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British Telecommunications Engineering

EDITORIAL

Over the past 12 months many changes have taken place in telecommunications in the UK, not least being the creation of British Telecommunications plc and the public sale of shares in the company. Within British Telecom, considerable reorganisation has taken place to meet the challenge of the new telecommunications environment. An article on p. 2 of this issue of the *Journal* describes the way in which one of the operating divisions of British Telecom, Local Communications Services, is being organised to respond to the new commercial factors and to serve better the needs of its customers.

Over the years, the telecommunications network has grown in response to customer demand. But at the same time technological developments have forced a continuing change of emphasis in the management of the network, and the administration has had to adapt to reflect the economic and social pressures brought about by these changes. Thus, reorganisation is not new; indeed, many of today's events have their parallels in history. An article on p. 30 reviews some of the events, innovations and developments reported in the *Journal* 25, 50, and 75 years ago.

Changes in organisation of the Business, however, do pose problems for the Institution and its *Journal.* In recent years, it has become more and more difficult to keep track of members and internal subscribers and the service given is not as good as might be desired. The Institution seeks to rectify this situation and a computer-based central register is being set up with the aim of distributing the *Journal* by direct mailing to home addresses. A leaflet included in this issue of the *Journal* explains the procedure. Your co-operation is requested in taking a few moments of your time to complete the form. Ultimately the success of the project will largely lie in the extent to which members co-operate.

LCS—Shaping up for the Future

Keynote Address to the Institution of British Telecommunications Engineers

I. D. T. VALLANCE, M.SC., B.A.†

UDC 654.01 : 621.39

This address was given by Mr. I. D. T. Vallance, Managing Director of British Telecom (BT) Local Communications Services (LCS), to the London Centre of the Institution of British Telecommunications Engineers on 19 September 1984. In his address, Mr. Vallance considered how LCS is to meet the challenges of the new telecommunications environment in the future. He began by identifying the two main businesses that LCS is in—running BT's local network and acting as its main distribution organisation—and the key factors for success. He described how LCS is being organised to deal with these businesses, the systems that are being developed to support the new organisation, its staffing, and the aims and values that will bind the new organisation together. In his closing message, Mr. Vallance looked to how LCS must meet the growing challenge of international competition to ensure a secure and remunerative future.

INTRODUCTION

The last few years have seen unprecedented change throughout the whole of British Telecom (BT). The 1981 Telecommunications Act started the process of liberalisation, and the 1984 Act has now given us a licence and Oftel; network competition is on the brow of the hill; we are now a plc in what, for most of us, is the new land of the private sector. And when one looks back over those three years it is scarcely believable just how many changes have happened over the period. One can sense throughout the organisation a level of uncertainty about what the next bout of changes is going to be—over what could happen if the next three years produce as much, or more, change as the last.

The importance of Local Communications Services (LCS) to all of this is self-evident. LCS is the division which represents something like 80% of the assets of the organisation, about 80% of the staff, though unfortunately not yet 80% of the income, and it is the primary contact for nearly all of our 20 million customers. Moreover, the other divisions, for better or for worse, are very much dependent on how we in LCS perform. National Networks get their trunk services to their customers over our network, BT International do the same, and BTE get most of their products to their customers through LCS. So far as the company's customers are concerned, LCS and BT are largely one and the same and, if LCS sneezes, BT as a whole catches a cold. We have to get LCS right to get BT right.

What then does the future hold for us in LCS? A key managerial job throughout the Division (with parallels perhaps throughout BT as a whole) is to try to answer half a dozen very basic questions. The first is: what business is LCS in? The second is: given that we know the business we are in, what are the key imperatives for making a success of it, to get it right? The third question is: are we properly organised to achieve these imperatives, have we got the right structure? The fourth is: do we have the right support systems for the organisation to make it work? The fifth is: do we have the right people (both the operational staff and the management) to get that organisation working properly? And the final question, and in some ways the most important, is: do we have a clear set of values, ideas, aspirations and goals that run through the organisation in which we all believe and which make everything tick? Let us consider each of those questions in turn.

† Corporate Director, Managing Director, British Telecom Local Communications Services

WHAT BUSINESS IS LCS IN?

It may seem a little odd to start by asking what business LCS is in. Surely, you may say, that is self-evident. But in reality it is not quite as easy as that. If you look at the way BT has developed over the last few years, at the new divisions which have been established, you will see that National Networks was set up afresh with a clear mission; likewise BT Enterprises; BT International has always been fairly independent but is now even more so; and in a sense LCS is what was left once the other divisions had been created. So we in LCS in particular need some re-ordering of our minds over what we are about before we can start answering questions on where we intend to go.

To make it very simple, LCS is in two main businesses. One is running the local network, and the other is operating as BT's main distribution organisation, an organisation which sells, installs and maintains other people's products. Those two businesses are very different from each other. The

BT Installer

network business is characterised by being highly capital-intensive, with long lead times, and is likely to remain regulated and a *de facto* monopoly for some time. It has high fixed costs with high margins from additional traffic. By contrast, if you look at the distribution business, it is largely labour-intensive, has very little capital, except for some working capital which it has to turn over very quickly; it has relatively low margins and the level of competition is much greater than it is (so far at least) in the network business. It also has short lead times, with products turning over more and more quickly. It follows that we have to address these two businesses quite separately because of these different characteristics.

KEY IMPERATIVES

Let us ask ourselves, then, what are the key factors for operating successfully in each of the two businesses that LCS is in, before looking at some common ground between the two.

Local Network Business

Investment Programme

Perhaps the key factor for the local network business is its investment programme. In the old organisation, when we were first of all Post Office Telecommunications and latterly BT, traditionally we took a somewhat broad brush view of what that investment programme should be. We had a monopoly; we knew that we could determine what would happen in our network as a whole and that, if we got it wrong, then inevitably our customers would be there to pick up the tab at the end of the day. We could decide, without too much pressure, to tackle the network in a uniform way, to take out a certain amount of one type of equipment over time and replace it with a new type of equipment. This was a standard monopoly approach, which is what you would have expected, and it was quite right for its time.

'Pulling the wedges' at Deal, in Kent, when the former Strowger telephone exchange was changed over to an electronic TXE4

But when we look at investment in the new environment we have to look at it somewhat differently, because if we get our investment decisions wrong in the new environment then it will not simply be the customer who pays for it. We will not be in our traditional position in aiming at a financial target of a certain real return on assets, where if the assets increase we can always take it out of tariffs; because now there will be competition, and there will be limits to what we can try to impose on our customers without driving them into the hands of our competitors. Neither will we be able, in the future, to determine entirely on our own just what kind of network we want to prescribe for people, because we will have to react to what others are doing by way of competing networks.

This applies not just to Mercury. We know broadly speaking what Mercury is doing in the short run, that its main target will probably be on long-distance services with perhaps a certain amount of bypass of our local network to large customers. But there is also cellular radio, and who knows what cellular radio is going to amount to later in the 1990s? Initially, it is clearly going to be a premium service, but premium services tend to become cheaper as volume increases and unit costs come down. So what is that going to mean for our own local networks in LCS in say 10 or 15 years' time? Resale is another element to consider. We know that under the Government's current policy, resale will not be allowed immediately, but from 1989 onwards resale will come along, and that will certainly include the resale of circuits on local networks. In the meantime, we can expect the growth of private networks and value-added network services, some of which will syphon off our traditional business. Cable television too, may be having a somewhat faltering start, but it will only be a matter of time before telecommunications services (either data services or voice telephony) will be run over or in association with broadband television networks. Finally, we need to ask ourselves about the quality of the service that Mercury and others are going to offer; for we need to strike the right competitive balance between quality and price.

All of these factors—the future development of the competitive networks that we are facing, the way in which our competitors invest, and the way in which they attack what had previously been our monopoly markets—will have to feed into how we think about our own investments in the future. This is not to suggest that our basic modernisation programmes are suddenly going to be swept aside. The modernisation of local exchanges, the installation of digital local exchanges, is bound to be needed given almost any competitive scenario, with the improvement in quality and in cost for our customers that it brings. But the pace and the priorities need to be examined. Other questions will arise as well, such as how fast and how far one introduces optical fibre on the local loop and whether we should try to pre-empt what is going to happen elsewhere by installing broadband capacity—do we take that investment leap or not? These are vital questions which we have to think through. The investment programme is a massive undertaking, with substantial cash flows and long lead times. If we get it wrong we will be wrong for a long time, unable to bail ourselves out in the future; while if we get it right then we shall be able to offer the range and quality of service that our customers want, and that will be the key to our success in the network business.

Network Utilisation

The other key imperative of the local network business concerns the utilisation of the networks. If you think about it, those copper pairs lying out there are very idle assets, used only for a few minutes each week, especially on residential lines. Yet, because of the high proportion of fixed costs and the capital intensiveness of our business, additional revenue from increased business goes straight to the bottom line, straight into our profit. So one of the key things we must ask ourselves is what scope there is for driving up the usage of those local networks. We could start by taking a few international comparisons. If you look at the USA, you find that the ratio of telephone usage there to that in the UK is something like 3:1. We know that many local networks in the USA have no charge for local calls but, even allowing for that factor, the usage in the USA is a good target for us to be aiming at. Even in other parts of Europe, particularly in Scandinavia, their usage of their networks is a good deal higher than it is in the UK.

So how do we get there? How can we stimulate the use of our networks to give us the profitability which allows us to invest in the future? There are a host of approaches we can try, some of which are new and others we have already been pursuing for some time. Phonepower is relatively new, but we have been working at it with some success. Star services are coming along, and they too will give a boost to the use of local networks. The derived services network that National Networks is setting up will help us. Call forwarding may also be helpful. The range of Guidelines is already very popular and new Guidelines are on the way. Call stimulation campaigns have a role to play too and there is strong evidence that the immediate reaction to our call stimulation campaigns repays the cost of advertising a number of times over very quickly after the advertising is done. So there are many positive steps we are taking. There is also another vital approach that you might classify as being the 'removal of barriers to usage'. The telephone in the UK is still rather awkward and not particularly simple to use. If you consider the ordinary residential customer, his telephone instrument is too often a single instrument, usually an old-fashioned dial telephone, in the hall, in the cold, a difficult place to get to, while the directories are under the stairs somewhere, hard to find when you need them, and so on. Whilst international comparisons show us that modern telephones, near at hand, attractive directories, an efficient enquiry service, fast signalling and clear transmission all lend themselves to high usage. There is probably a generation difference too, with the older generation tending to look at the telephone as being rather more expensive and special than the younger generation. So there are a whole range of possibilities for trying to get rid of the barriers of usage to drive up our profitability through increased utilisation.

You might ask what it is worth to us. Well, for each ordinary residential customer, one extra call per week of the sort he makes now adds something like £115M to the annual revenue of LCS. That is an enormous pot of gold. And, although it is not something that we have considered in quite that way in the past, when as a monopoly we were concerned more to give a service than to chase profits, the revenue from extra network usage now has to be a key marketing goal. Those 80% of BT's assets and the staff in LCS working in the network business have a vital role to play in generating the cash for BT as a whole, to be used for investment in information technology and all the other new ventures that the company will be moving into. Those same assets and people are in the mature part of the organisation, from which must come the cash flow for moving forward into the next phases of the company's plans. So, in summary, in the network business, the key problems are getting the investment right and driving up the usage—to fund our future.

Distribution Business

Product Range

What, then, about our second LCS activity, the distribution business? Again there are two key imperatives in the distribution business which we have to get right. One is only partly our problem and that concerns the product range. BT was lucky, when liberalisation was introduced after the 1981 Act, to have inherited a number of the ingredients of the current BTE product range. The Monarch is an obvious example, which was coming up as CDSS1, and we were able to take advantage of it. We have been able to churn the installed base extremely well over the two or three years since liberalisation has taken place. But as we move into the next generation of products, we are bound to find that the level of competition and the toughness of the competition becomes a good deal greater than it has been so far, especially as new distribution outlets are developed. So Peter Troughton and his people in BTE have a major job to do in developing the next generation of customer premises equipment, which will take us forward into office automation. We will be very dependent on that in LCS, and equally BTE are going to be very dependent on LCS in getting the distribution channels right.

Efficiency

The second imperative in the distribution business concerns our efficiency; that is our speed of response and the achievement of low costs. It is a low-margin business, with money coming through volume, and a need for very good support systems for our staff. We need to drive through our marketing and sales effort, and we need also to look at our installation and our maintenance procedures, as some of them are laborious and costly, and some insufficiently geared to the new markets that we are entering. To take an example; clearly the penetration of plugs and sockets is going to change the distribution outlets for consumer products in a major way. I would expect to see much more retailing through high-street outlets or by direct mail, and very much less of our own staff going into customers' premises to install telephones or to return later to maintain them. This will be a low-margin high-speed low-cost business, not the sort of thing we have traditionally been very good at, and we will need to work very hard at it.

BT's new shop at Southend sells a range of telephone systems for small businesses, as well as telephones for the home and telephone accessories. Customers can also pay their telephone bills, seek advice and make enquiries about services from BT

Customer-Responsive Service

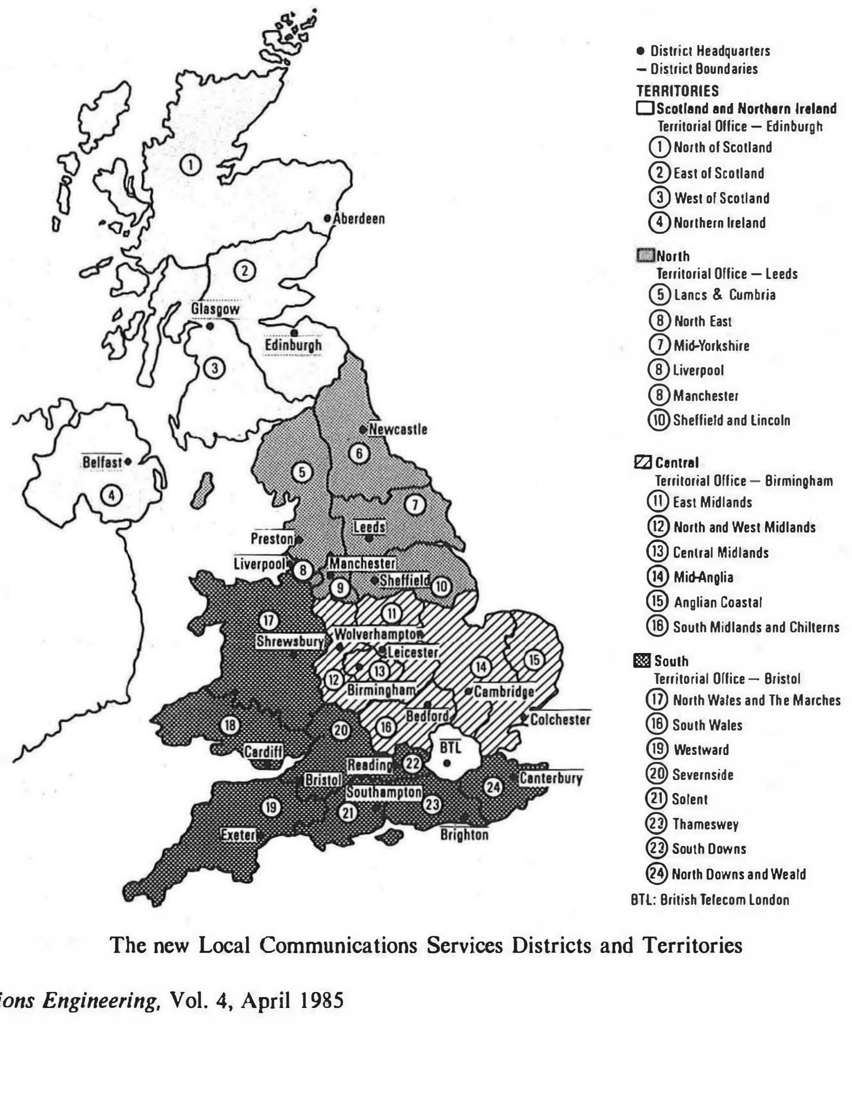
Despite the major differences between the two businesses that LCS is in, there is one key factor that straddles both of them, and that is the need to offer a first-class customer-responsive service. Until not very long ago we were substantially in the business of imitating Henry Ford, saying to our customers: 'You can have any instrument you like provided that its grey, and you can have it at a time of our choosing'. But the customer rules now and we have to find what he's about, to chase him and to woo him, not sitting behind our desks, but communicating with him, and talking to him in his language and not our jargon. So customer-responsive service, whether we're talking about the local network or about the distribution business, is another key factor for our success.

NEW ORGANISATION FOR LCS

The third of my original list of questions was: given that we know what businesses we're in and that we've sorted out the key priorities in those businesses, then do we have the right kind of organisation to deal with those businesses? The answer today is probably 'No'. Traditionally the old Post Office Telecommunications (and in a sense LCS is the legacy of that old organisation) was administered rather than managed. And the strength of its management, from the Civil Service tradition, was in administration and professional engineering (that is, its staff functions), and not in having strong commercial people with a strong tradition of line or general management. Only recently the staff-to-line ratio of middle managers in BT was 7:1, seven staff to one line. That is an extraordinary reflection on the way in which the business has been run, and the basic trend has to be reversed so that the people who are running the line units, and dealing with the commercial operation of the business, represent as strong a management group as our engineering professionals, since they will carry much of the burden in the future. Another result of the line-to-staff management ratio was that it generated bureaucracy, resulting in large volumes of paperwork, slow decision-making (because one needed to check with lots of people before doing anything), and a focus on internal considerations rather than on the customer.

Our intention now is to produce a slimmer and more efficient structure in the Division, with authority-to-act brought closer to the customer and further away from Headquarters. The basic pattern, as I am sure you all know, is to move away from the 61 Areas, 10 Regions and a large Headquarters into a structure with 24 Districts, 4 Territories plus London and a slim Headquarters. The Districts will be the basic unit of the new organisation, and will reflect the division we discussed before between the network business and the distribution business, but with shared common services, such as marketing, finance, personnel, materials management and so forth. The Districts will evolve into profit centres, with appropriate powers and responsibilities. This new structure requires us to dismantle what was previously the Regional organisation. Area reorganisation in 1983 was the first step towards this, but there remained a diffuseness of responsibility between the Regional Director and the General Manager. The General Manager is still not in a position to take decisions on many things which are key to his line role, such as marketing and engineering planning, and those and other functions need to be pushed much closer to the customer within the new District structure.

I know that some people are concerned that the new Territories will end up acting just like Regions but with a larger geographical coverage. But this is certainly not the case. The Territories will act as outposts of Headquarters and their Directors will act as my agents—monitoring, checking and advising and setting targets for the Districts, but in no way running as commercial units themselves. There will be no consolidation of District results by Territory, so that the Territory will act as a transparent organisation. The Territorial office will contain some experts on engineering, finance, personnel, and perhaps marketing, but the total numbers will be very small—tens rather than hundreds or thousands.



The new Local Communications Services Districts and Territories

Meanwhile, the LCS Headquarters is moving, and has indeed already largely moved, towards a classic headquarters structure with small teams on marketing, finance, personnel, engineering and business planning. We are already cutting back on the reporting requirements and the amount of information flowing from Districts into Headquarters. And the number of instructions from Headquarters to the Districts will also be reduced wherever possible. However, no one should make the mistake of seeing this as Headquarters abandoning its reponsibilities; the name of the game is avoiding undue interference rather than relinquishing control.

SUPPORT SYSTEMS FOR THE NEW ORGANISATION

Turning to the fourth of my questions we have to ask ourselves whether we have the right systems to make this new organisation work. Everyone knows that, unless you change the systems at the same time as you change the organisation itself, the danger is that the organisation drifts back into working the way it did before, and the signs from the Area reorganisation last year were that there was tendency for this to happen unless management was very much on its toes. When you look at our basic management systems in the field, we have to accept that they are nothing to be proud of—we are so to speak the cobbler's children. The telecommunications and computing systems within our Areas are not the sort of thing that we would really want to sell to our own customers. As an example of this we all know the problems we run in to when trying to ring our own General Manager's office for service as an individual customer. Our computing systems too demonstrate the sort of bureaucracy which we discussed earlier. Each functional unit at Headquarters has helped to try to develop particular computing systems for its own people in the Area, so that at Area level the relationship between systems is inadequate. To take a fairly obvious example, there are some Areas where such basic information as the customer's name, address and telephone number are input into five different systems in five different formats, and that clearly cannot be sensible for the future. Not only is such a system highly inefficient, but it also makes almost impossible the task of giving a good integrated service to the customer.

Customer Service System (CSS)

Our means of solving this problem is the Customer Service Systems (CSS) approach. Initially, we tried to see whether we could pull together the existing systems which existed in Areas in the different functions. But they were in such different situations when it came to the stage of development, computer language, operating hardware and so on that this quickly proved impossible. We also considered whether there was anything we could buy off-the-shelf from abroad, but we found, somewhat to our surprise, that overseas systems had many of the same problems as our own, having developed in a haphazard organic way so that it was impossible to buy a coherent wholesale system for our use. So, instead, we decided to take the bold step of setting up the CSS Task Force with the job of integrating the customer support systems to span the whole of the District and supporting the entire District organisation, with the emphasis again on customer service and slickness of response. The CSS development, reflecting the newly recognised importance of the field units, is driven largely by a user group which comes from the Areas. It is also being developed in an integrated fashion from the word go, rather than patched together at the end. The targets for CSS are to have the first phase up and running in Thameswey as the pilot District in the summer of 1985, and then the full systems running nationally by 1987/88. It represents a massive piece of systems and software development over that period, but an aim which we have every intention of achieving.

STAFFING

So far we have looked at the business which we are in, we have considered the imperatives for success in those businesses, and we have looked at the organisation and supporting systems. Supposing that we have all those right, we must next ask whether we have the right people. I am constantly delighted by the quality of many of our basic staff; we have first-rate people in almost any function that you consider, whether it is the clerical staff, the operators, the engineers, or the management. These staff are a tremendous resource which we have to manage very carefully during a period of difficult changes in our organisation, technology and markets.

The changes are difficult because they nearly all conspire to reduce the numbers employed within the Division. Over the last three years we have reduced by something like 14–15 000 staff and, although that is a substantial number, it has been made possible largely by good housekeeping, rather than radical change in what we do. In the future, there are a number of technological and market changes which will mean that the staff reduction will continue. Digital exchanges, for example, will mean a significant reduction in our exchange and maintenance staff; in operator services, the concentration of auto-manual centres (AMCs), the introduction of automatic call recording equipment (ACRE) and the directory assistance system (DAS) will allow us to run our operator services with fewer staff; the trends towards customers' own installation of domestic telephones will no doubt affect the numbers of our staff involved in these activities; and the new CSS systems will also make it possible to reduce clerical staff numbers. Furthermore, although we feel we have done very well in the last few years in terms of reducing manpower costs per unit of output within LCS, we know very well that international comparisons suggest that our numbers are still too high,

BT's inland directory enquiry (DQ) file is being transferred to computer to give DQ operators instant on-line retrieval; the new scheme is known as the *directory assistance system* (DAS) even if one discounts some of the obvious differences between Britain and other countries.

Many of the staff released by those factors which I have just described will be among our most capable and experienced individuals. Our Technical Officers, for example, are just the sort of people who can help us to cope with the shortage of trained software experts in the UK; and our operators are expert at dealing with customers on the telephone, which is of increasing importance to us. So the crucial factor will be to make good use of as many as possible of the staff who become available through other developments, rather than leaving them out in the cold.

What then about our management and professional staff? Here too we have some tremendous strengths, but also some weaknesses. As I mentioned earlier, we have not built up sufficient breadth of experience in all our line and general managers. We also have inherited weaknesses in our commercial arm, as we simply did not need a strong commercial function, when the company was a monopoly run as a single centralised profit centre. We have recently strengthened the financial side of the commercial team by recruiting new people into the Areas and Headquarters; and marketing, the other part of the commercial team which has also been weak, is again being strengthened by new recruits. The culture of the company's management has to be reoriented towards these new emphases—line management, and commercial skills—while at the same time not losing our traditional strengths, particularly engineering expertise. Through this reordering of our priorities shall we create an exciting environment for managers in the future, with appropriate risks and rewards.

VALUES AND GOALS

Now let us return to the last of my original questions, which asks whether we have a clear set of values and goals bringing the organisation together. This is probably the most interesting and the most important of all the questions, even though it is not one that is normally discussed.

When I visit Areas and Headquarters departments, I often ask how many of the people I am seeing have worked for either BT or the Post Office all their lives, and how many have had family who either work now or worked in the past for the company. In my experience, it very often turns out that nine out ten of the people have worked in the organisation all their lives, and that anything from one-third to one-half of the managers tend to have family who have themselves worked in the company. That is extremely important when it comes to understanding our values and the way in which we need to move from the old organisation to the new. Most of us who have worked all our lives in the one company and who have family in the organisation, too, share a strong common set of values concerning that company, whether we have recognised them before or not, and we need now to take them out and look them over to see whether they fit the new role for BT.

Customer Service

Perhaps we can take as the starting point the BTUC's anti-privatisation slogan, which was 'Public Service versus Private Profit'. The slogan seems to suggest a strong antithesis between the old regime and the one we are entering, but is this really true—what do we mean exactly by public service? I believe that there are two aspects of public service. The first concerns those 'social' services we undertake for our customers which a company driven solely by the profit motive would not necessarily do. For LCS, this includes the 999 service, telephone services in rural areas, public telephone box services, and so on. But those services are fully protected by the Licence under which we now operate. In the past, we provided them as a result of the general pressure from the Government of the day to keep them going, but now we have a full and formal obligation to support them. So it appears that in this respect at least our public service role will be as strong as ever.

A new range of up-to-date telephone booths will be appearing on Britain's streets as part of a major modernisation of BT's payphone services. Easier to clean, cheaper to maintain and more resistant to vandals, the booths have been designed with the needs of customers in mind, particularly wheelchair-bound users

The other aspect of public service is all pervasive and translates directly into service to the customer. That spirit of giving a first-rate service to our customers will be vital to our success in our new role. I believe that if you look back over the last decade or so, customer service in the old public service mode was something that became somewhat tawdry and tarnished. Somewhere along the line, giving good service to the customer took second place to operational convenience for ourselves. But now, in the commercial and competitive game we are moving into, service to the customer is the absolutely essential feature of those companies which are going to succeed and to remain in business. For many of our staff, giving good service is already second nature, and that is something which we need to encourage above all, getting others too to accept that this is the ultimate goal for each of us. So customer service is a common value which runs quite properly from the old organisation to the new.

Professionalism

Another of our traditional values was professionalism, which manifested itself in many areas of activity but perhaps most obviously in our engineering excellence. That professionalism will be crucial for us to maintain in the years to come, not just in the engineering profession (for we remain overwhelmingly an engineering industry), but also through all our other areas of activity—accounting, marketing and so on.

Fairness

Our old organisational values also placed a high priority on fairness both to customers and to staff. Fairness to customers is, again, enshrined in our Licence, where we are required not to show undue preference between one customer and another. But fairness to staff is equally important, and I believe that here again there has been some weakness in our performance over the last few years. I have the impression that fairness in dealing with staff became embedded in the rules and regulations, in national agreements and Technical Instructions (TIs), and so on, so that fairness in dealing with the individual often became a mechanical process, based on egalitarian principles, applied to staff as groups rather than as individuals and hence, lacking flexibility to take account of individual circumstances. In future, the direct relationship between the manager and the person he is managing will be vital and in that sense our tradition of fairness must not only be carried forward but strengthened and polished.

Loyalty

There is a final value which I hope very much will carry over from the old organisation to the new, and that is loyalty. The loyalty of our staff and our management in this organisation has been phenomenal and is reflected in our earlier thoughts about the numbers who stay in the organisation all their lives and indeed encourage their families to work for us too. That loyalty is an essential strength which we have and which we need to develop over the years to come. We can see in other industries what happens if the loyalty of the staff is turned away from the management at any one time, when it can become a destructive force in the industry rather than a force for good. That is a situation which we must avoid in British Telecommunications plc; we must harness the loyalty and enthusiasm of our staff and use it to the benefit of our customers, the company and the people who work in it. So maintaining the values of customer service, professionalism, fairness and loyalty are among the key tasks for LCS as we enter the privatised world in the future.

SUMMARY

Let me now summarise what we have considered so far. In LCS we are in two businesses, running the local network and running the distribution business. To succeed in the local network we need to get the investment right, an investment that has to be suitable for a competitive market in which the technology is changing more quickly than we have ever seen it change before. To make that investment profitable we have to go for growth in usage, using whatever methods are available to us. In the distribution business we have to get the right product line, which means feeding back properly into BTE information on what our customers want, and it means getting a slick, fast, low-margin, customer-responsive distribution business. We have to get our organisation right and to do that quickly before the competition gets any stronger. We have to get the right kind of support and information systems for that organisation so that our staff can give an efficient service to our customers, and that is what CSS is designed to achieve. We have to look carefully at our staffing numbers and skills, and face up to the need to reduce numbers and to ensure that the structure of our manpower reflects the new skills which are acquired. Finally we have to make sure that we know what our values are and that we each take it as an individual responsibility to translate those values from the old organisation into the new. That is not something which a managing director can do alone, but it requires action by managers at all levels, and for the message then to be picked up by the staff who work for them.

INTO THE FUTURE

Let me leave you with one final message. British Telecommunications plc as a company is moving into a world league and we need to think about the implications of that, because as a nationalised industry with a monopoly we were in a domestic league, with only one player; so that competing internationally with others is going to be a new experience. For a start, BT will be competing with other organisations for funds. This will mean vying not just with other UK companies such as ICI, Marks & Spencer, or BP but also with international telecommunications companies such as the Regional Holding Companies which were previously part of AT & T and the American independents. If you look in the financial press, nowadays, you will see these American companies setting out their wares for the benefit of London investors. And as you know, we ourselves have sold shares to America and Japan so that there we are competing with these organisations on their home ground. It is therefore vital that we consider how we appear to potential investors in the world markets and compare ourselves with the best telecommunications organisations abroad.

On some dimensions, that comparison leaves a lot to be desired. But, equally, we in BT have been offered a unique opportunity over the next few years to bring about a transformation in our activities, before full-blooded competition hits us. We must take that opportunity and set our sights on producing telecommunications services and products for the UK which (in terms of their range, quality, efficiency and value for money) are second to none. If we achieve that—and we can—we shall not only have the satisfaction of being in the first division of the world league, but we shall have provided the best possible defence against competition and thereby offered the people who work for LCS the best possible chance we can of a secure and remunerative future. We should settle for nothing less.

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 postgraduate 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 period as Assistant Managing Director of the then Inland Division, was appointed to his present post, Managing Director of Local Communications Services.

Teleprinter No. 74A: Puma 74A with Mailbox

M. G. DOWSETT†, and E. HOLTON*

UDC 621.394.34 : 621.394.4

The Puma range of teleprinters was the UK's first fully-electronic teleprinter for the public Telex network. These microprocessor-controlled machines are quiet in operation and are suitable for use in an ordinary office. This article describes the latest addition to the range, the Puma 74A display Telex terminal, which has a liquid crystal strip display and an electronic mailbox option that is fully capable of advanced inter-office communication. This, together with its powerful editing facilities and its ability to operate in foreground/background modes, makes the Puma 74A a very advanced Telex terminal.

INTRODUCTION

The Puma‡ range of teleprinters, manufactured by Trend Communications Ltd., was introduced in late-1981 with the Teleprinter No. 73 (the Puma 73), and was the first of a new generation of electronic teleprinters for the public Telex network. Facilities offered included automatic calling, message editing and storage, keyboard dialling and an internal directory.

The latest Puma display Telex terminal, the Teleprinter No. 74A, was launched in April 1984 and has all the advantages of fully automatic operation. In addition, it is equipped with a 40-character strip display and allows messages to be prepared at the same time as incoming calls are being received.

PUMA 74A

The Puma 74A (see Fig. 1) is marketed in the UK by British Telecom (BT) Merlin. Trend designed the Puma as a teleprinter of the future, capable of keeping pace with the latest state-of-the-art in office automation. This was in part due to the close association between Trend and Merlin and to the fact that Trend conducted extensive market research before starting the design work. Although it was launched before the liberalisation of the supply of customer equipment came into effect in July 1984, the Puma meets the new regulations.

Although the new Puma has many similar features to its predecessor, it nevertheless represents a dramatic change in the design of teleprinters. An immediately noticeable difference is the addition of a 40-character liquid crystal display (LCD). This facility enhances the editing function and provides operators with a menu-type guide. The memory of the Puma has been upgraded to a maximum of 40 Kbyte. The mailbox option, which represents the biggest advance in teleprinters to date, further increases the Puma's memory capacity to 80 Kbyte.

The communications port has been redesigned to operate at 300, 1200, 2400 or 9600 baud. X-on/X-off and hard-wire data flow control lines are incorporated into the port to prevent possible loss of information at transmission speeds above 300 baud. The higher baud rates, together with control lines, permit material from word processors or computers to be downloaded into the Puma faster than was previously possible. The use of the latest chip technology has enabled the electronics to be repackaged. Higher-density chips have been used to reduce the number of printed-wiring boards (2 chips replace 32), which leaves room under the microprocessor board for the addition of the new mailbox option.

† Product Marketing Manager, Trend Communications Ltd.
* Systems Engineering, British Telecom Enterprises
‡ Puma is a trade mark of British Telecom

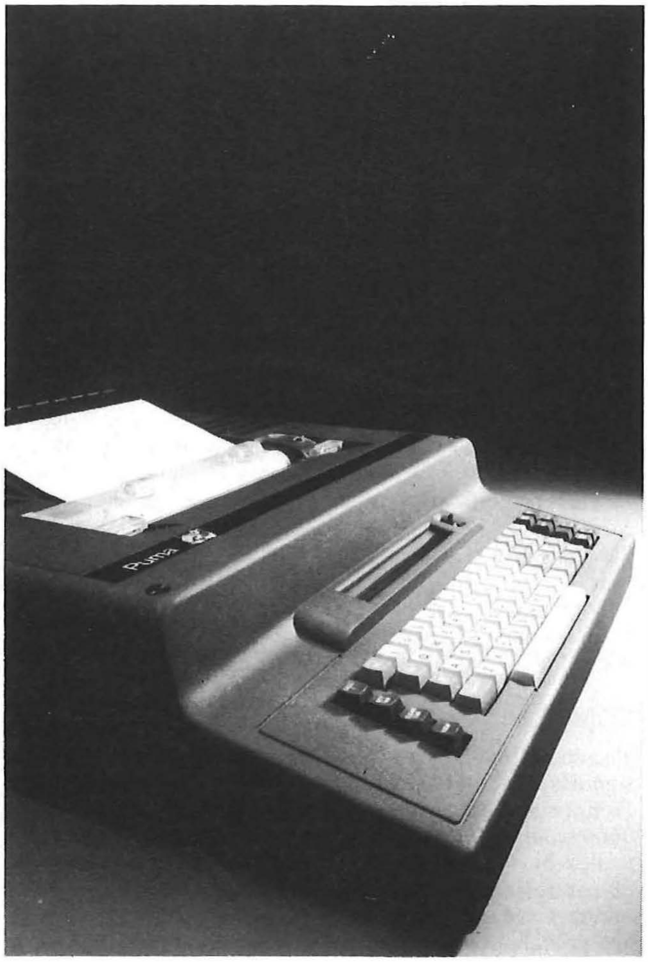


FIG. 1—Puma 74A display Telex terminal

The interface between the Puma 74A and the local exchange is by means of single-channel voice-frequency (SCVF) signalling rather than 80–0–80 V telegraph signalling. SCVF signalling, which gives improved transmission performance and safety, was adopted as the standard for the UK network in July 1984.

