ATR

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SPECIAL ISSUE

SYMPOSIUM – WHITHER COMMUNICATIONS?

Volume 7, Number 3, 1973

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FOREWORD

This issue of A.T.R. is the first special issue published outside the normal series. It is also the first commemorative issue.

It provides a welcome opportunity to record the high standard achieved in the celebration of the Golden Jubilee of the Australian Post Office Research Laboratories, as well as acknowledging the individual contributions which have been made. Arrangements for both the Symposium "Whither Communications?" together with the associated Jubilee Open Days displayed the same competence and enthusiasm which has placed the Australian Post Office in a leading technological position, both nationally and internationally.

We are all grateful to the eminent leaders in their fields who contributed to the Symposium providing us with such an authoritative preview into the future of telecommunications. This is the first occasion on which such a distinguished gathering has assembled in Australia to take stock of future developments. Mutual benefits have been derived from the presentation and discussion of papers presented at the symposium.

Lionel Bowen

Postmaster-General.

INTRODUCTION

Fifty years ago, a Research Laboratory was formed in the Australian Post Office to ensure that new developments and inventions could be considered in depth and in freedom from the distractions of the day-to-day activities. This reflected an early awareness that the technological content of communications will be continually expanding if we are to continue to meet the ever-increasing volume and increasing complexity of the needs of a vigorous and expanding nation.

The steady growth of the Research Laboratories has reflected the increasing introduction of new technologies into our technical operations. In-depth consideration of new developments has enabled us to conduct meaningful discussions with contractors, to assess competently the systems and equipment offered to us, and to install and operate the equipment without undue difficulty.

The work of the Research Laboratories is well known both inside and outside Australia. The staff is in regular contact with industry, the academic institutions and other research establishments. Staff interchange between the Research Laboratories and other bodies is common.

It is this involvement with new developments at an early stage, which has resulted in much of our technological strength. New developments in the laboratory stage usually require many years to reach application in the field, but it is in the first years of the development that the major operating features and characteristics are formed, which will greatly influence later application and utility. It is for this reason that it is so important to have a group dedicated to the contemplation of advanced concepts, systems and techniques.

The Symposium "Whither Communications?" is particularly fitting as it provides a commentary on many of the topics under consideration in the Research Laboratories; it is also pleasing to note that the Research Laboratories have strong ties with the organisations which have contributed.

The success and impact of the celebrations are due to the untiring efforts of many people, both inside and outside the Research Laboratories, at all levels and in many disciplines; they are to be congratulated on their efforts.

The Telecommunication Society of Australia is to be commended for its action in publishing all of the Symposium papers in one special issue; it will form a valuable record in the years to come for all who are concerned with future planning in telecommunications.

E Lane

Director-General.
Australian Post Office.

CHALLENGE . . .

"Whither Communications?"

Telecommunications is one of the most rapidly expanding public utilities in Australia, both in the volume of the business handled and in the variety of services being required. This is not a local phenomenon, but it is a pattern which is repeated in other parts of the world.

If we are to keep abreast of the twin demands of increased volume and increased services, we must be continually seeking new technologies which are able to meet these demands. However, the need for compatibility of new technologies and systems with the existing networks will always provide constraints on the latent advantages of new systems. For this reason alone, it is important that we should always survey the future, however ill-defined, so that undue constraints will not be introduced.

We are not only concerned with technological developments; the future developments of telecommunications will also be influenced by economic, demographic and sociological trends, all of which are interdependent.

These factors are well recognized in the Australian Post Office Research Laboratories, and this realization led to an examination of the future lines of development via the Symposium "Whither Communications?", held as part of the Golden Jubilee of the Laboratories. It is notable that sociological and economic factors are mentioned in many papers; one is devoted entirely to sociological considerations.

The collected views of experts from all over the world tend to be remarkably consistent, as is evidenced in the following papers. The way is pointed, the task of implementation will provide a continual challenge.

R. W. Turnbull

First Assistant Director-General
(Planning and Research)
Australian Post Office

The Integration of Telecommunications

W. J. BRAY
Director of Research, British Post Office

This paper will outline the expanding scope of telecommunication services including data, facsimile, videophone and TV conference facilities; the technical, operational and economic reasons that support the concept of a multi-purpose integrated switching and transmission network and the possibility for the exploitation of the existing, and possible future broadband, local distribution networks. In particular, the case is made for a multi-purpose national network as opposed to the fragmentation and inefficient use of resources that a multiplicity of independent competing networks would entail.

1. Introduction

It is indeed an honour to be invited to present this inaugural lecture on the occasion of the Golden Jubilee of the Research Laboratories of the Australian Post Office. It is also a very great pleasure since in the 50 years that telecommunications research has been conducted in both the Australian and British Post Offices, there has developed a close affinity of interests, involving inter-laboratory visits for technical discussions and exchanges of staff. I very much hope that the future will see an even closer collaboration in joint research projects.

My colleagues in the British Post Office join with me in wishing you a most successful and rewarding future in this fascinating and challenging business of telecommunications.

I have chosen as the basic theme for the lecture the "integration of telecommunications" — using this to mean all that is involved in the planning and design of the future network, so that it can provide flexibly and economically for the dominant requirements of telephone service growth together with a range of new customer services and facilities, utilizing to maximum advantage common plant for inter-city transmission, switching and local distribution. In my view this concept is important because the alternative approach, i.e. the provision of such services by a multiplicity of separate and uncoordinated means, is likely to be conducive neither to economy nor the efficient utilization of national resources.

Because of my personal background with the British Post Office the lecture is based largely on experience and developments in the United Kingdom, recognising however that the Australian environment is different and other approaches may be appropriate in that environment.

2. The Present Scene

Telecommunications in the United Kingdom is now at a critical phase of evolution after several decades of slow but steady growth of telephone service leading to some 40% penetration and a significant development of TELEX (teleprinter) and DATEL* (data transmission) services.

Inter-city transmission is currently on coaxial cable and microwave radio-relay systems using frequency-division multiplex (fdm) carrier techniques to transmit a thousand or more voice channels on each coaxial tube or microwave carrier. Pulse code modulation (pcm) time-division multiplex digital techniques are now making their appearance in multi-pair junction cables connecting exchanges where they enable two pairs of wires to carry up to 30 voice circuits.

Exchange switching in the United Kingdom — as in most countries of the world — is still dominated by electro-mechanical systems typified by the step-by-step Strowger switch. The success of the Strowger switching system has been due to its simplicity and low first cost; its limitations, notably the slow operating speed associated with the 10 impulses per second of the telephone dial, the limited flexibility and need for considerable maintenance, are becoming increasingly apparent as the network expands and new customer facilities and services are introduced. However, some 400 semi-electronic exchanges serving 400,000 customers are now in operational use in the United Kingdom and are providing speedier and better service, with lower maintenance costs. 200 more semi-electronic exchanges will be installed by next year, serving another 200,000 customers. These semi-electronic exchanges use rapid-operating, noise-free reed relays with contacts protected from the atmosphere and will provide faster call set-up in a modern network with push-button telephones.

3. The Challenge for the Future

Advances in technology are now taking place and new system concepts are being explored that will significantly affect the future of telecommunications. Typical of these are new transmission media of very wide bandwidth exploiting pcm digital techniques, computer-controlled switching systems using digital time-division as well as space-division switches, large-scale integrated circuits, high-speed logic circuits, large-capacity and fast access memory devices, and new types of solid-state visual display and image sensing devices. These technological advances will

* United Kingdom descriptions are indicated in capitals

not only contribute to the economic growth and improvement of telephone service, they will also make possible and economic many new telecommunication services such as higher-speed data and facsimile transmission, conference television, video telephones, access to data banks and visual information services. They could also enhance the range of entertainment sound and television services available in the home, and provide audio/visual services for educational and community purposes via broadband local distribution networks.

In highly industrialised countries such as the United Kingdom, with massive growth of telephone service forecast during the next two or three decades, these technological advances and new service possibilities will have a major impact on the structure and size of the future national network. They will in turn affect expenditures of \$1000's of millions, corresponding to some 2% of the gross national product, and could have major economic and sociological consequences in the long term. Amongst the sociological benefits of enhanced telecommunications could be a greater freedom to relocate and disperse units of industry and government, and the reduction of travel, e.g. home-to-office commuting, needed for information exchange and processing purposes. In a world likely to be increasingly dominated by shortages of the fossil fuels required for conventional transportation, the capability of telecommunications to annihilate distance at very little cost in energy consumption may well prove to be the greatest benefit of all.

Amongst this background, decisions concerning the nature and size of the future telecommunications network, its ability to adapt and evolve to meet changing needs, and the proportion of national, financial and other resources that should be allocated to its development and implementation, are seen as of crucial importance to the national economy and well being.

It is the purpose of this lecture to suggest that an integrated service and system approach to the future telecommunications network offers many advantages, recognising nevertheless that this presents major challenges to telecommunications administrations. Not the least of these is the need to respond speedily and satisfactorily to customer requirements, and to utilize effectively the innovative and competitive capabilities of industry.

There is too the difficult problem of evolving from the present telephony-centred network with its massive capital investment in existing plant to the multi-service integrated telecommunications network of the future. This evolution must take into account the need for the old and the new networks to co-exist and interwork; it must also recognise the financial considerations involved in premature obsolescence of existing plant and the large-scale provision of new plant.

Because the expanding role of telecommunications is not solely a matter of technology but is of vital concern to the national economy and the needs and well being of people and industry, the British Post Office has established a multi-disciplinary team of engineers, sociologists and economists — its Long Range Studies Division — to study the longer term future of telecommunications, its roles in domestic and business life, its impact on transportation, the environment, education and welfare, and to make recommendations as to preferred directions of development and the optimum utilization of resources. Another team — the Advisory Group on Systems Definitions — has been studying with industry an organizational framework for the future network and its division into sub-systems for switching, switch control and signalling, transmission and local distribution with defined interfaces. An essential feature of this framework is its evolutionary capability, i.e. to meet changing service needs and to take advantage of advances in technology.

4. New Telecommunication Services

The range of new services under study is wide and expanding (Fig. 1). Those to be described are indicative of only some of the possibilities being examined; clearly, firm decisions must be based on detailed assessment of marketing trials and economic prospects. Similar studies are being made by other telecommunications administrations, and the European Posts and Telecommunications Conference (CEPT) has put in hand a co-operative "needs research" program to establish the type and scale of telecommunication services likely to be required in Europe by 1985.

Whilst some of the "new" services are effectively extensions of the facilities offered by existing services (e.g. telephone call transfer, short-code dialling, telephone conference facilities, radio-paging and faster data transmission), many are in the field of visual telecommunications. Typical of the latter are facsimile, data access with visual displays, television conference facilities and videophones. As such they may be regarded as adding a new dimension to telecommunications by utilizing the sense of sight as well as, or as an alternative to, that of hearing.

4.1 Human Factor Studies

Basic problems for future customers will be the selection of the most appropriate service or facility from a rapidly increasing repertoire, and to cope with the operational problems of using the service

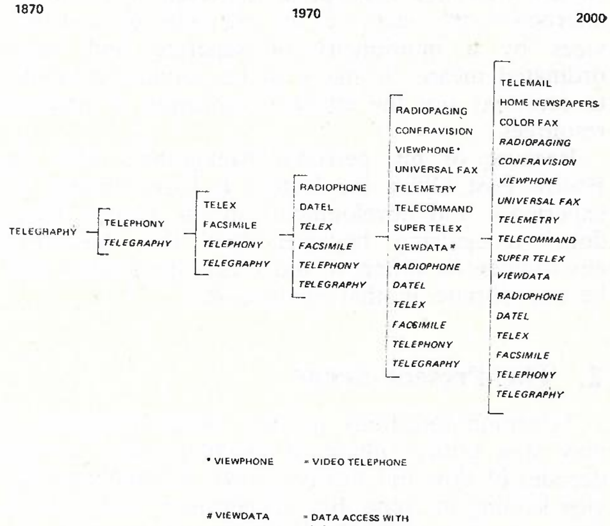


Fig. 1—Telecommunication services to year 2000

or facility. Human factors studies have an important role to play in making the system easier to use by customers, thereby increasing the potential profitability of the telecommunication system itself.

Where a visual telecommunication service is to substitute person-to-person or group-to-group face-to-face confrontation, as with the videophone or conference television, there is a need for more "human factors" studies to assess its effectiveness in a range of domestic and business situations*. Preliminary indications are that in such situations vision adds most effectively to communication when the participants are not known to one another, where the contact involves some measure of negotiation or argument, or where the establishment of personal relationships is relevant.

Human factors studies are also needed to establish the optimum "trade-off" between detail of the moving visual image, its format and bandwidth on the one hand, and its effectiveness as a mode of communication on the other. Such studies need to take into account the effects on the visual image of signal processing for bandwidth reduction. These considerations apply also to still picture, e.g. facsimile and document transmission, where transmission time, as well as bandwidth, is a significant parameter.

Human factors studies may well have an important bearing on the cost effectiveness and market acceptability of new visual telecommunication services, especially in the transitional stage when such services have to be provided in the existing network with its relatively high transmission costs. In this phase "narrow bandwidth" visual services are likely to prove more economic and attractive to customers. As new wideband transmission media are introduced, and the cost of transmission per unit of bandwidth decreases, wider bandwidth visual services offering a higher degree of customer satisfaction could come into their own.

The following outlines some of the new telecommunication services being studied by the British Post Office. It is to be noted that the status of these studies is "exploratory", no decisions concerning operational use have been made at the present time. They are nevertheless of considerable importance in planning the future integrated network.

4.2 Facsimile (UNIFAX)

A recent United Kingdom study (Ref. 1) has suggested that facsimile may become by the end of the century the most widely used of the new telecommunication services in view of its capability for transmitting all kinds of written, typescript, diagrammatic or photographic information, using the voice channels of the public switched telephone network. A major requirement before a universal facsimile service (UNIFAX) could be established is for machine compatability in all essential electrical and operational characteristics, based closely on internationall agreed CCITT standards.

A number of technological developments now being explored could contribute to the widespread use of facsimile, including the following:

— the use of solid-state image sensing the forming devices together with integrated circuits for signal processing; reducing costs and improving reliability as compared with current systems which depend on close-tolerance, electro-mechanical sub-systems;
— improved reprographic techniques giving better quality;
— signal processing and storage techniques permitting:
  (a) reduced transmission time, e.g. 30 seconds compared with 4 to 6 minutes for an A4 page, and
  (b) delayed, e.g. overnight transmission;
— automatic call set-up techniques, e.g. for use with overnight transmission.

In addition to the day time use of facsimile where rapid transmission may be required for business purposes, an overnight delayed service at preferential rates is envisaged. Such an arrangement could provide additional revenue from the switched telephone network when it is normally very lightly loaded. If machine costs can be reduced, and reliable automatic operation achieved, an overnight letter facsimile service (TELEMAIL) could become a serious competitor to the normal mail service, attracting both domestic and business users.

4.3 Data Access (VIEWDATA)

The switched telephone network could provide the means for obtaining visual access to data and information sources at present exploited only in terms of recorded voice responses, e.g. for weather forecasts, stock-exchange quotations and the like. The VIEWDATA service, (Fig. 2), envisages the use of the telephone dial or push-buttons to obtain two-way interactive access to a wide range of data and information sources, and computing services, in which the response is essentially visual using either a domestic TV receiver, a professional visual display unit (VDU) using a cathode ray tube, a solid-state (e.g. light emitting diode matrix) device or a modified videophone (VIEWPHONE). The customer access device may be simple, i.e. the telephone dial or pushbuttons, or more complex with an extended keyboard and light pen associated with

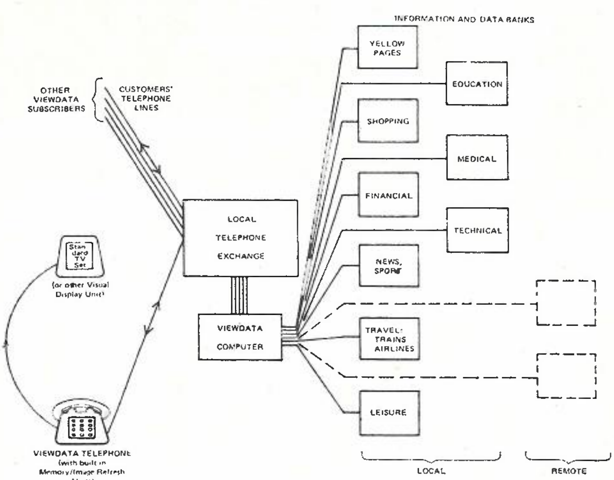


Fig. 2—Viewdata schematic

* Some valuable initial studies in this field are being made by the Communication Studies Group, University College, London, under the contract to the BPO and the Civil Service Department

a VDU. The displayed information may range from simple alpha-numeric to 500 or 1000 line graphics, depending on the complexity of the customer terminal.

Whilst the widest acceptability of VIEWDATA could be achieved by operation within the 3 kHz bandwidth of the switched telephone network, it is possible that alternative modes of operation offering higher definition and speedier access for document display may be of value to business users. This may be possible, for example, by exploiting the 1 MHz bandwidth of a VIEWPHONE channel.

The computer system supporting VIEWDATA would be located at a central exchange; it accepts dialled or keyed information from subscribers, ascertains their requirements by a simple question and answer dialogue and switches the customer to the required service.

Typical applications envisaged for VIEWDATA include:

Information Services
- Telephone directories, yellow pages
- Transport timetables
- What's on at local entertainment centres
- Weather

Hotel and Travel Reservations

Business Applications
- Payroll
- Accounting
- Secretarial Services
- Tax return preparation

Education
- Home courses for school-age children
- Specialized training courses for adults
- Link with "University of the Air"

Medical
- Self diagnosis
- Local doctor/hospital medical services

Professional Information and Services
- Literature retrieval
- Technical information
- Report preparation and editing

Shopping Aids
- Shopping and mail-order services
- Market prices
- Local stores and supermarkets

Message Communications
- Link with TELEX service
- Messages for absent customers

Computing Services
- Electronic "slide rule"
- Transfer of data and programmes between computers.

The broadcasting authorities in the United Kingdom, the British Broadcasting Corporation and the Independent Broadcasting Authority, are exploring the possibilities of data access services using information included in the broadcast television waveform (i.e. the BBC "CEEFAX" and IBA "ORACLE" systems). These are essentially one-way non-interactive information systems using domestic television receivers to display alpha-numeric information and aim at regional rather than local area coverage. Clearly a degree of compatability between VIEWDATA and the broadcast information services will be of value.

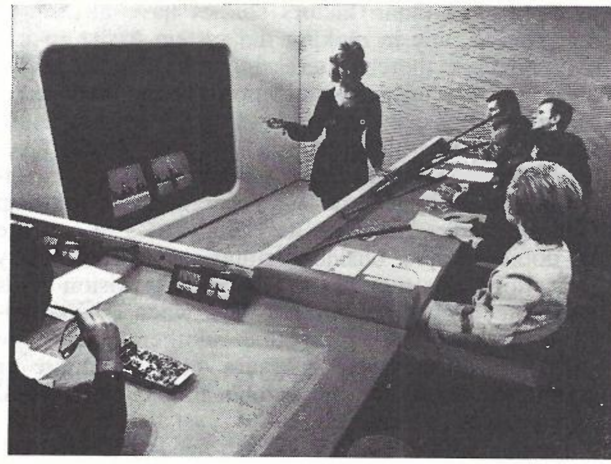


Fig. 3—Confravision terminal

4.4 Conference Television (CONFRAVISION)

At the present time the British Post Office is conducting a preliminary field trial of a CONFRAVISION system between 5 inter-linked public studios in major cities, enabling groups of up to six people at pairs of locations to see and hear one another, (Fig. 3). The trial system uses 625-line monochrome TV standards with high-quality 4-wire sound circuits. Vision links are provided by the protection channels of the inter-city microwave radio-relay system.

Experience to date has confirmed the effectiveness of CONFRAVISION as a means of communication between small groups of people in spite of the technical limitations of the present system. It is a striking fact that within minutes of entering the studio, discussion proceeds almost as freely as across a table, even when the participants have no previous experience of the system. Whilst the effectiveness of the system depends in considerable degree on high-quality sound there is no doubt that vision contributes substantially.

The value of a CONFRAVISION service to business organizations increases with distance and the greater time-saving it offers compared with conventional travel. The viability of the service and acceptability to customers will depend on several factors of which the following are important:

— the reduction of inter-city transmission costs, e.g. by exploiting new wideband transmission media such as waveguides and using signal bandwidth conservation techniques;

— the availability of wideband local distribution systems, e.g. on coaxial cable, optical fibre or millimetric microwave radio, enabling studios to be located at the premises of users and linked to the trunk transmission network.

In addition, studies are being made to optimise the picture format in order to conserve vision signal bandwidth, a horizontal narrow rectangle being more appropriate for CONFRAVISION than the nearly square aperture of conventional TV receiver screens. Also of interest for the future are:

— the large-screen projection techniques — possibly in 3-dimensional format;

— an "electronic" blackboard for high-definition still-picture document display;

fast facsimile making quickly available hard copies of documents under discussion;
— the use of "sound in-synch" techniques for the high-quality 4-wire sound circuits.

Privacy may be important in a business conference situation; for this purpose digital transmission with bit "scrambling" could offer a relatively high degree of privacy on both sound and vision circuit at an acceptable cost.

4.5 Videophone (VIEWPHONE)

As experience in the United States with the Bell "Picturephone" has demonstrated, the provision of a public videophone service has to be approached with considerable caution in view of the large capital investment involved and the need to be assured of customer acceptance of the offered service. Inter-city transmission costs are at present high because of the relatively wide bandwidth of the video signal, typically 1 MHz for a 319 line, 50 fields/sec standard. This situation could improve as new wide-band inter-city transmission links such as wave-guides with lower costs per unit of bandwidth are introduced. On the other hand, tests indicate that a large proportion of existing wire pairs between customers' premises and local exchanges in the United Kingdom are capable of transmitting satisfactorily analogue video signals of up to 1 MHz bandwidth, and this would enable additional use to be made of the substantial capital investment in the existing local distribution network. Furthermore, as processor controlled switching systems with more advanced signalling methods are introduced, the control and signalling methods could be shared between telephony and videophone service.

Reference has been made earlier to the need for more human factors studies to determine the value and acceptability of videophone service to customers, and to optimise design. These will need to be supplemented by field trials and marketing surveys before a public service can be contemplated.

Meanwhile, a number of private network applications of VIEWPHONE for specialised applications are being examined. These are, in general, applications where the ability of VIEWPHONE to indicate motion are important, e.g. traffic monitoring, security surveillance and for medical purposes such as access to specialist help on diagnosis. For such applications the ability to accommodate the video signals in existing wire pair cables rather than coaxial cable, and the relative ease of providing dial-up facilities, are valuable features.

Other studies are aimed at improving the present very limited ability of VIEWPHONE to handle alpha-numeric and documentary (graphics) information. This may be achieved by providing a local image store/refresh capability, e.g. in the form of a compact cathode ray tube "memory" device, capable of accepting say a 500 or 1000 line picture transmitted in two or four seconds, and rescanned 50 times per second for display on the VIEWPHONE screen, (Fig. 4). A high-definition graphics facility, which might be likened to "electronically turning the pages of a book", could be associated with a fast facsimile print-out of any selected display for which a permanent record was required.

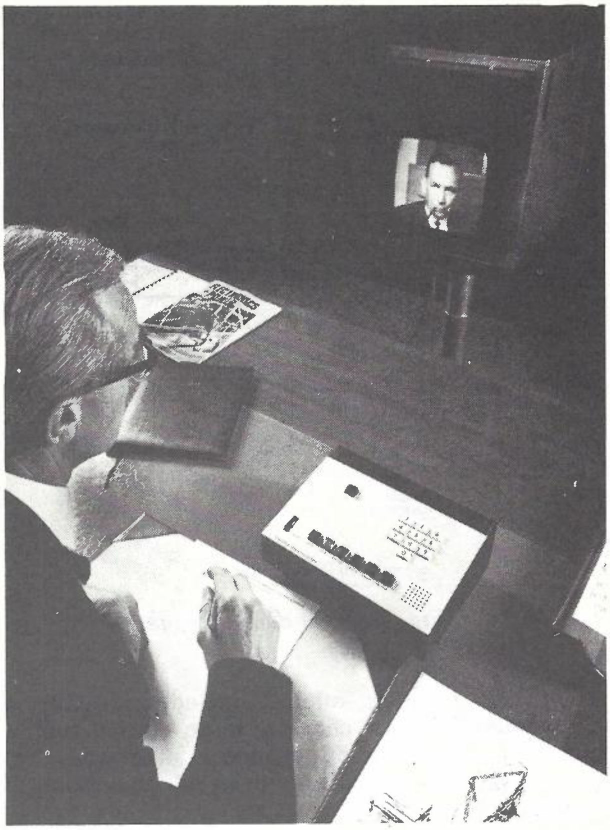


Fig. 4—Viewphone

4.6 Public Switched Data Service

Data communication is a fast growing service in the United Kingdom, with more terminals in use than in the rest of Europe. The present services, known under the generic title of "DATEL", offer speeds up to 2.4 kbit/s on leased lines and on the public switched telephone network. Adaptive equalization techniques now under development should enable these speeds to be increased to 4.8 kbit/s or more. In addition, a 48 kbit/s service is available on leased wideband circuits.

Recognising the need for lower data error rates than is practicable on the present public switched telephone network using fdm analogue techniques, plans have been prepared for a new public switched digital data service that could form part of an integrated telecommunications network, although functionally distinct.

The new service will provide a range of data speeds based on CCITT standards, including up to 600 bit/s non-synchronous, e.g. stop-start; 600 bit/s and 2.4, 9.6, 48 kbit/s synchronous. Transmission will be digital at 60 kbit/s and 2 Mbit/s over local lines and junction pair cables to data switching exchanges, and thence over digital links using group or super-group bands in fdm carrier systems, or on digital microwave or coaxial cable systems, (Fig.5).

Two different modes of operation are envisaged:

(ii) circuit switching, with a discrete path between calling and called customers;

(iii) packet switching, in which blocks of data are transmitted in intermittent short bursts.

The packet switching mode is regarded as an experiment designed to assess the claimed advan-

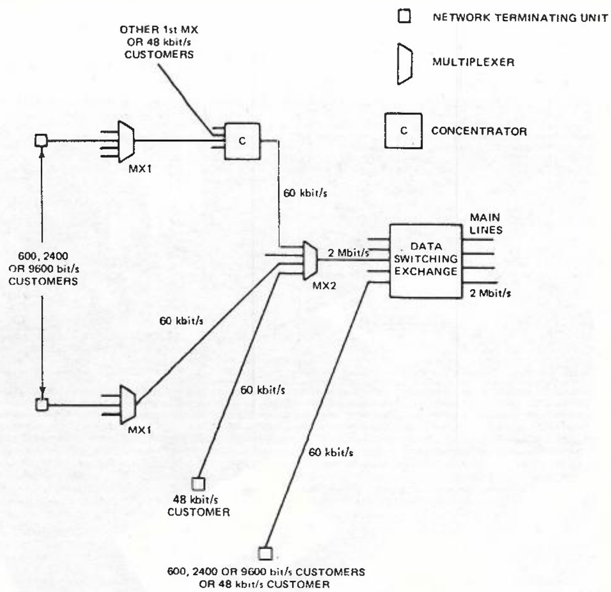


Fig. 5—New data network

tages and facilities offered, including: ability to accommodate speed changes; more efficient utilization of communication channels; automatic error correction and re-routing to avoid congestion or failure on main links.

5. Changing Technology and New System Concepts

5.1 Device Technology

One of the important advances in technology facilitating the introduction of new services is the continuing progress made in integrated circuits in terms of increased storage density, higher speed and reliability, and lower costs. This evolution is likely to continue for at least the next decade and will have a significant effect on system concepts and design, including more cost-effective electronic exchanges and processors for stored program switch control. Other benefits that advances in integrated circuits will bring include the following:

— increased information processing power in the customer equipment of the future, enabling signal bandwidth requirements to be reduced and providing greater flexibility for setting up connections and obtaining service facilities;
— more flexble local distribution systems, such as coaxial ring schemes incorporating traffic concentrators and distributed switching;
improved visual displays, e.g. through local picture-frame storage needed for many of the new visual services;
— replacement of certain electro-mechanical functions in existing exchanges, such as dial-pulse regenerators and relay sets using integrated circuit microprocessor techniques, thereby increasing reliability and reducing maintenance.

Research studies suggest that integrated circuits can be used to convert analogue signals to digital formats at costs that will be low enough to contemplate their use on an individual line basis. If substantiated this development could produce substantial changes in the topology of the switching and local distribution networks.

5.2 PCM Digital Techniques

The successful development of pcm digital techniques for transmission and switching is seen as of major importance in providing a basis for an integrated multi-service transmission and switching network. The reasons for this are as follows:

— the superior transmission quality offered by pcm digital systems compared with conventional fdm analogue systems, the quality remaining substantially independent of the numbers of repeaters or switching stages in tandem;
— the ability of pcm to accommodate all types of signal, e.g. speech, data, facsimile and video, on a common path such as a pair of wires, a coaxial cable or a microwave carrier without mutual interference;
— pcm digital signals are well adapted to the use of compact, highly reliable and low-cost integrated circuits for signal coding, decoding, multiplexing and regeneration.

24-channel/1.5 Mbit/s pcm systems have already found extensive application on de-loaded inter-exchange multi-pair junction cables in the United Kingdom, enabling substantial traffic growth to be accommodated without laying new cables.

However, the British Post Office has adopted the European 30-channel/2 Mbit/s pcm standard recommended by the CCITT, and this will form the basic "building block" for future systems. Clearly, the establishment, and international agreement on, a hierarchy of larger capacity pcm systems in multiples of the basic unit is a matter of considerable importance. It is also necessary that the hierarchy provide appropriate steps to match the bit rate requirements for transmission of other signals in addition to telephony, e.g. facsimile, data, videophone and television, (Fig. 6). It is also desirable to accommodate blocks of fdm channels, e.g. at the super-group or hyper-group levels, to enable pcm digital systems to interface with fdm analogue systems.

Theoretical studies, confirmed by field trials of a limited number of interconnected pcm digital links, have indicated that a large-scale national network can be expected to operate stably in a synchronous mode, provided that control is suitably dispersed in a hierarchical manner throughout the network. In particular, failure of synchronism on any one link must not create a major disturbance that propagates through the network.

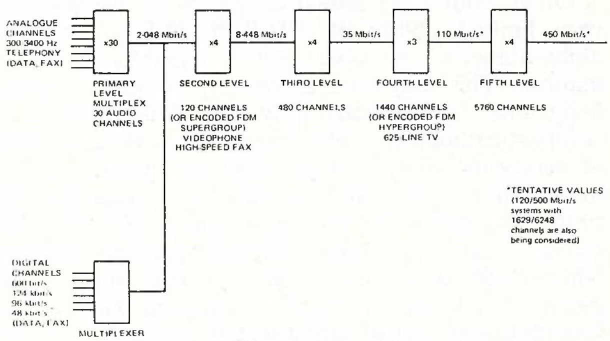


Fig. 6—PCM digital hierarchy

A detailed study by a British Post Office Trunk Task Force of the future United Kingdom trunk network has led to two important recommendations:

(i) to proceed as rapidly as is practicable with the provision of pcm digital transmission systems in the trunk network (partly for the operational reasons discussed above, but also because pcm was found to be cheaper than fdm by a small but significant margin);

(ii) once a pcm digital transmission capability has been established, to proceed with digital trunk switching (the trunk network then showing substantial overall cost savings compared with fdm transmission and space-division analogue switching).

5.3 New Broadband Transmission Systems

Following the recommendations of the Trunk Task Force a range of digital transmission systems is being investigated for use on trunk and junction routes in the United Kingdom; these are in various stages ranging from exploratory research, through advance development and development to field trial, as follows:

5.3.1 Digital Coaxial Cable

A 120 Mbit/s system is under development for an inter-city field trial using 4mm coaxial cable, and systems of a higher bit rate, e.g. 500 Mbit/s, are being studied.

5.3.2 30-110 GHz Waveguide

The 50 mm diameter waveguide system is in an advance development stage and a preliminary field trial on a 15 km section is in hand for 1975. Channel filters and other passive components are being provided for 16 + 16 channels at 500 MHz spacing in the 30-50 GHz band, for 8 + 8 channels at 2 GHz spacing between 50 and 90 GHz, and for waveguide performance assessment above 90 GHz. Prototype active repeaters exist for 500 Mbit/s per carrier (30-50 GHz) and are in laboratory development for 1 Gbit/s per carrier (50-90 GHz). When fully equipped the waveguide could accommodate the equivalent of 300,000 telephone circuits, 2,500 VIEWPHONE channels or 200 both-way television channels, or a combination of these.

5.3.3 6 MHz Microwave Radio-Relay

This is a low capacity digital system (2/6 Mbit/s per carrier) in the development phase; it uses the supervisory radio channels of the existing 6 GHz microwave radio-relay system.

5.3.4 11 GHz Microwave Radio-Relay

This system, which is at present in the advance development stage, provides 120 Mbit/s capacity per carrier and is intended for use at existing radio-relay sites with spacings of some 30 to 50 km.

5.3.5 20 GHz Microwave "Pole-Line"

The pole-line system uses compact microwave equipment at the top of roadside poles, spaced some 5 to 10 km with route diversity; it provides 250 Mbit/s capacity per carrier and is in the advance development stage.

5.3.6 Optical Fibre Systems

Two types of system are being studied as an exploratory research project:

(a) mono-mode fibre energised from a solid-state laser and providing a capacity of some hundreds of Mbit/s per fibre,

(b) multi-mode fibre energised from a light emitting semiconductor diode and providing a digital capacity of some tens of Mbit/s or an analogue capacity of tens of MHz.*

The outstanding characteristics of optical fibre cables are their small physical size and flexibility leading to a wide range of possible applications, including broadband local distribution as well as junction and trunk routes.

Not all the systems being studied will necessarily reach the stage of operational use; they provide a basis for selection for on-going design and production of those leading to most economic provision for routes of given capacity, growth rate and terrain.

In parallel with the foregoing, development is proceeding on a 60 MHz fdm coaxial cable system, and on modems to enable digital transmission at 120 kbit/s and 2 Mbit/s in group, and also on double super-group bands of this and existing fdm coaxial cable systems. By the latter means a useful amount of digital transmission capacity can be provided and service integration achieved, in advance of a fully integrated network.

5.4 Local Distribution

5.4.1 The Existing Local Line Network

Local distribution presents special problems in view of the very large capital investment in the existing wire line plant, and the fact that this already contains substantial provision to meet growth. It has therefore to be recognised that:

(i) modernization, e.g. the introduction of broadband line plant on a large scale, can only occur over a span of many years;

(ii) the maximum practicable use should be made of the existing line plant.

Tests on local line plant in the United Kingdom indicate that a large proportion of lines are capable of transmission up to at least 1 MHz without incurring excessive insertion loss or crosstalk. Bearing in mind that only 3 kHz is used for telephone speech — and that for generally less than 1% of the time — it is clear that there is considerable scope for utilization of this hitherto unexploited capacity to provide new services. For example, most local lines are capable of providing simplex data transmission up to 120 kbit/s or duplex at 48 kbit/s, or transmitting an analogue video signal with a bandwidth of some 1 MHz. Exploitation of the existing local line plant in this way could provide a valuable lead-in to an integrated multi-service system by facilitating the introduction of new services and securing some of the economic benefits to be obtained thereby.

* It is a pleasure to acknowledge the pioneering work of the Australian CSIRO, in co-operation with the APO, on liquid-filled multi-mode fibre.

5.4.2 New Broadband Local Distribution Networks

The full realization of the économic and operational potential of service integration and the shared use of common plant would require the introduction of broadband local distribution plant. The services that could be provided over such plant fall in two main categories:

(i) two-way fully switched services, e.g. telephony, data, facsimile, VIEWDATA, VIEWPHONE and CONFRAVISION;

(ii) one-way "broadcast" type services, including entertainment TV and sound programmes (these could involve either local or remote selection of a desired programme).

There are several technological possibilities for providing such services over broadband local distribution networks, such as specially designed pair or quad cables, coaxial cables, millimetric (e.g. 50-100 GHz) microwave radio and optical fibre cables. A variety of network configurations has also to be examined, e.g. star, tree or ring patterns.

The coaxial ring configuration has received detailed study and a laboratory model has been built (see Fig. 7). PCM digital signals circulate unidirectionally around the ring out from and back to a local digital exchange, providing an electronic highway with time slots that are seized when a telephone, data, facsimile or VIEWPHONE call is made. Microelectronic "Accessors" (traffic concentrators) are connected into the ring and are sited in footway boxes such that individual connexions to customers' premises may be made by short spur cables. These units enable customers, in groups of 10 or more, to gain access to the time slots circulating around the ring. Depending upon the traffic generated, up to perhaps 150 customers may use only one ring leading to considerable economies from the shared use of plant. When integrated via digital switches with the digital trunk network mentioned earlier, such a local distribution system actually should be a cheaper way of providing telephony alone than is the present arrangement of individual pairs and space switching. There are additional operational benefits such as stable and low transmission losses, and freedom from noise and crosstalk. Furthermore the wide bandwidth — 300 MHz or more — available on the coaxial ring

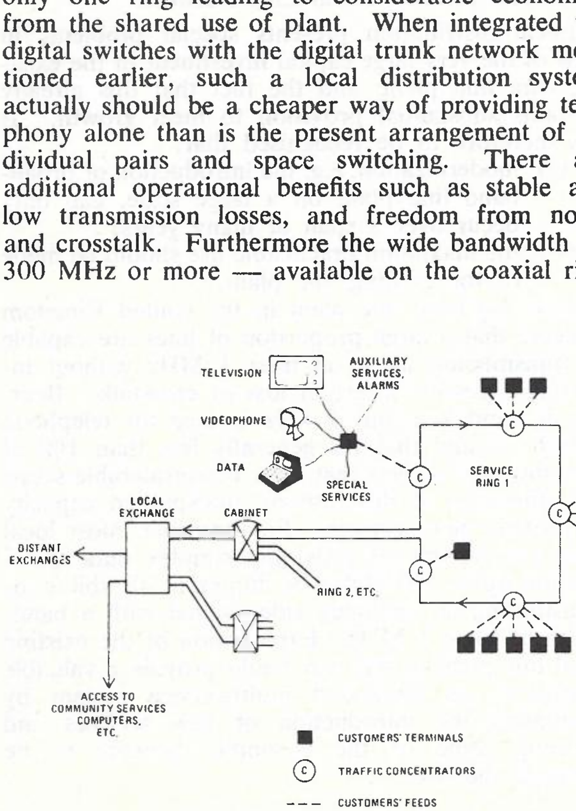


Fig. 7—Coaxial ring broadband local distribution network

would enable several broadband video services, e.g. entertainment and educational television and CONFRAVISION services, to be provided in addition to telephone, data, facsimile and VIEWPHONE services.

The British Post Office is acquiring considerable field experience in the provision of broadband distribution networks, notably in the new towns at Washington, Co. Durham; Milton Keynes, Buckinghamshire; Craigavon, Northern Ireland and Irvine, South-Western Scotland. These are essentially schemes providing telephone service on conventional pairs laid with coaxial cables sharing the same ducts and house entry points, and handling BBC and IBA television programmes. In addition, extensive coaxial cable networks have been provided for schools television; one for the Inner London Education Authority links some 1,500 schools in the London area.

In view of the need to prepare an economically viable and operationally practicable strategy for the future development of its local distribution network, the British Post Office has set up a Local Lines Task Force to carry out a study in depth of the emerging possibilities.

5.5 Processor Controlled Switching Systems

The development of processor controlled exchange switching, (Fig. 8), can be seen as extending to switching many of the possibilities for integration that are becoming available in transmission, with similar benefits arising from the shared use of common plant, flexibility to accommodate new services and equipment rationalization.

Processor control exploits computer concepts and technology, both in "hardware", i.e. electronic logic and storage devices, and "software", i.e. programs of instructions and the "language" in which they are written. Stored program control will facilitate integration because new services and facilities can be introduced with a minimum of change to installed equipment, the main changes being to the stored programs themselves.

Furthermore the separation of switching and control functions enables each to evolve separately and utilize new techniques as they become available; for example, the same processor may control both space-division analogue and time-division digital switch blocks. Similarly, a common processor may control the switching for several new services, whether in analogue or digital form, as well as for telephony.

A central processor may also remotely control geographically distributed switch units via data links; this facility could further contribute to the introduction of new services by enabling the switching function to take place where it could best be located from the viewpoints of economy and operational convenience.

Stored program control processors will also facilitate automatic call accounting and trunk ticketing, with charges for both new and existing services prepared and presented to customers in a unified manner.

