries in their relationships and responsibilities. In his address, Mr. Butler emphasised that 'the individual regulatory rules in a consortium of 163 members must be adequate on the one hand to meet the general conditions of the environment. On the other hand, the potential connection of two or more national environments has to be adequately provided for without detracting from the more detailed requirements of the wider relationships. Hence, taking the past into account, it may be possible to provide in the future for the rules and regulations to be classified under two broad categories to service adequately:

'First: provision of basic telecommunications of the type for which the objective is to bring about basic universal service to the public at large, such as the telegraph and telephone, and by further distinction the telematic or "tele" services, including data transmission, facsimile, etc. The rules need to be sufficient to meet all of the orderly service prerequisites including guarantee of service, delivery and performance, availability and reliability of official circuits, appropriate principles of tariff, revenue sharing and accounting, etc. as well as the responsibilities of one country to another, and of both towards the public.

'Second: more flexible provisions for the regulation of transmission or circuit facilities provided for international communications and covering the more general requirements and responsibilities in "facility service offerings" or "hardware service" are needed, but which need substantive telecommunication transmission capacity to satisfy the needs of the particular users or countries concerned. In effect, rather than being the transporter of basic telecommunication messages, large-scale facilities would be available for bulk or "highway" use. The accent would be on the importance of special agreements ("bilateral or multilateral") in respect of the transmission facilities, involving less and less action by the carrier as distinct from the category concerning universal service, but nevertheless taking account of certain basic regulatory provisions.'

WATTC 88

The World Administrative Telegraph and Telephone Conference (WATTC) in 1988 will work towards establishing the appropriate regulatory provisions and structural needs for the future evolution of transborder flow of communication. This is, in effect, the ITU in its conventional sense providing the regulatory basis for the establishment and provision of the related infrastructures and their operation and services. The conference is expected to elaborate the agreed guiding rules for observance by member states, their entities and the public. The scope of the challenge can best be assessed when recalling the basic thrust of Resolution No. 10 of the Plenipotentiary Conference of ITU which established a need for this WATTC, as well as the associated Resolution No. 15 of the Eighth Plenary Assembly of the International Telegraph and Telephone Consultative Committee (CCITT), one of the four permanent bodies of the ITU, in Malaga-Torremolinos in 1984, which stated 'that it is advisable to establish, to the extent necessary, a broad international regulatory framework for all existing and foreseen new telecommunication services;' and 'that the introduction and utilisation of new telecommunications services have given rise to a series of new problems relating to telecommunications.'

Referring to the changed context of WATTC 88 as compared to the previous Conference in 1973, ITU Secretary-General R. E. Butler said in his opening address to the 42nd Session of the ITU's Administrative Council: 'The many changes that have taken place, are taking place, and indeed will continue to take place more in the telecommunications sector are well known. Changes relate not only to the increasing range of services offered, but also to the growing institutional diversity of service providers and users. There are also the many, I stress many, institutions and entrepreneurs which will come to rely on the electronic transportation of information, data, software and new requirements which are not telecommunication services as such but telecommunication dependent. The environment has changed greatly since the last conference of this type in 1973. Many more changes will come.

'The 1988 Conference could thus well be a watershed in the history of the ITU. It is really a transborder infrastructure regulatory conference. The conference decisions will affect the future of the Union as an institution to keep up with the changing environment in a practical way.'

USERS AND DEVELOPING COUNTRIES

There is no doubt that the new telecommunications and telematic services, for which WATTC 88 is seeking a global regulatory framework, will also be of greatest benefit to developing nations as they contribute to the reshaping and reinforcement of basic structures (public administration, education and vocational training, health services), as well as to the expansion and modern alignment of production systems in such areas as industry, trade, tourism and agriculture.

Already in a discussion at the 1974 International Conference on Computer Communication, ITU Secretary-General R. E. Butler said that 'the potential of computer communication systems as a tool for economic, social and cultural development and national planning is truly enormous.'

But global networks will not function unless the gap between the levels of communications available within industrialised countries and within developing nations is bridged. The role of the industrialised nations must therefore be to provide technical guidance and support to the telecommunications organisations and administrations of the developing nations and to help in educating and training their personnel.

CONCLUSION

The world of telecommunications is heading towards a user-friendly environment of a global information communications network. To become reality, such a network will neither be the fruit of individual monopolies, nor of unlimited competition: it will rather be the result of active co-operation between users, telecommunications administrations, providers of hardware and software within the framework of the 163 member nations of ITU.

Broadcasting: Challenge of the Future

Frequency Spectrum Management

This article is based on a press feature published by the Public Relations Division of the International Telecommunication Union in connection with TELECOM 87. The article discusses the procedures for frequency spectrum management and describes some of the important problems being considered at present.

INTRODUCTION

Broadcasting in all its forms is currently undergoing radical technological change brought about by the communication media explosion. Fascinating developments lie ahead, as will be seen at the TELECOM 87 exhibition and, perhaps, to an even greater extent at ITU-COM, a new exhibition instigated by the International Telecommunication Union (ITU) and to be held for the first time in 1989 in Geneva.

What is less common knowledge is that the end result of all these advances would be total cacophony without the joint action taken by the ITU and its member countries to secure a modicum of order in a domain characterised by its flexibility, in order to offer each user reasonably satisfactory operating conditions. To this end, a series of international agreements have been concluded in the framework of the ITU and its permanent organ—the International Frequency Registration Board (IFRB). This article examines how this operates.

THE NEED FOR REGULATIONS

Radio broadcasts are characterised by frequencies corresponding to wavelengths which may vary from several kilometres (several kilohertz or thousands of hertz) to a few millimetres (several thousand gigahertz). This range—or, in other words, this part of the radio spectrum—has been the subject of international regulations drawn up in the ITU framework.

Why are regulations needed? As to the principle, the reply is simple: radiowaves are no respecters of frontiers. A user in a given country may interfere with another user in either the same country or a neighbouring one. When two users in the same country are involved, domestic legislation applies. When interference occurs between users in different countries, an international legal instrument is required to settle the 'dispute'. The ITU has drawn up regulations which, if they are followed, enable such disputes to be avoided.

THE DRAWING UP OF REGULATIONS

It should be noted first of all that interference, which is a consequence of radiowave propagation, may affect not only two or more users in different countries, but also users of different kinds. For example, a high-power broadcasting transmitter and a low-power aircraft transmitter may be involved They have different functions and different technical working conditions.

Therefore, the first step in drawing up regulations consists in defining the various types of users and reaching agreement on those definitions. Different 'services' have to be distinguished: the broadcasting service, the maritime mobile or aeronautical service, the fixed service (between two fixed points) comprising telephony and telegraphy and many others.

Since the radiowave spectrum is limited, the next step is to identify the various services which are able to cohabit in the same part of the spectrum or, in other words, in the same 'frequency band'.

For example, the same frequency band can be allocated to a maritime mobile and an aeronautical mobile service, for they both operate in similar technical conditions. On the other hand, an aeronautical mobile service should not be placed in the same frequency band as sound broadcasting, for it operates in very low-power technical conditions and may be concerned with the safety of life, whereas broadcasting involves extremely high-power transmissions designed to reach as many listeners as possible.

When the same frequency band can be allocated to several different services, the band is said to be *shared.* If, on the other hand, nobody else is allowed to use a band allocated to a particular service the allocation is *exclusive*.

The outcome of this distribution exercise is recorded in the table of frequency allocations, which shows, for the various services, either a world-wide allocation or one that is limited to a region. For this purpose the ITU has long divided the world into three regions:

- the first comprises Europe, Africa and the entire territory of the USSR;
- the second comprises the American continent; and
- the third comprises Asia and Australia.

Establishment of the table is the second stage in the process of drawing up international regulations. The third stage consists in considering the services not from the global standpoint but from that of individual users.

In some parts of the spectrum, because of radiowave propagation, there is always the danger that a user in another country may be affected. When any one of these parts of the spectrum is involved, a compulsory procedure must be followed. In other portions of the spectrum, where propagation is limited and the risk of causing interference to users in other countries is therefore smaller, the procedure is optional, although it may become compulsory in certain very specific cases.

