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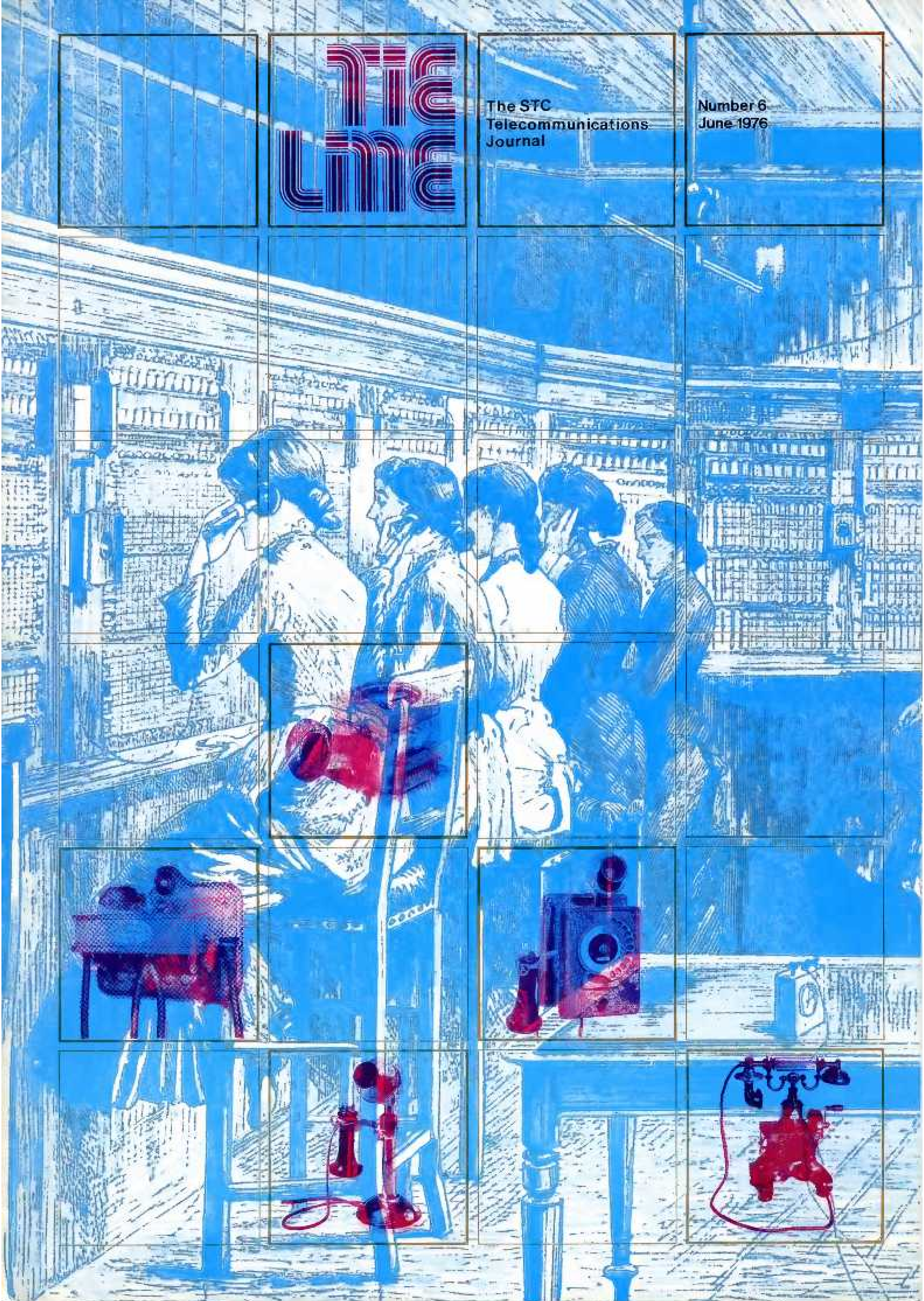

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It is perhaps appropriate in the centenary year of the telephone to reflect on the changes that have taken place in our society over the past hundred years, and also on the course that history might have taken had efficient electronic communications not developed in the way that it has done.

Early history is conveniently divided into ages according to the development of man's ability to work certain materials and to exploit natural resources. From the Stone Age, man progressed through the Bronze Age to the relative sophistication of the Iron Age. With several thousand years intervening, we have now arrived at what might be called the Petrochemical Age.

But if instead of judging history by man's skill in exploiting resources, it is judged by his ability to communicate, what pattern emerges? From the earliest forms of rudimentary speech, man progressed through grammatical speech to a written language. With the subsequent development of a mathematical notation, the first forms of effective government emerged through the ability to keep records and to promulgate laws. In the Middle Ages the development of printing gave fresh impetus to man's communicative skills, while the advent of mass literacy truly laid the foundation for the communications explosion of the last century.

Now with the mechanisation and electrification of many of our communications media, the communications industry, together with energy resources and an efficient distribution network, has become one of the pillars upon which our society today is built. These developments have provided powerful challenges for the engineer and technologist, but have also imposed substantial responsibilities to ensure that future developments are fully utilised for the maximum benefit of society as a whole.

Today, we are poised on the threshold of a new surge in telecommunications development. The prospect of wide-band communication into the home, the promise of long-distance optical communications, of digital switching and transmission, and the development of large scale integrated circuits offer possibilities undreamed of 50 years ago. Indeed we might forecast that the next 50 years will see more real progress in communications than the preceding century which has just been commemorated.

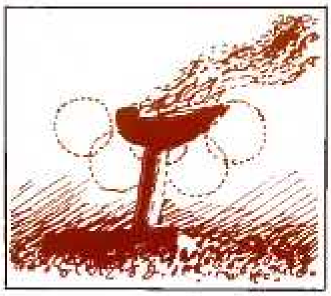
(cover picture)
A series of telephone subsets are shown against a background of an early telephone exchange.
Background picture by Radio Times Hulton Picture Library.

(frontispiece)
Alexander Graham Bell.
The Institution of Electrical Engineers.

The centenary of the telephone has been marked throughout the world by activities ranging from the issue of commemorative postage stamps to social functions and special exhibitions of telecommunications equipment. The telephone today forms part of the basic fabric of our society, and technological developments now taking place herald changes in the next century of equal significance to those in the first hundred years of telephony.

Should Alexander Graham Bell have invented the telephone (page 3)

100 years of the telephone . . . the dawn of a new era (page 9)

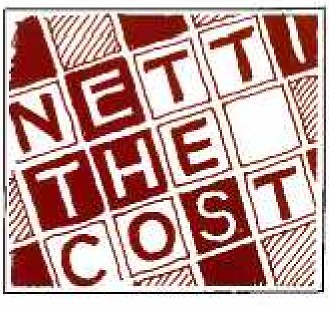


Behind the success of every public spectacle, such as an international sports event, lies a complex communications problem. National and international telecommunications networks are the unseen resource that bring news and pictures to our television screens and to newspaper offices across the world. An event as significant as the Winter Olympic Games poses its own special challenges to the telecommunications administration of the host country.

Telecommunications for the Winter Olympics (page 16)

When the topic of conversation turns to art and matters aesthetic, subjective opinions and views tend to be put forward. But 'art' has its objective facets too. In industry, the role of creative designers becomes more important as technology becomes more complex. The objective contribution of the industrial designer can determine the success and acceptability of a product, and can ensure that the needs of the user are not forgotten in the solving of engineering problems.

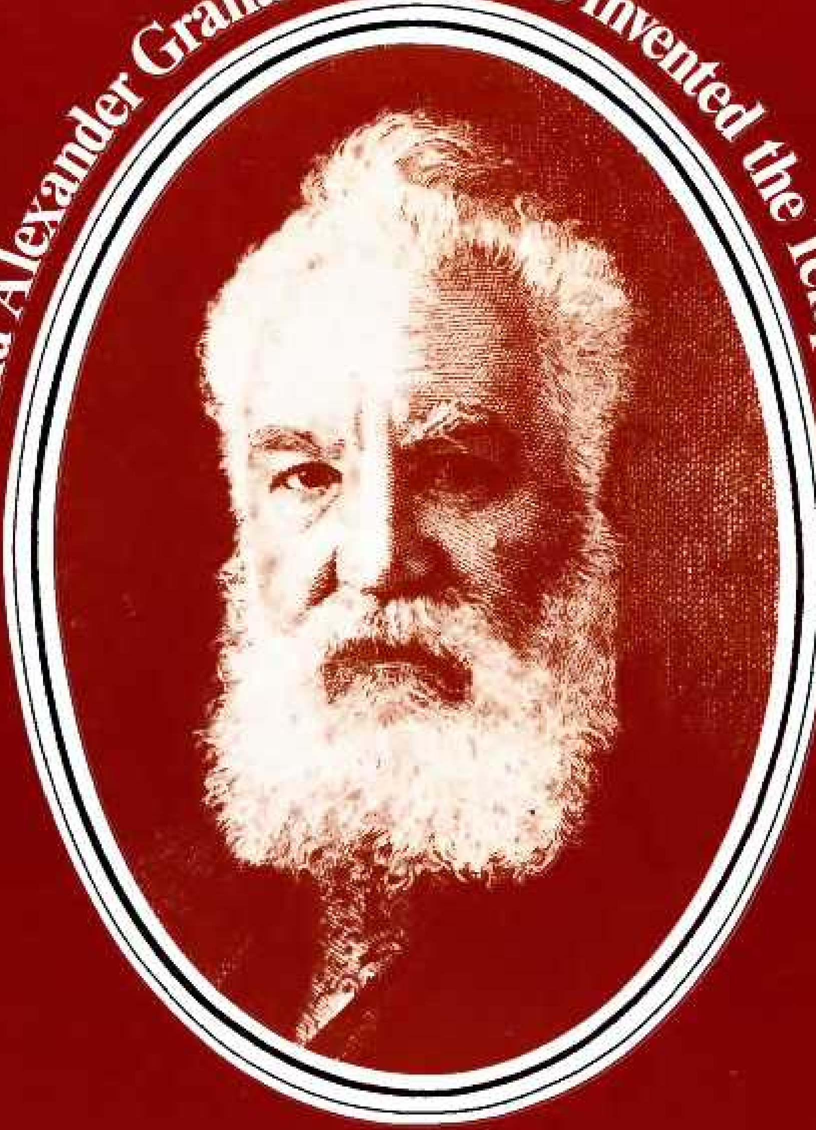
Art in industrial design (page 13)



As organisations grow, their communications needs also develop. As their communications facilities grow, the efficient management of these facilities becomes of increasing importance. Many companies now operate their own private communications between the various factory and office locations, using circuits leased for this purpose from the Post Office. It is, however, essential that the communications facilities should be matched to the needs of the organisation if maximum economic and operating benefits are to be obtained.

Netting the cost (page 19)

Should Alexander Graham Bell have invented the Telephone?



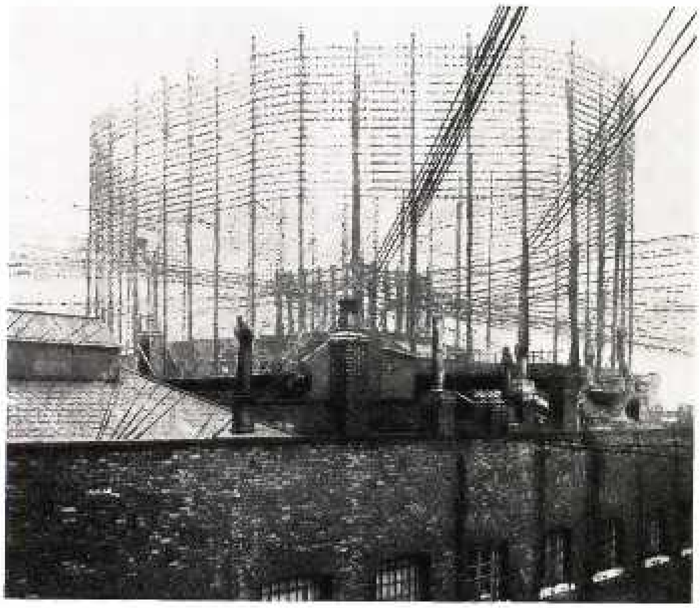
by W J Bray

It may well have been Alexander Graham Bell's successful demonstration on the 10th March 1876 of what was later claimed to be the world's first electronic transmission of intelligible speech – enshrined in Bell's historic call to his assistant 'Mr Watson, come here, I want to see you' – that set in motion what eventually became a major leap forward in communication at a distance. (1).

