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tele communications

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ONE SHILLING

AND

SIXPENCE

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Contents

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A Year of Achievement

IN its annual Report and Accounts for 1961–62, the first year in which it operated as a nationalised industry, the Post Office has a mixed story to tell.

Financially, the year was disappointing compared with the two previous years since business expanded more slowly and costs rose more rapidly. The telecommunications profit was only £12.6 million, against £18.4 million in 1960–61. But the achievements, both postal and telecommunications, were considerable.

Mechanisation and automatisation, says the Report, helped to produce a quicker, more efficient and cheaper telephone service. The number of telephones rose to 8.6 million and more calls then ever before—4,975 million —were made. Some 78 manual exchanges were converted to automatic working during the year so that at the end of March, 1962, there were 5,277 automatic exchanges, serving about 84 per cent. of all subscribers.

The Subscriber Trunk Dialling System was further expanded, the number of STD exchanges increasing to 250. Excellent progress was made, too, in the development of electronic exchanges and the first experimental one to carry public traffic will soon be brought into service. The telex service is also growing rapidly.

The overseas services were also expanded and improved, notably by extending the submarine cable system and increasing the speed and capacity of the telephone system through more mechanisation. The most significant achievement was the setting up of an experimental satellite communications ground station at Goonhilly which, as this issue went to press, was playing a leading part in the remarkably successful tests carried out with *Telstar* in bouncing telephone, telegraph, television and data transmission signals across the Atlantic.

Both at home and overseas the Post Office has provided a faster, more efficient and more widespread service but, as the Report emphasises, future success depends very largely on whether the customer is prepared to pay a price which fairly reflects what the service costs and gives an adequate return on the resources employed.

The 11th of July, 1962, was a memorable day in the exciting and exacting science of space communications. On that day the first television picture was flashed across the Atlantic by way of the artificial satellite *Telstar*. In the days that followed even more remarkable results were achieved on both sides of the Atlantic

TELSTAR

IT was 45 minutes past midnight on Wednesday, 11 July, and a team of engineers at the Post Office experimental satellite communication ground station at Goonhilly Downs, in Cornwall, began anxiously watching the monitor screens.

But the screens remained blank as the giant aerial outside changed its elevation and direction, searching the sky for an earth-bound satellite called *Telstar*. The minutes ticked by and still nothing happened.

Then, suddenly—at exactly 1 a.m.—a picture appeared on the screen, at first only a vague shape and then recognisable as Mr. Frederick Kappel, chairman of the American Telephone and Telegraph Company.

It was an historic and exciting moment. For the first time a television picture had been transmitted across the Atlantic by bouncing it off an artificial earth satellite. And, though Goonhilly experienced some technical difficulty and the picture lasted for only a minute before disappearing as *Telstar* went out of view on its sixth pass, it marked the beginning of a new era in the science of communications. The technical problems were soon overcome and on the following day the Goonhilly Station performed extremely well.

There were other no less historic and exciting moments within a few days of the transmission of the first television signal. In the early hours of Thursday, 12 July, television pictures of excellent quality were received at Goonhilly from the American ground station at Andover, Maine, and pictures which included some night scenes from Paris were received from the French station at Pleumeur-Boudou. Two hours later, as *Telstar* orbited the earth for the 16th time, the first live television pictures, showing the Goonhilly station and a young man and woman seated beside a river, were sent from Goonhilly to America. Reception in the United States was described as "brilliant and perfect", and the pictures were broadcast live over the CBS television network in the United States.

Early in the morning of 13 July, Post Office engineers at Goonhilly and engineers at the American station exchanged the first telephone calls by way of *Telstar* simultaneously with facsimile pictures, including one of Princess Anne, which were sent from London to New York and from New York to London with very satisfactory results.

The following day the first telephone call using the public network by way of *Telstar* was made when Sir Ronald German, Director General of the Post Office, spoke to Mr. Eugene McNeely, President of the American Telephone and Telegraph Company. Then, on Monday morning, 16 July, on the initiative of the Post Office and with the co-operation of BBC television, the first colour pictures to be sent across the Atlantic by

Continued overleaf

The first television picture by Telstar. *It shows Mr. Frederick Kappel, chairman of the AT and T Company, sitting at a desk, and was "bounced" off* Telstar *from America. Subsequent television pictures to and from the United States were of much better quality.*

TRIUMPHANT

A test card showing a map of Great Britain and bearing the Post Office crest was one of the first pictures to be sent from Goonhilly across the Atlantic to the American satellite communication ground station at Andover, in Maine.