THE PROCEDURE

An administration wishing to use a frequency itself or to authorise a user to do so notifies the frequency to the IFRB, together with a number of clearly specified technical characteristics. In an initial stage, the IFRB determines whether the planned utilisation complies with the frequency allocation table. If so, the utilisation is found to be consistent with the regulations and obtains what is known as the *right to international recognition.*

The IFRB then studies the planned utilisation in relation to the other utilisations which are already recorded, in order to determine the extent to which the latter will be affected. If the IFRB concludes that there is no risk of interference, the new utilisation is entered in the International Frequency Register and thus obtains protection *vis-a-vis* all newcomers. This, by and large, is how the system works.

THE INTERNATIONAL FREQUENCY REGISTRATION BOARD

The above explanations raise the question of the IFRB's precise nature. It is certainly not a supranational executive body. Neither does it act only as a mediator or arbiter. The IFRB performs a notarial function, because in a manner of speaking it records births, but at the same time it operates as an expert in undertaking technical studies, plays an advisory role in providing assistance, and acts as an arbiter invested with both moral and administrative authority.

Over and above these theoretical definitions, mention should be made of the human factor, for the five Members of the IFRB are individuals elected to carry out a specific mandate; they are based permanently in Geneva and they meet at least once a week. Their skills and diplomatic acumen are highly valued; indeed, they are frequently approached to solve other problems, lend assistance or arbitrate in cases where, in spite of precautions, interference has occurred.

SPACE: A SPECIAL CASE

So far, the discussion has been on radiocommunications from the terrestrial standpoint. The additional questions raised by the use of space are now examined. Since the issue is a more complex one a special procedure has been drawn up.

The procedure applicable to space utilisations comprises three main stages:

- First, a country which plans to launch a satellite must inform the IFRB not more than five and not less than two years before the launch date. The characteristics of the satellite, together with the purpose of the launch, are published to enable any other country to raise objections or submit comments.

  However, the main purpose of the publication is to keep all countries informed, so that they can take account of the relevant data when planning their own projects. This first stage is called *advance publication.*

- Second, calculations are made to determine which existing or planned satellites might be affected by the newcomer. These calculations are based on very clear rules set out in the Radio Regulations, which in themselves constitute an international treaty.

  On the basis of these calculations, the IFRB may reach the conclusion that the planned system is likely to affect one already installed in another country. That country must therefore be approached with a view to reaching an agreement which in turn, is published by the IFRB in order to apprise all countries of its existence and technical characteristics.

- Once the co-ordination exercise has been completed, the IFRB can proceed (as in the case of terrestrial radiocommunications) to notify and record the new utilisation together with its frequency.

NEXT STEP: THE PLAN

When a service or frequency band becomes too congested or when a service such as sound broadcasting becomes important from the political standpoint, the situation can no longer be left to evolve spontaneously in the manner described above.

The Members of the ITU therefore meet in order to choose the stations, frequencies and characteristics which may be used by each country concerned. This is how a *plan*, which is an internationally recognised instrument, comes into being. A large number of plans exist today: there is one for the maritime mobile service, applicable to telephone calls between ships, one for medium-wave broadcasting and one for frequency-modulation broadcasting. There is also one for satellite broadcasting and one for the aeronautical mobile service, as well as many regional plans affecting only the countries of a single region.

These plans always make provision for a procedure which enables countries to modify their stations characteristics or to add others. The IFRB is also involved in this procedure.

CURRENT IMPORTANT QUESTIONS

The question of plans is currently a hotly debated issue raising thorny problems. Consider the example of HF (short-wave) broadcasting, to which a conference was devoted in March 1987. A special protection procedure in relation to that described above is applied to HF broadcasting, which uses waves that can be propagated over very great distances (several thousand kilometres) with a very high risk of interference. For the IFRB, the solution consists in drawing up a *seasonal schedule* four times a year. For this purpose, it first compiles all the utilisations planned by the various countries for a given season and, on that basis, draws up a provisional schedule. Incompatibilities are then analysed, identified and published so that the countries concerned can take them into account in a clearly established process. Once the season has ended, the IFRB publishes a final schedule corresponding to actual utilisations during the period considered.

In 1979, a number of countries stated that the portion of the spectrum in question was so congested owing to the high number of users that there was no room left for a small country wishing to transmit in that frequency band. Accordingly, they requested that the possibility be studied of establishing a plan. A conference was convened, holding a first session in 1984 and a second in March 1987. It concluded that, for both technical and non-technical reasons, a plan would be difficult to produce.

The central point at issue is the following: since long-distance broadcasting is involved, the fact that a country has ratified a plan is tantamount to its accepting transmissions towards its own territory without any knowledge of their contents. Such a position is unacceptable to some countries, for reasons of principle relating to national sovereignty or even to national defence in the broadest sense.

Currently, therefore, an intermediate system is used which, as in the past, involves seasonal planning. When users encounter difficulties in transmitting on their chosen frequencies, the IFRB endeavours to solve the problems regardless of whether the users are small or large.

The possibility has been contemplated of establishing a plan which would play the role of an 'equitable distributor'; that is, a centralised system which would tell countries what line of action they should take. The question arises as to whether such a body would have the right to decree that a country must reduce its broadcasts. Clearly, this comes very close to infringing national sovereignty. In the case of the HF bands, the conference held in Geneva in March 1987 decided that the planned system required further refinement and that additional tests should be conducted with a view to finding a solution. It also decided on a trial basis, to divide the frequency band into two parts, one which would be subject to periodical planning whereas the other would continue to be governed by the present system based essentially on freedom of choice with regard to both frequency and conditions of use. A subsequent conference scheduled for 1992 will assess the results of this experiment.

A similar problem arises with regard to broadcasting in space. Here, a number of countries take the same view as they do in respect of the HF bands: since frequency zones tend to be congested, a number of small countries have requested that a plan be drawn up safeguarding their access to certain frequencies when they come to launch their own satellites.

The conference held in 1985 on this matter reached the conclusion that it would not be advisable to subject all the space services to the planning exercise, but decided that a plan should be drawn up for some of the fixed satellite services. This exercise is to be completed in time for the next session of the conference in 1988. Here too, fundamental issues are at stake. The question arises whether it is really appropriate and efficient to block frequency bands and orbital positions for several decades without using them.

THE COMMUNICATION EXPLOSION

Another hotly debated issue has been raised by the communication explosion, particularly in audio-visual media (sound and television broadcasting), owing mainly to the wind of liberalisation and privatisation blowing through certain parts of the world. In 1984, the ITU drew up a frequency-modulation broadcasting plan containing as many as 50 000 stations. The most serious difficulty is that the existence of so many high-power stations can cause problems not only inside but also outside the band, in the portion allocated in particular to aeronautical radionavigation. The safety of life is therefore at stake and finding solutions is a matter of urgency.

The fourth major problem of the moment deserving special mention is the explosion of land mobile transmission media. It is absolutely imperative to extend the frequency band concerned, which is already highly congested, for the mobile telephone has already started to replace the fixed telephone and the trend is bound to continue.

CONCLUSION

This article has discussed some of the problems faced today by the IFRB and the ITU which, quite clearly, play a crucial role in ensuring that broadcasting in all its forms, including the most advanced, takes place in the best possible conditions, both now and in the future.

Book Reviews

Nonlinear Circuits
Martin Hasler and Jacques Neirynck
Artech House, viii + 454 pp. 385 ills. £60·00.

Most circuit analysis books concentrate on the linear aspects of circuit analysis. This book concentrates on the more specialised nonlinear side, covering a wide range of nonlinear circuit properties and adopting a descriptive rather than mathematical approach. Because of the nature of the work, however, a good knowledge of mathematics is essential. The book is best used as a reference book by postgraduate nonlinear circuit analysts with a good knowledge of electronic circuit techniques. Starting with the fundamentals of circuit analysis, it proceeds to define the types of circuit solutions and concludes with analyses of highly nonlinear diode circuits for such applications as frequency translation.

The book is well structured and is separated into eight chapters covering key areas of nonlinear analysis. Each chapter is further broken down into self-contained circuit properties, which enhances the book's use for reference purposes. Each property review is defined both mathematically and descriptively, and includes examples and comments. The examples show how the techniques are used and outline the weaknesses and assumptions, while the comments highlight important or interesting features of the analysis. The examples and comments are an important part of the book as they greatly aid its use and comprehension.