But in the world of the mid-1800s there was already in existence in the United Kingdom and the United States a fairly extensive telegraph network, to which Cooke and Wheatstone had made substantial contributions, and which had been stimulated by the need of the railways for the long-distance transmission of control signals and information. (2). The discoveries in the field of electromagnetism by Oersted, Faraday and Henry in the period from 1820 to 1830 had not only made possible the electric telegraph, they had also created the essential foundation of scientific knowledge for the invention of the telephone.

174, 465 TELEGRAPHY. Alexander G. Bell Salem, Mass. (Filed Feb 14, 1876)

To all whom it may concern:
Be it known that I, ALEXANDER GRAHAM BELL, of Salem, Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification:



Why then should Alexander Graham Bell have invented the telephone in 1876? The reasons are not far to seek. First, stimulated by his father's interest and throughout his own long life, Bell was fascinated by the nature of speech and the problems of communicating with the deaf.
Secondly, the world of the 19th century was that of the industrial revolution; science, technology, manufacture and trade were on the march and new political forces were making themselves felt. There was a growing need to communicate, rapidly and in the most natural way possible.

The electric telegraph met these needs only partially; it was slow and conveyed little of the personality of the communicators. Human speech, developed during the many centuries of Man's evolution and closely linked to the maximum rate at which he could usefully create, absorb and respond to information, was clearly the most natural mode of person-to-person communication.

Against this background, and with the electric telegraph providing a convincing demonstration of the practicability of a nation-wide communication network using wires, the invention of the telephone was almost inevitable.

The history of the invention of the telephone is complex, confused and incomplete. Elisha Gray, whose own contribution was by no means insubstantial, was later to write:

> 'The history of the telephone will never be fully written. It is partly hidden in 20 or 30 thousand pages of testimony and partly lying in the hearts and consciences of a few whose lips are sealed – some in death and others by a golden clasp whose grip is even tighter.'

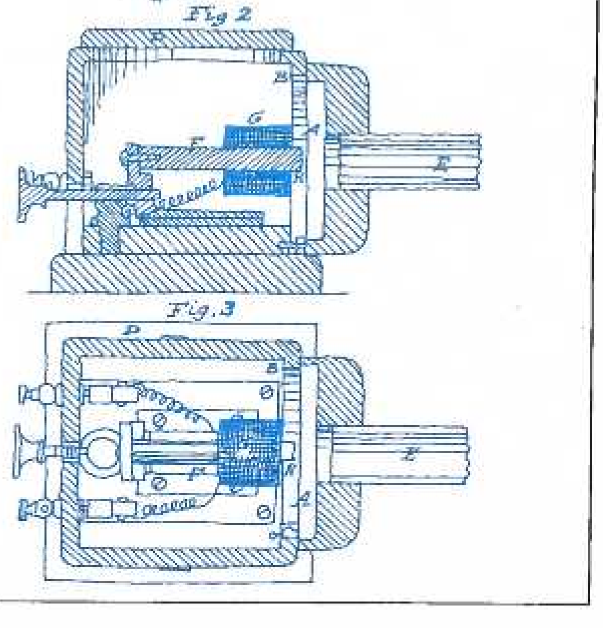
It is clear from the literature that Bell's contribution was by no means the unique and original one that many of his supporters have claimed. Between 1820 and 1876 a score or more of inventors had described, and some had made to work, devices that anticipated the essential features of the Bell telephone as described in his first two patents. These inventors included Meucci (Italy), Bourseul (France), Reis (Germany), and Drawbaugh, Elisha Gray and Thomas Edison (USA) (3).

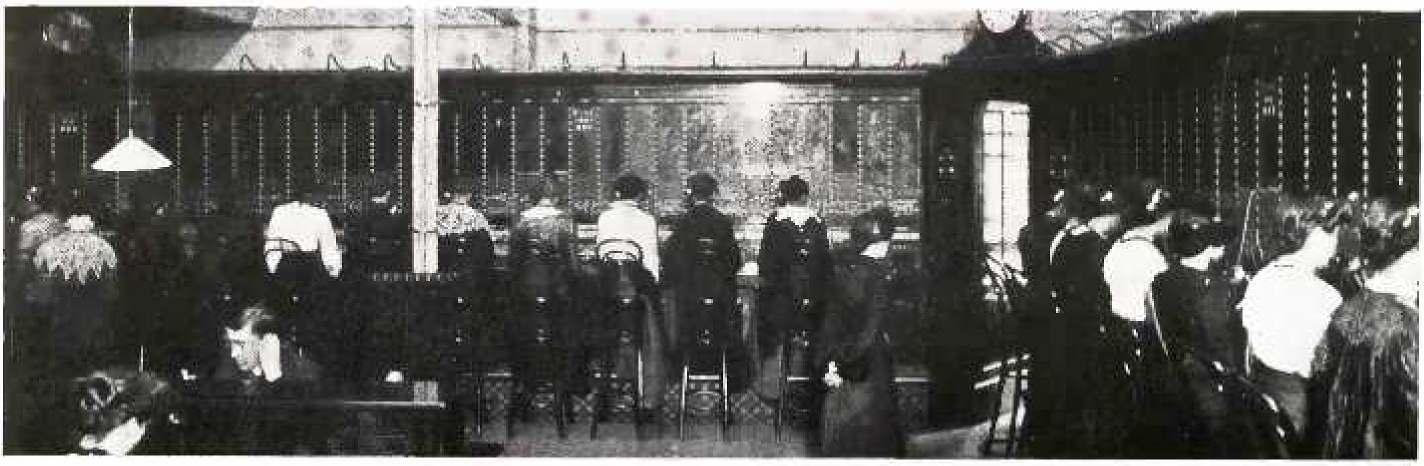
Bell's first patent (no 174 465 of March 1876) shows a battery-operated magneto-electric telephone, the transmitter and receiver being similar and equipped with membrane diaphragms. His second patent (no 186 787 of January 1877) covered the use of a permanent magnet and coil with a metallic

(left)
Introduction to Bell's first patent (number 174 465) filed on the 14th February 1876.

(above)
The old East India Avenue telephone exchange in the City of London was an example of the 'spider's web' of overhead subscribers' lines necessary in the 1800s. *Radio Times Hulton Picture Library.*

(below)
Diagrams from the second Bell patent (number 186 787) showing a more advanced telephone.





(above)
The switch room of the old manual telephone exchange at Holborn, London.

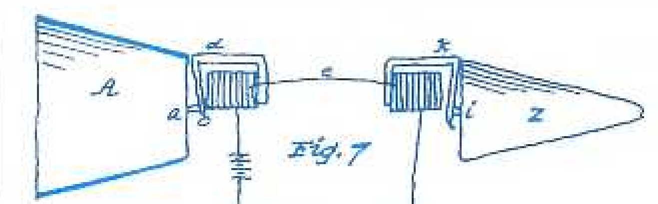


Diagram from Bell's first patent showing the proposal for a magneto-electric telephone transmitter.

diaphragm, enabling the battery to be dispensed with. The second patent included, almost as an afterthought and coincidentally with a caveat entered by Elisha Gray, a reference to the concept of an undulatory current generated by a liquid variable-resistance transmitter.

Bell himself is on record as saying that:

> '. . . if he had known more about electricity he would not have invented the principle of the telephone.'

Furthermore, he was under considerable pressure in the early stages of his experimental work on the telephone to give priority to his harmonic multiple telegraph – an early version, some 20 years before its time, of the frequency-division multiplex telegraph that eventually saw widespread use in long-distance telegraph networks.

Bell's words on the 10th March 1876 were nevertheless prophetic and showed that he had a fair vision of what the telephone might do:

> 'This is a great day with me and I feel I have at last struck the solution of a great problem – and the day is coming when telephone wires will be laid in to houses, just like water or gas, and friends converse with each other without leaving home.'

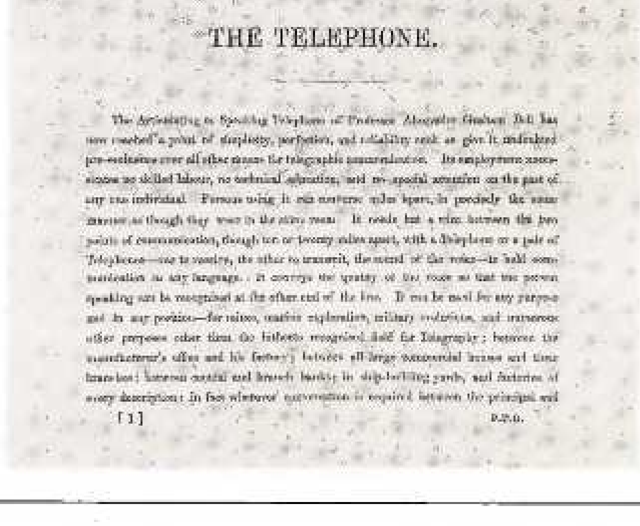
He foresaw too that:

> '. . . the telephone would be a major factor in the new urbanisation . . . without the telephone system the 20th century metropolis would have been stunted by congestion and slowed to the primordial pace of messengers and postmen. And the modern industrial age would have been born with cerebral palsy.' (1).

Not all in the 19th century were convinced of the value and future prospects of the telephone. William Orpen, president of the mighty Western Union Telegraph Company in the United States, turned down the opportunity to buy the rights to Bell's telephone patents for a song, thereby inhibiting indefinitely the prospect of a rational and economic integration of the two services in that country. And in the United Kingdom, the British Post Office showed a noticeable lack of enthusiasm for the telephone in its early days.

However, by the middle of 1877 there were more than 600 telephones in use in the USA, and Queen Victoria had been suitably impressed by a demonstration at Osborne House in the Isle of Wight. The Telephone Age had begun.

(below)
Part of an early handbill advertising the advantages of the newly invented telephone to potential subscribers. *Science Museum.*



With the growing commercial value and importance of the telephone, and the many rival inventors, it is not surprising that the next 20 years saw more than 600 cases of patent litigation, including a long drawn-out but unsuccessful suit by the United States courts against the Bell Telephone Company's monopoly claim to the use of electricity for the transmission of speech. (3).

There were of course then, as now, some who were dissatisfied with the performance of the new device. In 1890, Mark Twain, who was evidently having difficulty in hearing over the lines of the Hartford Telephone Company, wrote a letter to the New York World newspaper that read:

> 'It is my heart-warm and world-embracing Christmas hope and aspiration for all of us – the high, the low, the poor, the rich, the admired, the despised – may eventually be gathered together in a heaven of everlasting rest and peace and bliss – except the inventor of the telephone!'

The sociology of the telephone, in particular its role in the transition from the pre-industrial world of the 19th century to the largely industrial world of today, is a surprisingly neglected field of research, compared for example with studies on the impact of mechanical transportation, the technology of mass production, and the availability in quantity of electrical power (4). However, the available literature makes it clear that, as with Mark Twain, not all past and present users of the telephone give it unqualified support.
Some have objected to the telephone for its intrusions into personal privacy; Bell himself is said to have refused to have one in his study! Others have criticised the telephone for its adverse effect on letterwriting, once a civilised and cultivated art in Victorian times. The sheer speed and immediacy of telephone communication are not without disadvantages.

Sociologists fret about its over-rapid intimation of trouble and disaster, and its use as a means of promulgating dissent and disagreement. The instability and rapid collapse of the Wall Street stock market in 1926 was probably stimulated by the use of the telephone for panic selling of shares. More than one ambassador overseas, and no doubt generals too, have resented the lack of freedom of action created by the telephone link to the Foreign Office or Ministry of Defence.