There has been a growing awareness that telecommunication traffic control, including re-routing

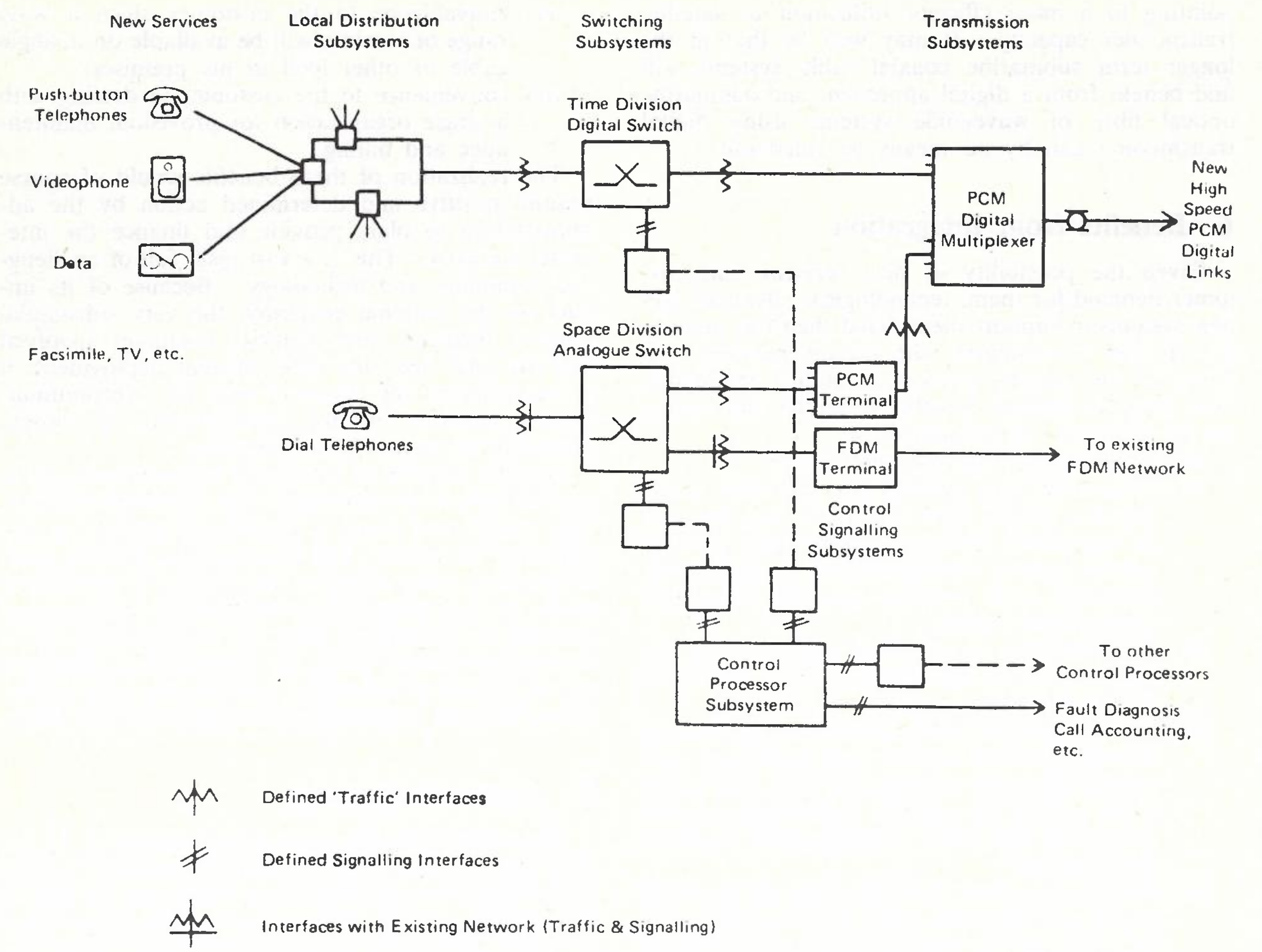


Fig. 8—Processor controlled switching system

to avoid congestion or equipment failure, should be treated on a total network basis. The recommendation of the Post Office/Industry Advisory Group on System Definitions (AGSD) is that the next generation of switching equipment should be designed on this basis and use of stored program control, with the capability for the processors in various exchanges to communicate directly with each other, i.e. over data links.*

5.6 Integrated Digital Transmission Switching

With the spread of digital transmission into the junction and trunk networks it could become attractive and economic to switch digitally at main switching units interfacing the junction and trunk networks.

It would then be possible and lead to further economies, because of the relatively low cost of digital transmission, to extend the circuits in digital form back towards customers by providing traffic concentrators and pcm codecs first at local exchanges and later nearer to customers' premises, e.g. in footway boxes, (Fig. 9). At a later stage, and in suitable environments, broadband circuits, e.g. using the coaxial ring approach, could be extended to main switching units.

As the use of digital techniques spreads in the inland transmission field, it will become advantageous to extend such techniques to international and inter-continental links. Already development in this direction can be seen in satellite communication, where digital time-division techniques are

* The Pitt Street installation pioneered by the Australian Post Office is an important example of a modern stored program control tandem/trunk exchange.

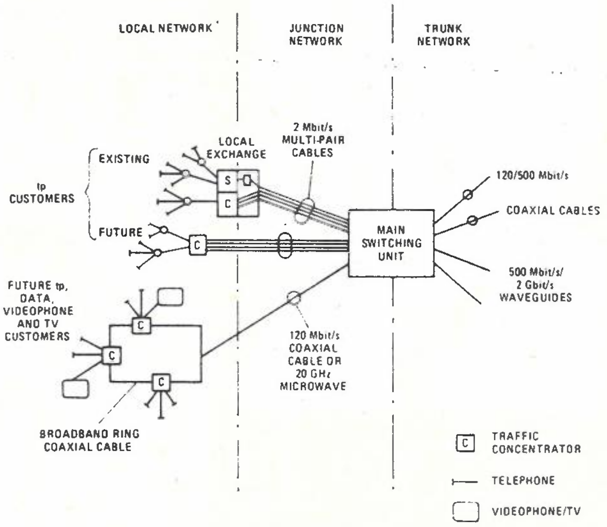


Fig. 9—Integrated digital transmission switching network

pointing to a more efficient utilization of satellite transponder capacity. It may well be that in the longer term submarine coaxial cable systems will find benefit from a digital approach, and submarine optical fibre of waveguide systems using digital transmission can by no means be ruled out.

6. Benefits from Integration

Given the possibility of new services and customer demand for them, technological advances and new systems to support them, what then has integration to offer as compared with the independent provision of the various services, including telephony, over separate systems possibly provided and operated by different organizations?

The main benefits are considered to be:

(i) substantial cost savings for inter-city transmission arising from the lower cost per unit of bandwidth available on new large capacity media such as waveguides and optical fibres, provided such systems can be adequately loaded with traffic;

(ii) the reduction of switching costs, e.g. by the exploitation of common processor controlled digital switching systems;

(iii) lower costs for local distribution by sharing between several services and groups of customers the costs of ducts, cabinets and house entry points as well as a common coaxial or optical fibe cable or millimetric distribution system;

(iv) flexibility in long term planning of the local and trunk networks since spare capacity can be taken up by various services as demand builds up;

(v) rationalized designs of customer equipment providing services singly or in groups, e.g. telephony, facsimile, VIEWDATA and VIEWPHONE, with unified procedures for setting up connections via exchanges;

(vi) convenience to the customer since a wide range of services will be available on a single cable or other feed to his premises;

(vii) convenience to the customer in dealing with a single organization for provision, maintenance and billing.

The realization of these benefits would of course require positive and determined action by the administration to plan, provide and finance the integrated network. This is a vast task, full of challenging economics and technology. Because of its impact on the national economy, the very substantial human, financial and material resources involved and the vital need for their efficient deployment, it is essential that the efforts of both the telecommunications industry and the administration be closely geared to its successful achievement.

But the benefits of integrated telecommunications are not only to the customers and the administration, they could well have a significant impact on the efficiency of industry and commerce by making communication more effective and rapid at acceptable costs, on the geographical location of industry and commerce, facilitating dispersal by reducing travel to and from cities solely for information exchange, on the spread of education and on the range of information and entertainment available in the home.

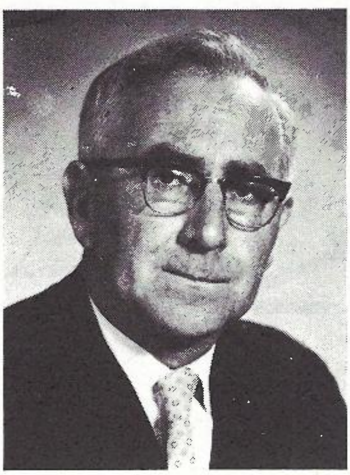
7. Acknowledgements

The author's thanks are due to Professor J. H. H. Merriman, Board Member for Technology, British Post Office, for permission to make use of official information in the preparation of this paper and to many colleagues in the British Post Office for their helpful ideas, criticism and comments.

8. References

1. The Buchanan Report (1973): "Transport, the Urban Environment and Telecommunications, 1971-2001."

Biography



Professor WILLIAM JOHN BRAY, Director of Research, British Post Office. Professor Bray — known to his colleagues in the B.P.O. and Industry, as "John Bray" — has been Director of Research since 1966. Born on 10/9/1911 in Portsmouth, he was educated at Imperial College, London University, and served an electrical engineering apprenticeship at the Portsmouth Naval Dockyard, in the period 1928-1932. He was awarded the Royal and Kitchener Scholarships for further studies at Imperial College in 1932-1934.

He joined the British Post Office Engineering Department as an Assistant Engineer in 1934. Appointed Staff Engineer, Inland Radio Branch in 1959, he led the UK team which developed the satellite earth station at Goonhilly, Cornwall, the designs of which have been since accepted as a basis for earth station design throughout the world. Just prior to this appointment (in 1956/57) John Bray was awarded the Commonwealth Fund Fellowship (Harkness Foundation) for study in the U.S.A.

John Bray has also played a leading role in the B.P.O. development of microwave communication systems for inter-city transmission of telephony and video signals. He has also been prominent in the activities of the International Radio Consultative Committee (C.C.I.R.) of the International Communication Union (I.T.U.), and it is largely due to his work that telecommunication administrations throughout the world have accepted, through the C.C.I.R., common standards for microwave radio relay systems. He has also been active in the work of the European Postal and Telecommunication Conferences.

In June 1972, John Bray was appointed Visiting Professor in the Department of Electronic and Electrical Engineering, University College, London.

He holds the degree of Master of Science (Engineering) (M.Sc. (Eng.)) and the Diploma of Imperial College (D.I.C.). He is a Fellow of the City and Guilds Institute (F.C.G.I.) of London and also a Fellow of the Institution of Electrical Engineers (F.I.E.E.).

Married with one daughter, John Bray lives at Woodbridge, Suffolk. His hobbies include sailing and travel.

Changing Patterns of Creativity and Innovation in Telecommunications

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This paper discusses the tactics and strategy necessary to maintain and improve the creativity of research and development and organisations in the telecommunications industry. A mix of short-range and long-range objectives must be defined that can be maintained in balance with other evolving technologies. This mix should be constantly re-examined to include not only advances in technical knowledge but also cultural changes in attitudes and values towards science and technology. Rather than aiming at a structure that is static or even in dynamic equilibrium, organisations should deliberately cycle back and forth between centralized and decentralized extremes, in harmony with these changes and periodicities. Currently there is a swing to decentralization in response to a shift in priorities from simply improving the level of performance in technological systems to a concern for the service of man in the form of economic systems.

1. Prologue

I would like to pay tribute to this anniversary celebration by giving you a little historical vignette. We will go back to 1923, when your Australian Post Office Research Laboratories was founded, and to one or two years preceding and following that time.

Those of you in the audience who are sufficiently aged will no doubt recall that in mid-1923 Australia had 5,693,000 people and 281,703 telephones, making an average of five telephones per 100 population, and you will also recall that the population of the United States was 111,950,000, and we had 15,369,454 telephones for an average of 13.7 telephones per 100 population.

In both our countries, telephone technology had clearly been brought to a very advanced level beyond which no future improvements would apparently be needed. Consider, for example, the most modern form of switchboard at that time (Fig. 1). And in the customer's home or office, the most up-to-date telephone instrument, (Fig. 2) and in transmission technology, the equipment for a four-

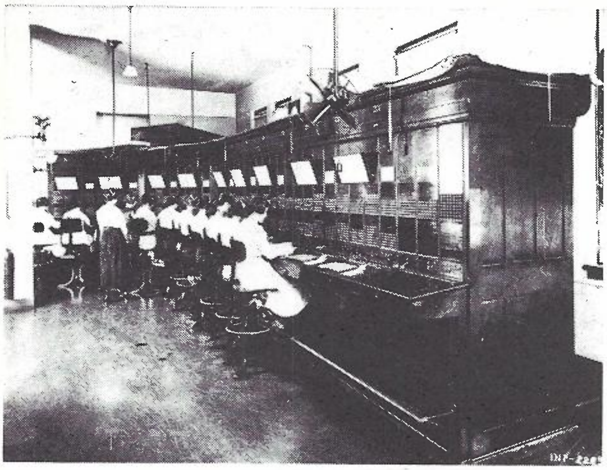


Fig. 1—A telephone switchboard in the early 1920's

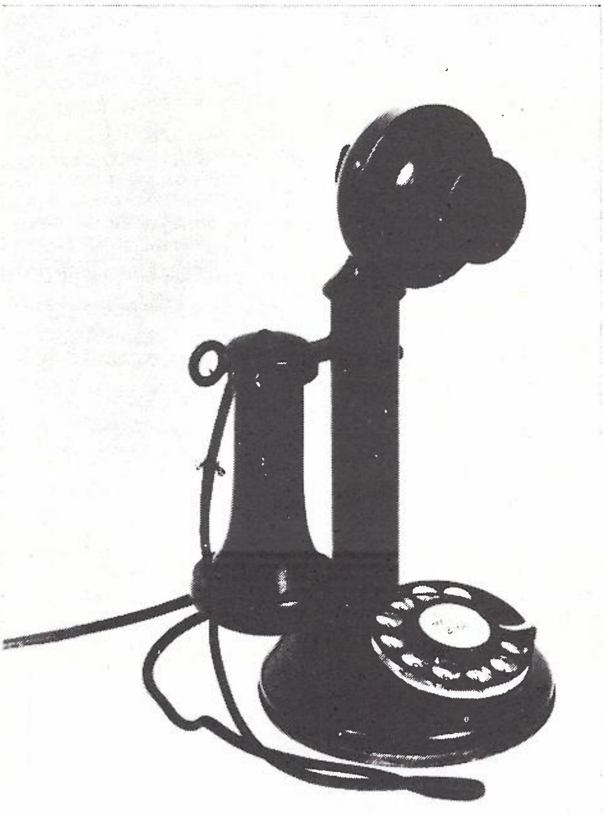


Fig. 2—An early telephone

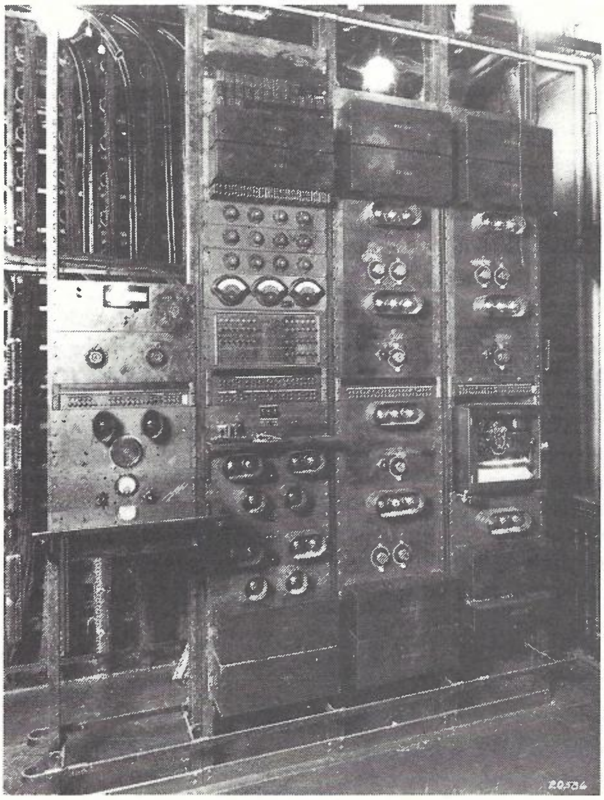


Fig. 3—Part of a four-channel carrier system

channel carrier system (Fig. 3) of which you will hear more shortly. Technological progress, moreover, was not confined to the telephone business alone. Valuable ancillary apparatus was becoming available. For example, Fig. 4 shows one of the earliest hearing aids, obviously bulky and hardly portable in any normal sense of the term, probably very costly, but a hearing aid nevertheless. And, as another example, Fig. 5 shows an early computer. This particular one, which we had in Bell Labs, was constructed by a concern in Zürich, Switzerland. It was called "The Millionaire", but whether that was because it was so expensive you had to be a millionaire to afford one, or whether if you owned one it would make you a millionaire, I don't know.

In the face of such advanced technology, it took foresight and courage to decide that future research and development was really needed and to establish your research laboratories, but farsighted people did take that step, and it went much the same way in the United States. Bell Telephone Laboratories was created in 1925 as a reorganization, with greater corporate independence and a wider definition of mission, of efforts previously conducted within the Western Electric Company. In a formal sense, therefore, we are two years your junior; we shall be celebrating our own Golden Anniversary in 1975.

To conclude this vignette I will remind you of an instance of intensive cooperation in the period 1923-25 between the Australian Post Office and the Bell System. This had to do with the purchase by Australia from the International Western Electric Company of a complete carrier system to be installed between Sydney and Melbourne, a distance of 586 miles, with three intermediate repeater stations. One Bell Laboratories man from our Toll Development Department came to Australia to supervise the installation. This was a four-channel carrier system, frequency division multiplex in other words, carried on a conventional two-wire line; and in fact, it relied upon the transmission equipment shown in Fig. 3.

Important ceremonies marked the inauguration of the Sydney-Melbourne carrier service, the Lord Mayors, presidents of chambers of commerce, telephone officials, and other dignitaries gathering at each end of the line to express amazement and to exchange compliments. Your Australian newspapers carried such headlines as "One Line — Four conversations", and "Eight Spoke, but no Babel". Here is a more detailed quote from the Sydney *Daily Guardian:*

"Eight persons conducted simultaneous chats between Sydney and Melbourne, over one wire.

While Mr. S. J. Newlands, President of the Chamber of Manufacturers of N.S.W., was dis-

Fig. 4—One of the first hearing aids

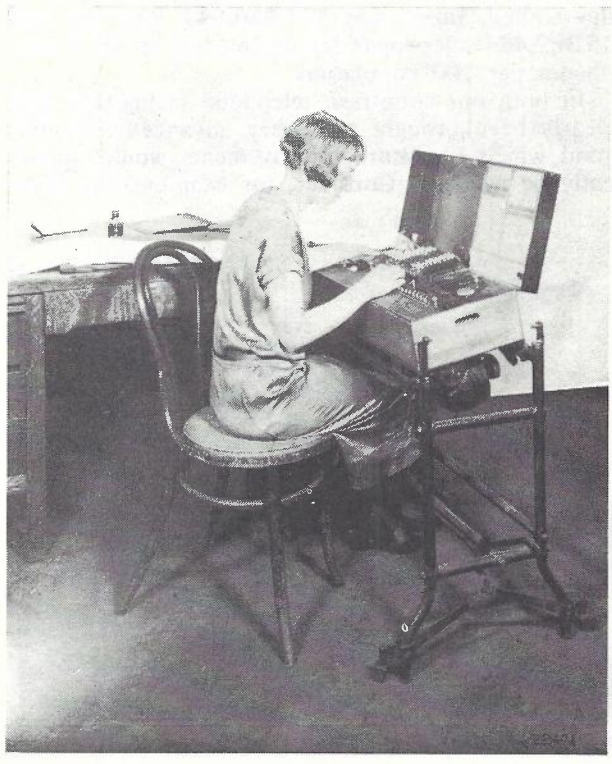


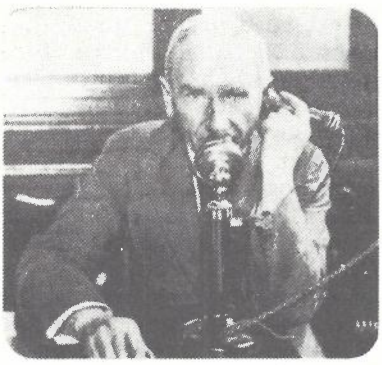
Fig. 5—'The Millionaire' computer

cussing health questions with Mr. Lewis, Victorian President, who was lying in bed at his home, Mr. J. S. Dunlop, President of the Chamber of Commerce, was remarking to his Victorian vis-a-vis what a wonderful thing it all was."

Fig. 6 is a page from the Melbourne newspaper *The Sun* of September 11, 1925 showing some of the Post Office people involved in the project. It is indicative of the close cooperation between our respective organizations that the gentleman on the extreme right was identified as a Post Office department engineer, when in fact he was the Bell Labs man sent to work with your predecessors. The second gentleman from the left, Mr. S. H. Witt, was the founder of the APO Research Laboratories, I am told; and I learn with deep regret that he died only a few weeks ago.

In spite of our completely successful joint technical effort, however, there seemed to be substantial ignorance and confusion about how a carrier system operates, and the *Daily Guardian* article concluded with these remarkable words:

> "What wonderful complications, if the speeches were to be audible to all parties! Yet this suggestion the department scouts. But it may prove unnerving to know that while you are speaking to somebody else's wife your wife may be speaking to somebody else's husband over the same line."



"HELLO, SYDNEY!"—Mr. R. B. Lemmon, president of the Melbourne Chamber of Commerce, speaking to Sydney yesterday during the try-out of the new "carrier wave" system.

FOURFOLD SUCCESS

Carrier Wave System Tested

Reports from four Melbourne men who spoke to Sydney at the inauguration of the carrier wave system yesterday, prove that the system is a wise move.

It is now possible for four separate conversations to be carried on over the two existing lines. In addition, two telegraph duplex circuits, on which four telegrams may be transmitted simultaneously will be accommodated.

The four conversations yesterday took place between the Lord Mayor of Sydney (Alderman Stokes) and Alderman Jefferies, who took the place of Cr. Brunton, who was absent in Adelaide; the President of the Sydney Chamber of Commerce (Mr. Dunlop) and the President of the Melbourne Chamber of Commerce (Mr. R. B. Lemmon); the President of the Sydney Chamber of Manufactures (Mr. Newlands) and the Melbourne Chamber of Manufactures (Mr. Lewis). The Sydney and Melbourne Exchange foremen also discussed the new system.

"SPLENDID"

"There is absolutely no doubt of the success of the new system," said the director-general of Post and Telegraphs (Mr. H. P. Brown), when the test was completed.

"The service has been extended 150 per cent., and there are now five circuits, as compared with the two which existed hitherto.

"Perfectly splendid," was the description of his conversation with Sydney's Lord Mayor by Alderman Jefferies. His opinion was endorsed by the three other conversants.

EIGHT VOICES PLAY LEAPFROG ON TWO WIRES.—Four men in Melbourne held independent conversations with four others in Sydney on one pair of wires yesterday. Between the two cities there will now be five telephonic channels instead of two. On the extreme left is the Postal Director (Mr. Brown) supervising a test of the apparatus before the demonstration. With him are Messrs. S. H. Witt, H. S. Robertson, G. H. Schmidt, R. G. Bussell and J. S. Jammer, departmental engineers.

Fig. 6—Inauguration of the Sydney-Melbourne carrier service as reported in the Melbourne 'Sun', 1925

2. Changing Patterns of Creativity and Innovation in Telecommunications

In summary, looking back those 50 years, we can see that telecommunications had obtained a respectable and substantial status, but it was still little more than a set of loosely connected discoveries and inventions. Since that time it has matured toward a more orderly science and technological discipline with broad guiding principles, where the interconnections among the various parts of the whole are appreciated and at least fairly well understood.

Looking ahead for the next 50 years to the year 2023, it is tempting to predict an uninterrupted flow of further landmarks and an ascent of communications science and technology ever onward and upward. Viewing the summaries of the other papers being presented at this symposium, I do indeed see many optimistic forecasts. Exciting discoveries and applications almost certainly lie ahead, I agree, but right now we have reached a most critical point. At least three major factors are operating currently, I believe, to create a juncture where recognizable problems and dangers confront the telecommunications industry. These are: (1) changing national priorities in the United States, and other countries too, (2) growth rate substantially greater than that of the economy as a whole, and (3) last but not least, the very successes in telecommunications which might make it appear that the technical fraternity should look elsewhere for challenge and opportunity. Management throughout telecommunications R&D, industry and operations must find new directions from today's critical turning point, and it is toward this matter that I address myself. However, I cannot possibly encompass such a very wide range of problems with so many ramifications, and I shall limit myself to that much smaller part of the whole of which I have been privileged to be an observer for some time, namely, the question of maintaining and improving creativity of R&D people and organizations.

To say it another way, in my own contemplation of the question "Whither Communications?", I tend to concentrate on the people working in the field, the scientists and engineers in our R&D labs, and I therefore narrow my inquiry to the question, "Can new guidelines be discerned which will help the R&D manager to keep his organization vital and effective?"

At the outset let me note that I shall use quite a large number of common words without defining them, words like creativity, innovation, productivity, research, development, and many others. For the purposes of this talk, I simply have to assume that you will all have a reasonably uniform understanding of these terms and that we can stay away from purely semantic quarrels or misunderstandings.

3. Necessary Conditions for Inventions to take place

I will start with some simple observations which can lead us towards a realization of today's problems in telecommunications R&D and toward some glimpses ahead for the next 50 years. Let us first consider what conditions must prevail for inventions to take place, whether the inventor is the old-fashioned lone wolf individual or whether, according to the newer fashion of large-scale corporate research, the inventor is a whole group of people. I see at least these four broad categories: perception of need, motivation to innovate, stimulating environment, and relevant science and technology. The term "perception of need" is used here to compromise a full understanding of the problem itself, all the various possible trade-offs, and at least some of the potential side effects. I will return later on to the matter of fully understanding the problem. With regard to the trade-offs, they can be many and varied, involving labor, capital, time, risks, and satisfaction/comfort/pleasure. For example, an invention may offer a saving of labor in return for an investment of capital and so on. With some of the most primitive inventions, the trade-offs are simple and obvious. When we examine a collection of inventions, some of them very sophisticated, as in the field of telecommunications as a whole, the balance of trade-offs becomes exceedingly complex. Here, as compared with sheer physical transport of people who wish to communicate and/or tranport the information itself, we are investing large amounts of capital and labor to obtain large savings in time at a very much lower risk, and with important gains in comfort. While I have juxtaposed satisfaction, comfort, and pleasure, they are by no means exactly synonomous. These factors are especially difficult to correlate with value judgments for trade-offs.

If estimation of trade-offs is difficult, evaluation of side effects is even more so. Any technical advance which, by investment of capital, can save labor and time has the potential of disturbing profoundly the markets for both labor and capital. So far, the expansion of communications in most countries has proceeded at such a rapid pace and with such generally beneficial results that the side effects of technological innovation have not yet appeared disturbing. From here on, however, perception of need will necessarily have to weigh interactive effects with the total environment.

Moving on to the second of the conditions judged important for invention, motivation to innovate, I see three different kinds of reward which serve as incentives: intellectual challenge or mental reward, monetary reward, and prestige or satisfaction or self-esteem, or, more generally, social reward. Today the inventor is likely to be well rewarded from a financial viewpoint, and we must concern ourselves more with the questions of whether he is sufficiently challenged intellectually in the telecommunications field and whether he will enjoy adequate recognition.

This leads rather naturally to an adjacent condition for invention, a stimulating environment, where I find it convenient to distinguish two categories of factors. Under the rather general heading of freedom of expression, I put such matters as opportunities to publish technical papers and to participate freely in the activities of appropriate professional societies. And under the heading of protection of the individual there are such features as the patent system whereby an invention can be formally protected and which offer opportunities and safeguards for recognition of a particular individual as the inventor. On this last point, I am not referring to social reward in the form of prestige but instead to mechanisms for identification of the innovator such as early publication, copyrighting, and other written or tangible evidence.

The fourth and last condition listed for innovation, relevant science and technology, is so obvious as to deserve little comment, other than to note that many would-be inventors have simply been "before their time" in trying to innovate without the necessary preliminary tools and building blocks.

When we ask ourselves how well in the past has the telecommunications business paid full heed to these conditions for innovation, the inescapable answer seems to be, very well indeed, witness the large amount of creativity which has been steadily at work in our field. From here on, however, it could be a different story, particularly if we do not take a fresh look at the broad objectives. Many of the speakers at this symposium will expand upon this matter, I am sure, and it suffices here merely to note that the objectives can be sorted into different categories: to meet public needs, to satisfy customer desires, and to achieve a balanced position in government and industry, and science and technology. I choose to distinguish here between meeting public needs and satisfying customer desires because I interpret the former category as the more elemental one of providing basic communications services to transact critical business and to preserve public safety, while the latter category includes many optional or voluntary features, even luxury items, and will be of increasing importance in the future if the right trade-offs can be presented to the customer. With regard to achieving a balanced position in government and the industrial world, it is clear that this lies considerably in the future; as noted earlier, our growth rate has exceeded that of industry as a whole, and this cannot keep up indefinitely. On the governmental front, particularly in the United States, but also elsewhere, there is much agitation to find a new equilibrium point between monopoly, so-called, and industrial competition.

In science and technology, a real danger, I fear, is that some of the newer fields, particularly the interdisciplinary ones such as biophysics and biochemistry, may lure too much talent away from participation in our almost too successful field. As I see it, the strategic goals of telecommunications R&D should indeed be to attract, hold, and manage adequately its full share of future talent and to have an adequate financial basis. For the support of the total endeavour in telecommunications, there are two different sources from within, namely, income derived from the service operations themselves and income related to profits of industrial production. I should note parenthetically that the R&D provided to the Bell System by the Bell Laboratories is supported strongly in a balanced way by both these sources. Fundamental research and systems engineering are financed by monies derived from the operating revenues, and the specific design development projects are funded by our manufacturing arm, Western Electric Company.

4. A Managerial Strategy for Research and Development

All of these preliminaries bring me finally to the main thrust of this talk, R&D managerial strategy which will keep pace with the rapidly changing patterns of our kaleidoscopic culture and civilization and, beyond merely keeping pace, will provide leadership in our field. Here my starting point is the observations and analyses made by our late J. A. Morton, culminating in his 1971 book, *Organizing for Innovation* (McGraw Hill). Technical creativity was identified by Dr. Morton as a connected process, from research all the way through to operational use, whereby people generate or adapt relevant science and transform it into new products and services. I endorse his idea that innovation is a "people process", requiring fullest attention to the selection, training and development of engineers and scientists as individuals capable of significant contributions, and to the organizing of people toward optimal productivity in group efforts.

Taking such assertions for granted, I will try in this paper to enlarge upon two theses not developed in his work: **first,** that telecommunications objectives must be restructured frequently to comprise a suitable mix of short-range and long-range goals which can be maintained in balance with the demands of other evolving technologies of our culture, and **second,** that R&D organizations must be restructured frequently so that there is a dominant feature of continual shifting back and forth between centralized and decentralized structures.

4.1 Restructuring of Telecommunications Objectives

Definition of long-range goals in the form of specific projects, a popular tactic for all planners, has been done from time to time for the telecommunications field. The papers presented at this APO Golden Jubilee program offer notable additions to such analysis. Here I emphasize the necessity to add short-range goals to long-range ones, also to stress those formulations which endow the unsolved problem areas with qualities of intellectual challenge, social relevance, and environmental compatibility. Priorities in future communications projects must be harmonized with the interests and sense of values of incoming waves of would-be scientists and engineers; and indeed, this requirement is one factor underlying the need for a completely dynamic approach in R&D strategy.

The crucial point now reached has been identified by our President W. O. Baker to be a transition from goals of "performance systems" to a search for "economic systems". Until now, the general concern has been the conception and utilization of technological systems which would provide a new kind or new level of performance. The situation from here on appears entirely different, our concern now being the service of man in the form of economic systems. From here on, then, while the eternal values of people and people-process-participation may remain, a shift in managerial strategy appears absolutely necessary even in such a well-established discipline as telecommunications.

This idea is strenghtened by the observation that telecommunications will necessarily be intertwined more than ever before with other areas of human activity: social and business needs, economic balance with government and industry, a match to physiological and mental capabilities of people, and many others. Further, we have important opportunities to offer new combinations of trade-offs to society as a whole, to the industrial world and to private individuals. For example, the next generation may decide that extra expenditures of labor and capital are justified to provide privacy features which increase comfort or satisfaction in the communications service.

4.2 Long-Range Problem Areas

My own choices of long-range problem areas, not much different from those in vogue except perhaps in emphasis and interpretation, are:

(i) Visual Communications: Video capabilities added to the telephone instrument and system, addition of graphics capabilities, provision of remote conference facilities.

(ii) Man-Machine Communications: Voice actuated equipment and controls, synthetic speech answerback, computerized interactive graphics, computer-aided instruction and design.

(iii) Information Processing for Automatic Control: Production line assembly by robots, automated housekeeping and inventory control in industrial plants.

(iv) Data Processing: Clerical recording, customer billing, banking accounts and other business transactions.

Leaving to others on this program the existing tasks of elaborating on new communications systems and services for the future, I display this list principally to remind you, in conjunction with my preliminary remarks, that there is much unexplored territory here. In many of the long-range problem areas just listed, we do not even have an adequate understanding of the problem. For example, take the case of remote conference facilities. There have already been noteworthy attempts in Australia, United States, Britain, and elsewhere to develop special conference room facilities, each room with a battery of video cameras and displays, and microphones and speakers, hooked together by one or more appropriate video links. In the preceding paper, Professor Bray has specifically touched upon the British Post Office work on their CONFRAVISION system. Such conference systems have proved interesting and of some value to the users, but I feel that so far no system has been successful in making the participants sense that the overall effect was virtually the same as a conference of all the participants within the same room. Closer examination suggests that we really do not understand in fundamental analytical terms what happens during a conference, or more particularly, what ingredients are necessary to give the users the same impressions and feelings of satisfactory participation. And parenthetically, I might note that a modest effort is under way at Bell Labs. to study the kind of human communication which takes place in a conference room.

And so on, in still broader terms, we do not yet have a complete perception of the needs with respect to most or all of these future systems; and clearly, a variety of basic and applied studies must be conducted to clarify even the starting point for future innovation on any large scale.

Another reason for reciting a list of specific long-range projects is to make the additional point that all such objectives, however noble and challenging, tend to lack the definiteness which can be provided by interpolating short-range objectives. In some cases the short-range goals can be defined as a sequence of logical, modest benchmarks along the way toward the more lofty objective. In other cases it is desirable to affix short-range goals derived from operational situations. For example, in today's telephone plant there are many opportunities for modest but significant improvement in several directions: service operations, utilization of plant, maintenance, modernization of equipment. Not only may the sum total of such smaller successes have a truly major impact on the efficiency and economy of the current telecommunications network and plant, but also such short-range objectives and R&D programs can often be made attractive and stimulating to some of the younger people in the R&D field, who otherwise may become bewildered or lost in the broader reaches of pure research. Incidentally, for all of the shorter range areas listed here, a popular approach currently is the application of minicomputers to such problems.

4.3 Short-Term and Long-Term Cycles of Change

It is axiomatic that objectives must be re-examined frequently, not only because some problems become partly or wholly solved by technical developments, but also importantly because attitudes and value judgments toward and within science and technology change with the passage of time. A variety of time constants or periodicities can be discerned. The shortest is related to successive waves of university students; within a span of five years or so, one college group is supplanted by the next, and major shifts in outlook can occur within such intervals. The longest time constant observable, that is, by others than historians, is 20 to 30 years, associated with successive generations of people in all parts of academia, government, and industry. Another change can be related to the industrial production process; it often takes eight or ten years for a large new development to be brought to full-scale production with sufficient usage to develop impact on and feedback from the market place. Other fluctuations can be linked to business cycles, from a few years to a decade or more. Although some changes in attitudes and value judgments are not repetitive, many others can be seen as oscillations, not necessarily between two fixed extreme points, and not occurring in a mathematically precise manner at a fixed frequency, but movement nonetheless back and forth, sometimes in several dimensions, among a number of different extremes.

4.4 Centralization and Decentralization in R&D Organization

These observations lead to my second thesis concerning the need for continual movement in R&D organizational structure. In a centralized structure, all R&D is performed by a single unified organization which may have considerable autonomy; in a decentralized structure, the R&D is spread out among various divisions of a company or various branches of a government, and each separate R&D group is a functional part of the local organization. Let me note that there are many different aspects of centralization, and they must be carefully distinguished; geographic location, organizational control, funding and budgets, program planning, development projects, cost control and design responsibility. The two features most commonly referred to are geographical concentration or dispersion and the site of organizational control. Other aspects are important, however, and are not necessarily dependent on administrative control: derivation of money to conduct R&D programs, the planning of programs and program priorities, the execution, down to the last detail, including cost control, of the development projects themselves; and finally, where is the design responsibility localized?

It would be rare to find an R&D laboratory which was completely centralized with respect to every one of these parameters. It would be more common to see an organization which was completely decentralized in every way. However, most R&D organizations have settled upon a particular formula whereby some features are centralized and others are decentralized. It is not hard to see why this is so. The advantages and disadvantages of centralized approaches stand out in bold relief. Information flow is extremely critical to an R&D organization. In a centralized structure, the passage of knowledge across the interface between the scientists and the outside world may be unusually well facilitated, but flow of design information to the manufacturer may be seriously blocked or impeded, whereas in a decentralized structure the reverse will often be the case. Likewise, the responsiveness of an R&D organization to outside inventions or discoveries is more likely to be quick in a centralized arrangement and slow in a decentralized one, whereas the exact opposite is true with regard to responsiveness to manufacturing or user needs.

There are other areas of substantial difference. Physical facilities such as laboratories and libraries tend to be better in a centralized organization. With regard to personnel, it will often be easier to attract outstanding scientific talent to the central research laboratory but easier to attract the practical engineer to the decentralized group. Another aspect of the personnel factor is the geographical preferences for places to live exhibited by engineers and scientists. At Bell Labs we have often encountered extreme resistance to transfer of locality. For technical personnel, however, we find that a most important advantage of centralization is the creation of an intellectual atmosphere which tends to attract and hold top talent.

And finally, there are significant differences in creativity and productivity. For sheer scientific creativity, the central research approach will probably be more innovative, but for productivity in the sense of effectiveness in manufacturing end products, the decentralized approach may often be superior.

The example with which I am most familiar, Bell Laboratories, has now become substantially decentralized geographically — we have about 20 locations spanning 2,000 miles east and west and 1,000 miles north and south. With respect to most of the remaining parameters, however, we are fairly strongly centralized, but our organization is far from monolithic, and we have some variabilities from one part of Bell Labs. to another.

Ours is not the most common pattern for R&D in the industrial world, however. A more frequently observed structure is the one where the more basic research is performed in a central research laboratory which is corporately funded, while design development is conducted in separate development organizations attached individually to the appropriate product divisions, usually located within the confines of the appropriate manufacturing location, and usually funded from the revenues of the individual product division. At first glance, we seem to have something similar at Bell Labs, as some of our development groups are located on the premises of eight Western Electric manufacturing establishments, but the resemblance stops there. These groups, branch laboratories we call them, are controlled organizationally by Bell Labs centralized management, and most other aspects of their operations are also centralized within Bell Labs and not directly connected with Western Electric Company.

Clearly, there are a great many different ways in which a company may mix different aspects of centralization and decentralization, and the same applies to the planning and performance of R&D in government organizations. Right now in the United States, indeed, substantial changes are portended in the support and execution of science and technology projects by our federal government. Generally speaking, both in government and industry, the most apparent current trend is toward decentralization, and with the new emphasis on making the R&D results relevant to the user and compatible with environmental constraints, and with the strong press toward economic systems, some pronounced moves toward decentralization may be particularly appropriate at this time. Nevertheless, I feel instinctively that this may be carried too far in many instances and that a swing back toward centralization will follow.

4.5 The Need for Dynamic R&D Structures

Bearing in mind the earlier thesis that long-range objectives must be redefined and retuned from time to time to be in proper accord both with technical progress and with shifting attitudes and value judgments of people involved in the innovation process, I conclude that previous organizational models have failed to incorporate sufficient dynamism. Neither the centralized form nor the decentralized form appears to be an adequate long-range solution for R&D in telecommunications. In contrast with organizational models which are inherently static or at best in a state of dynamic equilibrium, my conviction is toward an organizational structure which is deliberately cycled back and forth between centralized and decentralized extremes, with periodicities related to those already described. I am led to this concept by the observation that such movement seems to be happening not only in Bell Laboratories but also in many other establishments, even though the participants do not always have the perspective to see what is happening; and by the parallel observation that most R&D organizations do not seem to exist comfortably with a fixed structure for very long at all and do seem to require frequent adjustment.

I suspect that these observations, and the resulting conclusions that both objectives and organization need frequent realignment and restructuring, have very deep roots in human behaviour itself and have application to a very wide range of human activities, but I am content here to limit the application of such theses to the subject at hand, R&D in telecommunications.

4.6 Perspectives for the R&D Manager

Now, where does all this theorizing lead the R&D manager? Subject to a multitude of economic, social, and environmental constraints, and told now that objectives and organization must be restructured frequently, what real freedom is left to that manager? In my view, from here on the R&D leader *has more freedom of action than ever before.* It is neither necessary nor desirable that currently popular value judgments be slavishly followed; leadership must be provided. Further, the administrator must find the most viable mixture of goals perceived by younger people to be challenging and other goals not so exciting but perceived by the more experienced people as important and not yet adequately attained. Finally, as stressed by Morton, initiative and positive action must be exhibited to organize the R&D people in a way best suited to their talents and motivations and to the organizational goals.

In my own view, then, the R&D manager must be the helmsman. He must set the course, and he must organize for innovation; and in changing course frequently, he must reorganize accordingly.

5. Summary

All these observations and thoughts on managerial strategy for the future in telecommunications R&D are summarized as follows: I think each organization must find its own solution to restructuring objectives, finding that combination of short- and long-range goals which seems attainable and appropriate, turning in the future away from performance systems toward economic systems, and making sure that there is suitable conformity with values and factors in the rest of the economy. I further think that organization form should be frequently re-examined. In any large organization, there are many dimensions, there are many parameters, there are many opportunities for readjusting the framework. While I have not touched upon it previously, it is clearly desirable to introduce enough conflict and competition to provide challenge and to stimulate individual and group performance. Most importantly, I observe most organizations seesawing back and forth between varying amounts of centralization and decentralization. If there is any one concept which I hope you will carry away from this talk, it is the stress on conflict and competition, the dynamic aspects, most of all the idea that organizational change should not be regarded as a restless search for a single magic formula for success; rather, such movement back and forth along the centralization axis is a necessary, healthy ingredient of R&D management.

6. Epilogue

I started this talk with remarks about the state of the communications art 50 years ago. Since then there has been outstanding growth in both our countries, as shown in Table 1. In Australia, population has more than doubled, but the growth in number of telephones has been truly prodigious. In the United States growth has been large, too, though not as spectacular. It is figures like these that inspire me with confidence, even though we all have increasingly difficult tasks ahead of us in research and development. The future is bound to be bright if we set our minds to it.

Table 1—Growth in population and telephones in Australia and United States over the last 50 years

50 YEAR GROWTH			
	1923 (millions)	1973	Increase %
Australia			
Population	5.69	13.45	136
Telephones	0.282	4.65	1550
United States			
Population	112.0	211.	88
Telephones	15.4	133.	764

In this connection the best ending I can find is inspired by a quotation from the first Director of Research as Bell Labs, Dr. H. D. Arnold, writing nearly 50 years ago on "Organizing our Research". He said:

> "There is a vast body of fact and experience which is the stock-in-trade of the engineering profession . . . . There is a great mass of scientific information which has not yet won an accepted place in the equipment of engineers . . . . There is, furthermore, and most important of all, that enormous body of knowledge which the world will have in the coming years, but of which we are now entirely ignorant."