The book starts with Kirchoff's laws and then considers the electrical models of resistors, capacitors, inductors, memristors, voltage sources, operational amplifiers etc. These basic building blocks are not, however, all included in SPICE, a commonly used nonlinear circuit modelling package. These omissions are redeemed by a section on element equivalences.

The largest section is dedicated to identifying the solution types of nonlinear circuits. This analysis is spread over a number of chapters and starts with identifying the number of stable solutions and applying such techniques to nonlinear resistive circuits. Other nonlinear circuit elements are produced from the resistor using equivalent circuit techniques. This is followed by a mathematical descriptive treatment of asymptotic and stability behaviour of circuits with memory elements: capacitors and inductors, for example. Criteria are derived for predicting the behaviour in terms of circuit topology and stimuli. Periodic and almost periodic circuits is the last section on solution types and includes items on power distribution of harmonics produced by oscillator circuits.

The transform techniques of duality, adjoint circuit and Norton-Thévenin equivalence are outlined, together with examples of how the techniques can be used and what analysis advantages may be gained. The last chapter applies nonlinear techniques to diode circuits, for frequency translation, rectification and modulation. Several different circuits are considered and key circuit parameters calculated to identify the limitations of each circuit.

The book is a specialised reference book for the postgraduate nonlinear circuit analyst. The book starts from the fundamentals, through solution types and concludes with applications of nonlinear diode circuits, each topic being well illustrated with examples.

R. L. CALTON

Plastics in Telecommunications
Proceedings of the 4th International Conference on Plastics in Telecommunications. Organised by the Plastics and Rubber Institute, September 1986.
Science and Technology Publishers Ltd., 352 pp. 172 ills. £42·00.

The 'PIT IV' Conference, held in London last Autumn, was the most recent of a series run by the Plastics and Rubber Institute. British Telecom's (BT's) Polymeric Materials Laboratories (now part of the Materials and Components Centre (MCC)) have participated in the organisation of all of these gatherings, which have become the most important series of regular international meetings in this field. The opening address for this latest conference was given by BT's Chief Scientist, Dr. Leakey. The scope of the sessions embraces all of the materials providing protection, insulation and the 'defensive perimeter' around the working conductors, semiconductors and optics of telecommunications systems and equipment: it also now includes increasing numbers of organic materials which may supplement these older types, by actually carrying or converting the signals.

The 33 papers and 9 abstracts in this compilation are extremely varied in scope, and in depth. Recent Japanese work was well represented. Most papers report up-to-date investigations of front-end technical problems, including, for example, control of hydrogen evolution, fibre coating techniques, effects of behaviours of sheath materials upon optical cable performance, and forms of plastics to limit electrostatic damage and electromagnetic interferences. New materials opportunities discussed include three-dimensional moulded circuit boards, electroactive polymers, the 'self-reinforcing' liquid crystal polymers, and plastic optical fibres and devices. The inevitable risks of adverse interactions or of fire, when employing organic materials, also receive some attention. The conference was relatively free of pure commercial 'plugs' from suppliers of particular polymers: those manufacturers' representatives who presented papers generally offered some valuable new technical ideas or data. The disadvantages of simplistic tests, for materials properties which can be influenced by the geometries and means of manufacture of moulded parts (for example, connectors) was well brought out. Problems noted were in the fields, for example, of shrinkages, the associated distortions and cracking on ageing, surface resistivity changes in humid environments, and electromagnetic screening efficiencies.

The papers are directly reproduced from the typed texts distributed at the conference: texts, and the great majority of the figures, are clear. Because of the great range of topics covered, most of the papers will be of more use to specialists in the particular materials fields discussed, than to the general telecommunications engineer or systems designer. For this reason, all the sessions of the conference were attended by appropriate experts from the Polymeric Materials and Chemistry Section of the MCC. Assessments of the implications of the work reported, as affecting likely reliabilities, durabilities and hazards of BT equipment, can therefore be provided at need, from an internal BT source.

A. J. DUKE

British Telecom at TELECOM 87

A major highlight at British Telecom's display at TELECOM 87, the major international exhibition being held in Geneva, 20–27 October 1987, is a new generation of information technology equipment that will significantly advance the era of the electronic office for all sizes of business. The equipment, known as *Stanza*, brings together the impressive capability in telecommunications and information technology of BT and its subsidiary Mitel Corporation.

Heralding a new era in the practical integration of computer and telecommunications technologies, Stanza will spearhead a series of product launches and further developments from 1988 onwards. These will demonstrate new ways of harnessing computers to telecommunications to combine speech and processing in specific system applications. This will allow customers to be offered fully integrated computing and communications systems tailored to their individual businesses. At the same time, the concept of Stanza harmonises fully with current moves within the computing and communications industries in support of emerging standards for Open Systems Interconnection. The first applications to be launched during 1988 will include telemarketing. There will be a continuing series of expansions into other areas thereafter.

Alongside Stanza, BT is also presenting its newly developed Mezza communications system. At the heart of Mezza, is a Unix-based departmental multiprocessor minicomputer which fully integrates voice, data communications and computing. This information manager is linked to the PABX; it appears to become part of it, and extends its useful life.

The information manager converts the telephone installation served by the PABX into a powerful local area voice-text-data network serving screen-based VoiceStation terminals or IBM personal computers. Through a unique interface, the terminals present users with a range of services at the desk top—directory, voice mail, electronic mail, voice annotation, filing, dictation and transcription, together with a comprehensive office automation service.

Voice comments may be integrated with text documents and electronic mail messages. The voice mail system—Voice Desk—may be accessed from any multi-frequency telephone anywhere in the world. The system is produced at BT's factories at Brentford, West London. Capacity is now being stepped up to support early orders from North America—where Mezza is distributed by Gandalf Systems Group—and in the UK through BT's District sales offices.

BT's stand is divided into five sections. Four main areas cover technology, systems capability (advanced network systems and advanced business systems), business solutions, and world markets; there is also a BT corporate area.

Other principal exhibits in each area are listed below:

TECHNOLOGY

● BT & D Technologies (jointly-owned subsidiary with Du Pont) with a range of advanced opto-electronic transmitters, receivers, switches and couplers, for single-mode optical communications systems.

● Fulcrum Communications (wholly-owned subsidiary) showing digital slowscan (freeze-frame) television for remote site surveillance and security.

● British Telecom Research Laboratories demonstrating automatic translation of speech by computer, and interactive videodisc library service developed for use on BT's switched-star cable TV network.

ADVANCED NETWORK SYSTEMS

● Dialcom Inc. (wholly owned subsidiary), the leading international supplier of electronic mail and information services, is demonstrating a multi-vendor interconnection of public and private messaging systems complying with X.400.

● Communications Facilities Management division shows how BT can design, install, commission and manage corporate private communications and computing networks within the UK and world-wide.

● Primex is a private international packet-switched network service for multinationals provided by British Telecom International; it integrates fax, teleprinter, Teletex and data transmission.

● International videoconferencing, another BTI network service, is being demonstrated; a new multiconference facility linking up to five sites, plus reduced bandwidth transmission at 768 kbit/s is highlighted.

ADVANCED BUSINESS SYSTEMS

● IT440, top of the highly-successful Monarch range of medium-sized digital PABXs, offers up to 496 extensions, 128 trunks (exchange lines) and provision for 108 private circuit connections.

● Making its debut is the SX 2000S, a fully integrated digital voice and data PABX; a smaller version of the SX 2000, its capacity ranges from 100 to 600 extensions or trunks.

● The key-and-lamp unit, one of the most widely-used desk-top switching systems, is now available in electronic form (EKLU), catering for up to 8 or 16 lines.

● POET is a new 1+1 telephone system with executive facilities for manager-secretary, PABX featurephone, or facility-phone applications.

● QWERTYphone, a desk-top terminal with alphanumeric, function and telephone number keys plus 4-line liquid-crystal display, is being demonstrated as a low-cost computer and speech terminal.

● The 2100 series is a versatile point-to-point electronic messaging system run on the public network by using terminals combining VDU, keyboard and printer plugged into a standard telephone socket.

● Fax Mail, getting its first international demonstration, is a software package allowing a microcomputer to be linked to a standard fax transceiver to combine store-and-forward fax with text processing.

● Plans for the next generation of cordless telephones, known as *CT2*, will be highlighted.

● BT System 2 is a new optical-fibre digital line system for short-haul transmission at 2 Mbit/s to give high-quality performance at low cost.