In anticipation of future developments, Trend designed the Puma to accommodate the protocols not only of the present Strowger electromechanical exchange but, more importantly, the new electronic stored-program control (SPC) exchanges now being introduced by BT.

DEVELOPMENT SOFTWARE

Trend developed the software for the new Puma by using a Hewlett Packard 6400 development system with a 67 Mbyte Winchester disc to which a cluster of six terminals was attached. This allowed several people to work on large amounts of software development simultaneously. The software, which is written in Z80 assembler language, occupies 24 Kbyte compared with 12 Kbyte on the Puma 73. While the software is based on that developed for the old Puma, several modifications have been made. One of the fundamental differences between the two machines is that the new Puma is capable of multi-tasking. This background/foreground method of operating permits text to be prepared and stored without interruption by incoming or outgoing calls. This capability is an innovation in teleprinter development which makes the preparation of texts on the Puma 74A significantly easier. The store and the allocation of processor time have been restructured to allow more than one message to be open at a time. New software was developed to handle both the LCD and the increased editing facilities.

Trend deliberately did not use a high-level software language for Puma 74A. One of the main disadvantages of high-level languages is that they tend to be generalised and incorporate code which may not be necessary for a specific function. Thus, a loop of program may waste up to 50% of its time performing a non-essential task. This slows down considerably the operation of the machine when two tasks are to be carried out simultaneously; that is, background/foreground operations. Although high-level languages enable software to be written faster, be better documented and to be more easily updated, the code generated is much longer than that of an assembler language. A memory map of 64 Kbyte is available with an 8 bit processor; therefore, the longer the program the less space available for message store. The use of Z80 assembler language enabled Trend to limit the program size to 24 Kbyte, and to achieve the design objective of 40 Kbyte of usable memory.

While a high-level language would have been easier to write, it would have resulted in a machine that fell short of the goals at which Trend was aiming. In fact it took only a year to write the software and complete the main fault-finding tasks. This was made possible as a result of the programmers' familiarity with the processor, and the existence of clearly defined goals.

COMMUNICATIONS PORT

The local input/output port on the new Puma has been significantly improved as compared with that on the previous Puma, since transmission speeds ranging between 300 and 9600 baud can now be attained. The baud rates are controlled by switches on the microprocessor board. X-on/X-off controls (7 bit codes which are automatically transmitted and received and which have no effect on the message itself) are provided to prevent possible information loss at high-speed transmission of data from an external source into the teleprinter. No control is needed for rates of 300 baud, but at higher speeds X-on/X-off or hard-wire control lines are required.

This local interface transmits and receives ASCII†-coded data (that is, coding equivalent to the International Alphabet No. 5). The data structure is preset to 7 data bits, with 1 stop bit and parity set to 1, although other data structures can be selected. The electrical interface is to V28/RS232 standards.

The input/output port provides a means of connecting most electronic office equipment to the teleprinter, and thereby gives these machines access to the Telex network. A 25-way D-type male connector is situated at the back of the Puma. The port can either be used as a direct link to word processors, computers or memory typewriters, or it can be connected to a modem for use with a private automatic branch exchange (PABX) for message transmission. A switch box can be used to connect several remote devices.

Pin Information

The pin signals on the port are given in Table 1.

TABLE 1

Pin Information

Pin	Signal	Notes
7	Signal ground	
11	Control signal output	Normally HIGH—Puma data buffer ready; goes LOW when Puma data buffer not ready
15	Control signal input	Normally HIGH; must be taken LOW to halt transmission from the Puma
12	Transmitted data	Data output from the Puma
14	Received data	Data input to the Puma
16	Positive voltage output	Strap to 15 when control is not required or X-on/X-off protocol is used

Interface Arrangements

The Puma 74A is fitted with a basic V28 interface comprising transmit, receive and signal ground. A device linked to the Puma may have a V24/V28 interface, indicating that it operates at V28 voltage levels, while using some or all of the interchange circuits designed by CCITT* for a V24 interface. Before connecting any device, it is essential that its correct interface requirements are determined, since manufacturers assign their own pin/circuit combinations. As a general guide, V24 uses the interchange circuits and associated pin numbers as shown in Table 2.

TABLE 2

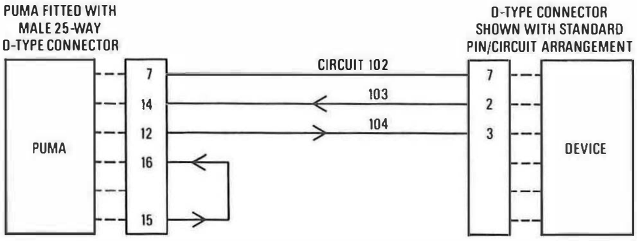
V24 Interchange Circuits

Circuit	Description	D-Type Pin Number
102	Common return	7
103	Transmitted data	2
104	Received data	3
106	Clear to send	5
107	Data set ready	6
108	Data terminal ready	20
109	Received line signal detector	8

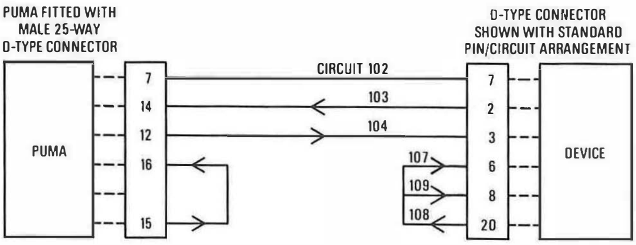
Examples of the interface arrangements for the Puma are shown in Fig. 2. In cases where the device to be connected has a simple 3-wire V28 interface and operates at 300 bit/s, there are no connection problems (see Fig. 2(*a*)). When the V24/V28 interface is used, a 3-wire cable with circuit straps fitted at both the device end and the Puma end of the cable (see Fig. 2(*b*)) allows correct operation. All figures show

† ASCII—American Standard Code for Information Interchange

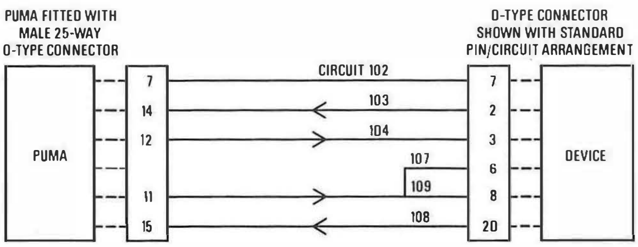
* CCITT—International Telegraph and Telephone Consultative Committee



(*a*) Simple 3-wire interfacing using 300 baud or X-on/X-off protocol, where no lines at external device device need to be strapped



(*b*) Simple 3-wire interfacing using 300 baud or X-on/X-off protocol, but where external device requires strapping of pins 6, 8 and 20



(*c*) 5-wire interface, where pins 6 and 8 on external device control flow of data to the Puma; pin 20 on external device controls flow of data from the Puma

FIG. 2—Communications port V24/V28 interface interconnections

the external device configured as data terminal equipment (DTE). In devices configured as data communications equipment (DCE), pins 2 and 3 must be reversed. Lines which control data flow vary dependent upon the type and configuration of equipment.

For operation at 1200 bit/s and above, X-on/X-off control is used with connections made as shown in Figs. 2(*a*) and 2(*b*). As an alternative, the control input and output signals on pins 11 and 15 can be used; however, this requires a 5-wire cable (see Fig. 2(*c*)).

Remote Devices

The maximum distance at which a remote device can be connected is up to 1 km and depends upon the electrical environment and the type of cable used. However, at distances over 30 m, there may be transmission problems; these problems can be overcome by installing a modem at each end of the circuit. The modems can be switched to and from the line by using S-switching on the telephones used to communicate between the operators of the Puma and the remote device.

Multiple Access

A number of devices can be connected to the Puma, but the method used depends upon the type of circuit required. Directly-connected devices require a line switching unit, whereas connections via modems can use either the public switched telephone network and/or a local PABX.

PRINTER

The printer is a serial dot-matrix impact printer operating at 30 characters/s. The character format is a 7 × 5 matrix and produces upper- and lower-case letters at 10 characters/inch. A standard red/black non-abrasive ribbon is used to print in red for transmitted messages and in black for received messages.

LIQUID CRYSTAL DISPLAY

The Puma 74A features an LCD which, together with a new software editing program, enables operators to edit and manipulate text more easily. The LCD is also designed to display messages to users to guide them through the operation of the Puma in a similar manner to that of a word processor. The display makes the Puma very easy to use, which is an advantage if no dedicated Telex operator is available. The LCD can automatically display messages being transmitted or received.

KEYBOARD

The keyboard has a conventional layout with automatic repeat on the keys. In addition, automatic figure and letter shift is provided together with tabulation facilities. A number of special function keys (see Fig. 3) are provided to assist the operator. The keyboard uses capacitive proximity switching, and has a 32-character buffer store.

FIG. 3—Function keys on the Puma 74A

EDITOR FUNCTION

The edit function is designed to give operators many of the features normally found on word processors. Information can be typed in without regard to the line length, as the editor automatically inserts carriage returns and line feeds, ensuring that there are a maximum number of words on a 69-character line. If words are later inserted into the text, thereby making the line longer, the editor invokes a word-wrap routine which automatically moves the text into the correct position. Mistakes are rectified by the operator moving the cursor to the letter to be changed and over typing. A DELETE key is available to erase text. Pressing the INSERT key causes the cursor to flash, which alerts the operator that the machine is in the INSERT mode and consequently anything typed in will be incorporated into the text. Operators can now prepare and adjust their text as required by using the editor to insert new paragraphs, short lines or underlining etc. Other editing commands allow users to find-and-replace text, incorporate text from other messages stored in the Puma, or to include messages from an external source, such as a word processor. Messages from paper tape can also be added to any text being prepared.

AUTODIAL

The Puma 74A has an advanced version of the autodial facility that was a feature of the previous Puma. Messages can be sent to a preselected number of addresses at a predetermined time. The new Puma allows a user to delay the transmission of any messages up to nine days in the future. Users may either send out messages immediately, or they can set the date and time at which a text should go out. This facility is especially useful on international calls where time differences are crucial. A priority code enables users to skip a queue of messages awaiting transmission that have not been scheduled to go out at any particular time.

Text stored in the Puma's memory (with the correct dialling and answerback information) is sent automatically by the Puma when the real-time clock reaches the prescribed time. Successful transmissions are deleted from the autodial list of calls, but the text is still retained in the memory and a copy is printed out on paper. If the machine is unable to complete the transmission, because the station called was occupied for instance, then the Puma will redial the call. A maximum of five attempts are made on occupied lines at various time intervals. The number of retries is set by algorithms included in the software.

SINGLE-CHANNEL VOICE-FREQUENCY SIGNALLING

From July 1984, BT adopted the SCVF signalling system for teleprinters rather than the old 80–0–80 V system. SCVF signalling operates on low-level analogue tones based on the CCITT Recommendation V21. By using two VF bands, SCVF allows for duplex working on a 2-wire circuit. The send and receive wires carry *mark* and *space* signals which are each assigned different frequencies. SCVF has several advantages that will serve to enhance the Telex network. Interference will be reduced in the modern low-voltage exchanges and between other systems using the cable network. SCVF is capable of working up to 300 baud, which is significantly higher than the 110 baud limit on the old 80–0–80 V interface.

MAILBOX FACILITY

The mailbox option is a new addition to the Puma which dramatically improves Telex operation. An additional card of electronics (see Fig. 4), which is easily clipped under the main microprocessor board, controls the mailbox from its own microprocessor and 40 Kbyte memory store. The Puma 74A can be easily upgraded to include the mailbox option at any time.

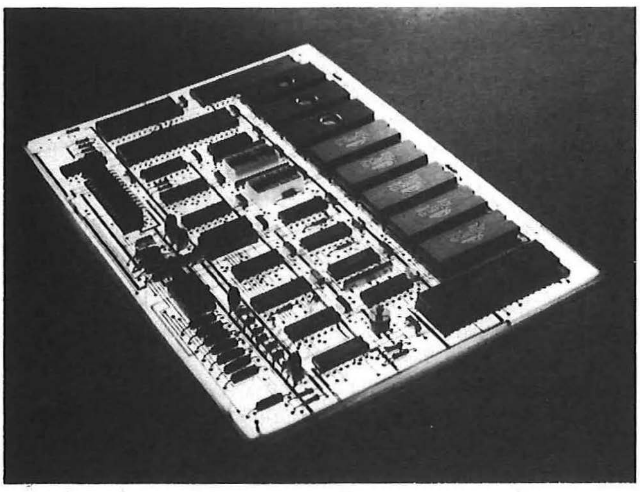


FIG. 4—Add-on mailbox facility card

As a safeguard against any, not necessarily approved, machine having direct access to the Telex network, the mailbox acts as a complete buffer between the Telex protocol and the remote terminal. In this way, the Puma maintains complete control over the Telex line, ensuring that British Standard Institution's (BSI's) specifications regarding answerback checks and retry times are met. Once a message is down loaded into the mailbox, no other device, be it mainframe computer or word processor, need take any further action.

When ASCII 8-unit characters are transmitted into the mailbox, it is necessary to convert them to the 5-level International Alphabet No. 2 before they can be retransmitted as a Telex message. All lower-case characters are changed to upper case, and characters which have a direct equivalent are converted. Abbreviations such as £, $, @, &, and % may be transferred into their word equivalents. Other print characters that cannot be converted are printed as a question mark. Non-convertible control characters, such as NULL or DELETE are ignored.

Essentially, the mailbox enables anyone with a terminal connected to the Puma to send Telex messages automatically without the intervention of a dedicated Telex operator. With the mailbox option, the Telex operator need take no action on messages that are being sent from remote devices such as visual display units (VDUs) and word processors for automatic transmission. Perhaps the best way of describing the mailbox function is to say that it is like posting a letter: once a message has been posted, the sender takes no further action.

Text prepared on a remote VDU has to include the correct mailbox format for dialling numbers and for answerback. The mailbox will not recognise or accept any text that does not contain this information. A user may request a timed or priority release to which the mailbox will react to implement appropriately the autodial facility. Paper copies of messages sent by the mailbox are printed automatically on the Puma.

If a mistake is made and a message cannot be transmitted (perhaps because incorrect dialling information has been included), the Telex operator can transfer it from the mailbox into the Puma. After the necessary corrections have been made, the operator has three available means of sending the text:

(*a*) returning it to the mailbox for automatic transmission;

(*b*) leaving it in the Puma store, from which it can go automatically; or

(*c*) transmitting it manually.

The mailbox option is a valuable addition to the Puma even if it is not connected to remote terminals since it provides a further 40 Kbyte memory store. This additional memory can serve to free that on the Puma itself, thereby increasing the volume of messages which may be stored. Multiple messages may be sent via the mailbox to several addresses. However, the mailbox may serve as the direct link into the Telex network for one or several remote devices, ranging from electronic typewriters up to mainframe computers. Connection between multiple devices and the mailbox is made via a switch box. Alternatively, the mailbox can be linked to a PABX with modems incorporated between the terminals and the Puma (see Fig. 5). The information is transmitted through the PABX into a modem and connected to the mailbox which then automatically answers the modem and takes the message.

Incoming calls through the mailbox are handled in the same way as on the Puma itself. Copies are made immediately on the printer rather than being passed straight into a memory to be printed later. However, depressing the RECEIVE (Rx) key allows a copy of the incoming message to be put into the Puma's memory if required. Storage in the mailbox is controlled by sending specific codes from the remote

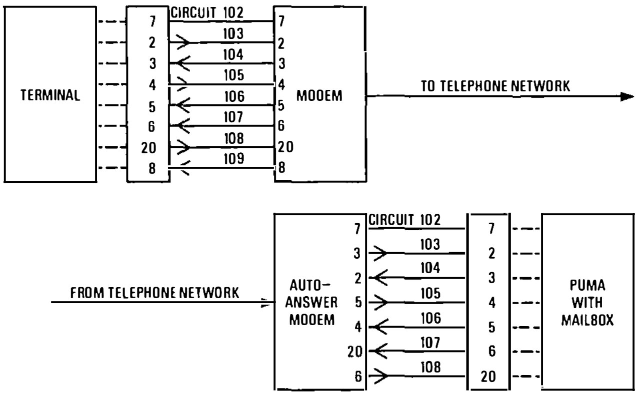


FIG. 5—Mailbox interfacing: example of interface via modems using public switched telephone network

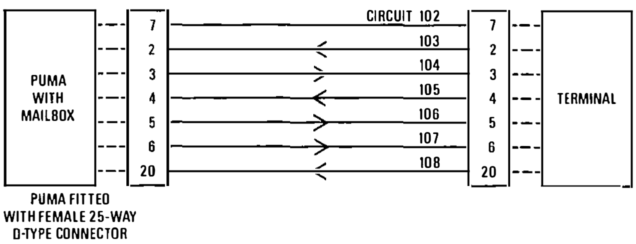


FIG. 6—Mailbox interfacing: example of 7-wire interface where terminal on-line/off-line control is on pins 6 and 20, and flow control is on pins 4 and 5

terminal (see Fig. 6). Telexes can be retrieved easily from memory by the Puma operator.

The mailbox card features a real-time clock with battery back-up. When the mailbox option is fitted, and in the event of a mains supply failure, both the mailbox and the Puma's clocks will continue to operate.

STORED-PROGRAM CONTROL EXCHANGES

BT is in the process of replacing the present Strowger electromechanical exchanges with electronic SPC exchanges. The advanced design of the Puma allows it to operate with both Strowger and SPC exchanges. The first SPC exchange was opened in Sheffield in November 1984, followed by Guildford and Keybridge, London. The schedule is to open one new SPC exchange per month, with the Fleet Exchange opening in late 1985. Foreseeing the change, Trend designed the Puma so that no modifications would have to be made when SPC exchanges are introduced. The introduction of SPC will open the way for Telex transmission speeds to be upgraded from 50 baud to 300 baud within the UK. Although, of course, 50 baud will remain the mainstay of the UK network for many years hence, customers who wish to will have the advantage of being able to connect equipment to the network which operates at 300 baud and uses the full ASCII character set. Interworking between UK customers, operating at speeds of 50 or 300 baud, and the international Telex network (on which it will be a considerable time before the faster speed is available) will be via speed and code conversion handled by the SPC exchange.

EQUIPMENT TRIALS

Trend completed their design work based on previous experience of working with BT Merlin and on the results of its extensive market research. Close liaison between BT Merlin and Trend allowed modifications to be made during the design stage of the Puma.

BT Merlin received the first Puma 74As in July 1983 and submitted them to rigorous testing. During the four stages of evaluation, the new Puma was found to be well within both the traditional and the new BSI specifications. These specifications came into force in July 1984, after the Puma was on the market. The Puma was tested by staff at BT Merlin who put it through exhaustive trials. The teleprinter was operated under unusually adverse conditions, but all attempts to produce a serious operational problem were unsuccessful.

After this vigorous testing procedure, BT Merlin then submitted the Puma to Alpha and Beta trials. During the Alpha trials, the Puma was put into normal use on Telex lines within BT Merlin. The Puma was also sent to BT Merlin's operations staff who are responsible for training Telex operators. Personnel and trainees were asked to comment on the user facilities, rather than the technical aspects of the Puma. Once again the comments were favourable.

During the Beta trials, Pumas were distributed to a range of BT Merlin customers in four inner London areas. Pumas were sent to heavy and light Telex users so that the machines could be tested over a range of operating conditions. The theory behind the method was that varying degrees of use highlight different potential problems. As the results from both the Alpha and Beta trials were very favourable, BT Merlin decided to launch the Puma 74A, and began marketing it in April of 1984.

CONCLUSION

The Puma 74A teleprinter, with its advanced features, is capable of total integration with modern office communication systems. It combines low noise levels with a compact design and simplicity of use. A significant feature is its ability to receive incoming messages while the operator is preparing messages locally. An electronic mailbox option allows existing office systems, including computers, word processors and electronic typewriters direct access to the Telex network.

Considerable market research has resulted in a very versatile microprocessor-controlled Telex machine well able to meet the needs of the business community both now and in the future. The Puma 74A was launched in April 1984 and over 5000 units are now in service.

Biographies

Martin Dowsett has more than 16 years experience in the communications industry. He is currently employed by Trend Telecommunications Ltd. in High Wycombe, Bucks, where he is Product Marketing Manager for Telex, Teletex and test equipment products. Previously, he was Sales Manger responsible for facsimile, Telex, Teletex and test equipment products for Siemens Ltd. His early training was with BT London South Area and he received his HNC in Electronic Engineering from Croydon Technical College. He is currently a member of TESG, the Telex Equipment Suppliers Group, and is a founder member of the BT/Industry Teletex Co-Ordination Committee.

Eric Holton joined the then Post Office in 1951 as a Youth-in-Training. He worked in the Engineer-in-Chief's Office Circuit Laboratory on circuit testing for subscriber trunk dialling (STD) equipment and on mechanical testing of Strowger switching equipment. In 1960, he transferred to the Subscriber and Miscellaneous Branch where he worked on the development of prototype customer apparatus including the evaluation and testing of transmitters, receivers, bells, tone sounders etc. and type-approval testing of small active and passive components. On promotion to Assistant Executive Engineer in 1970, he joined the Network Planning Department and was responsible for setting up and running a test centre/workshop for customer datel and telegraph equipment. In 1975, he joined the Group specialising in telegraph and Telex machines. This Group is now part of the Systems Engineering Division of BT Merlin.

Submarine Cable Systems—Their Optical Future

J. M. HORNE, C.ENG., M.I.E.R.E., D.M.S., and K. M. LANGRIDGE, B.SC.†

UDC 621.315.28 : 621.391.63

Contracts have recently been signed for the provision of the world's first repeatered international submarine cable systems to use optical fibres as the transmission medium. This article reviews some of the factors that have influenced this choice of system and briefly describes the first two systems—the UK–Belgium No. 5 and TAT 8.

INTRODUCTION

In a recent article in the *Journal*[1], an overview of optical-fibre transmission systems in British Telecom's (BT's) network was given and the possible use of such systems for undersea application was outlined.

With their recent signing of contracts for the UK–Belgium No. 5 system, the world's first international repeatered optical-fibre submarine system, and for TAT 8, the first transatlantic optical-fibre submarine system, BT is now in the forefront of the commercial application of such systems.

The UK–Belgium No. 5, due to be installed in 1985, and TAT 8, due to be ready for service in 1988, mark the culmination of the sequence of planning and development work that commenced in 1978. This work was set in motion by the following considerations:

(*a*) the need to provide larger-capacity submarine systems, with reduced circuit costs, in order to remain competitive with new satellite systems;

(*b*) the practical problems associated with using the existing analogue coaxial cable system technology to provide this increased capacity; and

(*c*) the proposed rapid introduction of digital systems into national networks and the consequent need to provide international digital interconnectivity.

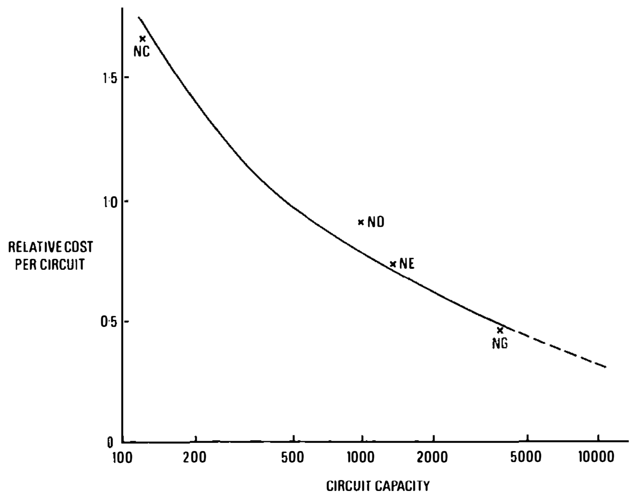
This article outlines the reasoning that has led to the conclusion that long-wavelength singlemode transmission at 1·3 μm would prove a viable and economic solution for submarine system applications. It also reviews some of the major development milestones, such as the Loch Fyne cable trial.

A brief technical description of the UK–Belgium No. 5 and TAT 8 systems is given. It is intended that fuller descriptions will be given in subsequent issues of the *Journal*.

HISTORICAL REVIEW

Since the inception of submarine cables, analogue systems have been designed and installed with increasing capacities commensurate with the increase in traffic. These systems have ranged from those provided in the early-1960s having a capacity of 120 circuits, to those currently available having a capacity of greater than 4000 circuits. This increase in system capacity has brought with it economies of scale, as illustrated in Fig. 1, which shows the resulting reductions in cost/circuit. Along with the benefits of reduced circuit cost, however, have arisen some operational and reliability difficulties.

† International Lines, British Telecom International



Note: NC, ND etc. refer to STC submarine system designations

FIG. 1—Reduction in cost/circuit

Operational Difficulties

As system frequency bandwidths have been increased to provide the required capacity, so a region of higher attenuation in the cable has been exploited. Coaxial cable of increased diameter and hence lower attenuation at the frequencies of interest has been provided in response to this situation and to maximise repeater spacing. There is, however, a limit to the diameter of cable that can be handled safely by the smaller cable repair ships, and this has now been reached with the current generation of coaxial cables. These cables typically have a diameter of 37 mm (1·47 inch) and, when heavily armoured to give protection against trawls and anchors in shallow water, can have an overall diameter of 89 mm (3·52 inch).

Reliability Difficulties

This increase in the diameter of the coaxial cable has not, however, totally compensated for the higher cable attenuation at the frequencies used, and repeater spacings have still been substantially reduced. This is shown in Fig. 2.

A consequence of this decrease in repeater spacings is that, for a given route, more repeaters and hence more repeater electronic components are required. As these numbers increase, the reliability targets become more onerous to meet: currently these are set at no more than three ship repairs due to component failure during the system lifetime of 25 years.

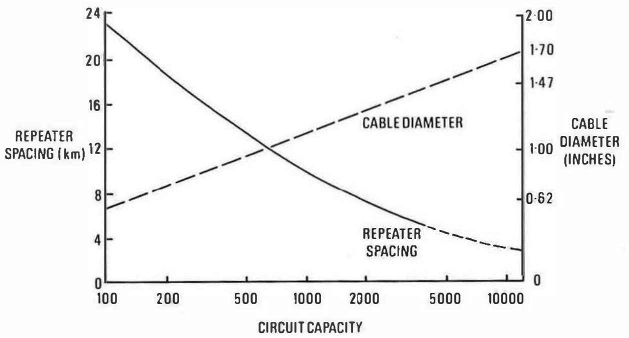


FIG. 2—Relationship between capacity, repeater spacing and cable diameter

Limited Development Potential

By the 1970s, it became apparent that with these operational and reliability constraints the further development potential of analogue coaxial systems was limited. It would not be possible with this technology to significantly increase system capacities and thus reduce cost/circuit to a level commensurate with need. Neither could analogue coaxial system technology provide the transparent digital media required to interconnect the fast growing national digital networks.

With these factors in mind, a search was started to find a replacement technology for use on submarine cable systems.

REPLACEMENT TECHNOLOGIES

To be acceptable, this replacement technology needed to provide the digital media required and a significant price reduction in cost/circuit but to retain the reliability and maintainability of the existing range of analogue coaxial submarine systems. Within British Telecom International (BTI) several alternatives were considered, including both digital coaxial and optical-fibre systems.

Digital coaxial systems, however, either required the use of two separate cables, or a single dual coaxial-cable structure. With the high line frequencies required, large-diameter cables would still be needed and regenerator spacings would be similar, or less than existing analogue systems. Therefore, similar operational and reliability constraints would exist.

At the time the study commenced, optical-fibre systems operating at the 0·85 μm wavelength and using multimode fibre were being developed for applications in the national network.

Studies indicated, however, that for optical-fibre submarine cables to be truly economic, repeater spacings of greater than 30 km with bit-rate capacities of at least 140 Mbit/s would be necessary.

However, this would necessitate the use of singlemode systems to achieve these requirements. At that time the longest laser wavelength was 1·3 μm and the system design was optimised at this wavelength; this technology, whilst barely attainable in the laboratory, appeared to be realisable within the required timescale.

THE OPTICAL WAY FORWARD

The conclusion that singlemode technology would be required for submarine-system applications was reached by BT in joint studies with the only submarine system supplier in the UK, Standard Telephones and Cables plc (STC). At about the same time, a similar conclusion had been reached by other telecommunications administrations and submarine-system suppliers in the world. As a result, an intensive five-year research and development programme was undertaken to transform this technology from laboratory models into commercially viable systems.

Within the UK, the first result of this activity was a combined project by BTI and STC for the laying in Loch Fyne, on the West Coast of Scotland, of a trial cable some 10 km in length containing two singlemode fibres. The following section gives a brief description of this trial.

LOCH FYNE CABLE TRIAL

The Loch Fyne installation was the world's first trial of a submarine cable incorporating optical fibres and commenced in February 1980. The cable was laid by the BTI cableship *CS Iris* to a depth of 100–150 m (see Fig. 3). This loch was chosen because, whilst having water depth and tidal conditions representative of the North Sea, it provided a sheltered location for the trial.

The 10 km length of cable was laid in a loop (see Fig. 4) and included an empty repeater housing. In a subsequent operation in May 1980, this housing was recovered and replaced by a 140 Mbit/s multimode regenerator and the cable relaid.

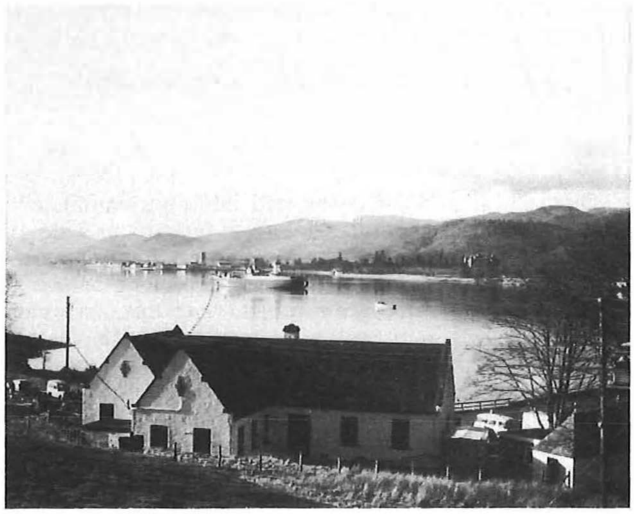


FIG. 3—Loch Fyne optical-fibre cable trial

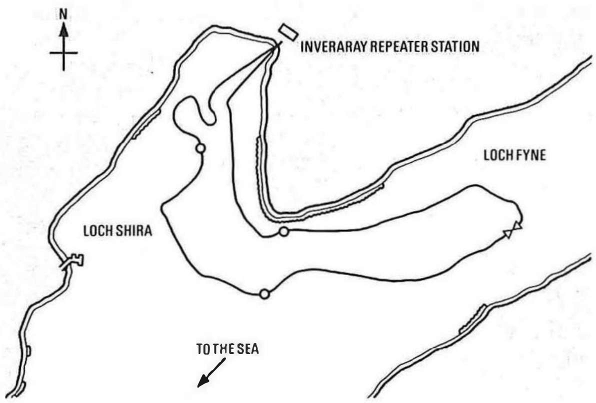


FIG. 4—Route of Loch Fyne optical-fibre cable trial

Cable Design

The cable consists of a central package comprising a nylon-covered steel central strength member around which six optical fibres (four multimode and two singlemode) and two constantan wires to act as a strain gauge, are wound on a very long helical lay (see Fig. 5). This arrangement keeps the fibres as near to the central axis of the cable as possible to minimise the extra strain upon those on the outside when the cable is bent.

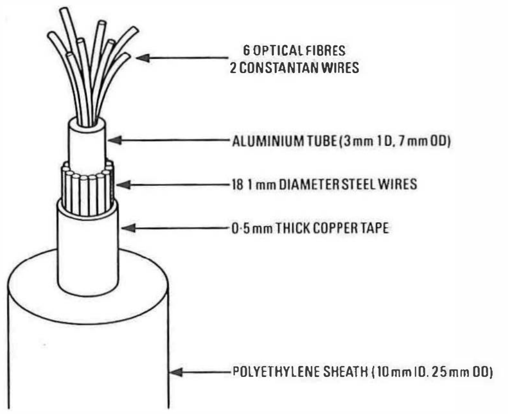


FIG. 5—Loch Fyne optical-fibre submarine cable

This central package is inserted into an aluminium 'C' section, which is then rolled into a tube to provide the required hydrostatic pressure resistance. Around this tube, 18 high-tensile steel wires are wound on a long helical lay to form the major strength member. Over this is a welded copper tube, which lowers the DC resistance of the metallic power feed path and provides a smooth surface on which to extrude the next layer, a layer of polyethylene. The polyethylene serves as a dielectric to insulate the power-feed path from the sea, and to prevent water penetrating the central package.

To protect the cable in the relatively shallow waters of the loch, a single layer of 18 steel armour wires was added. These were bedded on a layer of jute and then overwrapped with jute in the same manner as for analogue cables.

Transmission Measurements

Equipment was provided in the terminal building to monitor the system performance. This equipment included 30-channel pulse-code modulation (PCM) equipment, a data generator and error detector, and a continuous transmission loss monitor. In addition to monitoring continuously the transmission performance of the system, periodic high-accuracy attenuation measurements have been made on both of the singlemode fibres and on one of the multimode fibres. The results of these measurements over the past few years have shown a slight increase in loss. This has been small at the wavelength of interest, 1·3 μm (see Fig. 6), but slightly larger at two other sample wavelengths, 1·2 μm and 1·55 μm. The cause of this change has been identified as molecular hydrogen in proximity to the fibres.

The trial is being continued to monitor both the reliability of the submerged repeater and also the continued stability of the singlemode fibres. This trial represents the longest running measure of fibre stability in a submarine cable environment anywhere in the world.