The first live television picture sent to the United States from Europe showed the inside of the Goonhilly station. Seated (right to left) are: Mr. F. J. D. Taylor, Staff Engineer, Captain C. F. Booth, Deputy Engineer-in-Chief, and Mr. R. W. White, an Assistant Staff Engineer.

satellite were transmitted from Goonhilly. Andover reported: "Colour good; picture quality excellent."

Several days later—on Thursday, 19 July—the first press telephone calls were satisfactorily exchanged between Britain and America, followed by an exchange of colour television pictures between Andover and Goonhilly, again with excellent results.

On 23 July the first joint European television programme to the United States, preceded by a television programme from America to Europe, was sent across the Atlantic via *Telstar*. The European programme included pictures of Gaellivare, in the Arctic Circle in Sweden, the southern coast of Sicily, Vienna and Lands End to show the extent of the network, and contained shots from London, Paris and Belgrade, of the Sistine Chapel in Rome, blast furnaces at Duisburg, Germany, and the European Centre for Nuclear Research in Geneva.

Seldom can scientific achievement have been attended by so many remarkable successes—and all of them at the first attempt. Little imagination is needed to appreciate the technical promise of this new instrument of communication. World-wide television is only part of its possibilities for it will undoubtedly make a major contribution, too, to world-wide communications by telephone, telegraph, facsimile and data transmission.

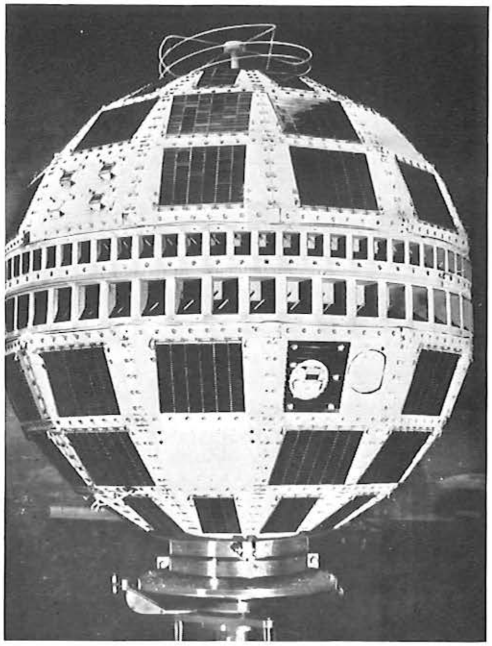
LEFT: *One of the first television pictures transmitted by the French station.* BELOW: *Sir Ronald German, Director General of the Post Office, who made the first public telephone call via* Telstar *to America.*

THIS IS TELSTAR

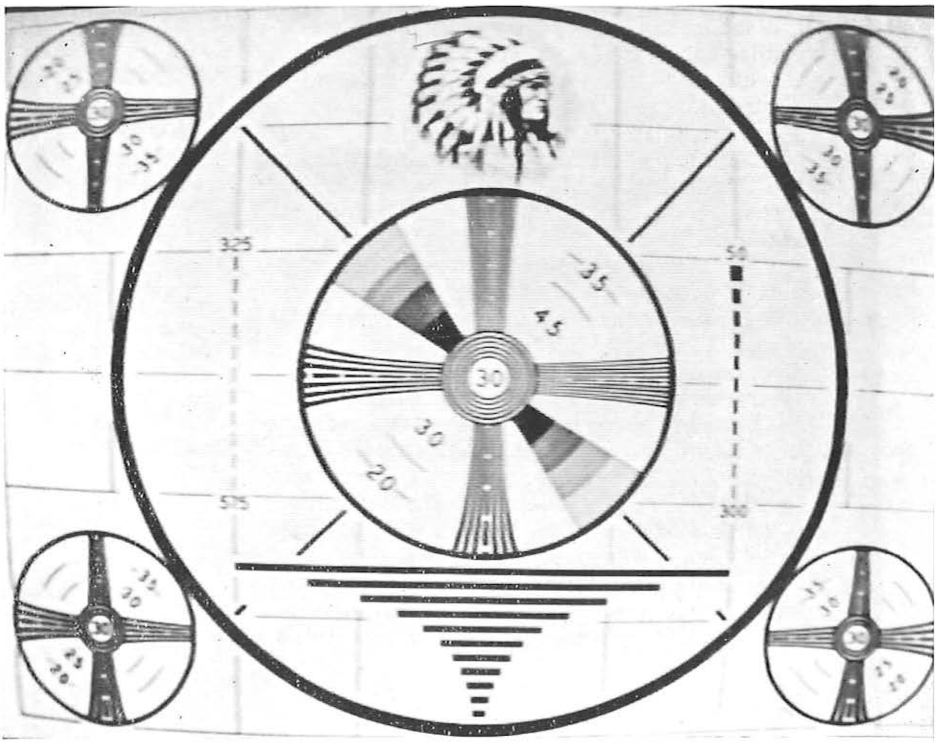
Telstar, the world's first broad band active communication satellite, was launched into orbit by the United States National Aeronautics and Space Administration from Cape Canaveral on 10 July. It is circling the earth once every 158 minutes at a height of between 600 to 3,500 miles and is mutually visible to the ground stations at Goonhilly and Andover, Maine, for up to some 30 minutes on each of three or four consecutive passes in each 24 hours.