● KSDM, the KiloStream speech and data multiplexer, combines up to four analogue with three data channels on a single 56/64 kbit/s link.

BUSINESS SOLUTIONS

● The integrated trading system (ITS), being publicly demonstrated for the first time, offers interchangeable key-based or touch-screen hardware, wide-ranging peripherals, powerful data capability and sophisticated software features in one comprehensive package.

● Touchline combines telephone call handling uniquely with data management and manipulation, to enable staff to answer calls quickly, efficiently and effectively, as shown in its first international demonstration.

● M6000 is BT's range of Unix-based minicomputers which form a highly configurable multi-user system supporting Uniplex 11+, the leading Unix office automation package, plus fourth-generation languages for database applications.
● LEKTOR, a high-security data encryption unit, protects data against eavesdroppers, provides user authentication, and offers a simplified key management system.
● BT's modem portfolio, one of the few with units meeting every CCITT recommendation, features a high level of modularity and standardisation to expedite planning and growth and reduce network equipment costs.
● Photo Applications Division is demonstrating its sophisticated technology for digitising and transmitting images, with applications covering advertising on cable TV, in-store or shopping centre retail display, property sales and picture databases.
● British Telecom Travel Service is demonstrating how it packages a wide range of travel information and transaction services to make travel and reservations easier for the agent and the traveller.
● Plans for Skyphone are unveiled; this will enable travellers to keep in touch while airborne by means of direct dialled air-to-ground international calls paid for by credit card.

WORLD MARKETS

● Customer administration system (CAS) is a new software package designed to help other Telcos and administrations streamline relations with customers in handling orders, billing, repair service and line plant.
● Provision of advanced digital services economically in rural areas is highlighted by a display of the UXD5 exchange, which may be configured from 150 to 600 lines.
● The advanced design electronic key system (ADEKS) is a line concentrator for use in operational communication and command management, ideally suited to control room applications in defence, aviation, public utility and emergency services.
● Firewatch has been designed to interface with ADEKS to provide a mobilising and communications system designed for emergency fire services but equally applicable to police and ambulance services.
● VMIS, BT's videomap and imaging system, being launched internationally, is an advanced interactive videodisk system for displaying maps, plans or photographs on a TV screen and overlaying the display with multicolour computer graphics.
● Gateway, a fast accurate remote line test system, which will test lines automatically or can be used to check faults reported by customers, is being shown publicly for the first time.
● A new range of telephones being unveiled features 10-number memory, secrecy button, last-number redial, and dual signalling, together with one-button access to network and PBX facilities.
● The electronic whiteboard makes its international debut; it allows a user with four coloured felt-tip markers to draw or write and then transmit the image live over an ordinary telephone connection to another whiteboard, colour monitor, TV projector or printer.
● Rendezvous Fiveline from BT's conferencing products division is a desk-top unit for setting up telephone meetings with participants talking over Fivelines and linked by two 'bridges', to double efficiency.

Product News

STEbus Backplanes

The new 4610 range of backplanes for the STEbus combine high performance with economy. Designed and made by British Telecom's Microprocessor Systems (BTMS) group, they are available in 5-and 10-slot versions.

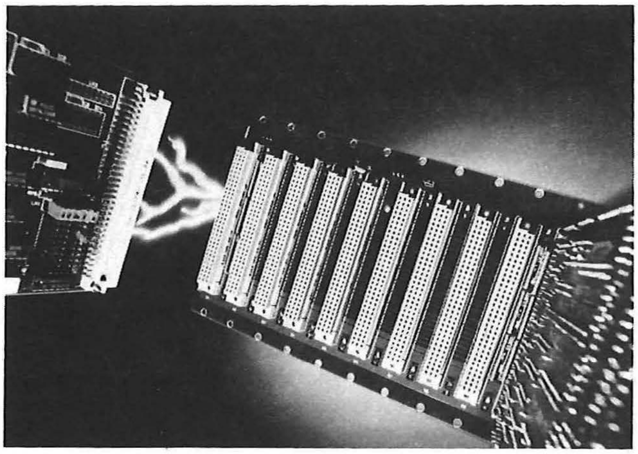
Multilayer construction is utilised in preference to standard double-sided techniques, because the extra layers allow the provision of separate 5 V and ground planes. This gives STEbus systems very high immunity to crosstalk and noise.

BTMS has side-stepped the cost penalty normally imposed by multilayer PCB construction by integrating the necessary STEbus termination circuitry. This avoids the need to purchase two extra termination PCBs at a typical cost of about £30.

The backplanes not only offer STEbus systems designers a high-integrity motherboard capable of reliable signal transmission up to the maximum STEbus bandwidth, but also minimise total STEbus system size. This is because the on-board termination circuitry is located between the connectors, and does not increase backplane length—often the case with plug-on discrete terminators. Moreover, this circuitry meets the requirements of the latest issue of the STEbus specification, which modifies the termination for the transfer error signal.

The backplanes are supplied populated with female DIN41612 connectors on the standard 0·8 inch pitch, and cost £65 and £105 for five and 10 slots respectively.

The new backplanes are the latest products to join BTMS' Martello range, a comprehensive product line of boards, software, development tools and accessories for data acquisition and control systems designers.



BT's new multilayer motherboards for the STEbus

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

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

General Secretary: Mr. J. H. Inchley, LNS2.1.1, Room 543, Williams National House, 11–13 Holborn Viaduct, London EC1A 2AT; Telephone: 01–356 9020.
(Membership and other enquiries should be directed to the appropriate Local-Centre Secretary as listed below.)

IBTE CENTRAL LIBRARY

The books listed below have been added to the IBTE Library. Copies of the 1982 edition of the library catalogue are available from the Librarian, IBTE, Room GJ, 2–12 Gresham Street, London EC2V 7AG. An abbreviated catalogue is included with this 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 (01–928 8686 Extn. 2233) 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.

5446 *Philosophy and the Brain.* J. Z. Young.

What is a brain, and is it distinct from the mind, which we believe controls our actions and constitutes our 'real self'? The author describes in simple terms what research and experiment have revealed about the brain and its functions. He demonstrates that perception is not a passive process but an active search for information. Human knowledge, it is suggested, may be a special development of the process of gathering information for life which is essential for all organisms.

5447 *Expert Systems for Personal Computers.* M. Chadwick and J. A. Hannah.

In this book, the authors allow readers to obtain a well-rounded view of the currently popular and important applications of artificial intelligence. After an introduction to expert systems, the authors introduce the important strategies used in present-day expert systems, and discuss the suitability of general-purpose languages such as BASIC and LOGO. Other languages such as LISP and PROLOG are also discussed. A suitable subset of BASIC is chosen to enable all microcomputer owners to use the complete and tested listings. General techniques for writing successful expert systems are covered in detail. These are used to produce full working examples that become expert in fields such as car maintenance. With the help of this book you can design your own expert system from scratch.

5448 *A Glossary of Computing Terms.* The British Computing Society.

With the development of the microprocessor, computers have become part of everyday life. For many, the terminology used may seem strange and bewildering. In this glossary, over 800 common computing terms are explained in simple language. All aspects of computing are included from programming languages to personnel, from architecture to application, from storage to systems, software etc.

5449 *Pascal in Practice: Using the Language.* Lawrence Moseley, John Sharp and Peter Salenieks.

The emphasis of this book is on using Pascal; it tries to encourage not just good programming but also good programming style. Although helping the beginner to write programs, its main purpose is to stimulate thought about developing programs to solve practical problems. It goes a long way towards encouraging programming in a high-level language. Each section contains a collection of problems addressing an important feature or concept, while developing useful routines and programs. Worked solutions illustrate the features and practical applicaions of Pascal.

5441 *The Secret Life of John Logie Baird.* Tom McArthur and Peter Weddell.

John Logie Baird is renowned for being the first person to demonstrate the principles of true television; but he was also an important pioneer of radar, and involved in many top-secret military research programmes, some of which have not been fully disclosed to this day. This new biography not only reappraises Baird's importance as an inventor, but also shows him to be an entirely different character than previously imagined. He was a man of great resolve who tackled powerful industrial monopolies, and won; who laced descriptions of his work with deliberate inaccuracies to mislead competitors; and who lived much of his personal life amid total secrecy.