The results of this cable trial, together with experimental work carried out at BTRL Martlesham Heath have been

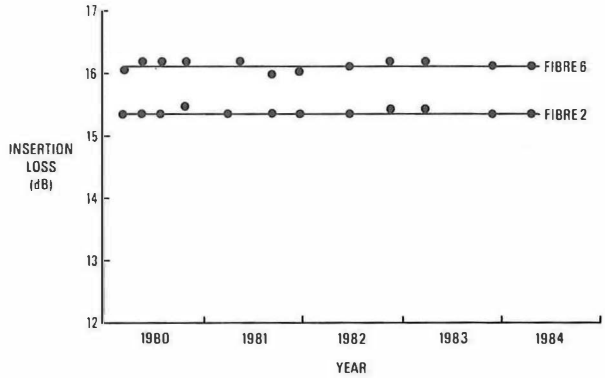


FIG. 6—Attenuation of singlemode optical fibres at 1·3 μm

used by STC to design an improved version of optical-fibre cable for commercial application, the first example of which will be the UK–Belgium No. 5 cable. This design is discussed in more detail below.

Problems with the Loch Fyne Cable Design

The original cable design used for the Loch Fyne cable trial was found to suffer from a number of design limitations:

(*a*) the cable elongated unduly under tensile stress;

(*b*) the results of trials (see Fig. 7) simulating trawl or anchor fouling showed that the fibre package within the cable would suffer unacceptable damage.

(*c*) the cable structure provided insufficient protection against the possibility of hydrogen being absorbed by the fibres and leading to excessive increases in fibre attenuation over the intended lifetime of the system.

Armed with this information, STC were able to carry out a major redesign of the cable. This has resulted in a new

FIG. 7—Cable trials at BTRL Martlesham Heath

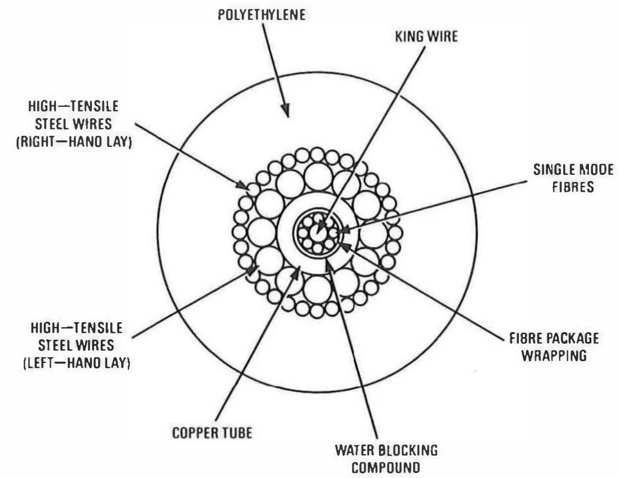


FIG. 8—Cross-section of UK–Belgium No. 5 optical cable

structure (see Fig. 8) which fully satisfies the design objectives and which is being provided for the UK–Belgium No. 5 cable.

Mechanical Improvements to the Loch Fyne Cable Design

The cable has been strengthened by the application of two layers of high-tensile steel wires, with opposite helical lays, around the C section. This change in design also has the beneficial effect of torsionally balancing the cable in its lightweight (that is, unarmoured) form. To reduce the weight of the cable, the welded copper tube applied over the strength member was removed. The resultant cable design, which had an outside diameter of 26·2 mm (approximately 1·0 inch) after the application of the polyethylene insulant, was then considered suitable for deep-water applications up to a depth of 6500 m. For use on the UK–Belgium No. 5, however, where the cable would be laid in water that was intensively fished, and where all the cable could not be protected by being buried, either with the plough designed by BTI (see Fig. 9) or by BTI's *Seadog* (see Fig. 10), it was decided to increase the polyethylene insulant thickness to provide an additional buffer against damage to the fibre package; this results in a cable diameter of 44·5 mm (1·75 inch).

FIG. 9—BTI prototype plough

FIG. 10—BTI *Seadog*

The cable will be armoured throughout. In buried sections, single conventional armour will be used, but where burial is not possible or shifting seabed conditions makes future exposure likely, an additional layer that is wound in a short helical lay (see Fig. 11) and known as *rock armour* will be used.

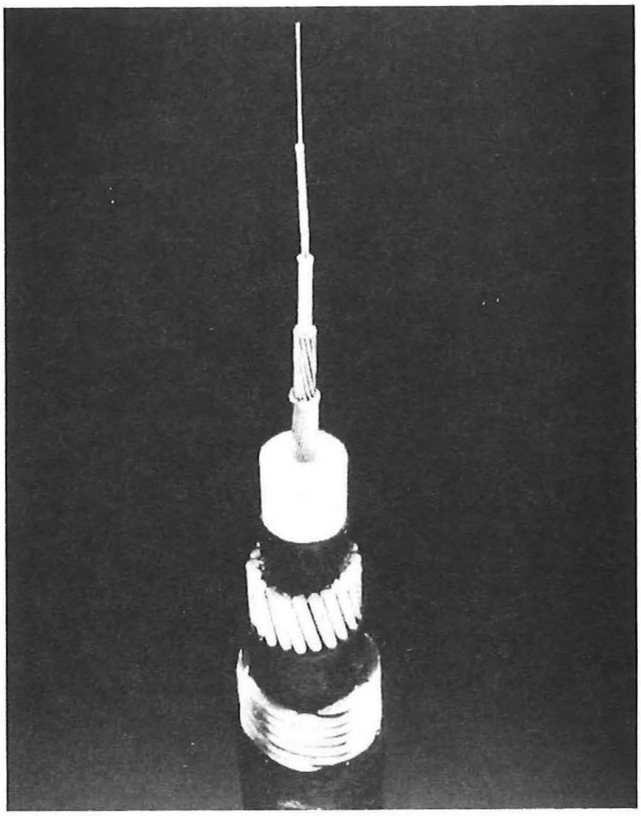


FIG. 11—Rock armour optical-fibre cable

Hydrogen

The presence of hydrogen in the structure of coaxial cables has been known for many years and has manifested itself spectacularly on occasions as a jet of flame as the gas has ignited whilst cutting through a recovered cable. Tests were therefore conducted:

(*a*) to quantify the effect of hydrogen on the fibre transmission loss at the system operating wavelength of 1·3 μm; and

(*b*) to identify the sources of hydrogen within a submarine cable, and the mechanisms by which it may come into contact with the fibres.

The results of this programme of work indicated that the major sources of hydrogen in dry intact cable were the hydrogen being generated on the armour wires and diffusing through the cable structure under the effect of hydrostatic pressure, and the hydrogen evolving from the materials used in the cable structure itself. In addition, if the cable was broken and water entered into the cable structure, hydrogen could be produced as a by-product of galvanic action between the different metallic materials used in the cable. From this programme, methods which could be applied to the structure of the cable to prevent hydrogen contaminating the fibres were developed, and these are described below.

Solutions to the Hydrogen Problem

Two further modifications have been introduced into the cable structure to try to overcome these problems. Firstly, it was decided that a barrier to hydrogen as close as possible to the fibre package would be required. It was found that copper was an excellent barrier and, therefore, the aluminium C-section pressure vessel has been replaced by one made of copper. To ensure a good seal, a welded longitudinal copper tape is applied directly over the copper C section.

Secondly, to prevent water ingress, the package and the steel strength members surrounding the C section have been continuously water blocked. Computer simulations carried out at BTRL have shown that for the UK–Belgium No. 5 cable, even under the worst-case conditions, the partial pressure of hydrogen adjacent to the fibre should be well within the safe margin to ensure a 25 year system life.

For future system requirements, the precautions outlined above may not be necessary. Work at BTRL[2] has indicated that fibre coatings such as silicon oxy-nitride may prevent hydrogen affecting the loss stability of fibres.

UK–BELGIUM No. 5 CABLE

After the success of the Loch Fyne cable trial, attention turned to identifying commercial applications. Several alternative routes seemed possible, but, eventually, the route to Belgium was chosen. After consultation between partner administrations (BT, the Belgium RTT, the Deutsche Bundespost and the Netherlands PTT), it was agreed to construct the system for completion in 1985 and a contract was placed with STC in December 1983. Since this would be the fifth submarine cable linking the two countries, it was entitled *UK–Belgium No. 5*.

The cable, approximately 113 km in length, is to be terminated at Broadstairs in the UK and at Ostend in Belgium. It provides six CCITT† 140 Mbit/s digital line sections over three pairs of fibre each operating at an information bit rate of 280 Mbit/s. The total capacity of the cable will, therefore, be 11 520 × 64 kbit/s digital paths. Three repeaters, spaced at approximately 40 km intervals, are required to house the submerged regenerators for the three fibre pairs.

† CCITT—International Telegraph and Telephone Consultative Committee

System Details

A 7B/8B line code has been adopted for each fibre-pair based system, and this increases the line bit rate to 325 Mbaud. The additional bits provided by the line code help maintain timing over each system and enable supervisory and speaker channel facilities to be provided.

The supervisory facilities provided in the submerged regenerators include:

(*a*) the electrical loopback of the transmission path,
(*b*) the measurement of the laser bias current, and
(*c*) the measurement of received light level.

The system not only has to operate at the high bit rates outlined above, but also has to meet the reliability criteria required for submarine cable systems. These considerations have required new families of components to be developed. The most important of which are outlined in summary below.

Integrated Circuits

For the main electrical functions of the regenerator a new generation of integrated circuits (ICs) using emitter-coupled logic (ECL) has been developed by BTRL under subcontract to STC. These devices, known as *ECL40* ICs, are based on the most recent of the discrete n p n silicon planar transistors, the type-40 family[3], used in analogue submarine repeaters. Features of the type 40 such as titanium-gold metallisation, which are crucial to its reliability, have been carried over into the IC design.

This design of IC enables all the digital regeneration and repeater supervisory functions to be provided by using just a few ICs.

Optical Transmitter

A semiconductor laser has been chosen as the transmitter for the system. The high output powers for low drive current characteristics of these devices make them very attractive for this application.

The device chosen by STC is an inverted rib waveguide (IRW) InP/GaInAsP laser[4], which provides a narrow output spectrum with a wide modulation bandwidth. This form of semiconductor laser uses a GaInAsP active layer on an InP substrate. The IRW construction of the device helps to produce singlemode operation with an output power of around −3 dBm.

Optical Receivers

The chosen optical receiver is of a PINFET design. The GaInAs PIN photodiode, which converts the optical signals into electrical signals, is incorporated into a package with a GaAs field-effect transistor (FET), which provides the first stage of amplification. This design results in a sensitivity of around −34 dBm.

TAT 8

The first long-haul optical-fibre submarine system in which BTI is a co-owner will be TAT 8, the eighth transatlantic telephone submarine cable and the first to use optical fibres. The system will be over 6000 km in length and use over 100 repeaters. Its information bit rate will be 280 Mbit/s per fibre pair and the operating wavelength will be 1·3 μm with repeaters spaced at about 50 km intervals. The system will be unique in two aspects. Firstly, it will be branched at a submerged branching unit where the two fibre pairs in the cable from Tuckerton in the USA are divided, one fibre pair going to Widemouth in the UK, and the other to Penmarch

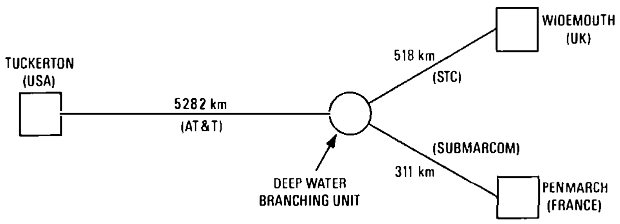


FIG. 12—TAT 8 configuration

in France (see Fig. 12). Secondly, the system will be manufactured jointly by AT&T, STC and Submarcom, with each manufacturer being responsible for supplying equipment up to the branching unit. This necessitates that each manufacturers' system design needs to be sufficiently common in the following areas to allow full interworking; namely, wavelength of operation, fibre parameters, bit rate, line code, power-feed line current, supervisory telemetry etc.

Redundant components and redundant fibre paths are incorporated in the system. The level of redundancy varies from one segment to another; for example, the USA-to-branching unit segment incorporates redundant lasers and redundant fibre paths, whereas the branching unit-to-UK segment incorporates redundant lasers only. The supervisory facilities provided differ in detail from one segment to another but generally include electrical loopback of the transmission path, measurement of laser bias, margin assessment and redundant path/component selection. The system is scheduled to be complete by mid-1988.

THE FUTURE

It will still be some time before the first international optical-fibre submarine cable carries traffic. However, such is the pace of new technology that further generations of optical systems are already under consideration. Probably the first change will be of the operating wavelength, from 1·3 μm as used on the first generation systems to 1·55 μm so as to exploit the lower fibre attenuation at this longer wavelength which is around half its value at 1·3 μm (see Fig. 13).

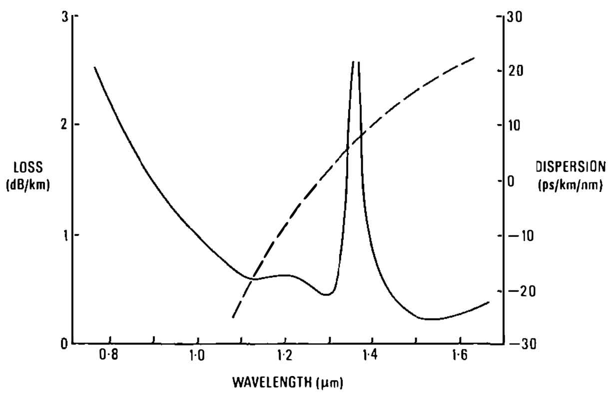


FIG. 13—Attenuation and dispersion of singlemode optical fibre

This reduced fibre attenuation will enable longer repeater spacings to be used and therefore reductions in system costs to be achieved. Advances in both fibre and laser technology are making this shift realisable in the near future, possibly around the early-1990s. Dispersion is, however, still a major problem to be overcome, either by using a truly single-line laser, or by utilising special fibre with very low dispersion at 1·55 μm. Both of these items have already been produced at BTRL Martlesham Heath[5, 6].

Developments in very high speed integrated circuitry will enable future systems to operate at higher transmission bit rates; for example, 565 Mbit/s or greater. This means that each fibre pair could have a capacity of about 8000 × 64 kbit/s digital paths. This could lead to cost savings on high-capacity routes by reducing the quantity of fibre and number of regenerators required in a system.

Another area of change will be the introduction of unregenerated systems on short-haul submarine cable routes. Current technology at 1·3 μm wavelength can provide a 75 km 140 Mbit/s unregenerated system, but future advances by using the 1·55 μm wavelength could more than double this figure. The potential cost savings will not be great, but the operational advantages are quite considerable. The most significant of these arises from the ability to increase the bit rate on the system and hence increase its capacity solely by the provision of different equipment at the terminals.

In order to extend this type of system further, feasibility studies into laser amplifiers are underway at BTRL. These devices amplify light directly without the need for conversion to electrical signals. Thus, an optical repeater using these devices would be considerably simpler than conventional regenerators and more flexible as it would still accept any bit rate.

Laser amplifiers could also be suitable for use in a system employing wavelength division multiplexing (WDM). This is a technique by which several digital line systems operate over a single fibre, each using a slightly different operating wavelength. The narrow line-width lasers required for such a system have already been produced at BTRL, and the wavelength multiplexers may be available within a few years. This method of transmission will drastically increase the transmission capability of a single-fibre pair, and is attractive in the short term for use over an unrepeatered system.

Research is also underway into coherent detection. Briefly, this technique involves optically mixing the incoming low-level optical signal with a reference signal to produce enhanced receiver sensitivity. Its complexity, however, may limit its use to unrepeatered systems and enable systems up to 250–300 km to be provided, although laser amplifiers may be able to extend this range further.

In the more distant future, there could be the implementation of a new form of optical fibre based on fluoride glass rather than, as currently, on silica glass. At wavelengths around 2·6 μm, fibre losses could be one fifth of their current value.

These are just some of the possibilities for the future of submarine optical transmission. There are considerable opportunities for increased capacity and reduced cost in what already appears to be a highly competitive media.

CONCLUSION

This article has outlined the future of optical-fibre submarine cable systems. In the short term these will be based on 1·3 μm wavelength technology, but it is expected that, by the early-1990s, technology will enable the 1·55 μm wavelength to be used, and thereby enable considerable economic advantages to be attained. The longer-wavelength technology will allow long unrepeatered systems to be provided, and these will bring considerable operational advantages. It is expected that optical-fibre technology will bring economic benefits that will enable submarine cable systems to maintain, if not increase, their share of the international communications market.

ACKNOWLEDGEMENTS

The authors would like to thank the Technical Director, Cable and Microwave Division, BTI, for permission to publish this paper and for his editorial assistance.

Biographies

John Horne joined BT as a Technical Apprentice in 1964. He has been working in the field of submarine cable systems since 1969, and as Head of System Engineering Design Group with specific responsibilities for optical submarine cable systems within BTI since 1981. He obtained a Diploma in Management Studies at Middlesex Polytechnic in 1981.

Keith Langridge gained an honours degree in Physics from the Imperial College of Science and Technology, London University, in 1982. He then joined the Cable and Microwave Division of BTI as an Assistant Executive Engineer and has since been working in the Systems Engineering and Design Group on optical-fibre submarine cables.

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Book Reviews

Telecommunications in the Information Age. Loy A. Singleton. Harper and Row Ltd. viii+239 pp. 2 ills. £13·50.

Professor Singleton entertains a somewhat idiosyncratic interpretation of the word 'telecommunications'. He claims he is using the original meaning of 'communicating at a distance' but then goes on to apply that definition to videodiscs, cassette recorders and other consumer products. So it might come as a surprise to readers of the *Journal* to find that a book flagging the word 'Telecommunications' in its title makes no reference whatsoever to coaxial cable, microwave radio, optical fibres, electronic switching or, indeed, to telephony or Telex.

Professor Singleton's aim is to dive straight into modern developments such as cable television or direct broadcasting satellites without wasting much time or effort on their predecessors.

Each chapter is devoted to a subject of highly topical interest. Thus the book gives us cable television, subscription television, the multipoint distribution service, communications satellites (the only reference to an elderly technology), direct broadcasting from satellites, satellite master antenna television, high-definition television, videotext, teletext, video cassette recorders (VCRs), videodiscs, personal computers and business networks. Each topic is treated in the same way: the chapter commences with 'Background' (how was it developed and when); then comes 'How it Works' (a non-technical description of its functions); 'Applications' (examples of use in real life); and, finally, 'Forecast' (future developments, including legal and social as well as technical issues).

The aim of describing some fairly complex modern technologies in non-technical terms presents the author, as one might imagine, with some problems. Here he is, for instance, in the 'How it Works' section on Videorecorders: 'The simple controls and ease of operation of a home VCR are made possible by an interior packed with printed-circuit boards and sophisticated miniature electronic components.'

Readers are advised not to use this answer when answering examination or promotion-board questions.

The author has probably hindered rather than helped himself by imposing this rigid format on every subject under review. There is really very little point in struggling to describe in non-technical language how, say, videotext works if the reader does not already know how a television receiver works.

The publisher's sleeve notes describe this book as 'the consumer report for both the specialist and general enthusiast'. It is difficult to sustain this claim for the specialist reader. However, the book could well be useful to the inquisitive intelligent layman who wants to keep track in his mind of the bewildering range of technologies and services that are showering down upon him.

D. WRAY

Power Supply Systems in Communications Engineering: Part 1, Principles. Hans Gumhalter. John Wiley and Sons Ltd. 230 pp. 201 ills. £21·50.

It is unusual to find a complete book devoted to the topic of power supplies for communications and, for this reason alone, it is a welcome addition to currently available technical books. The book is an interesting presentation of material dealing with the principles of power system design; however, it appears to lean heavily on the practices of the West German system (hardly surprising of course in view of its origin), and hence cannot necessarily be aligned to UK or British Telecom systems. In particular, the reader should note that the section on public supplies does not wholly apply to this country.

The opening chapters consider the various options for AC and DC power systems in schematic form and are clear and readily understandable; but the AC section is a rather superficial presentation. Some of the material on power filters, and the effects of power converters on the waveform of AC supplies, is particularly well set out, and the graphical diagrams are useful in clarifying a complex subject. Batteries are touched on, but the chapter is short and covers only limited ground.

The latter half of the book deals with basic circuits and components. These are related to power plant and, for instance, define techniques for using and controlling thyristors in applications as power rectifiers, and touch on the topic of switched-mode power supplies.

This book will be useful to students seeking information on the subject of power supplies related to telecommunications plant. There is a reasonably comprehensive bibliograhy and listing of standards and specifications, but the former are virtually all German in origin, and the latter are VDE or DIN standards, and this orientation must constitute a disadvantage for a book presumably aimed at an international audience.

This volume is to be supplemented by a second part which is to be issued later and which is claimed will give more detail on power supply equipment, and issues such as earthing and protection systems.

C. R. NIGHTINGALE

The Integrated Services Local Network

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The possible integration of speech, data and video so that they are carried by one transmission medium and switched in one switch could lead to exciting possibilities in the field of office automation. Current electronic office communications, however, are split into two distinct camps. The circuit-switched approach employed by the PABX is well suited to carrying voice but is inefficient and awkward when used for data communications. The packetised, virtual-circuit approach used by local area networks (LANs) is ideal for switching the majority of data but the delay characteristics of this method of transmission may make it unattractive for carrying voice traffic. The development of the integrated services local network (ISLN) involves solving the many problems resulting from the marrying of these dissimilar services and is currently at an embryonic stage. This article does not suggest a design for an ISLN, but examines the problems that must be solved before a complete system can be designed. This article is based on a paper that appeared in British Telecom Technology Journal.*

INTRODUCTION

The idea of an integrated services local network (ISLN) was first seriously considered some 5–10 years ago when designers started to look at the services that would be required in the 'office of the future'. They realised that rather than developing individual services (for example, data, voice, facsimile, etc.) a more integrated approach was needed whereby the different services were combined to give the user of an advanced workstation the information he wanted in the best possible form. Examples of such services would be voice-annotated text or video with overlayed data.

Some very small-scale research was done to assess the magnitude of the task that would confront the designers of the ISLN, and some exploratory work on isolated technical matters such as methods of providing the basic bearer service. The results from these smaller studies are now giving the designers the confidence to set about developing a complete system.

In April 1982, the Local Area Network Standardisation Project Team reported its proposals for UK developments concerning ISLNs[1] to the Government's FOCUS committee. The Project Team commented that '. .there is a growing convergence of the application of many types of traffic including voice, graphics, image and video in addition to data and text. . . . As this convergence continues, integrated workstations will be developed to avoid the need for multiple workstations on each desk. Within 3–5 years an integrated communication service or Integrated Services Local Network (ISLN) will be highly desirable'.

It was realised that this was a long-term solution, though, and a short-term answer was the close connection of a local area network (LAN) and a PABX. This interconnection, however, would not provide the true integration of the services that was required. The report recommended that the Government's Department of Trade and Industry part sponsor a 130 manyears and £5·7M project to develop a UK ISLN.

This report came at a time when commercial interest in ISLNs had been growing steadily over the previous 5 years. Several Japanese companies had presented papers[2] on high-speed LANs, usually running at a transmission speed of 30–50 Mbit/s on optical-fibre cable, and some field trial systems had been installed. In America, the American National Standards Institute (ANSI) had started work in late 1982 to produce a standard for an ISLN[3]. The work closely matched that done in the IEEE‡ Project 802.5 (Token Ring) LAN standardisation group, with some modifications to the protocol to make it more suitable for high-speed work. The standard, however, was to specify only the medium-access technique and physical layer.

The need for an ISLN has now been proven and exploratory work has shown that the technology is available to develop a commercial system. The studies that have been done over the past 10 years have revealed the enormity of any such project and have given some insight into the problems that remain to be solved. This article examines the problems and choices that confront the designer of the ISLN.

CENTRALISED OR DISTRIBUTED SWITCHING

The first aim of the ISLN will be to combine the two forms of office communication used at present: voice and data. These two forms of traffic are currently being switched in very different ways.

The voice traffic is switched by a PABX, using a centralised switch concentrated in one or two cabinets. This switch is capable of switching bit streams of predefined speeds, which are usually equal to, but sometimes greater than, the 64 kbit/s necessary for voice communication. Once a path has been established through the switch, it remains there for the duration of the call regardless of whether information is passing over the circuit or not.

The LAN, which is coming to the fore in data switching, uses a distributed switch. This distributed switch takes the form of a shared or common medium—for example, a piece of coaxial cable—onto which messages are broadcast to other stations in a manner directly analogous to radio communication, in which the shared medium is the air waves. Because the medium is shared, some form of protocol must be employed to ensure that only one station is transmitting onto the medium at any one instant. Whether this protocol allows the station to try and use the medium whenever it wants and then provides rules for the resolution of any contention that may occur, or whether it provides some form of scheduling of access, a station cannot guarantee that it will be able to transmit a message at a given time. Usually an upper bound on the delay can be established, although this may be a function of the volume of traffic on the system at that instant.

† System Evolution and Standards Department, British Telecom Development and Procurement

* WATSON, I. The Integrated Services Local Network, *Br. Telecom Technol. J.*, Sept. 1984, **2**(4), p. 26.

‡ IEEE—Institute of Electrical and Electronics Engineers Inc.

The bandwidth requirements of the services to be carried on the ISLN vary significantly, and consequently designers have considered a variable-bandwidth switch to be desirable in the ISLN. The switching techniques used by current-generation LANs provide such a switch, and so the major effort in development of the ISLN has started from the LAN ideas. At present, this approach seems to be the best and this article takes the same approach. This does not imply that an ISLN may not be developed using a mode of switching related more closely to that of the PABX.

REQUIREMENTS

Questions such as what services the ISLN should aim to provide, what volume of traffic should be expected, what the mix of traffic between the various services should be and what size(s) of network the customer wants can be answered only by detailed market research; this aspect of the development has been largely ignored until now as developers have worked to ensure that the basic idea of an ISLN was technically feasible.

The requirements of the ISLN can be considered in a similar light. Firstly, the ISLN will have to provide the necessary basic communication services and then satisfy the users' secondary requirements for enhanced facilities.

Basic Communication

Many of the facilities that the ISLN will be capable of providing will be new to the user, and the traffic patterns on implementations of the ISLN will change as users become accustomed to its possibilities. Perhaps the most important requirement of the ISLN will be its flexibility. This is the hardest requirement to meet, as the designers will have to make the basic ISLN design flexible enough to accommodate services not yet thought of. This has serious implications for the architecture of the system.

Although many of the facilities that the ISLN will be capable of providing have not been implemented on existing alternative systems, and some facilities have not even been considered yet, it is unlikely that these new facilities will be more than an expansion or integration of the basic video, voice and data services. To allow for these as yet undeveloped facilities, the designer must create a flexible system in which each of the basic services, either alone or in combination with other services, can be used efficiently to provide enhanced facilities. The correct implementation of the three basic services is therefore fundamental to the whole system, and so the requirements of these services need to be examined in some detail.

Voice

Of the two basic services, voice and data, already used in the office, the voice service is the more demanding in its requirements and by far the more prevalent. The user will have to be able to speak to another party, either directly connected to the ISLN or on the public switched telephone network (PSTN), across a normal speech-grade circuit. But what should the interface to this circuit be? A normal digital speech path, as provided by a current PABX, say, provides a 64 bit/s synchronous connection. Is this what the user wants?

It would be possible to use a 32 or 16 kbit/s circuit to provide the required speech quality, but the performance may be such that other services which currently use the analogue PSTN (for instance modems and group II facsimile machines) would not operate over this path. The ISLN would be less attractive if, while offering advanced new features, it could not support the large number of devices apart from the telephone which currently use the PSTN.

British Telecom Research Laboratories (BTRL) has been involved in investigating the subjective quality of voice traffic which has suffered from the loss and/or delay of speech samples[4]. Such degradations of the speech path are possible as a consequence of the method of providing the variable-bit-rate switch described above. When the system is under heavy load, a station may not be able to transmit a voice sample to its destination when it wants. The transmitting station may have to wait a significant amount of time, perhaps of the order of milliseconds, before it is able to transmit. The voice sample's arrival at the destination may therefore be delayed. By using a buffer, this delay, which may well vary for different samples as the instantaneous system load varies, can be evened out, but there is still a possibility that, to maintain the synchronism of the speech path (an overriding consideration), the receiving station will have to make a substitution for a delayed speech sample.

The work done by BTRL was based on the delay performance results from the simulation of a 20 Mbit/s token-passing ring carrying 102 simultaneous conversations. These results suggested that, under peak load and with a 1 ms buffering delay, the probability of losing one sample was 1 in 1000 and the probability of losing two consecutive samples was 1 in 100 000. The subjective tests simulated such loss rates on an ISLN with a 6 ms cross-network delay and tested three methods of substituting lost samples. The first method substituted a null sample for the lost one, the second method substituted the previous sample divided by two for the lost sample and the third method repeated the previous sample.

The results from the tests showed that a loss rate of 1 in 16 was acceptable to the listener and was just discernible from a loss rate of 1 in 1000. Surprisingly, even at a loss rate of 1 in 2 the conversation was intelligible, although of a very poor quality. The difference in the effects of the various substitution techniques was apparent only at the highest error rate. The results gained at this extreme error rate may not be valid under normal conditions. The loss of samples was noticeable only when conversation was taking place, loss during periods of silence being undetectable. The noise induced by these losses was described by the subjects of the test as fuzzy or metallic and quite unlike the clicks and bangs caused by bit errors in conventional line systems (as opposed to the sample errors in this system).

These results present the designer of the ISLN with another choice. At periods of high usage of the system when the volume of traffic is beginning to cause sample loss, should the designer prohibit the establishment of further calls, and thus maintain the quality of those already in progress, or allow unrestricted access and accept the resultant reduction in quality?

These studies have been based on standard 64 kbit/s pulse-code modulation (PCM) encoded speech; it must be bourne in mind that this is not the only encoding technique or the only transmission speed that can be used for voice traffic.

Data

The data requirements will probably be the most varied of the services carried, although paradoxically the easiest to accommodate. Speeds can range from a teletype working at 110 bit/s to a disc-to-CPU highway operating at 9·6 Mbit/s. The service could be synchronous or asynchronous. Data has the advantage, however, that it can be carried by using an error-protecting protocol, which will correct errors and disturbances induced in the data stream by the ISLN. Thus the ISLN can afford to 'lose' packets of data or delay them to allow more critical traffic access to the system, knowing that errors so induced will be corrected.

Video

The most demanding service to be carried will be video. The high bandwidth and synchronous nature of this service will put stringent requirements on the bearer service.

The use of video in offices has been discussed for some time, but its role is still uncertain. Certainly, videoconferencing is becoming accepted now that it is more readily accessible, and the advent of video recorders and laser discs has had a large impact on job training. But where will video fit into the everyday operation of the office? Will the ISLN make the use of the videophone feasible?

It may be some decades before the office requirement for video appears, but in industry the need will arise much sooner. Video monitoring is essential to the safe and efficient operation of large industrial processes. Advances in computer pattern-recognition techniques mean that video monitoring of processes will increase as computers are developed to process visual input. The integration of visual sensing with conventional computer control is an area in which the ISLN has a large role to play.

The problems related to the use of video circuits across an ISLN have not been studied in any great detail. The work done on developing and standardising compression techniques will have great impact on the use of video on the ISLN. Current compression techniques such as the COST 211† codec[5] require synchronous channels of at least 1·544 MHz. The subjective effects of errors in the bit stream have not been studied in any great depth, but current thoughts are that an error rate worse than 1 in 1 000 000 would require that some form of forward error correction be used. More advanced coding techniques are being developed which, as well as permitting lower transmission rates to be used, will diminish the subjective effects of errors. The development of techniques to allow 768 kbit/s and even 384 kbit/s transmission paths to be used is currently underway, and such developments must be taken into consideration by the ISLN designer.

The lower the transmission bandwidth required for a video channel and therefore the more complex the encoding technique, the longer the delay necessary to allow the compression and decompression of the signal. This processing delay when added to the delay induced by the ISLN may cause subjective degradation of the service and is another aspect of the development that needs to be considered.

Additional Requirements

As well as being able to carry these basic services, the ISLN must satisfy some other criteria, basic to the needs of all ISLNs.

Reliability

One problem that results from all the communications of one organisation being carried on one system is reliability. The ISLN as a whole must be secure. No communications manager would survive long in his job if one cable break or equipment failure meant his organisation lost all internal and external communications. This need for reliability and the methods of achieving it also have a great bearing on the system's architecture.

British Telecom (BT) has been involved in producing reliable systems for use in telephone exchanges for many years, and the experience gained in this field has been applied in preliminary studies of the reliability of various network topologies. These results are detailed further in this article in the section on topologies and access protocols.

Expansion and Installation Cost

Although the ISLN may well surpass the PABX as far as performance and provision of enhanced facilities goes, it will not sell if the user does not consider its facilities and performance to be worth the price charged. At the most basic level, the ISLN must be competitive with the PABX on the price per telephone connection. Not only must this be the case for initial network installation, but also for future system expansion. The novel design of the ISLN may mean that different techniques from those used with current PABXs will be available to expand the capacity of the ISLN, but this expansion will still have to be compared with the cost of expanding a PABX and/or LAN.

† COST 211 is a project of the committee for European Co-operation in Scientific and Technical Research

TOPOLOGIES AND ACCESS PROTOCOLS

Node Interconnection

The topology of the ISLN has a serious impact on its performance, cost, expandability and reliability. The choice of media-access technique and type of physical connection between nodes on the system is closely related to the choice of topology. The three main contenders for choice of topology are the bus, the star and the ring, and these are treated in detail below.

The Bus

The bus was the first topology to be used with any degree of commercial success. The Ethernet† system and its standardised version, the IEEE 802.3[6] system, both use a length of coaxial cable as their medium. The use of coaxial cable in this mode has presented the designers with several problems relating to the earthing of equipment for technical and safety reasons, and these have resulted in installation difficulties. The bus system, unless duplicated and the duplicate diversely routed, is also vulnerable to cable breakage. The cable must be very finely balanced and terminated to avoid electrical reflections, and a cut taken at random in the cable is almost certain to leave two electrically unbalanced halves. This electrical imbalance means that no two stations can communicate with each other and that the system is unusable until the cable break is located and repaired.

Only two protocols for accessing a bus system have been developed: the CSMA/CD* system and the token-passing bus system. Neither of these is suited to the high speeds and traffic restraints of the ISLN.

The CSMA/CD system is non-deterministic and no upper bound on the time a station must wait to access the medium can be given. Because the propagation delay along the cable is constant, various critical times in the protocol remain constant and do not scale with frequency. As the transmission rate of the system is increased therefore, these times become more significant and cause the throughput of the system to drop markedly.

The token-passing protocol[7] is deterministic, but the use of a logical ring on a physical bus requires complicated token and network management protocols. The protocol is attractive for use in the ISLN because of the incorporation of a priority system, which could be used to give the more demanding services better access to the system than the less demanding.