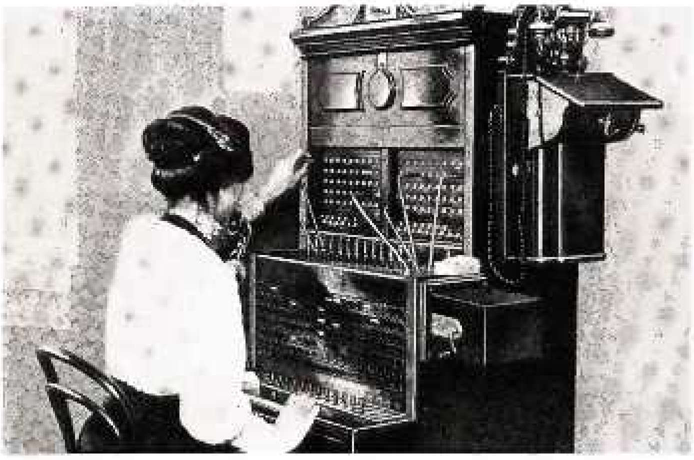
Professor Colin Cherry has speculated as to whether the telephone, with other means of world communication, augurs for ill or good, but concludes that effective communications are essential for the creation of 'a better world order through varied, flexible and overlapping federations of countries, according to a host of specific, defined mutual interests.' (5).
Professor Dennis Gabor has postulated a 'Gresham's Law of Communications' by which 'bad truth drives out good truth', but goes on to point out the potential value of good communications as an instrument for more effective social control, for example in minimising the likelihood of armed conflict between nations, avoiding the problems of over-urbanisation by facilitating the dispersal of cities, and assisting in the control of crime. (6). Others have drawn attention to the existence of 'communications stress' that arises from an excessive flow of information beyond the limit that an individual can effectively absorb, and which could lead to mental illness. (7).

But overall the evidence in favour of the telephone is clear and overwhelming. There are now some 20 million telephones in use in the United Kingdom, 150 million in the United States, and more than 350 million in the World, and these figures are increasing, economic recessions and civil or military strife notwithstanding.

It is evident that the telephone satisfies economically a vast range of human communication needs for social, business, industrial and governmental purposes. And this is because it provides speedy, two-way interactive communication directly between people in a manner not possible with mass-communication media such as broadcasting and newspapers, and in a way that closely identifies the personalities of the participants.
On this last point consider just a few examples of the value of personal identification – a young child's first telephone call to a distant grandparent, a call for help by a potential suicide on the 'Samaritan' telephone, and a presidential call on the international 'hot line' heading off nuclear disaster.

The significance of the telephone has been well summed up by an American sociologist, Sydney H Aronson. He has written:

> '. . . it has helped to transform life in cities and on farms, and to change the conduct of American business, both legitimate and illegitimate; it imparted an impulse towards the development of a 'mass culture' and 'mass society' at the same time it affected particular institutional patterns in education and medicine, in law and warfare, in manners and morals, in crime and police work, in the handling of crises and the ordinary routines of life. It markedly affected the gathering of news and the patterns of leisure activity; it



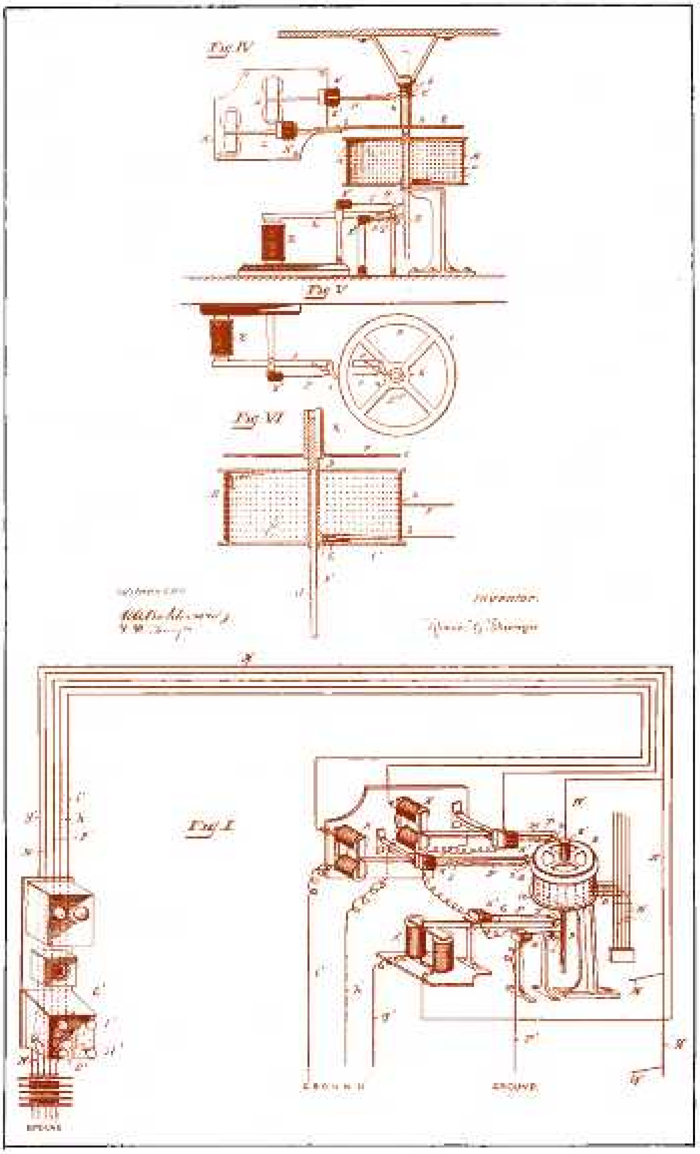
changed the context and even the meaning of the neighborhood and of friendship; it gave the traditional family an important means to adapt itself to the demands of modernisation and it paved the way both technologically and psychologically for the thematically 20th century media of communication; radio and television.' (4).

So I believe we can answer a confident 'yes' – with perhaps some qualification – to the question 'Should Alexander Graham Bell (or possibly some other person!) have invented the telephone.'

(left)
The switch room of a London central office in 1883 worked by the slipper board system. *Radio Times Hulton Picture Library.*

(above)
An early private branch exchange installed by Western Electric at the turn of the century.

(right)
Diagrams of the first automatic telephone exchange patented by Almon B. Strowger, a Kansas undertaker, in 1891.



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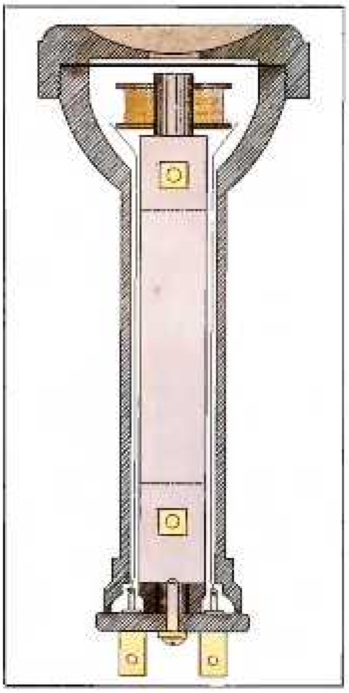
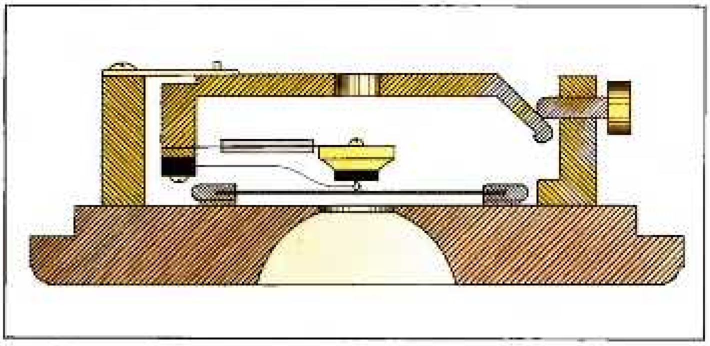
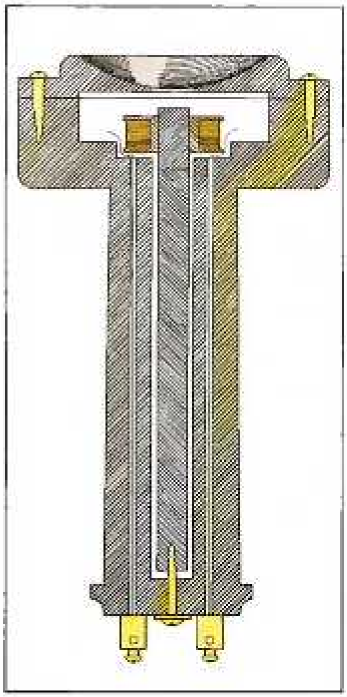
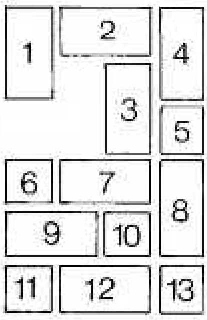
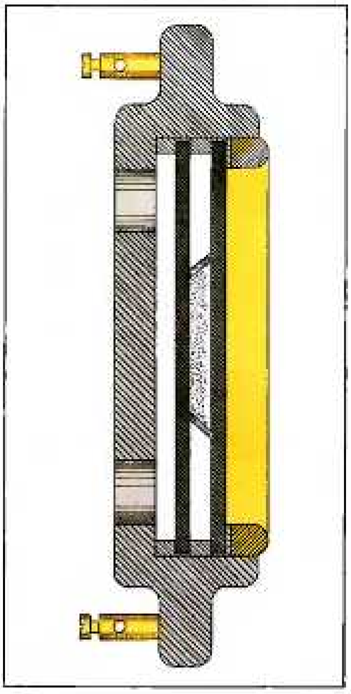
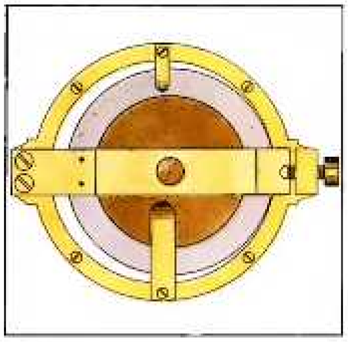
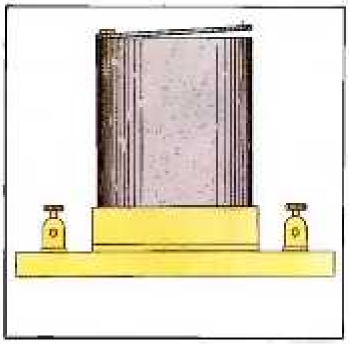
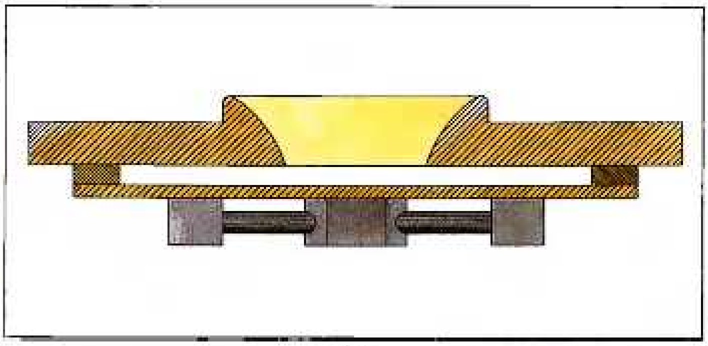
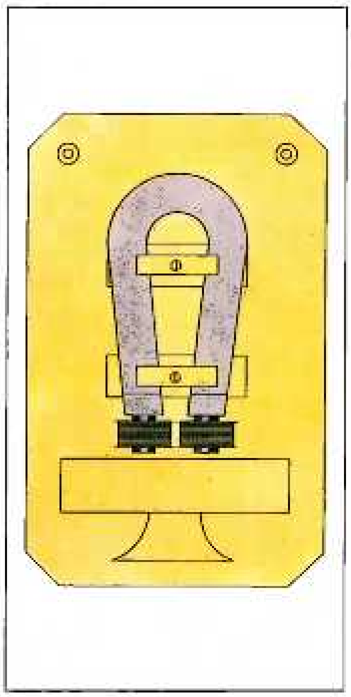
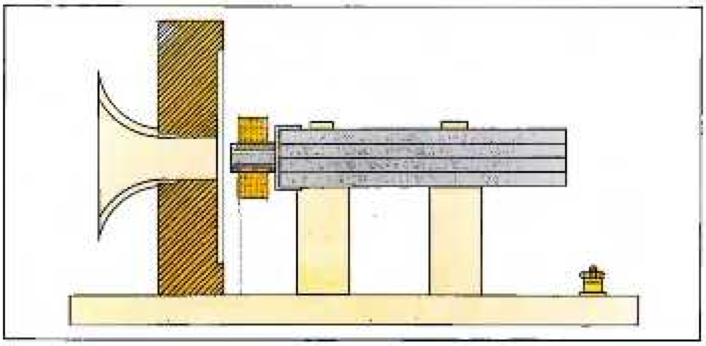
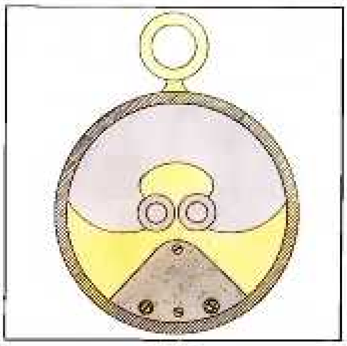
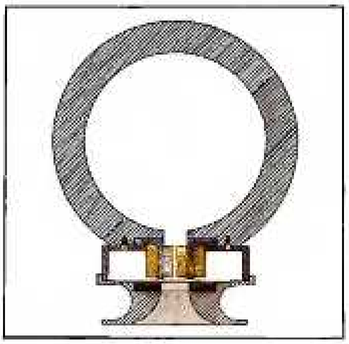
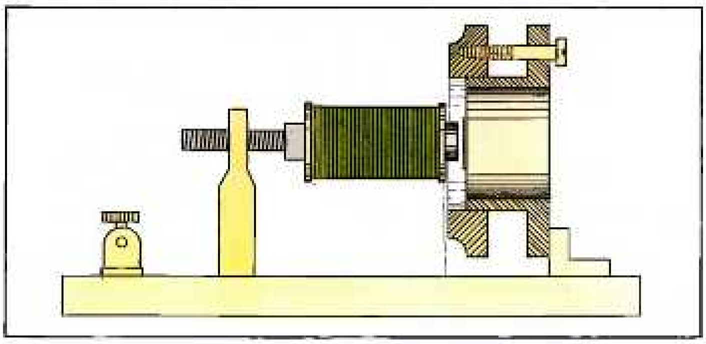
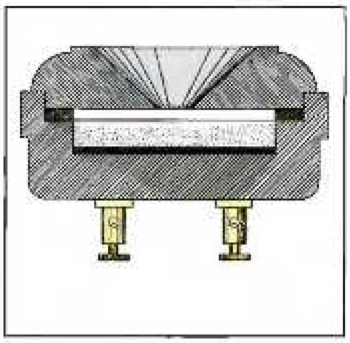
This article is based on the Centenary Lecture of the STC Telephone Technical Society, presented by the author on the 17th February 1976.