He further stated:

> "The fundamental duties of the Research Department are to obtain new scientific knowledge which may serve our art, and to consider ways in which this information may be utilized. Of its output, inventions are a valuable part, but invention is not to be scheduled nor coerced. It follows research through the operation of genius: and the best that any department can do to promote it is to provide a suitable environment."

My parting thought here is that throughout the next 50 years creativity will still remain an act of individual talent and genius and that to nurture it properly the R&D manager must do all those things which will optimize the environment all along the pathways to future progress.

Biography

WARREN A. TYRRELL is executive director of the Technical Relations Division at Bell Laboratories, Murray Hill, N.J. He is responsible for coordinating technical exchanges between Bell Laboratories and domestic and foreign organizations, particularly industrial and governmental laboratories. These exchanges concern the various fields of research and development of interest to the Bell System. His division also serves as the focal point for liaison with AT&T and Western Electric Company on various matters affecting technical exchanges, notably patent licensing activities and relationships with foreign telephone administrations. More generally, his mission is to guide and optimize the professional relationships of the Bell Labs Technical Staff with outside organizations.

After joining Bell Laboratories in 1939, Dr. Tyrrell became engaged in microwave research. During World War II, he worked on various radar projects. He was granted a number of patents on microwave devices and systems. In 1948 he commenced one of the earliest efforts on modern optical research in communications. In 1952 he was promoted to head of the Telephone Instrument Research Department. In 1956 he was appointed head of the Underwater Acoustics Research Department with project responsibilities for a number of U.S. Navy contracts. In the following years he served on several advisory committees connected with the Office of Naval Research. He also was active on the Anti-Submarine Warfare Advisory Committee of the National Security Industrial Association. He became manager of technical relations in 1965 and assumed his present position in February, 1970.

Dr. Tyrrell received his B.S. and Ph.D. degrees in physics from Yale University in 1935 and 1939, respectively. He is a Fellow of the Acoustical Society of America, and a member of the American Association for the Advancement of Science.

Communications and Social Change

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Although most literature on social change deals with the impact of science and technology on society it is equally possible, and valid, to argue that scientific and technological advances are a response to social demand, and that technology is reactive as much as it is creative. This paper attempts to treat communication as a socio-technical system, in which the roles of social demand and technological impact are kept in balance. Firstly, the nature of the social demand for communication services and the ways in which it is likely to change are examined by considering the various components of this demand; population, urbanization, education, the 'information explosion', leisure and recreation, industrial organization, the structure of the work force, geographical mobility, etc. Secondly, actual and possible consequences of technological innovation in communications, including economic, psychological, political and legal implications are examined.

1. Introduction

The year 1830 has a special significance in human history. From it, we can date the beginning of the communications revolution. Organised society depends for its very existence on the transport of things, people, and messages between individuals, groups of people, and places. Until the 1830's, the methods available for such transport had remained virtually unchanged since the beginning of civilisation, depending still on muscle power, wind and water. It took as long to send a letter or a consignment of goods from London to Rome in 1830 as it had done in the heyday of the Roman Empire, and their arrival was probably less dependable. Communications were restricted to beacons, smoke signals, and semaphore, as they had been for thousands of years. In the 1830's, with the introduction of railways, the discovery of electro-magnetic induction, and the invention of the screw propeller, the world began to move and has continued to move faster and faster ever since. By the 1860's, Jules Verne could send his hero round the world in 80 days; in the 1960's, an aeroplane could fly around the globe in time with the sun. Shakespeare's Puck declared that he could girdle the earth in 40 minutes; today, it would take him more like 40 seconds.

So spectacular has this change been that we are constantly in danger of being dazzled by the hardware to the exclusion of what we might call software, i.e. the processes of social interaction which generate the demand for transport and communication, and did so long before any kind of hardware had been created. Alternatively, we can express this point by emphasising that physical technology is always linked with social technology, and that the relations between them vary a great deal. This is particularly true in the case of communication, which depends on the existence of speech, language, and writing. Language could, in fact, be described as the basic social technology which makes social existence possible. This is true not only of man but of animals. Aristotle had already noticed that bees make regular wagging movements with their bodies when they return to the hive, and deduced correctly that they were transmitting information about sources of nectar. In the 20th century, von Frisch and others (Ref. 1) have demonstrated the complex code of signals involved in this transmission process, which deserves to be called a language. The study of ethology has demonstrated the existence of equally complex signalling codes among other species, from birds to dolphins; Lorenz even learned to reproduce the calls of the greylag goose and to hold 'conversations' with his feathered friends (Ref. 2).

The extent to which we identify social development with physical technology is reflected in the evolutionary succession of the ages of mankind on which schoolchildren have been brought up since the middle of the 19th century — Old Stone Age, New Stone Age, Bronze Age, Iron Age. Not only does this classification over-simplify history by tying it too closely to the progress of physical technology; it also over-simplifies physical technology by equating it with the use of materials. It would be a simple matter to find alternatives based on different conceptions of technology. We could plausibly invent a historical sequence based on the development of communication, which might run through rudimentary speech, grammatical speech, written language, mathematical notation, printing and mass literacy, to the age of mechanisation and electrification of communication media. It is possible to link these with other historical phases. Written language, for instance, appears to be an indispensable precondition for the establishment of cities and of stable government. Mathematics was essential for the civilisations of Egypt, Greece, Babylon, China, and India. The Middle Ages in Europe came to an end with the invention of printing and of world-wide navigation. The growth of modern cities is inextricably bound up with mechanical and electrical means of transport and communication.

It is necessary to stress this point of view, if only as a corrective to the widespread overemphasis on the role of technology which is characteristic of the 20th century. One often hears about the impact of science and technology on society, as though they were independent, self-generated forces acting on a passive social organism. The fallacies of this view have been exposed by economists, historians and sociologists like Hansen, Ogburn, and Heilbroner (Ref. 3), but its plausibility is very difficult to resist in the age of nuclear energy, antibiotics, electronics, synthetic fibres, supersonic flight, space travel, and communication satellites. This conception of technology acting on society finds one of its popular current expressions in the vogue for 'technology assessment'. Technology assessment and technological forecasting are closely related, since the assessment process involves a study of the probable effects of a new technological development. Although there are many definitions of technology assessment, they are all based on the notion of the technological impact on society. Thus, one of the contributors to a recent symposium on technology assessment describes it as 'the systematic study of the secondary and higher order effects or impacts on society of a present or proposed application of technology. In its fullest form, it should anticipate, forecast, and evaluate the impacts of the technological intrusion on all sectors of society' (Ref. 4). Another writer in the same symposium criticises this deterministic view of technology, which treats technological innovation as something that will happen regardless of social change or politics. This style of argument, when it recognises social factors, assumes that it is technology which has an impact on society, rather than the other way round. Yet it is clear, he concludes, that 'social values can affect technological priorities or the allocation of resources; technological innovation often results as a response to social or economic demand and takes place only if a willingness exists on the part of society to put a new technology to use' (Ref. 5).

Technology assessment and technological forecasting are, in fact, statements about the future, i.e. about social change. In the nature of the case, they are frequently made by physical scientists and engineers whose insight into social processes is rather less than their familiarity with the laws of physics or the properties of materials. On the other hand, social scientists are liable to take physical technology for granted and consequently to overlook the extent to which social arrangements may be governed by technological imperatives. The task of overcoming these complementary difficulties is itself a major problem in communication, to which there is no easy or obvious solution. One of my objects in this paper is to develop some concepts which may be a small contribution to bridging this gap, and to apply them to the particular case of communication.

For this purpose we will regard communication as a 'socio-technical system', which may be defined as a complex model representing the connection between human needs, demands, and imperatives on the one hand, and the interrelated networks of institutions, social roles, physical techniques and instruments which arise in response to these needs, demands and imperatives. A socio-technical system is not primarily a description of the structure of organised society, but an analytical and heuristic device for representing the processes of social change, especially the interaction between social institutions, social behaviour, and technological change. Food, energy, transport, the use of materials, the provision of shelter, health, and communications are examples of topics which should lend themselves to this kind of model building.

The term 'socio-technical system' has been current for over 20 years, and is particularly associated with the work of the Tavistock Institute on industrial management problems, although similar concepts have been used by other workers (Ref. 6). It was originally applied by Trist & Bamforth in 1951 to interpret the problems which had arisen in the mechanisation of coal mines, where productivity had failed to rise in accordance with expectations. This failure, they argued, was due to a lack of recognition that physical technology is embedded in a social matrix, which does not change automatically in response to a technological change. Coal mining was a socio-technical system in which the techniques of coal extraction were linked with a structure of occupational roles. This gave it social, economic, and technological dimensions which were interdependent but also had independent values of their own (Ref. 7).

Systems thinking of this kind does not need to be restricted to management questions, especially if we recognise its connection with a parallel tradition in anthropology, psychology, and sociology which treats social relations as open or adaptive systems characterised by response to environmental demands, by internal and external sources of change, tension, and selection, and by feedback processes which may either balance or unbalance the system (Ref. 8). Socio-technical systems, in other words, are also cultural systems, and we may note that the anthropologist uses the term 'culture' to embrace both the material and the psychological aspects of social life. This is a particularly relevant observation in the case of communication, where the relation between 'hardware' and 'software' is of fundamental importance.

2. Needs, Demands and Imperatives

Without spending too much time on a general discussion of socio-technical systems, let us see how these concepts may be applied to the particular case of communication. First, we may examine the needs, demands, and imperatives which are served by the communication process. In doing so, it is logical to deal with transport as a related system. Not only do transport and communication arise from a single cluster of needs and demands, but their operations are closely interwoven at many points, and their reciprocal effects should be always born in mind. The following list involves considerable overlap between categories, but each heading indicates a distinctive cluster of phenomena.

2.1 Movement of Persons

The gratification of human needs entails physical movement between locations, requiring both physical effort in transportation and information about direction (i.e. communication).

2.2 Physical Transfer of Objects

The same applies as in 2.1.

2.3 Personal Interaction

With or without movement, social life requires interaction between persons, from the basic dyad to the mass movement. This may involve transport (crossing the city to see a friend), communication (a long telephone conversation or a postal chess game), or a mixture of both (telephone call plus visit).

2.4 Learning and Socialisation

This entails both transport and communication in a variety of senses. Language, non-verbal messages, mathematical notation, and visual design are all necessary to transmit information, inculcate attitudes, impart skills, and exchange ideas. Institutions of formal education require frequent movement by large numbers of people and quantities of physical goods. The mass media depend on a variety of intricate combinations of hardware and software.

2.5 Information storage and analysis

Although this is related to 2.4, it is a significant phenomenon in its own right, and not wholly novel. In ancient Egypt, agricultural policy was made when Joseph correctly decoded a dream forecast by the Pharaoh, resulting in a highly organised system of communication, transport, storage and distribution of grain. Today, computerised analysis of massive data inputs guides international commodity markets, and the growth of specialised knowledge generates new technologies for recording, retrieving and analysing it. It also generates exchange through associations, conferences, meetings and training courses.

2.6 Recreation and Entertainment

This is another area of intricate relations between transport and communication, as in the case of tourism. The role of the mass media in entertainment hardly needs emphasis. A large part of advertising is devoted to leisure-time activities.

2.7 Collective Behaviour

Communication and transport are essential for collective behaviour. Political life depends on communication between governments and the governed, between political leaders and the public, between levels of government and between governments. The modern centralised state was a product of the railways and the telegraph. Mass communication is a powerful agent of political solidarity and also of political upheaval. The role of the B.B.C. during the Second World War is well known. General de Gaulle's return to power in May 1958 is sometimes attributed to the availability of transistor radios, which have also been credited with the rapid spread of disaffection in May 1968. Communication and transport are essential agencies of security against threats to society, either by human agencies or natural disaster. The working of society also requires various social groups to be aware of the existence, functions, and problems of one another. Secret intelligence, espionage, and 'bugging' are a significant part of this process.

2.8 Co-ordinated Activity

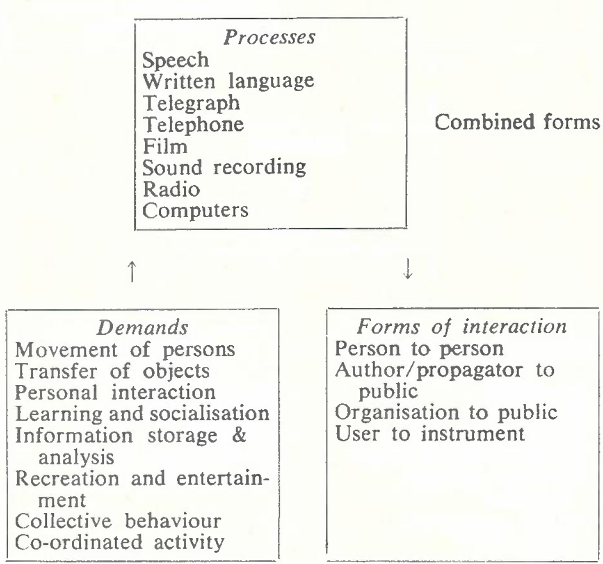
One of the outstanding features of our society is its reliance on organisation — the growth of purposive, specialised, corporate groupings of people. This tendency was first diagnosed in detail by the historian and sociologist Max Weber, who described it as the 'rationalisation' of social life through the formation of 'functional associations' which operated under 'legal-rational' rules and hence were predominantly 'bureaucratic' in character. Whatever else may be said about formal organizations, they undoubtedly generate an enormous demand for communication in the form of letters, documents, telephone calls, telex machines, cable messages, meetings, and business trips.

3. Communication as a Socio-Technical System

The next stage of our analysis should be to examine socio-technical mechanisms which arise in response to the needs, demands, and imperatives I have outlined. This means looking at the communication sector proper, and from now I shall only refer to transport incidentally.

There is no pre-eminent method of organising concepts of data to display all the structures, linkages, feedback loops, flows and interactions which make up our socio-technical system. In principle, this could be done by dynamic modelling using a specially devised computer program, but this would not serve our immediate requirement of verbal presentation. We have here, in fact, a nice problem in communication, and I shall endeavour to deal with it by a series of partial presentations. We may begin by looking at the available and prospective forms of technology, of which the elementary and universal form is the psycho-physiological process of speech, involving no hardware whatever. This gives us the list of processes shown in Fig. 1.

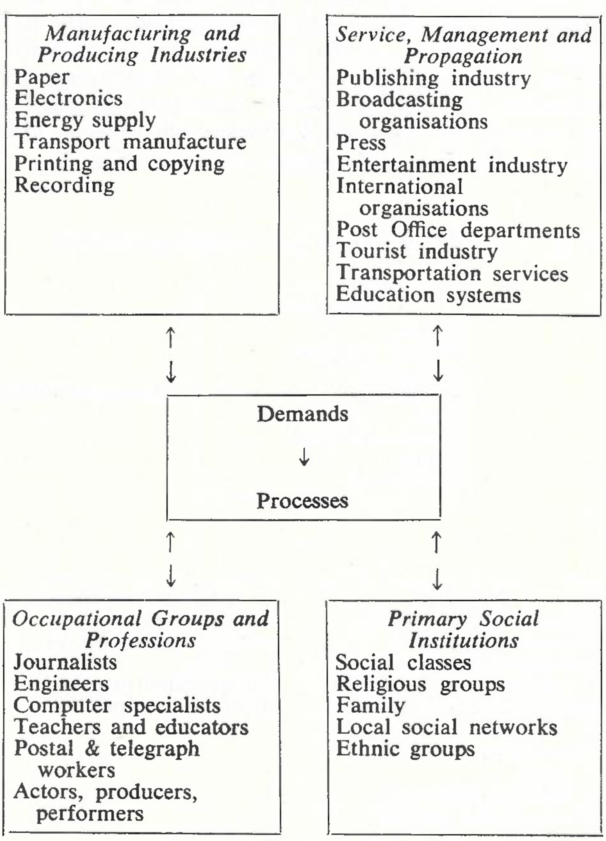
Fig. 1 — Mechanisms for Satisfying Demand



From this basic list of processes can be derived a large number of combinations, so that by the year 2000 — the magic figure in the forecasting business — we may expect to see something over 20 distinguishable methods in use, ranging from direct speech and simple letter-writing to telemail, super-telex, colour facsimile, and portable computer terminals. As one British computer scientist has remarked, the computer terminal in the briefcase will replace the E-type Jaguar as the up-and-coming executive's status symbol. These developments exemplify two outstanding characteristics of communications media — their ability to form combinations, and their cumulative rather than substitutive quality, i.e. no method ever completely replaces another method.

Technical processes are only one part of the socio-technical system. Physical technology is everywhere intertwined with social technology in the form of organisations, rules and rule-making bodies, professional and occupational groups, and also with primary social institutions like the family, ethnic groups, religion, and social class. I have attempted to set out these relationships in Fig. 2. The existence of these relationships creates secondary demands and imperatives which are just as real and important as some of the primary needs and demands I have described. Technological progress is often determined by the structure of the producing industries. Thus, magnetic tape was developed long before it became generally available for recording purposes, and it is well known that it was held back because of the oligopolistic character of the industry. Again, the structure of the economy and

Fig. 2 —
Social Technologies, Institutions, and Organisations



of the political system in the Soviet bloc has various restrictive effects on the development of communications, giving rise to the remarkable phenomenon of 'samizdat' or 'self-publishing'.

My object in giving this detailed analysis of communication as a socio-technical system is to provide a context for the question of forecasting. Extrapolation of present technological possibilities can tell us what devices may be available in the year 2000, but this alone does not provide a basis for policy concerning the availability of these devices. Nor does it tell us much about the social costs of investing in new technologies, or the social desirability of maintaining, extending or discouraging certain kinds of technologies and services. The picture I have presented may look somewhat complicated, but we have learnt to distrust over-simplified assumptions and forecasts, especially those which suggest that complicated and ambitious advances in high technology will be relatively easy and inexpensive. The over-simplified nature of technology assessment and technological forecasting is emphasised in two important reports on the subject by the U.S. National Academies of Sciences & Engineering (Ref. 9). Both reports underline the need to place technological forecasting in a social context. The N.A.S. report concludes that it is more important and more realistic to foresee the full range of possibilities than to predict the most probable direction of development. The N.A.E. report observes that technology assessment is based on a broad range of assumptions and associated forecasts covering not only technical but economic, social, and political futures, and that most forecasts involve serious errors of timing. Both reports underline the need to develop social indicators which can provide a more accurate context for forecasts. This involves not only the collection of statistics, but the working out of valid conceptual structures to justify such indicators (Ref. 10). Indeed, the very collection of statistics depends on prior decisions as to what is socially meaningful.

4. The Impact of Social Change on Communications

At this stage, we should say something about the process of social change and the impacts it is likely to have on social demand for communications. Under present day conditions, there are three outstanding aspects of social change which command our attention — population growth, technological change, and economic growth. Whatever the actual increase in population in the next 30 years, it will unquestionably be one of the most rapid in human history, and even those countries with stable populations will be affected by world-wide growth. Economic growth is inescapable partly because of massive population increases, and partly because it is still an overriding political aim in most countries of the world. Technological change will continue partly because of its own momentum; partly because it is spurred by population growth, economic expansion, and military demands; and partly because the adverse consequences of existing technologies are a stimulus to corrective action.

The combined impact of these processes may be seen with particular clarity in the growth of cities since the beginning of the 19th century. Urban growth reflects population growth; it corresponds to the various stages of industrial development; and it has been made possible by the technologies of transport and communication. The relationship is reciprocal, as the demands generated by urban growth have greatly stimulated the technology of communication; conversely, patterns of urban growth have been powerfully affected by the development of transport and of the telephone. It has been said that the modern American university or 'multiversity' is most readily defined as a cluster of schools and research institutes with a common parking problem. We could equally define a city in terms of its public transport system or its telephone network. The exact relationship between city life and the demands which it generates is still only dimly understood, yet this kind of understanding is essential to any well-informed forecasting about communication.

The impact of social change on communications may be illustrated with a few statistics. I shall relate these, as far as possible, to the items in Fig. 2. The world consumption of paper for 'cultural' purposes rose from 33.6 million metric tons in 1959 to 44.6 million metric tons in 1969. Book publication, which accounted for about one-third of this, rose from 285,000 new titles in 1955 to 364,000 in 1960 and 546,000 in 1970. The number of new books published in Oceania (of which Australia is the largest component) rose from 1,000 to 1955 to 7,000 in 1970 (Ref. 11). The circulation of daily newspapers and periodicals has risen over the same period, with the most spectacular increase being in scientific and technical journals. The National Lending Library for science and technology in the United Kingdom currently takes over 30,000 journals. The calculations of Price (Ref. 12) on this subject are well known. In 1963, he calculated that 10 million scientific papers were in existence, and that the doubling time was ten years. If the rate of publication has continued in conformity with Price's calculations, we should reach 20 million papers in the current year.

If we move from writing to interaction, we have a similar but even more spectacular rate of increase. According to calculations made by Cherry, the number of listed international organisations increased by an average annual rate of 100 between 1948 and 1968 (Ref. 13). McHale has estimated that the number of international conferences, governmental and non-governmental, rose from 22 in 1850 to 1100 in 1900 and 9000 in 1970 (Ref. 14). Tourism and business trips are, of course, major influences on international movement.

The educational 'explosion' is naturally part of this scene. Bell has noted that the university population of the United States has doubled every 20 years since 1879 (Ref. 15). Since 1947, the number of bachelor's degrees conferred annually has more than doubled and the number of doctorates more than trebled. In other countries, the rate of increase has been much slower and enrolment rates are still far behind the American figures, but there has been considerable convergence since 1945. Between 1960 and 1970, enrolments in higher education rose by a factor of more than 2 in most of the 'advanced' countries. McHale estimates that formal education, which was zero for most of humanity from the Palaeolithic era to the middle of the 18th century, now accounts for 7 percent of the lifetime of civilised man (Ref. 16).

Although it would not be difficult to add to these data, the gaps are more noticeable than the available statistics. As I remarked before, conceptions as to what is significant largely dictate what information is collected. The concept of socio-technical systems has yet to be established, and until then we will continue to lack many social indicators. Telephones are one area where data are relatively plentiful, perhaps because the capital investment is so large that even a small percentage devoted to data collection would represent a substantial amount. In addition, the demand for telephones has risen so fast that forward planning is indispensable if installations are to bear any relationship to demand. There are a number of interesting features about telephones which suggest that they would readily lend themselves to the kind of socio-technical analysis I have described.

Rapid growth of telephone installations has been characteristic of all advanced countries since 1945. Before that time, telephones were far more common in the U.S.A. than in any other country. By 1935, there were already more than 17 million installations, covering 13.7 per cent of the population, with a capital investment of nearly 5 billion dollars (U.S. billions) and a gross operating revenue of nearly $100 million (Ref. 17). The telephone industry was the third largest public utility in the U.S., and according to one contemporary estimate, A. T. & T. was the biggest corporation in the world in terms of property values (Ref. 18). Other industrial, affluent countries are now reaching the same level of telephone intensity as the United States had before the war. In particular, the telephone is becoming a normal item of domestic use, whereas until recently it was much more important for business purposes. The leads to two general characteristics of the growth of telephones. Firstly, there is relatively little variation in the use of telephones for economic purposes, but wide variations in domestic use (Ref. 19). Switzerland, which has more telephones per 100 population in the economic sphere than the U.S.A. (20.2 as against 12.6) has only half as many in the domestic sphere (17.6 as against 35.0). The U.K., with 10.6 per 100 in the economic sphere, has only 8.9 in the domestic sphere. These differences have flattened out considerably, and the rate of new installations in the affluent industrial countries since about 1960 has been of the order of 80 private to 20 business connections (Ref. 20). The second characteristic is that despite these differences, the growth of telephone installations over the past century has, in most countries, followed a logarithmic pattern more or less closely. The 'Prospectives' forecasting group attached to the French central planning commissariat has tried to formulate this rule precisely in the following equation:

$$\log d = a + b \log G + E$$

(where d is connections per 100 residents, a is the negative logarithm of income elasticity, b is the positive logarithm of income elasticity, G is gross domestic product per head, and E is a constant).

The value of b ranges from 0.76 for Sweden (which had the highest rate of installation in the 1950's and 60's) to 1.8 for Greece (which had one of the lowest). The value of b for Australia was 0.97 (Ref. 21).

A similar calculation has been carried out by Cherry, using correlation methods (Ref. 22). In this case, there is a rank correlation of 0.94 $\pm$ 0.02, between GNP per head and number of telephones per hundred of population. It is interesting to notice that New Zealand, Denmark, Norway and the Netherlands are well above the regression line in this analysis, and Switzerland, Canada, Australia, France and the German Federal Republic are well below it. So, for that matter, is the United States, whose high incidence of telephones can obscure the facts that it possesses relatively few telephones in relation to its wealth and that there is a steep gradient in telephone ownership, again correlated closely with income per head, which corresponds closely to the geography of the United States. We possess comparatively little information on this question. A British survey of family expenditure showed that families with weekly incomes of £50 or over (in 1967), who might be expected to possess telephones, spent only 0.7 per cent of their weekly expenditure on mail and telecommunications, compared with 8.7 per cent on motor vehicles and 2.7 per cent on fares for other forms of transport (Ref. 23). Studies by the Post Office in Britain show a low level of telephone ownership among the working class, as might be expected, but also a rapid rise. In the early 1960's, 92 per cent of households where the breadwinner earned more than £40 per week had telephones, compared with 15 per cent of households where earnings were between £10 and £20 per week. A longitudinal study in Sheffield found that 13 per cent of working-class homes had telephones in 1960, but this had jumped to 25 per cent by 1965 (Ref. 24).

5. Conclusions

As we draw to the close of this paper, it might well be asked what, if any, cash value such an analysis could have as a guide to policy-making? This is a good question, although to answer it properly would require another paper as long as this one, which has been concerned to establish a conceptual structure rather than apply it in detail. There has been a certain amount of forecasting in the field of communications, most of it concerned with technological projections, and virtually all of it based on the extrapolation of existing trends. This kind of forecasting has not shown itself to be particularly accurate or helpful. The British Select Committee on Nationalised Industries observed mildly that Post Office forecasts had been 'inaccurate in recent years' (Ref. 25). A witness from the telecommunications industry admitted to the committee that everyone had been taken by surprise by the great upsurge in demand for telephones and other services. This upsurge is reflected in the fact that, between 1950 and 1970, telephone installations rose from 5 million to 14 million, calls from 3,000 million to 9,500 million, telex lines from a trivial number to 30,000, and data terminals from nil to 12,000. (Professor H. M. Merriman, the Post Office Corporation's member for technology, has predicted that by 1980 telephones will rise to 34 million, data terminals to 300,000, and telex lines to 140,000). Cherry notes the importance of forecasting for policy-making on telecommunications, and points out that there is no simple method of estimating long-term growth in demand for telephones, possibly because domestic and economic demands are controlled by different factors. It is precisely this kind of point with which the present paper is concerned (Ref. 26). Perhaps this kind of analysis will assist in the development of more sophisticated methods of estimation. As Herman Kahn has said, the aim of forecasting is to provide 'surprise-free' methods of prediction.

In addition, the approach to forecasting implied in this analysis should help to avoid some of the more simple-minded errors which I have labelled as 'technological determinism'. There is a common predisposition, particularly strong in the United States, to assert that certain things 'will' follow in the wake of technical advances. New developments in telecommunications will, it has been asserted by authoritative persons, contribute to the cure of urban blight, make education universally available throughout a person's lifetime, democratise politics through community control of the media, prevent the growth of megalopolitan cities by encouraging decentralisation, and reduce the need for travel by substituting 'confravision' for actual meetings. All these assertions are little more than just that — assertions. Insofar as solid evidence is available, it does not support them. A Canadian study of communication between various city pairs in the Toronto-Montreal region indicated that there was a similarity between telecommunications and travel hierarchies, with little evidence of the telephone substituting for travel. Indeed, one might expect an increase in telephone usage between cities to lead to an increase in demand for travel between those cities. The existence of big urban centres with large and growing central business districts generates demand for a variety of forms of contact which are not interchangeable (Ref. 27).

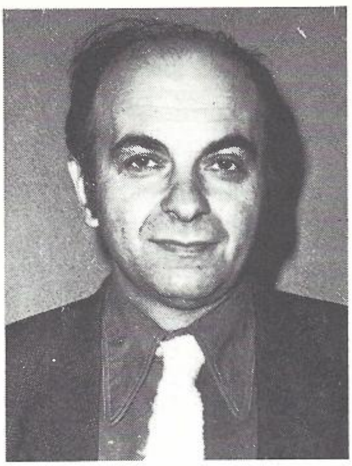
Thomas Carlyle, himself a great communicator, had many perceptive things to say about communication. The three great elements of modern civilisation, he declared, were gunpowder, printing, and the Protestant religion. He also described a good book as the purest essence of a human soul, and a true university as a collection of books. Yet, in the end, he praised silence more than speech. Under all speech that is good for anything, he wrote, there is a silence that is better. Speech is as shallow as time, but silence is as deep as eternity. The English, he hoped, would long maintain their great talent for silence. As we contemplate the exponential growth of the media of communication since Carlyle's day, we might well reflect upon this praise of silence. And suiting the action to the word, I will shut up.

6. References

1. Karl von Frisch, *The Dancing Bees,* Methuen, 1966; Martin Lindauer, *Communication Among Social Bees,* Harvard University Press, 1961.
2. Konrad Lorenz, *King Solomon's Ring,* Methuen, 1952.
3. Alvin Hansen, "The technological interpretation of history", *Quarterly Journal of Economics,* vol. 36, no. 1, 1921; Robert L. Heilbroner, "Do machines

make history?", *Technology & Culture,* vol. 8, no. 3, 1967; W. F. Ogburn, *On Culture & Social Change* (ed. O. D. Duncan), Chicago University Press, 1964, pp. 132-3.
4. Joseph Coates, "Interdisciplinary considerations in technology assessments", in Cetron & Bartocha (eds.), *Technology Assessment in a Dynamic Environment,* Gordon & Breach, 1973, p. 271.
5. D. M. Kiefer, "Technology assessment in technological forecasting", in ibid., p. 950.
6. F. E. Emery (ed.), *Systems Thinking,* Penguin, 1969.
7. F. E. Emery, *Characteristics of Socio-Technical Systems,* Tavistock Institute, paper no. 527, 1959.
8. W. Buckley, *Sociology and Modern Systems Theory,* Prentice-Hall, 1967; Gregory Bateson, *Steps to an Ecology of Mind,* Paladin, 1973, part 4.
9. National Academy of Science, *Technology: Processes of Assessment & Choice,* Washington D.C., 1969; National Academy of Engineering, *A Study of Technology Assessment,* Washington D.C., 1969.
10. Elaine Carlisle, "The conceptual structure of social indicators", in Andrew Shonfield & Stella Shaw (eds.), *Social Indicators & Social Policy,* Heinemann, 1972.
11. UNESCO Yearbook, 1971.
12. D. J. de Solla Price, *Little Science, Big Science,* Columbia University Press, 1963, p. 73.
13. Colin Cherry, *World Communication: Threat or Promise,* Wiley, 1971, pp. 121-6.
14. John McHale, *The Future of the Future,* Braziller, 1969, p. 272.
15. Daniel Bell, "Knowledge & Technology", in E. B. Sheldon & W. E. Moore, *Indicators of Social Change,* Russell Sage Foundation, 1968, p. 205.
16. McHale, op. cit., p. 275.
17. *Technological Trends & National Policy,* a report by the National Resources Committee, Washington D.C., 1937.
18. C. C. Furnas, *The Next Hundred Years,* Cassell, 1936, p. 235.
19. Cherry, op. cit., pp. 75-6.
20. *Plan et Prospectives* series, *Postes et Telecommunications,* Armend Colin 1970.
21. ibid.
22. Cherry, op. cit., pp. 143-5.
23. J. S. Whyte, "Telecommunications & city planning", in *City in the Year 2000,* British Post Office, Long Range Studies Division report no. 19, 1969.
24. Report of Select Committee on Nationalised Industries, House of Commons Papers, 1966-67, vol. 17, ch. 7.
25. ibid., para. 60.
26. Cherry, op. cit., p. 77.
27. Personal communication from Mr. C. Beaumont Lewis of the Canadian Ministry of Transportation.

Biography



Professor S. ENCEL was born in 1925 and after seeing war service in the R.A.A.F. in 1944-1945, was awarded a B.A. in 1949, an M.A. in 1952 and a Ph.D. in 1960 at the University of Melbourne.

In 1955 he was Lecturer in Political Science at the University of Melbourne until the following year when he accepted the post of Senior Lecturer and Reader in Political Science at the Australian National University. In 1966 he became Professor of Sociology and Head of Department at the University of New South Wales, a position held to the present time. He was chosen to be a Rockefeller Travelling Fellow at Harvard in 1960 as part of the Science and Public Policy Programme. He has been involved in the study of science policy since 1958, initially worked on a contract to the Australian Atomic Energy Commission. He has published numerous papers in this field in Australian and International journals.

Currently he is a Visiting Fellow of the Science Policy Research Unit, University of Sussex, as a member of the team working on a long-term forecasting project entitled "Social and Technological Alternatives for the Future", and will continue this connection as a Visiting Professor.

Professor Encel is the author of *Cabinet Government in Australia,* 1962; *Australian Society: a Sociological Introduction,* 1965, and 1970; *Equality and Authority,* 1970; and *Women and Society* (in press).

Aspects of Future Telecommunications Services of Particular Relevance to Australia

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While Australia continues to rely heavily on imported communications technology, the A.P.O. Research Laboratories makes important contributions to telecommunications science and technology in fields which are of special interest to the Australian Post Office. This paper presents a discussion of the progress made in several fields of telecommunication research and provides an insight into what is involved in planning for the future. Advanced work is being carried out in an integrated switching and transmission system using digital techniques and offering the possibility of the integration of separate networks such as telephony, data and telex. Development of optical fibres for use in wideband reticulation is continuing and, providing several technical problems can be overcome, they will find many applications in future communications systems. Of particular relevance to Australian conditions is satellite communication and ways are being studied to utilise satellites to augment and extend our existing telecommunications network. Aside from advances in technology there is an increasing involvement in the sociology of communications in planning to meet our telecommunication needs.

1. Introduction

In considering the theme "Whither Communications?" we can be sure that the telecommunication services available and the use made of them in 30-40 years time will be vastly different from the position today. Nevertheless we must acknowledge that in many respects the services that will be in use in Australia will be the same as those in use in other developed countries. We will continue to use systems and techniques and services that in some cases are first developed overseas and are later adapted to our use.

This is not surprising. When one considers that in Australia we have less than 2% of the world telephones, it would be futile for us to attempt to develop all our own telecommunications technology. However, despite the flow of information and technology from abroad there are some aspects of the Australian situation that are peculiar to our own situation and in this paper I want to discuss some of these.

2. Value of a Research Laboratory in the Australian Post Office

The first is the question: recognising the great flow of information and technology from other sources, why maintain a research and development laboratory? Would it not be sufficient to identify our requirements and to rely on industry to provide them from local or overseas sources. Experience over many years has shown that this is not enough. The major developments in telecommunications originate in densely populated countries in the northern hemisphere. Because of our different local conditions it is only very rarely that an overseas developed system can be adopted without modification.

There are a number of advantages in having our own research and development laboratories.

(i) It provides a knowledge base—a reservoir of skill and knowledge that is available for use whenever required in the Post Office — covering the whole range of telecommunications and allied disciplines.

(ii) It provides information and expertise that enables the Post Office to apply new technology with confidence, to adequately specify its requirements for new types of equipment and to appraise equipment and techniques that are offered to it.

(iii) It provides the capacity to handle problems for which no appropriate solutions are available from elsewhere — that is, those problems that are peculiar to our conditions. Examples include work on subscriber communications in sparsely settled areas, microwave propagation in desert regions or millimetric wave propagation in tropical rain storms, local materials for use in equipment manufacture and ant and termite resistant sheaths for plastic cables.

(iv) There are additional benefits; e.g. it is an appropriate location for providing time and frequency standards, transmission standards and other standards of measurement.

A research laboratory in good standing is an attractive entry point for talented young professional staff, many of whom in later years will move to other areas of the Post Office where their high intelligence and trained minds will be brought to bear on other types of problems, and it provides an outlet for the creative talents of staff, many of whom are of high calibre and who otherwise would be lost to the Post Office and perhaps to Australia.

It provides a focus for telecommunications research in Australia and acts as a stimulus for a great deal more research and development in Universities and in industry.

Over the past 50 years our R & D effort has increased at an average of about 6% per annum until now. We have a staff of over 500 with 120 engineers and 30 physical scientists. We see no reason why this growth rate should diminish in the next few decades. In fact, with increasing complexity and diversity of telecommunications and with growing awareness of the need to apply the knowledge and insights of non-technical disciplines to telecommunications problems, I believe we will need to increase the rate of growth of our R & D resources.

3. A National Telecommunications Plan

I mentioned earlier that telecommunications in the future will be vastly different in scope and diversity to those existing today and the question arises — what will communications be like in, say, 30 years — and how do we get from where we are now to where we will be, in the most economical manner and without false starts?

The questions are not easy ones and vet it is tremendously important that we have the best answers available.

At the present time we have assets in the A.P.O. with a book value of about $3000 M and we are adding to them at about $400 M per annum. Over the next 5 years alone we expect to spend $2000 M — $3000 M in enlarging and diversifying our network. We need a clear idea of where we are going or we may commit the development of our telecommunications network in the wrong direction.

There are two approaches to the long term planning required — the first — the forward projection of what we have, supplemented by the ad hoc addition of new services and the ad hoc adoption of new technology. This technique is reasonably effective in the short term but it has disadvantages in the middle and long term. It is difficult to determine correct timing for innovations and it is difficult to cope with the unexpected. In addition, a succession of ad hoc decisions can lead to a situation when later desirable developments are constrained.

The second approach is to attempt to project ourselves forward to where we might be and then to work back and determine the steps and timing required to get there. This approach is difficult as there are numbers of possible destinations, some of which may be mutually exclusive. Nevertheless, it does permit the postulation of a number of alternative goals and the definition of a growth strategy which does not unwittingly preclude the attainment of any of the goals.

There is a long tradition of forward planning in the Australian Post Office, one of the milestones being the Community Telephone Plan published in 1959. This Plan was a telephony plan and enunciated the major principles that have guided our progress towards a nationwide fully automatic telephone network. The goals laid down have been substantially achieved and the Plan is still guiding our expansion programme. However, there is an increasing area of policy and planning for telecommunications that is outside the scope of the Community Telephone Plan of the 1960's. At that time the planners were preparing to supply telephone and telegraph services to meet an established demand for a familiar product. They were reacting to sociological and economic factors of a discernible and predictable nature.

At this Symposium we are hearing of some of the advanced telecommunications services now in prospect. These are much more basic in their impact on society — they could have significant effects on the structure and location of cities and rural communities, on transport and education and the nature of the information media as well as on life styles in general. Changing political, sociological and economic needs or constraints will have a strong influence on the range and structure of the services required. An effort must be made to discern the range of telecommunication probabilities for the next 25-30 years, as without it the ad hoc extension of the existing network might foreclose or inhibit possibilities that emerge as desirable, or even essential, in the long term.

The Australian Post Office has recognised this problem and is establishing a long term planning group with the task of preparing a National Telecommunication Plan. The group will be a multidisciplinary group comprising engineers, economists, sociologists and marketing experts. It is the task of the National Telecommunications Planning group to identify future community needs for telecommunications facilities in Australia and to define the objectives to meet those needs. Such objectives must necessarily include questions of cost, resources and timing and will provide a framework for decisions on charging, grade of service and network arrangements.

It is a formidable task which will require all the skills of our inter-disciplinary team and all the techniques of technological forecasting to achieve any measure of reliability. Naturally our Research Laboratories with their advanced technological insights will contribute to the planning process and, in turn, in the Laboratories we will obtain guidance on fields of work and priorities for our own programmes.

4. Integrated Switching and Transmission

Informed judgments on future technology are essential inputs to the national telecommunications planning activity. Research and advanced development is carried out so that we might have enough advanced knowledge to assist in these judgments. Advanced switching techniques and advanced transmission techniques are of considerable interest to us. In the switching area it has been our experience that although in the past we have adopted overseas systems (Strowger, L.M. Ericsson Crossbar and I.T.T. 10C processor-controlled exchanges), a great deal of special work has been necessary to adapt these systems to the Australian network. Clearly our network is becoming increasingly unique, and in the Research Laboratories we consider it a possibility that the next generation of switching equipment will be developed and manufactured in Australia.

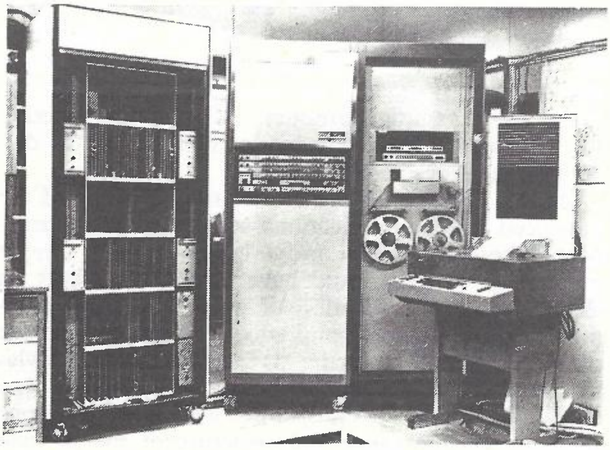

Fig. 1—Model I.S.T. exchange

As digital techniques will play a major role in the network of the future, we decided to investigate the integration of switching and transmission using digital techniques — I.S.T. as it is known. There are several features of I.S.T. that make it attractive for future systems:

- Digital techniques would be used for both switching and transmission throughout the network. This will permit rationalisation of manufacture, installations, maintenance and operation.
- Electronic logic is used throughout. This lends itself to cost reduction through improved design techniques and improved manufacturing methods.
- An I.S.T. network will carry bit streams on which a number of different types of messages such as telephony, data, telex, etc. are interleaved without the necessity for demodulation at the switching points.

Some years ago we commenced an I.S.T. project and work is proceeding on three main fronts.

(i) A model I.S.T. exchange is being built. This will carry live telephone traffic and will enable the technique to be tested under realistic operating conditions. (See Fig. 1).