The bus topology is not as flexible as others and the protocols developed for it do not scale well with frequency. Consequently, little work has been done on using the bus in an ISLN development, and its use in a commercial ISLN development seems very unlikely.

The Star

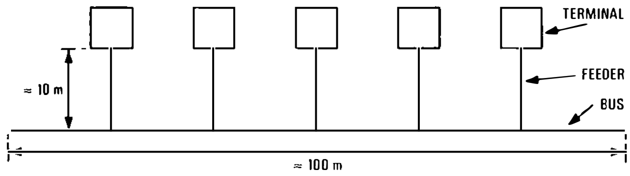
The star topology is already widely in use in the PABX field. The reliability of the topology is relatively good, as a cable break affects only one node. Duplication of the central switch gives protection against equipment failure. The concentration of the switching equipment in one area greatly facilitates network management functions such as fault location and

† Ethernet is a trademark of the Xerox Corporation

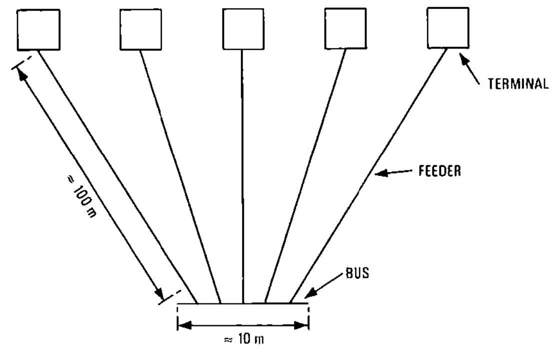
* CSMA/CD—Carrier sense multiple access with collision detection

isolation. There are two main drawbacks to the topology. Firstly, the geographical centralisation of the switch results in large amounts of wiring between the nodes and the switch. Secondly, the topology seems to require a central switch of the type used in a PABX, and a variable-bit-rate version of such a switch does not exist.

The second drawback mentioned above, however, can be solved by using a switch that is different from those currently used in PABXs. All the possible systems employ a central shared medium with feeders onto it from the nodes. As these feeders increase in length, the systems begin to look more like star topologies (Fig. 1). It can be seen that all these



(*a*) Conventional bus topology



(*b*) The bus as the star 'point'

FIG. 1—The bus and star topologies

systems are essentially stars and that the switching methods could be employed in the central switch of the star topology.

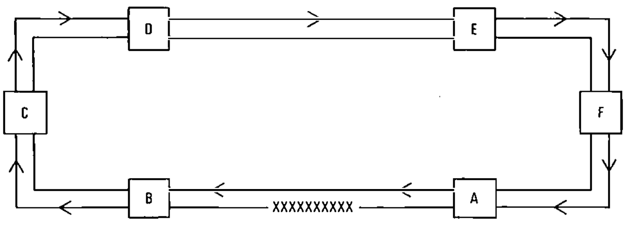
The star topology thus appears to have one main advantage, that of easier network management because of the geographical concentration of the switch; and one main disadvantage, that of the lengths of cable necessary to access this central switch from the extremities of the system.

The Ring

By far the most popular topology for ISLN investigations has been the ring. Several suitable media-access techniques have been developed for this topology, and these are examined in greater detail below. Perhaps the most useful feature of the ring, though, is that the inter-node connections can be made resilient to errors. BT has carried out studies on various techniques for making rings secure[8]. The four principal methods are as follows:

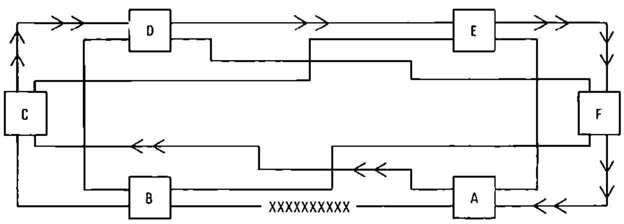
(*a*) *The Double Ring* (See Fig. 2(*a*).) Two cables exist between one station and the next. Should one break, the downstream station realises the lack of meaningful input that results and sets off a chain of events that leads to the upstream station switching transmission to the second cable, thus bypassing the break. Ideally the cable should be routed between the two stations in different ducts.

(*b*) *The Braided Ring* (See Fig. 2(*b*).) Each station has two or more cables on which it can transmit. The first cable goes to the downstream station, the second to the station



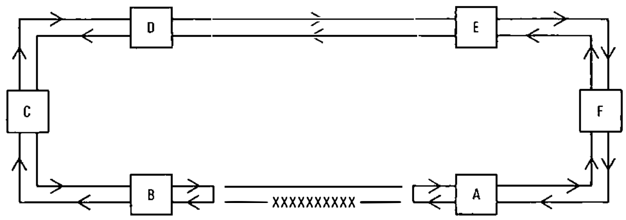
Note: Station A is transmitting to station B on the inner ring because of a break in the main outer ring

(*a*) The double ring



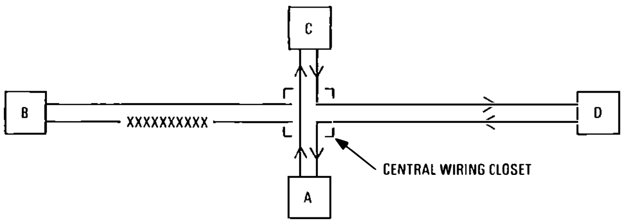
Note: Station A is transmitting to station C on its second braid because of a break in its primary braid, and thus is bypassing station B

(*b*) The braided ring



Note: Stations A and B have 'looped back' to avoid the cable break between them

(*c*)The loop-back ring



Note: Station A is transmitting direct to station C, and avoiding the cable break on the feeder to station B

(*d*) The star-connected ring

FIG. 2—The four principal methods of making rings secure

downstream from that and so on. Should a cable break or a station fault be detected, the fault can be bypassed by switching from one output to the next.

(*c*) *The Loop-Back Ring* (See Fig. 2(*c*).) A double ring is used with traffic flow being opposite in the two rings. When a fault is discovered, the two stations either side of the fault each join the two rings together, making one longer, but continuous, ring which does not include the fault. It should be noted that, with this technique, diverse routeing of the two rings is not necessary, as with the other techniques, because this method can tolerate a break (in the same section) of both rings.

(*d*) *The Star-Connected Ring* (See Fig. 2(*d*).) The ring is formed into a series of 'petals', with the stations at the points of the petals. In the event of a cable break in one of the petals or a station failure, the petal containing the fault can be bypassed at the central point.

These reliability features and the suitability of the media-access techniques associated with rings have made this the currently preferred topology for the ISLN.

The Multi-Ring

The cost of interfacing to the ISLN is roughly proportional to the transmission rate on the shared medium. One possible method of reducing this transmission rate would be to connect together several smaller, slower rings in a mesh. If the exact topology were adapted to the prevalent traffic patterns so that the users of the system were grouped together and the majority of traffic was intra-group rather than inter-group, then the transmission rate on the smaller rings could be a fraction of that on the one larger ring necessary to carry the traffic.

The problems with this architecture are the need for accurate traffic forecasting, the complexities of inter-ring traffic routeing and the difficulties of system expansion. Such systems are being considered for slow-speed data-only LANs, where the savings accrued by not passing the cost breakpoint that exists at about 5 Mbit/s pay for the increased complexity. They are not viable for the ISLN, because the relevant cost breakpoints will be passed on each individual ring in the multi-ring system.

Terminal Connection

The policy to be employed for the connecting of terminals to the ISLN also affects the overall topology. The shared medium will be operating at high speeds and consequently the hardware to access it will be expensive. High-speed devices which are relatively expensive in their own right may justify a direct connection onto the medium, but simpler and cheaper devices, such as the telephone or visual display unit, may prove too expensive if the overhead of a direct connection has to be charged for as well. One solution to this problem would be to connect terminals to the ISLN through multiplexers, but this would suffer from the problems associated with star topologies.

The decisions made regarding terminal connection are very important, as the cost and flexibility of the commercial system are heavily dependent on them.

MEDIA-ACCESS TECHNIQUES

The majority of research done on ISLN-related topics to date has been aimed at developing the 'best' media-access technique. The choice of media-access technique is a very important one, but no more so than some of the others detailed in this article.

Several media-access techniques are available for the currently popular ring topology, including register insertion, the slotted ring and token passing. These and other techniques have been well documented elsewhere[9], and their performance analysed many times (frequently with differing results). It is worthwhile reviewing some of their qualities here.

Register Insertion

The advantage of the register insertion technique is that a station can transmit a message at almost any time. This is achieved by inserting a register containing the message into the ring and removing the register when the message has circulated back to the transmitting station.

The system has two drawbacks however. Firstly, although access to the ring for a message is not delayed, the time taken to traverse the ring depends on the number of other stations that have registers inserted in the ring. The delay induced by the ring is therefore random, and this causes problems for a system trying to provide synchronous transmission. Secondly, the technique has had very little commercial support. Limited numbers of conventional LANs using this technique have been produced and the theoretical studies done on its performance have not encouraged work into the problems of implementing it.

The Slotted Ring

Several varieties of slotted ring varying in complexity and bandwidth utilisation have been proposed. The physical ring, owing to the finite velocity of electromagnetic radiation, can contain several packets of information along its length, giving it the appearance of a shift register.

One advantage of the slotted ring can be demonstrated by considering a ring containing two slots and two stations on geographically opposite sides of the ring. As the *start* bits of the slots pass the two stations, they can start filling them. This gives an instantaneous information rate of twice the ring line rate. If a conventional Cambridge Ring is used, however, the ring would be carrying no information for the period during which the slots were returning from their destinations to their sources. Techniques have been developed[9, 10] which will allow the reuse of these returning slots, and extensions on this can mean that a ring can be carrying an information rate many times its line rate.

The delay performance of the slotted ring can also be well controlled by using a suitable management protocol, and this media-access technique appears to be the best technical choice.

Token Passing

The token-passing protocols (again there are a few variants) cannot offer the enhanced use of the line rate that slotted rings can (unless multiple tokens are used, a solution often mentioned but never seriously investigated), but can offer priority schemes which help in guaranteeing enhanced access to the ring for more demanding classes of traffic.

The major asset of the token-passing ring may be its commercial support in data LANs and its standardisation internationally.

STANDARDS

The development of an ISLN product is a major project for any organisation, and the price of the product will be high. Multi-vendor support for a product is therefore desirable both from the producers' point of view, as the whole project can be split into several smaller parts if deemed necessary, and from that of the consumer, who is not tied to a monopoly supplier. The definition of interface and protocol standards will allow the manufacture of equipment to provide added facilities, and this will result in the rapid exploitation of the ISLN's possibilities.

Work has already started in the ANSI to define the media-access technique (token passing, as it happens) and physical layer characteristics for a 100 Mbit/s system. This work follows on closely from that done on data-only LANs in the IEEE, but is moving towards being a protocol for integrated services. There is a growing awareness among the committees responsible for the development of Open Systems Interconnection (OSI)[11] that work needs to be done to incorporate circuit-switching techniques, such as those used for voice, into the OSI Reference Model. This integration of services within the standards is vital to progress on the ISLN as a whole.

In the UK, the Department of Trade and Industry's Information Technology Standards Unit (ITSU) commissioned a report[12] on standards for a multi-service LAN from Standard Telephone Laboratories. This report is now generally available and mainly comprises a set of draft standards for such a multi-service LAN. Although it is not clear if the ITSU will progress these draft standards (or if they do, how and where they will do so), the documents do give a good idea of the complexity of the issues involved.

This article has attempted to demonstrate that the choice of media-access technique is far from being the only, or the most important, decision facing the designers, and this must be borne in mind by those involved with setting standards. It is necessary to define standards for the communication of information, but as well as this, and perhaps more importantly, the standardisation of network management functions, such as name serving, access authorisation, billing and accounting, down-line software loading, and fault location, isolation and correction, need to be defined if true vendor independence is to be achieved.

CONCLUSIONS

This article has detailed some of the decisions that must be made before an ISLN product can be produced. In doing so it has highlighted three points:

(*a*) that the development of an ISLN is a very large undertaking which will involve great effort in many disciplines;

(*b*) that, although the whole project can be considered in smaller, more-detailed, parts, these should never be considered in isolation, as decisions made concerning one area may, and probably will, have a significant impact on other areas of work; and

(*c*) that the essence of the ISLN is that it is an integrated system and, to ensure that any component or process can be integrated into the system, adequate standards must be developed concurrently with, if not in advance of, products.

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Copies of References 4 and 8 are available by writing to TEP 2.1, British Telecom Research Laboratories, Martlesham Heath Ipswich, IP5 7RE.

Biography

Ian Watson received the B.A. degree in engineering from Churchill College, Cambridge in 1982. He is currently working with BT's Communication Standards Division on standards for the ISLN and on LAN/PABX interconnection. Since 1982, he has been a member of the IEEE Project 802 LAN Standardisation committee.

Book Review

Practical Aspects of Data Communications. Paul S. Kreager. McGraw-Hill Book Co. Ltd. xii+201 pp. 98 ills. £24·95.

This book concentrates on the problems associated with the cable and terminations provided to serve computer terminals and other data communication devices at a single location. The core of the book is a description of the practical solutions to cabling problems that the author encountered in his job as network manager for the Washington State University Computing Centre. It lays great emphasis on standardisation and documentation, gives a very detailed account of the methods he has used, and contains many photographs to illustrate the points made in the text. The author assumes that his readers are familiar with data-communications terms such as *RS-232* and that they have a working knowledge of terminal equipment; but most of the text is understandable without such knowledge.

The main object of the book is to encourage a standard well-thought-out approach to cabling a building for data equipment. The standardisation follows from the need to provide adequate facilities and ease of maintenance where there is likely to be rapid growth and frequent changes to a building's network. This situation is reminiscent of telephone services within a building, and it is no surprise to find that, since most of the cables use twisted pairs, the author uses methods borrowed from the local (American) telephone company.

Not all the practices look familiar to the UK telecommunications engineer, and the materials listed in the appendix are too American to be of value in the UK, but the methods are appropriate and appear sound. This is a book to be read for background information rather than to be slavishly followed. It is not a reference volume, which would require a more detailed discussion of the methods used and their alternatives. The requirements of each installation modifies the practices used; the methods that the author used for the University Computing Centre would be inappropriate for an office block with a small population of intercommunicating word processors. The author does indicate the areas of policy, planning, techniques and documentation that anyone responsible for providing or adapting a network should consider.

The main virtue of the book lies in the hints and wrinkles provided by the author's practical experience. The book will be useful to those without practical experience of the subject, to indicate problem areas and typical solutions. It would also be useful as a checklist for those approaching the installation of a large network in a building.

B. REINCKE

The Introduction of UXD5 Small Digital Local Exchanges

M. A. FITTER, C.ENG., M.I.E.R.E.†

UDC 621.395.2 : 621.374

The UXD5 is a small digital local exchange suitable for use in rural locations. This article summarises the introduction of these systems into public service.

INTRODUCTION

Earlier articles in this *Journal*[1,2] have described the technical aspects of British Telecom's (BT's) small digital local exchanges: the UXD5A and UXD5B. In conjunction with System X, the UXD5 system forms part of BT's telephone exchange modernisation strategy. The UXD5 provides cost-effective advanced customer and administration facilities for sparsely-populated rural areas (see Fig. 1). This article summarises the introduction of these systems into public service, in terms of the implementation programme, the experience gained[3] and the support arrangements.

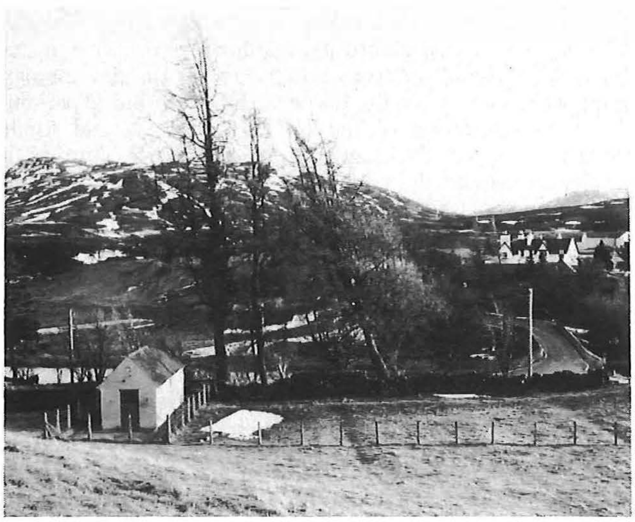

FIG. 1—Typical rural environment for UXD5

UXD5A 150-LINE EXCHANGE

The main design objective of this version of UXD5 was to make available a modern electronic exchange as a replacement for ageing unit automatic exchanges (UAX12), many of which had exceeded their economic life. The Monarch 120 call-connection system[4] was chosen as the basis for the replacement system, and a programme of development was undertaken by BT engineers to adapt the system for application as a local telephone exchange.

As part of the development programme, a laboratory prototype was constructed and subsequently introduced into public service in July 1979 in Glenkindie, Scotland. The experience gained during this trial of the equipment was fed back to a team of hardware and software development engineers; this resulted in the production of nine evaluation models (EMs) by BT Factories, the first of which was introduced into continuous service in January 1982 at Butterstone, Scotland. Sufficient confidence was gained from the performance of these models for a further 41 systems to be ordered from Plessey Major Systems Ltd. (PMSL). To enable the company to manufacture the equipment, PMSL was also awarded an industrialisation contract. Part of this was for the supply of two pre-production models, which have since been used as in-service exchanges. The first pre-production exchange was used in an initial proving role to gain confidence in the manufacturer's production equipment. The second system has now replaced the original Glenkindie prototype, which was withdrawn from service after 3½ years of continuous service.

All of the 52 UXD5A exchanges are now in service, and Fig. 2 shows their rate of introduction. Some 3500 customers are currently being served by UXD5A exchanges, and benefitting from the quiet and much superior transmission performance which results from digital switching.

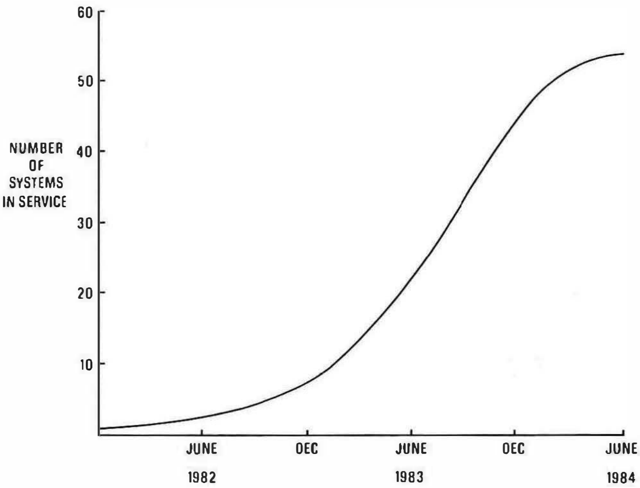

FIG. 2—Rate of introduction of UXD5A into service

In addition to being used in Scotland, the UXD5A has been deployed in a small way overseas. In fact, the very first exchange to go into continuous public service was in Redinha, Portugal, in April 1982, and was one of BT Factories' EM type. PMSL has also exported systems to Brunei and Botswana.

UXD5B 300/600-LINE EXCHANGE

During the production of the UXD5A, it was realised that by making use of an enhancement to the digital line cards being carried out for the Monarch system, the capacity of the original UXD5A system could be increased from 150 to 300 lines, and that by linking two 300-line units together a 600-line exchange could be realised; also, a significant

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proportion of UXD5A and Monarch equipment could still be utilised. With this increase in capacity, the UXD5B could, therefore, be considered as a replacement for not only UAX12, but also UAX13 and small satellite automatic exchanges (SAXs), and the potential application in the UK was estimated at around 1000 exchanges.

After the BT Board had approved the introduction of the UXD5B, 359 exchanges were ordered mainly for installation in Scotland and Wales, and a few in the South West of England.

The development of UXD5B has been a joint venture between BT and the British Telecommunications Industry, with PMSL acting as lead contractor and the General Electric Company (GEC) as a subcontractor to produce a full 600-line system. Fig. 3 shows a UXD5B 600-line equipment.

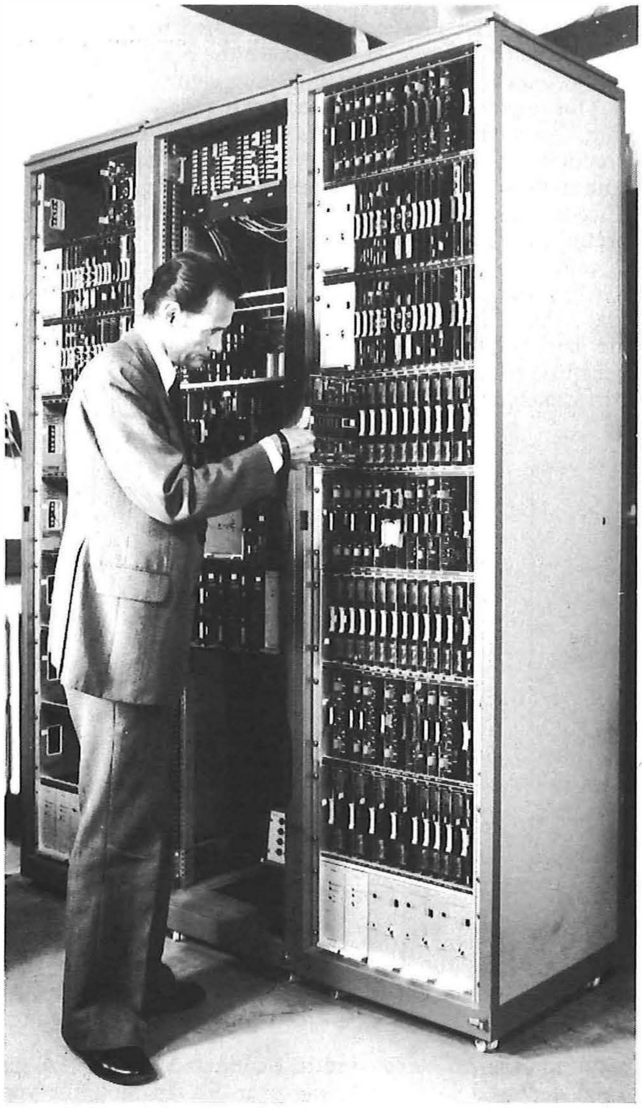

FIG. 3—UXD5B 600-line equipment

The first demonstration of UXD5B took place in October 1983 at Telecom 83, where working models were exhibited by both BT and Industry. It generated considerable international interest among foreign telecommunications administrations and major international telecommunication manufacturers, because it was one of the leading designs of telephone systems in this size range in the world to use digital switching technology. Fig. 4 illustrates the technology used in the UXD5B equipment.

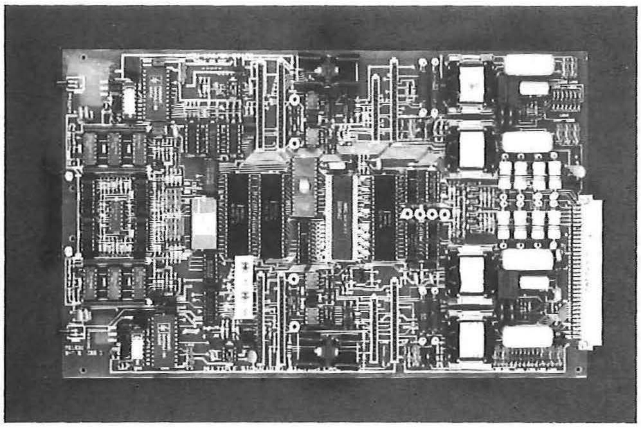

FIG. 4—UXD5B junction card illustrating the technology used

A UXD5B system was also used by the British Government for the telephone service during the Prime Ministers' Commonwealth Conference in Goa, India, during November 1983. The equipment was supplied by PMSL as part of an export agreement to supply exchange systems to India.

The first UXD5B exchange to enter full-time public service was one of three systems exported by GEC to the Solomon Islands in June 1984. The first UK exchange went into full-time public service on 2 July 1984, at Muckhart, near Gleneagles in Perthshire, Scotland.

Muckhart was specifically chosen for three reasons. Firstly, it was well placed geographically with easy access by road, rail and air from Edinburgh for the development support teams. Secondly, the local BT staff had experience in the introduction of the UXD5A systems and kindly offered to support the launching of the UXD5B. Thirdly, the exchange offered the opportunity to progressively enhance the equipment as the development work proceeded to gain early in-service experience. Initially, the exchange opened as a 300-line unit, but when the development of the 600-line unit is completed, the exchange will be upgraded to a 600-line unit. Ultimately, after completion of system trials, the exchange will be amalgamated with another exchange, Glendevon, currently of the UAX12 type.

The main part of a three-year production programme has now begun, and this will build up to a target delivery of 15 systems per month. By mid-January 1985, some 70 systems have been delivered of which four are in public service. The last of the 359 systems that have been ordered is scheduled for delivery by mid-1986, by which time UXD5B systems will then be serving some 100 000 connections. Fig. 5 shows the planned delivery programme for UXD5B.

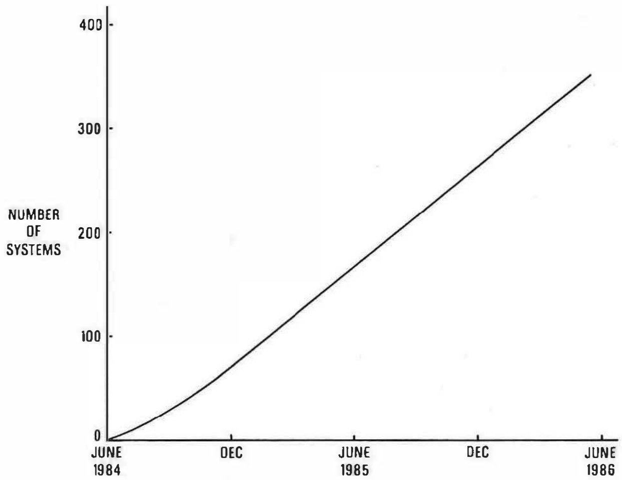

FIG. 5—UXD5B planned delivery programme

UXD5A EXPERIENCE

A number of defects in the design of the UXD5A were identified during the introductory phase; generally these were interworking problems concerning customer or junction equipment. Because of the robust nature of the system architecture, which uses distributed and duplicated microprocessor control and automatic diagnostic software, the system has provided a high level of operational performance. The design stability of the system has been demonstrated by the fact that only one complete system software upgrade has been applied and no significant hardware modifications have had to be undertaken since the system was launched.

UXD5B EXPERIENCE

The first exchange (Muckhart) was opened for public service with an early release of software in order to gain operational experience. This showed that some known defects, whilst tolerable when encounterted individually, could cause operational difficulties when coincident. Although customer service was generally unaffected, the system's software was upgraded to overcome these problems. The full operational software for the UXD5B has now been trialled at Muckhart, and this has led to the introduction of further systems into public service. Experience based on the first four systems shows that the UXD5B system is providing good customer service.

OPERATIONAL SUPPORT

System support is required to cover a number of features:

(*a*) the development of software and hardware to correct defects and provide new facilities,

(*b*) the training of staff,

(*c*) the provision of repair facilities, and

(*d*) the provision of maintenance support of a general nature.

For the UXD5A, which is exclusive to Scotland, arrangements have been made for the Scottish Regional Office to provide field support, operational instructions and to co-ordinate technician training courses. Design changes and special investigations are co-ordinated by the development teams at BT Headquarters.

Repairs to the system have been carried out by the contractor during the 12-month warranty period but, where this has expired, repairs to slide-in units have been undertaken by the Scottish area repair centres (ARCs).

A fault-escalation procedure to enable serious problems to be progressively raised via local Areas, through Regional (District) Offices to Headquarters, has been established to cater for emergencies. Telephone advice, remote interrogation (when these facilities are provided) and prompt visits to sites are available under the procedure. Experience has shown that in the early stages of the introduction of the UXD5A, both local and Regional staff had limited experience and that escalation to Headquarters was quite frequent, although immediate site visits by staff were never necessary. It is to the Scottish regional team's credit that its expertise had reached a level that necessitated only infrequent telephone consultations to Headquarters staff after 12 months of in-service experience.

In the case of the UXD5B, where the system is to be used in very much greater numbers than the UXD5A and geographically situated over the whole of the UK, a strengthening of the support facilities has become necessary. Dedicated support teams have been established at Headquarters to offer hardware and software development expertise, fault escalation capability and a centralised maintenance agency to co-ordinate and manage the evolution of the system. To support these activities, comprehensive computing facilities have been established. Field support models have also been arranged so that site problems can be simulated and corrective action proved before field implementation. Repair facilities will be handled by the ARCs following the expiry of the manufacturer's warranty period.

Technician training is now being conducted centrally by British Telecom Technical College (BTTC) at Stone, and the college offer a high level of technical training on production standard systems.

Studies on the level of fault-escalation support needed to achieve acceptable site-attendance times emphasise the need to establish de-centralised support expertise within the District. The size, quantity and location of this function has yet to be finalised, but it is envisaged that response times of between one and two hours for site attendances should be an objective and that staff should have a high level of expertise and be equipped to deal with the vast majority of site problems that may arise. The role of the Headquarters fault-escalation support team is to support the first few exchanges that have significant enhancements of hardware or software for an initial period. During this time, the more locally-based support units will undergo site training with a view to gaining sufficient expertise to provide support beyond that period.

CONCLUSIONS

A UXD5 has been providing telephone service at Glenkindie since July 1979. All 52 UXD5A systems are now in public service and providing a high level of service.

The first of the UXD5B systems entered full-time public service in July 1984 and thereby paved the way for the introduction of the 359 systems that have been ordered. The delivery programme has commenced at a rate of approximately 15 systems per month, with completion planned by mid-1986. To cope with the greater numbers of UXD5B over UXD5A and their wider geographical application, Headquarters support has been enhanced, and studies are under way to determine the most advantageous method of providing site support during emergencies.

ACKNOWLEDGEMENT

The author is indebted to all those colleagues involved in the UXD5 project both in BT and the British Telecommunications Industry for their help and advice during the preparation of this article.

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Biography

Mick Fitter is Head of UXD5 Launch and System Support Group in BT's Local Exchange Services Department. He joined BT in 1960 in BT London South West Area, and moved to Headquarters in 1968, where he was involved in a variety of developments on crossbar exchange systems. He became a Chartered Engineer in 1969. In 1980, he joined the UXD5 development team to lead the introduction into service of the UXD5 system.

Journals Past—A Review

INTRODUCTION

From time to time, it is proposed to review some of the events, innovations and equipment as reported in issues of the *Journal* 25, 50 and 75 years ago.

75 YEARS AGO—Vol. 3, April 1910

This early issue contained articles on special telegraph arrangements for the general election, a history of the wireless telegraph, and the electrostatic charging of telegraph wires by locomotives, albeit in Natal. In particular there was:

The Experimenting Room

A new experimenting room at the Engineer-in-Chief's Office had been opened because the previous accommodation was required for extending the facilities of the Central Telegraph Office. However, the move had its compensations "..in the new room, where for the first time it has been possible for most of the apparatus to be permanently fixed in position and kept in adjustment ready for immediate use."

The new accommodation measured 50 ft × 34 ft and included a photographic darkroom, a chemical bench and fume cupboard, and an oven for high-temperature work. In addition, a portion of the wall was painted white to serve as a screen for the display of lantern slides—the lantern belonging to the oscillograph set being used for this purpose.

Apart from the various measuring instruments, most of the floor area was taken up by the telegraph experimenting table, although some wireless telegraphy apparatus and a cell testing rack were installed.

"In addition to the main apparatus room, a smaller room is set apart exclusively for telephonic research work." This room included a length of standard cable and "..the standard telephone apparatus with which comparisons are made has been, so to speak, dissected, and each part connected to separate terminals. By this means any portion of the telephone set which may be submitted for examination can be compared with the corresponding portion of the standard set merely by the turn of a switch,.."

Institution Notes

The Institution Notes of this period provide considerable insight into the activities of the Engineering Department. However, one paragraph seems to be open to all manner of interpretation: "The Chairman read to Council a draft letter which the Engineer-in-Chief proposed to send out to each clerical officer on the subject of the possession of technical knowledge by members of the Clerical Staff. A slight amendment was suggested and accepted, and the Council endorsed the issue of the letter as being calculated to at any rate remove much of the prevalent mishapprehension as to the Department's attitude on the subject."

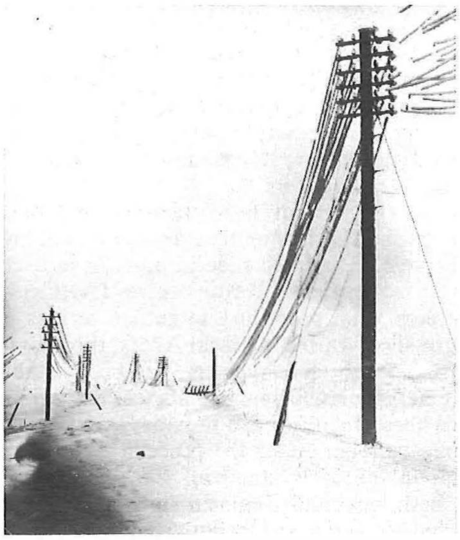
Post Office Engineering Department Dinner

The *Journal* reported the speeches at the Engineering Department's 7th Annual Dinner; the Engineer-in-Chief and the Postmaster General were in attendance.

In his speech, the Postmaster General touched upon certain events that have their parallels 75 years later. First, reorganisation: "..I have referred to the revision of the Engineering Department—the long overdue revision—a revision which had been expected for some time.. ..since then that revision has taken place, and although I do not suppose any revision gives complete satisfaction to any department, at all events it was a very considerable revision, and one you will feel has been a considerable step forward." Second, nationalisation: "..the State has now aquired what we may call the internal wireless system of this country. We were able to aquire it at a reasonable price, which I am afraid our friends in the National Telephone Company would not accept for their system as a whole, namely £15 000.", and "..we have had negotiations with the National Telephone Company with a view of providing for the inevitable taking over of the Company at the end of 1911.. ..we have to put it [the telephone system] on an efficient and economic basis. We desire to make it an efficient service, and if possible more efficient than the National Telephone Company's service." [The National Telephone Company was awarded £12·5M for its plant when it was acquired by the State.]

A Record Breakdown

Considerable coverage was given to the effects of severe storms, particularly around Newcastle-upon-Tyne, in the Northern District. In this area alone, 61 poles were broken; 54 'H' poles and 1010 single poles were seriously deflected and 2100 miles (4000 km) of wire had to be renewed. Service protection was provided by routeing calls from Newcastle to Aberdeen via Middlesbrough, Leeds and the West Coast, whilst Morpeth (24 km north of Newcastle) was given service via Glasgow and Edinburgh.



Typical storm damage caused by the weight of snow

In addition to the natural hazards, the Department had to cope with striking miners who took down telegraph poles to delay messages being sent to the police.