Circular in shape and painted sapphire-blue and silver, *Telstar* has nearly 15,000 parts stored inside its 34-inch diameter. It draws its power from the 3,600 solar cells on the surface which turn the light of the sun into electrical energy for supplying the electronic equipment in the satellite and picks up the faint signals from the transmitting ground station, amplifies and re-transmits them on another frequency to the receiving ground station. The satellite contains equipment suitable for a television picture, or up to some 600 telephone channels.

Telstar was designed by the Bell Telephone Laboratories.



This was one of the first test cards to be sent from Andover, Maine, to Goonhilly. Similar transmissions were exchanged between the United States, British and French satellite communication ground stations.



John Logie Baird
(Courtesy of BBC)

Baird Was The First In 1928!

WHEN was the first television picture sent across the Atlantic? If you think it was on 11 July this year, by way of *Telstar*, you would be wrong.

It happened, in fact, 34 years ago and the man who sent it was John Logie Baird, the "father of television".

At midnight one February day in 1928, Baird set up his television "camera" in a London office and placed a ventriloquist's dummy in front of it so that the four men in Hartsdale, on the outskirts of New York, he had asked to watch their receiver could tune their set. The image of the dummy was first sent by telephone line to a house in Coulsdon, Surrey, and then transmitted across the Atlantic on a wavelength of 45 metres. The signals were bounced back off the ionosphere and picked up satisfactorily in Hartsdale.

The men in Hartsdale immediately sent a message to Baird to transmit more pictures and a number of people in the London office, including Baird himself, took turns in posing before the camera. Their images were all received in Hartsdale.

A month later, Baird repeated his coup by sending the picture of a woman from London to the ship *Berengaria*, 1,000 miles out at sea, and three years later transmitted the Derby from Epsom to London.

Why, then, were no television pictures transmitted across the Atlantic after Baird's remarkable success until *Telstar* came along? The answer is that Baird's system was of low definition using medium or short wavelength radio waves and when the broadcasting committees later had to choose a system for television they decided on a high definition system using much shorter wavelengths (very high frequencies), which meant that signals could not be bounced off the ionosphere. Baird's transmissions to America were possible only because he used low definition and operated on relatively long wavelength signals which the ionosphere can reflect and in view of the vagaries of the ionosphere reception was far from reliable.

What goes

ON a wild stretch of moorland at the western extremity of England, a huge radio aerial towers above a block of concrete buildings.

Here, at Goonhilly Downs on the Lizard Peninsula, is the Post Office experimental satellite ground station—Britain's first space communication terminal—which played a leading part in the recent series of trans-Atlantic tests with *Telstar* and which may in due course become part of an operational world-wide satellite communication system.

The Goonhilly station, its site chosen as far west as possible to obtain the maximum period of visibility to the United States and because the area is remote from sources of radio interference, is a remarkable technical achievement.

It was built in less than a year and cost only about £750,000, a quarter of the cost of the American ground station at Andover, Maine.