W J Bray is a former Director of Research with the Post Office.


1 Bell receiver used by Swiss PTT
2 Blake's transmitter
3 Hunnings' transmitter
4 Bell's instrument
5 Blake's transmitter
6 Bell telephone
7 Crossley's transmitter
8 Bell's 'ironbox' telephone
9 Bell's 'ironbox' telephone
10 Ader's receiver
11 Ader's receiver
12 Bell telephone
13 Hunnings' transmitter

Photographs from drawings in the archives of the Institution of Electrical Engineers.

100 Years of the Telephone... the dawn of a new era

by Roy Atterbury

Alexander Graham Bell achieved worldwide acclaim and a certain place in history by the slender margin of 60 minutes. He filed his first patent application on an 'Improvement in telegraphy' in February 1876. Just one hour later, an inventor called Elisha Gray attended the same office to file a patent which proved to be almost identical.
Thus it was that Bell assumed his proud role as the inventor of the telephone, and poor Mr. Gray melted away into almost complete obscurity.

One hundred years have passed since the first primitive telephone. We need to go even further back to find the first recorded reference to the concept of using electrical apparatus to transmit the human voice. In 1854, the Frenchman Charles Bourseul wrote 'It is certain that in a more or less distant future, speech will be transmitted by electricity'. Words, indeed, of great portent.

Seven years later, in 1861, a German physicist called Reis developed a 'transmitter' in which the circuit was made or broken by vibration of a membrane under the action of sound. The 'receiver' was simply an iron rod contained within a solenoid – the rod emitting a faint sound when the solenoid was energised.

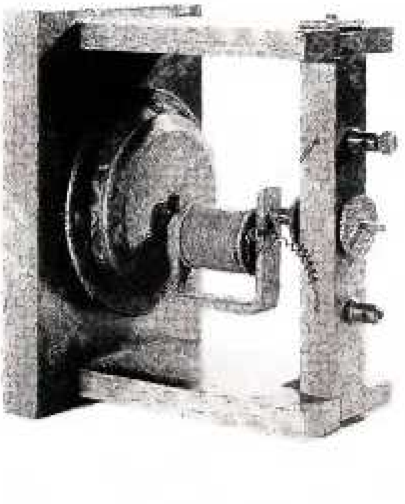
The style of an early telephone from the private collection of Mr. L. D. Nichols, STL, is contrasted with the latest pushbutton Quickstep Deltaphone. *Photograph by Paul Brierley.*

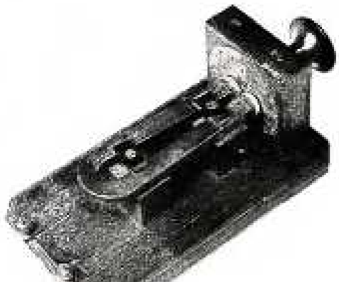
Bell's experiments in 1875 were not concerned with voice transmission but with simultaneous transmission of telegraph messages. The summer that year in Boston, Massachusetts was hot and humid, and played havoc with Bell's delicate equipment. He was endeavouring, unsuccessfully, to transmit six simultaneous messages along a single wire using electromagnets to activate steel springs and thus create a signal.

It seemed like the final straw to Bell and his assistant, Thomas Watson, when a transmitter failure caused one of the springs to become welded to a contact breaker. However, Watson decided to pluck at the spring to start it vibrating again and Bell, who was in another room, heard the plucking noise coming through a receiver.
Bell realised that the spring (or vibrating reed) had generated a 'sound-shaped' undulating current rather than an intermittent current and the potential of his 'discovery' was obvious. He immediately decided to follow this new line of research, despite the pleas of his backers who believed that his experiments in telegraphy would eventually prove more fruitful.
His initial patent, in addition to his electromagnetic transmitter, also contained reference to a variable resistance form of transmitter using a battery – the aim being to improve the sensitivity. In the same month, the variable resistance concept was put into effect when Bell developed his 'liquid' transmitter. It was with this that those famous and first-ever intelligible words spoken on a telephone passed from the lips of Mr. Bell to the ear of Mr. Watson – 'Mr. Watson, come here, I want to see you'.

This event took place on the 10th March 1876 and was truly the birthday of the telephone as we know it today. The variable-resistance transmitter concept, in a much more developed form, is used in almost every telephone that we now see around us.

Improvements on Bell's concept followed fast and furiously. In 1877, Emile Berliner produced a transmitter consisting of a metal diaphragm in contact with a metal ball. Vibration of the diaphragm produced corresponding variations in the contact pressure between the ball and the diaphragm giving required variable resistance.
In 1878, Professor Hughes presented an historic paper to the Royal Society in which he revealed his discovery that any system of loose contacts will form a transmitter. About the





same time, Thomas Edison was hotly pursuing the possibility that carbon was the best material for the purpose. Edison, in fact, had made the next vital breakthrough.

For a while, carbon received the undivided attention of inventors. The Reverend H. Hunnings achieved much better results by using carbon granules instead of a solid formation. The Hunnings transmitter, unfortunately, suffered from the fact that it had to be operated in vertical position in order for the granules to maintain constant contact with the diaphragm. This problem was later solved by other designers.

Up to now, this article has been concerned with telephone transmitters simply because the development of the telephone, and the associated systems used for exchange equipment, were completely dependent upon this aspect of the device. Receivers, although they have developed with the passing of time, have always tended to be of the electromagnetic type using a flexible iron diaphragm. Varying magnetic pull on the diaphragm causes it to vibrate according to the variations in current received.

There are, however, two major design factors which must be faced in receiver development. Firstly, the available energy is less than 0.1 μW and maximum use of this energy must be made to convert the diaphragm vibrations into audible sound. In addition, the diaphragm must also be capable of reproducing a wide range of frequencies with a high degree of response.

The first telephones to be installed were used for communication between two fixed points – for example, a master's study and, say, his butler's room. The instruments generally consisted of two Bell telephones – one receiving and the other transmitting – together with a bell which indicated a call, a press button to make a call, a battery, and hook for carrying the receiver which also served as the telephone line switch.

In Great Britain, the first company formed to provide these simple systems was The Telephone Company Limited, which had the task of promoting Bell's patents. The company was launched in June 1878 with American equipment and just ten clients but, over the next 3 years, interest in the new 'toy' grew rapidly and its use spread into many commercial applications.

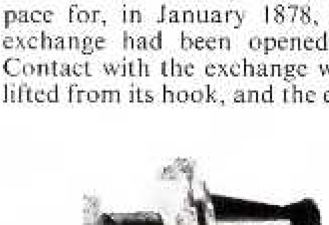
In the United States, events were proceeding at an even faster pace for, in January 1878, the first commercial telephone exchange had been opened at New Haven, Connecticut. Contact with the exchange was made when the receiver was lifted from its hook, and the exchange operator connected the

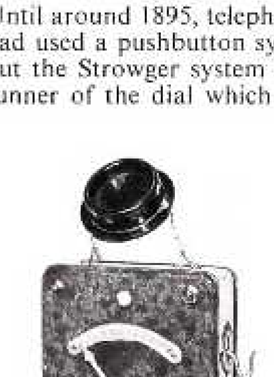
A proposal for a business terminal for the Viewdata service. *Post Office.*

caller's line to the line of the person being called. The limitations of such a system are obvious. In 1892, the first public automatic exchange was opened in Indiana, USA. Six years later, telephones first used battery power provided from the exchanges.

The search was now on in the United Kingdom for a reliable, high-performance, automatic exchange system. The world leaders in the field were the American Telephone and Telegraph Company and its associate, Western Electric, which developed the 'Director' system and an improved version of the Strowger system, together with the Bell Manufacturing Company which promoted the very complex 'panel' system. These received lengthy consideration from the British Post Office (which had taken over all existing exchanges in 1912) but, in 1922, the decision was made to opt for the refined Strowger 'step-by-step' system.

Until around 1895, telephones linked to automatic exchanges had used a pushbutton system to signal the subscriber code, but the Strowger system changed the emphasis to the forerunner of the dial which we know today. Early telephones





were generally wall mounted, with the transmitter in the wall unit and the receiver held to the ear by hand. The 'candlestick' telephone, which was developed in 1900, allowed telephones to be held, for the first time, in two hands – the transmitter on the top of the 'stick' in one hand and the receiver taken from the cradle in the other.

Telephone system pioneers, in addition to companies already mentioned, included such names as Siemens, the General Electric Company, and Ericsson. In the United Kingdom a major force continued to be the Western Electric Company which had opened its first office in Moorgate, London in 1883. In 1925, the name of the British Western Electric Company Limited was changed to Standard Telephones and Cables Limited, and the organisation became a member of the International Telephone and Telegraph Corporation.

Both the British Post Office and the telephone manufacturers had, for some time, been experimenting with various forms of handsets. Their design, ease of handling, and the critical nature of their dimensions had become a precise science. The problem of side tone, accentuated by vowel sounds such as 'ah' and 'aw', had to be eliminated and the transmitter mouthpiece had to be able to compensate for the variations in sound input, dependent upon the strength of the voice and distance from the mouthpiece. It was the Post Office's intention to standardise on one design and there was obviously tremendous competition to gain the contract.

In 1927/8 STC completed a major development for ITT of a completely new telephone designed by L. C. Pocock. Pocock's development incorporated an entirely new design of handset with associated transmitter and receiver designed with anti-side-tone properties. The set was subsequently widely manufactured throughout the world.
Now committed to the telephone set business, STC continued to feed the home market with piece parts such as dials, transmitters and receivers. In 1938, STC produced the J.S.P. Roberton equalised receiver which became the standard Post Office type 2P, the receiver playing a big part in wartime communication systems.

After the war, new telephones of improved efficiency and incorporating equalisation were required – able to operate over ever increasing distances from exchanges. In the United Kingdom, telephones had to be operable over 1000 ohm lines, and STC, with its combination of the rocking armature receiver and the number 16 type carbon transmitter, played a

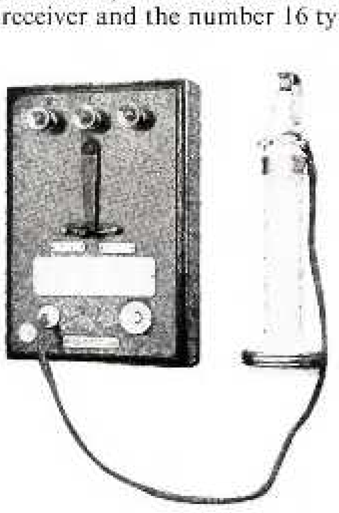
The latest loudspeaking telephone draws inspiration from the design of the earlier Deltaphone subset, together with the modern features of the pushbutton Quickstep Deltaphone.

leading part in the development of the type 706 telephone instrument which is still in use, with minor modifications, to this day.