(ii) Studies are being made to enable the model to be extended to carry data and telex traffic.

(iii) The economic potential of the technique is being assessed in relation to conventional techniques.

The model exchange will be connected directly to a working exchange at Windsor here in Melbourne and also to two other exchanges via 24 channel P.C.M. systems operating at 1.544 megabits/sec. The equipment will be capable of handling 96 circuits and it will be controlled by two of 32,000 sixteen bit words.

We expect that the introduction of the I.S.T. concept in a network would alter the balance between switching and transmission costs and permit the use of fewer exchanges with greater numbers of circuits linking them. By the use of small concentrators close to the subscribers, the average length of the subscribers' lines can be reduced. These possible changes in network topology provide substantial potential for overall savings. Because I.S.T. operates on streams of pulses it can handle any service which is capable of being converted into digital form. P.C.M. systems are readily available to do this for speech; data and telegraph type signals are already suitable and require only translation — a much cheaper and simpler process than modulation. Using appropriate fast signalling techniques, the various services can be interleaved, thus permitting a number of quite different services to be carried simultaneously through a single network. It is this network unifying potential of I.S.T. which is one of its great attractions.

Up to the present our I.S.T. work has been carried out with the objective of providing advanced knowledge and understanding of new types of systems offered by industry. However, we do not discount the possibility that the work could lead to an Australian developed and manufactured system. A decision to develop, manufacture and introduce a new switching and transmission system is of considerable moment and no such decision has been made nor is it under consideration. Nevertheless the concept of I.S.T. is attractive and our studies are aimed at providing information on which such a decision could be based. Overall costs will be an important consideration and our studies include economic as well as technical matters.

If a decision to adopt an I.S.T. system is made using the present developments as a basis, we would need to collaborate with industry in the further development and manufacture. There are notable examples of Government — Industry collaboration of this sort overseas, e.g. *Ellemtel* in Sweden and *Socotel* in France, and we would be paying close attention to these various arrangements if we attempt to embark on a scheme in Australia. At this stage the most that can be said is that we would want to preserve a situation where competition exists, and we would want proper protection and recognition of our legitimate share of the industrial property arising from the development.

5. Wideband Services and Optical Fibres

Experience in other countries shows that there is likely to be a demand for domestic reticulation of wideband services, and already there is talk of a total communication system whereby the total telecommunications requirements for the subscriber are handled by a single network. Telephone and data services, information services, facsimile, videophone and videoprogrammes are major services that could be included.

For such a system the transmission medium will have to handle a variety of signals of differing bandwidths or bit rates and a constraint is the high cost of the transmission medium. The choice of the transmission medium depends on whether we are considering the trunk or the local network and whether there is switching in the network. For example, without switching, a bandwidth of something like 200 MHz would be required to handle all available television channels and other services and the actual selection of a service or programme would be done by the subscriber at his terminal equipment. On the other hand one can envisage a more sophisticated system in which any particular transmission is fed to the subscriber from some switching centre. With this system the capacity of the subscribers' link need be no more than one or two baseband video channels and if real time visual communications are not required, the existing cable pairs would be able to handle most other services.

In the trunk network, the present techniques are microwave radio and coaxial cable with developments in coaxial cable techniques showing considerable advances in reduction of channel cost. Under development in several countries is the transmission waveguide which has the greatest potential capacity and promises lowest cost per voice channel.

In the local network the only practicable medium for signals exceeding the capacity of pair wires is the coaxial cable, which is available in several sizes varying from very small diameter cable up to standard trunk type coaxial. The local network represents 75% of the total installed cable and cost would be a major consideration in the local reticulation of wideband services if we were obliged to use coaxial cable. A breakthrough in this area would make a tremendous impact.

A most promising development in recent times is the optical fibre. Work on low loss fibres has been going on in several different countries for a number of years, and several years ago scientists in the Division of Tribophysics, C.S.I.R.O., here in Melbourne discovered a technique for making low loss liquid filled optical fibres. The technique is in world class, and as early as two years ago we were able to get kilometre lengths of fibre having attenuations of the order of 10-12 dB/km. This gave our Research Laboratories the opportunity of participating in the development of a transmission medium that could be of world interest. As so often happens the C.S.I.R.O. scientists were not alone in their discovery and the Bell Laboratories and English groups at S.R.D.E. and the University of Southampton were in the field almost simultaneously. Even now it is not clear who was the first with the low loss liquid filled fibre. Here in Melbourne the C.S.I.R.O. is collaborating with Amalgamated Wireless (A/sia) and with our Laboratories in the applied research and development required to determine whether the liquid filled fibre can be developed to provide a viable transmission medium.

We recognise, of course, that the multimode fibre is limited in capacity compared with a single mode fibre due to signal dispersion. However, this would not be a disadvantage in a local reticulation system. A good deal of work has still to be done on the actual fibres and associated production techniques, on electro-optical devices and coupling arrangements and on the mechanical problems of handling and jointing the fibres. Although at this stage we are optimistic that the liquid filled fibre will provide a transmission medium that will be competitive with coaxial cable in the techno-economic sense, this has still to be demonstrated and the next two or three years will be very interesting.

In making a techno-economic assessment, a relevant factor which does not normally come into consideration is the channel capacity per unit of duct space. It would seem that the small size of a fibre relative to its transmission capacity would be a great advantage over other comparable media. One could imagine that in some circumstances it could be profitable to remove wire cables from existing ducts and replace them by optic fibre cables, perhaps even for the reticulation of telephone channels. We see the optical fibre work as being of great significance in the context of a total communications system. However, we do not expect it to replace other media but more likely it will provide an additional technical option. Also we are not sure that the first practical system will be based on liquid filled fibres. However, the work that we are able to do on the liquid filled fibres that are available to us, through the good offices of the C.S.I.R.O., will enable us to obtain knowledge and experience that will be equally applicable to any other optic fibre technology.

6. Satellite Communications for Domestic Purposes

Satellite communications are of high interest in Australia not only because of their use by our colleagues in the Overseas Telecommunications Commission for international communications, but also because they offer a means of overcoming some of the problems of providing communications to remote locations, often across most inhospitable country. The fact that the cost and the quality of service is largely independent of distance or the type of terrain is of considerable attraction. At the present time a special Task Group is considering how best, and when best, to introduce a national satellite system as an integral part of our internal communications network. Such studies include economic comparisons, as there would be no point in establishing a satellite system, if it would cost less to provide the services by alternative means. We see such a system as augmenting and extending the existing trunk network and the network for relaying of television. It could also be used to provide services that would be impractical or uneconomic by terrestrial means. Present indications are that the right time to establish a national satellite system will be in about 5 years.

To integrate a satellite system into the network in an overall optimum manner requires reconsideration of network topology and transmission performance objectives. For example, to what degree should multiple access and demand assignment be included in the system design and in what terms should noise performance objectives be set for the various services to be provided? These are some of the problems being faced by the Task Group which contains representatives of our Research Laboratories and of our Planning Sub-Division.

In telephone communications by satellite we face the problem of propagation delays which would be beyond the present international standard of a national satellite link if connected in series with an international one. The major problem with delay is the presence of audible echo. Present day echo suppressors which operate by voice switching of attenuation into the echo return path are not completely satisfactory under all circumstances and adaptive echo cancellation devices are under development. An adaptive echo canceller developed in our own Laboratories operated successfully in live traffic trials several years ago when we leased circuits from Intelsat to carry excess traffic between the East and West of Australia for some months. An improved model is under construction and will be ready for trials towards the end of this year.

One of the new services which we see as possible is to bring good quality telephone service to subscribers in remote areas. In 1970 we were able to demonstrate, using the NASA ATS1 satellite, that with a single channel per carrier demand assignment scheme, it would be possible to accommodate several hundred subscribers with one satellite transponder. Each subscriber would require only a fairly modest earth station with a 3-4 metre diameter antenna, an uncooled amplifier and, hopefully, a solid state transmitter. The 1970 experiments demonstrated technical feasibility and further study is continuing. We are also considering the possibility of incorporating a television receiving capability in the same package.

An important decision is the choice of operating frequencies. Present day commercial systems almost all use the 4 and 6 GHz bands and there are difficult co-ordination problems with terrestrial systems operating in the same bands. Frequencies above 10 GHz are now available for satellite use, and as these have not been used to any extent for terrestrial systems in Australia they would be free of co-ordination problems.

Such frequencies do suffer from significant attenuation by heavy rain and, although some data is available on attenuation due to rain in temperate regions, we have no data for tropical rain storms that is applicable to Australian conditions. At the present time we are conducting rainfall attenuation measurements at 11 GHz using a solar radiometer at Innisfail in Queensland. (see Fig. 2). The radiometer monitors the radiation at 11 GHz from the sun thus giving the absorption due to the rain that the radiation passes through. Innisfail has an annual rainfall of about 400 cms. and is subject to tropical cyclones. A network of rate measuring rain gauges has been installed so that an attempt can be made to correlate rainfall and rain cell size with the observed attenuation. Observations have been made continuously since December 1972, and have included one cyclone.

Our preliminary conclusions are in qualitative agreement with results obtained in temperate zones but with higher values of attenuation being observed due to the heavier rains. An exception was the observations in the cyclone (see Fig. 3). Rainfall measurements indicated that the rainfall was fairly uniform over the whole measuring area — about 10-12 km diameter with a rate of 10 cms./hour for the worst 30 minutes and over 5 cms./hour for over an hour. Attenuation was in excess of 3 dB for 4 hours and in excess of 6 dB for 1 hour. Overseas data suggested that a 3 dB fade margin for a system would be satisfactory at 11 GHz and two stations separated by 5-10 km and working in space diversity would overcome rain attenuation. This is obviously not valid for a cyclone of this type. If one is to rely on space diversity, a station separation of much more than 5-10 km — perhaps 20-30 km — will be necessary in these areas.

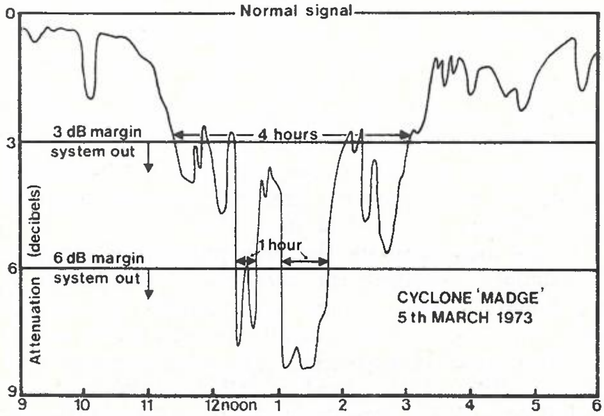

Fig. 3—Attenuation at 11 GHz experienced during tropical cyclone

We are proposing to do further measurements in the Darwin area at both 11 and 14 GHz where we believe the rainfall intensity can be even higher than in Innisfail. Darwin is particularly important as it would be a major terminal in a national system and significant system outages could not be tolerated. At less important stations there is the possibility of a trade off between outage time and cost of installation to overcome the extra attenuation and our investigation programme is designed to provide the information necessary to assess this relativity.

There is no doubt in our minds that satellite communications will play an important part in the future telecommunications system in Australia, and the Post Office is preparing for this through the activities of its Satellite Communications Task Group and the associated investigations in our Research Laboratories.

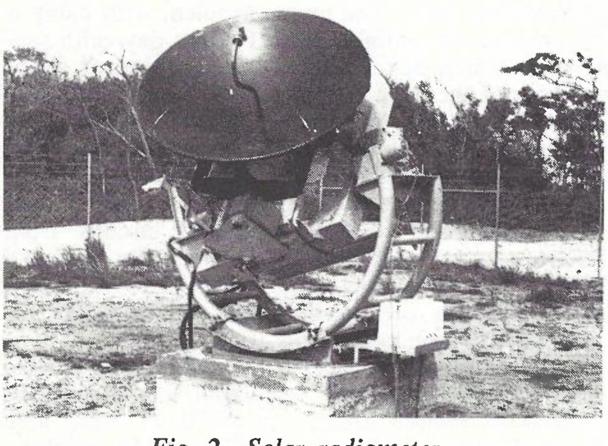

Fig. 2—Solar radiometer

7. Conclusion

In the last 50 years we have come a long way towards satisfying a basic human requirement, to communicate quickly and reliably over a distance with a satisfying measure of personal interaction, and at a reasonable cost.

In the next 50 years we will enter a situation where virtually any form of telecommunication will be possible and administrations will be faced with the necessity to choose the form these communications will take. Great demands will be made on decision makers to identify those improvements that are socially desirable, and on scientists and engineers to introduce them in a timely and economical manner.

Biography

Mr. P. R. BRETT joined the Post Office as a Clerk in 1940 at the age of 16 years. He graduated Bachelor of Science from the University of Melbourne in 1944, majoring in Physics and Radio Physics, after a period of war service.

After graduation he was appointed Physicist Grade 1 in the Research Laboratories, joining the team of physical Scientists then being built up in the Laboratories. Mr. Brett went on to head this team in 1958 when he was promoted Sectional Engineer, Physical Sciences, a position he occupied until 1963. His main technical contributions during this period were in the field of materials and components and their environmental behaviour, and he was involved in establishing the understanding and standards required for the adoption of modern polymer materials in Departmental equipment.

In 1963, he was promoted to the position of Assistant Director-General, Apparatus and Services, and in 1964, to his present position of Senior Assistant Director-General, Research.

In more recent years, he has been concerned with management of the research programme to obtain maximum relevance to the immediate and long term needs of the Department, and with developing and maintaining an awareness of the needs for forward looking R & D in telecommunications, both within the Department and also in universities and industry.

Mr. Brett has been closely associated with the work of the Standards Association of Australia for many years, and he is a member of the S.A.A. Council and Chairman of the Telecommunications and Electronics Industry Standards Committee.

He is also a member of the Faculty of Engineering at the University of Melbourne, and of the Academic Policy and the College Staffs Committees of the Victoria Institute of Colleges. He is a graduate of the Australian Administrative Staff College, 1963; a Fellow of the Institution of Radio and Electronics Engineers; and a member of the Radio Research Board and of the Australian National Committee for Radio Science.

Communications, Technology, Society and Education: Reconciled?

A. E. KARBOWIAK,
Professor of Electrical Engineering — Communications,
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A brief review of the key developments in communications is given together with a discussion of the likely benefits. The events are then examined on a longer time scale taking into account likely developments in technology and in the social patterns. Against this background the role of the Universities is considered and the value of some new goals emerging is examined. It appears that technology is now emerging in a new role; as a powerful force in education if only the society would care to accept it with a more positive attitude of mind.

1. Introduction

In the last few decades we have witnessed an unprecedented rise in the demands on communication channels. There is every indication that the increase in demands on communication channels will continue at a rapid rate. These demands are so real that a phrase "explosion of communications" has been coined to describe the situation. Nowadays, many thousands of speech channels are required to provide for communication between large cities. In addition television requirements have risen enormously, and these demand channel capacities many times in excess of those needed for speech communication.

We can foresee new demands for communication channels for various reasons which are already apparent. There are increased needs for facsimile transmission and data transmission for various business purposes such as in commerce or banking, in addition to the growing requirements for communication with computers. For everyday use videotelephone has already been developed and could be put into operation, provided that the greatly increased demands on communication channels could be satisfied. We foresee a great increase in the use of picture as well as speech transmission for purposes such as conferences between managers of different branches of the same company, or for direct communication of technical information within the structure of a company, and also for transmission of technical and other information from central computer memory store to various customers.

Indeed, in the years to come, there should be no need for people to spend hours in patent or technical libraries searching for information needed in their work. Such functions can be performed much more economically and efficiently by direct communication with a computer. The computer, in response to a request from a customer, would automatically search the stored information and then display the information requested on a television screen at the customer's home or office. Indeed, there seems to be no end to the variety of services which could be provided in the years to come by direct communication with computers. At the moment, however, such possibilities must wait their implementation until the problem of providing large numbers of communication channels is solved.

When assessing the future possibilities for new communication channels, it is useful to examine the possible limitations arising from the fundamentals of physics. First of all, it is necessary to accept that in the future it will not be possible to make more extensive use of radio waves for point to point communication, because they will be needed for communication with moving objects such as aeroplanes and ships to an ever increasing extent. But there are distinct possibilities in the use of satellite communications using UHF frequencies in that, a properly planned satellite communication system would offer a more economical use of the radio frequency spectrum. There are however, definite limitations and it would appear, on the evidence before us, that satellite communications cannot offer a long term solution to the problems ahead, the reason being that while a satellite can be designed to handle simultaneously 10 or 20 TV channels or the equivalent in other facilities, there is a limit to the number of satellites which can be accommodated in the space around the earth, without undue mutual interference. Let us then assume that satellite communication systems prove economically attractive: then each and every nation would wish to have a satellite or a share in one and if this were the case then only a fraction of the customers could be satisfied. The outstanding problem of providing alternative communication means would therefore remain.

What are the alternatives? Possibilities would seem to lie in greater exploitation of higher frequencies than UHF. Here we have in mind (see Table 1) the utilisation of the frequencies well beyond the microwave part of the spectrum, such as the millimetric spectrum (frequencies corresponding to the band 30-300 GHz or the sub-millimetric part of the spectrum 300-3000 GHz). It is also possible that frequencies even higher than those could be

TABLE 1. — *Comparison of communication media*

NOTE: One super channel — 4 Mc/s

Type		Operating frequency	Channel capacity	Repeater spacing (attenuation)
Open wire	One pair	36 to 84 kc/s (go) 92 to 140 kc/s (return)	12 + 3 + (1) = 15 + (1)	60 to 70 miles (0.4 db/mile)
	Maximum 16 pairs	As above	240 + (16)	
Balanced pair	One pair	12 to 252 kc/s	60	12 to 30 miles (4 db/mile)
	Maximum 24 pairs	As above	1440	
Coaxial G.B.		Up to 4 Mc/s	960 (One super channel)	6 miles
		Up to 12 Mc/s	3 super channels	3 miles
Coaxial U.S.		Up to about 3 Mc/s	720	8 miles
		L3 system	1 TV channel + 600 speech channels	4 miles
Single wire transmission line		About 100 to 1,000 Mc/s	Probably a few TV channels	About 2 to 10 miles
Microwave links		Below 500 Mc/s	Maximum of 60	40 to 50 miles
		500 to 1,000 Mc/s	Up to 120	40 to 50 miles
		2,000 Mc/s	240 x 6 or 1 TV x 6	30 to 40 miles
		4,000 Mc/s	600 x 6 or 1 TV x 6	25 to 30 miles
		6,000 Mc/s to 8,000 Mc/s	600 x 6 or 1 TV x 6 Maximum 2 TV x 6	25 to 30 miles
		11,000 Mc/s	Less than 600	Less than 20 miles
Long haul waveguide (H_{01})		30,000 Mc/s up to about 100,000 Mc/s	1,000 super channels = several hundreds of TV channels = several hundred thousands of speech channels	20 to 40 miles (attenuation 2 to 4 db/mile)

used for communication. We can now generate optical frequencies almost as efficiently as we can produce radio waves. Thus, point to point optical communication is one possibility, but the really exciting future lies ahead in systems utilising guided optical waves. Fibre and thin-film guides are particular embodiments. Millimetric as well as submillimetric waves offer exciting possibilities. Communication by trunk waveguide is an outstanding example.

The recent advances which have been made in materials science and in the technology of microminiature circuits have opened up new possibilities in all-digital integrated microwave communication systems. No doubt in the next two decades we shall witness great progress in such communication systems.

2. The Future

Looking further ahead, there seems to be no reason why communication on a wider scale should not be made possible; to provide hearing for the deaf and vision for the blind are distinct possibilities with present technology. But while these possibilities are under investigation, new possibilities emerge by extending the capacity of the remaining human senses. Here we have in mind remote sensing by touch, smell or even taste. The basic issues here are the invention of suitable transducers, in the same way as telephone communication was made possible through the invention of the microphone, and the earphone.

We can also speculate that through the developments in miniature computers new possibilities will open up. The personal computer of the future will be no bigger than the portable transistor radio receiver today. Yet such a computer will have sizeable power and will be backed by a selection of miniature magnetic tape stores in addition to a sizeable immediate access store. Among other things, such a portable computer would represent a sophisticated "notebook", an immediate access library, and be a general mental aid for its owner. In addition, the personal computer would be capable of being plugged into a communication network (accessible through a wideband outlet on subscriber premises, whether it is in his home or office) of vast computers capable of rendering a wide variety of services ranging from library or patent searches, education, entertainment, to advice on an unlimited variety of topics, including pictorial explanations available on consoles mounted on subscriber premises.

On another front, work is currently proceeding to try to expand the communication theory into the domain of semantics. There would seem to be a field of difficulties ahead, but nonetheless, once we learn to understand how to communicate semantics, we shall have opened new possibilities in communications. Some philosophers even go so far as to foresee direct communication of meaning as well as human feelings. It would seem that even the basic ideas behind human thoughts will be explored. While it is true to say that such possibilities are not, at the moment, within the scope of present day technology, they cannot be excluded from possible exploitation in the future. But, before such systems become a reality, we should do well to examine the likely effect which they might have on human societies.

3. Response of Society

While most of us are aware of the important contribution science is making, to a very high degree it is progress in technology which determines the prosperity and welfare of society at large. Yet, paradoxically, the very success which technology is enjoying seems to evoke feelings of apprehension in some of us. The achievements in the fields of electronics, computers and communications have been truly spectacular and unparallelled. It is perhaps for this reason that some view these disciplines with suspicion and fear the consequences of many of the developments. With this attitude there is a tendency, even to the point of irrationality, to denounce all "progress" as evil. We now recognise that technology in itself is not evil, but like all human knowledge and skills, it can be used for evil purposes. It is easy to claim that many of our present day ills are caused by technology; it is perhaps less easy to accept that they stem from society itself.

Many — even leaders of societies — have blamed disasters and misfortunes on developments in technology, even such fantastic associations as blaming bad weather or poor crops on the "wild developments" in radio links, or electric power systems, or the atomic bomb. It seems that technology is to replace the scapegoats of the middle ages; the witches who were blamed for all sorts of evil. And, there is nothing new about it, Romans were afflicted by the same disease. Thus, Tertullian (circa 190AD) writes "They take the Christians to be the cause of every disaster to the State, of every misfortune to the people. If the Tiber reaches the wall, if the Nile does not reach the fields, if the sky does not move, or if the earth does, if there is a famine, if there is a plague, the cry is at once: 'The Christians to the lions!'" It is prejudices of this kind that bring to light the educational level of our society.

What then should be our attitude? Should one run away from reality and modern technology, or worse still sink into a slough of despair? Does not the solution lie in our readiness to accept what technology has to offer and turn it to good use? It seems that better education, throughout the society is the answer: One fears the unknown, but knowledge is a source of strength. We recognise that it is important for all of us to be literate as well as numerate. But should the future of the country be entrusted to those who have no appreciation of technology?

I would not trust the management of the nation's affairs to men who had no first-hand knowledge of what was happening in this quickly changing world, and who did not understand even the language of technology. But, I do not want the world to be run by scientists and technologists, because science and technology are of value only as servants of society. I want to see at the head of affairs basically educated men, science-oriented humanists. They must understand the values of mankind, they must have a view of history and a view of the future. They should have a very strong flavour of science about them, but not enough to turn them into scientists.

SIR LEON BAGRIT
The Age of Automation,
Penguin Books 1965

4. Education: The Healer of all Ills

Thanks to our forefathers in the Freudian and the post-Freudian areas, we are now much better equipped to examine ourselves and our societies. We know that very few hereditary factors can be blamed for ills in our society, but that most behavioural characteristics can be traced to the environment. Education implies the existence of an environment that will help to bring out the best in man. However, age is an important factor. It is now well established that while for a person of 25 years of age, a healthy working environment might be important as a background for reaching self-fulfilment, the environmental factors in earlier years are far more important. For example, managerial skills of a matured man might relate to his training and experience in earlier years, but his success as a manager depends to a very large degree on the type of interaction which he had with the environment between the ages of about 17 and 22 years. More importantly, professional attitudes and dexterity are traceable to an even earlier period in one's life (about 9-12 years).

It needs to be stressed that while the university is perhaps the most important nursery of human intellect, education neither starts nor finishes there. As far as the student is concerned, the most important events which enable the educational processes to flourish at a university have happened to him long before he entered the university. While secondary schools have, clearly, an important role to play, education really starts at home. Parents of integrity who are not in conflict with themselves or the world around them, and who are filled with a genuine concern for the future of the next generation, make the most important contribution to education. And social surveys show that success at a university depends largely on the home. Moreover, when it comes to attitudes to society and behavioural patterns, these are traceable to events before the child reaches the age of seven. And research shows that gross personal maladjustment to society, highly deviant behaviour, etc. has its roots firmly in the early period of infancy and the cradle (0 to 1 year). In the same way, in one's professional life the first steps and the early experiences are most important in that they colour the image of the future and affect one's attitude to life.

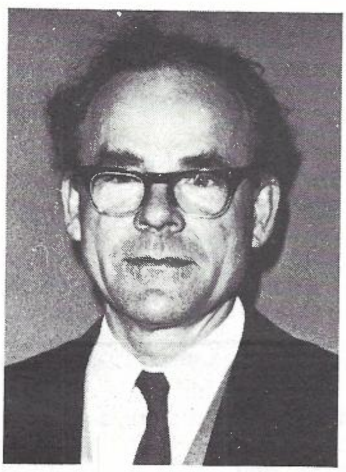
By what other means can the students learn the vital lesson that the progress of humanity is more the outcome of (non-self-seeking) co-operative venture, than inaction? Universities, industry, research institutions and politicians are all engaged with the students in a major project. The particular topic is of lesser importance but the circumstances and attitudes surrounding the student's work will affect the very foundations of his profession and colour his outlook for life.

It needs to be appreciated that, with modern technology, a systems approach to engineering projects will become a more common practice. Simultaneously, there is a greater need for specialisation, and to succeed today one must specialise in a relatively narrow field. With an increased degree of specialisation, teamwork becomes essential but, at the same time, more difficult to realise because of the attitude of many experts in becoming increasingly self-centred. Thus a major task for education emerges, a task which calls for an altered attitude of mind and a much higher level of educational achievement, permitting group rather than self-oriented motivation.

The solution lies in the introduction of a healthier atmosphere throughout the educational system from primary schools right through to the post-graduate levels of universities. It is not so much a question of what we teach, but how we teach. And not so much a question of how we teach (by preaching?) but by example that the student retains: How does a manager go about his tasks in industry? How does a politician behave in public? Or in what manner is the discussion carried out between, say, an academic and and engineer in industry? Are the projects in industry and government research laboratories freely discussed with the academics and students at a university in an atmosphere of trust and mutual respect? Is the student and his work a part of it? This active and ready co-operation between departments of different organisations is badly needed and would be indicative of a high-level of educational attaiment — a goal at which we might care to aim in the next decades. It implies an attitude of mind to be encouraged in our students. To reach such goals is not primarily a question of money but rather of attitude of mind.

It needs to be recognised that the real value of education cannot be measured: It evolves. In much the same way, a teacher's competence is made apparent by his long-term effect on his students. Moreover, the student's attitude of mind is affected, not so much by the content of the lectures he hears, as by the attitude of those who surround him. He is inspired by those who love their profession and are devoted to their work. What a student understands by co-operation, professional integrity, etc., is what he sees in action. He must see these things applied and practised, not only preached. He must see co-operation between universities, industry and other research organisations in application and he must be part of it. Let us always remember that the future of the world is in the hands of the young, but that we — the present generation — provide the all important environment.

Biography



Professor A. E. KARBOWIAK graduated from London University, England, with the B.Sc. (Eng.) Hons. degree in electrical engineering in 1949. He was awarded the Ph. D. degree in 1953 from London University for research on surface waves.

From 1953 he was with Standard Telecommunications Laboratories Limited, England, carrying out research on communication systems and specialising in microwaves. In 1958 he became Head of the Microwave Department, and worked for several years on Long Distance Communication by waveguide using millimetric waves. In 1962, he became Head of the Optical Systems Group at S.T.L. Ltd. until 1964, when he accepted the Chair of Electrical Engineering at the University of New South Wales, where he is at present Head of the Department of Communications. He spent the year 1971 with the Post Office Research Laboratories in the U.K., carrying out research on future communication systems, including the Trunk Waveguide System.

Professor Karbowiak has published over 60 technical articles and papers dealing with various aspects of research and two books: *"Trunk Waveguide Communications"* (Chapman & Hall, 1965) and *"Theory of Communication"* (Oliver & Boyd, 1969). He is a co-editor of a text book *"Information, Computers, Machines and Man"* (John Wiley & Sons, 1971). In 1968 he was awarded D.Sc. (Eng.) degree from London University for his work in the field of communication.

Trends and Research in Telecommunications — The Future to the Year 2000

H. BUSIGNIES
Senior Vice-President and Chief Scientist, International Telephone and Telegraph Corporation

Communication is the fundamental factor in progress and civilization. A brief review is given of the present state of technologies and the expected technical progress in the foreseeable future from electronic switching to cables and satellites, wide-band technologies and data transmission. Some important issues which will bear heavily on this progress and where a number of aspects of research should be expanded or undertaken, include the introduction of digital transmission and switching, the development of private and public data networks, computer communications and terminals, relations of man to computer through languages and terminals and to information storage. A review is made of many developing applications seen from the user's standpoint, in the next 30 years. In conclusion, a discussion is presented of the dangers of improper use of telecommunications, the dangers of biased one-way communications, the benefit of two-way communications and the need for proper planning and control of interactive TV systems to insure that this form of exchange gives balanced information and the proper time and conditions for the subscribers to express their views.

1. Introduction

Telecommunications as a fundamental factor of Progress

New interest in all aspects of communication has developed in the last ten years. Everyone involved knew communications were the key to human progress but when some new dramatic achievements were revealed, imaginations started working. Submarine cables, satellites, data transmission, computer access and exchange were the outstanding ones, aided by transistors and integrated circuits.

The expected further progress of electrical communication is so vast that I will have to present limited descriptions only of a number of present and future possibilities in the areas of transmission of voice, data and pictures, in satellites and submarine cables, and in switching connections between communicating parties, all meant to satisfy society's present, future and sometimes not yet well defined needs.

Obviously, some of the applications, that we will discuss later, will become very widespread, some will fail to develop and the geographic distribution of all will be quite uneven. After a short discussion of the progress in technologies which would make them possible, these applications will be discussed as to the probability of their acceptance and their meaning to society mostly from the user standpoint. Many of these applications require technical progress and we will try to assess briefly the technological advances expected as well as the economic and social considerations which could control their acceptance.

Much research work is in progress in many countries, the outcome of which will have a strong bearing of the technologies and their successful application. We will discuss the research work underway, in planning and some of our suggestions. There are important issues that will be presented involving national and international decisions, the solution of which will bear heavily on the progress, particularly in the introduction of digital transmission and switching, of public and private data networks, of computer communications and relations of man to computer and to information storage.

2. Present State of Technologies and Expected Technical Progress

The existing networks around the globe are meant to permit voice exchange on the telephone, and to transmit messages and data. It seems certain that the number of telephones in the world, which was 200 million in the late 1960's, will reach 1 billion in the year 2000, i.e. an expansion of 5 times in 30 years. On a global basis the number of international voice circuits went from 1,000 in 1957 to 20,000 in 1969 and it is conservatively expected that the number of channels will grow ten times in the next 10 years. Data communication will increase regularly with industrialized nations leading by a large margin to the point that the use of lines for data may be 10 to 20% of the use for telephone conversation time-wise by 1985.

Computers are meant to constantly absorb, organize and produce a large amount of information. This information has to come to them, the results have to be distributed and circulated. In 1975, 80% of the computers will be connected to the communication networks.

The transmission of voice, data and pictures will continue to be achieved for voice and medium-speed data by the ordinary telephone line for short distances (to the central office), and by coaxial cables for high-speed data and pictures and long-distance voice circuits. On coaxial cable we may now transmit 2,700 telephone channels (12 MHz band) and in the future 10,800 telephone channels (60 MHz). Microwave radio links of similar capacities are available. Of course, many coaxials can be in the same sheath multiplying these numbers many times. The latest transatlantic TAT-5 cable has 720 channels. In the last 5 years the total channel miles of submarine cables installed in the world has increased 3 times. The prospects for the 1970's are for cables of 1,840 channels, already installed between Spain, the Canary Islands and the Balearic Islands and many others planned, followed by 4,000 channels and 10,000 channels in 1980.

All these successful developments have resulted in a large reduction of the cost of transmission. This trend will continue and a major breakthrough might develop in the form of a practical microwave waveguide or of an optical fiber transmission system which would have an enormous bandwidth capacity. The bandwidth of an optical fiber transmission system could accommodate hundreds of television channels, with of course no limitation in the number of systems. The successful completion of research on the optical fiber would also result in the same very large bandwidth capacity in submarine cables.

In 1959 (this was years before Comsat) I presented to the Committee of Science and Astronautics of the United States Congress a project of synchronous satellite communications system with date of completion, capacity and cost estimates which turned out to be quite close to the first commercial application of Intelsat 1. The greatest advantage of the satellite is that it can interconnect a large number of countries together (I mentioned up to 46 at the time) in an efficient manner, adapted to their needs. (No foreseeable terrestrial system could achieve this at a reasonable cost.) Several countries are considering the use of satellites for domestic communication and several projects are under consideration in the United States, Canada, Australia, Europe and other countries. Intelsat III (for which we developed the communication equipment) has a capacity of 1,500 channels or 2 television links. Intelsat IV has a capacity of 3,000 to 9,000 channels (depending upon the assignment system in the multiple access concept), or 12 television channels. In the more distant future, the capacity of each satellite (each equipped with a number of repeaters) may reach 20 to 30 thousand circuits. These high capacities may not be required for some time on international circuits but are being considered for U.S. domestic satellites and probably in other countries.

My forecast is that satellites will be in considerable use because of the flexibility of far reaching multiple access that they permit, but it is probable that the coaxial cables, guides and fibres will have to assume the greatest role between the areas of the world requiring a very large amount of communication in Europe, in the U.S., between the U.S. and Europe and later toward the Far East, Australia and Latin America, and some parts of Africa and Asia. There is no radio spectrum saturation on cable or optical fibre systems.

What is the present situation on data transmission? We have a very extensive telephone network, very practical to use for transmission of data when the connection can be set up quickly by direct dialling. Then we have Telex networks with specialized switching, grouping a number of users for the transmission of messages. We have message switching of the "store and forward" type in which the message is transmitted to a centre where it is recorded, and then transmitted to its destination, when the line becomes available. (This is generally a specialized network, for instance for an airline or a large organization.) Many large users (I cite the airlines because it is an easy case to mention) want to have a network of their own, because they have found that without this special network they cannot have the type of rapid national or worldwide communication that is indispensable for their business. When these systems are conceived, or later in their operation, voice-data networks combining telephone and data transmission will be considered and obviously widely applied. Depending upon the applications that data systems are designed for, different rates of transmission up to 48 kHz or more are used, with switched networks providing connections on a few seconds basis. The switching is generally performed by reed switches with electronic or computer control. They are all different, but use common technologies meant to satisfy the special needs of the users. The circuits of the required bandwidths are leased or owned by the telecommunications administrations or organizations. Many cross the Atlantic and the Pacific.

Would it be possible in the future to rationalize all these very varied requirements and to make an integrated common system for data transmission? Experimental systems are being studied which would accept messages coming from terminals operating in a broad range of speeds, and converting all these data speeds into a single higher speed of transmission at conversion centers. The reverse would happen at the receiving end, so the data rates of terminals would not have to be related. The concept is very interesting but the responsibility of the administration to satisfy the requirements of rapid connection and the needs for expansion are enormous; failure to satisfy these requirements could be catastrophic for the users. Data transmission is facing a problem created by the very wide range of requirements from the users. It is difficult to rationalize these requirements and to give the customers a universal but flexible service.

This points up some tasks to be undertaken by the transmission and switching engineers; they will have to provide for flexibility in bandwidth assignments and wider bandwidths, and develop and apply broadband systems with direct dialling. But the technologies are available and will be able to transmit any type of information we can practically conceive of, using telephones, printers, tape recorders, facsimile, computers, visual displays, picture phones, sensors, alarms and TV-pictures.

The terminals must be able to reach each other (at least by categories), or be able to reach an information center and/or a computer. This is a function of switching which is very complex and which we cannot cover in detail. From the relatively simple concept of the step-by-step switch and rotary switch, switching has evolved into the computer-controlled reed relays or miniature switches, known as electronic switching. In electronic switching, the number called, for short or long distance connection, is recorded in the memory of the computer which decides what switches to operate throughout the exchange to establish the connection or to reach another similar exchange, or a toll or international exchange. The time and length of the communication is recorded, alternate routings are provided, special functions involving operator assistance are introduced, and special services are provided such as call transfers, call waiting tone, abbreviated dialling and conference calls. This computer controlled operation provides for flexibility and adaptation to conditions, and functions by programming.

3. The Important Issues in Future Communication Systems

In many, if not all countries, communications administrations or communication companies see clearly the importance of data communications, its contribution to economic development, its value in ensuring successful competition on a world wide basis, the need for fast exchange of information and fast access to information and the needs for computers to receive and transmit large amounts of information rapidly.

Many large business organizations in need of such data handling on a national or international basis, have already placed in service data networks — the airlines are a good example — to satisfy their requirements, generally by leasing channels from the administrations or companies, and organizing their switching centers, terminals, etc. Many of these networks are quite efficient and successful. They permit almost instantaneous communication irrespective of the distance, which is absolutely indispensable in many data applications. Other private networks using the store and forward principle for message and data have also been placed in operation.

However, in general, these independent, private systems cannot communicate effectively with each other. It is logical to think of building public data networks which could serve all users at various rate for instance 600, 2,400, 9,600, and 48,000 bits/second, according to the draft recommendations of the CCITT. It is generally agreed that such networks would use digital transmission and switching.

As digital transmission (PCM) is developing rapidly for telephony and as digital switching applications grow rapidly, it is normal to think of future integrated digital networks to satisfy all communications requirements. No general agreement exists on this and the present investment in the telephone network is such that a complete overhaul could not be considered for many years. However, it would not be impossible to add progressively digital telephone circuits and networks to the existing one. Conditions vary widely between countries, depending on the extent of their present telephone networks, plans for digital transmission, prospects for videophone transmission and switching requirements and plans for telephone electronic switching. However the needs for international agreements to permit efficient interconnection are overwhelming, and while many countries may have their own plans to study digital data network applications and the progressive introduction of integrated digital transmission and switching, it remains indispensable to think on a worldwide basis. It is clear that this will prevail, as much wasted effort and money would result from independent actions. In all cases an important factor has to be kept in mind: data transmission applications in a majority of cases require practically instantaneous connections and immediate answers. Nothing of the kind of delays still observed in many places in the use of the telephone will be acceptable.

There are of course many other issues of importance in such a broad field. The availability of communication satellites raises a number of them, many are solved already; both cables and satellites have their fundamental utility and their best applications. Many issues are mostly administrative. Those we selected above for a brief presentation are of great importance in their mixing of technical achievements with national and international administrative problems, in facing the tremendous development of exchange and processing of information.

4. Research

Research is actively pursued in many places in the world leading to better, cheaper, sometimes simpler solutions to the problems facing the development of the applications — new as well as existing — that we are presenting. But there are also many areas of technologies or applications which would justify additional research effort or for which research effort is certainly needed to make the applications successful. In listing briefly the most important areas of research, we will try to associate them with their expected applications.

4.1 Optical Communications

This includes research on glass fibres, liquid filled fibres, sources of light and all associated components. All this effort is connected with wideband technologies and digital transmission.

4.2 Wideband Technologies

This includes wideband switching, methods of modulation, components and amplification for wire, coaxial cables, wave guides and optical wave guides and fibres.

These two important areas of research control the future of widespread use of wideband systems, at home, in business and on an international basis. The present picture phone is of relatively poor quality. The success of research on the two items above will determine the future success of the picture phone, perhaps in color and high definition, and of the applications of many displays and terminals for many different uses. The development of these applications will require proper wideband switching which will also require some research effort.

4.3 Terminals, Displays, Facsimile and Printers

While some research is being carried out in these areas, a greater effort should be applied to find better and cheaper solutions. Most future applications of telecommunications will require some form of terminals for data, pictures, displays or printing.

There are no color facsimile terminals available. High quality will be required.

4.4 Digital Transmission and Switching; Partial and Total Integration of all Applications

Progressive use of digital transmission and switching is taking place but in a non-coordinated way. Each involved country is proceeding with partial solutions and different standards are used. In spite of the efforts of the CCITT, international agreements are difficult to reach. Still, some time in the future, there will be a need for agreement. Research is needed to assist the indispensable planning of the future, to estimate and determine how digital transmission and switching can be progressively incorporated in the analog networks, and eventually perhaps take over all aspects of electrical communication, including videophone. The quality of the solutions of the wideband problems will have decisive influence.

4.5 Public Data Networks (transmission and switching)

While private data networks expand rapidly through the use of leased circuits, the planning of public networks for data exchange by PTT Administrations and communications companies is moving ahead and many countries are in the process of planning data systems which would permit the rapid interconnection of terminals and storage devices using different rates of transmission from low (present telex) to very high (communications between computers and video signals).

While the concept of public flexibile data networks is of great importance, it raises important questions for more research work, particularly the need to insure very rapid connections in all practical circumstances of traffic, as for many new applications delays would be catastrophic. The requirements for wideband switching and for possible integration — and to what extent — of the large existing telephone network expanded for videophone and of the new data network, shows the need for further research work.

4.6 Liaison: Man with Communication Information Centres

As all information — at least at certain levels — has to be originated or received by man's senses and intelligence or has to be organized by man at various levels of organization, programming, and microprogramming, this liaison dominates the communication problem with its languages, efficiency, and orderliness requirements. This requires much more research in depth. Research into artificial intelligence of machines is directly related. The next item is directly connected with this problem.

4.7 Biological Relations between Man and Machine

A greater knowledge of the workings of the human brain and of its emotional and logical operations is essential to ensure that machines will be the servants of men with satisfactory and beneficial coupling.

4.8 Communications and Education

Education results from an efficient communication process. We are just at the very beginning of understanding how communications with proper terminals, computers, information centers can efficiently assist education. More research is needed as well as practical applications of research results to achieve progress in this area.