Continued on page 108

A FIRST FOR THE JOURNAL, TOO

THE editor of the Telecommunications Journal *was one of 24 British journalists to speak to the United States through* Telstar *when the first public demonstration of bouncing telephony signals off the satellite took place on Thursday evening, 19 July.*

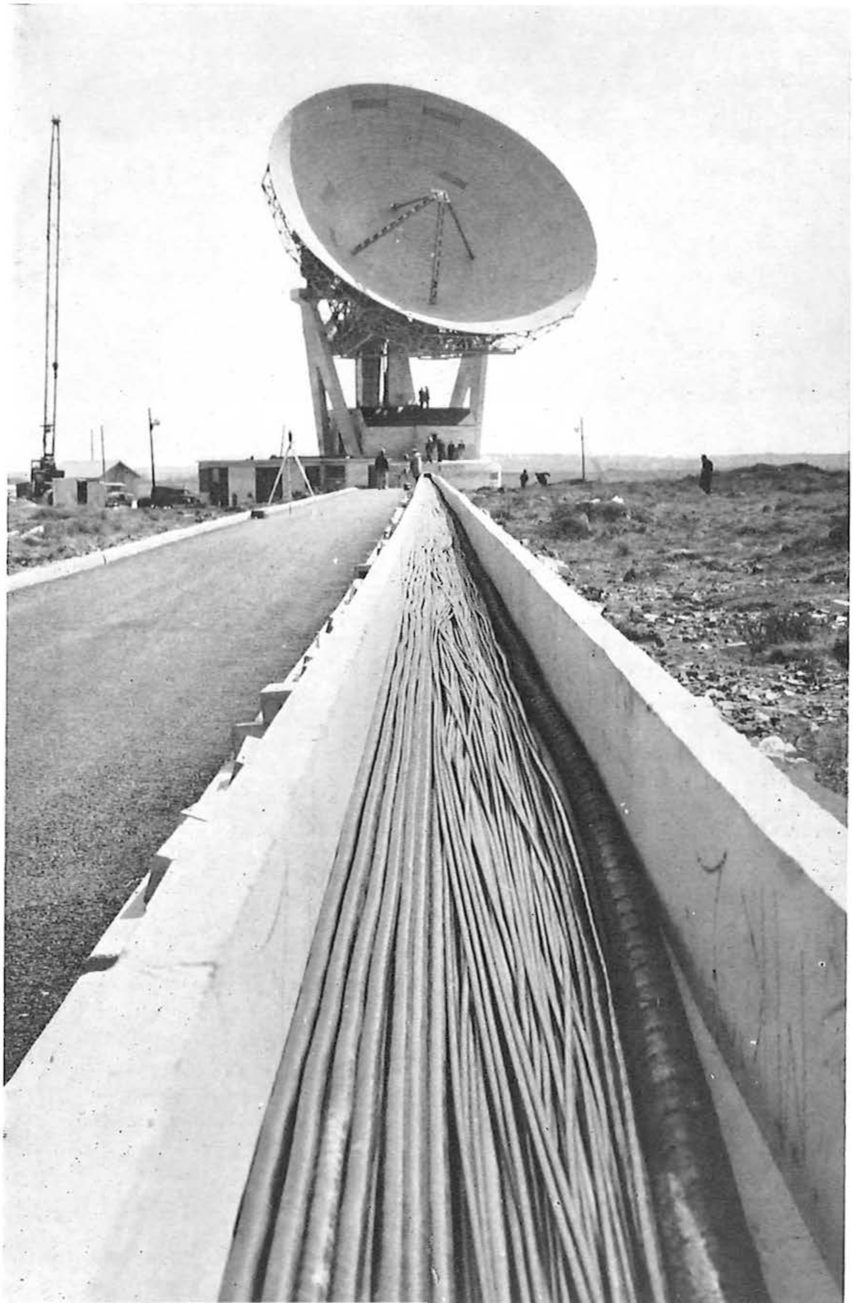
It was 9.41 p.m. when, at the Fleet Building in London, John Grove, the Journal *editor, picked up a telephone and said: "Good-evening, how are you?" to Mr. George E. Schindler, editor of the* Bell System Technical Journal, *sitting in an office* 3,000 *miles away in New York.*

The two editors spoke to each other for five minutes, discussing Telstar's *achievements and potentialities and exchanging greetings on behalf of their two publications.*

Although the voices had to travel up to and down from a satellite racing at 16,000 *miles an hour at a height of* 2,500 *miles, reception both in London and New York was excellent. "It was as clear," says the* Journal's *editor, "as speaking to a subscriber just across the road."*

on at Goonhilly...