IBTE LOCAL-CENTRE PROGRAMMES, 1987–88

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

Bletchley Centre

11 November 1987:

The Changing Role of the Engineer in British Telecom by J. W. Young, Territory Engineer, Central Territory. Meeting will be held at Bletchley Park, commencing at 14.15 hours.

20 January 1988:

The Modernisation of the UK Network. (Provisional.) Meeting will be held Bletchley Park, commencing at 14.15 hours.

17 February 1988:

Centrex by Business Exchange Services, UK Communications. Meeting will be held at Bletchley Park, commencing at 14.15 hours.

Central Midlands Centre

12 November 1987:

Optical Local Network by K. A. Oakley, Local Lines Services, UK Communications. Meeting will be held in Room UG35, Berkley House, 245 Broad Street, Birmingham.

18 November 1987:

Flight Simulators by Squadron Leader Hickmott of Messrs. Singer-Link-Miles Co. Joint IEE/IBTE meeting. Meeting will be held at the Birmingham Chamber of Commerce, 75 Harbourne Road, Edgbaston, Birmingham. Refreshments from 17.30 hours, lecture commences at 18.30 hours.

26 November 1987:

Gaydon Technology by Mr. D. Bray and Mr. D. Cartwright, Gaydon Technology Research, Kineton, Warwickshire. Meeting will be held at the British Telecom Sport and Social Club, 1st Floor, Regency House, Queen's Road, Coventry, commencing at 19.30 hours. Buffet.

10 December 1987:

Customer Service Systems—Implementation in Central Midlands District by A. Czeriawaski and G. Duffield, CSS Group, Central Midlands District. Meeting will be held in Room UG35, Berkley House, 245 Broad Street, Birmingham.

East Anglia Centre

18 November 1987:

High Speed Letter Sorting by R. Vick, Research Engineer, Post Office Research Centre, Swindon. Meeting will be held in LTB5, University of Essex, commencing at 14.00 hours.

16 December 1987:

Network 2000 by H. Mothersole, Local Switching Manager, East Anglia District. Meeting will be held in LTB5, University of Essex, commencing at 14.00 hours.

10 February 1988:

The Regulation of Telecommunications by Professor Bryan V. Carsberg, Director General of Telecommunications, Office of Telecommunications. Meeting will be held in the Council Chamber, The Guildhall, Cambridge, commencing at 14.00 hours.

16 March 1988:

Towards Zero Defects by K. Freeman, Quality Programme Manager, IBM. Meeting will be held in The Music Room, Assembly House, Norwich, commencing at 14.00 hours.

Liverpool Centre

Except where stated otherwise, meetings will be held in the Liverpool Museum, William Brown Street, Liverpool, commencing at 14.00 hours.

26 January 1988:

The Network Control Centre at Oswestry by Mr. J. Davidson, Trunk Network Operations, UK Communications.

18 February 1988:

Direct Broadcasting by Satellite by Mr. A. J. Harwood, Principle Engineering Information Officer, IBA.

Martlesham Heath

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

11 November 1987:

Designing without Breadboards (Hardware design automation in electronics) by Dr. F. N. Sunnaduri, IT Products Department, British Telecom Research Laboratories.

19 November 1987:

Research, Development and Decline: A TE Perspective by Dr. A. W. Rudge, O.B.E., Director Research and Technology.

9 December 1987:

Switching to the Future (providing flexible networks) by Dr. D. H. Newman, Network Systems Department, British Telecom Research Laboratories.

4 January 1988:

'In the Beginning there was. .' (pages from the memoirs of John Bray) by Dr. W. J. Bray.

26 January 1988:

Is there Life after Martlesham—A View from the Districts by D. R. Borley, UK Communications.

17 February 1988:

Meganetworks and Teracomputers (the future of large computers and access to them) by Professor R. Rossner, University of London.

3 March 1988:

BT & D: Light Engineering Returns to Ipswich by Dr. J. Speight, BT & D.

North and West Midlands Centre

10 November 1987:

Network Evolution by R. Culshaw, District Engineer, North and West Midlands District. Meeting will be held in the Video Room, Central Building, British Telecom Technical College, Stone, Staffordshire, commencing at 13.45 hours.

17 November 1987:

Network Evolution by R. Culshaw, District Engineer, North and West Midlands District. Meeting will be held in Wolverhampton, commencing at 13.45 hours.

7 December 1987:

Meeting to be announced. Joint IEE, IRE and IBTE meeting. Meeting will be held in the Staff Lounge, British Telecom Technical College, Stone, Staffordshire, commencing at 18.15 hours (refreshments from 17.30 hours).

North Wales and the Marches Centre

All meetings will commence at 14.00 hours unless otherwise stated.

10 November 1987:

Telecommunications Networks—Some Possible Developments Over the Next Decade by Dr. D. Leakey, Chief Scientist, British Telecom. Meeting will be held at Whittington House, Oswestry.

8 December 1987:

Cable Pressurisation Monitoring by P. D. Jones, Exchange Network Design and Service Manager, North Wales

District. Meeting will be held at Communications House, Shrewsbury, commencing at 18.00 hours and preceded by a buffet.

12 January 1988:

The Changing Role of the Engineer in British Telecom by J. W. Young, Territorial Engineer, Central Territory. Meeting will be held at Queen Hotel, Chester.

9 February 1988:

Whatever Happened to the Candlestick? by Dr. I. S. Groves, Head of Consumer Products Division, British Telecom Technology Applications Department. Meeting will be held at Whittington House, Oswestry.

8 March 1988:

The Future of the Local Exchange by K. E. Ward, Chief Engineer, Planning and Works, UK Communications. Meeting will be held at the Beauchamp Hotel Shrewsbury.

Northern Ireland Centre

Meetings will be held in the YMCA Minor Hall, Wellington Place, Belfast, commencing at 15.30 hours.

11 November 1987:

Energy Efficiency in Buildings by F. Cogan, Consulting Engineer, Cogan and Shackleton.

9 December 1987:

Materials Management in Northern Ireland by J. McDowell and J. Elliott, British Telecom Northern Ireland.

13 January 1988:

Computing in BSS EC by B. McClean, Computer Applications and Software Development Division, Belfast.

10 February 1988:

Derived Services Network by N. Jefferies, Systems Engineering Planning, UK Communications.

9 March 1988:

Tommorow's External Plant by D. Clow, Local Line Services, UK Communications.

Severnside Centre

Meetings will be held in Nova House, Bristol, commencing at 14.15 hours.

2 December 1987:

Information Technology by Dr. A. W. Livingstone, Head Information Technology Division.

3 February 1988:

Operation and Control of Digital Exchanges by K. Richardson.

2 March 1988:

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

Solent Centre

Unless otherwise stated, all meetings will be held at the 7th floor coffee lounge, Solent District Office, commencing at 18.30 hours; refreshments from 18.00 hours.

19 November 1987:

Cellular Radio by D. Wordly, Director, Market and Product Development Group, British Telecom.

28 January 1988:

Commercial Strategy for FAST (Flexibile Access System) by T. Hart, Product and Services/Service Development Manager, British Telecom.

23 February 1988:

Faraday Lecture: *The Intelligent Car* by The Ford Motor Company. Meeting will be held at The Mayflower Theatre, Southhampton, commencing at 14.00 hours. Tickets from G. Nunes, Local-Centre Secretary.

24 March 1988:

Network Modernisation by K. E. Ward, Chief Engineer, Planning and Works, UK Communications.

South Downs Centre

Meetings will be held in the Lecture Theatre, Central Library, Worthing, commencing at 12.00 hours.

17 November 1987:

Video Maps by BT Fulcrum.

15 December 1987:

City Fibre Networks by A. C. Misson, District Engineer, City of London District.

19 January 1988:

Satellite TV by South East Trunk Network Operations.

16 February 1988:

The Changing Role of the Engineer in BT by J. W. Young, Territory Engineer, Central Territory, BT.

Thameswey Centre

Unless otherwise stated, meetings will be held in the BT Business Centre, Reading, commencing at 12.30 hours.

11 November 1987:

Messaging by C. Jones, Manager, BT Value Added Business Systems. Meeting will be geld at the Post House, Reading, commencing at 14.00 hours (by ticket only).

19 January 1988:

Energy Conservation by J. Edwards, Building Services Manager, Thameswey District.

27 January 1988:

Energy Conservation (repeat of above). Meeting will be held in the Conference Room, Aldershot GMO, commencing at 12.30 hours.