Despite the deep snow, help was available from some unexpected quarters: "..at Otterburn there lives a retired linesman, who, after being in charge of a long section of the main line to Scotland for over 30 years, retired under the age limit a few years ago. ..when the engineer penetrated as far as Otterburn he found that Mr Sacker [the retired linesman] had turned out with his own tools, and was busily engaged in clearing the line."

Telephone Progress in London

A summary of the previous year's progress in London showed that the total number of stations was 60 091, an increase of 7669.

50 YEARS AGO—Vol. 28, April 1935

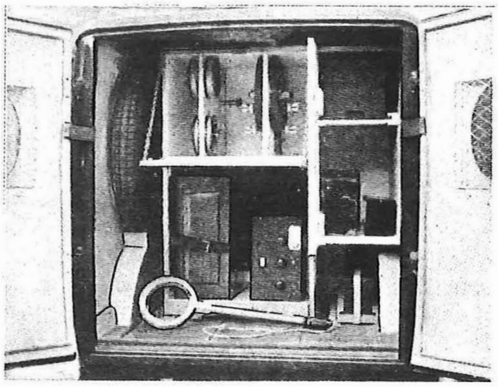
By 1935, the conversion of the telephone network to automatic working was underway, and the conversion of Central Exchange in Faraday Building in London is recorded in the *Journal*. 'An Automatic Traffic Recorder' is detailed as is a 'Valveless Differential Echo-Suppressor'. Telegraph enthusiasts are catered for with details of a 'Teleprinter Broadcast System', while the academics are given a treatise on 'Telephone Transmission', 'On the Hunting of Linefinders' and the use of thermal agitation noise as the calibration source of a field strength measuring set.

Radio interference was, however, becoming a problem:

Broadcast Interference Investigation

"A fleet of light vans, labelled 'Post Office Radio Service', now patrols the country as guardians of the ether."

Some seven million licences had been issued in 1934 and the number of complaints of radio interference had shown a four-fold increase over the previous four years—hence the need for the new vehicles. To assist the listener, a range of suppressors had been developed for such things as hair dryers, vacuum cleaners, flashing and neon signs, and trolley buses.



Broadcast interference vehicle—rear view of van showing portable search coil and test equipment

Telephone plant in the UK

The number of telephones now in use in London was 862 423 out of a national total of 2 317 399.

Notes and Comments

By now, the Engineering Department's Annual Dinner (if it still existed) is not reported in the *Journal*, although the address given by the Postmaster General to the Institution of Electrical Engineers at their dinner is included: "One of the parts of the Post Office of which I am very proud is the very fine Research Station [at Dollis Hill and officially opened in 1933] we have, one of the best equipped in the country." Almost as an afterthought, the Postmaster General mentions the birth of one of the greatest revolutions in communications: "Only a few days ago in the House of Commons I made an announcement of the opening stages in this country of television."

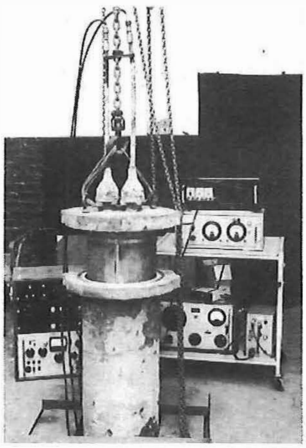
Supplement

The educational supplement to the *Journal* was first published with the July 1931 issue. Now, some four years on, it was covering a wide range of City and Guilds of London Institute examinations in telecommunications. For example: "What use is made of the intermediate distribution frame at a central-battery manual exchange? Sketch the connexions of a subscriber's line circuit, and mark on the sketch the positions of the terminals and cross-connexions on the intermediate distribution frame."

25 YEARS AGO—Vol. 53, April 1960

In 1960, the *Journal* was begining to reflect the rapid advances in telecommunications taking place in the UK. The articles covered 'The Repair of Shallow-Water Submerged Repeaters' and 'A Magnetic-Drum-Type Automatic Traffic Equipment with Transistor Switching Elements'. Telegraphs were well represented with 'Frequency-Modulated Voice-Frequency Telegraph Systems for Radio Telegraph Services' and 'A Monitor for 7-Unit Synchronous Error-Correcting Systems for Use on Radio-Telegraph Circuits'. Customer apparatus was also in evidence with 'A New Telephone for Deaf Subscribers—Handset No. 4', 'An Answering Set for Telephone Subscribers', 'Trial of a New Type of Wall Telephone' [Telephone No. 1/706] and 'An Improved Trigger-Type Dial—Dial Automatic, No. 21'.

Radio interference was still proving to be a problem. The first investigation vehicles, introduced 25 years earlier, had been replaced in 1947. 'A Vehicle for Radio Investigation Work' was now introduced to replace those brought into service in 1947.



Repair of submerged repeater—lifting the repeater from its housing

Interior of new radio investigation vehicle showing operating position, apparatus cabinet and aerial support

Supplement

The *Supplement* was now well established and covered most of the City and Guilds subjects and filled some 80 pages each year. The *Supplement* thus provided a wealth of material for learning or for just revision purposes. The questions and answers were able to cover the latest advances in telecommunications without the more traditional aspects being neglected:

"Sketch a diagram of a subscriber's line circuit on a central-battery manual exchange and describe the operation of the circuit on:

(*a*) a call incoming to a subscriber, and
(*b*) an effective call originated by a subscriber.

How would the circuit operation be affected if there were a disconnexion in the sleeve wire of the triple jumper on the intermediate distribution frame?"

Readers who are unsure of the answer can purchase back issues of the *Journal* from the Editorial Office.

Merlin Voice Mail VM600

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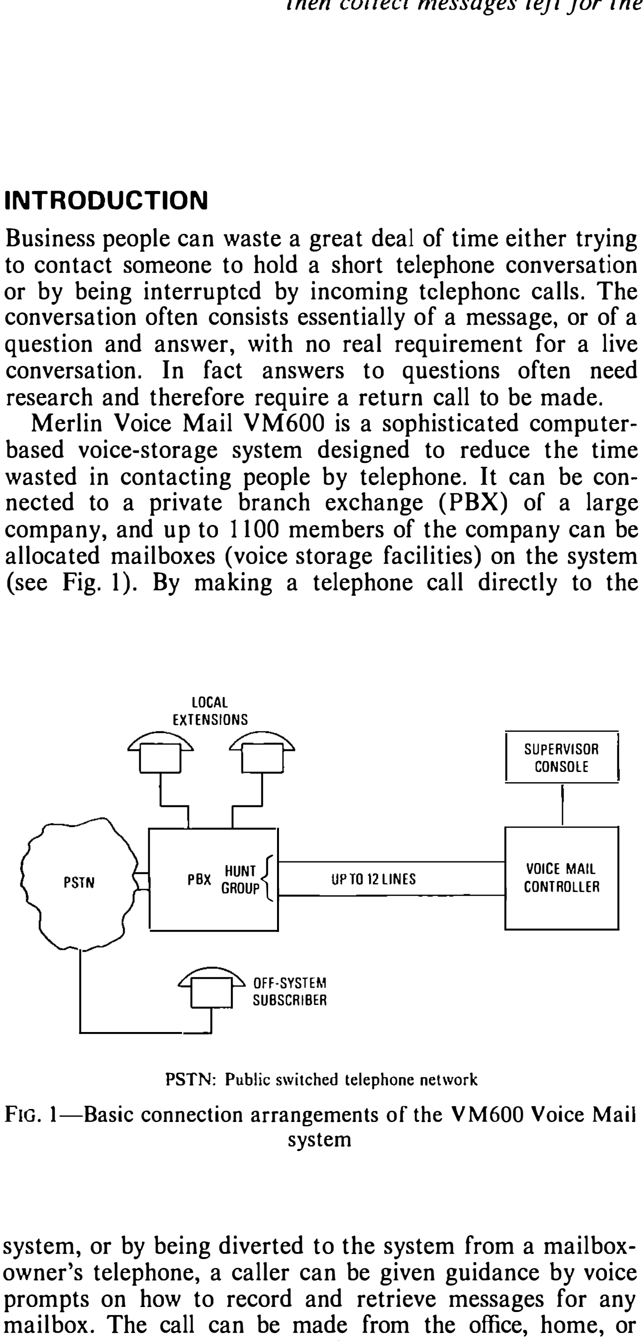
UDC 621.395 : 621.397.12 : 681.327.1

This article describes the VM600 Voice Mail system available from British Telecom Merlin. VM600 is a sophisticated computer-based voice-storage system which provides a service that can best be described as the voice equivalent of electronic mail. Users can dictate messages into the system from a telephone, and these are stored in voice form. Recipients of these messages can then collect messages left for them from any telephone having access to the public network.

INTRODUCTION

Business people can waste a great deal of time either trying to contact someone to hold a short telephone conversation or by being interrupted by incoming telephone calls. The conversation often consists essentially of a message, or of a question and answer, with no real requirement for a live conversation. In fact answers to questions often need research and therefore require a return call to be made.

Merlin Voice Mail VM600 is a sophisticated computer-based voice-storage system designed to reduce the time wasted in contacting people by telephone. It can be connected to a private branch exchange (PBX) of a large company, and up to 1100 members of the company can be allocated mailboxes (voice storage facilities) on the system (see Fig. 1). By making a telephone call directly to the system, or by being diverted to the system from a mailbox-owner's telephone, a caller can be given guidance by voice prompts on how to record and retrieve messages for any mailbox. The call can be made from the office, home, or almost anywhere in the world. No special equipment is required except for a small hand-held tone-sender, and even this is not required when dual-tone multi-frequency (DTMF)* press-button telephones supplied with most modern PBXs are used. When recording a message, the caller may review and, if necessary, re-record it before depositing it in the recipient's mailbox. The system offers users many facilities, including distribution of messages to up to 60 mailboxes, forced delivery of messages by ringing the recipient's telephone, and confirmed delivery, the means by which a sender is informed that a message has been read.



PSTN: Public switched telephone network

FIG. 1—Basic connection arrangements of the VM600 Voice Mail system

As an option, 'message waiting' indicators, such as lamps on telephones, can be provided for mailbox owners. This saves the user having to regularly interrogate a mailbox, and generally improves response times for urgent messages.

SYSTEM DESIGN

The equipment for the VM600 system is designed for siting in an office environment, and consists of a controller cabinet, a visual display unit (VDU), a keyboard and a printer. The hardware can be considered as being made up of a main processor with a 2 Mbyte memory and the following three subsystems:

(*a*) speech handling,
(*b*) disc, and
(*c*) supervisor.

The speech-handling subsystem provides the interface between the PBX and the main processor. It consists of microprocessor-controlled line cards, audio cards, telephone line interface cards and a message-waiting indicator card. The audio cards and telephone line interface cards provide line isolation, PBX ringing current and tone detection, DTMF signal decoders and senders, and conversion from analogue speech signals to digital signals and vice versa. Line cards handle the user interface program and each combination of line card, audio card, and telephone line interface card is able to handle three PBX extension line access ports to the Voice Mail system; up to four such combinations can be incorporated in any one controller cabinet, to give a total of 12 PBX line ports (see Fig. 2).

The disc subsystem provides the mass storage facilities and is used primarily for the storage and retrieval of digitised voice messages. It consists of Winchester disc drives, disc controller units, and a streamer tape unit. The maximum configuration is two 32 Mbyte discs plus two 128 Mbyte discs and provides approximately 30 hours of voice message storage. The streamer tape unit provides a means of loading and dumping data or software to or from the system by means of 19 Mbyte cartridges.

The supervisor subsystem provides the means for inputting user information and for outputting the usage statistics and message log. It is also used for running the fault diagnostics software package. It consists of an 80-character × 26-line VDU, a keyboard, and an 80-column dot matrix printer.

The software for the system consists essentially of an operating system which controls the peripherals, including the disc subsystem and VDU, and the following application tasks:

† British Telecom Business Systems, British Telecom Enterprises

* CCITT Technical Features of Push Button Telephones. CCITT Recommendation Q23.

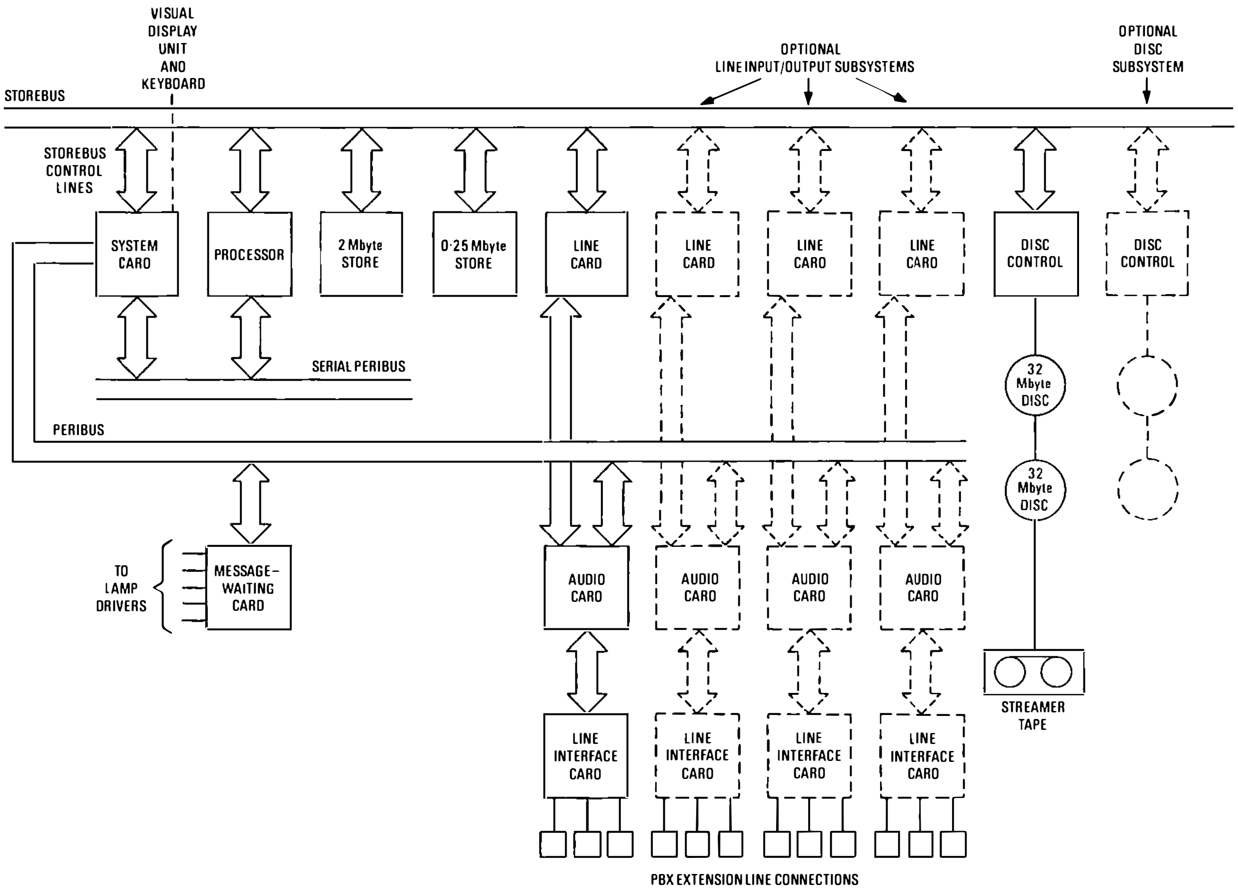


FIG. 2—System block diagram

(*a*) handling voice-message transactions between the speech subsystem and the disc subsystem—a high-priority real-time task;

(*b*) message administration, including data collection for statistics and special requirements for delivering messages such as distribution, timed and forced delivery—a lower-priority real-time task; and

(*c*) supervisor administration of the system, including setting up and amending user information, gathering usage statistics, purging of messages and so on.

An additional software package, which can be loaded by maintenance staff, tests all the hardware modules and identifies any item of equipment that may have become faulty.

PRINCIPLES OF OPERATION

To record a message, a call is made to the VM600 system. The speech-handling subsystem recognises the incoming ringing signal and loops the line. DTMF control signals are then sent by the caller or PBX to open a mailbox and the incoming analogue speech waveform is digitised into a 22·5 kbit/s data stream by means of a continuously-variable slope-delta (CVSD) modulator. This data is packaged and sent to the disc subsystem for storage under the control of the user interface program on the line card. Message retrieval is a similar process, except that messages are read from disc and converted to analogue speech for transmission to the caller. Callers are guided through the menu of facilities by voice prompts, some of which can be pre-empted by familiar users. The comprehensive range of facilities available is outlined in Appendix 1. An example of the procedure for sending and retrieving messages is shown in Appendix 2.

SPEECH ENCODER

A block diagram of the speech encoder is shown in Fig. 3. In simple terms, the speech encoder (CVSD modulator) consists of a comparator that compares the amplitude of the incoming signal with that of a locally generated predicted signal. If the amplitude is greater than the predicted signal, the digital output of the quantiser is logic 1, and logic 0 if the amplitude is less. The quantiser output is sampled 22 500 times a second, and this forms the digital output. The

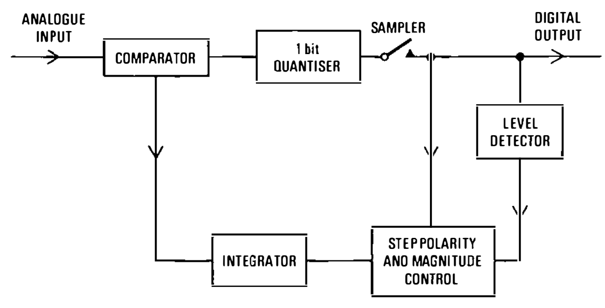


FIG. 3—Speech encoder

predicted signal is generated by integrating the digital output; however, to reduce slope overload distortion, three consecutive samples of logic 1 or logic 0 cause the pulse magnitude at the integrator input to increase or decrease appropriately. Periods of silence exceeding three seconds are not coded. CVSD demodulators consist of an integrator and associated circuitry that takes account of the step size change introduced by the predictor in the encoder.

VOICE PROMPTS

Voice prompts are constructed from smaller entities, called *utterances*, which are stored in digital form as part of the vocabulary file. To cater for system enhancements, a special piece of software can be used to build new prompts by joining up several utterances. Unwanted silences and noise at the beginning of utterances can be easily edited out. A great deal of human factors research has been used in developing the user interface program that generates these prompts.

FUTURE DEVELOPMENTS

This article has described a stand-alone voice mail system designed for attachment to large PBXs. Future developments will permit the interconnection of voice mail systems which are geographically remote from one another, and, with the integration of systems with PBXs, the true functionality of a telephone answering machine will be made available and the notification of waiting messages will be improved. The functionality of a telephone answering machine will enable callers to a mailbox-owner's telephone to be diverted to a mailbox on the voice mail system and invited to leave a message without the need to send control signals from a tone-sender. As an addition or alternative to a message-waiting indication provided by the PBX, systems will be able to dial out to radiopaging equipment when urgent messages are received.

In the long term, text-to-speech converters should lead to a greater degree of integration between non-voice and voice messaging systems, and advances in speech-recognition techniques could permit the voice instead of DTMF signals to be used for remotely controlling the system.

ACKNOWLEDGEMENTS

The author wishes to thank Ferranti Computer Systems Ltd. (Wythenshawe Division), the developer of the system, for permission to use information and material contained in this article.

Biography

Colin Newson is an Executive Engineer with British Telecom Business Systems. He joined the then Post Office in 1963 as a Youth-in-Training in the Tunbridge Wells Telephone Area. After a short period on exchange and transmission planning, he moved to the Headquarters Development Department to work on telegraph, Telex and data systems. On his promotion to Executive Engineer, in 1979, he worked on national and international standards for text preparation and interchange equipment, and the CCITT-defined teletex service, with responsibility for the 1980 and 1984 CCITT Recomendations for character coding and Teletex terminal characteristics. Since 1982, his work has also included the evaluation of small business computers and voice messaging systems. He is currently involved with the launch of the VM600 system.

APPENDIX 1
FACILITIES OF VOICE MAIL VM600
Facilities for Callers

(*a*) Messages can be of any length. They have time and date stored automatically, and they can be reviewed, re-recorded or deleted.

(*b*) Messages can be broadcast to a number of recipients on a predefined distribution list held by the system, or *ad hoc* distribution lists can be set up by the caller.

(*c*) Messages can have delivery deferred until a specified time and date.

(*d*) Separate messages for any number of recipients can be left in one call.

(*e*) Privileged callers can leave high-priority messages.

(*f*) 'Recorded delivery' is available so that callers are informed when the recipient has accessed the message.

(*g*) Rotary dial telephones can be used via portable tone-generation units.

(*h*) The system can be requested to make regular attempts to deliver an important message by ringing the recipient's telephone at intervals.

(*i*) Dictation facilities, with a secretary as the recipient, are available.

(*j*) Several callers (depending on the number of free system ports) can record a message for the same recipient at the same time.

Additional Facilities for Recipients

(*a*) Message queues are protected by security code to prevent unauthorised reading of messages. A secretary can have limited access where a recipient has two security codes.

(*b*) Access to all messages is guaranteed once access to the system is obtained.

(*c*) Notification of any long messages waiting is given.

(*d*) Notification of the number of new and priority messages is given.

(*e*) The following can be controlled by the keypad: pause, continue, skip forwards, skip back, skip to next message, skip to previous message.

(*f*) When a sequence of messages is read, replies to any particular message can be sent after that message, without the position in the message queue being lost.

(*g*) Messages can be deleted or retained after retrieval.

(*h*) Personal announcements can be dictated so that any caller hears the announcement before being invited to leave a message.

(*i*) Messages can be retransmitted to other destinations with or without preamble; for example, when an action is transferred to a colleague or subordinate.

(*j*) A special class of user can have immunity from purging of messages stored for longer than a specified time.

(*k*) Shared extensions with automatic verbal listing of participants are available.

(*l*) Recipients can access their own messages via the public telephone system when they are away from base.

Supervisory Facilities

(*a*) Details of users and facilities allocated can be set up, changed and deleted.

(*b*) System alarms and warnings are handled; for example, failure to deliver forced messages.

(*c*) Standard distribution lists can be set up, changed and deleted.

(*d*) All users of the system can be listed.

(*e*) A summary of line traffic and usage of system facilities over a 28-day period is available.

(*f*) A continuous log of events on the system is available.

(*g*) Security codes can be allocated.

(*h*) Messages can be purged.

(*i*) Information on the use of facilities by particular users is available.

APPENDIX 2
PROCEDURE FOR SENDING AND RETRIEVING MESSAGES

Fig. 4 shows the main interactions and menu options. The letters in circles refer to the voice prompts given by the system, the texts of which are shown underneath, and the digits in rectangles refer to DTMF signals sent by the caller.

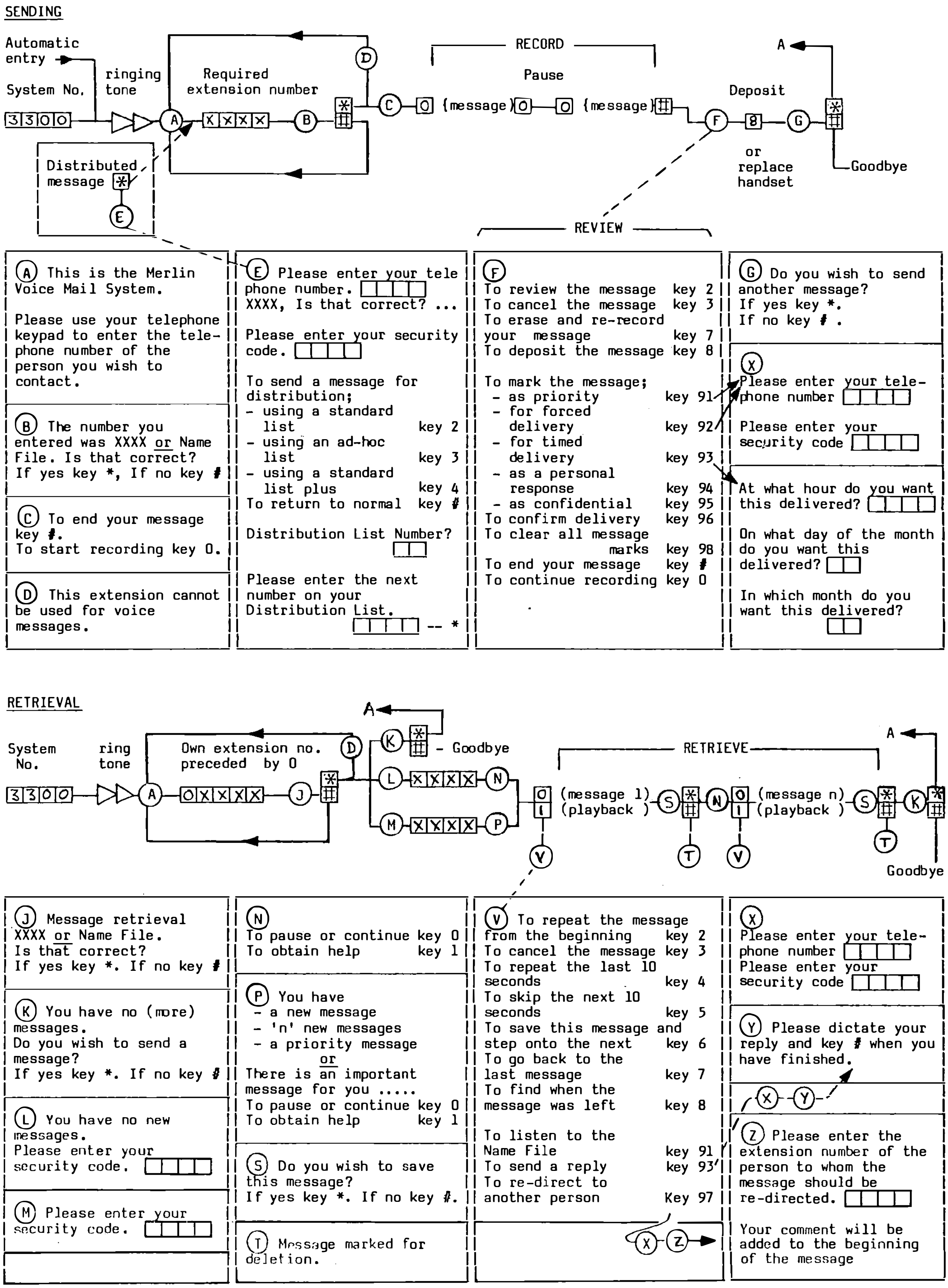


FIG. 4—Procedure for sending and retrieving messages

Inphone— Into Christmas— In the Future

The IBTE Christmas Family Lecture 1984

D. A. SPURGIN, C.ENG., F.I.E.E., and
K. R. CROOKS, C.ENG., F.I.E.R.E., F.B.I.M.†

INSTITUTION OF
BRITISH TELECOMMUNICATIONS ENGINEERS

I... N PHONE
INTO CHRISTMAS
IN THE FUTURE...

CHRISTMAS FAMILY LECTURE 1984

INTRODUCTION

The London Centre of the Institution of British Telecommunications Engineers (IBTE) held its third Christmas Family Lecture, *Inphone—Into Christmas—In the Future*, at the Institution of Electrical Engineers, Savoy Place, on 15 December 1984. On this occasion it was presented by Johnny Ball, the well-known host of BBC Children's Television *Think of a Number* and *Think Again* programmes. The lecture was designed to give an insight into the history of the telephone as an instrument and to demonstrate the present and future trends in design, technology and alternative use to which the telephone network can be put. All 600 seats for the event had been fully booked five weeks before the lecture, which was an indication of the popularity of the subject and its presenter.

GENERAL

Johnny Ball had been invited to give the lecture by the London Centre because of his recognised talent for communicating matters of a scientific nature to young people; he proved to be an ideal choice as the audience showed by its enthusiastic reception. The theme had been chosen because it was a highly-visual and topical subject that lent itself to the use of demonstrations, working models, slides and closed-circuit projection television etc. and gave an opportunity for audience involvement. The humour and personality of the presenter made the 100-minute 'lecture' a lively, entertaining and memorable event. An exhibition organised by British Telecom Enterprises was open before and after the lecture to show a range of products, including many used in the presentation.

EARLY TELEPHONE DEVELOPMENTS

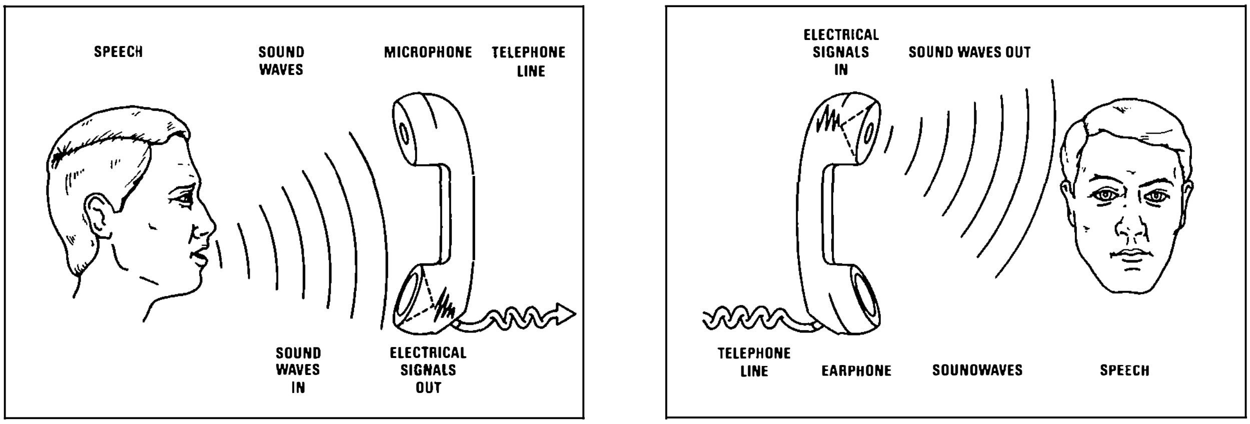
Johnny Ball began the lecture by reminding the audience of the need for long-distance communication and demonstrated various ways in which people communicated with each other. Elementary forms included drums, smoke signals and reflecting mirrors, and the more advanced systems, Chappe's semaphore, Morse code and Wheatstone's five- and two-needle telegraphs.

The beginnings of the telephone were explained with illustrations and a model of Bell's original telephone transmitter/receiver, together with a slide demonstration of how speech is converted into electrical energy, transmitted down a line and reconstituted as speech at the distant end.

† Mr. Spurgin is Chairman of the London Centre IBTE, and Mr. Crooks its Vice-Chairman

Part of the Inphone exhibition

The lecture in action



(*a*) Transmission (*b*) Reception

Simplified diagram of speech transmission and reception via the telephone

The early Ericsson telephone, the Telephone No. 150 (candlestick), the Telephone No. 332 and a giant telephone were used to demonstrate how the physical locations of the human mouth and ear are a limitation on instrument design. A method which the then General Post Office used to educate the public in the use of the automatic dial telephone was illustrated by showing part of the 1934 film, *Fairy of the Phone*.

This was followed by a closed-circuit projection television examination of the internal construction and operation of a Telephone No. 746 and of the larger components, such as bell coils and gongs, induction coil, switch hook etc., which dictated the shape of this and earlier telephone-instrument designs.

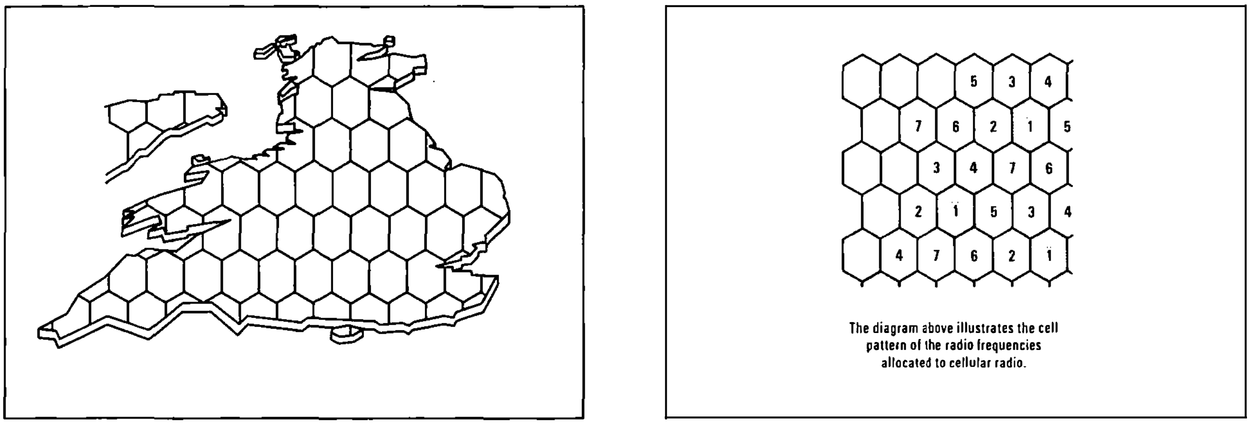
MODERN TELEPHONES

The presentation then moved on to consider the new range of modern telephones and, as an introduction, two of BT's Inphone television commercials were projected on to the large screen. These set the scene for the 'electronics and plastics revolution' in telephone design that was about to be described. A close-up projection television view of the inside of a *Viscount* telephone showed, in contrast with the Telephone No. 746, how printed circuitry and modern transducers have considerably reduced the space required and have enabled the design of the exterior shape of instruments to be much more flexible than was possible previously. Johnny Ball focussed on the design of the keypad, which he highlighted as the modern equivalent and more versatile version of the dial, and, to press his point home, took the keypad apart and explained the flexibility of design that modern plastic mouldings have facilitated. Further models were then demonstrated including the *Snoopy*, *Contempra*, *Slimtel* and *Easikom* telephones, along with their redial facilities; slides were shown as each model was mentioned so that the whole audience could see what was being described.

TALKING WITHOUT WIRES

Johnny Ball moved on to the next stage in the lecture by emphasising the limitations of modern telephones, which need to be attached to a flexible wire connection. He produced a pair of cocoa tins linked by a piece of string and invited two members of the audience to conduct a conversation from either side of the lecture hall—it came as no surprise that it failed to work when the string was cut. However, by using the principle of sympathetic oscillation, he then showed that a sound could be transmitted to several independent milk bottles held by the audience. Using this as a demonstration of the principle of elementary radio transmission, he moved on to consider the *Hawk* cordless telephone. The assistance of a young member of the audience enabled the effectiveness of this telephone to be demonstrated, for as the helper walked through the theatre and eventually to the outside of the hall, the quality of the conversation was heard by everyone from a loudspeaking telephone on the stage.

This led naturally to a consideration of mobile telephones and the new modular cellular-radio service. At this point Johnny Ball described, with the help of two slides, how cellular radio will provide nationwide communication.