In the late 1950s, the Post Office and the Council of Industrial Design were stressing the need for a more luxurious home telephone unit. In 1963, STC launched the two-colour Deltaphone. Its lightweight body was only slightly wider than the dial itself, and the handset, about half the weight of previous types, rested along the major axis of the set, resulting in a very compact design.

An electronic tone caller replaced the usual bell and a volume control allowed the user to set tone loudness at an acceptable level. Automatic line equalisation ensured the best possible communications conditions irrespective of the length of the line being used, and the acoustic principles employed were the same as those adopted for the high-efficiency operator's headset previously developed by STC and adopted as standard by the British Post Office.

The Deltaphone, and its intercom counterpart the Deltaline, received high recognition when they won Design Awards in



1966 and they remain popular to this day. While continuing the same design line, the new pushbutton telephone, the Quickstep Deltaphone, is being equally well received in international markets. This instrument contains a semiconductor memory that stores impulses from the keyboard, however quickly entered, and then transmits them at a speed acceptable to any exchange system.
The pushbutton telephone is the first of a new range of developments made possible by advances in semiconductor technology. An early established and remaining principle in telephone systems is that electrical power is provided by the exchange. The rapid improvements in semiconductor circuits has brought miniaturisation and an ability to work with minute currents and voltages, both opening up the possibility of telephone facilities other than speech.
Already developed are repertory diallers in which semiconductor memories in the telephone can store a personal selection of directory numbers. By operating a pushbutton a stored number is selected and transmitted to the exchange.

Semiconductors are also used to achieve loudspeaking telephones with which remote speaking and listening makes conferencing possible. This is realised in the loudspeaking Deltaphone. Microcircuits play an even greater part in the new generation key system which is now in an advanced state of development and allows a telephone to have multiline access, intercommunication conference and other facilities which were originally only possible through a branch exchange system.

Advances in material and processing technology are also beginning to change the basic parts of telephony, the microphone and earphone, Current development makes possible improved performance from units no larger than a drawing pin, which when combined with microcircuits will allow improved speech quality over longer telephone lines.

In the not too distant future, the telephone will become a miniature home or office computer terminal with access to data banks, and a video capability allowing face-to-face conversation. Much of the 'talking' will then be conveyed by digital signals allowing direct transaction with banks, stores or public services to be achieved.
It will also contribute to changes in teaching techniques and the organisation of industrial and commercial activity. Already the Post Office's Viewdata system is planned to provide subscribers with a vast information store which can be tapped at will.

A variation on the theme of the pushbutton telephone is this repertory dialler, which stores up to ten frequently-used numbers and dials them automatically at the push of a button.

Today, Alexander Graham Bell could walk into an office and exclaim 'Surely, that is a telephone!' But tomorrow, he is likely to look at it with the awe and amazement the Wright Brothers might have on seeing Concorde.

Roy Atterbury, formerly with ITT Semiconductors, is now a consultant.

Photographs courtesy of the Science Museum, Post Office and STC.

ART IN INDUSTRIAL DESIGN

by Benedict Austen

Few people question the origin of products. Most accept as inevitable those that exist, and may but occasionally offer criticism or praise of those who have been responsible for their design. The criticism or praise would rightly fall on the team of specialists who perhaps years earlier had tried to strike a balance between the elements of profit and cost, marketing, manufacture, electrical and mechanical engineering, and in many cases industrial design.

In order to appreciate the contribution of the industrial designer in striking this balance, it is useful to consider his historic context. For thousands of years the things that people have used were designed and made in accordance with long-standing traditions determined by trial and error, success and failure.

Improvements to design were gradually evolved over the centuries until products reached a high degree of sophistication, both functionally and aesthetically, all the time being designed and manufactured at the hands of a skilled artist, craftsmen who had developed a sensuous and intellectual feeling for materials and the use and function of the product, as well as for its appearance and decoration.

With the coming of the industrial revolution, the craftsman manufacturer was displaced from his once essential role as maker, and the articles which had been lovingly made by him were from then on to be produced by the new machinery of industry.

With this demise of the manufacturing craftsman, the 'artistic' element in products went too; but almost immediately there was an urgent call by minorities for an 'injection of art into industry', and it was this appeal that sowed the seeds of the industrial design profession in the early 18th century.

It was from this time that discussions about the function and raison d'être of the industrial designer, though yet not so named, began. The debate has been coloured by varying interpretations of the word art or those aspects of 'art' which relate to the industrial manufacture of products, be they concerned with appearance, decoration, form, colour or a newer consideration embracing both situational and aesthetic matters.

Industrial design has become concerned with the right, acceptable or best solution to a design problem in a particular place at a particular time in history. Thus the concept of 'situational aesthetics' has arisen where one can talk in terms of a higher level of aesthetic achievement being reached by those products that gain the greatest acceptance by the total community, divided though it may be by time and geography.

But whilst all the philosophising about the nature of industrial design was going on, designers continued designing. Since the industrial revolution they have become progressively involved with more technologically complex products. Whereas in the early days they were, as individuals, concerned with the shape and decoration of such products as textiles, pottery and furniture, they now frequently work together in teams of other specialists, among them mechanical and electrical engineers.

Unfortunately, in certain quarters, designers have had to live down the doubtful reputation built up by some artist/sculptors during the second and third decades of this century. These 'artists' had attempted to 'inject art into industry', which was what they then thought to be the missing ingredient in industrial design.

Many of these pioneering designers, ignorant of the properties of new materials, and of manufacturing and forming techniques, designed visually exciting, and certainly controversial, shapes which stretched the skills of production engineers to the limits. The ghosts of these designers, or their early contributions, still haunt the industrial scene today.

It was not until the late 1940s that industrial design courses were set up for students to be trained for the light engineering industries. These courses over the last 30 years, based principally on learning by doing which had been the philosophy of art and design colleges since the turn of the century, have been successful. Furthermore, the way has been made more easy for the new graduates to find employment by the absence of engineers trained in design.

Engineering courses since the war, perhaps in an attempt to become more academically respectable, drifted from design as an objective and concentrated on the acquisition of technological knowledge and the pursuit of pure research. New engineering graduates were left at the end of their courses to develop their design expertise as they progressed in industry.

With the immediately daily pressures of work, engineers frequently had to remain content with merely producing design solutions that worked. They rarely had the time, initiative or incentive to attack design problems at their roots, let alone to approach the design of a product as a total concept.

Nowadays, industrial designers, by their peculiar training, are taught to question their brief (even if only inwardly), to examine the market, to consider the interface between the product and the user, and to ask if the product is a nice thing to have, if it is easy to use, does it look good, and is it right to have the product anyway?

The situation has now arisen where better-trained industrial designers can exist happily in teams complementing the work of engineers, the engineer's principle concern being to ensure that the product will function and do the job for which it was designed. The industrial designer, on the other hand, cannot rest until the relationship between the product and the user has been fully considered, thereby ensuring an acceptable product not only in terms of appearance but also ease of use. The latter concern can be seen in many present-day consumer products, in table ware, furniture and domestic appliances, and not least in probably the most familiar product peculiar to the 20th century, the telephone handset.

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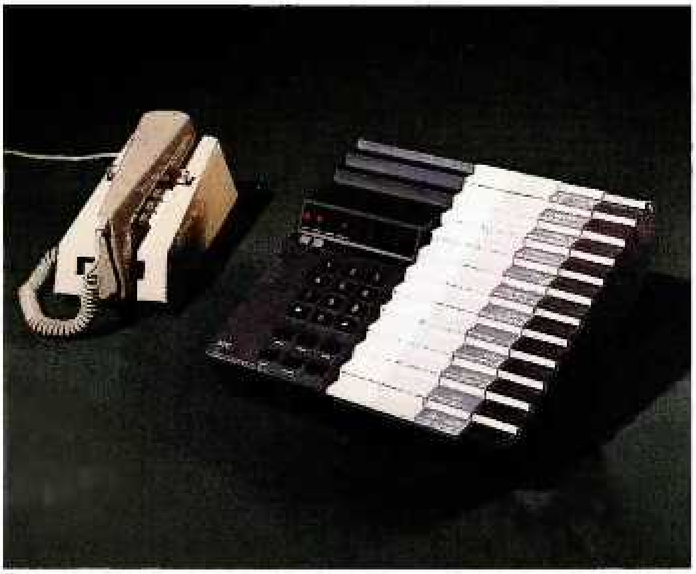

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The design of the telephone clearly has a variety of solutions, each with its own important visual, tactile and ergonomic expression, and represents a clear example of the product/user interface. When the technologist has translated the research of the scientists into a practical application, there remains the physical manifestation of the product which has to be conceived, designed and manufactured, as well as be used and seen by countless millions of people each day.

Were the telephone a new social phenomenon, the modern industrial designer might have questioned or commented on its desirability . . . he might have consulted a sociologist. Perhaps he would have commented on the quality of sound or referred to an electronics or acoustics expert for advice. The tactile, visual and ergonomic aspects most closely relate to his unique preserve, and he would hold these considerations close to his heart. If he had decided or been advised on the plastic to use for its constructions, he would be aware that certain plastics have undesirable smells and that their specification should be avoided.

Whether or not his design solution can be reproduced easily in mass production, he would resolve with a plastics technologist and production engineer, and its sales appeal would be discussed with the marketing people. The true industrial designer has matured out of his earlier simple role as 'artist visualiser', and his work now impinges on and penetrates the contribution of many other specialists and because of this he co-operates closely with them thus developing a working knowledge of their disciplines.
He comes into his own when he consults and coordinates the requirements of the relevant professions, with their often conflicting requirement, and conceives a solution, drawing sketches and making models and prototypes, at the same time writing specifications to ensure that the product can be reproduced economically and repetitively by the mass production techniques of industry.

The interface between the product and the user is often not immediately obvious. For example, if one considers much of the switching and transmission equipment used in the telecommunications network, one would be tempted at first glance to think these pieces of apparatus are made, boxed in and left to function on their own – that there is no human interface. Further thought, however, reveals that the human interface remains, be it occasional or periodic, and it is, in this complex equipment, vital.
Quick assembly, access for inspection, testing and repair are important where loss of use represents significant loss of money. If the equipment has not been designed to facilitate these activities the industrial design input is lacking, both from the social point of view (ease of use/frustration) and the functional point of view (speed of use/loss of money). It is here that the industrial designer can make an important contribution to rationalising methods of assembly and layout of components for access in inspection, testing and repair.

But he can and does contribute more to the appearance of these products. A suite of controls of a computer installation should show an attractive functional solution to the problems involved with the presentation of complex information from the machine to the operator, and, at a less technical level, small instruments can provide a refined and delightful face to those who have to live and work with them.
The increasing awareness of the surroundings by the community, and mans' current questioning of the fundamental principles which determine the shape of his environment, highlight the importance of the contribution of the industrial and engineering designer. The industrial designers' work is becoming no longer considered as a luxury for the elite, but as a necessity for a good economy and the creation of an habitable environment. His peculiar training encourages him to approach design problems with an unusually open and sensitive mind, which has variously been referred to as lateral or divergent.

His present and future concern is to look at design problems not merely in the light of satisfying a brief put to him by his client, but to put his brief, as all professionals should, into a global context, where the economic solution to a problem is recognised as only part of the answer.

Benedict Austen is manager, professional services with the Design Council.

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(page 13) As products become increasingly complex, the industrial designer works more closely with the technologists involved. In this visual display unit, the designer has worked with computer and electronics engineers in exploiting fully the advantages of an electronic readout to provide an ergonomic solution to the presentation of information and also an attractive working environment.

1 Good design, as well as fulfilling the functional requirements of a product, must incorporate the requirements of the user. Should the equipment be operated in a sitting position, as with a teleprinter, the equipment needs to be positioned on a work surface at a height related to the height of the operator's seat, thus ensuring that the hands of the operator coincide with the manual keyboard at the right height and in a comfortable position.

2 A new design of repertory dialler offers a high degree of aesthetic achievement, as well as technical performance and ease of manufacture, compared to the previous generation of similar product which was a combination of craft and sculpture, and modern materials.