4.9 Efficient Utilization of the Radio Frequency Spectrum

Research will show many ways of increasing the efficiency of the use of the spectrum. This is needed particularly for mobile applications and satellites, communications and navigation. Higher frequencies for satellites (11, 14, 20, 23 GHz) will have to be used. Modulation techniques, polarization selection and the influence of digital transmission need further research effort.

4.10 Voice Coding

Successful research on coding of voice with cheap coders and decoders could result in large savings in the entire telephone network, in combination with digital transmission systems, if the cost benefits can compare favorably with the cost reduction achieved through new wideband technology.

4.11 Other Problems to be Solved

The United States National Academy of Engineering has made a review of the further assistance that communications could offer to help solve some of the problems of our complex society, particularly in the cities but often as well in rural areas: Transportation operations (Information to users); Medical services (remote operations and assistance to older citizens. Rapid information handling); City services relations with the citizens (Information Centers); Programs of education and training at home; Pollution control; Emergency services such as police, fire department, ambulances; City programs, cable television, interactive systems; Interactive home terminals; Importance and future of home wideband systems.

Pilot projects in selected locations is the form of research recommended to determine the usefulness, the value and the success of these applications and decide on their further expansion.

4.12 Excessive Communications

The effects are not known. What is a level of excessive one-way communication; how do the harmful effects vary with different characters, personalities and intelligence levels. Research on this subject is very important for the future. Equally important is the form of interactive communication on present and future cable television systems, and the way interactive systems will be used in order to avoid the pressure for rapid unthoughtout answers to questions organized by authors.

4.13 International Communications

The International Telecommunication Union (ITU) is the controlling organization setting the standards. While the human voice as a standard permitted easy agreements to be reached with the result that the signalling problems were solved, the international data traffic and the progressive introduction of digital systems will pose very large problems for which there is a need for international research work.

4.14 International Broadcasting

While the present technologies will soon permit satellite broadcasting covering large areas of the earth, it is clear that it may never be possible to reach agreement between nations. Is cooperative international research possible in cases involving social sciences, legal and political matters, etc.?

4.15 Pollution

Pollution control could have been associated with some of the items above, but it seems worthwhile to mention it separately, as communications will permit excellent monitoring of pollution conditions, whilst not itself producing any pollution except indirectly through manufacturing and power production (power requirements are small).

In fact, electrical communications solve millions of problems every hour, large and small, which would otherwise require transportation and visits. This trend will continue and will always be in the direction of reducing excessive transportation and pollution. Research work resulting in economical, high quality, large size color television would have a considerable additional impact on the organization of work in society.

4.16 Mobile Communications

There are possibilities for considerable improvements in quality and variety of services in mobile communications. This is an area where radio is needed, but not necessarily over long distances. Opportunities exist for economies in the radio spectrum and in the broadening of applications.

5. The Future of Telecommunications from the User's Standpoint

We will try now to list the possible applications of telecommunications in the next 30 years and to forecast their progress and their future. Some of them are more directed towards private life, while others are more business oriented. Others are more concerned with groups of people and urban life. There are also some which will affect the important aspect of international relations.

5.1 New Services

Call transfer, call waiting tone, abbreviated dialling and conference calls will be used extensively by 10 to 30 per cent of the subscribers, mostly in business whatever its size, and for private use, particularly in the areas served by electronic switching, which may reach more than half the United States by 1980. Call recording, answering and quick dialling will often be used.

5.2 Picture Phone

This will be used for general purposes by business and administrations of large organizations, extensively over short distances, in a limited way over long distances. Individuals will use it on a limited basis because of the high cost unless a breakthrough occurs. Such a breakthrough in bandwidth technology might raise the use to 2 to 5 per cent of the telephone subscribers in the United States and industrialized countries by the year 2000. While 2 to 5% appears to be small, it would in fact be an enormous achievement. Many private exchanges will be equipped with picture phone for internal usage.

5.3 Data Displays and Data Terminals in the Home

These will be used by 10 to 20 per cent of the subscribers for the applications mentioned in the next three sections, and for some specific applications: continued education, training and additional interests. The economics are satisfactory for the specific needs. Businessmen may use these devices to keep in contact with their office when working at home. Portable data terminals will be in substantial use by businessmen.

5.4 Working at Home

My belief is that this will be quite limited except in specific business situations of time and geography and for special problems. Executives would make use of terminals in these special cases. The economics are satisfactory.

5.5 Computer Assistance in School Education

Between 5 and 10 per cent of the students through high school may use it in 1980 and many more by the year 2000. Television education programs are one form of assistance to education but in conventional distribution, two way exchange with the student is impossible; interactive operation poses many problems which will not be easy to resolve in a reasonable time (10 years). On the other hand, if transmission to a centralized computer is achieved, students can get into a two-way private communication exchange irrespective of the large number of simultaneous connections. Some programs have been tried already for different age groups and subjects, with very encouraging results: the children are very interested and reach a degree of concentration, for ten or fifteen minutes at a time, that they may never reach with a teacher. This concentration is a great help to the memory.

In many places of the world, the aim should be to provide to the more isolated children in schools in remote areas, the same quality of general education that is available in the more favoured areas. This can be achieved by these means. The use of computer assisted continued education through communications terminals will be of assistance to business on many updating and training programs. Above the high school level, in colleges and universities, the use of computers for various purposes will also require communication, generally on a time-shared basis.

5.6 Shopping, Banking and Monitoring

These various services, except for TV shopping and visual information access, can all be obtained over the telephone line, with displays, data printers and recorders, and we can expect progressive development in the use of these services to a fraction of subscribers, as no large expenses are involved. Reading of meters and monitoring of sensors over telephone lines may become the practice when the economics are satisfactory 10 to 15 years from now, with processing and billing by computer.

The use of TV, one-way or two-way involving wideband networks and wideband switching may become widespread, if the broadband breakthrough develops. In the meantime, the economics are not very favourable to the development of shopping by TV, or visual information access, because of the high cost of networks and TV switching. The present picture phone definition is not sufficient for shopping and colour is needed. Obviously, some of these applications will develop, others will fail.

5.7 Access to News

The extent of this application is difficult to forecast with certainty because so many solutions to this information problem can develop and compete. But in all cases electrical communication will be involved. While public demand is difficult to evaluate, specialized use by many businesses and organizations in their own field of interest will be great, if not universal, again through the use of data displays or voice recording.

5.8 Access to Libraries

Universities, schools, private organizations, private citizens, businesses and generally all organizations or people in need of this service will be utilizing various forms of access to the information when the information centers become available. The costs involved in organizing these information centers may prevent a broad application for a long time, but smaller, specific applications will probably develop.

5.9 Verbal Inquiries

This is a special category of voice exchange of the nature of "access to libraries" but on an aural basis. This may turn out to be practical only for short and relatively simple inquiries. Answers could be by computerized voice. Again the cost of developing such centers of information may for a long time be prohibitive.

5.10 Integrated Voice-Data Private Business Exchanges

We must mention under this item the considerable future use of voice-data systems by organizations having a private telephone exchange. This telephone exchange will, in many organizations be combined with a data system which will give to a selected group, or to all telephone lines connected to this exchange, access to private or time-shared computers, access to information and files within or without the organization, through data terminals, displays, TV tape recorders, printers and specifically adapted reproducing systems.

The technology is already available on a commercial basis and the economics of such services are satisfactory. Only long-distance two-way TV, as picture phone, is still quite expensive, but local picture phone within an exchange is available and the economics are satisfactory.

The logical extension of the voice-data technique is the spread of a private voice-data system over several locations in a country or over several countries via rented lines, all controlled by one or more computer-controlled switching units. This would give the same communication facilities which are so convenient in a single location private exchange in several locations and countries. These systems will meet considerable success with business and large organizations operating in many locations. Of course, communication administrations will cooperate but will also try to demonstrate that their public services will be able to give the same quality service. This is a point we have covered in sections 3 and 4.

5.11 Access to Computers

All administrations, businesses and industries, will have access to computers, either their own, or on a shared basis. This will mean many data terminals and displays in the offices of all those in need of computer assistance or computer information. Of course, business is already deeply involved and the trend is going to develop much further.

5.12 Access to Computers through Pushbutton Telephones

Large use can be forecast by small and medium size businesses; all transmission of information or requests for information will be transmitted by the pushbutton set and data received on data and display terminals.

5.13 Electronic Mail

Telex and TWX networks are a form of electronic mail widely used by business. Later a full alphabet will transform such messages into the equivalent of conventional letters. Letters already on magnetic tape could also be transmitted by a digital attachment to the telephone, or through a facsimile system. A new network, perhaps through a satellite, with many ground distribution centers may be the solution of the future.

The cost of these electrical solutions is higher than the mail and further studies in depth are necessary before predictions can be made on the broad use of an electronic mail system meant to handle the ordinary mail, as we know it on a collective basis, and the industrial and commercial mail problem may be solved first. In many organizations the digital and facsimile transmission of printed material will also replace the conventional telex system or will combine with it.

The reception of magazines and newspapers at home is not resolved. The transmission is entirely possible, by several means, during the night but printing at home has no solution yet in sight. Also it is not practical to be tied down to a television screen to read the news, except selected news for a specific purpose.

5.14 Telephones on Cars and Mobiles

Telephones on vehicles will develop much further and a large fraction of business subscribers will rely on them during their journeys. More radio spectrum will be assigned to this application. Much later in time a different distribution network by wire and radio, with a multiplicity of transmitters and receivers may be developed. Again the portable data terminal will be found very useful.

5.15 Personal Radio Telephone

For use on the move and for paging, it will develop further in business and industry. Personal radiotelephones will be used by a percentage of the subscribers for business which require movement of executive and lower personnel. More radio spectrum will be assigned to this and expand applications. Economics will be satisfactory. Some businessmen will add a portable data terminal to this telephone.

5.16 Large Choice of T.V. Programs — Cable Distribution

It is difficult to predict the number of programs, national or local, which could be made simultaneously available on an economical basis. The evolution of society will be a determining factor. However, the capacity of cable distribution permits assignment of channels to education, public services, local information and programs of assistance to urban life. One can expect a strong development of these urban applications after a period of 10 years of experimentation.

5.17 Urban Services

This is a group of services (see section 4.11) the purpose of which is to improve the quality of life in the urban environment to the maximum possible. The technologies are, and will be, available but this application is very much under the control of administrative and social considerations. The extent to which people will react and use the planned services is difficult to predict, but the prospects are good.

5.18 Assistance to Health Care

The telephone, with data and display attachments, and sometimes the picture phone will be progressively, and later widely, used by the medical profession to give better care with less (wasted) travelling time by physicians and greater use of paramedical professionals. Fast access to information through any telephone line will become widespread when the initial computerization has been achieved.

5.19 Role in New Cities

While the above (urban services) is particularly related to older cities and their problems, this item relates to new cities in which planning would involve communication as a basis of improved quality of life and efficiency. One can expect the use of data and display terminals at home and in business for many forms of information exchange, and of two-way television in some applications. Business will be involved as well as public authorities.

5.20 International Dialling

Direct international dialling will develop further between all countries which have a good, fast working, direct long-distance national telephone service. (In Holland for instance a high percentage of telephones have access to this service.)

It is not practical when the national long distance services are not rapid and of good transmission quality, or if there is a shortage of international circuits. Therefore, it is going to develop progressively first between the major cities of the world and then to the more distant points in the countries.

This international telephone service will be complemented by a data service and some day a video service. This demonstrates the importance of the issues discussed in section 3 of this paper, and of the research discussed in section 4.

This is of major importance to international business and multinational companies. Other communication services will link a number of points throughout the world through dedicated international circuits in such a way that an executive, in his office, can dial any executive, all located in other cities of the world as he would have done on his local private exchange.

5.21 T.V. and Radio Broadcasting by Satellite

While the technology of broadcasting by satellite has not been discussed, we can mention that it will find many applications in the world, including education and information.

It is generally thought of in three forms. The first application will be the distribution of programs to TV and radio transmitting stations. This is technically feasible. Secondly, in the planning stage is transmission to a special receiver to be viewed by large groups of people for education, information and entertainment. The technologies are available and a first application is planned in India in 1975 in cooperation between India and NASA of the U.S. Thirdly, we have direct transmission to home receivers equipped with an attachment and a new antenna. In many instances this will involve program problems between nations. The technology would be available 6 to 12 years from now (more power has to be available on the satellite than presently available).

6. In Conclusion

In conclusion let us comment on the possible impacts of these developments.

As with any assessment and forecast, this one can be subject to violent change due to discoveries, inventions and changes in the desires of men and values developed by society which will take place in the next 30 years. But excepting human tremors on this globe, this seems more of a minimum than a maximum.

As business is completely based on communications the beneficial impact of all that progress to business will be great. A powerful impact of this progress in telecommunications will be a further increase in the speed of business communications. All important letters will join the messages, which themselves will take the appearance of letters, and will be transmitted in a matter of minutes, or in the case of important documents in a few hours or overnight. The implication is that the answers and action will be accelerated. This will be achieved by the immediate use of much more up to date information, already in report form, or accessible through data terminals connected to computers.

Communication is the indispensable complement to transportation and the essence of progress. The dramatic rate of increase of long distances and international communications through satellites and submarine telephone cables demonstrates the wish of people to communicate. A country which limits the travel and communication of its people with the rest of the world, hides the true state of the world and its opinions from its citizens and conversely. Of course, electrical communication, like the human language itself can be used for good or bad. It is the responsibility of people, and their leaders, to dedicate themselves to progressive understanding, but it is clear that large conflicts have little chance of developing between nations which maintain extensive communications and it is conversely obvious that possibilities of large conflicts may exist between nations maintaining little or no communication.

In this respect the conversation between two persons directly, or through a telephone connection, generally means better understanding and is fruitful. We call it two-way communication. The one-way communication, in which no exchange is possible such as conventional radio broadcasting and particularly television, needs to be studied further and, if possible at all, developed into a better process of exchange by which the obvious dangers of one-way communication could be reduced. It is too easy to cover undue influence, whatever its origin, under the stated purpose of free expression.

Also, while we want and need a well informed society, we must remember that the human mind is not designed to constantly receive information on all the events in the entire universe, without some form of progressive damage or inappropriate reaction. This is not new of course, but let us be conscious all the time in the future of the danger of possibly excessive use of one-way communication in the enormous flow that present and future technologies will permit. There must be some kind of a balance between the good and the bad news, while excluding any notion of censorship. This is a difficult problem to solve as we really do not know all the short and long term effects of excessive one-way communication of this type.

All those who will contribute to transform the one-way stream of information into a beneficial and more satisfactory exchange, or will educate people on all the effects of information, will render a great service to society. A number of studies and projects have been started on interactive systems where answers and comments could be obtained from the listeners. This is work in the right direction, even though technical problems due to the large numbers of answers and their processing have to be solved, and psychological studies are necessary on the question of timing of the answers, time for reflection, necessity to have representative answers and meaningful answers from all.

I want to express the common concern of dedicated people at seeing that progress in communications will result in the greatest benefits for mankind.

Biography

Dr. HENRI BUSIGNIES is Senior Vice President and Chief Scientist of International Telephone and Telegraph Corporation and holds more than 140 patents in the air navigation, radar and communication fields. He joined the I.T.T. system in 1928, as an Engineer in the Corporation's Paris laboratories.

Since 1941, when he participated in the founding of I.T.T. Laboratories, Dr. Busignies has played a major role in the growth of the I.T.T.'s U.S. activities. He became a Technical Director of the Laboratories in 1949, Vice President in 1953, Executive Vice President in 1949, Vice President in 1953, Executive Vice President in 1954 and laboratories President until 1960, when he was advanced to Vice President and General Technical Director of the I.T.T. parent corporation. He became a Senior Vice President in 1965.

Among Dr. Busignies' many inventions are included the word's first automatic direction finder for aircraft and the moving-target-indicator (MTI) radar in world-wide use at airports for navigation and traffic control. In 1964, he received the David Sarnoff Award of the Institute of Electrical and Electronics Engineers (I.E.E.E.) for outstanding achievements in the field of electronics.

Dr. Busignies was the first chairman of the National Security Industrial Association Research and Development Advisory Committee, and served as a Trustee of the Association. In 1958 he was awarded a D.Sc. by the Newark College of Engineering and in 1971 the D.Eng. Degree by the Polytechnic Institute of Brooklyn. He has been the recipient of many awards including the Award for International Communication 1970 (I.E.E.E.) and the Industrial Research Institute Medal in 1971. He was elected a Member of the National Academy of Engineering in 1966, and presently is chairman of the Committee on Telecommunications. Since 1965, he has travelled extensively throughout the world, advising and lecturing on the applications of the latest techniques and the future of telecommunications.

Information in 1984

K. Teer
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This paper views the future social and technical developments expected in information distribution. This involves studying the effect technical innovation has on society as well as the frequently under-valued effects due to changes and trends in social values. Attention is drawn to the importance of developing the periphery of technical systems, of improving the information retrieval facilities and of encouraging person to person contact. With the year 1984 chosen as a reference point a summary of various predictions about the future is presented. It is stressed that innovations are to be used to benefit and not to control the individual.

1. Introduction

Long, long ago, before typewriters had come into the world, a meeting was held about the future of pencil and paper. Along with commercial and technical managers there was also a man there from the research laboratory, who had been invited because he always knew everything so much earlier. He was an interesting man, not only because he had definite views about how mankind was going to develop, but he also brought technology of the future with him. "This, gentlemen", he said, "is the future of pencil and paper", and he unveiled a machine that had a roller and 40 keys, and demonstrated at some length how you could use it to write with. There followed a somewhat confused discussion full of admiration, scepticism, curiosity and excitement, until the chairman intervened as usual to impose order and to evaluate this innovation. They looked in turn at the price, feasibility, economics, speed, reliability, portability and other features of the new instrument. A comparison was drawn between the existing solution, pencil and paper, and the proposed new one. Finally the chairman summed up. They had found that the new solution, which was immediately given the name "typewriter", was five hundred times more expensive, a thousand times heavier and five times slower. What is more, the existing solution, pencil and paper, was a hundred per cent reliable, and could be carried by anyone anywhere. It was only too obvious that this innovation had no future at all. In Table 1 you see the results in detail, and with this picture stamped on his memory the downcast inventor picked up his machine and went home.

Table 1. The New Solution

	Pencil and Paper	*New Solution* (so-called typewriter)
readability	reasonable	very good
copies	2-3	up to 7
speed	1	1/5 (apart from special training)
ergonomics	very good	not too bad
portability	everywhere for everyone	perhaps in the future
reliability	100%	?
service	do it yourself	specialist
standardization	difficult	easy
weight	1	1000
price	1	500

This story was inspired by a comparison which a colleague in our laboratories used to bring up whenever the discussion turned on the significance of new inventions. From the same laboratories I should like to quote yet another specimen of wisdom, from the yellowed minutes of an actual meeting held way back in 1935 on the subject of television broadcast. We find the following pronouncement:

> "As far as we are able to judge at the moment television will always remain a very costly thing, within the reach of only relatively few people . . . . . . For instance, the transmission from Brocken (1600 metres) could not properly be received in Berlin some 100 kilometres away. If only for this reason, television will have to remain limited to the densely populated centres. Added to this is the fact that the selling price of a television receiver will in all probability not be under 1000 guilders. The much lower prices mentioned earlier are pure fantasy, and no more has recently been heard about them."

These ironic illustrations of the power of prediction may perhaps best be followed with a dictum of the physicist Faraday. When in 1832 he showed the Royal Institution his first dynamo, a difficult contraption for generating electric current, somebody in the hall wanted to know what was the use of such a queer thing. Faraday countered the question by asking: "What's the use of a new-born baby?"

This pronouncement makes the essential point of my introductory anecdotes: The point is not so much that the innovation is going to grow and develop, but how and when. That is where the uncertainty lies.

I shall therefore not concentrate on a description of future technical media themselves. Society has already accepted the fact that all these things are to be added unto us: the videophone, the video cassette recorder, the video disk, cable television, computer-aided instruction and the home facsimile. Here we are more interested in the structural relationship of these technical innovations with society than in the innovations themselves.*

* Much of the content of this paper was presented at the Distripress Conference (October, 1972).

2. Structure

One of the great protagonists of this structural approach is a much discussed author, Marshall McLuhan (Ref. 1). He attributes great influence to a hidden intrinsic essence of a new technical system, which when developed transforms society. Somehow his somewhat breathless descriptions have to fit into the cultural analyses built up by the sociologists such as Gurvitch (Ref. 2), which present a calm and ordered picture of the phenomena we talk about so much. Gurvitch distinguishes four levels in the concept of culture:

I	*Physical structures*	(buildings, machines, goods)
II	*Organization*	(law, school, enterprise)
III	*Behaviour*	(attitude, education, free time)
IV	*Inspiration*	(religion, creativity, charity)

First of all, there is the visible world of buildings, machines and goods. Under that lies the second level of organization such as law, schools, business enterprises and political parties. Then comes the third level, where things are no longer so tangible as in the first, nor so simple to put into words as in the second. Here we have the rules of social conduct, the "values" of behaviour, of attitude, and of education. Finally, there is the fourth level where the sources of thinking and action lie, the level of inspiration, religion, charity and creativity etc.

Technical entities themselves are of course found in the upper level. However, we have just postulated that we are not interested in them as such but in their interplay with the second and third levels. If we consider the how and when to be so important, then we must direct our attention above all to the process of acceptance and appreciation in level 3 of the innovations in level 1, and see how this leads to new structures in level 2. Any such study will therefore have to be concerned in particular with what is found in level 3. As we all know, however, it is not so simple to obtain relevant facts about sociological situations. As a technical scientist I always doubt whether this is due to the essential intangibility of the data or due to a lack of a clean, systematic approach.

Table 2. Trends in Values and Attitudes

VALUES	
Upgrading	*Downgrading*
1. mankind-oriented values	nation-oriented values
2. intellectual virtues	domestic virtues
3. reasonableness & rationality	responsibility & accountability
4. civic virtues	independence
5. group acceptance	self-reliance, self-sufficiency
6. social welfare	individualism
7. social accountability	self-advancement
8. order	economic security

I have not the facility and the capability to elaborate very much on this point but I can bring forward two examples of studies about future attitudes. Firstly, Baier and Rescher of the University of Pittsburg organized a series of studies concerning the definition and dynamism of the concept "Values" (Ref. 3). Table 2 indicates the changes that in 1966 were thought likely to take place in the values of society during the next decade. Very briefly, it was thought that a shift would take place from nation, individual, property, progress and economic welfare, to world, group, services and well-being. As a second example there was a Dutch investigation held in 1970. The Dutch population in the age interval 24-49 was questioned about their views, expectations and appreciation of developments to come (Ref. 4). Here are those items where the answers showed a clear pro-contro or yes-no outcome, namely in a ratio of at least 2 to 1.

In the present situation it is the opinion:
— that the educational system works satisfactorily
— that real happiness in family life occurs only with children
— that in general the interests of women are undervalued
— that people do have sufficient free time

For the future one expects:
— an increase in welfare
— a deterioration of the social and psychological climate in terms of pollution, population density, political inefficiency
— a greater influence of the government and the big companies
— an increase in protest actions

For the future one appreciates:
— a rapid increase of living standard for the underdeveloped countries
— a prolongment of the obligatory school period to 18 years
— free availability of contraceptives for children above the age of 18
— an interdiction for motor cars in the city

And one depreciates:
— an increased influence of government and big companies
— a European government
— an increase in protest actions
— alternative forms of family life

The outcome is not altogether clear. We are not sure whether such a straightforward inquiry is a necessary condition in determining trends in attitudes, it certainly is not a sufficient conditions. What must be answered is, of course, where the autonomous changes will occur, where the causes lie and whether the consequences will be apparent. In McLuhan's view, the source is to be found in the upper level; he considers that in every manifestation of technology there is something intrinsic present, that will reform the values and organization of society. Conversely, one might suppose that value concepts in society are primary and that it is these which mould the technical innovation — which may take many forms in its application — in such a way that the new component of technology becomes accepted in the community and is able to develop there. At all events, our own experience tells us that the phenomena in level 1 take place faster than in the underlying levels. We all feel, however, that level 3, that of behaviour, is nevertheless much more dynamic than level 2, that of organization and rules. School children have the idea that they change faster than the school system, and the citizens consider that they change faster than the laws. If we now ask what kind of signals can be detected at this moment about future developments in this interplay, then I believe there are three comments that are relevant.

First there is a marked increase in the interconnection of all events and situations, in terms of place and time. The old axioms, "divide and rule", "cobbler stick to your last", "there is a time and place for everything", are being radically undermined, and it is daily being made clear to us that all things are bound up with one another. Education is no longer simply for the young but for everyone for a lifetime; the exhaust pipe is no longer just something belonging to a car, but is a part of the whole environment; a sports game is not just a game to be watched from the stands but a spectacle for the living room. This means that the innovations that society demands, are new systems rather than new products. The problems of education, communication, urbanization, pollution, transport or public health will not be solved by a video disk, a gadget for the motor car, a new deodorant or a new blood pressure meter. These problems cannot be solved by teams from the APO, Bell, or Philips in the classical multidisciplinary manner — they need the co-operative approach of several institutions, each with its own technical or non-technical expertise having its own special competence. In this sense it is more appropriate to speak of a multi-institutional approach rather than a multi-disciplinary approach.

A second trend partly related to the foregoing is the shift in values mentioned before. In analysing these shifts it is obviously important to watch what the young are doing, and to keep in contact with them. If the young are becoming more visual, less career-conscious, then these are aspects that are significant. There is not much point in asking people between the ages of 50 and 60 what the world is going to be like and what it ought to be like; it is more to the point to observe the 20 to 30-year olds. Parallel with the present day changing of values, one may note a diminishing interest in science and technology. Although you may feel that I am rather arrogant about this, I believe that this tendency to turn away from technology and science could be put to the good if it meant that the power of analytical thinking were thereby diverted to non-technical circles such as management, the social sciences and the humanities generally. I believe that these areas suffer from a deficiency of rational thinking and that an injection from the exact sciences would be most stimulating. On the other hand I believe that it might be a good thing if clever young people were sometimes confronted with an environment where straightforward thinking is regarded as only half the truth; such a confrontation might well be salutary to our rational thinking.

3. Technological Capability

Up till now I have taken the rather easy course of circumventing a discussion on technical and scientific innovations under the assumption that this is not of prime interest. There is still, however, the more general question of what are the limits of our technological capabilities. Although of course this is not a question that can be answered in a few words. I shall try to indicate a few outlines.

First of all, I would point out that from the "information handling" point of view, technology cannot really do so much at all. Admittedly, we can compress information enormously and transmit it very far and fast and very accurately, but technology cannot solve a simple jigsaw problem as any toddler could do, technology cannot remove the spelling mistakes as any school boy can do, and technology cannot translate a story as well as any secondary school-boy can. The machine finds recognition, association and learning incredibly difficult. It is true that technology has taken over from the porter, the clerk, the copyist, the craftsman, the courier, the common crier, the calculator and the administrator but will technology also take over from the archivist, the translator, the teacher, the secretary, the observer, the analyst and the information desk? This depends not so much on hardware technology but much more on the software, on the programme of reasoning that we are able to put into the machine and on non-materialized ingenuity. I think that in this context a more fundamental attack is necessary in order to find the essence of technical data processing. It is necessary to bring more order to methodologies and to explore the limitations of the man-machine action and to formulate basic bottle necks. At present these fields lack, to a large extent, a systematic exploration, however we can be sure that we will constantly make the discovery that man himself is an exceptionally clever and versatile information processor and that technology is able to penetrate only a very little way into the field of perception and other simple intelligence functions.

Technology took over from

porter
clerk
copyist
craftsmen
courier
common crier
calculator
administrator

Will technology take over from?

archivist
translator
teacher
secretary
observer
analyst
information desk

Two other limitations on our technological ability should be mentioned. Firstly, there is in principle a limitation in organisational possibilities, but I think that this is not a severe one. Man's past and recent history has proven that very complex organisations for the realisation of technical systems can function. The second is a limitation in resources and on acceptance of side effects like pollution. Evidently this is of tremendous influence. It will restrict our activity in technical innovation in one way but will also be a catalyst for technical innovation in another way, namely to circumvent the problems of pollution and reduced resources. It is very likely that more and more attention will have to be paid to energy production, biological processes, material science and exploration of resources.

4. Information technology

So much, in general terms, about technology. I would now like to say more about the specific field of providing information for our fellowmen. As a result of technology, there has been an enormous increase in the presentation of information for instruction, enlightenment and entertainment, but two very serious disequilibria have arisen:

- There is too much data and too little information;
- There is too much information and too little communication.

At your work you are swamped with telephone calls, telex messages and xeroxes. At home you are bombarded by magazines, radio and television programmes. You are completely flooded by a stream of messages of all kinds, and willy-nilly you try to cope with them. You don't look at the sequence, you don't look at the priority, you simply let it all come at you. You are completely on the defensive. You only really get anywhere when there is an interaction that gradually gets the subject over to you, through which you get to know the background, the good and the bad and the true and the doubtful aspects. That is what you need.

There is a great and pressing need to dam the stream of information and to hand over the initiative to the individual. There is a pressing need for a selection mechanism that can be used by the individual. In this connection it seems to me that the newspaper is a more agreeable medium than T.V. In that respect a gramophone record is better than radio, the video cassette better than cable television, and cable television a little better than broadcast television. In this context the retrieval facilities at a data centre are better than archives. It is not the sending of information that has primarily to be speeded up, but the process of looking up the information, the process of retrieval.

But demand on flexibility in access to information is only part of the question. In almost any type of communication the information consists only as a minor part of pure factual data, the major part is generated by the human being himself. In the comment on the news, in the teaching of mathematics, in the instruction how to use computers, in the entertainment of the public and of course in the person to person contact we highly rely on this second type of information. A bestseller is mainly an author and never just a neatly ordered collection of data and facts. Only with the weather forecasts, timetables and stockmarket quotations can I do without a personal signature, but even in an encyclopaedia I very much like to know who wrote the interpretation of the item I look up. This leads to the conclusion that our technical means should be developed to stimulate contact with the human background behind the facts as much as possible. It is an illusion to try to subordinate the man on the machine. This is why I have a strong belief in the videophone as a contribution to communication and this is why I am sceptical about teaching machines but favour neutral tools which broaden the facilities of the teacher like the videodisk and video cassette. I think these latter media have to be as convenient and accessible as possible to artists, teachers, authors and educators, just like the art of printing is now.

I have now mentioned in passing some media that can help us to fulfil the urgent need for selection and interaction: the retrieval system, the videophone, the video cassette. An exceptionally important point, again, is what the structure is in which the media are contained. It is striking that in a very general sense, far beyond the scope of information handling, the most important part of that structure, and often the most vulnerable, is the part nearest to the consumer. In the telephone system the part to which you are directly connected as a subscriber is the most expensive, the most capital-intensive and the least flexible part of the network. For the manufacturer of consumer goods it is the dealer organization and the service organization. In government it is contact with the electorate and for newspaper publishers it is the distributing system. In short I believe that in order to refine any communication system, of whatever nature, it is essential first and foremost to pay attention to selection, initiative, the human factor in information and the peripheral distribution network.

5. Nineteen eighty-four

Having elaborated on the difficulty in technical prediction, the limitations on technology, the trends in information handling, we still are confronted with the need for a clearly specified description about the things to come. It is interesting to put forward the question of what disciplines should be consulted for such a forecast. Is it the technologist, the sociologist, the philosopher or the novelist? Having made a quick check by rereading in retrospect the transactions of former symposia on the future, I have the impression that the artist and the philosopher have a better developed "clairvoyance" than the technologist and the sociologist. This may be a good subject for a separate extended historical study. The only consequence of this observation for this paper is that I have chosen the year 1984 because of its close relation to the field of fiction and literature. Apart from that it is also a convenient distance from now, not too close and not too distant. We shall talk about that period in three ways: as a neat compilation of what has been predicted by professional futurology in literature and at conferences. For the second case I shall try to put qualitatively in words what I feel about the subject and for the third case the connection with Orwellian science fiction is discussed.

Table 3. Summary of Communications Forecasting

	1972	1984
World of electronics		
consumer	$14.10^9	$32.10^9
communication	$9.10^9	$38.10^9
U.S.A.		
— percentage employees in service industry	65%	80%
— simple teaching machine	1972-1980	1974
— sophisticated teaching machine	1975-1990	1975
— automation libraries	1971-1982	1976
— 3D colour T.V. set		1980
— two-way cable television		1985
— facsimile news service in the home		1990
— remote facsimile newspaper	1992-2022	

In Table 3 we see what awaits society in 1984 according to experts and literature sources, surveys and statistics (See for example Ref. 5). World sales of electronic devices to consumers will rise from 14 thousand million to 32 thousand million dollars. World sales of electronic communication media will rise from 9 thousand million to 38 thousand million dollars. The percentage of employees working in the service industry in the United States will go up from 65% to 80%. Between 1972 and

1980, with 1974 as the average date, the U.S.A. starts using simple teaching machines. The more sophisticated teaching machines come into use between 1975 and 1990. Automation libraries come on to the scene in 1976, three dimensional (stereoscopic) colour television sets enter American homes in 1980, two-way cable television in 1985, and at that time we are looking forward to 1990 for the introduction of the facsimile news service, and the remote facsimile newspaper in the year 2005. These are the probabilities derived from reports, conferences and opinion polls. To these I add my own prophecies.

I am convinced that in 1984 the video cassette recorder and the video disk will each have found a place, and will undergo the same flourishing development as colour TV today. What the functional division will be between one medium, the disk, with the advantages of inexpensive reproduction and easy access to any given part of a programme, and the other medium, the recorder, that provides a very convenient means of directly recording, erasing and re-recording, will depend to a large extent on the categories in the community that create the programmes, or software. The two new media in combination will have a tremendous influence on instruction in the professional environment and on entertainment and self study in the home. With videodisk the accent will most probably lie on entertainment (cheap copy) and self study (flexibility in access and speed) whereas the videocassette will extend the effect and use of programs brought to the home by the broadcast and cable TV-system (self-recording). At all events, these media will considerably expand the individual's possession of information. I think that cable TV systems, differing essentially from the present forms, will be slow in emerging, and that for a long time they will retain the classical form of a multi-programme choice without the viewer having much direct influence. Also, there will be an enormous demand for programmers. Programming will increasingly come to the fore as a very highly esteemed skill, and among programmers I include all those who have to do with the choice of the material, the didactic content, production and presentation.

In all these prophecies the tacit assumption is that the devices and media will be made available to the individual. In other words, we have not considered the possibility of their use by the state to control the individual in totalitarian systems. It is remarkable that this possibility is disregarded in all forward-looking literature and forecasts in this field. But it is to be found in novels about the future. If we analyze Orwell's famous book (Ref. 6) for the use made of technical aids for the transmission of information, we find three striking examples. In the first place, there is two-way telecommunication for keeping a watch on individual behaviour. The two-way TV system is under the slogan: *Big Brother is watching you.* In the second place, automated files and libraries play an important part in the rewriting of history. The Records Department of the "Ministry of Truth" is daily engaged in correcting earlier statements by government leaders and data about the enemy to bring them into line with present, while people and events can simply be erased from the records. A third use of technical aids is particularly remarkable, since it does not concern any hardware technology like the atom bomb, space vehicles or radar towers, but relates to the field of software. A new language is in use in Orwell's world of 1984, called "newspeak", in which people can only express themselves in accordance with the directive of the government system and whereby mental betrayal of the system can be detected and defined by such concepts as "facecrime", "thoughtcrime", "ownlife", etc. It says a great deal for Orwell's genius when you consider that formal, unambiguously constructed languages for programming and manipulating computers are now intensely being studied, but were virtually unknown in 1948 when this novel was written. I have dwelt on this topic at great length in order to show what a tremendous influence technological aids can have if they are systematically designed and used for the purposes of a totalitarian system.

6. Conclusion

Faced with this peril we come to the following conclusions. The means by which people can learn, communicate with each other, participate in cultural events and learn a new profession will increase far beyond that permitted by the classical art of printing. The visual-dynamic element will be an important aspect of this development and convenience in access and selection will be another. To produce the software, people of the highest calibre will have to devote their intellectual power and creativity to the business of enlightenment and presentation. All who take part in forming the "information society" will contribute to the structure that it acquires which, if it is to remain viable, will have to be based on the individual being free to find out what he wants to know, being able to make his views and opinions known and being able to receive instruction on any subject desired. Of course this freedom cannot alone save humanity but it provides the most civilized method for solving social problems while protecting the integrity of the individual. This being so it has to be concluded that it is of utmost importance for a society to have the infrastructure of modern communications media, its principle, its management and its control carefully studied and organized. This need arises because, as Gerbner states (Ref. 7): "Never before have so many people in so many places shared such a common system of messages, images and assumptions about life, society and the world that the system embodies . . . . . . It shapes the consciousness of what is important, what is right and what is related to what else."

It is an understatement to say that for most countries, at present, not everything is quite satisfactory and well prepared for future developments. In some cases government control is of an unacceptable exclusivity. In some cases commercialism leads only to the propagation of mass oriented publicity. There are instances where there is a very unclear pattern of governmental, semi-governmental and private bodies and examples where mass media are overruled by *l'art pour l'art radicalism.* I do not think that there is one case where there exists a far fetched planning and guidance of the communication system in equilibrium with its essence and importance, as mentioned above. It remains for us to strive for the achievement of such a situation.

6. References

1. McLuhan, M., *Understanding Media,* McGraw Hill, New York, 1969.
2. Gurvitch, G., *La Vocation Actuelle de la Sociologie,* Paris, 1950.
3. Baier, K. and Rescher, N., *Values of the Future,* The Free Press, New York, 1969.
4. Electronic Industries Association Conference, *Electronics 1985,* Chicago, 1972.
5. Gordan and Helmer, *Report on a long forecasting study,* Rand Corporation, 1965.
6. Orwell, G., *Nineteen eighty-four,* Secker and Warburg, 1949.
7. Gerbner, G., *Communication and Social Environment,* Scientific American, Sept., 1972.

Biography

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Dr. Teer was born in Holland in 1925. He obtained a Masters degree from the Technical University in Delft in 1949. He joined Philips Research Laboratories in Eindhoven, Holland in 1950 and did research work in the fields of colour television systems, redundancy in visual information, principles of magnetic recording, electro-acoustics and electronic circuitry. In 1959 he obtained his doctors degree. His doctoral thesis was on television bandwidth compression. He was appointed a deputy director in Philips Research Laboratories in 1966 and became the managing director for electronic systems in 1968. The Electronic Systems Division is one of the four main divisions in Philips Research Laboratories, the others being Physics, Chemistry and Applied Physics.

New Devices for Future Communications

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Networks of voice communications are growing very rapidly throughout the world, demands for global communications are increasing, and needs for new communication services, such as data, facsimile and video, are growing. Such needs are advancing research and development of new devices, and in turn, new devices are innovating new systems and services. In order to make new communication services economically feasible, the importance of integrating most communication networks has been recognised. In this, digital technology will play an important part. This paper presents the current research and development status of these new devices which include millimeter and optical devices including transmission media, LSI, information storage devices and display devices. Some important problems for realising new services are discussed.

1. Introduction

Networks of voice communication are expanding very rapidly throughout the world, demands for global communication are increasing, and needs for new communication services such as data, facsimile and video are growing. Such demands and needs are advancing research and development of new devices and, in turn, new devices are innovating new systems and services. In order to make new communication services economically impressive, the importance of integrating most communication networks has been recognized. The digital technology will play an important role in realizing the integrated communication network.

This paper will briefly discuss a future prospect of communications needs. It also will present NEC's research and development status concerning new devices advanced by these needs and which are most likely to have strong impacts on future communications.

2. Prospects

Telecommunication technology so far has continued developing remarkably, to meet mankind's basic desire to be able to talk with anyone, any place and any time. With the recent marked advance of society in the industrial, informational and international activities, communication has to meet more the sophisticated desire to see, to communicate with machines, and to collect information from monitoring stations on and under the ground, on the ocean bed and in space. Vast amounts of data and information needed to meet these desires have to be transferred rapidly, over a great distance, not only between people but also between machines, and with great reliability. These communications are not only between fixed terminals, but also with mobile terminals.

In order to meet these public needs, video communication systems and facsimile communication systems should make rapid progress. Data communication systems, a combination of computers, communication networks and terminals, should achieve a further development. Electronic switching systems for handling various forms of signal and services should be developed. An integrated and efficient exchange and the transmission of such information as well as the development of super-wide-band transmission line will be important.

Even though there exist strong needs for new communication services, it does not necessarily mean full acceptance of the services that we provide. That acceptance depends largely on the cost-effectiveness of the services. The effectiveness is influenced by many factors, but it is mostly evaluated by the terminals, through which direct services are provided to users. Therefore, the development of terminals of various forms and for different social customs is extremely important. In order to extend the new services to individual homes, terminals which feature low cost, handling ease, and freedom from maintenance have to be developed. This is a very difficult task.

As mobile radio communications services become popular and wide use of satellite communications is explored for various services, the radio spectrum will be extremely crowded. Effective use and management of the frequency spectrum has to be studied and new spectrums have to be explored. Although guided wave transmission media of broad frequency characteristics and of low cost are very important, it will be necessary to allocate as much free space as possible for communications that are impractical through guided transmission media. Band compression, multi access and multi-level transmission of information are important in the effective use of the frequency spectrum.