9 February 1988:

Fibre Optic Cabling—Cost Reduction by Sub-Duct Techniques by L. Webb, Wedge International.

23 March 1988:

The Major Customer Service Centre by Dick Roberts, Business Customer Support.

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.
Bletchley/South Midlands	Mr. D. R. Norman	British Telcom, ES2.3.4, Telecom House, 25–27 St. Johns Street, Bedford MK42 0BA. Tel: (0234) 274069.
Central Midlands	Mr. G. R. Chattaway	British Telecom, BES5.5, Leofric TE, Little Park Street, Coventry CV1 2JY. Tel: (0203) 28396.
East Anglia	Mr. T. W. Birdseye	East Anglia District PD2.1.5, Telephone House, 45 Victoria Avenue, Southend-on-Sea, Essex SS2 6BA. Tel: (0702) 373723.
East Midlands	Mr. D. W. Sharman	British Telecom East District Training Office, PS32, 200 Charles Street, Leicester LE1 1BA. Tel: (0533) 534409.
Liverpool	Mr. B. Stewart	British Telecom Liverpool District, CP43, Lancaster House, Old Hall Street, Liverpool L3 9PY. Tel: 051–229 4450.
London	Mr. L. J. Hobson	British Telecom, BSSU3.6, Room 344, Procter House, 100–110 High Holborn, London WC1V 6LD. Tel: 01–728 8810.
Manchester	Mr. J. M. Asquith	British Telecom, NE20, Telecom House, 91 London Road, Manchester M60 1HQ. Tel: 061–600 2947.
Martlesham Heath	Mr. K. R. Rose	British Telecom Research Laboratories, R18.1.1, Martlesham Heath, Ipswich IP5 7RE. Tel: (0473) 642676.
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. D. Jones	E3, Telephone House, Smithfield Road, Shrewsbury SY1 1BA. Tel: (0743) 69807.
Northern Ireland	Mr. B. Hume	EI4, RAC House, 79 Chichester Street, Belfast BT1 4JE. Tel: (0232) 227152.
Preston	Mr. A. J. Oxley	TNW6/NW2.2.6, 10th Floor, Guild Centre, Lords Walk, Preston PR1 1RA. Tel: (0772) 22599.
Scotland East	Mr. B. Curry	British Telecom East of Scotland District, NJ3, Telephone House, 357 Gorgie Road, Edinburgh EH11 2RP. Tel: 031–345 4218.
Severnside	Mr. P. C. James	British Telecom, ED2, St. Clements House, Marsh Street, Bristol BS1 4AY. Tel: (0272) 296281.
Solent	Mr. G. R. F. Nunes	BE57, Solent District Office, 70–75 High Street, Southampton SO9 1BB. Tel: (0703) 734257.
South Downs	Mr. C. J. Mayhew	British Telecom South Downs District Office, ED7.1.1, Grenville House, 52 Churchill Square, Brighton, BN1 2ER. Tel: (0273) 225011.
South Wales	Mr. D. A. Randles	British Telecom South Wales District, EP1, 25 Pendwyallt Road, Coryton, Cardiff CF4 7YR. Tel: (0222) 379622.
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. C. S. Gould	British Telecom, NS3, Exbridge House, Commercial Road, Exeter EX2 4BB. Tel: (0392) 212663.
Yorkshire and Lincolnshire	Mr. R. S. Kirby	UKC/SNE & NI/QO1.3, Netel House, 6 Grace Street, Leeds LS1 1EA. Tel: (0532) 466366.

ASSOCIATE SECTION REGIONAL CONTACT POINTS

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

Region	*Local Secretary*	*Telephone Number*
East	Mr. T. Turner	(0582) 573301 (evenings only)
London	Mr. P. Lendon	01–829 3180
Midlands	Mr. M. P. Melbourne	(0623) 650276
North East	Mr. K. Whalley	(0642) 310937
North West	Mr. R. Craig	(0772) 267236
Northern Ireland	Mr. S. Heraghty	(0504) 261029
Scotland	Mr. G. Lyall	031–345 4120
South East	Mr. R. P. Coveney	(0634) 45500
South West	Mr. J. R. Dymott	(0202) 206497
Wales North	Mr. R. Fairley	(0352) 713190
Wales South	Mr. H. P. Duggan	(0222) 379732

British Telecom Press Notices

Radiopaging by Satellite—A Trial Service

Trials of BT's world-first satellite radiopaging service are to start at the end of the year. It will enable drivers of long-distance lorries to be contacted immediately by their companies while they are on the road—particularly those of road haulage firms operating on routes across Europe, the Middle East and Africa. The service will provide another international extension to the existing radiopaging service operated in the UK by British Telecom Mobile Communications (BTMC).

Earlier this year, BTMC announced that it would provide a transatlantic paging service through a joint operation with Metrocast, a US-based paging company. The Metrocast service, due to be launched this autumn, uses a frequency-agile pager, and does not depend on satellite transmission.

The satellite paging system was conceived in July last year by research engineers at British Telecom International (BTI), who, this February, carried out the first successful experimental trials.

Customers taking part in the trials will make their satellite paging calls in exactly the same way as an inland paging call. Messages will be routed via BTI's satellite earth station at Goonhilly Downs, Cornwall, to an INMARSAT satellite. The signal sent back to earth by the satellite will be received by a small 'patch' antenna, comprising a flat plate, approximately 120 mm square and 10 mm thick, mounted flush with the roof of the lorry cab, and wired to a small low-noise receiver mounted in a box underneath. A Message Master pager in the cab will display the message, and a printer will provide a paper copy. The combined Message Master pager and printer fits conveniently on the parcel shelf of the cab dashboard. The Message Master pagers to be used in the trial will allow short messages of up to 90 characters to be sent with the characteristic bleep-tones, will have seven-digit numbers, and a liquid crystal display similar to those widely used in Britain. The receiving equipment forms the most compact mobile receive-only satellite earth terminal yet designed, while it requires no more power from the vehicle's battery than a 6 W side-light bulb.

Translating Speech by Computer

People who cannot speak a word of each other's language will soon be able to talk over the telephone by using a system developed by BT. The world's first instantaneous translation of speech by computer was unveiled publicly in August by BT's Research Laboratories.

Simple sentences in English were translated into French and vice-versa. The prototype equipment can translate English into German, Spanish, Swedish and Italian and the reverse capability is being developed. This will then also make possible translation between any pair of these languages, such as French–German, Swedish–Italian.

Each speaker has a microphone linked to a Merlin 5200 personal microcomputer. These are connected by a telephone circuit capable of handling computer data. The first participant speaks a sentence in English into the microphone, saying each word clearly and deliberately. The computer repeats the sentence in its own synthetic voice to check that it has understood correctly. When this is confirmed—by saying a single word 'yes'—the originating computer sends the message to the distant computer which translates and speaks in, say, French in its own synthetic voice. When the French speaker replies, the process is repeated in the reverse direction.

The system is based on a set of more than 400 phrases in common business use stored in each computer's memory. Although this involves a vocabulary of more than 1000 words, the computers are programmed to recognise only 100 key words. These are used to identify the appropriate phrases, to reduce the word-recognition task required. The system also recognises spoken proper names, such as John Smith, for example, and makes no attempt to translate them; for example, rendering 'Mr. White' into 'Monsieur Blanc'. Instead, the names are repeated in the original speaker's voice in the translation.

National Computer Network to Streamline International Trade

Maritime Cargo Processing (MCP) and BT have agreed to collaborate in forming a national computer system linking sea and air ports to streamline the country's international trade. The system will allow all organisations engaged in imports and exports, whether by air or sea, to exchange messages and data about their consignments.

MCP currently provides computer services to port communities for inventory control of sea-borne cargo into and out of the UK. It has 400 customers at 10 ports around the country. Through its services, agents are able to declare their cargo imports and exports to HM Customs and Excise automatically, which results in clearance in a matter of hours. BT, through its Applied Technology Division (BTAT), provides similar services to the trade communities at Heathrow, Manchester and Gatwick airports, serving agents and 50 international airlines, and to the Port of London serving 150 customers. BTAT also manages the nation-wide system which, on behalf of HM Customs and Excise, automatically collects and processes cargo import and export data from major sea and airports.