3 Where individual products are used in systems, both the system and product designs have to be considered. The ITT 600 *ADX* message switching system, which received a Design Council award in 1972, is an example of a system incorporating elements of computer and telecommunications technology.

4 The concern for the human interface is not always evident in complex equipment. However, assembly, installation, testing, fault finding and maintenance are aspects of the human interface that figure prominently in the design of telecommunications transmission equipment.

5 In the past, the appearance of specialist electronic equipment has often been neglected. Modern instruments, typified by this laboratory power supply, are easy and pleasing to operate and present an attractive face which can help to increase their sales appeal.

6 The word 'modular' is often associated with attempts by industrial designers to rationalise the development of products. In the context of the design challenge posed by a modern electronic telephone exchange system, the modular solution provides clear technical and manufacturing advantages as well as facilitating the human interface with the various component parts of the system.

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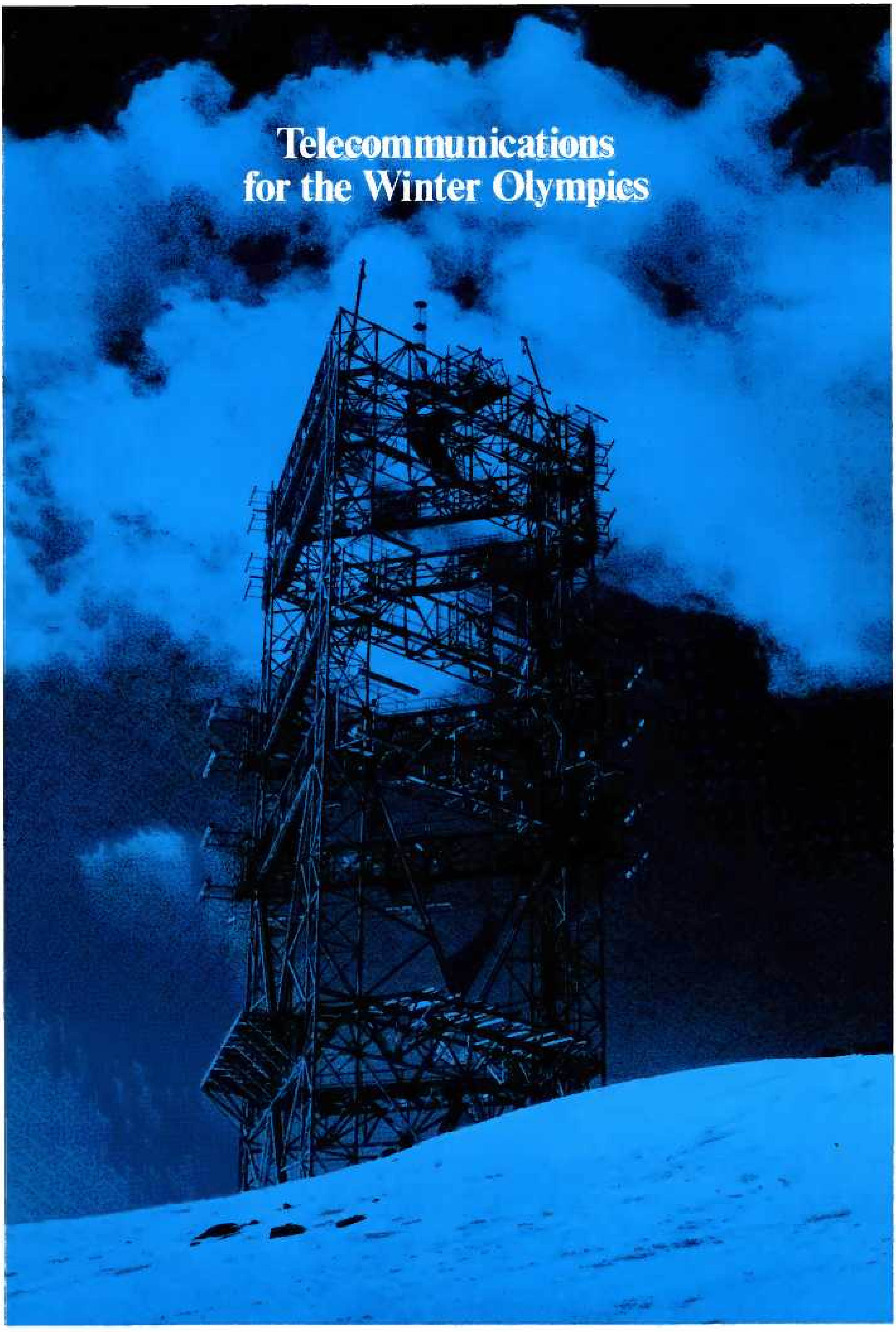
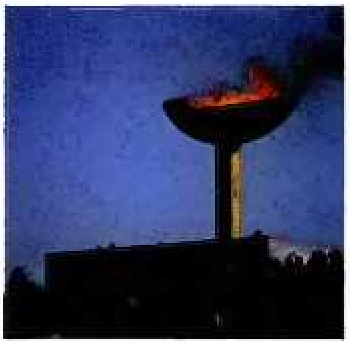
Telecommunications for the Winter Olympics





Innsbruck, heart of Austria's Tyrol region, and scene of the XII Winter Olympic Games. The Winter Olympics are a spectacle few are fortunate to attend, but which millions can enjoy through the facilities provided by modern telecommunications technology.

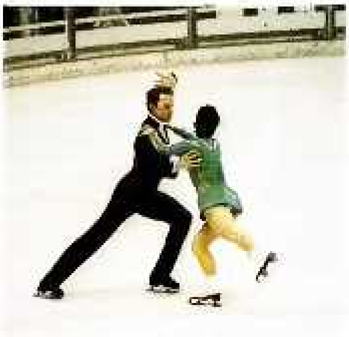
To cater for the needs of television and radio broadcasters and newspaper journalists from all over the world, extensive television, telephony and telex communications facilities are required. Only a small proportion of these circuits could be provided from the existing public telecommunications network and from the remainder of the circuits installed specially for the Winter Olympics last held in Innsbruck 12 years ago, most of which have now been taken into the public network of the Austrian telephone administration (Osterreichische Post- und Telegraphenverwaltung – OPT).

In addition to the demand to special circuits, the public telecommunications network serving both national and international routes has had to be substantially extended to serve the 100 000 plus visitors to Innsbruck and the whole Tyrol region. Extensions of the public network in the Tyrol which had been planned for 1976 and 1977 were therefore brought forward, in addition to further new installations of switching and transmission equipment for the duration of the Games.

In the course of extensions to automatic telephone exchanges in the Tyrol area, some 30 000 exchange connections were installed, which will provide the basis for the installation of a corresponding number of new subscriber lines during the next few years. In the field of telex switching, equipment for 180 additional connections was installed in the Innsbruck telex exchange, while 312 carrier telegraphy channels were installed to link outlying districts with the teleprinter network.

A new long-distance 6 GHz wideband radio link system providing three plus one television and 1800 telephone channels was also built to link Innsbruck with Pander and Feldkirch in the far west of the country. This route uses relay stations located at easily accessible points in the mountains, so that, besides doubling the capacity of the existing facilities on another alternative route, the new systems are easier to maintain and give a higher security of service.

To realise such a large project – six repeater sections with an overall line length of almost 600 km – in a short space of time, most of the new relay stations were housed in containers rather than in fixed buildings. These containers were partly equipped before being transported to their sites in the mountains by helicopters provided by the Austrian Army, some of the relay station sites being between 2000 m and 3000 m above sea level.



In a similar way the antenna platforms were also transported by helicopter and installed right over the containers already *in situ*. Using this method, it was possible to install a completely new radio link system in difficult circumstances in under a year.

On the international link between Innsbruck and Munich, the existing radio link systems were extended for the duration of the games by two television channels. In Innsbruck itself a new radio link system with eight television channels was established between the transmission centre of the OPT and the Olympic Games broadcast centre. Television cameras serving the different sports areas were provided with their own mobile radio link systems to connect with the broadcast centre, these mobile systems feeding television signals into the long-distance transmission systems of the OPT via video switching equipment specially installed for the Olympic Games.

To improve the telecommunications facilities in the areas immediately to the west of Innsbruck where a lot of sports events took place, two new 4 MHz coaxial line systems each with 960 channel capacity were installed. After the Olympic Games, one of these systems will be extended to the western border of Austria through the new Arlberg road tunnel, and will then be equipped with a 12 MHz system for public telephony.

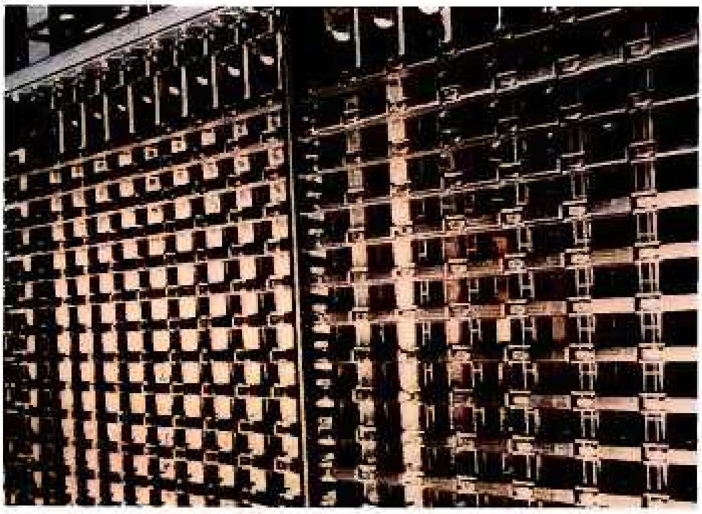
The coaxial line systems each handled 16 primary groups for the purposes of the Games, while for the increase in the number of public circuits a similar number of groups was needed. In the Lizum area where most of the ski races took place, these groups were extended by 12-channel systems operating over symmetrical cable pairs. A number of other coaxial systems providing 120, 300 and 600 telephone circuits were also installed in the Tyrol area.

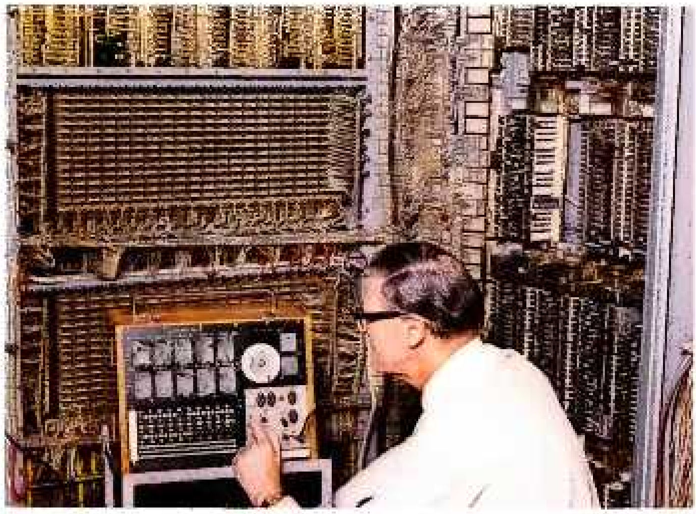
Besides frequency division multiplex telephony and television systems, a number of symmetric pair links with up to 900 pairs per cable were necessary to connect the different centres. These included smaller cables between the various press centres and the connecting stations near the different sports areas (the ice stadium, ski jumping area, bob route, ski route etc.) and also the commentary points along the ski and bob routes themselves.

To facilitate the work of the world's press corps attending the Games, the OPT installed 206 telephone booths and 85 teleprinters, with 42 tape machines and 70 radiophoto connections. For the special Olympics services in the Innsbruck area, 599 OPT employees were seconded for the duration of the Games including technicians and exchange operators. Those employed as telephone or telex operators underwent a specially-designed 6 week English language course using the most up-to-date methods of instruction and employing teaching machines.

Through its transmission division, STC has supplied equipment to the OPT in connection with the Winter Olympics. Substantial quantities of multiplex equipment were ordered for the expansion of the communication facilities in the Innsbruck area, and the company has also supplied all of the 12 MHz coaxial line systems which constitute the OPT's backbone trunk network.

Photographs courtesy of Austrian National Tourist Office, OPT and Frank Wilcox/Rex Features.





The Post Office twice increased telephone call charges during 1975. Several organisations reacted on the second occasion by, among other things, restricting outside calls during the morning peak period. The result was that mornings became frustrating and afternoons chaotic, so that far from being an essential instrument of business, the telephone suddenly became looked upon as a sieve leaking money.