Considering social needs and the trend of future telecommunication system technology, pursuing the course of service integration and digitalization is considered. Massive resources invested in data processing and integrated circuit technology will unavoidably strengthen this trend, except if new analog functional devices that simplify data processing are

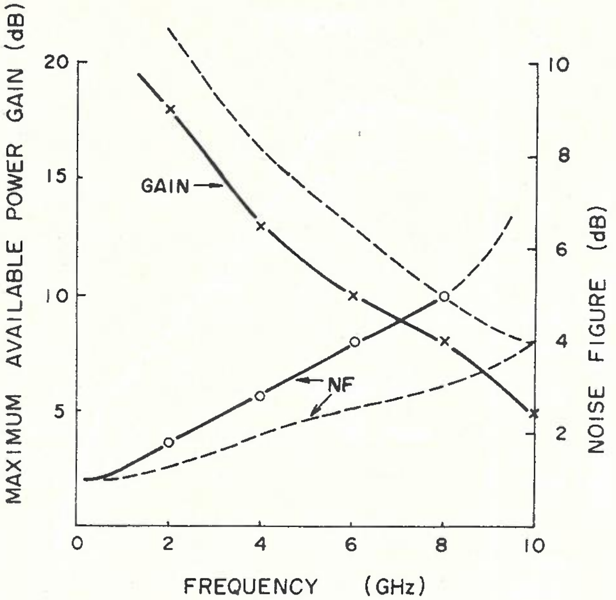


Fig. 1—Maximum power gain and noise figure characteristics vs frequency of bipolar transistors

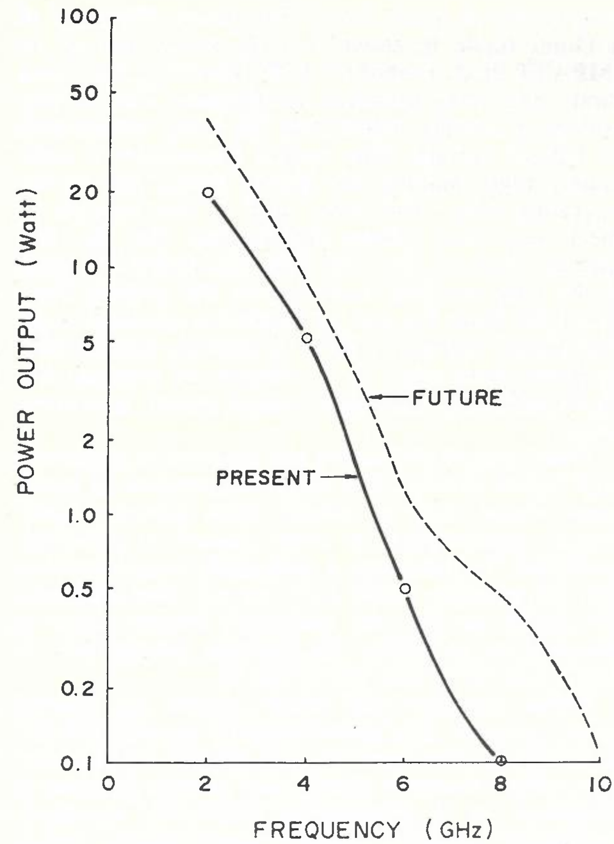


Fig. 2—CW output power vs frequency characteristics of bipolar transistors

invented and substantial reduction in service cost can be proven by use of such devices. PCM technology and its evaluation should be very important.

3. New Devices

In order to make these new technologies and communication services economically feasible, the performance and reliability of components have to be improved considerably, new devices that simplify new systems must be innovated, and, at the same time, their cost has to be reduced substantially. This necessitates increased efforts in research and development of materials and devices.

3.1 Microwave and Millimeter Wave Devices

For reliability and low cost broad-band communication, future microwave and millimeter wave repeaters, as well as satellite electronics, will have to be all solid state. We have developed almost all the devices for such needs, for example microwave bipolar transistors, Gunn and IMPATT diodes, varactors and mixer diodes up to 100 GHz. Fig. 1 shows the best data of Si bipolar transistors for maximum available power gain and noise figure. The solid lines show our best data for laboratory models, and the dotted lines show predicted improvements. Fig. 2 shows the current top cw output power levels (solid line) and predicted improvements. These performances are more repeatable these days with the use of advanced process technology, such as electron beam lithography and ion implantation. Even though the performance of Gunn and IMPATT diodes is improving, the steady progress of microwave transistors is facilitating the design of microwave equipment. The recent progress in GaAs FET is very remarkable. We have measured a maximum available gain of 13 dB and noise figure of 3.5 dB at 6 GHz by using GaAs FET of 1μ gate width and fmax = 35 GHz. It is expected that the practical frequency limit will be extended to about 30 GHz, noise figure will be reduced below 4 dB at 10 GHz, and output power will be increased to about 1 watt at 20 GHz. To make these predictions a reality, the device design has to be improved. All necessary circuits have to be integrated in the package. An example is shown in Fig. 3.

Fig. 4 shows our maximum output powers of Gunn diodes up to 50 GHz. Fig. 5 shows similar data for IMPATT diodes. A Gunn diode is not as efficient as an IMPATT diode, hence its output

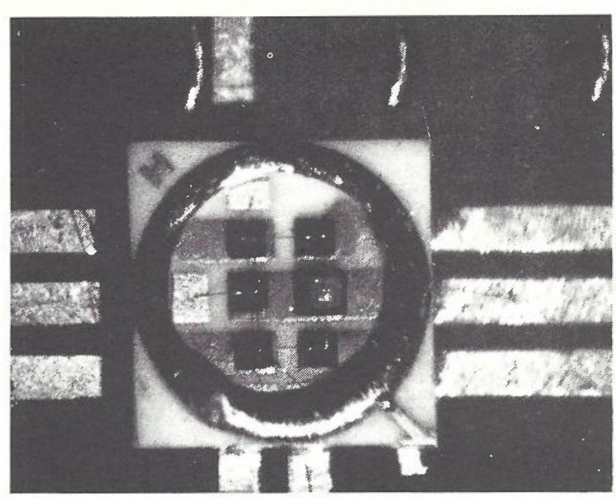


Fig. 3—An example of an integrated microwave bipolar transistor package

power level is much lower. The power efficiency of a Gunn diode is about 3—7%, while that of an IMPATT diode is about 7-17%. However, the Gunn diode has many practical advantages: The dc bias voltage is usually lower than 20 volts, comparable to battery voltage. The output impedance is sufficiently high, making the circuit design and device operation easy. The noise level is low enough to meet long haul system applications. For the frequency range of 50—120 GHz, the IMPATT diode is the only practical candidate at the present time. The LSA diode has not yet reached a practical stage. The GaAs IMPATT diode is making considerable progress these days. It is simpler to process, has higher efficiency and higher output power, and lower noise.

These microwave diodes are operated at extremely high power density. The diode temperature at maximum power level is usually near burn-up point. Hence, performance is often related to reliability problems. To guarantee a sufficiently long operation life, for example 1,000 FIT, we are now designing the diodes so that the maximum output power is obtained at, or below, the junction temperature of 230°C for GaAs and 180°C for Si.

GaAs varactors and mixer diodes are making steady progress. For remote satellite ground stations, maintenance free receivers are needed. At the present, these receivers mostly use cooled parametric amplifiers as a preamplifier. However, cryogenic equipment requires frequent maintenance, hence there exist strong demands for uncooled parametric amplifiers. We have developed extremely high quality varactors with a self resonant frequency of 60 GHz. It is now possible to make practical, uncooled

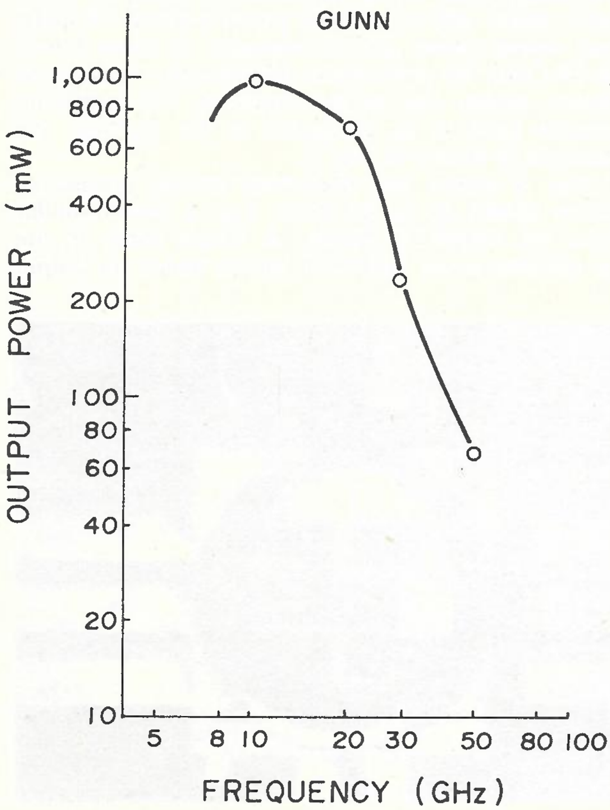


Fig. 4—CW output power vs frequency characteristics of Gunn diodes

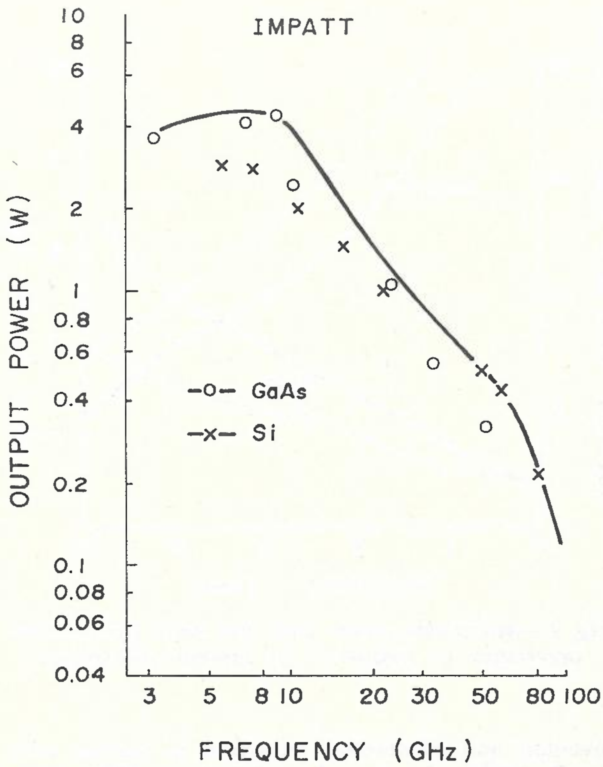


Fig. 5—CW output power vs frequency characteristics of IMPATT diodes

parametric amplifiers with noise temperatures of lower than 50°K at 4 GHz and a bandwidth of more than 500 MHz. We expect to achieve 18 GHz parametric amplifiers with 150°K noise temperature at room temperature and 30°K noise temperature at 20°K.

Fig. 6 shows a photograph of an 80 GHz mixer. It includes a GaAs Schottky barrier diode and a 1.8 GHz IF preamplifier. Its overall noise figure is 10 dB now, but this is expected to be reduced to 7 dB in the future. If GaAs FET is used in the preamplifier, instead of the Si bipolar transistor that is now used, the mixer can be cooled down to 20°K and a substantial improvement in noise performance is expected.

Microwave IC technology is widely used in present microwave devices. The previous mixer in Fig. 6

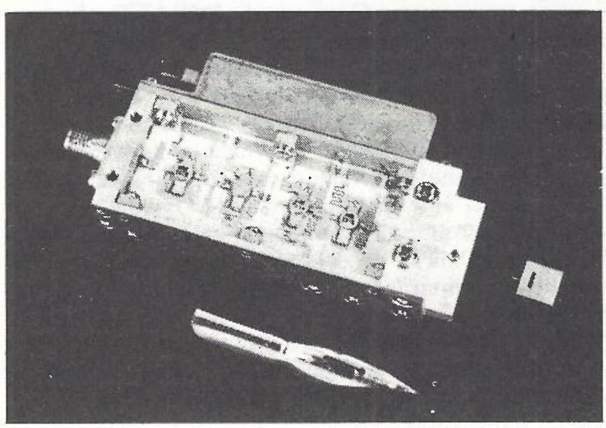


Fig. 6—Photograph of 80 GHz mixer with preamplifier

uses a microwave IC. Fig. 7 shows a 1.8 GHz main IF amplifier for a millimeter wave repeater and a 18 GHz repeater. This includes an automatic gain control circuit. Fig. 8 shows an x-band radar head. This includes a Gunn oscillator for local signal, a balanced mixer, a PIN diode TR switch, and two circulators. A similar device was commercialized for color TV transmission using two IMPATT oscillators. For accomplishing frequency stability, the stabilizing cavities are coupled to IC circuits. Using microwave IC devices, the size of microwave equipment can be reduced to a book case size or even to a lunch box size. Not only are these microwave devices improving the cost performance of conventional communications equipment, but they are also advancing the development of synthetic automobile information systems, automobile safety systems, and remote monitoring station systems. Microwave IC will include more and more monolithic IC's depending on need and technology.

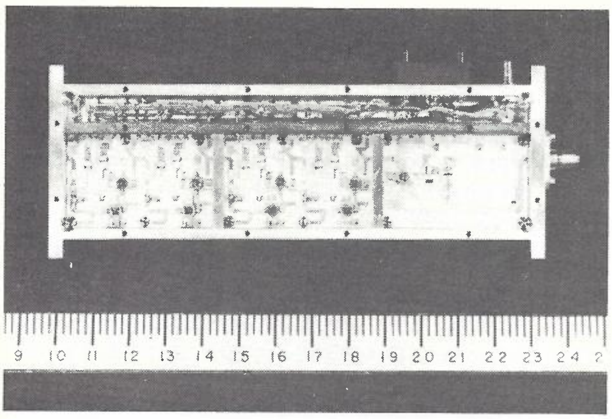


Fig. 7—1.8 GHz main IF amplifier with automatic gain control

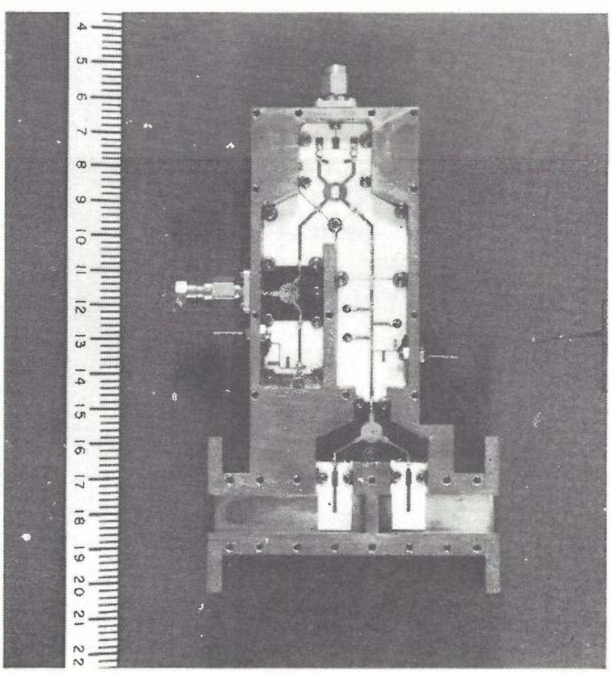


Fig. 8—An example of microwave IC for X-band radar head

3.2 Integrated Circuits

Semiconductor integrated circuits are playing an important role in modern electronics. For future communications and data processings, they will be indispensable devices and subsystems. Until new functional devices are invented, which provide functions comparable to or better than present IC and LSI, and have structures much simpler than the present IC, device development will be largely an extension of present IC technology. Trends will be the integration of subsystem design and device design. Such examples are the single chip calculator and one chip computer. An IC memory chip now includes most peripheral circuits and is no longer just the integration of memory elements, but a memory subsystem.

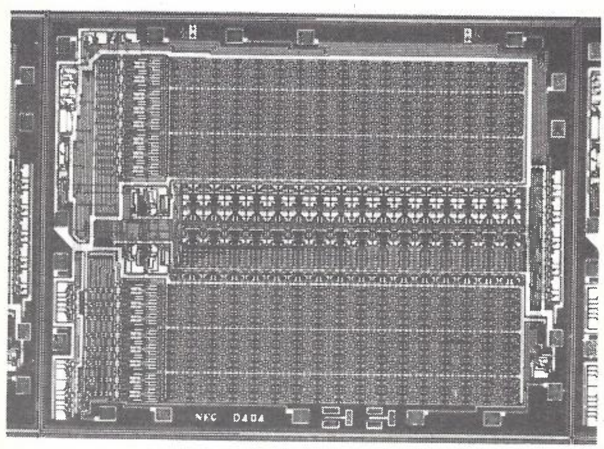


Fig. 9—Enlarged view of 1.02 bits N-channel MOS RAM chip.

As a leading IC manufacturerd in Japan, NEC has developed numerous IC and LSI for computers, electronic switching, data communications, PCM carriers, terminals, desk calculators and other consumer products such as color TV. Fig. 9 shows an enlarged photograph of a 1,024 bits N-channel MOS RAM chip. Fig. 10 shows a 4 kw x 9 bits memory

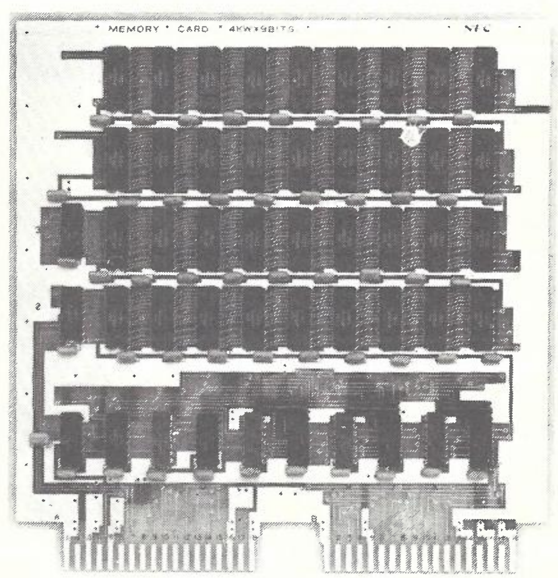


Fig. 10—4 kw x 9 bits memory card

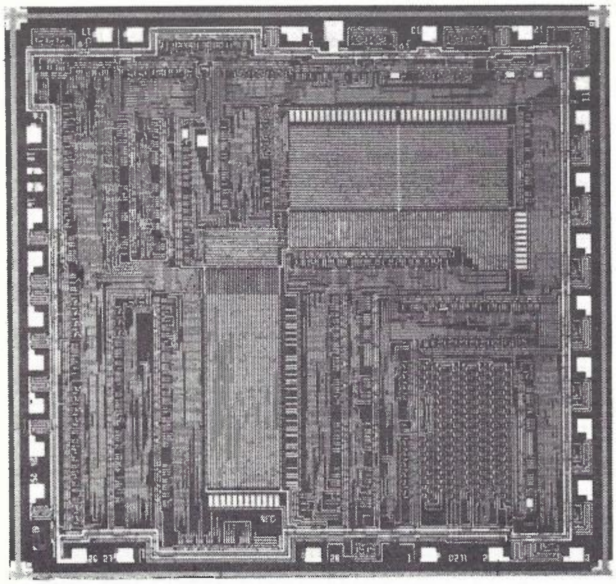


Fig. 11—Enlarged view of a single chip desk calculator chip

card using the previous chips. We are now developing 4 kb and 8 kb chips with decoder circuits. Fig. 11 shows a very complicated single chip desk calculator chip.

One chip CPU with logic gates of more than 1,000 are creating heavy demand for such LSI for various applications. These LSI are presently using p-channel MOS technology, and hence the speed is slow. For many applications, especially communications, demands for improved speed are very strong. The bipolar transistor logic is the fastest one at present, but it consumes too much power. When more than several thousand gates are integrated on a single chip, the power consumption per gate has to be of the order of 0.1 mW. A new high performance IC, designated ESBIC (Enhancement Mode Schottky Barrier Gate IC) features substantially lower power consumption, high speed operating capability and increased reliability. It is expected to be used as a low power memory as well as a logic LSI of highest quality. A model of the cross-section of an ESB FET is shown in Fig. 12. The epitaxial Si layer under the gate, which is about 0.5 μ thick and formed accurately by ion implantation, is com-

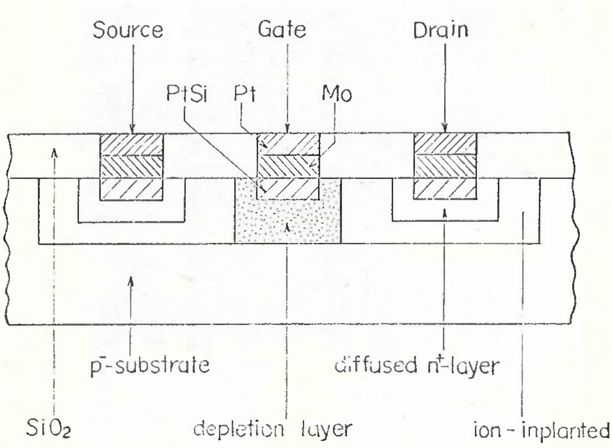


Fig. 12—Cross section model of ESB FET

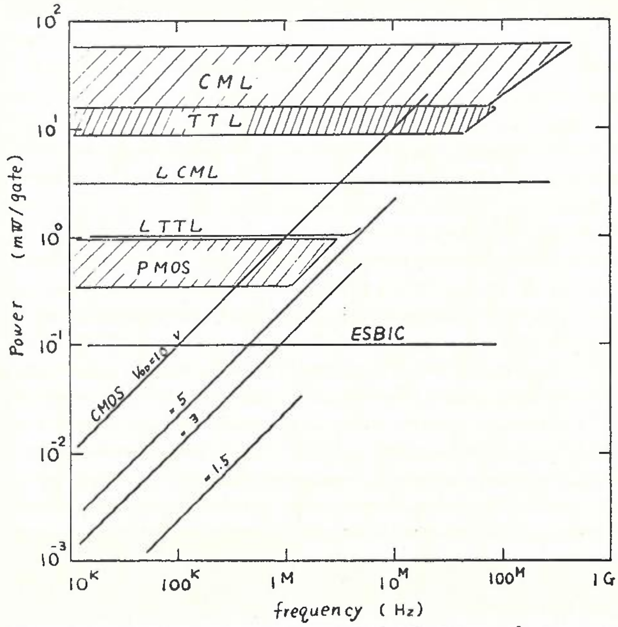


Fig. 13—Power dissipation vs frequency characteristics for various logic gate circuits

pletely depleted by the built-in potential of the PtSi-Si Schottky barrier. Therefore, no drain current flows without a positive gate voltage. Fig. 13 shows power dissipation vs frequency characteristics for various gate circuits. ESBIC has the lowest power capability at higher frequencies. We have already demonstrated the feasibility by developing a 256 bit memory. We are now aiming at 5000 gate logic LSI.

For five-level 800 Mb/s PCM systems, we have developed a series of hybrid IC logic circuits. Fig. 14

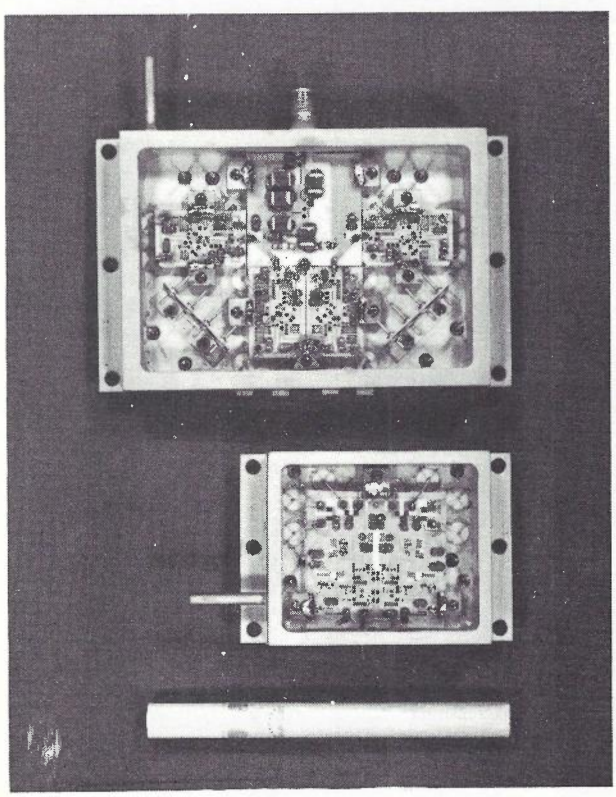


Fig. 14—Hybrid IC logic circuits for 800 Mb/s PCM system. Upper photo is DEC and lower one is MLG

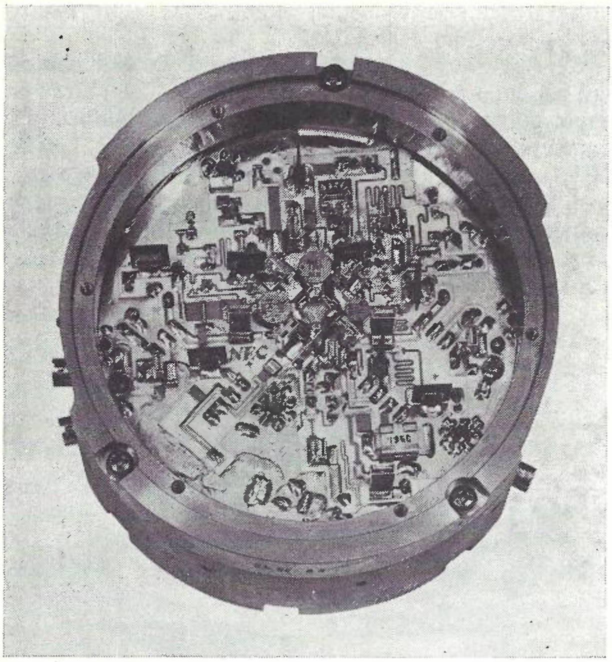


Fig. 15—Amplifier portion of 36 MHz submarine cable repeater

shows two such examples. The upper one is a discriminator and the lower one is a multi-level generator. Fig. 15 shows the amplifier portion of a 36 MHz submarine cable repeater. For achieving good linearity and high reliability, very advanced technology and careful processing is needed. We are developing further giga-bit devices by using improved transistor designs and bulk-effect functional devices. These will eventually become mostly monolithic.

3.3 Video Devices

To make video and facsimile communication services more economical, further developments in devices, equipment and systems are needed. Reliable, but economical solid state image sensors, scan converters and display (printing) devices are a few such examples. We have developed a silicon image sensor with 200 x 200 sensor arrays using MOS LSI technology. Fig. 16 shows of a sensor with scan generators. A camera using this sensor is the size

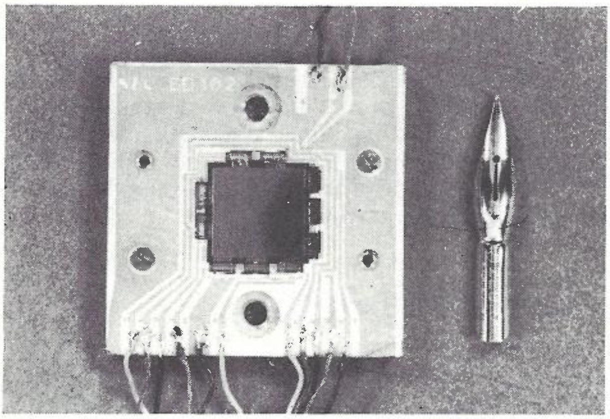


Fig. 16—Solid state imaging sensor LSI

Fig. 17—A video output of solid state camera

of a small 8 mm movie camera. An example of video output is shown in Fig. 17. We are developing further much larger arrays comparable to a commercial vidicon by using CCD (Charge Coupled Device) technology. With the same technology, the scan converter and signal delay line, which are very useful for large band compression of video signals, can be developed. When it is fully developed, it could mean considerable innovation in the video and facsimile communication field as well as in the video data processing.

Another new development in facsimile communication is a self scanning gas plasma printer. The heart of the printer is a flat rectangular glass tube as shown in Fig. 18. A row of large numbers of electro-static printing thin-film styli is located at the flat end of the tube. Each stylus is connected to a probe electrode of gas discharge cells as shown in Fig. 19. A gas plasma scans a row of gas discharge cells, with the aid of a three phase scanning signal, switches the styli and applies a signal voltage for electro-static printing. This tube is made by IC technology and is suited for massproduction. It will offer a compact, low cost, maintenance free facsimile receiver.

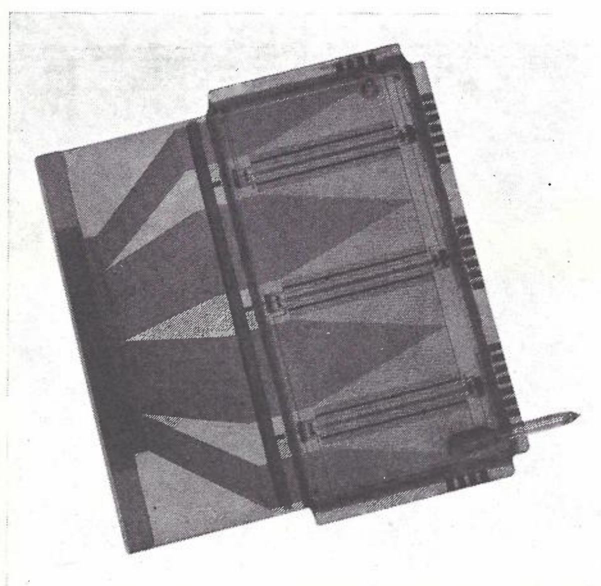


Fig. 18—Self scanning gas plasma printer tube

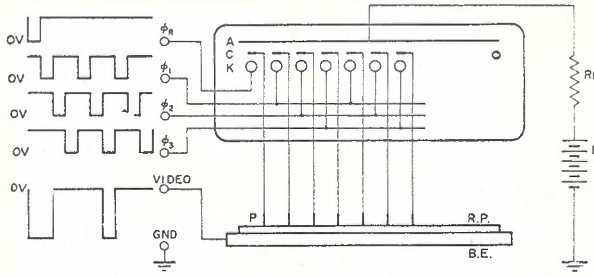


Fig. 19—A block diagram of plasma printer

3.4 Optical Devices

As new communication services increase, carriers of broader bandwidth will have to be transmitted. Since the microwave band is already crowded, much higher frequency bands have to be explored. Since the invention of the laser, the possibility of optical communication have been much discussed. Simple optical communication through open air is now in service for private uses. Because of the vulnerability of laser beam propagation through air, it is not reliable for public communications. The laser beam has to be transmitted through a completely controlled media for reliable communications. One promising candidate for such a media is an optical glass fiber. We have developed a glass fiber guide called "SELFOC", which has a parabolic distribution in the index of refraction. The index of refraction is highest at the fiber axis and lowest at the surface. Hence, the velocity of light is slowest along the axis and fastest along the surface. The light beam takes a sinusoidal path around the axis as shown in Fig. 20. The phase velocity of light along the axis is constant and independent of its path. Therefore, the phase distortion of signal is extremely small. A laser pulse train of 0.2 ns width generated by a Q-switched YAG laser was propagated through a length of SELFOC 1 km long. It was found to have negligible broadening in pulse width. We estimate that more than seven giga hertz bandwidth is possible. This is much greater than of the multimode glass fibers, being developed by other companies, with bandwidths less than 100 MHz.

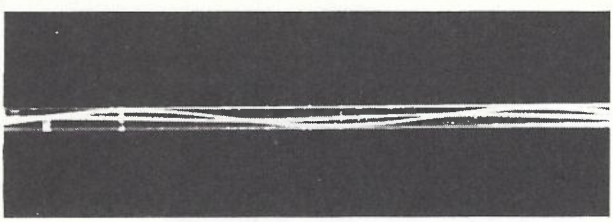


Fig. 20—Laser beam path in SELFOC

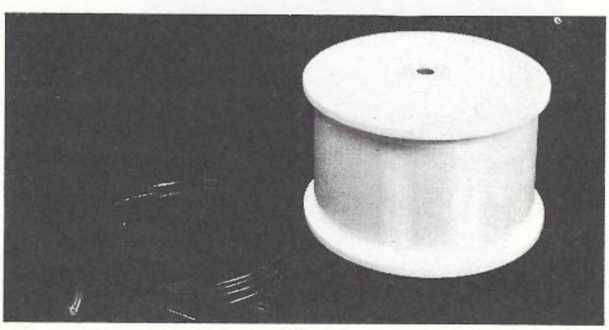


Fig. 21—A SELFOC cable with end connector

We have already developed plastic coated cables and an interconnection technique. Fig. 21 shows a single guide cable of 1 km with an interconnecting connector. Its transmission loss is still 20 dB/km at 0.85μ semiconductor laser wave-length, but we expect to reduce it to below 10 dB/km. The interconnection is as simple as a conventional coaxial cable connector, and its loss is less than 1%. This is a special feature of SELFOC.

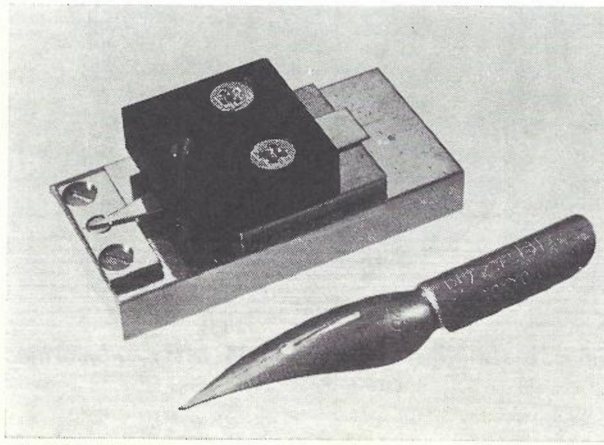


Fig. 22—Double heteroepitaxial GaAs laser

We have developed a single mode semiconductor laser capable of continuous operation at room temperature. Fig. 22 shows an example. We have spent considerable effort solving the reliability problems. In the past the semiconductor laser had lasted only minutes or at most 100 hours. We now understand the degradation mechanisms and have most of the solutions. Our lasers are now operating without degradation for over 4000 hours. We expect them to last more than 10,000 hours. We have developed most of the components needed for optical communications and we are now developing integrated optics components for achieving extremely stable and reliable optical communications systems.

The cable optical communication system has many merits over the coaxial cable communication system. For example, the transmission characteristic of the optical cable can be considered practically constant over the carrier band; complicated phase delay compensation circuits are eliminated. Optical communication is essentially optical carrier transmission, and does not require careful bipolar transmission. The optical cable is so thin, about 1 mm in diameter, and so inexpensive that a master group of 400—800 MHz in bandwidth can be transmitted economically through a single fiber, thus eliminating a super group multiplexer and demultiplexer and complicated channel filters. Therefore, we can simplify the repeater and reduce cost substantially.

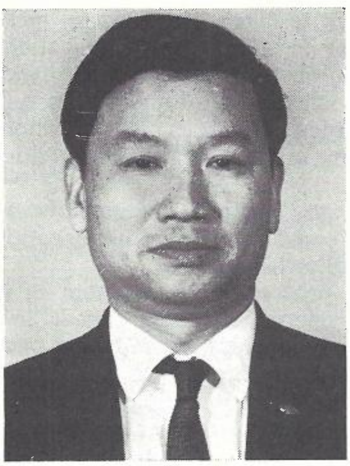
4. Concluding Remarks

I have described only a few examples of our new devices that will contribute to the progress of future communications. It is difficult to cover all the important devices within a limited space, and almost impossible to cover all developments within a single company or in a single country. Communication is no longer a local event, it is already an international event. International cooperation is needed not only for services but also for research and development.

To meet growing social needs in both developed and developing countries, telecommunications technology has advanced remarkably in the preceding decades. People in many countries are now able to speak to each other over the international telephone as if they were in the same city. They can watch, in their homes, television programs showing various events occurring in other countries and even on the surface of the moon. However, the real telecommunications age is believed to be coming in the next decade or decades. This is because the technological innovations carried out over the past twenty years have changed the form of communication in extent, quantity and quality, and the role of telecommunications in society is becoming increasingly important independent of the degree of social development.

Telecommunication systems handling various kinds of information will become very complicated. It is very important to achieve an efficient service integration of telecommunication systems after careful analysis of what information will be utilized and to what extent. For this purpose, many new developments are needed to realize large capacity transmission, electronic switching, digital communication, and various terminals and devices. In this respect there is no longer a clear boundary between systems and devices as they are heavily interrelated with each other. We R & D engineers will have to know social needs and manufacturing as much as the device engineer has to know systems, and the system engineer has to know new devices. Future communication will need more innovations in technology and services as well as in engineering concepts.

Biography



MICHIYUKI UENOHARA received his B.S. degree from Nihon University, Tokyo, Japan, in 1949, his M.S. and Ph.D degrees from Ohio State University, Columbus, U.S.A. in 1953 and 1956, and the Doctor of Engineering degree from Tohuku University, Sendai, Japan in 1958. From 1949 to 1952 and again from 1956 to 1957, he taught and did research on microwave tubes and gas plasma at Nihon University. At Ohio State University he held a Research Assistantship and Associateship and did work on millimeter tubes. In 1957 he joined the Bell Telephone Laboratories, Murray Hill, New Jersey, and supervised a parametric amplifier group and a bulk effect device group. In 1967 he returned to Japan and joined Nippon Electric Co., where he managed the Electron Device Laboratory, the Quantum Device Laboratory, and then the Memory Research Laboratory. He had served as a corporate chief engineer, Assistant Manager of Corporate Strategy Planning Office, and Assistant General Manager of Central Research Laboratories until he became General Manager.

He received the Inada Award from the Inst. of Electrical Communication Engineers of Japan in 1957, the National Electronic Conference Award in 1967, and the Distinguished Alumnus Award from Ohio State University in 1971. He is a Fellow of IEEE. Dr. Uenohara also serves various Governmental, industrial and academic committees in Japan.

Custom Microelectronics in Communications Development

G. A. RIGBY
Senior Engineer, A.W.A. Microelectronics Pty. Ltd.

The role played by custom microcircuits in communications development has been to enable advanced systems to be modelled and studied in a form which represents their final production configurations. The techniques used involve special devices for use in optoelectronics (for example), medium-to-large scale monolithics, and multichip hybrids. Applications of these are described and the important role played by computer-aided design and testing in this activity is also noted.

1. Introduction

From the beginning of telecommunications until 5-10 years ago, the role which electronics played was limited to conventional radio techniques in non-telephone applications and to trunk transmission techniques in the telephone network. It is obvious however, that the development of telecommunications from now on is involving electronics in many more roles than these. In turn, microelectronics is one of the key developments which is making this evolution both economically and technically feasible.

To measure the progress made in the relatively brief 12 year history of microcircuits, the following achievements could be cited:

(i) The reduction in cost of an elementary logic function (gate) from >\$5.00 to <0.5c. (When part of an LSI array.)

(ii) The achievement of IC module reliabilities which correspond to <.00001% device failures per 1000 hours.

(iii) The fabrication of IC chips with more than 10,000 active devices.

(iv) The reduction of device areas to a point where 100,000 logic functions per sq. in. can be carried out.

(v) The realization of sub-nanosecond switching speeds in relatively complex arrays.

This paper is primarily concerned with the developmental stages of new microcircuits, that is, when they are at the "custom device" stage. This brings the future a little closer, in the sense that it is possible to look at techniques which are experimental at present and form judgments about what will be routine in 5-10 years time. Because the future of communications is so closely linked to electronic techniques and because microcircuits have become a prime medium for realizing these, we are entitled to place great emphasis on the role they play. In fact, we could claim that some telecommunications developments have resulted from, rather than caused, developments in microelectronics.

2. Local Capability

In Australia at present, two companies have silicon IC diffusion plants, four have IC assembly lines and at least six are developing, or have established hybrid microcircuit facilities.

Two major government laboratories have hybrid facilities and significant research programs in microelectronics exist in at least 6 tertiary educational establishments. Much of the diffusion and hybrid work in the industry sphere is custom and, in turn, much of it is concerned with telecommunications, this being the dominant market area for professional electronics.

The existence of an Australian capability for custom microcircuits contributes to communications development in the following ways:

(a) Where complex processing in a system is required, custom microcircuits can result in a more cost-effective approach by reducing package count, and likewise increasing reliability.

(b) The use of hybrids, in particular, enables a high level of modularity to be achieved which simplifies system design, testing and maintenance.

(c) At the materials and devices level, special characteristics are frequently required which are not provided by standard semiconductor devices.

(d) Because of the critical relationship between system design and microcircuit design, close interaction between these two activities is essential and greatly enhances the total design process.

3. Examples

The following examples are representative of local microelectronic developments and are used to illustrate these observations.

The economics and characteristics of new communications media are taking us increasingly towards digital traffic at high data rates. To this end, AWA for one has been involved in PCM and delta codec development for several years. In the case of delta modulation, four complete generations of IC designs have occurred.

These have included pre-multiplexed and post-multiplexed versions, three different companding laws, the incorporation of signalling functions and an evolution from an all-bipolar technology, through

PMOS-bipolar to CMOS-bipolar. At present, all functions necessary for a duplex delta modulation channel can be carried out on two MSI chips and, with the maturing of a compatible CMOS-bipolar process, a single chip per channel is perfectly feasible. Further reductions in device count are possible through the use of pre-multiplexing.

A similar pattern is emerging in custom PCM functions, though the modules are more complex. A two-chip PCM codec has been developed, which makes heavier use of the bipolar technology and results in approximately twice the chip area of its delta counterpart. In both cases, however, a reduction in package count by a factor of 3-5, with its attendant cost and reliability implications, has been achieved.

These developments also point to a degree of fluidity in system design questions at present. Not only does the choice between PCM and delta encoding involve a number of trade-offs but, more interestingly, the parameters governing how close to a subscriber's instrument digital traffic should go, are changing. As the cost and power per function in IC's fall, it is likely that encoding will become cost-effective within the telephone instrument itself.

A further complex example is in the push-button decadic dialling telephone. Here, because of the low current and voltage available on a limit-line telephone and the undesirability of using a battery, a very low-power technique is required. CMOS provides this and a 1000-device LSI chip has been developed in this technology which carries out this function. Fig. 1 shows the control chip for this device.

At the device level, three examples from recent work illustrate some of the special requirements that arise in communications development. One is in the electret-microphone telephone transmitter in which the low source capacitance of the device and variations in telephone line-length necessitates special circuit techniques and device designs.

Similarly, in the development of fibre-optics communication links, non-standard emitter and detector structures are required for efficient coupling to the fibre. An example of this is a junction photo-detector into the centre of which a well has been etched.