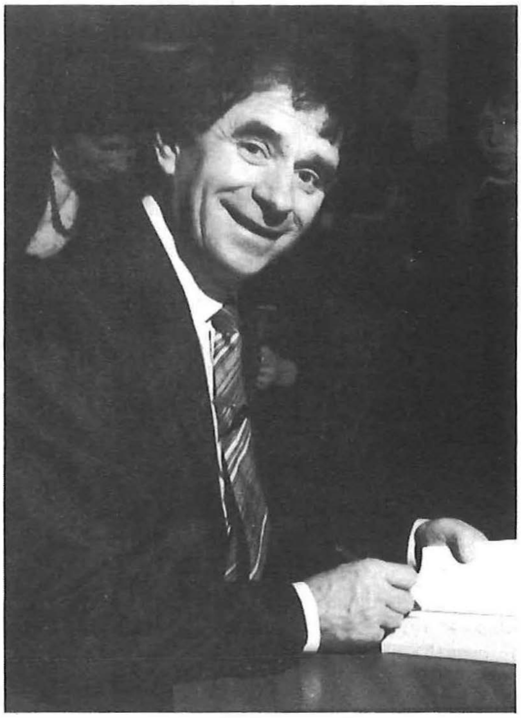


Principle of cellular radio coverage showing honeycomb of communication cells

He then went on to mention the modernisation of the telephone network with System X exchanges at the switching nodes and with optical-fibre cables connecting them together. This led to the subject of digital transmission, which was then explained with the aid of a video presentation showing how digital transmission has enabled the telephone network to be used for non-voice services. Some of Prestel's capabilities were demonstrated; again the information was projected onto the theatre screen so that all could see it. Such things as BT's share price and the weather forecast were shown as examples and then, to emphasise the interactive capability of Prestel, Johnny Ball ordered some wine to be delivered to him at the theatre.

The lecture so far had concentrated on the background to our communication needs and how the technological developments of the age had been harnessed to provide the present level of sophistication in telephone design and facility. But what of the future?

The state of present technology is such that the use of a single telephone line to serve the home office and to enable personal computers to intercommunicate is only a small step away. Already it is possible to download software from program providers over the telephone, and access to databanks and electronic shopping facilities is also becoming available. One of the latest devices, which is being developed, is the 'Automatic Speech Controlled Telephone' (ASCOT). A model specially loaned from British Telecom Research Laboratories (BTRL) Martlesham Heath was put through its paces to demonstrate how a call could be set up simply by giving it verbal instructions. This could well lead to increased use of the telephone by blind and paralysed customers.



Johnny Ball—Presenter

CONCLUSION

The lecture concluded with Johnny Ball pointing out that all of the telephone developments had taken place during the past 100 years and posing the question of what the next century would bring; maybe the possibility of a personal 'robotic' secretary. The Centre Chairman then delivered the wine, ordered earlier by Prestel, and with Johnny Ball wished the audience a Merry Christmas and a Happy New Year.

After the lecture, a large number of the young audience queued to meet Johnny Ball, obtain his autograph and to collect some of BT's publicity gifts. All agreed that the lecture had been a great success and that they had learned a great deal about the development of the telephone.

Acknowledgements

The authors wish to thank British Telecom Enterprises/ Consumer Products, the BT London Outside Broadcast Group, The Telecom Technology Showcase and BTRL for their assistance in the preparation and the production of this lecture.

Microcircuit Failure Analysis

R. G. TAYLOR, and C. E. STEPHENS†

UDC 621.3.049.77.004.6

Every system repair is expensive, often costing two or three orders of magnitude more than the component replaced. Microcircuit failure analysis is important because it determines whether failures are related to system, environmental or inherent component-quality factors, and allows the correct remedial action to be initiated. This article outlines the procedures adopted by a small specialised group within British Telecom's Materials and Components Centre to identify the cause of failure. Four case histories are included to illustrate the effectiveness of failure analysis.

INTRODUCTION

During the past three years, the impact of the microcircuit revolution on British Telecom's (BT's) systems has been evident by the ever-increasing facilities being made available to the customer. The high penetration of integrated circuits into BT's systems and their increasing complexity, as shown in Fig. 1, means that system reliability is becoming more dependent on the reliability of the devices chosen. Hence, it has become even more important to ensure that the parts used are of sufficient quality to give fault-free service for the expected life of the equipment.

In the current competitive atmosphere, any effort that results in increased customer satisfaction and confidence, while helping to reduce the massive costs of maintenance, can be nothing but beneficial to BT. One such area is the failure analysis of microcircuits; that is, the examination of failed micro-electronic components to establish the cause of premature failure. Feedback of this fault information to the relevant authority, circuit manufacturer and/or system designer can lead to changes in the manufacturing process, and even to re-appraisal of the component or its application.

In the longer term, failure analysis, together with an associated range of materials and component-assessment techniques and effective quality-assurance operations, will enhance BT's reputation with industry as an organisation interested in accepting only quality products, and result in more reliable equipment.

ORGANISATION

One group in the Materials Science Laboratories of the Materials and Components Centre (MCC) has the responsibility for co-ordinating failure analysis and carrying out analysis exercises on active microcircuits.

Failed components from field equipment are returned, via the component and reliability evaluation (CARE) recall system, from Area repair centres, BT workshops and equipment manufacturers' production sites to a central MCC office. Here, all pertinent component, system and failure information is recorded on an IBM computer database. Selected components are then forwarded for analysis. In addition, circuits are submitted from laboratory reliability experiments, device approval and quality assessment operations.

† Materials and Components Centre, British Telecom Development and Procurement

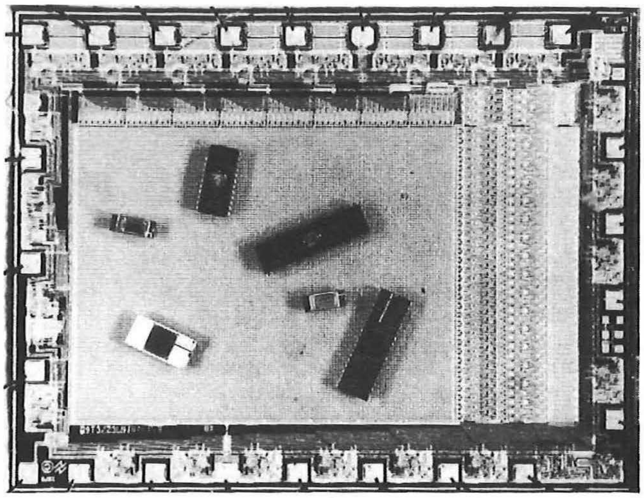


FIG. 1—An enlarged view of the silicon die from a CMOS memory circuit, with typical packaged microcircuits shown superimposed

FAILURE ANALYSIS PROCEDURES

The practical techniques used to investigate any particular failure vary considerably, and may be as simple as a low-power optical microscope, or as complex as Sentry VII automatic test equipment (ATE) or a scanning electron microscope. Irrespective of the equipment used in failure analysis, however, a disciplined analytical approach to the work is needed. Successful failure analysis is rarely achieved by sixth-sense guesswork, and what must be avoided at all costs is the destruction of important evidence by the use of an haphazard approach.

A correctly structured sequence of tests has been devised and is now used for all investigations into the failure of semiconductors. Standard documents and report forms have been drawn up for this purpose, and these greatly simplify the task of scheduling the work.

An outline of failure-analysis work flow is given below, together with a brief description of the equipment used and the failure mechanisms under consideration at each stage of the analysis.

PROCEDURAL FLOWCHART

Data Search

From the data compiled on the database, background information relating to the component can be obtained. Such information includes board performance and reliability figures, and the results of any previous quality or failure-analysis assessments concerning that component in its particular circuit location.

External Visual Inspection

The first stage of an analysis is to use a low-power microscope to inspect the external package. Assessment can be made of external problems such as mechanical and/or electrical damage, lead-frame integrity, plating, whiskers and evidence of non-hermeticity. (See Figs. 2 and 3.)

FIG. 2—A hole in the package caused by internal arcing between the emitter post and the metal lid

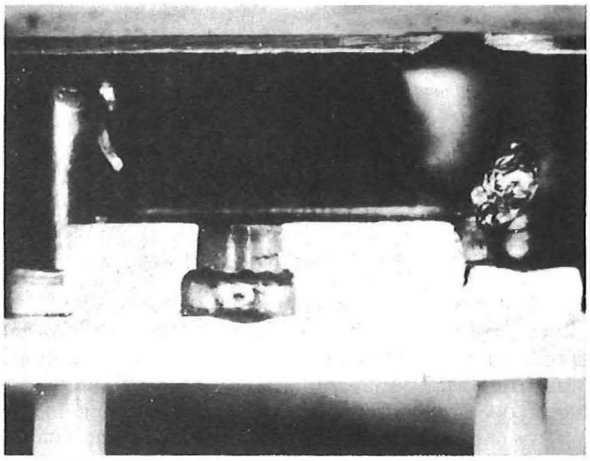


FIG. 3—A cross-section of the component in Fig. 2, showing the hole in the metal lid and the fused emitter post

Electrical Test

A full electrical test is made by using the relevant equipment, which ranges from relatively inexpensive curve tracers to sophisticated automatic test equipment (see Fig. 4). This is necessary to confirm non-functionality or parameter degradation, and is performed at the extremes of the specified temperature operating range.

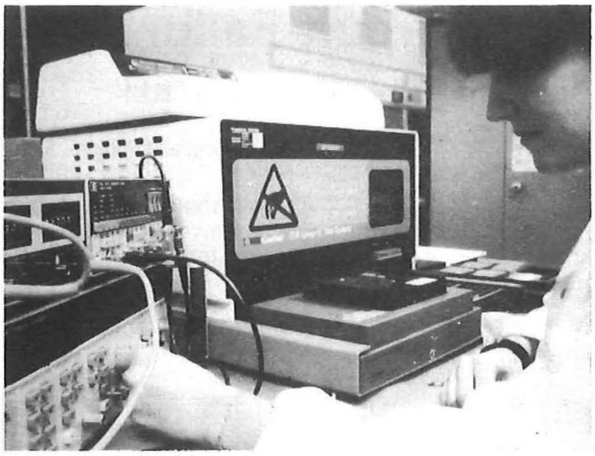


FIG. 4—Bench-top component automatic test equipment

Bake and Electrical Retest

Certain failure mechanisms are caused by ionic contamination within the package. A short high-temperature unbiased bake, followed by an electrical retest, can often confirm this type of failure.

X-Radiography

X-radiographic analysis is used to check internal geometries, alignments and connections, such as bond wires and eutectic die attach methods (see Fig. 5). This analysis is most useful when the decapsulation method to be used to expose the die could have some damaging effect.

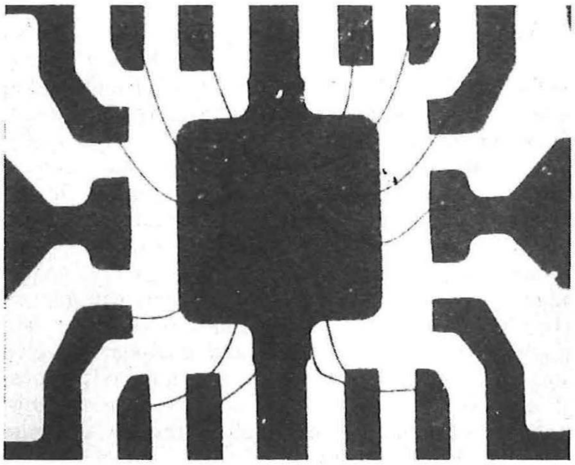


FIG. 5—Radiograph of a plastic-encapsulated device, showing deformation of internal bond wires caused during moulding

Hermeticity and Internal Atmosphere

Corrosion of die metallisation is attributed to the presence of moisture. There are three common causes:

(*a*) poor hermeticity—a consequence of inadequate package sealing;
(*b*) internal atmosphere—arising from poor environmental control during the sealing process, resulting in trapped moisture (see Fig. 6); and
(*c*) moisture ingress in plastic encapsulated parts—resulting from poor adhesion of encapsulation to the lead frame.

Specialised techniques exist to determine hermeticity and internal atmospheric conditions.

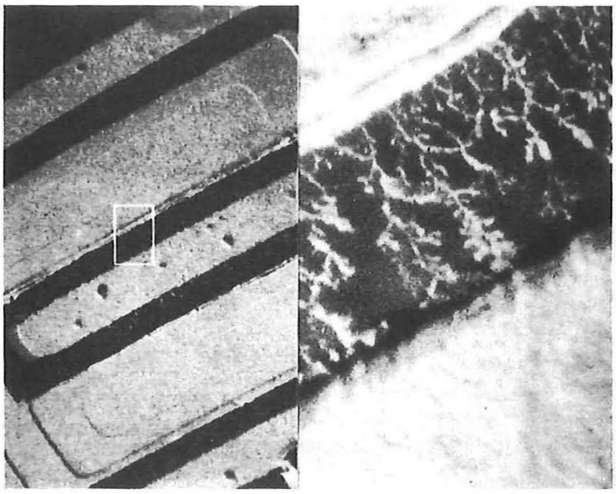


FIG. 6—Gold migration between metallisation, accelerated by the presence of moisture

Decapsulation

Before an internal visual inspection is performed, the die has to be exposed. This is achieved by a variety of mechanical or chemical methods, depending upon the package type. Mechanical methods include the use of trepanning tools, blades and diamond saws. Chemical processes involve total or partial exposure to various proprietary solvents and acids.

Electrical Retest

To ensure that no damage has been sustained by the sample and that no modification of its electrical characteristics has been made by decapsulation, a further electrical retest is required before other analytical techniques are used.

Internal Visual Inspection

A number of visual techniques can now be used. These range from simple optical instruments to complex scanning electron microscopes with all the associated techniques such as electron-beam induced current (EBIC) or voltage contrast. If the electron microscope is used, however, care must be taken to ensure that beam energies that could permanently damage the sample are avoided. Figs. 7 and 8 show examples of failures where the damage is readily observable by using an optical microscope.

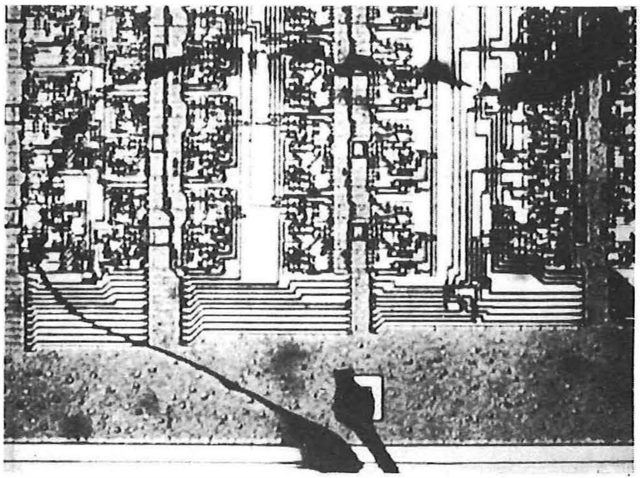


FIG. 7—Major die fractures caused by stress under service conditions as a result of poor die attach (magnification × 25)

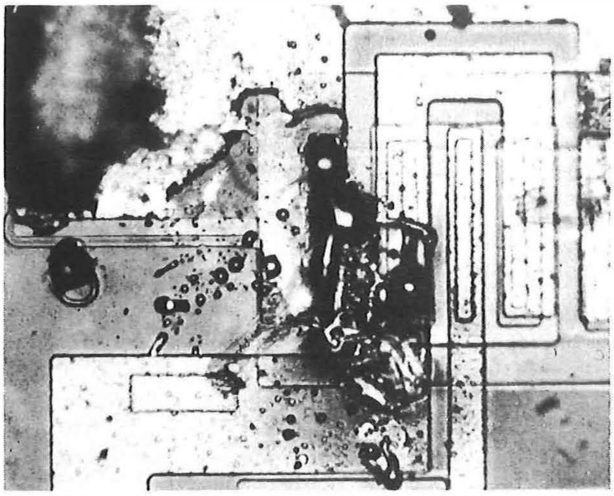


FIG. 8—Excessive electrical overstress (magnification × 300)

Non-Destructive Analytical Techniques

If the cause of failure has still not been established at this stage in an investigation, more sophisticated test methods must be used. Here, the failure analyst can call on more advanced high-vacuum electron-beam techniques, such as auger electron spectroscopy, and energy or wavelength dispersive spectrometry, to analyse and identify chemical elements present in the circuit. Thermal analysis, using either liquid crystals or infra-red microradiometry, is used to detect local hot spots, possibly caused by design and fabrication problems or electrostatic discharge. (See Fig. 9.)

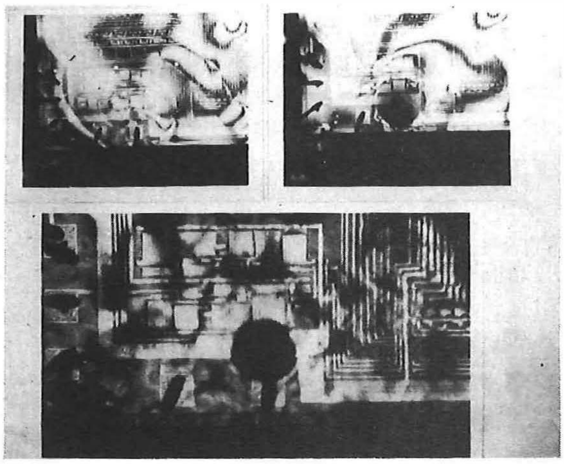


FIG. 9—Isolated hot-spots identified by an opaque circle in a liquid-crystal film; sequence shows that the exact location is readily observable by controlling the hot-spot temperature

Destructive Analytical Techniques

The remaining techniques available involve the physical destruction of the component to various degrees and could include:

(*a*) *Probing* Small diameter probes are used to measure the electrical behaviour at internal nodes. Together with ultrasonic trace cutting equipment, individual circuit components can be isolated for detailed analysis.

(*b*) *Bond Pull and Die Shear Testing* This enables an appreciation of the quality of the bond wire and die attachment strengths to be gained.

(*c*) *Selective Etching* This is akin to reverse engineering, where chemicals used in microcircuit fabrication can be utilised to remove layers selectively in order to reveal defects not visible on the surface.

(*d*) *Section and Stain* This involves precision microsectioning of the die, in conjunction with chemical staining to allow bulk silicon defects to be examined and junction depths to be measured. (See Fig. 10.)

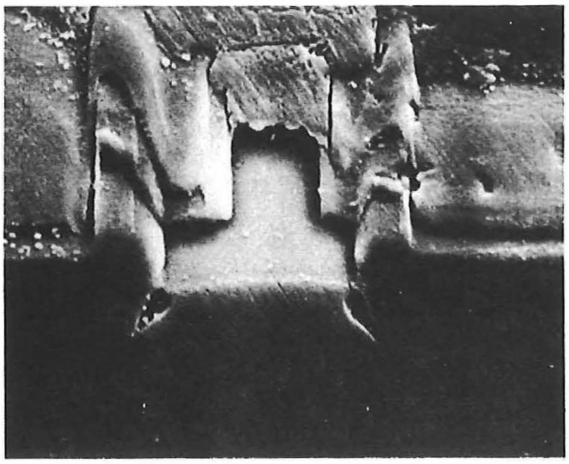


FIG. 10—Tapered microsection through defect site, showing damage (teardrops) caused by electrostatic discharge transient (magnification × 2000)

CASE STUDIES

Four case studies, which give an insight into why and how semiconductor micro-electronic components can fail, are described. The studies show a range in the nature of failures, ranging from the evident to the physically non-detectable.

Corrosion

DEVICE TYPE: Various samples from one component manufacturer

DEVICE DESCRIPTION: 4000 Series CMOS

DEVICE TECHNOLOGY: CMOS

FIELD FAILURE: Yes

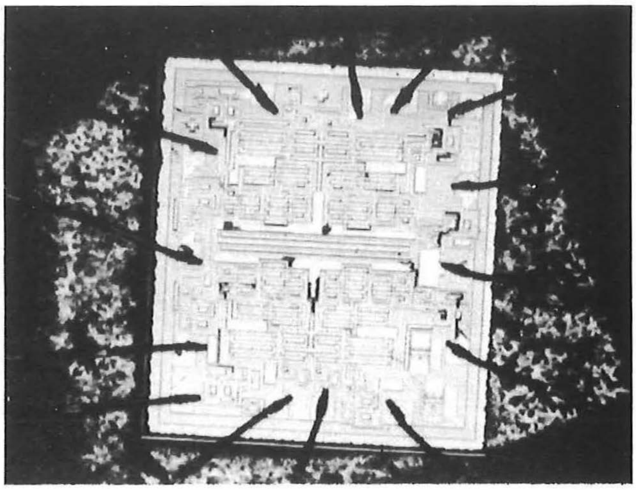
ELECTRICAL FAILURE MODE: Functional and parametric failures suggesting open circuits

FAILURE SUMMARY: Failures resulted from corrosion of the metallisation

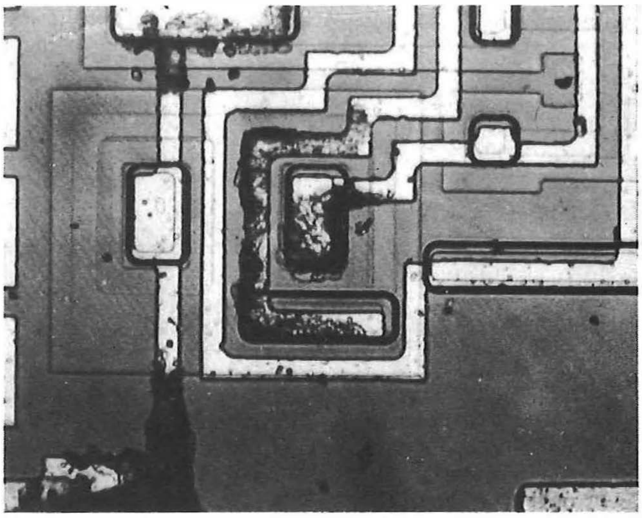
DIAGNOSIS: Measurements of the internal moisture level indicated the presence of excessive moisture content within the package cavity. The samples passed the hermeticity test. On decapsulation, physical evidence of metallisation corrosion was observed, as illustrated in Fig. 11.

CAUSE: Inadequate environmental control during assembly allowed moisture to be trapped within the package, and led to metallisation corrosion and, subsequently, to premature failure.

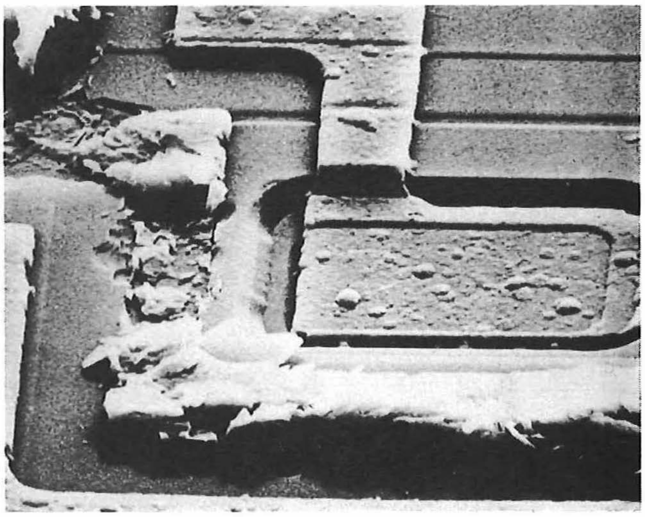
FEEDBACK: Early failure analysis of failed samples enabled the corrosion problem in this batch of parts from the manufacturer to be identified before the effect on system reliability had become unacceptable. Replacement of all parts from this manufacturer is intended in units with high populations of suspect components. Stocks of replacement components are to be held for units where normal service replacement is considered adequate. Further evaluation of this manufacturer's product has shown that its quality after a specific assembly period has improved and, if maintained, should prove reliable.



(*a*) Low-power optical view of corrosion site



(*b*) Higher magnification view of corrosion site



(*c*) Scanning electron photomicrograph showing open-circuit metallisation (× 1500)

FIG. 11—Examination of metallisation corrosion

Intermetallic Diffusion

DEVICE TYPE: 1013

DEVICE DESCRIPTION: Terminal control circuit

DEVICE TECHNOLOGY: PMOS

ELECTRICAL FAILURE MODE: Fluctuations in threshold voltages

FAILURE ANALYSIS SUMMARY: Intermittent high resistance was associated with the die-to-header aluminium wire bond. A visual examination showed no unusual features, but the scanning electron microscope revealed what has been termed the *woolly sock* (see Figs. 12 and 13). Analysis of the sock showed it to be approximately 84% gold; 13% silicon; and 3% aluminium. This phenomenon was present only on bonds that were made to the header in the scrubbed area associated with the die gold/silicon eutectic bond. The failure mode could be corrected by rebonding (see Fig. 14).

CAUSE: The die is attached to the gold-plated lead-frame header by a gentle scrubbing action carried out at 400°C. (Note: a 6% silicon, 94% gold alloy is liquid at 370°C). Consequently, the scrubbed area surrounding the die is rich in silicon (5–10%). If an aluminium wire is then bonded in this area, and a glass-sealed ceramic package is used, the subsequent package sealing temperature (typically 450°C) results in the scrubbed area becoming liquid and the gold/silicon diffusing *en masse* into the aluminium. Also at the liquid phase, the wire bond could float, and the outcome, in both instances, is a brittle joint. The bond would then be subjected to thermal stresses during operation of the device, creating an unstable high-resistance bond and eventual device failure.

FEEDBACK: The failure mode is not restricted to this particular type of device, but occurs in all MOS technologies where it is necessary to maintain the die substrate at a fixed voltage via a wire bond to the header. Because of this, component manufacturers have tightened up their quality-assurance inspection procedures and/or, in most instances, overcome the risk by the use of an intermediate jumper chip.

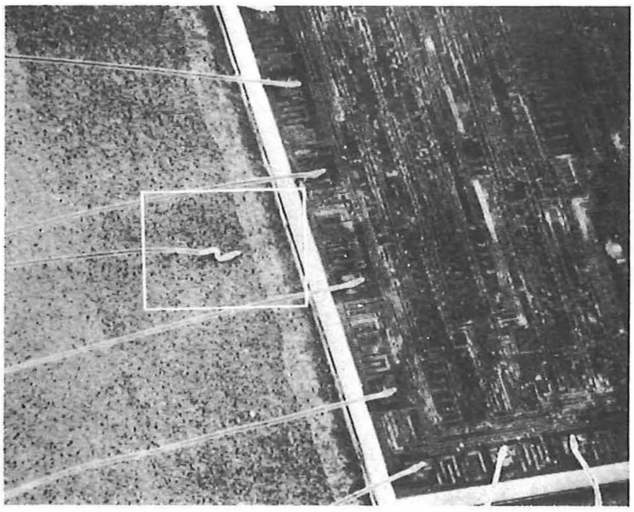


FIG. 12—Low-power scanning electron photomicrograph illustrating defective header bond

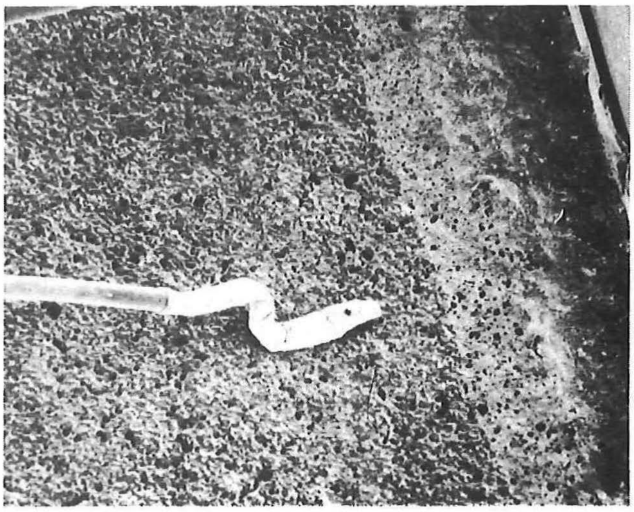


FIG. 13—'Woolly sock' appearance of defective header bond shown in Fig. 12

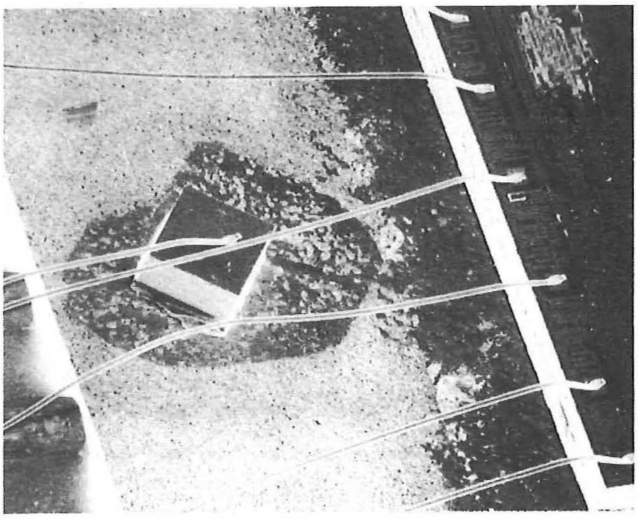


FIG. 14—Jumper chip used to overcome 'woolly sock' problem

Electrostatic Discharge Damage

DEVICE TYPE: AY-3-9900

DEVICE DESCRIPTION: Single-channel pulse-code modulation codec

DEVICE TECHNOLOGY: NMOS

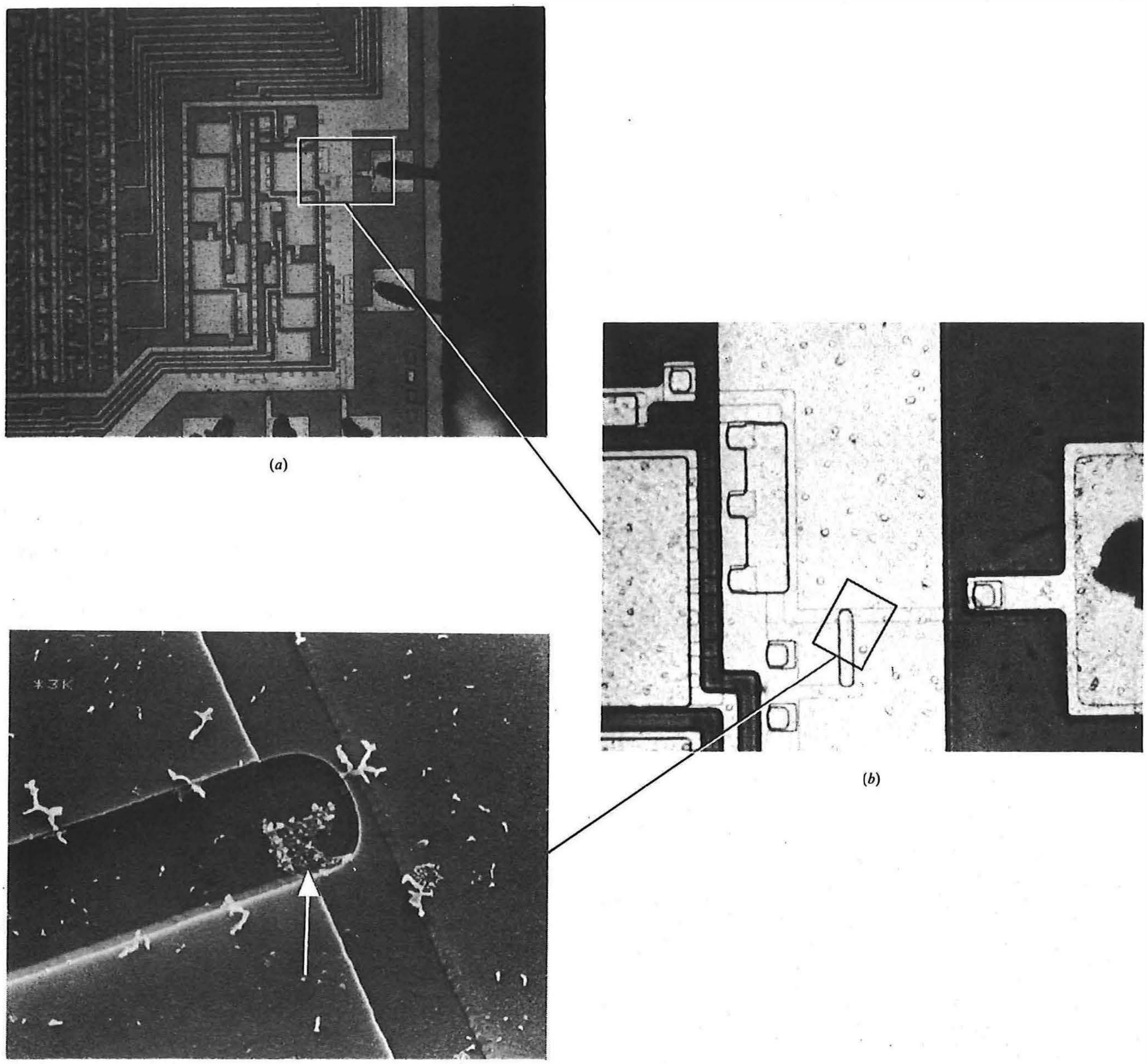
FIELD FAILURE: Yes

ELECTRICAL FAILURE MODE: High input leakage current

FAILURE ANALYSIS SUMMARY: Dielectric breakdown occurred because of an electrostatic transient. There was no visual evidence of the failure site, but a liquid-crystal technique highlighted a localised hot spot. Selective layer removal revealed a defect site at the same location (see Fig. 15)

POTENTIAL CAUSES: Handling during either installation, maintenance or repair operations

FEEDBACK: The on-chip input protection circuit showed a weakness in design. The circuit manufacturer was made aware of this. In addition, and because of similar findings on other devices, a wide-scale campaign was undertaken by the MCC to demonstrate the problems created by static, and how to overcome them.



(*a*)

(*b*)

(*c*)

(*a*) Optical low-magnification view of area

(*b*) Optical high-magnification view of area shown boxed

(*c*) Scanning electron photomicrograph showing extent of damage (arrowed) following selective layer removal of glassivation and metallisation. Surface debris is residual silicon not removed by metallisation etch, commonly known as *freckling*

FIG. 15—Sequence showing analysis of electrostatic discharge transient damage

Surface Charge

DEVICE TYPE: SP9685

DEVICE DESCRIPTION: Ultra-fast comparator

DEVICE TECHNOLOGY: Ion implant bipolar

FIELD FAILURE: Yes

ELECTRICAL FAILURE MODE: Parameter degradation leading to early life failure

FAILURE ANALYSIS SUMMARY: The component was available in three package variants: ceramic and sidebrazed dual-in line (DIL) and TO5 metal can. All failures were found to be packaged in the sidebrazed DIL. The only discernible difference between the three variants was the environment at the time of package sealing. The ceramic DIL and TO5 encapsulations were all sealed in a dry nitrogen environment, while the sidebrazed DIL was sealed in forming gas, a hydrogen-nitrogen mixture. Ambient-temperature life testing of circuit test structures was used to confirm failure and monitor circuit performance of all three different encapsulations. (See Figs. 16, 17 and 18.)