After this initial reaction more managements took a closer look at the problem, and have shown an interest in one solution that helps cut costs and increase efficiency. This is the creation of their own private communications network. It involves taking a leaf out of the Post Office's book, and what an organisation does is to emulate the public subscriber trunk dialling (s.t.d.) system in terms of its own needs.

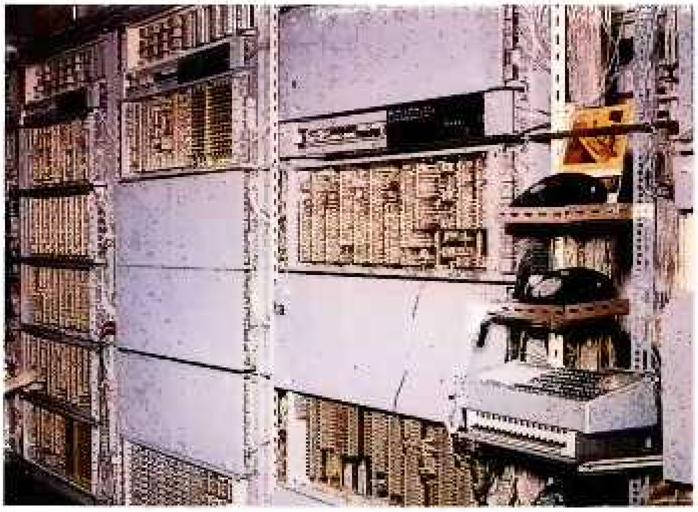
For example, Unilever, which opened Britain's largest private network during the very month that telephone charges went up, has desk-to-desk communication for over 30 000 extensions in 177 locations. These locations are linked by lines leased from the Post Office. This is a unified system in that a user, wherever he is within the organisation, dials the same digit to get access to the network and then the address code for a particular location followed by the extension he requires.

All this is under the control of the organisation's own automatic switching centres. There is a common dialling code book, as for the public network. This is a planned and engineered system, and must not be confused with a spiderwork of interconnected lines that has grown haphazardly over the years. In that kind of pseudonetwork one has to check, when visiting another location, what the dialling routine is for getting back to one's own office.

A planned and engineered network is not just the prerogative of a large organisation like Unilever. It can be adopted where there are only three locations. Whether it is economic depends initially upon the pattern of the telephone traffic and how many calls are made at each location. This has to be established by a traffic study over a period of at least a week – a 1-day period is not sufficient to establish a pattern – to assess the number of calls, their individual duration and total distribution over the working day. Important figures to establish are the greatest volume of traffic and the time at which it occurs.

To get an accurate picture, employees need to be asked to log their calls to other locations for the complete study period, or the Post Office will undertake this investigation on a company's behalf. The traffic logged can then be costed for the public network and a comparison made with a possible private network that will cope with an average volume of busy hour calls, taking into account the cost of installing one's own switching centres, the leasing of lines from the Post Office, traffic growth and any other significant factors.

Nearly always a loading factor has to be agreed to allow for contingencies and the extra traffic that will be generated simply because a quick and efficient system is to hand. Analysis for a large installation has to be done on a computer, and the planning and design of an appropriate system could take as much as 2 years.



'Traffic patterns obviously vary according to the structure of organisation, the nature of their business, whether one division has a community of interest with another, and so on', points out Owen Case, communications manager of GKN. 'Networks are individual, each meeting a different set of specific needs'. For this reason they are often described as 'dedicated'.

Nobody has yet created the self-contained bureaucracy postulated by Professor Parkinson in which the staff pass messages entirely to one another and have no contact with the outside world. Certainly the cost of making calls to the outside world has increased so much and so often that more managements are looking to private networks as a possible economy.

Wideband circuits, the main telecommunications 'highways', can be leased from the Post Office at a negotiated rate. A major cost item can thus be calculated. Once operating, a system can be used for 24 hours a day, 7 days a week for no further circuit charge.

(far left) A close view of a crossbar multiswitch

(above left and centre left) A tandem exchange system established by ITT Business Systems at its Foots Cray site to solve interswitching problems between step-by-step and crossbar exchanges.

(below left) Part of a tandem switching centre

(above) Pentomat private automatic branch exchange consoles situated in a modern office environment.

(above right) A tandem switching centre showing the alarm signals.

(right) A bay of switching racks for a Pentomat 1000T exchange.

Executives do not have to reorganise their day to avoid making morning telephone calls, making life more convenient and business more efficient. Nor in the evenings do they have to curse because the switchboard operator has gone home. The desk-to-desk communication is still there.
Indeed, by reducing dependence upon the public network an organisation may well be able to economise on its number of outside lines and on operators. A good internal network also makes it easier to bar certain extensions from access to the public network.

Switching centres do not necessarily have to be sited in high-cost city areas. British Steel's manager, speech and transmission, Fred Harris, has been working closely with ITT Business Systems on the planning and engineering of a network that will have six centres: one in its London headquarters, the largest one near Rotherham, one on Teesside, another at Ravenscraig in Scotland, and two in South Wales. Metal Box has its centres at Acton in West London, Worcester and Westhoughton near Bolton. 'This last was the most economic of six possible sites in the area', says Jim Davey, Metal Box communications manager.

Dialling on a private network involves fewer digits for a better service. For example, from a London office a public call to Liverpool involves dialling 11 digits which usually only gets you to the distant operator who will have to connect you to your extension. Compare this with Unilever's private system; using a maximum of seven digits you can dial from London to Port Sunlight and be talking to the extension you need.

Connections are faster on a private network because you are not competing with other public subscribers for a line. 'Our direct dialling system gives us immediate connection to any one of some 4500 extensions', quotes Jim Davey. 'These are spread over 54 locations'. A call is also routed through fewer exchanges on higher quality lines so the speech is clearer. If crossbar switching is used, as in the Unilever system, then the speed of connection between centres is increased.

All these advantages have become more apparent within the last year, as communications costs have risen. Higher telex charges have made managements more conscious of the value of operating their own message switching systems. For some time there has been an increasing pressure exerted by data processing managers concerned with the transmission of data from terminals to computers and from one computer to another. Many people have had the network notion.

This has highlighted the role of the communications manager, who, it is increasingly being realised, has a much more important function that just advising on individual pieces of equipment. His job is becoming more and more divorced from office management. He has to look at the provision of integrated systems, be they for voice or data, or more ambitiously for both.
Far-sighted managements are looking at networks including facsimile transmission; at the use of Telenote, a 'moving facsimile' that reproduces sketches and notes as they are being drawn at the other end of the line; at message switching systems using modern teleprinters that are as compact and quiet as electric typewriters; at visual telecommunications conference facilities to save groups of people travelling; at the possibility of correspondence being composed at one location and typed in another, with the communications network doing the postman's job.

Nor is the application of these ideas limited by national boundaries. Multinational organisations will more and more develop multinational communications. As major users they will expect telecommunications to provide the facilities so necessary for the efficient conduct of international business.

Those who were early to put the network notion into practice were able to see the cost advantages only too clearly. In such circumstances the advantages must be very well defined. Installing a network undoubtedly increases the efficiency of an organisation, and properly designed it will bring great economic benefits.

First fibre optic link ensures Police communications

14.05 Car involved in accident outside the New Street Garage. Petrol spilt on the road. Nobody injured.

14.06 PCs 700 and 301 traffic east attending.

14.08 Traffic supervision attending.

14.09 Fire control informed of possible fire hazard.

14.11 Local authority requested to sand road.

15.00 Car removed. Road now clear.

A fictitious, but typical, incident of the type dealt with daily by Dorset police in the eastern division control room at Bournemouth. It could equally have been a serious crime or a major civil disaster. Or a distraught mother who had lost her child. But in all cases, two common factors would prevail. The need to know, almost instantaneously, an accurate location and duty commitment of both foot and mobile police patrols, and the means of deploying the nearest unit to deal with the problem quickly and effectively.

Thus communications and control are the essence of modern police work. To preserve the integrity of its command system, the Dorset police have recently installed what is believed to be the world's first operational fibre optic link (as opposed to experimental prototypes). This is used to connect visual display units in the control room with the computer in another part of the building which contains details of the disposition of the various police patrols.

The police communication system is based on both v.h.f. and u.h.f. networks, the former being used by mobile patrols and the latter for the personal radios of panda and foot patrols. So that the duty and location of any mobile patrol is known in the control room at any given moment, semi-automatic car locators are fitted into all vehicles. These use a coded tone generator, set by the vehicle crew, to transmit information to the control room, where it is automatically recorded on punched tape and committed to the computer memory.

Similar information for the foot patrols is sent by speech, the details then being encoded and entered into the memory via a keyboard. However, the Dorset police are experimenting with methods of sending coded data via u.h.f. pocket radios in the same way as with the car locator system. It is probable that in the future all police patrols will send routine information about their duty and location, whether by v.h.f. or u.h.f., by these means, leaving the communications channels clear for urgent operational messages in plain language.

With valid data about the disposition of patrols available, which is automatically updated when a vehicle crew resets its locator system or a foot patrol reports a new duty, the police radio controllers can readily alert the nearest patrols and reassign resources to meet any emergency situation. This information is obtained from the computer by a visual display unit located on the controllers' desk. By keying-in an area code, a list of nearby patrols and their status is presented in alphanumeric form on the v.d.u. screen, and the positions are also presented on a wall map to provide a complete geographic picture.

It is this link between the computer and the control room which is vital to the continuing efficiency of police operations. In 1974 the link was put out of operation by a lightning strike, which caused severe damage to the computer installation and disrupted communications for several hours. The loss of real time data for operational control and management information purposes lasted for several months, and it was to prevent such a recurrence that a fibre optic link was installed.

Since the concept of optical communications was first put forward ten years ago by Standard Telecommunication Laboratories at Harlow, research and development activities have highlighted a number of advantages for fibre optic systems. The use of optical means for the transmission of information provides a high bandwidth, a high degree of security, no cross talk between adjacent channels, freedom from electromagnetic or radio frequency interference, and, as in this application, immunity to damage from electromagnetic surges such as are produced by a lightning strike.

The system employed by the Dorset police was designed and installed by the Leeds-based optical equipment division of ITT Components Group Europe, in association with the Home Office Police Scientific Development Branch. Based on optical fibre cable and terminal technology developed by STL and ITT Components Group, the system uses pulse position modulation techniques for the transmission of an analogue video signal to the visual display units.

The system consists of two terminals and a length of optical fibre cable, with optical connections being made by means of modified ITT Cannon circular multiway connectors. The cable itself consists of three plastic-coated low-loss operational optical fibres, together with five stand-by fibres which help to preserve cable geometry and a central plastic strength member, the latter ensuring that undue stress is not experienced by the optical fibres. The whole is encapsulated in an extruded polyethylene sheath.

(above)
The control room of Dorset Police's eastern division at Bournemouth.

SPACE AGE SOUTERS OF SELKIRK

by John Wilson

The border is barely marked as you cross from Northumberland through the Cheviot Hills into Scotland. Change, at first, is barely perceptible but you suddenly realise that this is it – the Scottish Borderlands of Roxburgh, Selkirkshire and Berwickshire.

A landscape of rolling hills well stocked with Black-face, Highland and Cheviot sheep, and Galloway and other hardy breeds of cattle. In the valleys, the fast-running salmon and trout streams of the Teviot, Yarrow and Jed flowing into the River Tweed. Fragments of forts and ruined, but still noble, abbeys are a reminder of centuries of border skirmishes.

Above all, this is the country of Sir Walter Scott who immortalised it through his poems and novels, and once in the area it is hard to escape from him. After the enormous 200 ft-high Gothic memorial at Edinburgh, the city of his birth, his most enduring monument is Abbotsford House, near Melrose, which he built and furnished over a period of 12 years and at which he died in September 1832. Like many prolific authors, Scott was also profligate and needed an enormous output to keep abreast of accumulating debts, not least those arising from Abbotsford House.

Walk through the town of Selkirk and you'll find a statue of Sir Walter Scott, who was Sheriff there from 1799 to 1832. Although small, with a population of only some 6000 souls, Selkirk is the county town of Selkirkshire, with a Royal Burgh Charter granted by David I in the 12th century and renewed by James V in 1535.