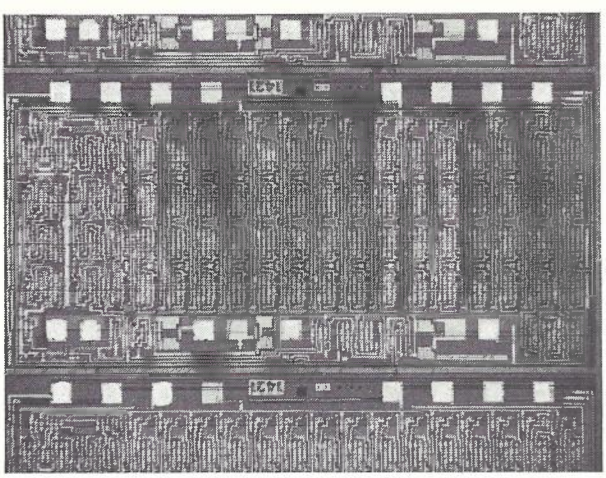


Fig. 1—Photomicrograph of a complementary MOS control chip for a push-button decadic telephone. The .070" x .140" chip contains more than 1000 devices

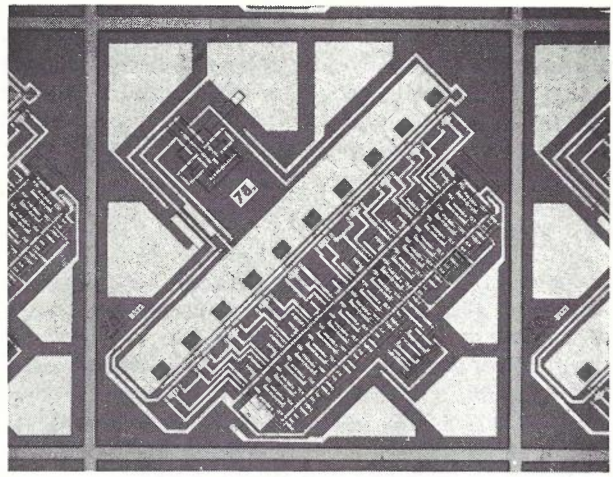


Fig. 2—A ten-element self-scanned photodiode array incorporating a CMOS shift register and bipolar video amplifier

This has the effect of coupling light from the fibre directly into the depletion layer of the diode.

The third example, illustrated in Fig. 2, is of a self-scanned photodiode array. This simple 10-element array can be used for character reading and other man-machine interface applications.

4. Hybrid Microelectronics

The examples cited above involve monolithic IC techniques, but to achieve the degree of modularity mentioned above, hybrid techniques are being used to extend the level of system integration. Thin-film and thick-film hybrid technologies enable micro-circuit modules to be constructed which combine monolithic chips, discrete transistors and passive components. As a result, the frequency limits of monolithic IC's can be extended into the microwave region and power levels above 100W can be handled.

A more important general result, though, is that a hybrid module can be constructed, tested and installed as a complete functional entity. Dynamic trimming of critical parameters by laser-beam techniques and the introduction of high-reliability chip bonding methods, such as are offered by the beam-

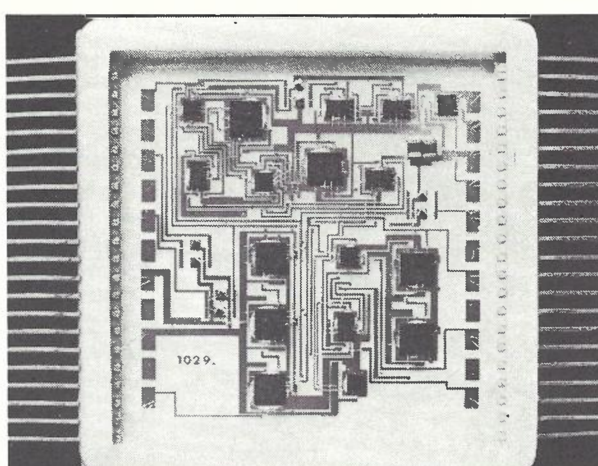


Fig. 3—A 1" x 1" thin-film multichip hybrid containing 17 IC chips and 8 discrete transistors

lead technology, are now established. As a consequence, an increase in sub-system reliability, which is an essential requirement for the scale of future electronic systems, should be achieved. Fig. 3 shows an example of a high-density multi-chip hybrid.

5. Discussion

Because many of the microcircuit developments described above are at an early stage in their evolution towards large-volume production, we describe them generally as "custom" devices. But the real contribution of custom microelectronics to telecommunications is that it allows experimental developments in new systems to be carried out in terms of optimum technologies and circuit designs.

From the custom microcircuit manufacturer's viewpoint, providing this service presents some challenges. One is to provide a rapid and efficient turnaround on new designs. The key to this lies in computer-aids both to design and testing. In Australia, significant progress has been made in these areas and an improvement in development efficiency has already been experienced. In the second place, the high technologies which will be required in the future pose a perpetual challenge to us in determining which of the many will be the most useful. In the short term, there is little doubt that bipolar, MOS and CMOS monolithic technologies, together with thick-film hybrids are the ones. But for the future, it is necessary to review continually the developing importance of such technologies as GaAs, silicon-on-sapphire, and new magnetic materials.

Biography

GRAHAM A. RIGBY was born and educated in Melbourne, Victoria. He received the degrees of B.Sc. (Physics) and M.Sc. (Electrical Engineering) from the University of Melbourne in 1961 and 1963 respectively. From 1963-1964 he was an Assistant Lecturer in Electrical Engineering at Melbourne.

In 1966 he received his Ph.D. from the University of California at Berkeley and was an Assistant Professor of E.E. from 1966-1968. During the period 1964-68 he also held temporary and consulting positions with Westinghouse Corp., Bell Telephone Laboratories, Fairchild Instrumentation and Signetics Corp.

He returned to Australia in 1968 to head the IC design and development group at AWA Microelectronics. In addition he is a Part-time Lecturer at the University of New South Wales.

Dr. Rigby's research interests have been in active filters, large-scale digital circuits and digital communications. He is a member of the IREE, IEEE and Sigma Xi.

The Role of Computers in Future Communication Systems

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This paper discusses the roles computers can play in existing and future telecommunication systems. There are already technical, operating and economic advantages in adding on small, low-cost computers to supplement a variety of existing electromechanical switching systems. Functions can be continued by the basic services in the event of computer failure. The problems in adapting larger machines for direct control of switching operations are discussed. These include the need for computers to maintain continuous service in the presence of malfunctions and to be capable of executing a large number of programs simultaneously. It appears that the optimum marriage between telecommunication and computer systems will follow by adopting principles and structures applicable to both systems. Integrated switching and transmission networks are to be introduced and advanced computer system organisations resemble the control areas found in conventional telecommunication systems.

1. Introduction

Most people will have experienced the situation of having an existing process turned into a form where it can be handled by an electronic data processing installation. The usual outcome is that the basic process itself becomes transformed, far more than one would imagine to be necessary from the standpoint of computerising an existing operation. Telecommunications has proved to follow the same kind of principle, and although there are examples of existing telecommunications systems being driven by conventional types of computer, it is quite clear that the best results are only going to be obtained where the use of computers in association with telecommunications has been borne in mind right from the outset, and indeed where the telecommunications application of the computer itself has been taken into account in its design.

Early in 1957, a group of people at the Whippany laboratories of Bell Labs in the United States made the first disclosures of a system, subsequently to be put on field trial at Morris in Illinois, and which first introduced the concept which has since been universally recognised, known as stored program control. Since that time, just over 16 years ago, progress has been rapid, and there is now hardly a telecommunications manufacturing company in the world which does not have in manufacture or in the late stages of development a stored program control system of one kind or another, and most of the larger administrations have at least trial installations if not large scale use of SPC equipment.

2. Review of Computer — Communication Interactions

The role of the computer is however far wider than just its application to stored program control telecommunications switching systems, and I would like to review some of the many ways in which computers and communications are interacting.

The first, and possibly still the most significant, is the use of one kind or another of computer for the direct control of telecommunications systems, usually in the switching sense. The second is the use of computers, again of varying kinds, to add new features or facilities to existing telecommunications systems, commonly electromechanical. The third is the use of technology closely related to that developed for computers in telecommunications applications, and the fourth, conversely, is the use of telecommunications type technology in computer systems. Of these applications, possibly the most widely known is the first, the provision of so-called stored program control.

2.1 Use of Computers for Stored Program Control

It is perhaps worth recalling that the first telecommunications switching system, the manual operator (see Fig. 1), really pointed the way towards stored program control, and by comparison with a human operator, a conventional electromechanical switch-

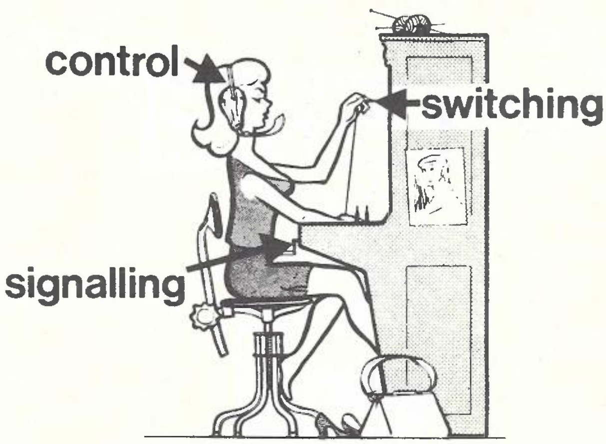


Fig. 1—Organisation by Function — 1

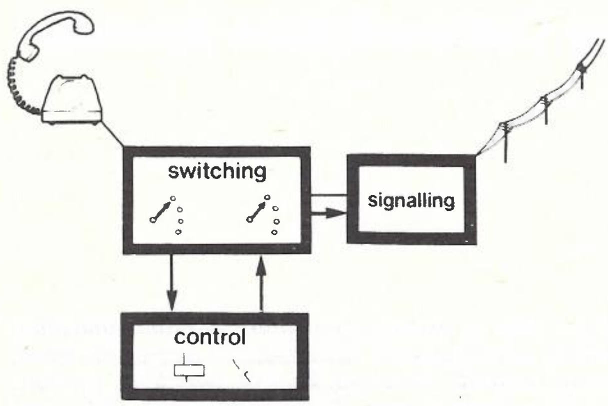


Fig. 2—Organisation by Function — 2

ing system is a very rudimentary object. The first attribute of the human operator is the ability to react in a widely different set of ways, depending on the information which is fed in. Not only can the operator connect you to the appropriate number if you ask for the number, but most operators can connect you to the right line if you ask for the person who should be found on that line, and some operators have even been known to connect you to the appropriate but apparently wrong line because they know the person you want is in fact away from home and on the line to which you are being connected. The second thing we need to note about the human operator situation is the functional separation into switching, control and signalling, allowing the use of different technologies in one and the same systems organisation. As I hope to show you, we do not begin to return to this kind of flexibility until we get into the very latest kinds of stored program control systems.

A conventional electromechanical switching system can be represented in the same way (see Fig. 2), with a separation between switching signalling and control but at least in step-by-step systems, the switching, control and signalling are pretty closely interlinked and not so easily separated functionally. Nevertheless, at least in theory it is possible to take such a system, remove the existing electromechanical control, and replace it by a computer (see Fig. 3). However, as anybody who has received a bill for 99,999 dollars and 99 cents will readily understand this is not necessarily the best way of organising a computer controlled switching system, since computers are fairly delicate animals not capable of indefinitely long periods of fault-free running. The situation is much better, from the standpoint of system reliability, if two computers are provided, so that one can be carrying the traffic while the other one is being attended to (see Fig. 4), but except for the larger system, this straight duplication with a working and standby machine is apt to be expensive.

What we require is a kind of computer, subsequently to be referred to as a processor, which is specialised in the real-time control of telecommunications switching systems (see Fig. 5). As we shall see later, this machine has a number of attributes not commonly found, nor even required in conventional data processing applications. Assuming such a machine can be devised, we then have a situation in which we can identify a number of benefits and indeed a number of problems arising from its use.

Control of the telecommunications system by such a processor certainly provides great flexibility in use and considerable ease in altering the facilities, features and other performance attributes of the system. The problem areas include, even in the face of specialist organisation of the processor, the question of reliability and ability to give continuous service, and that of economy both in operation and in use. I personally believe that techniques and technologies are now available as a result of which it is possible to offer a satisfactory and economic solution to the stored program control requirement, and I shall be returning to this topic in due course.

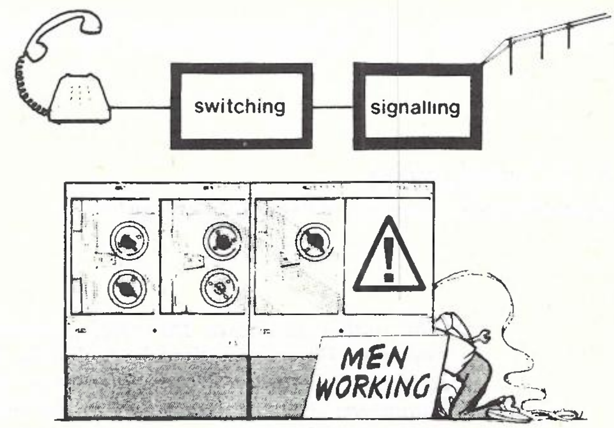


Fig. 4—Control by working/standby computers

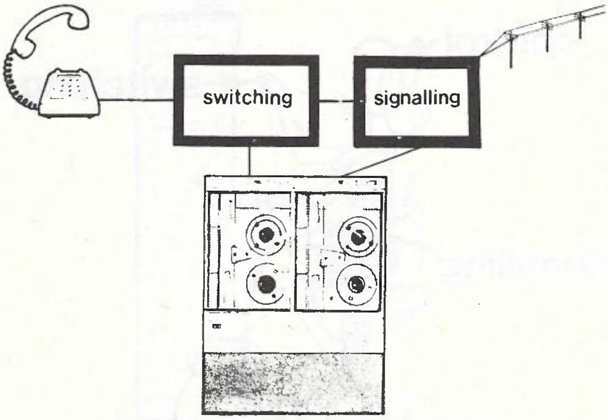


Fig. 3—Control by single computer

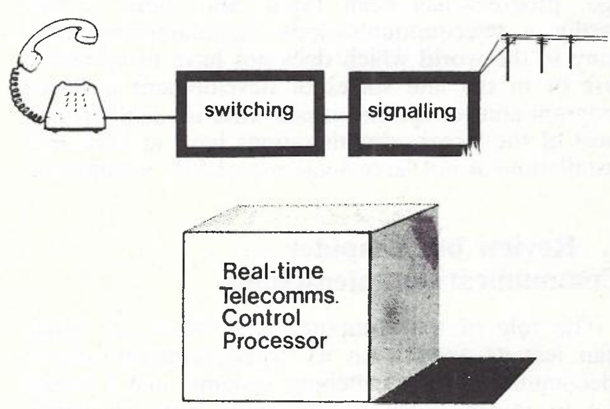


Fig. 5—Control by specialist machine

At such time as this system (with all the desirable attributes and none of the problems) becomes available, there will still be a very large number of existing exchanges of conventional electromechanical form which are not able to give new services and new features, whether of interest to telephone users or the administration, and these existing systems will in the ordinary way, be expected to remain in service for the rest of their useful life, anything between 20 and 40 years.

2.2 Use of Computers as Applique Processors

One way of providing new services in this sense is that in which a processor, not necessarily a telecommunications specialist processor, is added as an appliqué to an existing telephone exchange in such a way that the processor is effectively addressed when the subscriber dials a particular digit (see Fig. 6). Subsequent dialling information from the subscriber goes into the appliqué processor, which then takes the necessary action. Examples of services which can be provided in this way include short-code dialling, call diversion, and an alarm or wake-up call. The use of these services is obvious, and in particular call diversion, whereby a subscriber dials a code which arranges for incoming calls to be diverted to a designated alternative number, and which is available in England on the TXE2 electronic exchange, is already finding a great deal of application.

The previous arrangement was one in which supplementary services were required, not necessarily applying to all services or all subscribers. Where all calls need new facilities, for example the first introduction of subscriber trunk dialling into an existing network, the principle remains the same, that of adding a processor to an existing system. In this case the processor is added at the beginning of the switching train, and by analogy with computing terminology, it has become known as a front-end processor. Applications for this method are widespread in the sense of using register translators to extend the dialling range and switching capability on existing offices, for uses such as long distance dialling and international dialling.

Perhaps the most significant use of add-on processors is however in the sense of the services which are becoming known as network management. Fig. 7 shows some aspects of the way in which this kind of arrangement can be made. It consists of having a data processing centre, linked by data circuits to a number of telephone exchanges within a particular telecommunications geographical district. The ordinary speech circuits are shown linking the telephone exchanges directly. In operation, the data processing centre is connected over its data links to the information reporting channels in the telephone exchanges, no matter what technology these exchanges employ. All modern systems, whether crossbar or electronic, usually have some kind of fault analysis and maintenance aids built in, and in the organisation shown in the diagram, these are effectively extended, by way of suitable interfaces, to the remote data processing centre. For the application shown this can literally be a data processing centre, since it is not directly concerned with the control of the telecommunications switching aspects of the area shown. The telephone exchanges themselves, of whatever form they may happen to be, still continue to perform as normal telecommunications switching systems. As shown in Fig. 7 the information which flows to and from the data processing centre relates to compilation of telephone traffic statistics, compilation of information relating to the billing of telephone call charges, the analysis of faults existing in the network and a variety of other maintenance aids.

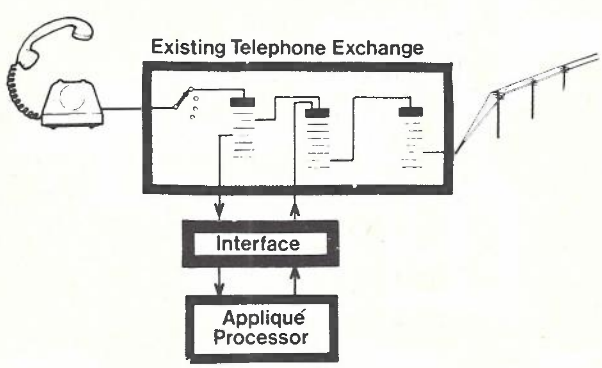


Fig. 6—Applique processor for additional services

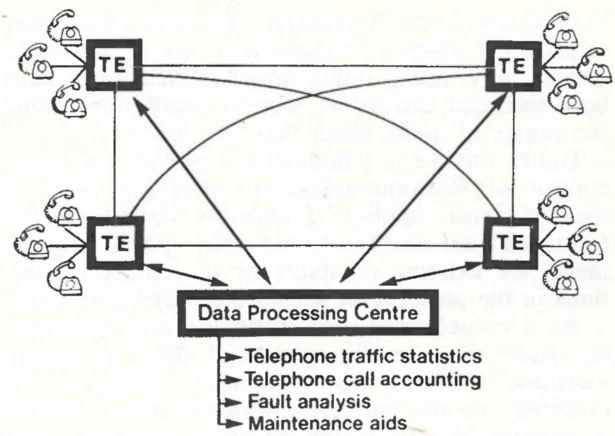


Fig. 7—Centralised network management

The use of electronic data processing methods for the first two applications is self-evident, but it is not quite so obvious in respect of the last two.

If all the exchanges concerned were of the same type, such as crossbar, it might be sufficient to extend the local fault indication and analysis equipment to a remote centre and display it in the same form as it is in the maintenance centre in the local exchanges currently in use. However, a very distinct possibility exists that the exchanges will be of different types, and possibly employing different technology, and therefore an electronic data processing machine or computer with its ability to be loaded with a variety of different programs while still using the same hardware, gives a much better chance of analysing the faults and maintenance requirements of a variety of telephone exchanges than does a more conventional approach of merely extending the alarm and other indication circuits to a remote centre. In the same way, the maintenance aids can include the ability for the data processing centre to interrogate the peripheral telephone exchanges, to ascertain which of the common control units is in service, how many faults or incomplete calls have been recorded and so on, thereby greatly facilitating the repair of faults when they are found.

Unlike the use of computers to provide the direct control of telecommunications switching plant in the SPC sense, appliqué processors for most of the tasks need not necessarily have any special requirements for extreme reliability or the ability to continue in the presence of software or hardware faults.

As a consequence, use could for most purposes be made of a small commercial data processing machine, provided the relationship between this machine and the basic telecommunications systems is such that during periods when the machine is not available basic telecommunications service continues to be given by the existing individual exchanges.

There are already a number of field trials of systems of this nature, particularly concentrating on the centralisation of fault analysis and maintenance, but one which has been built in tc a new system is that found in the E10 system, whose adoption was recently announced by the PTT in France. In this system, which makes use of both analogue and digital switching, a remote information processing centre is provided which carries out the functions and in addition serves to provide updating and program changing facilities for the individual telephone exchanges, so that these can be operated entirely unattended. In spite of this, the information processing centre uses a commercial data processing machine, without any provision for alternate or standby operation, on the basis that if this machine is faulty, at least basic telephone service is available from the remaining equipment, and only a few supplementary services for subscribers will be affected. It is of course true that during any breakdown period in the information processing centre there are no statistics available on the maintenance aspects of operation of the entire network, but as the information processing centre is the only one which is staffed continuously, it is in the best position to get quick repairs done.

2.3 Influence of Computer Technology on Communications Systems

So far we have been talking about the use of computers to control or supplement the working of telecommunications networks. At least as important in this sense is the use of computer technology in the modernisation of telecommunications operations, in the sense that electronic data processing has always paid a great deal of attention to modern technology — in fact some of its critics would say it is obsessed with technology — whereas telecommunications, in terms of technology employed in computing, is something between old-fashioned and out of date.

One particular way in which computer-like technology has been injected into telecommunications systems, and of which notable examples exist here in Australia, is the move towards handling all information in digital form. It is now becoming commonplace to sample and encode speech signals into the form which has become known as pulse code modulation, and although there have been a number of different ways of tackling the problem, there is now a substantial measure of international standardisation on the way in which to implement the sampling and coding processes. The effect of all these processes is to express the analogue waveform, in which speech has hitherto been handled, by a series of binary pulses, grouped in such a way that a particular train corresponding to a particular speech channel, contains information from which the instantaneous amplitude at the sampling times can be recreated, thereby enabling the original speech waveform to be recovered with a fidelity entirely adequate for telephone traffic.

In Europe systems employing pulse code modulation have been installed primarily for point-to-point links between exchanges which employ analogue switching, that is to say the PCM use is confined only to the links between exchanges. There are however a number of installations in Europe, and a very significant one here in Australia, of networks in which the speech once encoded into digital form remains in digital form throughout the entire process of transmission to remote centres, including transit switching, local switching and subsequent recovery of the speech envelope for local line transmission to the subscriber concerned.

The combination of this system of handling all information in digital form, together with overall control of local switching in the complete network by computers, gives rise to a system of very great flexibility and enormous potential for future network development.

Fig. 8 shows the way in which PCM channels are proposed to be stacked so as to produce high capacity digital systems. It relates to the current UK proposals, and although it is primarily concerned with transmission the impact on switching is obvious. Indeed, the British Post Office network planning department has concluded that all future long distance high-capacity transmission, and switching related to it, that is to say in the larger trunk transit centres, should be entirely in terms of high order PCM channelling along the lines shown in this chart, and negotiations are currently in hand with regard to the way in which the digital transit switching exchange can best be implemented. In addition to the speech transmission up to the extent of 1680 channels shown in the chart, it is also possible to replace blocks of channels by digital data traffic at various bit rates. A single PCM speech channel provides the equivalent of 64,000 bits per second,

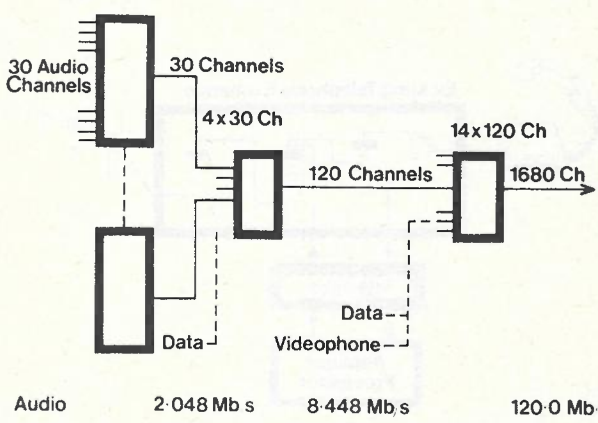


Fig. 8—Proposed PCM higher order multiplexors

and a group of 30 channels provides the equivalent, including the signalling and control bits, of 2.048 megabits per second. Four such groups are combined in a higher order multiplex to produce an output stream, including other control and synchronising elements, at 8.448 megabits per second, and this is a convenient frequency for digitally encoded closed circuit television or videophone service. A larger number of such channels can then be combined to produce the ultimate line signal at 120 megabits per second, or 1680 audio channels. Development work is in hand to extend this to still higher orders and higher channel capacities.

2.4 Influence of Communication Technology on Computers

So far I have been discussing the impact of various kinds of computer in communications systems. I would now like to consider the reverse process, namely the way in which communications is influencing computers. The first and most obvious impact of communications on computing was in the setting up of the so-called time sharing networks, in which a large number of individual users can all be given access to a central high power computing machine on a dial-up basis from remote locations. The user has some kind of keyboard and printing machine such as a teleprinter, a modem to turn the teleprinter signals into a form suitable for transmission over a basically speech network, and at the remote end a similar modem turns the signals back into a form suitable for connexion to the computer. This principle has now been extended using high capacity links, to remote job entry, in which quite massive quantities of data are loaded, using a telecommunications link of appropriate capacity, into a remote computer and the resulting output is returned and reproduced on high speed printers.

There is however another and more significant way in which communications is influencing computing. Earlier in discussing stored program control the need emerged for a telecommunications oriented processor for the control duties. If we examine the way in which a conventional, perhaps electromechanical control system carries out its functions in a telephone exchange, it is clear that it has some important points of difference in its organisation, quite apart from the aspects of pure technology, from the organisation of an electronic data processing system. The EDP system must not make mistakes, and if it shows any tendency in that direction the data processing activity must instantly be stopped until the machine can be checked or repaired. The telecommunications switching or transmission plant on the other hand can make the occasional error, but must never totally deny service to users. In the presence of faults, it may possibly take longer for calls to be set up, but the possibility must still exist that calls can be set up.

This situation is arrived at in the telecommunications sense by organising the control as a series of blocks, each of which carries out a certain proportion of the call processing load, and as many sections and replicates within sections are provided as is needed to carry the telecommunications traffic, usually with a small margin. This means in effect that if one or more sections or replicates are out of action, the worst that will happen is some delay in call processing, provided the relationships between the replicates is such that if one is faulty it does not disable all the rest of the same kind.

This gives us a clue as to how we can organise a processor structure suitable for the control of telecommunications networks. First of all, it must be divided in terms of traffic rather than functions, so that in the event of partial failure the call processing capacity is reduced, rather than totally eliminated in respect of certain functions. Secondly, there must be protection such that in the presence of faults the remaining fault free equipment can continue to give satisfactory call processing service within its traffic capacity, without being corrupted or interrupted by the faulty apparatus.

Fig. 9 shows the methods of organising a control processor complex which meets the requirements of traffic sharing. It consists of as many blocks of processing equipment or central processing units (CPU) as are required to handle the total traffic to be processed. In addition, it contains as many blocks of memory as are needed in total to handle the data and programs needed to carry out the processing manipulations. Each processor effectively controls a busbar, and by way of store access units the stores can be connected to any of the processor busbars. The signals on the busbars are also taken to multiplexors. So far, what we have achieved by this arrangement is the situation in which the combined processor power is available on the effective sum of the busbars, that is to say via the multiplexors. The remaining requirement is to ensure that any piece of equipment, whether hardware or software, which is faulty cannot corrupt or interfere with processing by the items which are in good working order.

For this, we make use of the concept which has become known as a capability. A capability defines the area, that is to say the address or location of a piece of information, and it also defines the type of access which can be had to it. For example, a capability can be used to define the base and limit addresses of a memory block, together with the class of access which is permitted, which in this case could be read-only or read and write. Other capabilities can define other blocks and other classes of access, including the ability to execute programs.

Items of information within programming and other operations all carry with them a capability. The capability is expressed in the form of base, limit and type of access, and acts as a sort of lock and key system with which to provide a high level of protection for information. If for example an

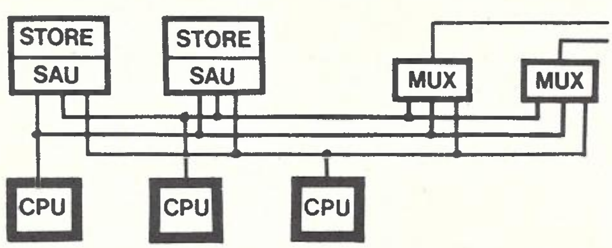


Fig. 9—Structure of secure modular System 250 control

address is generated by a program step which is outside the normal permitted access for the program concerned, it is extremely improbable that other malfunctioning will generate the appropriate matching capability, and as a result the simple hardware check of matching the address and the capability will establish that there is an error and interrupt the processing before data or other information in the memory area concerned can be corrupted.

Capabilities used in this way then provide protection between working and faulty items, whether hardware or software, and provide this protection both in normal use of the machine and during periods where the machine is having program changes or maintenance operations carried out, so that even deliberate misuse cannot cause the system to go off the air, short of a complete loss of a substantial part of the hardware.

The system of capability protection extends throughout our processor structure, and enables a modular approach to be adopted in the software, so there cannot be interference between individual elements of the software in any way which would destroy the system. The system organisation that arises from this then enables an exact correspondence between hardware elements and software elements to be preserved through the system. For each identifiable item of hardware, there is a corresponding segment of program with boundaries and relationships between the hardware items and the corresponding software items all being defined in terms of capabilities, thereby greatly simplifying not only the use and maintenance of the system, but also the basic aspect of program preparation.

3. Conclusion

It now seems clear that there is a way ahead for substantial introduction of computer based technology into telecommunications and telecommunications systems organisation into computing. The success in Australia and in other countries of trials of integrated switching and transmission systems have demonstrated the validity of the concepts of digital handling of all information, and I believe that our work on real-time multi-processing control systems is showing an equally realistic way towards genuinely telecommunications oriented computer control systems.

4. Acknowledgements

I would like to acknowledge the support of many of my colleagues in providing information on which this paper is based and to the Directors of Plessey for permission to present it.

Biography

JOHN R. POLLARD was born in Leicester, England in 1921. He was educated at Kings College, Cambridge and took a First Degree in Physics in 1942. During the war years he was with the de Havilland Company working in the field of vibration analysis and flight instrumentation. In 1947 he joined Ericsson Telephones Limited to set up laboratories for the development of electronic telecommunications systems and became head of research of that Company at a time when it was collaborating with the British Post Office and other British companies in the development of the first Time Division Multiplex system to be installed in public service (in the summer of 1959). Since the merger of Ericsson Telephones Limited into the Plessey Company in 1961 he has held various appoinments within Plessey and is currently based at their Nottingham site as Systems Planning Executive for the Telecommunications Group.

He is a Member of I.E.E.E., and for some years served on the Electronics Divisional Board of the Institution of Electrical Engineers in London and recently became Chairman of this Division of the IEE, taking office in October 1973

Telecommunications Trends in Japan

M. YAMAUCHI
Director, Yokosuka Electrical Communication Laboratory, and Deputy Director-General of Research and Development, Nippon Telegraph and Telephone Public Corporation

With the land distribution and the concentration of population and industry in urban districts found in Japan, one of the keystones in improving the organization of the country and reducing many of the inconveniences of modern society is in the development and realization of telecommunication facilities. To this end, digital telecommunication systems with a very large capacity and varied communication services such as visual communication, document communication and so on become necessary. Furthermore, their connection to computers will allow a more sophisticated system. As this sophistication increases so does the impact on our lives from any failure in the system. This fact necessitates an increased reliability in the network configuration — especially in a country like Japan subject to many natural disasters. In this paper a perspective into future telecommunication systems will be attempted from the research and development programs of telecommunication technology currently underway.

1. Problems Confronting Japan

Geographically, Japan occupies only about one four hundredth of the total land area of the earth and two thirds of this is mountainous. On the other hand, it accounts for a thirty-fifth of the world population, consumes a twentieth of the world energy and, in terms of Gross National Product, ranks third in the world.

Fig. 1 shows population, energy consumption, Gross National Product and some other social indicators per unit of habitable land of several countries. Habitable land implies that it does not include areas such as mountains, deserts, forests, lakes, marshes etc. The values in the diagram are normalized by the US value as one hundred. The diagram shows how high the density of Japan's economic activity is.

This great growth of Japan's economic activity is achieved mainly by the diligent efforts of the people. But, unfortunately it has resulted in air, water and other types of pollution as well as traffic, housing and other urban problems. These problems are typically conspicuous in Japan now, but will eventually prove to be major problems in many countries in the world in the future.

Concentration of people in the already overcrowded cities and busy movements of multitudes of travellers are most often prompted by their efforts at acquiring information in its broadest sense, including education and amusement. This has caused overcrowding, traffic jams and wasteful consumption of energy. To solve these problems, it is necessary to develop technical means by which needed information can be obtained immediately from anywhere. More specifically, it is essential to achieve progress in the following telecommunication technologies:

(i) Construction of a super high capacity transmission network throughout the country to allow greater flow of information.
(ii) Various types of terminals that enable individuals and enterprises access to information freely from anywhere.
(iii) Closer linkage between computers and a telecommunication network to allow accurate and speedy processing of information.
(iv) Construction of a reliable, stable, economical telecommunication network by incorporating the three means mentioned above.

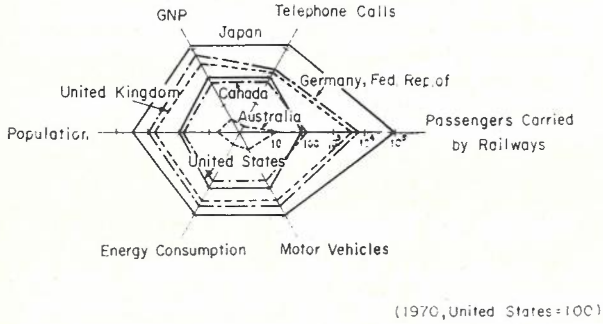


Fig. 1—Social activities per unit of habitable land

2. Trends in Super High Capacity Transmission Systems

Research on high capacity transmission systems has been carried out for a long time in our country. Fig. 2 shows the development of different high capacity transmission systems and how an increase in capacity contributes to a reduction in the cost per channel. Solid lines in the graph show those systems already put into commercial use.

In the area of FDM technology, the 12 MHz coaxial system and 5 GHz microwave system, both with a system capacity of 2,700 channels, are used in the basic trunk network. The 60 MHz coaxial system with a capacity of 10,800 channels was put into service in the spring of 1973 connecting Tachikawa and Ikebukuro, a suburban area of Tokyo. Furthermore, a 200 MHz coaxial system is also under investigation.

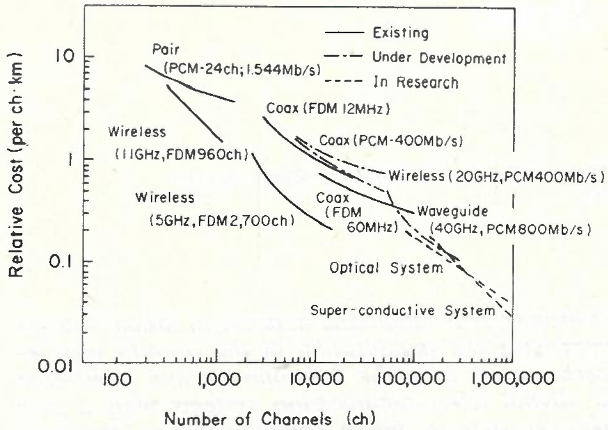


Fig. 2—Transmission lines and their relative costs

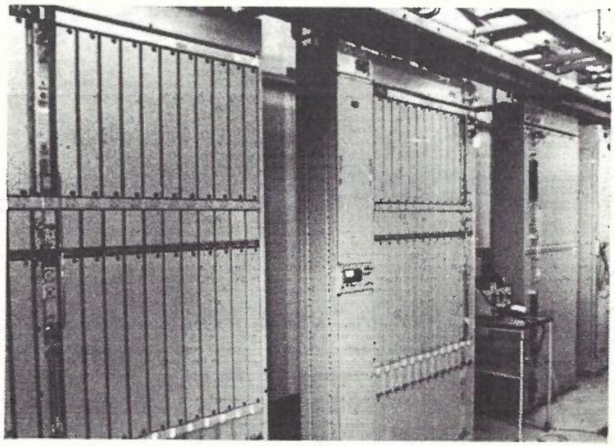


Fig. 4—Repeater station of a guided millimeter wave system

In the PCM technology area, a coaxial system with a system capacity of 5,760 channels is under development. The quasi-millimeter wave radio system and the guided millimeter wave system are both undergoing field tests now.

Fig. 3 shows a repeater station of the quasi-millimeter wave radio system. Using repeater stations like this, a transmission line was constructed between Yokosuka Laboratory and the Musashino Laboratory, about 60 km apart. This system has been under field test since April, 1973. This 400 Mb/s system occupies from 17.7 GHz to 21.2 GHz and has a system capacity of 5,760 channels. Total route capacity of this system is about 40,000 channels under a protection ratio of 7 to 1, that is seven normal systems and one emergency system per route. It uses a radome covered Cassegrain antenna, 1.8 meters in diameter, which is capable of both transmission and reception.

A guided millimeter wave system has been undergoing field tests since December 1972 with an experimental circular wave guide about 23 km long connecting the Ibaraki Laboratory and the Mito Telephone Office, located about 100 km northeast of Tokyo. Fig. 4 shows the inside of a repeater station for the system. This 40 to 80 GHz system is able to carry about 300,000 telephone channels or 2,500 1 MHz video telephone channels. Its repeater station span is about 20 km.

Fig. 3—Repeater station of a quasi-millimeter wave radio system

Systems using a still higher frequency band, such as optical transmission systems and superconductive coaxial systems are being developed at our laboratories. These future super high capacity transmission systems will all utilize digital technology because of the characteristics of transmission media, the flexibility requirements of repeatered lines for transmitted information and the advances in electronic devices. This trend will not be limited to trunk lines, but will gradually make its way to subscriber lines.

Japan is surrounded by the sea and its major cities all face the sea. Construction work on the densely populated land area is getting more and more difficult. A broad band submarine coaxial system is being studied for these reasons. In 1971, a 36 MHz shallow water submarine system with a system capacity of 2,700 x 4 kHz speech channels was put into service between Kure City and Matsuyama City on the Inland Sea. This is being improved to increase its capacity and to allow usage in the deeper sea. The troubles with submarine systems almost always occur at a point close to the seashore. To eliminate such troubles, an off-shore floating microwave station is being investigated where a submarine cable is terminated and signals are transmitted the rest of the way to the land through a microwave system.

Fig. 5 shows an offshore floating microwave station placed near Oshima Island, about 100 km south of Tokyo. This floating repeater station stands 35 m high above the sea and extends about 100 m deep under the sea. It weighs about 1,600 tons. Four antennas (having diameters about 2.4 m), transmission equipment and batteries are housed in the chamber at the top. A built-in power generator is in the underwater chamber. The station is moored to the bottom of the sea.

Our future transmission network will be constructed by combining these new systems.

3. Variety of Terminals

The telephone set has been most widely used in telecommunication and will continue to play an essential part in it. It will be further improved for easier handling and better quality.

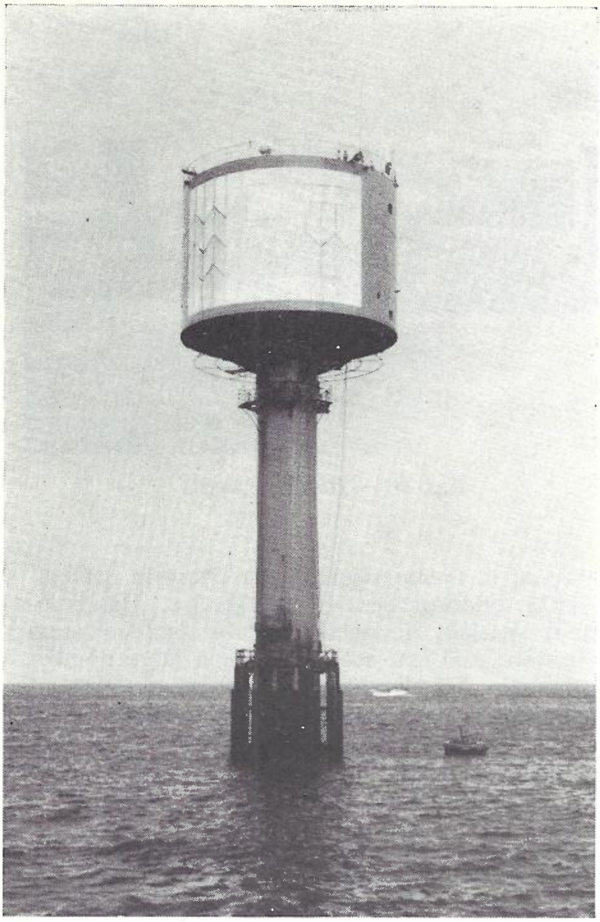


Fig. 5—Offshore floating microwave station

Fig. 6 shows a mini pushbutton telephone set soon to be commercially available in our country. It makes full use of IC technology and uses the same type of electromagnetic transducer for both the transmitter and receiver. It features such extra functions as a tone ringer and automatic equalization.

However our next research targets will be centered around visual communication. Currently being developed are video telephones and still picture terminals for video communication, facsimile sets, various subscriber printers and typewriter units for communication requiring hard copies. Fig. 7 shows a video telephone and a facsimile set. Though hard to see clearly, the video telephone in the photograph is displaying Chinese characters. These character signals are transmitted from a computer installed at a telephone exchange. In this way, these terminals will be widely used for communication, not only between customers but between a customer and a computer.

Fig. 7—Video telephone and facsimile set

In the mobile communication area, efforts are currently being made in the development of an automatic automobile telephone system featuring high capacity and a wide service area. This fully automatic system adopts small radio zones and uses about 850 channels in the 800 MHz band. Therefore, the system will be able to serve up to one million customers in our country. The technology acquired will lead to a small telephone set for use by individuals.

Fig. 8 shows a portable telephone set exhibited at the EXPO '70 held in Osaka three years ago. At that time the set was usable only within a pavilion. Eventually, a portable telephone set like the one in the photograph will be carried by travellers, permitting them to make a phone call from anywhere in the country.

Fig. 6—Mini-pushbutton telephone set

Fig. 8—Portable telephone set

4. Connection of Computers to Telecommunication Networks

We will use the term *Data Communication System* as the one which includes both data processing and data transmission. A few hundred data communication systems are now in use in Japan utilizing leased lines, including various banking systems and seat reservation systems. Among them, the Nationwide Banking System is typical in its extensive use of the communication network all over the country (see Fig. 9). This is an on-line message switching system which mainly carries out settlements of the inter-bank domestic exchange transactions among 88 independent banks. Each bank has its own in-house banking system which processes internal transactions. Any branch office with an in-house system can transact business with any office of the other banks, through the Nationwide Banking System. Serving as many as 6,800 branch offices, the system is contributing greatly to rapid and economical processing of transactions.