CAUSE: Hydrogen, present as a constituent of the forming gas, creates surface charge above the active regions of shallow-junction reverse-biased circuit elements.

FEEDBACK: This was a special case in that the circuit configuration called for a particular element to be continually reverse biased. The manufacturer has withdrawn all components using this type of circuit configuration packaged in a hydrogen environment, while a more detailed evaluation study is carried out.

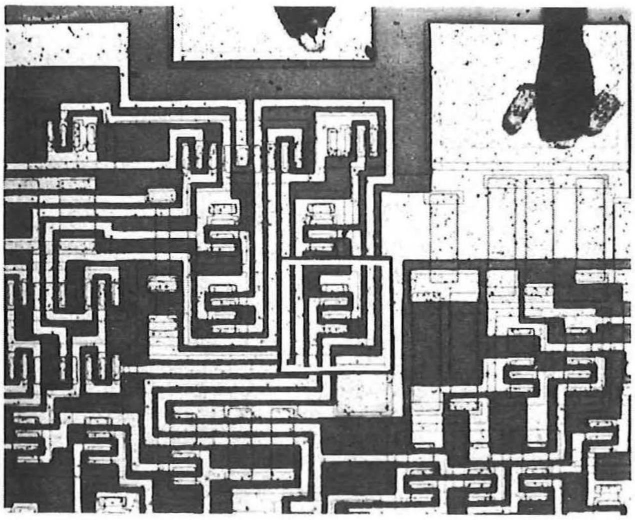


FIG. 16—Accumulation of charge in the circuit element (boxed) leads to parameter degradation and device failure

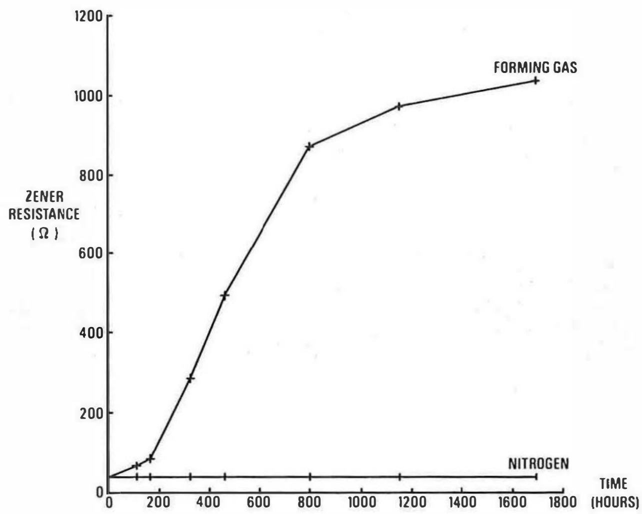
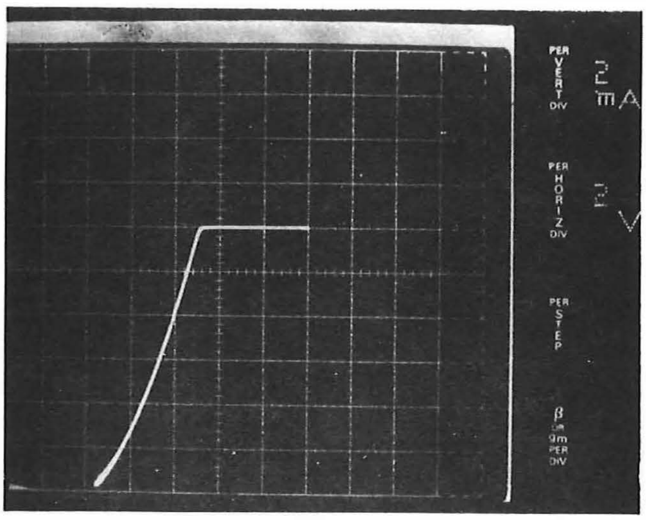


FIG. 17—Graph illustrating change of Zener slope resistance, due to charge build up in forming gas and nitrogen packaging environments



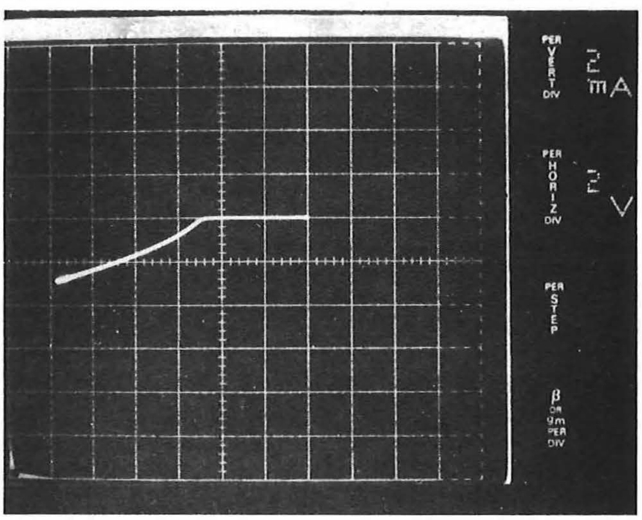


FIG. 18—Curve-tracer display of good (left) and defective (right) circuit element

DISCUSSION

For reliable components, the conventional wear-out mechanisms associated with the recognised 'bath-tub' curve (see Fig. 19) are never experienced in real life, since their longevity far exceeds the expected equipment service life.

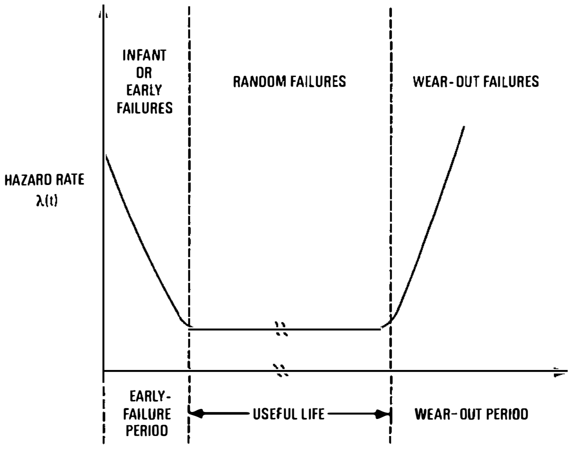


FIG. 19—Bath-tub curve showing relationship between component failure and time

Inevitably, occasional quality and process failings do occur, and result in potential large-scale problems. The case histories described above illustrate that process problems in microcircuits are time dependent and manifest themselves as failures some 2–3 years into service life. At this stage, manufacturers' warranty periods have expired and the problems rest firmly with BT. The importance of certain components, particularly in high revenue earning equipment, then becomes only too apparent.

As the cumulative number of failed microcircuits begins to become significant, failure analysis enables the cause to be identified, recommendations to be made and remedial action to be taken.

CONCLUSIONS

Failure analysis is one aspect of the MCC's task in maintaining high-quality cost-effective semiconductor products. The case histories are just four of many examples that could be cited, and highlight the need for such a facility in BT.

The large volume of components, and the demand for more reliable products, make it more meaningful to talk about quality in terms of parts-per-million (PPM) rather than percentages. End users with substantial applications for semiconductor components are encouraged by manufacturers to feed-back their field experience in an attempt to sustain and improve product quality. The expertise that exists within the MCC, together with the support from the British Telecom Research Laboratories at Martlesham Heath, is widely acknowledged, and considered an important part of that PPM concept.

Biographies

Bob Taylor is an Executive Engineer at BT's Birmingham Materials Science Laboratories (Materials and Components Centre). He joined BT in 1966 and his work in material sciences has encompassed nearly all types of electronic components. Since 1979, he has concentrated on materials studies relating to semiconductor components with particular emphasis on failure analysis. His present work includes investigations into electrostatic discharge and electrical overstress and their related problems.

Chris Stephens is an Executive Engineer at the Birmingham Materials Science Laboratories of the Materials and Components Centre. He joined BT at the Research Station at Dollis Hill in 1967 and worked in a number of areas of semiconductor reliability assessment, including thermal characterisation and component evaluation. In 1980, at the BT Research Laboratories at Martlesham Heath, he became involved in semiconductor failure analysis and analytical technique development. In 1983, he moved to Birmingham, where he currently works in the failure analysis area of the Microelectronic Technologies Group.

Book Review

GaInAsP Alloy Semiconductors. T. P. Pearsall. John Wiley and Sons Ltd. xi+468 pp. 254 ills. £23·75.

GaInAsP alloy semiconductors are based on Gallium Arsenide with some of the Gallium replaced by Indium and some of the Arsenic replaced by Phosphorus. The resulting range of alloys have two particular uses: one for opto-electronic devices such as lasers, light-emitting diodes (LEDs) and detectors for the 1·1–1·7 μm wavelength region of particular relevance to optical communications; the other is for high-speed electronic devices. This book starts with chapters on each of the four main material preparation techniques and on the problems of high-purity material and ion implantation. These are followed by seven chapters on material properties of which four are on transport properties; it is terminated by four chapters on lasers, detectors and field-effect transistors (FETs).

The book combines many aspects of the technology, applications and understanding of a very rapidly moving topic; it can thus be only an appraisal of that topic at a particular stage of development. In this respect it is excellent. It surveys the subject in a comprehensive manner, and incorporates a useful chapter on the main aspects of GaInAsP lasers, but avoids the temptation of giving too much of the detail which is readily available in more specialist publications. Yet it takes advantage of the opportunity to collate the previously scattered information on FETs and the associated transport properties of these semiconductors. Since the book was prepared, knowledge of the subject has advanced substantially but, in general, the book's contents form a sound foundation that will be useful to all those using or studying the material.

Although there is an increasing number of people using devices based on GaInAsP, this book would be too specialist to be of much use to them; however, for those who are involved in the continued development of electronic or optoelectronic devices based on GaInAsP or in its preparation, this book is a useful source of background information. It will remain a useful foundation for researchers who need to become acquainted with the topic for several years to come.

A. G. STEVENTON

Local Lines—The Way Ahead

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The local-line network is the vital link from the customer's premises to the telephone exchange and thence to the junction and main networks. It represents a major part of British Telecom's assets. Today, it is an almost wholly analogue network, but the trends to digital customer services will mean considerable changes over the next few years. This article reviews the present network, considers developments already in hand and attempts to look further into the future.

INTRODUCTION

Although the use of digital transmission is now standard practice for British Telecom's (BT's) main and junction networks, it has so far had relatively little impact on the local-line network. But many of today's trends (for example, integrated services digital network (ISDN), digital private branch exchanges (PBXs), digital private services, personal computer workstations and other digital terminal equipment) will change this noticeably. One effect will be a change in emphasis from a network based on analogue transmission over metallic-pair cables to one in which digital transmission systems employing significant amounts of electronic equipment will play an increasing role. This has implications not only for the development of suitable hardware, but also for planning strategies and for network planning, installation and maintenance procedures.

This article reviews the present network and outlines the requirements for digital services. It then describes a range of digital systems available today and in the near future for use in the local network; these include systems for metallic-pair cables, optical fibres and microwave radio. This is followed by an assessment of likely future trends.

PRESENT NETWORK

The present network has been built-up over many decades, and is based on metallic-pair cables. Its configuration, shown diagrammatically in Fig. 1, is well known. It is based on large cables radiating from the exchange to a flexibility point, known as a *primary cross-connection point* (PCP), forming the local-main network, and smaller cables radiating from the PCP to the customers, forming the local-distribution network. The principle of flexibility is shown in Fig. 2.

† Local Line Services, British Telecom Local Communications Services

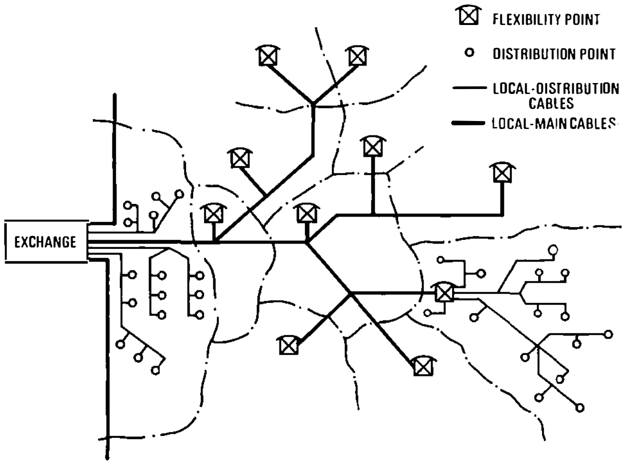


FIG. 1—Local-line network configuration

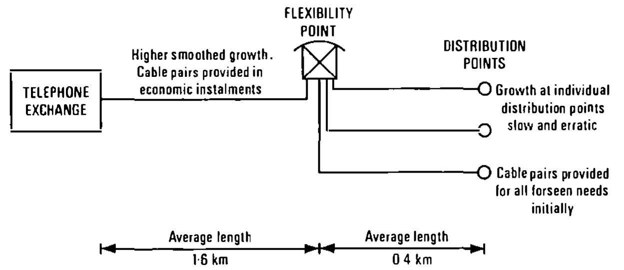


FIG. 2—The principle of flexibility

Cable sizes from 100 to 4800 pairs are used in the local-main network, and from 2 to 100 pairs in the local-distribution network. Some cables, notably to large business premises, do not pass via a PCP and are terminated directly at the customer's premises. Virtually all local-main cables are installed in duct, as are a high proportion of local-distribution cables.

The existing local-line network is a major asset and its scale can be deduced from the amount of plant used on it:

200 000 bore-km of duct
3 million manholes and joint-boxes
25 million pairs from exchanges
84 000 flexibility points
2·7 million distribution points (DPs)

However, although predominantly a cable and external-plant network, electronics has already had some part to play. The most widespread application is the 1 + 1 subscribers carrier system whereby a common pair is used for two exchange lines, one using the normal audio range and the other using analogue high-frequency (HF) techniques. Another application is the use of line-extenders to amplify and correct signals on cable-pairs which otherwise would be inadequate. This allows lower-cost smaller-gauge cables to be used more widely, with the small number of long connections being dealt with through the use of line-extenders. A further application of electronics in the current network has been in the use of a small number of analogue line-concentrators, principally in rural areas. One such device permits up to 96 customers to be connected to the exchange over 17 cable pairs. A new development, which includes a pole-top unit for the distant end, will permit 14 customers to be connected over 5 cable pairs.

CIRCUIT REQUIREMENTS FOR DIGITAL SERVICES

Until recently, data transmission requirements have mostly fallen into the 0–9·6 kbit/s range, which can comfortably be accommodated on existing audio local plant using modems located in customer's premises. However, many developments are in-hand to extend the data-rate requirements. By far the most important of these is the development of digital PBXs which, together with the trends towards ISDN, is leading to the availability of a range of digital terminal equipment (for example, computing workstations, facsimile, slow-scan television) operating at 64 kbit/s. The availability of this terminal equipment will lead to a demand for digital transmission both at 64 kbit/s and, from a PABX to a digital exchange, at 2 Mbit/s, so that the terminals can have access to the digital network and hence to other users.

To some extent the availability of digital terminal equipment before the public switched network is capable of handling it is also leading to an increase in requirements for digital private services; this is being met by the KiloStream, MegaStream and Packet SwitchStream services, which also have their own clearly separate markets.

MODERN NETWORK

Digital plant is already being provided today in the local-line network to provide the digital services outlined above. It falls into the following categories: pair-type cables, transmission systems for pair-type cables, optical cables and systems, and microwave radio systems; all of these are considered below.

Pair-Type Cables

The existing cables in the local-line network have different cable gauges, many spurs, and flexibility points. Multiple services already working over these cables involve signals such as 50 V dial pulses, 75 V ringing current, 80 V telegraph, analogue HF carrier systems and many others. All these factors together make the existing network a hostile environment for the use of digital signals. Nevertheless, existing cables are already being used for 64 kbit/s private services using 4-wire WAL2 transmission, and tests have shown that 2-wire 96 kbit/s line-rate echo-cancelling systems will operate over the majority (say 95%) of existing pairs. Evaluation of burst-mode line systems with instantaneous line-rates of 256 kbit/s has also shown that about 65% of existing pairs would fall within the attenuation limits.

At higher bit-rates, the use of existing cables is less clear. At 2 Mbit/s, tests have shown that existing cables can support this rate, but that the measured values of attenuation and crosstalk are very variable between apparently similar situations. The presence of impulsive noise and flexibility points also leads to wide variations in performance. In short, existing local cables are a poor host for 2 Mbit/s services, and the best that can be achieved reliably is probably on short (maximum 1 km) direct links to business customers. Even then such provision is to be regarded as a short-term expedient pending the provision of a longer-term solution. The possible use of 6- or 10-channel systems in the future does, however, increase the prospect for using existing cables. The problems at 2 Mbit/s outlined above mean that, at present, such services are provided over specially-provided purpose-designed digital transmission cables of transverse-screen design. These are installed in one of three configurations (see Fig. 3).

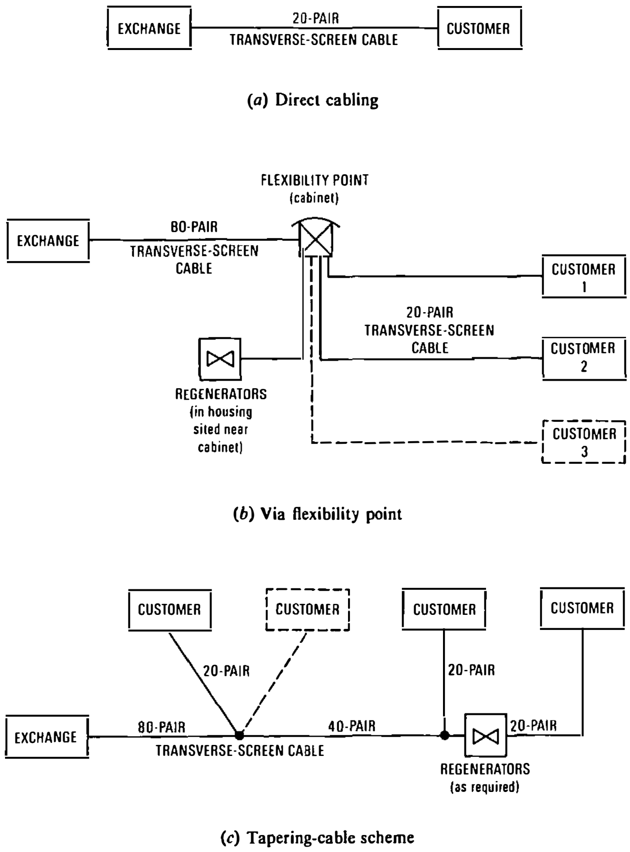


FIG. 3—Transverse-screen cable configurations

(*a*) *Direct from exchange to customer* This is acceptable when there are only small numbers of customers for 2 Mbit/s services on an exchange. Each customer would be served by a 20-pair transverse-screen cable, which is the smallest practicable size for manufacture and installation. The problem is that continuing with *ad hoc* provision in this form leads to poor utilisation of duct capacity, especially in the vicinity of exchanges, and usually an overprovision of pairs.

(*b*) *Indirect via flexibility point* The provision of a larger cable, such as an 80-pair transverse-screen cable, to a flexibility point (cabinet) from which smaller cables, such as 20-pair transverse-screen cables, radiate to customers. Regenerators can be housed close to the flexibility point, and cabled to it, for connection into the circuits as required.

(*c*) *Tapering-cable scheme* Where probable future customers can be identified, a tapering-cable scheme can be installed. The cable can be provided to serve the first known customer with allowances made for possible future spurs to other customers, but careful consideration has to be given to future crosstalk levels.

Cable has already been installed at various locations in all these configurations for, or in readiness for, 2 Mbit/s services. Although transverse-screen cables are a readily-available cost-effective method of providing 2 Mbit/s service, they are likely to be superseded by optical-fibre cable for new provision in the foreseeable future.

Digital Transmission Systems For Pair-Type Cables

Digital 1 + 1 Systems

One of the early applications of digital transmission is for a 1 + 1 subscriber carrier system. This is rather different to the other digital systems discussed because it provides analogue terminal interfaces; that is, it interfaces with standard telephones at one end and an analogue exchange at the other. Two slightly different versions are being purchased, but both use the echo-cancelling hybrid technique. One, with a 96 kbit/s line rate, provides: 64 kbit/s for the telephony channel; 16 kbit/s for signalling, frame alignment, monitoring and control; and 2 × 8 kbit/s data channels. The second, with an 80 kbit/s line-rate, provides: 64 kbit/s for the telephony channel; 2 kbit/s for housekeeping; with the remainder available as 1 × 8 kbit/s and 3 × 2 kbit/s data channels.

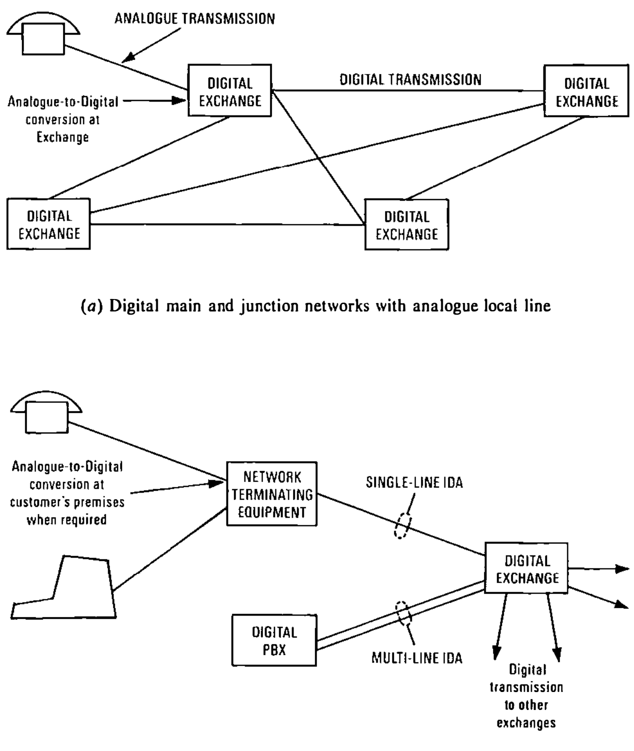
Although principally intended for analogue telephony, the unit is potentially significant because access to the 64 kbit/s and other data channels is available at a logic level permitting add-on units to provide a range of digital facilities. The basic design is also being reconfigured for other applications.

64 kbit/s Private Services

The KiloStream service marketed by BT offers user rates of 2·4, 4·8, 9·6 or 48 kbit/s with control and supervisory facilities, or 64 kbit/s without. The control and supervisory facilities are provided via a 6 + 2 coding structure giving rates of 3·2, 6·4, 12·8 or 64 kbit/s. The three lowest rates are sent to line at 12·8 kbit/s (the two lowest being reiterated to form a 12·8 kbit/s signal), and the remaining options at 64 kbit/s. The 12·8 or 64 kbit/s signal is transmitted to line over a 4-wire circuit using the encoding technique known as *WAL2*, but by late 1985 a variation of the digital 1 + 1 system will be used to provide service over a 2-wire circuit.

Single-Line Integrated Digital Access

The ISDN provides customers with speech and/or digitally presented services based on a 64 kbit/s switched network. Fig. 4 shows that the evolution from digital main and junction networks with digital switching to full ISDN rests upon digital transmission being taken directly to the customer; that is, integrated digital access (IDA). These services are marketed as *single-line IDA* and, for the 2 Mbit/s service for digital PBXs, as *multi-line IDA*.



(*a*) Digital main and junction networks with analogue local line

IDA: Integrated digital access

(*b*) ISDN with digital transmission to customers

FIG. 4—Evolution from digital main and junction networks to full ISDN

Single-line IDA, which provides two user channels, transmits information over an existing pair in the local distribution network. It terminates at the customer's premises on network terminating equipment (NTE), and the user then has access to a range of standard interfaces for the connection of terminals. These can cover CCITT† X- and V-series terminals at transmission rates of up to 64 kbit/s, as well as high-quality telephony terminals.

The first phase of introducing ISDN to the UK is based on providing one 64 kbit/s channel and one 8 kbit/s channel as the two user channels. In addition, a further 8 kbit/s is required for signalling and control purposes, giving a total requirement of 80 kbit/s. The transmission system for this is embodied in the exchange equipment at one end and in the customer located NTE at at the other. It uses a conventional existing pair of wires and employs a technique, known as *burst-mode*, which results in an instantaneous line-rate of 256 kbit/s. Later phases of ISDN will provide two user channels of 64 kbit/s which, together with 16 kbit/s for signalling and control, will result in a total requirement of 144 kbit/s. The precise methods of providing the facilities and transmission are still being formulated, but it is most likely that the exchange-end local-line transmission system will be situated in a multiplexer which serves 15 customers and which connects to the digital exchange at 2 Mbit/s. Likewise, the customer-end of the transmission system will be located in the NTE. The transmission system is most likely to use the echo-cancelling hybrid technique which is now gaining widespread international acceptance.

2 Mbit/s Private Services and Multi-line IDA

The 2 Mbit/s transmission systems used in the local-line network are similar to those in the junction network. Minor variations relate to power-feeding and the use of attenuators to adjust signal levels to minimise crosstalk on multi-spur cables and special housings for customers' premises.

A lower-bit-rate system providing 10 channels of 64 kbit/s, but compatible with 2 Mbit/s, is being evaluated in the junction network, and may have local applications; this uses a 4B3T line code at 528 kbaud.

Optical Systems

There is already a small demand for private services at greater than 2 Mbit/s and, as the transverse-screen cable is not easily adapted for use above 2 Mbit/s, the main transmission medium for these services is already optical fibre. There are also a few applications where, irrespective of bit-rate, the special attributes of optical fibres, for example, electrical isolation, make them the inevitable choice. However, cost reductions on optical-fibre systems already hold out the promise of using them for 2 Mbit/s applications in the near future. If this is fulfilled, they would then become widespread not just for private services but for multi-line IDA as well.

Current Provision

So far, provision of optical-fibre systems to customers' premises for point-to-point private services has fallen into two categories:

(*a*) Exchange-to-customer links for services which interconnect at the exchange with the national network of higher-

† CCITT—International Telegraph and Telephone Consultative Committee

order systems for connection to a distant location. The hardware used has been the same as that for junction systems.

(*b*) Short-distance customer-to-customer links, usually also using hardware common to junction systems but sometimes purpose designed equipment.

At this point it is also worth noting the installation during the past two years of an optical-fibre network in Central London which permits the rapid provision of private services of up to 140 Mbit/s between customers in about 40 exchange areas. The cable and equipment for this network is similar to that used for junction and short-distance trunk applications, although some video equipment has also been installed. The network is pre-provided between exchanges with the exchange-to-customer link provided on demand. The inter-exchange network can also be used for junctions where the capacity is not required for private services.

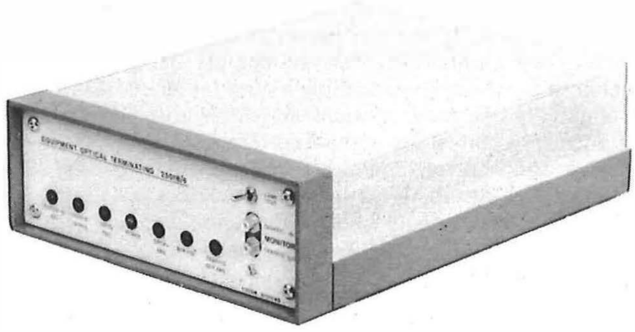


FIG. 5—Optical modem

Lower-Cost Solutions

Until very recently, optical-fibre applications in the local-line network have, as outlined above, made use of cable and equipment designed principally for junction applications. However, there are some features of local-line networks which have an impact on optical-system design and which are leading to lower-cost solutions.

The first feature that distinguishes the local-line network from other applications is, of course, short distance. The average distance from exchange to customer is only about 2 km, and business lines longer than 4 km are in a minority. In terms of multimode optical fibre, this has important implications for the choice of wavelength, attenuation and the bandwidth characteristics of the fibre, and in turn affects equipment design; these lead to lower costs for the majority of applications. Most telecommunication providers are now turning to 1300 nm and 1550 nm wavelengths and single-mode fibres in search of ever longer repeater sections and higher bit-rate capability. However, some of the advantages of using the 850 nm wavelength, principally lower device costs, cannot be ignored in the short-term for local applications. End-to-end attenuation, even if low-grade multimode fibre is used, will be fairly low because of the short distances involved, and the usable bandwidth will still be comparatively high.

The development of low-cost terminal equipment requires a critical decision on cost in the choice of optical devices. It is here that the short-distance requirements of the local-line network are of importance in the use of low-cost devices. A pair of devices (high-radiance LED and PIN photodiode) operating in the 850 nm window, with a power budget in the range 23–28 dB, can be obtained at a very small percentage of the cost of devices suitable for long-haul applications working at 1300 nm. Monitoring and fault location is another area where cost reduction can be achieved. There is not, for instance, the problem of locating faults at remote repeaters. The alarm facilities can thus be pared to an essential minimum.

An example of a low-cost 2 Mbit/s optical terminal embodying these attributes is shown in Fig. 5. A free-standing version is shown, but an electrically identical rack mounting version is also available. Items from two manufacturers are available, but they are similar in most respects. Another variant operating at 8 Mbit/s, similar in appearance and of only marginally increased cost, is also available. The first system using the 2 Mbit/s equipment has recently been commissioned. A further low-cost terminal developed along similar principles is also of interest. This has been designed with cable-television (cable-TV) applications in mind to permit four video channels to be sent (unidirectionally) over one fibre. Tests have shown that the video channels are capable of passing 2 Mbit/s and 8 Mbit/s signals. Potentially, such a system (providing bi-directional working) is of interest for local applications in providing flexible communications systems to business customers.

The availability of a variety of optical terminal equipment such as that outlined above, in addition to the existing junction range, means that changing and/or upgrading the facilities for customers is very much more easily achieved than by alternative solutions.

Cable is the other significant area of cost; it is dictated both by the type, grade and number of fibres used and the method of fabrication. A range of cost-reduced cables containing 4, 8, 12 or 16 fibres and suited to local applications has been introduced in the junction network. The range of cables initially used for cable-TV having 10 to 160 fibres are also available.

Microwave Radio Systems

These subdivide into point-to-point and multi-point systems.

Point-to-Point

At present, customer links using 19 GHz equipment are provided in some circumstances. They are most useful for expedient relief purposes for services at 2 Mbit/s and higher, particularly in view of the competitive pressures now facing BT. Systems operating at 29 GHz were also evaluated and installed during 1984, and further purchases are being considered. These systems are suitable for 2 and 8 Mbit/s services, with possible future variants catering for higher bit-rate and video applications.

19 GHz Multi-Point Radio

This is a system for taking low bit-rate (for example, 12·8, 64 kbit/s) circuits to customers that are difficult to serve by more conventional means. A central station serves a sector that is typically 90° or 120° wide and up to 10 km distance. Within this sector, outstations receive and transmit low bit-rate channels selected from an aggregate bit-rate at the central station of about 8 Mbit/s, and typically about 90 × 64 kbit/s channels can be served in one sector. The first equipment of this type will be delivered to BT during 1985.

FUTURE TRENDS

The systems described above allow a wide range of digital services, both public-switched and private, to be provided now. However, this is still the beginning of the digital era in the local-line network. Much more is technically possible and, whilst the market justification for a great deal of it is still unclear, several trends are already apparent.

Rapid Introduction of Digital PBXs

The attractions of digital PBXs for integrating office computing and communications will become rapidly apparent to users, and a fast rate of introduction is likely as more designs enter the market. The rate is likely to be increased by PBX designs using local area network (LAN) ring structures for internal communication. The added advantages that then accrue from their connection to a digitally-switched network giving internationally recognised and compatible ISDN facilities will further increase the pace of change. The effect of this will be to make 2 Mbit/s provision to business customers a commonplace event.

Integrated Services Digital Network

Increasing demand for single-line IDA could eventually lead to problems with attenuation and crosstalk on existing cables, although new transmission systems and line codes will mitigate the effects. This could, however, increase the trend to the more widespread use of optical-fibre cables.

Multiplexers

Where several customers requiring 64 kbit/s service are located in close proximity, it is likely that a multiplexer will be sited in one remote location to feed a number of customers. The prospect of externally located (cabinet and/or buried) multiplexers will also arise and provide challenges to designers in terms of reliability, low power and technical capability. The availability of remote multiplexers would allow the network to develop by using optical links from exchange to multiplexer and metallic-pairs for the final distribution to the customer.

Concentrators

Pair-gain concentrators with digital links to the exchange have been available for some time (for example, Northern Telecom's DMS1A), and remote concentrators for digital switching exchanges are being developed by their manufacturers. These applications merge with those for small digital exchanges such as the UXD5. The end result is a blurring of traditional local-line network and junction boundaries, and consequent implications for network structure and design.

Optical Systems

Although multimode optical fibres are being used to provide initial local optical systems, the application of research effort to lower cost singlemode systems makes the prospect of a move towards this almost inevitable. The wider bandwidths which would then become available hold out the possibilities of altogether different network structures and ranges of services.

The decision to make a change in provision policy from multimode to singlemode fibres is dependent on cost and technology considerations, but the decision could be potentially eased by another possibility of great interest. This is a radically new approach to the installation of optical-fibres by the viscous flow of air†. In this technique, which is being developed at the British Telecom Research Laboratories (BTRL), a simple cable sheath comprising several empty mini-bores, each typically of 6 mm diameter, is installed. Bundles of fibres are installed as required by 'blowing' them into one of the bores with compressed air. If this can be turned into a practical field system, it could transform the viability of local fibre systems by the deferral of fibre costs and make the widespread introduction of singlemode fibres possible earlier than would otherwise be the case.

† Cassidy, S. A., and Reeve, M. H. A Radically New Approach to the Installation of Optical Fibre using the Viscous Flow of Air. *Br. Telecom Technol. J.*, Jan. 1984, **2**(1), p. 56.

Cable-TV Systems

In many countries cable-TV systems have existed for some time, but until relatively recently they have been thought of as supplying domestic consumers only with entertainment channels. Now there is a prospect of providing telephony, and related interactive services, to residential customers, and digital services to business customers. However, the impact of cable-TV on the development of the local-line network is as likely to depend on the commercial and regulatory framework of the day as on technical developments.

Metropolitan Area Networks

The concepts, techniques and developments applicable to LANs for within-building data-distribution can easily be extended to inter-building and even inter-community applications where they are known as metropolitan area networks (MANs). In many cases the systems use cable-TV cable types and technology. Whether or not MANs are integrated with consumer vision services, they provide an interesting addition to the conventional systems described so far, and offer challenges in network design as the compatibility of the data-ring approach with the conventional star network requires careful evaluation.