The ancient craft of the citizens was shoemaking and in the dialect of that day those employed as shoemakers or cobblers were known as 'souters', a term which still lives on. Selkirk's souters were eventually to abandon shoemaking in favour of the woollen trade, which is the most ancient of Britain's staple industries and of great importance since medieval times. Scotland has a long history as a manufacturing area for specialised high-quality woollen cloth, and the Border counties especially for the style and quality of cloth known as tweed.

Galashiels, Hawick, Selkirk and Peebles are the best-known tweed and knitwear towns, and are still very active in wool. But the advent of man-made fibres and the ready availability of cheaply imported goods from low-cost labour areas throughout the world has necessarily reflected on the prosperity of the traditional local industry. New industries needed to be introduced, and today we find that some of the descendants of the ancient souters of Selkirk are involved in space-age technology.

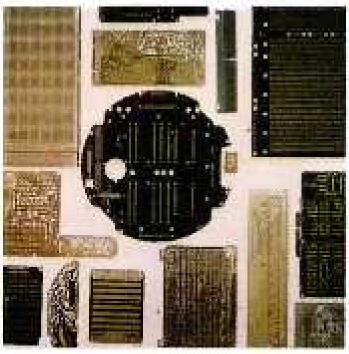
One of the most modern factories in Selkirk is owned by Exacta Circuits Limited, founded in 1962 by two men and now one of the top three manufacturers of printed circuits in

Photographs courtesy of British Tourist Authority, Hawker Siddeley and Exacta Circuits Limited.










the United Kingdom. During its early years Exacta occupied, appropriately enough, a former textile mill in nearby Galashiels, but rapid expansion of business dictated a move. Land was acquired at Selkirk and the present main plant and offices, completed in 1971, were the first in Britain to be designed specifically for the large-scale manufacture of printed circuit boards. With the opening of the new factory, the old premises at Galashiels were retained as a store and as a manufacturing facility for short-run and specialised circuits.

Printed circuit boards have revolutionised the construction methods, the performance and reliability, and the cost of electronic equipment. The technology is comparatively new, the first printed wiring being achieved in pioneering form in 1941 and the first patents being filed in 1943. In the post-war years the techniques have advanced rapidly and present-day achievements in data processing, aerospace, telecommunications, industrial electronics and home entertainment all depend on the printed circuit as a fundamental building block. Printed circuit board design and production is a multi-disciplinary activity employing the skills of the chemist, the metallurgist, the electronics engineer, the printer and the mechanical engineer.

As with most products for the electronics industry, the total market may be divided into the consumer and professional sectors, the former market being dominated by cost and volume of production and the professional market with quality and reliability as the predominant factors. The policy of Exacta, since its earliest days, has been to serve the professional market, and now its customers include almost every major manufacturer of professional electronic equipment in the United Kingdom, as well as large international corporations and hundreds of medium and small manufacturers.

The basic technique in p.c.b. manufacture is to take an insulating board coated with copper foil and to print the layout of the required 'tracks' (wiring) with acid resistant ink. Surplus metal may then be etched away leaving the wiring 'printed' on the board. The simplest of these boards have wiring on one side only, but double sided boards are also made by this process.

Where more complex circuitry is involved, boards can also be manufactured with tracks on both sides, interconnected by copper deposited in drilled holes. These boards can use soldered through, through pinned or p.t.h. (plated through hole) techniques. In the latter case they are generally made from a copper-clad epoxy glass laminate by first drilling and chemically metallising the required hole pattern and then electroplating 0.025 mm of copper on the hole walls and track pattern. The track pattern is defined by a plating mask applied either by screen printing or, in the case of highly complex patterns, by a photomechanical mask. Finally, the tracks are over-plated usually with tin/lead (solder), the mask removed and the unwanted copper between the tracks etched away.

Plated through hole techniques enable up to 150 integrated circuits to be mounted on one board with often more than 4000 holes and as many tracks interconnecting them. Exacta Circuits has specialised in the production of these types of p.c.b.s since 1966.

Further technical developments resulted in the multilayer board, in which several layers are bonded together under heat and pressure with the result that copper tracks are at various levels throughout the interior. Naturally, such boards can carry even more tracks than a double-sided p.c.b.

For applications where space is at a real premium Exacta Circuits has developed special manufacturing techniques. An example is the Harrier jump-jet where, in conjunction with the customer, Ferranti, multilayer circuits with inner layers constructed in Kapton were developed, enabling flexible tails to extend directly from inside the board to contact points on various parts of the airborne equipment.

Printed circuit board manufacture is a capital intensive industry with high levels of automation in the production processes and great sophistication in equipment and methods of inspection and quality control. As well as numerically-controlled multispindle drills and fully-automated electroplating lines, computer-controlled production and quotation systems are used for speed and efficiency. The Exactaplan system has also been developed, in which use is made of a standard grid system for customers who need experimental prototypes and small production quantities with quick delivery at modest cost.

A new production line has recently been established at the old premises in Galashiels and this will be used exclusively for volume production of high-quality printed circuits for the new generation of TXE4 electronic telephone exchanges which, were developed by STC in conjunction with the British Post Office. The production contract is such that Exacta will this year become one of Britain's biggest industrial users of gold for plating the connector 'fingers' on the plug-in edge of each board.

The burghers of Selkirk have a proud history and live on, adapting their skills to modern needs. But Sir Walter Scott, novelist and poet, could never have imagined in his days as Sheriff that the 1970s would see the souters operating along the new borders of space-age technology.

John Wilson is a writer and journalist specialising in the telecommunications and electronics industries.

New Hydrospace Division formed

A growing area of activity where STC's traditional expertise in communications is facing new and exciting challenges is in hydrospace. With over 120 years experience of the development, manufacture and supply of undersea cables, systems and equipment, STC and its predecessor companies have acquired an extensive knowledge and expertise of the problems to be overcome in a harsh underwater environment.

The continuing growth and success of the company's activities in this demanding field has now led to the formation of a new hydrospace division. This brings together the hydrospace activities formerly carried on in the company's telephone cable and submarine systems divisions.

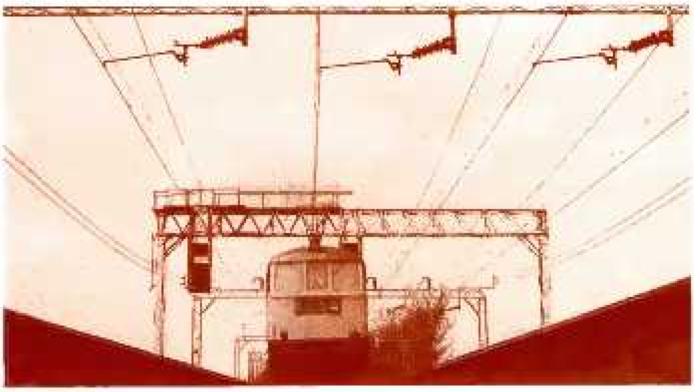
Hydrospace activities within STC include the design and manufacture of special-purpose electrical and electromechanical cables, shipboard cable and mechanical handling systems, and cable glands and terminations. A complete marine system capability is available, ranging from initial survey, through design, manufacture and installation, to final commissioning.

The company is an international leader in underwater electromechanical cable technology. These cables combine electrical circuitry with mechanical load-bearing capacity and are employed in both static and dynamic modes. Some types incorporate pneumatic and/or hydraulic services. They must withstand the vibrational forces and shock loads associated with towing underwater bodies in sea states up to gale force conditions, and operate reliably under all other marine and environmental conditions.

Over 500 electromechanical cable types, each specially designed to meet a specific need, have been produced to date. Cables for the remote control of underwater vehicles, towing cable for sonar devices, underwater cables for offshore drilling applications, and cable for undersea surveillance systems and life-support umbilicals are some of the many types already developed. Lightweight optical cable is also being tested for use in some of these applications.

Complete shipboard handling systems for submarine cables, diving chambers, towed systems and other underwater equipment are engineered, produced and installed, together with a range of high-quality pressure-tight housings, cable glands, encapsulated products and cable jointing equipment. A plug and socket has recently been developed which is unique in enabling true underwater connection while energised.

TOPS Goes Nationwide



The final stage of British Rail's nationwide computer-based system which continuously monitors and provides up to the minute reports on the operations of its 175 million ton a year freight business was inaugurated in October 1975 by the minister for transport, Dr. John Gilbert.

A brief ceremony marked both the end of a quiet revolution on British Rail, during which thousands of its employees have learnt new technical skills, and the beginning of a new era of freight management where the information for decision making is now at the finger tips of local staff. Now that the £16 million TOPS system covers the national rail network, substantial financial benefits are expected to accrue from a reduction in the wagon fleet, from lower train movement costs, and from providing a better service to the customer.

Through computers located in London, which are linked to 155 freight centres throughout British Rail's 11 500 route mile network, TOPS (which stands for Total Operations Processing System) provides continuously updated information about the location and status of every wagon in the fleet. Freight managers thus have immediate access to all details of every wagon in or en route to their areas, yard managers can get several hours notice of the volume and type of traffic with which they will have to deal, and headquarters staff can monitor the performance of any part of the network.

At present TOPS is mainly being used for processing information about wagons, a total of around 300 000, including privately owned and ferry wagons and some 30 000 used for engineering purposes. But plans are in hand for the scope of its operations to be extended to embrace parcel vans and locomotives. With details of all these wagons stored in the computer's memory, together with an hour-by-hour record of their use in traffic, TOPS will provide a valuable bank of information for a wide range of planning and operational needs.

Information for the operation of the TOPS system is routed to the communication data control centre in London via British Rail's own telecommunications network. This is comprised in the main of a nationwide web of coaxial cables, capable of carrying up to 960 high-quality telephone or data circuits.

Through its telephone cable and transmission divisions, STC has supplied much of the equipment for this network, including coaxial cable, coaxial line systems and frequency division multiplex equipment, as part of the development of British Rail's national telecommunications plan.

First 30-channel Systems

With the completion of installation and commissioning work at the British Post Office's Skyport telephone exchange near Heathrow in November 1975, the first complete 30-channel pulse code modulation systems to be ready for field trial operation in Britain were handed over to the Post Office by STC's transmission division.

Operating over a 27 km route from the Faraday exchange in central London, the field trial systems were developed by STC under a contract awarded in 1974, and 124 dependent regenerative repeaters and 12 terminals were supplied for operation over existing audio-pair cables.

The 30-channel p.c.m. systems provide up to 30 telephone circuits over two pairs of audio cables in the junction network. Such systems have a transmission rate of 2.048 Mbit/s and form the first level in the Post Office's planned digital communications network.

Following the invention of the concept of pulse code modulation by the late Alec Reeves of Standard Telecommunication Laboratories in 1938, it was not until the development of modern semiconductor technology that economic systems could be produced.

STC pioneered this work with experimental systems in the early 1950s, followed by the first working 24-channel p.c.m. system in 1956. Subsequently over 1700 such systems have been supplied to telecommunications administrations throughout the world. The latest 30-channel systems mark the latest step forward in the development of digital transmission.

The Largest Ever Export Order . . .

A single export order worth £40 million for an undersea telephone transmission system between Europe and South America has been won by STC's submarine systems division. This is the company's largest-ever single export order and is for a 3240 nautical mile long link capable of carrying 1840 simultaneous telephone conversations between the Canary Islands and Venezuela, the contract being placed jointly by the telecommunications administrations of Spain and Venezuela.

Named Columbus, the system will be Venezuela's first direct cable link with Europe and will supplement its existing satellite communication links. STC will manufacture and install the entire system, which will be ready for service before the end of September 1977.

The cable runs from Maiquetia, near Caracas in Venezuela, to Aguimes on Gran Canaria. Connection between the Canary Islands and the Spanish mainland, and thus to Europe and beyond, is over the existing Pencan 1 and 2 undersea telephone systems. Totalling 2000 circuits, these systems were also supplied by STC.

Columbus will be the third such major STC project involving a Latin American country. Undersea telephone systems previously supplied by the company are in operation between Brazil and the Canary Islands and between Venezuela and the Virgin Islands.

. . . Order for World's Largest Capacity System

The company's submarine systems division has also been awarded a £25 million contract for a high-capacity undersea telecommunications link with Spain, the order being awarded by the Compania Telefonica Nacional de Espana. The system, to be called Pencan-3, will run for 750 nautical miles between Chipiona on the Spanish mainland and San Cristobal in the Canary Islands.

The system has a bandwidth of 45 MHz and will have a capacity of 5520 circuits on this route. It is the largest-capacity submarine communication system available anywhere in the world, and when ready for service by the end of 1977, it will be the fourth and longest of its type to be installed.