On the other hand, the telephone network is used to serve *Scientific and Engineering Calculation System* (nicknamed DEMOS), *Sales and Inventory Management System* (nicknamed DRESS), and *Calculation-by-Telephone System* (nicknamed DIALS). DIALS enables customers to use the push-button telephone set as if it were a desk-top calculator.

In cooperation with the national government, Nippon Telegraph and Telephone Public Corporation is promoting the development of what are called National Projects which directly promote social welfare, utilizing computer and communication technologies. Development of the Emergency Medical Information System is one of these projects. This system automatically collects and updates information concerning vacant beds, available doctors, location of serums etc. The information is accessible quickly from hospitals, clinics, ambulance dispatching centres and other medical institutions. Thus, the system will improve the security of life through assisting emergency medical care activities and furnishing medical information to citizens as well as doctors.

A large capacity computer system, called DIPS-1, has been developed by NTT for such applications (see Fig. 10). The DIPS-1 is under field test in the Shiba Telephone Office in Tokyo and is scheduled to proceed to the commercial test phase in September 1973, offering the DEMOS service. This computer is specially designed for data communication applications and can accommodate a large number of terminals. Development of a series of DIPS-11 systems which aims at a better cost to performance ratio by incorporating advanced technologies, such as large scale integrated circuits for their central processors and main memories, will be completed in 1975 and 1976.

Fig. 10—DIPS-I system

Since data communication essentially deals with digital codes, it is obviously advantageous to use a digital network for data communication. Therefore, a digital data switching network is being developed. Fig. 11 shows an experimental data switching system, DDX-1, installed in the Musashino Laboratory.

This switching system provides both circuit switching and packet switching functions and is controlled by the same central processor as is used in the electronic switching system for telephones. Various data communication terminals, either synchronous or asynchronous, with transmission speeds from 50 b/s to 48 kb/s, and high speed facsimile sets of 96 kb/s can be connected to the switching system. All terminals are concentrated by the remote line concentrators before going into the switching system. The base band transmission technology is employed for connection between a subscriber ter-

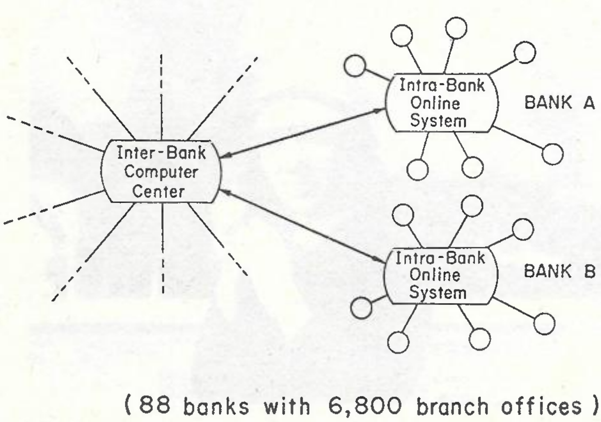


Fig. 9—Nationwide banking system configuration

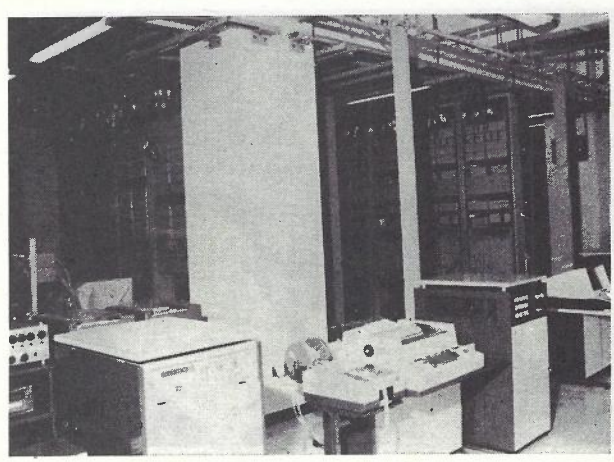


Fig. 11—DDX-1 System

minal and a line concentrator. The 1.544 Mb/s transmission lines, that is our standard PCM 24 channel transmission systems, are utilized for the connections among switching systems and line concentrators. The transmission line is connected to the time division speech path of the switching system with the help of synchronization equipment. The switching system also has new service functions, such as multi-address call, and speed conversion for terminals of different speeds. The objective for connection delay between customers is less than one second. Combined together, computers and telecommunication will not only offer better services to customers but will also interact on each other to induce technological progress.

TYPE	NO. OF LINES	APPLICABLE SWITCHING SYSTEMS
D-10	4,000-40,000	LS, TS, TLS, CES
DEX-A11	1,000-16,000	LS, TS, TLS
DEX-R1	4,000-16,000	LS, TLS (Remote Control)
DEX-R3	250- 4,000	CES (Remote Control)
DDX-1	- 8,000	Data Switching System

LS: Local Switch, TS: Toll Switch

TLS: Toll and Local Switch, CES: Centrex

Table 1—Electronic switching systems in Japan

5. Formation of a Total Communications Network

Future telecommunication will provide data communication, video communication and mobile communication along with the conventional telephone service. It is considered desirable in our country to form a flexible, total communications network, rather than letting each service form its own individual network.

Fig. 12 is a schematic diagram of a total communications network. It is expected that the various transmission lines, computers and terminals will be coordinated by program controlled electronic switching systems. The electronic switching systems in our country are shown in Table 1.

The electronic switching system designed for large exchanges, called D-10, is now in commercial service at eight exchanges, and a further eleven exchanges are under installation. The small to medium system, DEX-A11, and remote control systems, DEX R1 and R3, are undergoing field tests. Furthermore, research efforts on a new, larger central processor of the electronic switching system, which employs advanced large scale integration technology, are being pushed to meet the future demands. Though the present electronic switching system is composed of space division switches, in view of the development trend in transmission systems, digital time division switching will become dominant in the future.

Once trouble occurs in a huge telecommunication network like that shown in Fig. 12, its influence on

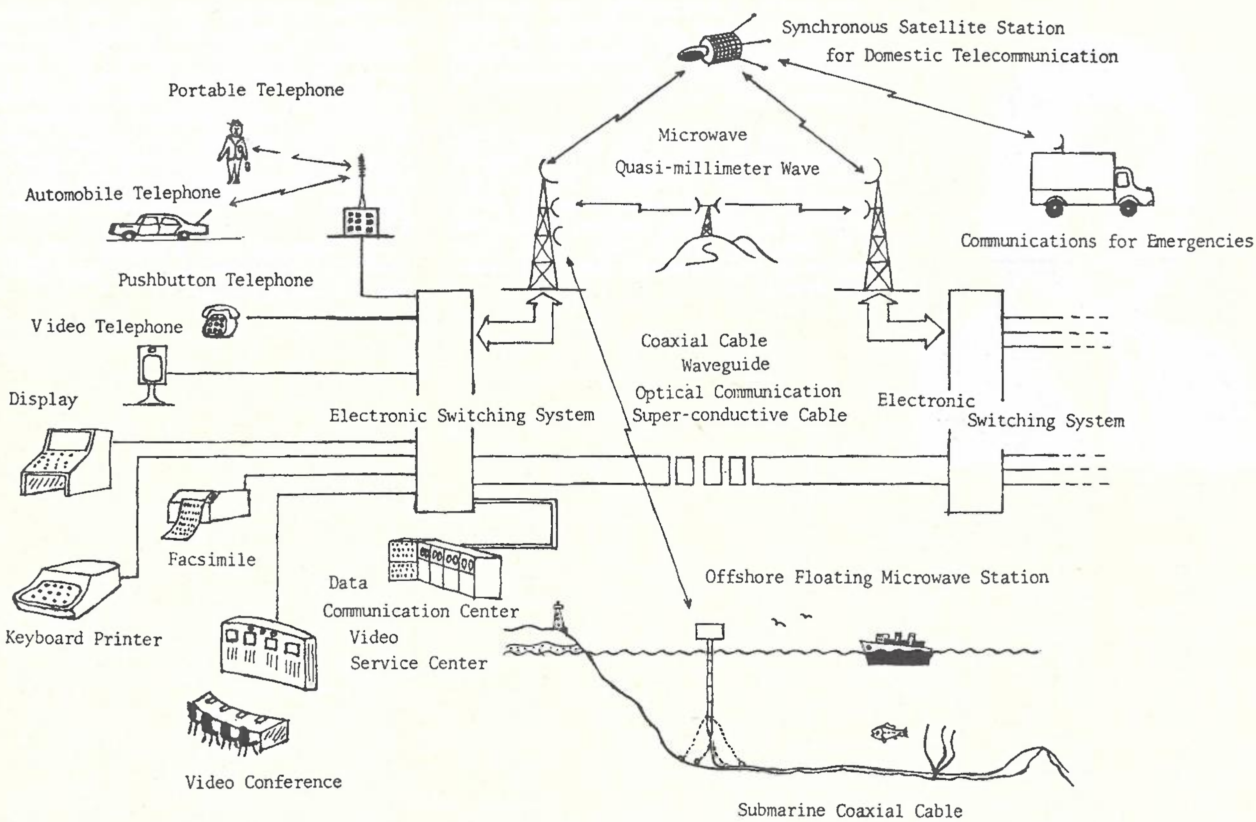


Fig. 12—Total communications network

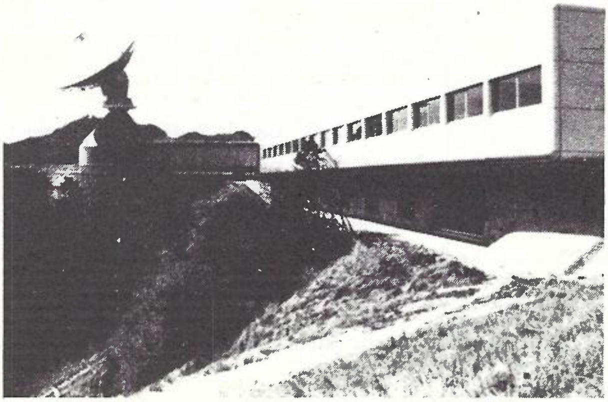


Fig. 13—Ground station for satellite communication

social activities will be very profound. Since Japan is subject to numerous natural disasters, such as earthquakes and typhoons, various measures are taken against them. Individual equipment and office buildings are designed to meet safety objectives. Network reliability is enhanced by the parallel installation of wired and wireless transmission systems, alternate routing and dispersion of main regional center functions. Furthermore, a domestic satellite communication system with portable ground stations is being studied for emergency use in the event of a natural disaster.

Fig. 13 shows an experimental ground station for satellite communication at the Yokosuka Laboratory. In preparation against natural disasters, we plan to use a synchronous satellite that weighs about 300 kgm and handles 4,000 channels in the quasi-millimeter wave band or in the microwave band. In the latter half of the 1970's, several fixed and portable ground stations will be available to restore important traffic in affected areas in case of emergency.

Network reliability will also be improved by an automatic network control using common channel interoffice signalling. It is hoped that this latter technology will lead to a flexible routing system, which is independent of exchange hierarchy and utilizes conjugate selection of interexchange links. This will result not only in improved reliability, but also in cost reduction of the network. The future telecommunication network described so far can be made possible only after a considerable number of electronic switching systems are introduced.

6. Concluding Remarks

Social demands and advancements in new technologies are prompting all the advanced countries in the world to enter an era of information renovation.

Our wisdom and creativity must be united internationally to employ our telecommunication technology to overcome negative effects that may stem from the renovation and to achieve true happiness of mankind. We deeply respect the efforts of the Australian Post Office for their sponsoring of this significant international symposium.

Biography

MASAYA YAMAUCHI was born in Hokkaido, Japan, on November 15, 1922. He received the B.E. degree in electrical engineering from the University of Tokyo, Japan, in 1945.

In 1945, he joined the Post and Telecommunication Ministry, now Nippon Telegraph and Telephone Public Corporation, where he worked on the development of switching systems, such as the toll charging system, the trailer type exchange, and especially the C400 crossbar system.

From 1968 to 1972, he was mainly engaged in leading the development of electronic switching systems, D10 and so on, as Director of Switching System Development Division, the Musashino Electrical Communication Laboratory, NTT. He is presently Director of Yokosuka Electrical Communication Laboratory and Deputy Director-General of the Research and Development Bureau, NTT.

Mr. Yamauchi is a member of the Institute of Electronics and Communication Engineers of Japan.

Future Developments in Sound and Vision and Broadcasting in Australia

E. J. WILKINSON
Director, Technical Services, Australian Broadcasting Control Board

This paper discusses future developments in sound and vision broadcasting. The future can be assessed to some degree by the technical advances made in recent years and a knowledge of experimental work currently underway. It is more difficult, however, to assess the degree of acceptance of new broadcasting systems by the broadcasters and general public. New systems have to be either attractive enough to warrant replacement of existing public-owned receiving equipment or they must be phased-in as old equipment is replaced. There is also the difficulty of large investment by industry and government in existing broadcasting plant. Despite these problems the technological developments still likely to find wide acceptance are discussed. These include high fidelity sound transmissions using frequency modulation, the possible changes in existing amplitude modulated services once FM services are introduced, and the developments which may occur in television services after colour transmissions are established, particularly the multiplexing of information read out services within the television signals.

1. Differences between the Telecommunication and Broadcasting Philosophies

In speaking on future developments in Telecommunications it seems desirable to begin by stressing some of the differences in the circumstances of broadcasting planning when compared with the general telecommunication planning criteria.

At the beginning, let me also clarify one point on terminology and indicate the course I propose to follow during this presentation. By broadcasting I mean both sound and vision broadcasting — "broadcasting" is used as the generic word.

Regarding the course to be followed — the ensuing presentation will discuss future developments in broadcasting systems rather than the developments in equipment. Naturally, the possibilities of changes in systems cannot be referred to without accepting the availability of new hardware. Let me stress, however, that the position which broadcasting planners face is in choosing which (if any) of the exciting developments in broadcasting equipment should find applications in the future systems.

Not only are there many attractive equipment developments of recent years which have not found application in the Australian systems, there is evidence of even more attractive developments in the offing. It is not very difficult to predict the likely technological developments in broadcasting. The difficulty is in predicting the acceptance of the developments by the "broadcasters" and particularly their acceptance by the public. This issue is not unique to broadcasting and has been referred to by other speakers in the subscribers' facilities area of common carrier telecommunications.

The issue, which is unique, lies in the public ownership of such a high percentage of the plant used in broadcasting. Any technological change which will require the replacement of the equipment owned by the public — receivers and aerial systems — must offer such substantial attractions as to ensure ready and rapid purchase of the new equipment or, if the new system is not so attractive, it must be "phased in" over a long period as the older equipment comes up for replacement. This situation is, perhaps, best demonstrated by examples.

The impending change from monochrome television to colour is one case where the "selling power" of colour programmes can be expected to lead to a rapid (although not always accurately predictable) rate of growth of new colour receivers in homes. On the other hand, if the next change is a requirement for U.H.F. tuning facilities on receivers, to enable the present programmes to be radiated in the U.H.F. band as a method of improving existing services or of extending service areas, a much slower rate of growth of the population of new receivers would be expected.

Along with the problem of public acceptance is the usual problem of industry and Government investment in the programme generating and transmitting plant. Again, an example can be used.

As the number of conventional terrestrial V.H.F. television transmitting stations has grown in Australia since the inception of television in 1956, the case for using direct satellite transmissions, to the areas which remain unserved, has become harder to justify, despite the rapid developments in satellite technology and the steady reduction in the costs of both the space and terrestrial hardware for satellite communication systems.

2. Possible New Developments in Australia

Despite the impediments mentioned above there are still several areas of technological development which are worthy of consideration for adoption as changes or extensions to the Australian broadcasting systems.

2.1 Sound Services — Frequency Modulation

The Australian Broadcasting Control Board's recommendation to the Government on the introduction of frequency modulation services in Australia are set out in its Report of June, 1972. Several of the issues associated with this Report have become matters of public debate in Australia and, indeed, are currently under examination by the Senate Standing Committee on Education, Science and the Arts in the course of its reference on Broadcasting and Television.

The most contentious issue in the FM recommendation concerns the proposal to use the lower end of the UHF band, near 520 MHz, for the new service. May I summarize the factors which led the Board to this recommendation:

(i) It is very desirable that any new system introduced in Australia has a capability for providing at least the numbers of stations which can be provided by the FM systems used overseas.

(ii) As a result of the Government decision in 1961 to allocate the internationally accepted V.H.F. FM band (88—108 MHz) to television services in Australia, FM could now only be introduced in Australia (if an adequate number of stations are to be provided) by transferring the television stations (Channels 3, 4, 5, which now serve 25% of the Australian viewers) to new channels which would have to be in the U.H.F. band.

(iii) This transfer would involve high costs to the operators of the stations concerned but, more importantly, would require the present viewers of Channels 3, 4 or 5 to purchase new receiving equipment including aerials.

(iv) By comparison with the difficulties and costs which arise in transferring the television services, the difficulties of introducing a new FM sound service at U.H.F. are not very great and from the purely communication theory viewpoints of station coverage, receiving equipment, design, etc., it is infinitely preferable to leave the fragile, wide bandwidth, television services at V.H.F. and locate the more robust, narrow band, FM sound service at U.H.F.

The Board's recommendations include the use of 15 kHz, high fidelity transmissions with encoding for at least two channel and possible four channel stereophonic sound reproduction. With a "de novo" situation in Australia it is also possible to consider alternatives to the commonly used analogue stereophonic encoding systems in the interests of improved transmission quality and, particularly, of reduced receiver costs.

The Board's aim in planning the new system is to provide for three categories of FM reception:—

(i) A very high quality stereophonic service for use in a quiet listening situation where high quality sound reproducing equipment is associated with an equally high quality receiver and, depending upon the location of the listener, an adequate outdoor aerial system may be required to derive full advantage from the transmission.

(ii) A lesser quality but stereophonic service for use in motor vehicles where a simple low height aerial, only, could be used and where the quality of reception will be marred by the restricted size and high noise level of the listening area.

(iii) A simple, still lower quality, monophonic, service from hand held portable receivers comparable with the existing medium frequency transistor radio sets.

The ultimate U.H.F. FM system parameters, station locations, and powers must be such as to provide the services listed above.

2.2 Sound Services — Amplitude Modulation

Referring to the existing medium frequency A.M. services, which are an example of the very slow change in broadcasting technology, there are many views on future possibilities.

(i) As a slow process the MF services could be largely replaced by UHF FM services in the more densely settled areas leaving the MF channels for the wider coverage country services.

(ii) Another school of thought, after contemplating the practicability in the future of using S.S.B. modulation for MF broadcasting and thus securing additional channels, (and perhaps even more by reducing the bandwidth of the radiated signals after high quality FM is securely established for the music stations) would reserve the MF services for "speech only" type broadcasting for public broadcasting stations, educational services, Parliamentary broadcasts, etc.

There is little doubt that medium frequency sound services will be with us for many years to come. Of course there will be changes; those more likely in the near future are the greater use of directional radiating systems to improve channel usage and permit more stations to be established, the possibility of increases in transmitter power to combat the increasing levels of man made noise and, later, of co-channel interference from areas adjacent to Australia.

2.3 Television Services

When the current phase of extensions to outback areas is completed, about 98% of the Australian population will be able to receive at least one television programme. The remaining 2% are scattered over some 75% to 80% of our land mass and further extensions to serve the very small pockets of population involved will be expensive if traditional methods are used.

It is likely that many of the remote communities could be served initially with a totally recorded or "packaged" programme radiated from a low power VHF transmitting station as has been done in outback Canada and is already being done at some mining locations in Australia. Alice Springs is now being provided with the National service on this basis but using a slightly higher powered transmitting station. The packaged or "repeater" stations as they are called in the Australian Broadcasting and Television Act are then ready for a low cost earth station to replace the tape replay equipment when domestic satellite services become available.

In all of the television service extensions in Australia there has been a close integration between the telecommunication extensions and television. It has been claimed that it was the requirement to relay National television service programmes to the major country regions which helped launch the Australian broadband bearer systems in the early 1960's. There is no uncertainty that the later television extensions to more remote areas followed behind and were a direct result of trunk system extensions. The still further extensions which remain to be carried out must also await broadband trunk extensions on domestic satellite circuits if they are to have real time programmes. In the interim some of these areas could use packaged replay stations.

Speaking of satellites for television services in Australia, the present position is that it would be very difficult to justify a domestic satellite for direct broadcasting or even for programme relay purposes on the broadcasting needs alone. The cost per viewer if satellite methods were used to serve the 2% of people still awaiting a television service is at least two orders higher than the cost per head in the current (Seventh Stage) television extension programme. If a broadcasting transponder (of the programme relay type provided in the Canadian Domestic Satellite) could be included in an Australian multi-purpose satellite system of the near future, it would provide a programme to the outback repeater type stations and could enable further low power VHF services to be added in many if not all of the unserved areas.

The other justification from the broadcasting area in considering a domestic satellite system in Australia in the near future could come from any need to provide another nation-wide programme. Such a need could arise from the educational requirements, such as University of the Air; the televising and direct distribution of Parliament; the need for a second National entertainment network; or the establishment of a national network operation among commercial operators. I am poaching on Post Office territory now but one could predict that, if the need for a full time relay to every television service area in Australia arose, it would be an attractive proposition to meet such a need with a satellite service.

Cable television must be mentioned in looking to the future in television. This subject is under careful scrutiny by the Post Office and the A.B.C.B. at the moment and a joint report to the Government is nearly ready for presentation.

From the purely engineering aspects, it can be said that cable reticulation is a very desirable, in fact overdue, addition to the repertoire of broadcast planners. The typical modern built-up area which uses vertical instead of horizontal distribution of living and working areas is ideally suited to the use of conducted rather than radiated broadcasting signals. With the existing overload on the VHF television channels it would also be attractive to use some of the less sophisticated cable reticulation methods in certain country areas, not because VHF transmissions would not work, but because there are now channels left for the translators which should be used in remedying defects in coverage due to topographical features. The same situation exists on the outer edges of the metropolitan sprawls in some States. From the technical viewpoints, cable reticulation is an urgent need. From the operational, licensing and business viewpoints, there are many difficulties in fitting it into the Australian broadcasting scene.

Professor Bray mentioned the developments in information "add ons" to the British television services. The Australian broadcasting planners are watching the developments in the B.B.C. *Ceefax* and I.B.A. *Oracle* systems with interest.

Again, there is a great attraction from the engineering viewpoint to exploit the capability of the television waveform as a common carrier for the provision of additional facilities. The question is whether the public will be sufficiently attracted by the services which could be provided to invest in the additional equipment as adaptors to their existing television sets or to purchase new receivers incorporating the information read out capabilities. Perhaps, the public reactions in the U.K. will give us a lead as to the value of *Ceefax* or *Oracle*, or any variations to these systems, for Australia.

Now that colour is on the way it is difficult to foresee any other additions to the television system. UHF transmissions will have to be introduced — possibly sooner than we would wish — to help improve reception where cable or satellites are not available or applicable. I suppose if I were drawn out, I would have to agree that the "blue sky" type view is for more and more integration of the broadcasting services with telecommunication services ending with the completely "wired city". However I cannot foresee the complete removal of radiated services in Australia even when I peer into the outer limits of the blue sky.

The radiated service must be used for service to moving vehicles and to moving people if we are ever to achieve total personal communications. And with the vast open spaces of Australia, radiated broadcasting from terrestrial stations in the MF, VHF and UHF bands will be with us for many, many generations.

3. Conclusion

Let me conclude on a point that was raised in Dr. Busignies' paper regarding the care for duplex communication in the broadcasting system. I have always believed that the one-way nature of broadcasting can be justified and that it is in fact one of its strengths. From the viewpoint of communication theory it is highly efficient with a very large number of circuits per watt of radiated power and per megahertz of spectrum utilized. But I take Dr. Busignies' point that as wide bandwidth conducted broadcasting systems replace the present radiated systems the opportunity should be taken to provide at least a low information capacity return path from the listener/viewer to the broadcaster.

It should not be beyond our combined wit to provide some indication to the broadcaster of the number of people receiving his programme — particularly the number who, after beginning to watch/listen, have since abandoned the programme!

Biography

Mr. EDWARD JAMES WILKINSON is currently Director, Technical Services Division, Australian Broadcasting Control Board, having transferred to the above position from his previous position of Assistant Director-General Radio, at the Australian Post Office Headquarters, early in 1972.

During his 35 years in the Radio Sections of the Engineering Divisions of the Post Office, Mr. Wilkinson had a close personal involvement in the Post Office areas of broadcasting having been associated in turn with broadcasting studio installation and operations in Victoria as well as with the various transmitting stations of the National Broadcasting Service. He was a member of the large Post Office team of engineers involved in the establishment of the high power Radio Australia station at Shepparton and, upon his transfer to the Australian Post Office Headquarters in 1949, began a long association with broadcasting services which included medium frequency and high frequency transmitting station developments, the early VHF, FM, experimental stations, the additions to Radio Australia plant at Shepparton and, later, the establishing of the new station at Darwin. He was leader of the Post Office team at Headquarters which undertook the large scale Phase 3 and 4 television transmitting station expansion of the 60's. In more recent years he has become involved in spectrum engineering studies and is currently chairman of the Frequency Review Sub Committee of the Australian Inter-Departmental Telecommunications Advisory Committee.

Mr. Wilkinson is a Fellow of the Institute of Radio Engineers Australia and a Member of the Institute of Engineers Australia.

The Future Scene in International Telecommunications

W. G. GOSEWINCKEL
Chief Planning Officer, Overseas Telecommunications Commission, Australia

Against the background of forecast trends in the demand for international telecommunications the magnitude and character of the problems which face the development of the world's telecommunication networks over the next ten to twenty years are discussed. The many difficulties associated with the development of fully co-ordinated future plans for international facilities and networks are examined — many of which arise from the need for multi-national negotiations and agreements. The paper describes the importance of financial agreements as a prerequisite to effective planning and how two worldwide organisations, INTELSAT and the British Commonwealth Telecommunications Organisation, have tackled the problems of forward planning in the international environment.

1. Introduction

When one looks at international telecommunications one is first struck by the very high growth characteristic. Taking international telephony as an example, current growth on a global basis is of the order of 25% per annum or doubling every three years. Individual traffic streams have a very much higher growth characteristic — typically those streams between developing countries or where high quality service has recently been introduced.

Other international telecommunications services such as telex and higher speed forms of digital transmission have exhibited even higher growth rates for some years. For example, Australia's current growth rate for telex service to most countries of the world has sustained a growth rate of over 30% per annum for several years and is expected to continue to exhibit such growth for at least the next five years. The next 10 years will see the progressive development of the international telephone service with the introduction of International Subscriber Dialling, already in use between the U.S.A. and major European countries, whereby subscribers directly dial almost any subscriber in the world.

In addition to these traditional services, new services are emerging, some of which can be expected to become major services in the future. These include several forms of visual telecommunications including international conferences by television and visual telephone systems. It is also expected that services tailored to meet the need for very high speed transmission of data between computer installations throughout the world will be further developed. These developments will bring with them the need not only to substantially increase the capacity of international links but also to increase their availability and reliability. The concept of service continuity in international telecommunications is already moving away from the situation where emergency systems are brought into service only during major system failures. Instead, the trend is to provide service via facilities which are continuously available and which employ diverse transmission media and routings and with sufficient redundancy

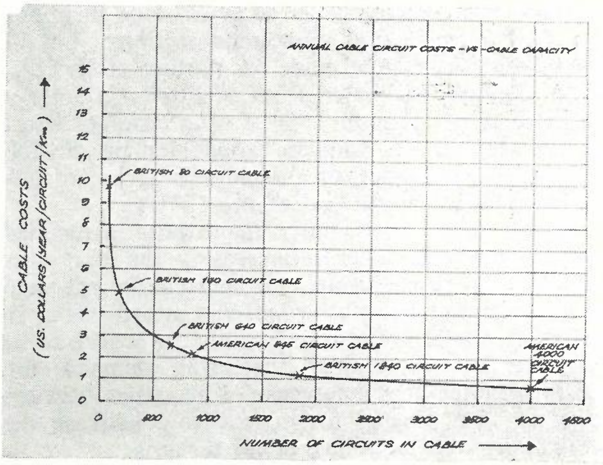


Fig. 1—Reduction in annual cable circuit costs as cable capacity increases

such that service can be maintained, even in the presence of a relatively major system failure.

Another interesting characteristic of international telecommunications and one of the important factors which has stimulated demand, is that, in almost every country of the world, the rates charged to the subscriber for telephone, telex, data services etc. are decreasing. This, coupled with instant, high quality service means that a greater and greater percentage of the public are using international services. This progressive reduction in the price charged to the subscriber is a reflection of the progressively reducing cost of the intercontinental link. Figure 1 indicates how the per circuit costs for submarine cables has progressively and quite dramatically declined as a result of new technology and economies of scale. The graph indicates how the annual cost per circuit per kilometer has dropped from the early British 80-circuit submarine cable design, as used in the existing Australia-Canada cable (COMPAC), to one-tenth of the cost for the latest British design which is planned for use between Britain and Canada, and even lower again for the latest, U.S. designed, 4,000 circuit cable system. Similarly, the

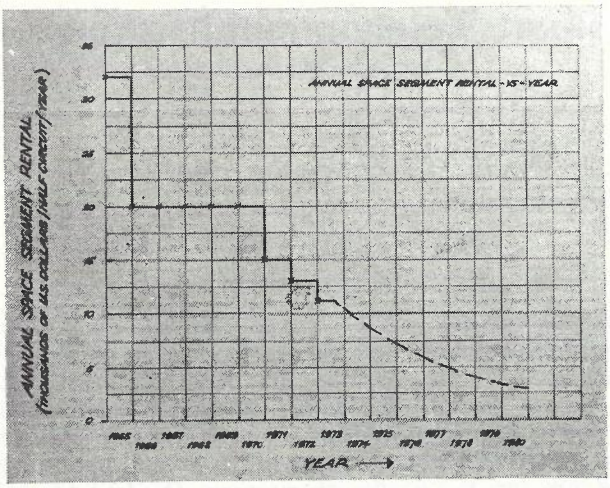


Fig. 2—Reduction in rental costs for INTELSAT satellites

costs associated with the use of communications satellites have progressively declined since their first use for international telecommunications. Fig. 2 shows how the charge made for the use of INTELSAT satellites has fallen from $32,000 (U.S.) per half circuit per year in 1964, to the current charge of $11,160 (U.S.), with an expectation by the INTELSAT organisation of a decline to approximately $2,500 (U.S.) by the end of the 1970's.

Whilst some costs other than those associated with transmission plant are increasing, the total costs and thus the charge to the customer can be expected to continue the already evident downward trend. In summary, the future international scene is seen to be characterised by rapidly increasing demand for existing services, the emergence of many new services together with a need to progressively increase the availability and reliability of all services.

2. Technological Change and the Challenge of the Future

In the past, new technology and innovation has met, and in many cases actually stimulated, demand. In the field of intercontinental submarine telephone cables the capacity has risen from 48 telephone circuits of the first trans-Atlantic cable in 1956, to the latest system design of over 4,000 telephone circuits for trans-oceanic use. Separately, the development of commercial communications satellites has produced successive generations of satellites since 1965 with capacities of some 250, 1,200 and 5,000 telephone circuits, while the capacity of the next generation of INTELSAT satellites is forecast as being in the range 12,000 to 20,000 circuits.

Submarine cable technology was responsible for elevating intercontinental telephony from the vagaries associated with high frequency radio to a quality similar to that encountered on local telephone connections. Similarly it was satellite technology which made available for the first time sufficiently large increments of transmission capacity to make intercontinental television a reliable reality. Over the next 20 years it is expected that these two basic forms of telecommunications technology will continue to provide the means of interconnecting the continents of the world. When one considers the future requirement for greater reliability, the availability of these two very different types of systems assumes great significance. Whilst different in almost every respect, the two technologies provide systems with many complementary characteristics. For example, each operates in a totally different environment — one in space, the other on the ocean floor — and, as one might expect, situations affecting the operation of one are unlikely to simultaneously affect the other. Secondly, the access of each system is different — the cable providing essentially point-to-point communications whilst a satellite can be accessed from any location within its coverage zone.

The transmission delay, of great importance for telephony, associated with satellites is comparatively high and independent of distance whilst that of cables is lower and almost directly proportional to distance. Similarly, the costs of a satellite link are the same irrespective of the distance traversed, whilst circuits derived from cable systems are almost directly dependent upon the cable length. These differing and often complementary characteristics provide the designers of the international networks of the future with almost ideal ingredients. For example, the different media used by each system can, with balanced use, lead to increased reliability whilst the differing cost versus distance characteristic can lead, by selection, to reduced overall costs.

The rapid technological advances of the past 10 years in both of these fields of communication can confidently be expected to continue. Thus the major challenges for the future are not seen to arise so much in the area of technical development but more from the need to develop strategies on a global basis to ensure that modern technology is utilised in a co-ordinated and effective manner.

3. Facilities and Network Planning

As with domestic telecommunications systems, the planning of international networks has two distinct phases. Firstly, planning for the establishment of major facilities such as earth stations, satellites, submarine cables, microwave systems, switching centres etc. and secondly, a plan for their co-ordinated interconnection to form a network adequate in terms of capacity and reliability.

In the international field decisions on both of these matters require bilateral and in many cases multilateral agreement. These planning processes take, at least in theory, the same form as planning for national telecommunications networks but are complicated by many factors which derive from their multi-national character:

(i) Bearing in mind the varying stages of development of different countries and the state of development of their domestic networks, it is not surprising that different views are held on the weight to be placed on such aspects as the desirable reliability and need for diversification of international circuits, and the technical performance of the international system as a whole.

(ii) Further, the stage of development of a country has a substantial bearing on the importance attached to individual services; to a developing country the telegraph service may be the most important of all, while to a highly developed country the wideband data service could assume a great degree of significance, particularly for forward planning purposes.

(iii) Imposition of Government views takes a different form depending on whether the international service is the responsibility of a Department of State, a public corporation as is the case in very many countries, or of private companies, such as in the U.S.A. where Government control is applied by regulation through a Federal agency (the F.C.C.). The position in some countries is further complicated by the fact that cable and satellite services are operated on a competitive rather than complementary basis.

These many differences found between countries in the telecommunications world make their active participation in the planning of global networks, involved as it must be in relatively large financial commitments, a very complex task. As in other fields it is difficult (and sometimes impossible) to get individual countries to agree on any particular matter — even more so where financial gain or loss is implicit and where the best solution financially for one may not be the best solution financially for all.

Against this background of rapidly expanding demand and multi-national involvement it is interesting to examine two worldwide organisations which have recognised the problems associated with the planning, implementation and utilisation of telecommunications systems on an international basis and have, over the past two years, established planning forums for their resolution. The two organisations are INTELSAT, an international consortium of 83 countries who collectively own the world's commercial satellite system, and the British Commonwealth Telecommunications Organisation which plans, designs, provides and operates international networks linking Commonwealth countries with each other and with non-Commonwealth countries. It is interesting to note that both of these organisations share one important characteristic, and one which has meant the difference between a theoretical exercise in planning and a real and effective one. Each organisation operates under a formal international agreement involving financial commitment by the participants. In the case of INTELSAT the costs associated with the in-orbit satellite system are shared by each participating country in accordance with that country's use of the system. Similarly, in the Commonwealth organisation each Partner to the scheme may make use of the total submarine cable and satellite facility network and meets his share of the total cost in accordance with the extent of his use. Thus, participating countries to planning studies conducted by these two organisations are aware that the results of the collective studies will impact on them financially as well as operationally.

4. INTELSAT

The INTELSAT organisation was established in 1964, by agreement between the Governments of several countries, to provide for the establishment and operation of a global system of commercial communications satellites. The system is owned by participating countries in accordance with a quota determined by each country's use of the facilities. Thus the capital funding of INTELSAT is provided by each country in accordance with that country's quota.

The management of the INTELSAT system is vested in a Board of Governors comprised of representatives of those countries which have a quota in excess of a certain minimum figure. A total of 83 countries are currently members of INTELSAT. The Board of Governors of INTELSAT has established a number of specialist committees to advise them on several matters relevant to the management of the global satellite system. The most recently established committee is that for the long-range planning of satellite facilities. Its function is to:

- study the global requirements expected to be met by the satellite system between the years 1978 and 1988;
- formulate a long-term implementation plan for satellites in each ocean area of the world to meet projected requirements — again over the period 1978-1988.

5. The British Commonwealth Telecommunications Organization

Another somewhat similar planning organisation dealing with telecommunications on a worldwide basis is that established within the British Commonwealth Telecommunications Organisation. The Commonwealth Telecommunications Organisation is an association of 23 Commonwealth countries which collectively represent more than one quarter of the world's international telecommunications. Its purpose is to provide the efficient and effective communications between countries of the Commonwealth as a collaborative, financially based exercise.

The financial agreement which makes possible the collaborative global networks is based upon the concept that all network costs, such as those for satellite earth stations, submarine cable systems, international gateway exchanges etc., are aggregated with each Partner meeting these costs in proportion to this actual use of the network. This arrangement enables

- the co-ordination of facilities, leading to more efficient use of them than would otherwise be the case;
- the carriage of non-Commonwealth traffic leading to economies of scale and thus enhanced profitability;
- the encouragement of development programmes which in turn stimulate traffic to the benefit of individual Partner countries and the network as a whole.

The body primarily responsible for the oversight of the development of the network and the administration of the Organisation's financial arrangements is the Commonwealth Telecommunications Council. Assisting Council is a number of Specialist Groups covering such disciplines as planning, operations, tariffs and finance. One of these Groups dealing with System Development is specifically concerned with developing techniques for evaluating long-term network options in terms of economic and operational consequences. This group has been charged with the task of formulating principles, objectives and criteria for the long-term development of services and facilities of the British Commonwealth and to produce, in accordance with those principles, a long-term plan for the future.

The Commonwealth international telephone network is a hierarchical network somewhat similar in type to that defined by the C.C.I.T.T. in their recommendations for a worldwide routing plan for the international telephone service. The only important difference is that the Commonwealth network does not specifically categorise transit switching centres into particular levels but rather determines the network design into taking into account such factors as the capacity of interconnecting facilities and the resultant overall network costs.

6. Problems with other Planning and Operating Methods

Whilst the C.C.I.T.T. world routing plan was developed some ten years ago it is interesting and perhaps significant that, apart from the Commonwealth network, world communications have continued on essentially a point-to-point basis with most countries separately developing a radial network to those other countries of the world with which they have significant volumes of communications. This unco-ordinated and inefficient method of operation derives itself from history where, because of high transit charges made at intermediate transit points, direct operation from one country to another without involving a third country, although costly, keeps the revenue with the two countries directly involved. A change in approach can only be seen as a practical possibility if effective financial arrangements can be established on a worldwide basis such that, as with Commonwealth countries, financial benefits of transit network operation are shared equitably between all participants in the scheme. Only after such arrangements are agreed and endorsed by the countries of the world can we expect to have effective planning towards a unified, efficiently utilised worldwide network for the future.

A somewhat different forum set up with the aim of assisting the international planning process was established some years ago by the International Telecommunication Union (I.T.U.). The I.T.U.'s World Plan Committee has been of considerable value in the past and is expected to play an important role in the future for the preparation of forecasts of international traffic and for the recording of each individual country's facilities and future plans. To date the Plan Committee has not achieved the aim of some Administrations of developing a fully detailed worldwide network model, primarily because of the difficulty of accurately reflecting into the work of the Committee the impact of commercial agreements between Administrations, both for the provision of new facilities on the one hand and the routing of traffic on the other. However, the Plan Committee is now moving towards the provision of reliable data on which Administrations may base their future plans.

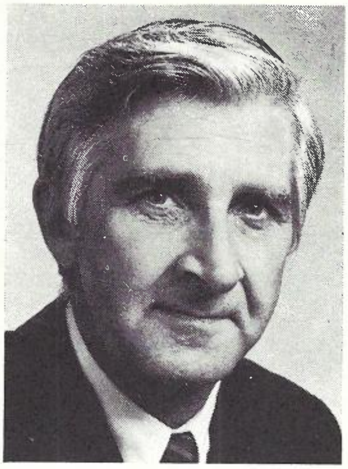
It is becoming clear that the service objectives of most administrations will call for the parallel future development of cable and satellite systems, and that the advance of cable technology will create cables of such capacity as to require multilateral ownership in an increasing number of cases. Separately, it will be necessary to continue to develop traffic engineering methods in order to utilise facilities most efficiently. The challenge for the future is to develop viable means of planning and developing the total global system, taking account of available and still-to-be-developed technologies, using different technologies to complement each other, and providing the necessary grade of service at the minimum cost. This will require co-ordination and consultation between administrations at a level substantially higher than has previously been necessary, and will create planning organisational problems to which solutions will not readily emerge. A fundamental requisite to the generation of solutions is considered to be the recognition that effective facilities planning and facilities utilisation on a worldwide scale require financial involvement in which the economic benefits of efficient planning flow to all participants.

7. Summary

The future is expected to bring with it continuing rapid growth in world telecommunications with decreases in costs adding stimulus to the existing very high growth rates. New services will emerge and existing services will become more sophisticated

- The main methods employed for intercontinental transmission will be submarine cables and communications satellites — which need to be seen by communicators not as competing but as complementary systems.
- Technology will almost certainly be available when required to meet demand.
- The practical means of achieving a properly coordinated effective and efficient world network of the future will rest on the ability of the users of technology — the international telecommunications organisations of the world — to jointly develop the necessary financing and planning machinery on a global basis to ensure that advanced technology is effectively exploited.
- The INTELSAT organisation seems to provide a useful guide for the financing, planning and implementing of major international facilities of the future, whilst the British Commonwealth Telecommunications Organisation provides an example of how, given the right financial arrangements and incentives, these facilities can be effectively interconnected to form an efficient and effective integrated world network for the benefit of all.
- Effective network development and utilisation on an international basis can only be performed against a framework of financial involvement, in both the planning and operational stages.

Biography



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As Chief Planning Officer Mr. Gosewinckel is head of the planning organisation of the Overseas Telecommunications Commission (Australia), a position he has occupied since 1967. Prior to that time he held several senior engineering appointments with O.T.C.(A.).

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Mr. Gosewinckel has represented O.T.C.(A.) and Australia in many international forums including the I.T.U., INTELSAT, and the British Commonwealth Telecommunications Organization.

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