The joint facilities offered by BT and MCP will link all users of cargo control systems that each company now manages. This will be the first step in creating a nation-wide network to enable agents, shipping firms and airlines to interchange trade documents electronically, and offer access to importers and exporters.

The system will encourage the development of open systems for trade by supporting the emerging standards for trade data interchange, such as those produced by the EEC and United Nations and the International Air Transport Association. Automated entry of customs data by computer has been pioneered by HM Customs and Excise and major UK trade communities. Currently, more than 80% of UK consignments are cleared by computer, involving approximately 5 million direct trade entries a year. This is by far the highest proportion of any major trading nation.

Notes and Comments

INCREASE IN SUBSCRIPTION RATES

The Board of Editors regrets to announce that the price of the *Journal* to external customers (that is, not employees of British Telecom or The Post Office) will increase from the January 1988 issue. The new price will be as follows:

Price per copy:
£1·50 (plus 50p for postage and packaging UK)
(plus £1·00 postage and packaging overseas)

One year's subscription: £8·00 UK
£10·00 overseas

Because of high bank charges, US customers are requested to pay by sterling drafts drawn on London for £10·00 (for one year's subscription). Payment by cheque drawn in US dollars, for one year's subscription, will be accepted at the price of $22.

QUARTERLY REVIEW

BT and STC are joining forces to develop and promote digital cordless communications (CT2) by producing the first of a series of products which will allow effective communication—even in conditions of high traffic density—and which will be useable universally for domestic and business purposes.

BT has placed an initial development contract valued at £6M with STC Telecommunications. It will draw on the results of advanced research carried out by both companies in telephony and the very large scale integration (VLSI) techniques required for digital radio, and will lead to new generations of cordless communication products based on the CT2 standard. The development, the first of its kind in the world, will create the enabling technology for digital communications at 900 MHz, extend the number of channels available to 40 and open up a wide range of personal mobile communications in the 1990s.

CT2-based products will be simple and inexpensive and will connect directly to the public telephone network. They will have access to all the services provided through the network, including the widening range of new services arising from the introduction of digital exchanges.

Telecom Gold, BT's market-leading electronic messaging service, has expanded the range of facilities available to its customers by the introduction of the Gold 400 message handling service. Gold 400 is capable of interconnecting different public and private electronic mail systems, and permits messages to be sent between them and the Telex and facsimile services. It is the first public service implementing the internationally agreed X.400 standard for message handling. This will permit users to exchange messages between different office automation systems available from a wide variety of suppliers. The system and software for Gold 400 was supplied by Dialcom Inc., one of BT's North American subsidiary companies. Through Dialcom, BT is now able to supply X.400 message handling software to all Dialcom licencees, which operate in 17 countries.

The following Board changes were announced at BT's Annual General Meeting on 9 September, and came into effect on 1 October. Iain Vallance, formerly BT's Chief Executive, has become Chairman of the Group, succeeding Sir George Jefferson. Graeme Odgers, formerly Deputy Chairman and Chief Finance Officer, has become Group Managing Director, through whom the Managing Directors of the five operating Divisions will report. John Raisman, formerly a non-executive director, has become non-executive Deputy Chairman.

Mr. Jonathan Rickford has been appointed Solicitor to BT. He succeeds Mr. Philip Ashcroft, who retired at the end of August. Major General Gordon Oehlers has been appointed BT's director of security and investigation, succeeding Mr. Laurie Heatherington.

As reported in the April 1987 issue of this *Journal*, BT's £30M a year 999 emergency service, which handles free up to 50 000 life and death calls a day, was 50 years old on 1 July. Starting next year, calls to Britain's best-known telephone number will be switched to police, fire, ambulance, coastguard and cave and mountain rescue services even faster as part of the introduction of a new system for handling all assistance calls to BT's operator services.

The BT operator service system (BTOSS) is a digital switchboard which has operator consoles equipped with special VDUs and keyboards. The system will enable BT's 14 000 specially trained operators at 200 exchanges throughout the UK to know immediately when there is an emergency call on the line.

The call will be given prority over all waiting calls for connection to the first available operator. A special emergency call format will appear on the VDU, and if the call is from a digital exchange the system will automatically display the calling number and the emergency authorities' numbers. The operator will select the number of the required service and BTOSS then connects the call.

On 27 July, an agreement was signed in Paris to strengthen communications between the Channel Islands and the British mainland. A new digital route is to be provided across France to augment existing direct cable and microwave links between the Channel Islands and the UK. The new route will go by microwave from Dover to Boulogne, cross Normandy by microwave and cable to Barneville, and then by microwave to Jersey, where it will link into the Channel Islands' own microwave system.

At present, the Channel Islands are linked to the UK by three cables, with a total capacity equivalent to 3240 simultaneous telephone calls, and by stand-by microwave radio between the Isle of Wight and Alderney, able to carry 960 calls simultaneously. The microwave link—abnormally long at 120 km—is affected by weather conditions, while the existing cables are liable to damage by shipping. A new submarine optical-fibre cable with 12 optical fibres is planned to be brought into service by early-1989. This will be digital and operate at 140 Mbit/s with two fibre pairs equipped to provide capacity for approximately 4000 simultaneous calls. The new route across France will also operate at 140 Mbit/s with a capacity of nearly 2000 simultaneous calls. When it comes into service, due at the end of November 1988, it will provide greater diversity and security of communications.

BT has awarded a £2·6M contract to EB Communications (Great Britain) Ltd. for the equipment which will automatically connect airline passengers' telephone calls to customers on the ground. The contract completes the puchasing of all the major equipment and software required for Skyphone. Trials of the new service, with calls connected by the operator, will begin next April on three British Airways 747 airliners to allow passengers to make international telephone calls during flight. The new contract represents a first for BT because the equipment will be the first designed to meet the full INMARSAT aeronautical standards for ground earth stations. It will be installed at BTI's satellite earth station at Goonhilly Downs.

BT has announced that, by the end of the year, it will have completed modifications to all its 78 400 public payphones which will help customers make calls even when equipment is attacked by thieves and vandals. As well as making 999 calls, callers will now be able to contact the operator to make transfer-charge calls, call directory enquiries, make 0800 and 0345 LinkLine calls, and report faults. These modifications are part of BT's £160M payphones modernisation programme, which already has achieved: 99% of all public telephones fitted with modern electronic equipment; 20 000 modern kiosks and booths; the installation of 8000 Cardphones in popular sites with 14 000 retailers selling Phonecards; expansion of the CreditCall service, which allows the use of charge and credit cards, after a successful London trial; keeping up the pressure to catch and prosecute payphone thieves and vandals; and 70 500 payphones already modified for transfer charge calls when in 999-mode only.

Beginning in October in the City of London, £15M worth of automatic line test equipment, based on the 4TEL test system developed and supplied by Teradyne, is to be installed in London's 87 repair service controls (RSCs), to speed fault detection and repair. It will automatically test customers' lines and equipment to pinpoint degradation before it develops into faults which could affect telephone service. It will also be operated by BT's customer service officers at RSCs to test lines reported faulty by users dialling 151. This will give accurate diagnosis of the fault and will ensure that the right engineer is despatched to repair it.

BT is introducing a new look to the alphabetical listings of its Phone Book directories, which, from next year, will include full postcodes with addresses. The use of a new, more legible, and more versatile typeface, combined with design changes and space-saving measures in how information is presented, will allow BT to include postcodes for the first time, in co-operation with the Post Office. BT will also be adding to the range of attractive advertising options for business customers by enabling them to take semi-display advertisements within columns in addition to the existing Bold and Superbold typefaces to allow companies to achieve more prominence in their entries.

Changes are to be introduced nationally in a phased programme over the next two years. From April, many new editions will consist of single books split into separate residential and business sections, to make it easier for customers to find the correct entry. Eventually, there will be separate business and residential sections to all Phone Books. Advertising will be concentrated in the business section, while residential entries may be shown in four space-saving columns a page instead of the present three. The use of four columns for residential entries will be made possible by omitting repetitive telephone exchange names and code numbers wherever practicable to save space, and by using a single-heading entry for repeated surnames. Subsequent entries under the same surname will be identified by initials or forenames in alphabetical order. Postcodes will start appearing in all Phone Books from the latter half of next year.