CONCLUSION

The local-line network is at the beginning of a major move towards digital services driven principally by requirements of business customers; but ultimately they will affect the whole network. Of all the influences at work at the present time, the introduction of the digital PBX and the move to optical fibres are probably of the greatest significance. For the future, however, many possibilities exist, and it is too early to anticipate a specific network structure. The choice of which of the options to develop and adopt will depend mainly on commercial considerations and a number of studies are in hand to provide pointers to this. Whatever the results, an exciting period of change for the local-line network lies ahead.

Biography

Ian Dufour is Head of the Local and Junction Operations Division in BT Local Communications Services (LCS). He joined BT as a Youth-in-Training in Oxford Area in 1962. He subsequently worked in the Eastern Region on transmission systems commissioning and on PCM/cable planning. On transferring to Headquarters, he worked on the design of planning/provisioning computer aids and in the junction network planning and cable/transmission equipment installation standards groups. Most recently, he was Head of the Local Network Planning and Works Section. He is currently responsible for planning, installation and maintenance policy for the LCS network. This includes steering through the conversion of the junction network to digital working by the widespread use of optical fibres, and the modernisation of the local network to allow the introduction of a wide range of digital services. In addition, he is also responsible for several major computer systems and for the approval/development of a range of transmission equipment. He is also the LCS Network Quality Manager.

Engineering Education and Training for the 1980s and 1990s

The Engineering Council has published a policy statement which marks a major step in the development of its policy on engineering qualifications. *Standards and Routes to Registration*† sets out clearly the paths leading to the three qualifications—Chartered Engineer (C. Eng.), Technician Engineer (T. Eng.) and Engineering Technician (Eng. Tech.), which the Engineering Council is empowered to grant to those on its register of engineers; at present, some 300 000 names are on the Council's register.

The policy statement sets improved academic and training standards, but recognises that not all individuals follow a standard pattern and that engineering has a crucial role to play in the creation of wealth. It seeks to switch the emphasis in training from time-serving to the achievement of standards.

The statement adopts the watchwords 'integration' and 'relevance' to guide the development of engineering education and training during the decades ahead. *Integration* is between academic courses and training programmes to bring about high technical competance. *Relevance* applies to developing industrial, commercial and national needs. The Engineering Council says that these watchwords should be interpreted with flexibility to meet the rapidly changing needs of new and different types of engineers and technologists in the future.

The implementation of The Engineering Council's policy, which will begin in June 1985, and be complete by 1992, provides a challenge and an opportunity for industry, the professional institutions, academic establishments and other interested statutory and chartered bodies to work together with The Engineering Council in a progressive manner in the years ahead. The Council views the document as part of a process in which standards and routes will periodically be reviewed in line with the needs of individuals, the profession, industry and commerce.

The Council provides a new basic definition of an engineer as one who acquires and uses scientific, technical and other pertinent knowledge and skills to create, operate and maintain efficient systems, structures, machines, plant, processes and devices of practical and economic value. The successful practice of engineering requires an interdisciplinary and interdependent team effort. Those involved include:

(*a*) *Chartered Engineers* who are concerned with the development of technology through innovation, creativity and change and the effective and beneficial management of people and resources;

(*b*) *Technician Engineers* who perform technical duties of an established or novel character and maintain existing technology efficiently; and

(*c*) *Engineering Technicians* who, under direction, apply proven techniques and procedures to the solution of practical problems.

The C. Eng., T. Eng., and Eng. Tech. designations denote that individual registrants have reached standards expressed by a 'package' of academic qualifications (Stage 1 of each section of the register), training (Stage 2) and responsible experience (Stage 3). The Council works with and through 'Nominated Bodies' comprising engineering institutions and others that are willing and able to apply the standards.

The routes by which the great majority of engineers are expected to qualify in future will consist of accredited courses and approved training programmes followed by monitored responsible experience. However, the Council recognises engineering talent at whatever stage it can be identified, and so plenty of ladders and bridges enable individuals to progress from stage to stage and section to section of the register. Individuals can register even if their initial education and training does not conform to the standard pattern. These may include scientists and mathematicians, and mature candidates who can demonstrate appropriate knowledge and competence but who may not have any formal qualifications.

The Council will accredit academic courses not just in traditional disciplines, but also in broadly based specialisations, as well as courses of a unified, interdisciplinary or modular nature. Accredited courses should emphasise the watchwords 'integration' and 'relevance', the teaching of fundamentals and their application to the solution of practical problems, the impact of new technologies and the need for students to work in interdisciplinary teams. The academic standard for Chartered Engineer has been raised from a degree to an accredited honours degree and will have the new title of Bachelor of Engineering (B. Eng.). Such courses will bc enhanced in a number of ways; for example, by the mandatory inclusion of design studies, problem-solving using the latest technology, technical decision-making and cultivation of communication skills. Enhanced and extended courses will lead to the title Master of Engineering (M. Eng.). The Council states that some M. Eng. courses could, with advantage, introduce the concept of 'Engineering for the market' so that graduates are produced who have as deep an understanding of markets and profits as they have technical excellence. As a new provision, courses of appropriate academic level, but not containing sufficient engineering (for example, honours degrees in Physics) may be accorded 'part accredited' status; this enables successful students later on to enter Stage 1 Chartered Engineer by means of 'topping-up' studies.

The mainstream route for Technician Engineers and Engineering Technicians is via the Business and Technician Education Council (BTEC) and the Scottish Vocational Education Council (SCOTVEC) courses. The minimum qualifications are a Higher National Certificate for Technician Engineers and a National Certificate for Engineering Technicians. Higher National Diplomas and ordinary degrees of three years' duration may also qualify for Stage 1 of the T. Eng. Register and, in case of the latter, students may take additional 'bolt-on' courses leading to C. Eng. status. The Engineering Council defines training, in relation to Stage 2 of the Register, as instruction and practice in developing intellectual and practical skills. It says emphasis should be taken off 'time-serving' and placed on the attainment of standards, knowledge and skills. The third, and final, stage of registration concerns responsible experience and, as with training, emphasis should be placed on performance in the job, any stated minimum periods being guidelines only. It is important that those intending to become Chartered Engineers or Technician Engineers should be entrusted with early responsibility.

Certification of training and responsible experience is an essential prerequisite for registration. Chartered Engineers and Technician Engineers must also satisfy the requirements of a Professional Review, which normally includes a written report and an interview.

† *Standards and Routes to Registration* is available from The Engineering Council, Canberra House, Maltravers Street, London WC2R 3ER; price £8·00 (including UK postage)

Book Reviews

Packet Switching Tomorrow's Communications Today. Roy D. Rosner. Lifetime Learning Publications. xvii+371 pp. 263 ills. £34·00.

This is a highly readable book, written by a packet-switching enthusiast, which provides a good introduction to the principles and merits of packet switching. It is written in a very effective tutorial style, one that makes, in its 23 short chapters, use of modern ideas in methods of effective study. Each chapter begins with a brief preview of the major topics to be introduced, and ends with a review of what has been covered and a few suggested references for readers wishing to pursue topics in greater depth. A useful glossary is included. Despite the occasional appearance of awesome formulae (for example, on p. 238), the book does not demand much from the reader in terms of mathematics.

The book has six parts. Part 1, which includes a chapter on elementary traffic engineering, introduces the basic ideas of packet switching and compares it with circuit and message switching. The author's view is that packet switching is the most efficient technique for implementing a public switched data network. He makes the important point, often missed, that, because of the differences in traffic pattern, a circuit-switched network designed for voice traffic can be overloaded by relatively little data traffic.

Part 2 discusses the protocols used in packet-switched networks, and gives a brief introduction to the problems of network control. A brief description of X25 is included. Part 3, which considers aspects of practical network design, focuses on the choice of network topology and routeing method.

Part 4 covers the application of packet switching in satellite and terrestrial radio systems, and introduces the basic ideas and characteristics of the ALOHA channel, together with the slotted and reservation-based enhancements to increase channel capacity, and the idea of a mixed satellite/terrestrial packet network, with a discussion of the number and location of earth stations. It also includes a brief outline of carrier sense multiple access methods in terrestrial radio packet broadcast systems.

Part 5 describes the common carrier situation in the USA (at the time the book was written), including samples of tariffs, and reviews the emergence, status and prospects of the value-added carriers offering packet-switched services in the USA.

Part 6 considers the future development of packet switching. After reviewing ways in which packet switching could be integrated with circuit switching to form a hybrid switched network, the author concludes that packet switching probably offers the cheapest form of integrated services network suitable for both voice and data traffic.

This book is clearly not aimed at packet-switching experts. It is intended by the author both as a learning tool and as a reference for professionals in computing and telecommunications. He succeeds in the first of these aims, but not the second. Applying a tutorial approach to such a wide range of topics inevitably means that the coverage tends to be superficial, and that important topics (such as network flow and congestion control) are omitted. Furthermore, the emphasis is very much on packet switching in the USA. For example, while the background provided in Part 5 is interesting, it is of little value for reference outside the USA; less than a page is devoted to packet-switching developments in the rest of the world.

In summary, the author's primary achievement is to provide a book that is a good learning tool. It can be recommended to anyone seeking a good introduction to the art of packet switching.

J. W. ATKINS

Microcomputer Tools for Communications Engineering. Shing Ted di, John W. Rockway, James C. Logan, and Daniel W. S. Tam. Artech House Inc. x+266 pp. 99 ills. £41·00.

This book contains 25 computer programs for communication engineers. These are written in BASIC language and 'an attempt has been made to keep the programming straightforward with no machine dependent programming steps'. The subjects covered include antennas, circuits, filters, impedance matching, propagation, radio and frequency interference.

Each chapter includes a short description of a problem followed by theoretical background in some detail, and relevant literature references. The use of each program is then very well illustrated by an example; program notes and the variables used in each program are also included.

Chapters 1–5 deal with antenna design and analysis, and include two programs on the design of folded antennas and log-periodic dipole arrays. A program on the design of long-wire antennas also calculates the patterns for travelling wave dipole, VEE and rhombic antennas. The design and analysis of wire antennas is covered in depth, and the computer program for this is claimed to be a reduced version of the most advanced computer code available for the analysis of thin-wire antennas. A general moment method analysis for wire antennas is presented, and would be useful for both analysis and synthesis. In this case, the detailed program notes also identify the calculations performed in various parts of the program.

Chapters 6–10 deal with programs on AC/DC circuit analysis, phasor calculations and transmission lines. The program on circuit analysis calculates the node voltages, gain and port impedances for linear AC circuits under steady-state conditions with current sources used to model active circuits. The DC analysis program is a variation of the AC one and is limited to resistors as the only linear elements. The transmission-line program calculates characteristic impedance of different line configurations such as coaxial, single wire with a square enclosure, and parallel strip line etc.

Chapters 11–13 deal with the synthesis and attenuation characteristics of Butterworth, Chebyshev and image-parameter filters. Programs on maximally flat and equiripple passband filters are restricted to the design of low- and high-pass networks.

Broadband and stub matching techniques are considered in Chapters 14 and 15. One program deals with the design, based on a trial and error procedure, of a broadband matching network at an antenna feed point to improve the performance of a broadband antenna.

Chapters 16–19 cover ground-wave and sky-wave propagations. The programs deal with the calculations of ground-wave transmission loss/distance, maximum/minimum useable frequencies for sky-wave propagation and sky-wave signal strength and signal-to-noise ratio at the receiver.

Chapters 20–21 cover programs to calculate the intermodulation order on a given frequency produced by a number of transmit frequencies, and programs to calculate the intermodulation frequencies of a given intermodulation order produced by up to three transmitters.

Chapters 22–23 deal with satellite communications. One program calculates the distance between a ground station and a satellite, and the zenith and bearing angles at the ground. The second program determines the ground trace and altitude for communications satellites from known relevant satellite data.

The other chapters deal with programs on US amateur frequency allocation and a self-teaching course on Morse code.

On the whole, the book covers a very wide range of subjects. Detailed descriptions of the programs are not included in most cases, and comment statements are missing. Consequently, to make any alterations to suit the reader can be time consuming. However, the programs are relatively short in most cases. This book will certainly be useful to students and engineers as a reference guide for the programs as well as a source of theoretical background information on various subjects.

S. A. MOHAMED

Institution of British Telecommunications Engineers

(formerly Institution of Post Office Electrical Engineers)

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(Membership and other local enquiries should be directed to the appropriate Local-Centre Secretary as listed in the October 1984 issue on p. 211)

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Members about to retire are reminded that they, too, may secure life membership of the Institution at a once-and-for-all cost of £10·00 and so continue to enjoy the facilities provided, including a free copy of this *Journal* posted to their home address. Enquiries should be directed to the appropriate Local-Centre Secretary.

J. BATEMAN
Secretary

British Telecom Press Notice

SATELLITE SERVICE FOR OFFSHORE INDUSTRY

By next year, British Telecom (BT) will be providing a satellite communications system, to be known as *SatStream Offshore*, for oil and gas production platforms in the North Sea.

Contracts for the provision of a permanent service to a floating production platform in June 1986 have been signed by BT and the North Sea Sun Oil Company. This service will be the first of its kind between the UK's mainland and an installation in the North Sea.

BT will be building, near Aberdeen, a new satellite earth station using an 8 m diameter dish. This earth station will work to the European Communications Satellite, EUTELSAT 1-F2, and will offer satellite facilities to platforms in any part of the UK's offshore exploration and development areas.

SatStream Offshore is the result of extensive studies and development, and has been designed to meet, economically, the special requirements of the UK's offshore production industry. It will provide all mainstream communications services, such as national and international direct dialling for telephone and Telex, and will offer customers high-capacity digital transmission at rates of between 64 kbit/s and 2 Mbit/s.

BT has worked closely with the North Sea Sun Oil Company for this first application of SatStream Offshore. Unlike previous trials of offshore satellite services, this link will be to a floating production platform which, although moored to the seabed, will have pitch, roll and yaw similar to a ship. This, together with the hostile environment of the North Sea, makes precise alignment of the platform aerial an important aspect.

SatStream Offshore will augment the services already provided by BT to the offshore industry, which, at present, uses line-of-sight or tropospheric-scatter radio systems. Currently, more than 30 offshore platforms are served directly or via host platforms by BT's radio services.

British Telecom Press Notices

BRITISH TELECOM RADIOPAGING'S MESSAGE MASTER

British Telecom (BT) Radiopaging's new radiopager, known as *Message Master*, can display written messages received from virtually anywhere in the country. The new radiopager has a screen for displaying information that can be conveyed in up to 70 characters. This can be anything from names and addresses of people that need to be visited, telephone numbers to ring back, share prices or travel information. Moreover, up to 10 messages can be stored for future reference in its memory facility, which has a total storage capacity of up to 300 characters. When a message is received, a tone and flashing light alert the user, but a mute facility is provided where discretion is important; for example, meetings.

BT Radiopaging has introduced Message Master to meet the increasing demands of today's mobile business executive, who is becoming more and more dependant on being continuously in touch and well informed. Vital information can now be sent to key people when they are on the road, in a train or even while they are actually in crucial meetings.

Messages can be sent to Message Master direct by Telex or Datel (operating at 300 baud). People without access to these facilities can simply telephone a central BT Radiopaging bureau, where an operator will take down details of the message and forward it to the pager through a fully computerised system.

Message Master operates in all 40 radiopaging zones that comprise the 'National' system, but users choose and pay for only those areas in which they wish to receive calls.

BT Radiopaging offers the widest coverage available from any paging system in the UK, as well as the most comprehensive range of products, and aims to fulfill the most demanding of radiopaging needs. The Message Master, regarded as the flagship of BT Radiopaging's range, meets the real need of the modern businessman to have the most current information to hand virtually anywhere.

Message Master

NEW VERSIONS OF VICEROY AND KINSMAN, AND A NEW FEATUREPHONE

Sophisticated new versions of the popular Viceroy and Kinsman telephone systems are now available from British Telecom (BT) Merlin, and are complemented by a new advanced featurephone, known as the *TX14*.

The Viceroy 243 and Kinsman 543 telephone systems have many time-saving features, including abbreviated dialling for up to 60 centrally-stored numbers and last-number redial. Office efficiency will be greatly improved and the number of 'lost calls' reduced by the use of a variety of call-diversion facilities such as diversion on no reply, diversion of all calls, and divert on busy. A call-logging component can be added to the new systems to provide management information on both incoming and outgoing calls, and to identify telephone usage within a company. Discriminatory call barring is also available. Special features, such as message waiting and automatic alarm wake-up are ideal for small- to medium-sized hotels. Itemized billing can be provided for hotel guests when a call management system is attached.

Existing Kinsman systems can be upgraded on site to the standards of Kinsman 543, so that the new facilities can be made available to existing users.

The new TX14 featurephone is a sophisticated telephone that has many applications. It is specifically for use with the Viceroy 243 and Kinsman 543, to which it has single-button access to system features. It is also compatible with the Regent telephone system. The liquid-crystal display on the TX14 gives the user instructions and information from its bank of pre-programmed messages. Among its many other facilities are hands-free loudspeaking, auto-answering, call transfer and automatic call back. The TX14 can have a direct trunk access arrangement and multi-line appearances.

The Viceroy 243 can drive up to a maximum of eight TX14 featurephones; the Kinsman 543 can support up to 16, and the Regent system up to 64 TX14s. The Kinsman is now available in an extensive range of sizes: up to 12 lines and 48 extensions, or up to 8 lines and 72 extensions for low extension usage such as in a hotel. Systems that are not fully provided initially can be extended at a later date.

The TX14 featurephone (bottom left) pictured with the Viceroy and Kinsman systems

British Telecom Press Notices

TONTO

British Telecom (BT) Merlin is now the UK distributor of the new personal information centre, Tonto. This is Merlin's version of the recently announced ICL product, whose development was aided by significant contributions from BT development engineers. Tonto offers business users features previously unattainable in a single unit that was compact and cost effective. In fact, there is no simple description for a terminal that provides sophisticated features such as a comprehensive telephone directory and auto-calling, text messaging, database access facilities, and computing with the integrated business software package *Xchange* from the highly regarded software house of Psion. All of these features are designed for simplicity and convenience of use.

Tonto has been specifically developed for the business user who requires a multi-task desk-top terminal that is responsive to the many and varied office needs of today. While Tonto is likely to have obvious attractions for larger organisations, it will also have considerable appeal to small businesses and self-employed individuals with communications and computing needs.

BT's contribution to the development of the product stemmed from its considerable experience in the communications field. This ensured that the comprehensive communications package in Tonto provides the most complete set of features so far available in a product of this type. In addition to telephony, it provides access to Telecom Gold and viewdata services such as Prestel, and incorporates Merlin's T-link protocol for text messaging between Tontos over the public telephone network. Tonto can also gain access to Packet SwitchStream (PSS) via a packet assembler/dissassembler (PAD), and, by using its built-in modem, dial-up access to mainframe computers.

Unique to BT Merlin's Tonto is an optional data communications adaptor, which provides a standard RS423 interface with VT100 emulation so that it can be connected to a local computer, via a protocol converter if necessary, or to a local area network (LAN).

Merlin Tonto

Merlin offers a choice of printers for use with Tonto: a dot-matrix version, providing versatility and low cost, and a daisy-wheel printer, where letter-quality output is required. At a later stage, Merlin will also be adding a thermal transfer printer to its range.

BT has established a reputation for its customer support for business communications equipment. For this new and exciting product, which brings the two fields of computing and communications together, that same nationwide support for installation and a comprehensive after-sales service will be available.

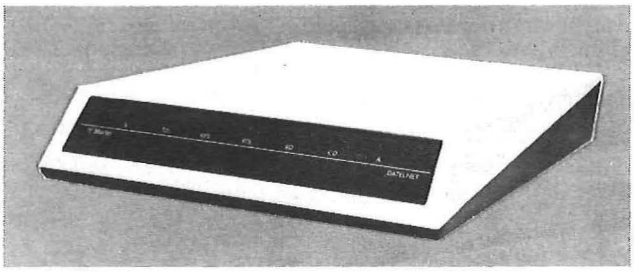
MERLIN DATELNET 500

Datelnet 500, a new addition to British Telecom (BT) Merlin's range of networking products, provides a set of equipment modules designed to give a simple and inexpensive system providing simultaneous but independent speech and data transmission over existing PABX extension cabling. Datelnet 500 can support point-to-point and multidrop data networks and permits interworking of computers, work stations, printers and terminals. Together with Merlin's Datelmux 5500 statistical multiplexers acting as a local data switch, full interlinking between terminals and computing resources can be provided.

The benefit of data-over-voice equipment is that, in using existing internal telephone wiring, it enables computers and peripheral equipment to be installed or re-sited without the need for special cabling. Thus it offers a rapid and flexible means of coping with sudden or greatly increased demand for data communications by providing, effectively, a low-cost local area network (LAN) overlayed on the telephone system.

Merlin Datelnet 500 devices make use of the under-utilised bandwidth available on ordinary PABX extension wiring. The data channel employs the higher frequency range not used in voice transmission; this allows speech and data to be carried at the same time, but avoids interference between them.

Two basic types of unit are available—desk and central—to provide these extra data communications channels. The desk units can be wall or desk mounted, and can simply be plugged into the new standard telephone sockets. The telephone and data terminal are then linked in by standard interfaces. The central units are rack-mounted near to the PABX computer. Transmission can be synchronous or asynchronous at data rates up to 19 200 bit/s with full-duplex operation.


Desk-top Datelnet 500 unit

Examples of applications for the new equipment are factories or offices where high costs of new cable, disruption caused by recabling or problems presented by old buildings or rambling sites could make prohibitive the capital risk of installing a proprietory LAN product.

Notes and Comments

CORRESPONDENCE

Mr. Whitaker's question of why automatic working at Epsom exchange, the first automatic exchange in the UK, was discontinued ('Notes and Comments', April 1984, Vol. 3, p. 65) prompted several interesting replies.

Mr. M. Clemitson's research into back issues of the *Journal* led him to write the following:

British Telecom,
Planning and Works Division,
Cardiff.

Dear Sir,

D. Whitaker asks in the April 1984 issue of *British Telecommunications Engineering* of the circumstances regarding the conversion of Epsom from automatic to manual working. As our office has a full set of IPOEE/IBTE *Journals*, I wondered if these may throw any light on the question.

Thus, following the transfer of the National Telephone Company's assets to the Post Office on 31 December 1911, occasioning the transfer of its Epsom subscribers to the Epsom manual exchange, Epsom automatic exchange opened at 3pm on Saturday 18 May 1912 with 600 multiple and two manual positions. Epsom, it is reported, was chosen for the first public automatic exchange on account of its relatively high percentage of local traffic, the nature of its climatic conditions, the character of its telephoning public and its proximity to London, which would allow the performance to be monitored by headquarters personnel.

An extension of 200 multiple was added in 1923, and a further extension of 300 multiple is reported in 1931. And there the trail goes cold, subsequent issues of the *POEEJ* being silent on the change to manual working at Epsom.

Despite the obvious advantages of automatic telephony, new manual exchanges were of course being opened elsewhere; for example, 1931 saw the opening of those at Morecambe and Worthing, both of which I am fairly sure were still in service into the late-sixties. Clearly, the increasing size of the telephone service (from 159 000 exchange lines in the London District at March 1921 to 414 000 at March 1931) put great demand on the equipment and financial resources available, and it was not feasible to install automatic equipment in every case. Mr. G. F. O'Dell of the Engineer-in-Chief's office explained in 1934: 'In actual practise, however, the adoption of automatic working can, generally speaking, only be justified if the annual cost of automatic working is less than that of manual working.'

Presumably this was not the case for Epsom when the 1912 equipment became exhausted on age or accommodation grounds, and as a result a replacement manual exchange was ordered.

I am indebted to Mr. D. A. Randles, the IBTE Local-Centre Secretary, for allowing me ready access to his collection of IPOEE *Journals*.

Yours faithfully,
M. Clemitson

Mr. T. J. Morgan of Brighton, Sussex, provided a similar explanation: '..It [Epsom exchange] was replaced in 1931 by a manual exchange because it was the policy at that time for small exchanges to be manual...'

Mr. M. W. Bayley's letter gave another reason:

Gloucester

Dear Sir,

In the absence of more reliable information, I may be able to help answer Mr. Whitaker's query.

When I joined the old Telegraph Branch, Engineer-in-Chief's Office (E-in-CO), in 1949, there were still those about who had been transferred from the National Telephone Company.

It was fairly common knowledge then that Epsom had been the first automatic exchange, although at that time it was of course CB. The explanation always given was that, as today, all new ideas and developments have to be 'field trialled' to make sure that their performance is as predicted. Epsom was already automatic and located near to the E-in-CO. Where better to try things out? Undoubtedly, subscribers in Epsom had an affinity with those in London and, in all probability, many of the alternatives which led up to the ultimate call code indicator (CCI) were tried there.

In the end, the Epsom subscribers became so fed up with the frequent changes in their dialling instructions that, or so I am told, they petitioned the Postmaster General, asking that the automatic equipment should be replaced by a simple manual exchange. I never knew when this occurred but I would imagine that this was during the 1920s when preparations were being made for the London director system.

Yours sincerely,
M. W. Bayley

Mr. Sparrow of Lewis in East Sussex wrote in a similar vein: '..Epsom went automatic in 1912, but it was such a disaster that it had to be converted back to manual, and the subscribers were promised that they would not go automatic again until all the remaining London exchanges were automatic. This promise was kept; in fact, it was nearly the last exchange to go automatic in the country...'

Finally, Mr. A. W. Smith gave, perhaps, the most likely explanation:

Thorpe Bay,
Southend-on-Sea.

Dear Sir,

D. Whitaker's letter concerning the reversion of the UK's first automatic exchange at Epsom to manual working prompted memories from the mid-1940's spent as a Y2YC in the South West Telephone Area, London Telecommunications Region.

Epsom automatic exchange simply could not cope with the telephone traffic generated during 'Derby week'. The amount of automatic equipment required was far in excess of that required for the rest of the year and it was not economic to provide it. Investment limits existed even in those halcyon days!

During the 1940s, telephone operators from nearby manual exchanges such as Vigilant, Fairlands, Wallington and Wimbledon were loaned to Epsom exchange during race week and all the manual board positions were double manned (womanned) in order to cope with the traffic.

It was not unusual for all the operators' cord circuits to be in use simultaneously during Derby week.

Yours faithfully,
A. W. Smith

PUBLICATION OF CORRESPONDENCE

The editors were pleased at the number of replies to Mr. Whitaker's letter, and would like to encourage more letters intended for publication in the *Journal*. A regular correspondence column could become a lively and interesting feature. Readers are therefore invited to write to the editor 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 should be sent to the Managing Editor at the address given below.

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 *Supplement* included with the January 1985 issue of the *Journal* contained the final part of the educational paper entitled *Microcomputer Systems*—a revised version of one of British Telecom's series of *Educational Pamphlets*. The Editors hope to publish further similar educational papers in forthcoming issues of the *Supplement*.

The Editors would like to hear from anyone who feels that they could contribute further papers in this series. Papers could be revisions of other *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 those who are new to the telecommunications field, and would be useful for revision and reference and for finding out about new topics.

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

Guidance for Authors

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

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

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

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

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*, NN/CMS2.2, Room 704, Lutyens House, Finsbury Circus, London EC2M 7LY.

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IMPORTANT ANNOUNCEMENT ABOUT DISTRIBUTION OF THE JOURNAL

The Council of the Institution of British Telecommunications Engineers has been concerned for some time at the difficulties of distributing copies of *British Telecommunications Engineering* to members and subscribers in British Telecom (BT) or the Post Office (PO). The Council has therefore decided to computerise the records of its members and subscribers, and to mail the *Journal* direct to their homes. The computerised record will enable the Institution to provide a better service for its members.

All Full Members of the Institution, and Associate Section Members and other employees of BT and the PO who subscribe to the *Journal* by deductions from pay, are therefore asked to complete the gold-coloured form inserted in this issue of the *Journal* and to return it to the address printed on the form.

Members and subscribers should return the form as soon as possible. The first issue of the *Journal* to be distributed by the new system will be the October 1985 issue. From then on, the present arrangements for distributing the *Journal* to staff in BT or the PO will cease. External subscribers, Retired Members, Corresponding Members and Honorary Members are not required to complete the form.

Future issues of the *Journal* will contain a return slip for use by those who change their address.

Forthcoming Conferences

Further details can be obtained from the conferences department of the organising body.

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

CONFERENCES

Software Engineering
28–30 August 1985
Imperial College, London

Measurements for Telecommunication Transmission Systems
27–28 November 1985
Institution of Electrical Engineers

Computerised Quality Assurance
23–26 March 1986
University of Sussex, Brighton
Synopses by: 17 May 1985

Software Engineering for Telecommunication Switching Systems
14–18 April 1986
Eindhoven, The Netherlands

VACATION SCHOOLS

Land Mobile Radio Systems
7–12 July 1985
University of Bath

Transmission for Telecommunications
14–19 July 1985
University of Aston in Birmingham

Computer-Aided Tools for VLSI System Design
21–26 July 1985
University of Newcastle-upon-Tyne

Software Engineering for Microprocessor Systems
21–26 July 1985
University of York

Designing against RF Emission
1–6 September 1985
University of Sussex, Brighton

Industrial Digital Control Systems
8–13 September 1985
Balliol College, Oxford

Microwave Measurements
8–14 September 1985
University of Kent

Cable TV
9–13 September 1985
Leeds Polytechnic

Semi-Custom IC Design and VLSI
22–27 September 1985
King's College, Cambridge

Data Communications and Networks
22–27 September 1985
University of Aston in Birmingham

Power Electronics
September 1985
University College of Swansea

Institution of Electronic and Radio Engineers, 99 Gower Street, London WC1E 6AZ.
Telephone: 01–388 3071.

Advanced Manufacturing Techniques in Electronics
2–4 September 1985
University of Edinburgh

Networks and Electronic Systems
17–19 September 1985
Forum Hotel, London

Technology Management
3–4 October 1985
Grand Hotel, Eastbourne

Statistics for Industry (UK) Ltd., 14 Kirkgate, Knaresborough, North Yorkshire HG5 8AD.
Telephone: 0423 865955.

Introduction and Statistics for Engineers
22–23 July 1985
University of Warwick

Introduction to Reliability Analysis
24 July 1985
University of Warwick

23 October 1984
Bloomsbury Crest Hotel, London

Online Conferences Ltd., Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE.
Telephone: 01–868 4466.

NETWORKS 85
25–27 June 1985
Wembley Conference Centre, London

Cellular Communications International
5–7 November 1985
Wembley Conference Centre, London

EUROCON 86 General Secretariat, 11 Rue Hamelin, F-75783 Paris Cedex 16, France.

Advanced Technologies and Processes in Communication and Power Systems (EUROCON 86)
21 – 23 April 1986
Paris, France
Abstracts by: 1 June 1985

COMPINT 85, PO Box 577, Desjardins Postal Station, Montréal, Québec, Canada H5B 1B7.

Computer Aided Technologies (COMPINT 85)
9 – 12 September 1985
Montreal

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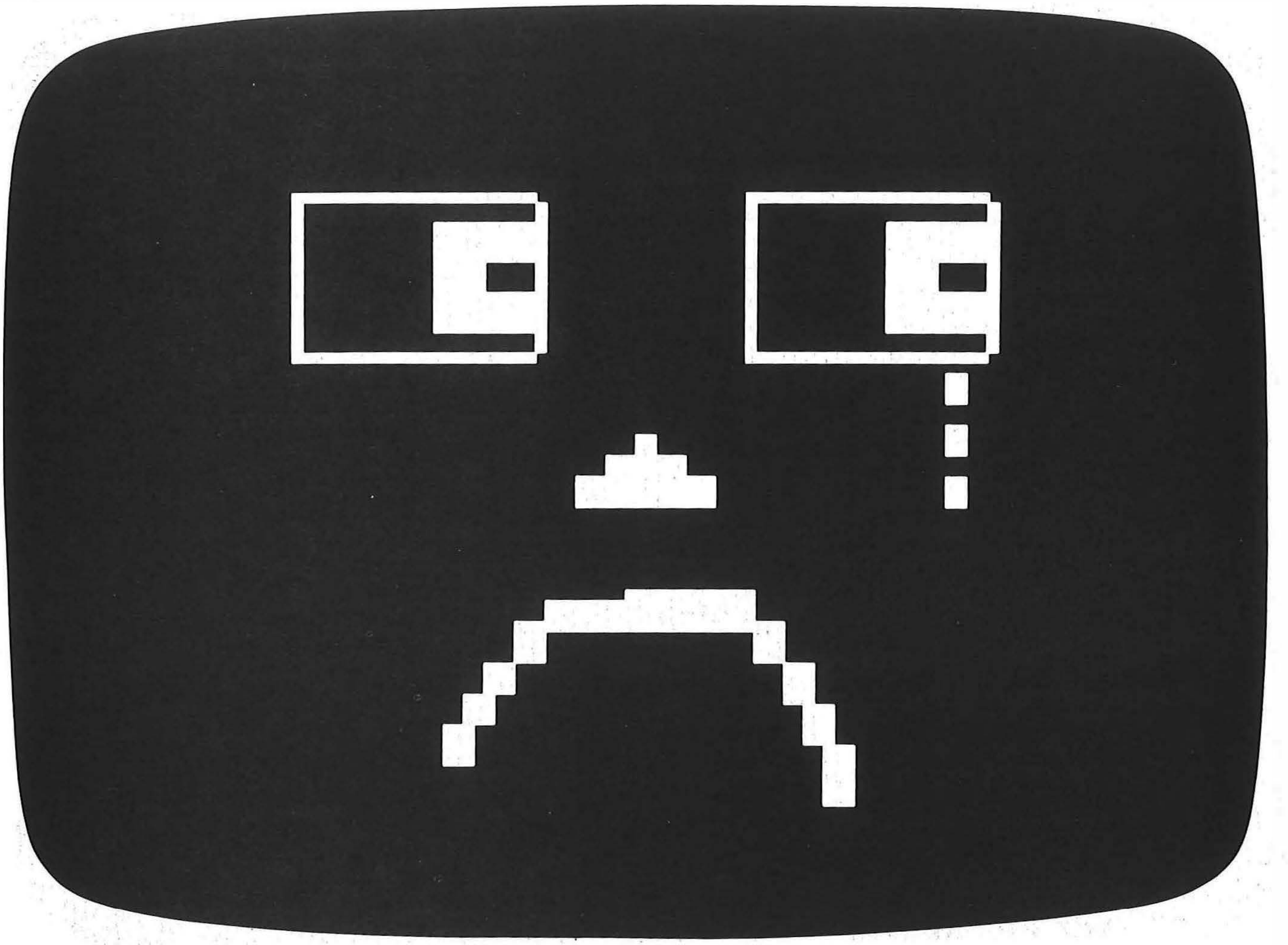

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