BT has been awarded a contract to supply the Royal Air Force (RAF) with a network based on 90 digital switchboards and 14 000 secure telephones. BT will act as subcontractors to the Defence Systems division of GEC Telecommunications, to provide the RAF with a brand-new voice and data communication system. The circuit-switched network will be designed, installed and commissioned by BT between now and 1990. The switching equipment to be supplied is a military variant of the BTeX digital PABX, with a number of added special facilities, as well as hardening against electromagnetic pulse (EMP). The new digital network, known as *UNITER*, serves more than 50 user sites in the UK.

In September, BT announced that it had won the contract to supply advanced digital telephone systems to the Yorkshire Electricity Board (YEB) as part of a complete refurbishment of the telephone network throughout the YEB's area. This order includes the 1000th iSDX system to be supplied by BT.

BT is to install six iSDX systems at key sites. This further extension will enhance the system to give the YEB one of the most sophisticated corporate telephone networks in the country. It will be the first electricity board to have an advanced digital private network signalling system (DPNSS) connecting all its area offices.

The YEB serves 2 million customers in West and South Yorkshire and Humberside. The iSDX exchange systems, linked by DPNSS, will form the background of the Board's voice communications and data transfer systems, and will enable it to provide a more efficient and cost-effective service to its customers. The new telephone network will allow customers' enquiries, including emergency calls, such as those reporting a loss of supply, to be dealt with more quickly. Customers' calls will soon be automatically transferred to the appropriate YEB centres at local charge rates.

In a contract worth more than £2M, British Gas Southern has chosen BT to re-equip its entire trunk communications network. The order, won against strong competition from home and abroad, is for one of the largest private networks supplied by BT and the first time that a complete ready-to-switch-on system has been provided entirely by BT staff. The system will enable British Gas Southern to concentrate most internal telephone, mobile radio calls and data communications over a single integrated digital system. It will also carry information about pressure and flow in the Region's gas grid.

The new network will allow the British Gas Southern organisation to improve the efficiency of its customer service and internal communications as well as cutting telephone costs. The system is more than just a digital-for-analogue replacement; it will provide much greater security as a result of the fail-safe MegaStream circuits which will back up the trunk microwave links in the event of failure in the radio equipment. The backbone of the network comprises a total of 21 microwave radio links, operating at 1·5, 7·5 and 13 GHz. Work will be completed by March 1989, when it will replace the existing analogue equipment.

NEW BOOK ON TELEPHONES

The Institution of Electrical Engineers has commissioned two BT men, Peter Povey and Reg Earl, to write a new book on the telephone instrument. Both authors were curators of telecommunications museums for over 25 years. Reg Earl was founder and, until he retired this year, the Curator of Oxford's well-known BT Museum. Peter Povey was Curator of BT's Taunton Museum and, in 1974, was awarded the British Empire Medal for his services to telecommunications history. The book, which will be called *Vintage Telephones of the World*, will cover the development of the telephone instrument from its invention until the production of the first plastic telephones.

The main difficulty with writing such a comprehensive history has been making a selection from the wealth of information that the authors' have unearthed. They have gone right back to original documents and made some remarkable discoveries. This will be the only book in which all this information is brought together under one cover. Both Peter Povey and Reg Earl have written previous books. Peter is author of *The Telephone and the Exchange* published by Pitman and used extensively in schools and colleges. It has also been published in Spanish. Reg Earl is author of *The Development of the Telephone in Oxford* which, after two editions, is now a collector's piece.

The research for the authors' latest book has already been done and they estimate that the text and pictures will be ready within six months. The book will be produced by Peter Peregrinus Ltd.—the IEE's publishing company—and is expected to be on sale early in 1988.

CORRESPONDENCE

Dear Sir,

Looking back over the last 40 years since World War II, one is reminded of the many inventions researched for applications in telecommunications. Cold-cathode tubes, saturable-reactor switches, ferro-resonant devices, thyratron valves and magnetic drums are but a few of the many innovations which come under scrutiny and experimentation.

Before these fascinating examples of the technology of the day become buried irretrievably into the annuls of time, it would be fitting to be reminded through your excellent *Journal* of the work that was done to develop them for telephone switching and transmission purposes.

The GEC group routining and charging equipment using voltage-transfer cold cathode tube circuits; the AEI fringe area register-translator using decatron tubes; the Lee Green magnetic drum and the Richmond cold cathode tube directors are illustrations of the many techniques harnessed, some of which enjoyed appreciable service before being scrapped.

Even Highgate Wood, the UK's first pulse amplitude modulation switched highways TDM electronic exchange had a brief moment of glory in service, hardly justifying however the millions of pounds it had cost to produce!

Of course, we gain experience and learn lessons from the past; and for this reason it is informative to look back and take stock. Now that the *Journal*'s scope is being broadened in its range of articles and topics, are there any engineers of the 'old brigade' who could recount any of these and other developments, before they fade into obscurity?

Yours sincerely,
Brian D. Simmons

Editors' Note: Are there any readers ready to pick up the challenge? Please contact the editors.

PUBLICATION OF CORRESPONDENCE

A regular correspondence column would make a lively and interesting feature in the *Journal*. Readers are therefore invited to write to the editors on any engineering, technical or other aspects of articles published in the *Journal*, or on related topics. Letters of sufficient interest will be published under 'Notes and Comments'. Letters intended for publication should be sent to the Managing Editor at the address given below.

DISTRIBUTION OF THE JOURNAL

Many IBTE Members and other employees of British Telecom and the Post Office who subscribe to the *Journal* by deductions from pay have still not yet supplied their home addresses to the IBTE Administration Office so that copies of the *Journal* can be sent directly to their homes. Back issues of the *Journal* since October 1985, when this new method of distribution was started, are being held in store for these Members and readers until this information is received. Members and readers are asked to remind their colleagues to supply this information as soon as possible if they have not already done so; a form for this purpose was included with the April 1985 issue of the *Journal*. These Members and readers will then be sent the back issues and all future issues to their home address. Any enquires about this notice should be directed to The IBTE Administration Manager, Room 107 Intel House, 24 Southwark Bridge Road, London SEl 9HJ; Telephone: 01–928 8686 Extn. 2233.

CONTRIBUTIONS TO THE JOURNAL

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

Educational Papers

The Editors would like to hear from anyone who feels that they could contribute further papers in the series of educational papers published in the *Supplement* (for example, see the paper entitled *Digital Multiplexing*, included with the April 1986 issue of the *Supplement*). Papers could be revisions of British Telecom's series of *Educational Pamphlets* or, indeed, they could be completely new papers. It is intended that they would deal with telecommunications-related topics at a more basic level than would normally be covered by articles in the *Journal*. They would deal with, for example, established systems and technologies, and would therefore be of particular interest to newcomers to the telecommunications field, and would be useful as a source for revision and reference and for those researching new topics.

Intending authors should write to the Deputy Managing Editor, at the address given below, giving a brief synopsis of the material that they would like to prepare. An honorarium would be offered for suitable papers.

Guidance for Authors

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

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

As a guide, there are about 750 words to a page, allowing for illustrations, and the average length of an article is about six pages, although shorter articles are welcome. Contributions should preferably be illustrated with photographs, diagrams or sketches. Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that is required. Photographs should be clear and sharply focused. Prints should preferably be glossy and should be unmounted, any notes or captions being written on a separate sheet of paper. Good colour slides can be accepted for black-and-white reproduction. Negatives are not required.

It is important that approval for publication is given at organisational level 5, and authors should seek approval, through supervising officers if appropriate, before submitting manuscripts.

EDITORIAL OFFICE

All correspondence relating to editorial matters ('letters to the editor', submissions of articles and educational papers, requests for authors' notes etc.) should be sent to the Managing Editor or Deputy Managing Editor, as appropriate, at the following address: *British Telecommunications Engineering*, Room 107, Intel House, 24 Southwark Bridge Road, London SEl 9HJ. (Telephone: 01–928 8686 Extn. 2233.)

British Telecommunications Engineering

If you wish to subscribe to *British Telecommunications Engineering*, please complete the relevant section of the order form below and send it to the address given. British Telecom (BT) and British Post Office (BPO) staff should complete the upper section and other subscribers the lower section. A photocopy of this form is acceptable.

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Room 107, Intel House, 24 Southwark
Bridge Road, London SE1 9HJ.

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Rank .... Pay No. (Note 2) ....

District/Area/Dept. ....

Pay group reference (Note 2) ....

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