Near the spot where Marconi sent the first radio signals to America, Post Office scientists and engineers are working to make a system of world-wide communications by satellite a reality within the next few years



The gigantic steerable dish aerial at Goonhilly, showing the mass of cables leading back into the station control room. The dish is 85 feet across and is made up of 365 separate sections. Though the rotating part of the aerial weighs over 800 tons it can be moved by a 2 horse-power motor in good weather.

The aerial steering room in the Control Tower at Goonhilly. From here an engineer keeps watch over the station, corrects faults indicated by the instruments in front of him and, if necessary, steers the giant aerial.

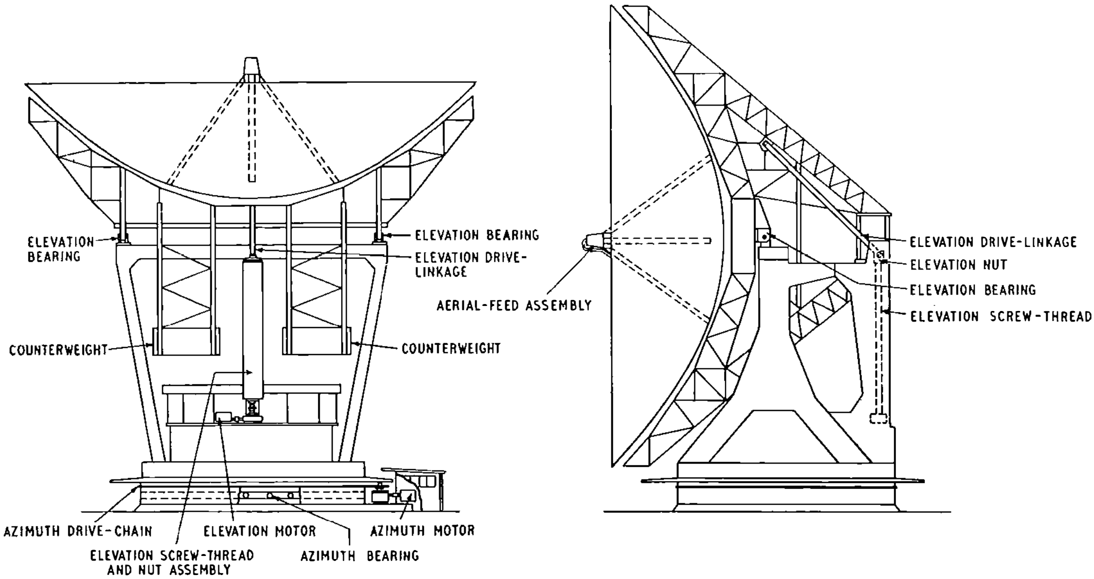
Almost all its complex equipment, including the huge dish aerial—the most accurate radio aerial in the world—is of British design and construction. Much of the electronic equipment has been built with the full co-operation and help of the British electronics industry by the Post Office Engineering Department.

How does Goonhilly station transmit and receive radio signals by way of an active satellite such as *Telstar?* Briefly, and simply, by pointing its radio aerial at the satellite as it moves across the sky and sending signals which are amplified by the equipment in the satellite and re-transmitted to a distant station. Signals from a distant station are received in the same manner.

But this is an over-simplification of the many difficult problems that have to be overcome, as the *Telecommunications Journal* discovered when it visited Goonhilly recently.

Since the signals from a satellite are very weak and a large collecting area is needed, one of the most vital parts of the equipment at Goonhilly is the massive radio telescope aerial—a steerable dish 85 ft. in diameter—which is used both for transmitting and receiving. It is designed to operate at radio frequencies up to 8,000 Mc/s and its transmission signal power is concentrated into a narrow beam only one-fifth of a degree wide. For this reason and because satellites move rapidly across the sky the aerial has to be able to track with great precision. Hence, to enable it to operate accurately even in high winds, the aerial has to be a very sturdy construction.

In spite of its size, the aerial is so well balanced that its rotating part, weighing more than 870 tons, can be steered in reasonable weather by a 2-horse-power motor, although two 100 h.p. electric motors are provided to allow for high winds. The mechanical arrangements for steering provide for variation of the azimuth by rotating the complete aerial structure on a circular horizontal turntable and for elevation variation by tilting the dish above a horizontal axis. The maximum speed of movement is one degree per second elevation and two degrees per second azimuth, maximum acceleration being 1.33 degrees per second per second.



These simplified drawings of the Goonhilly steerable aerial show how the instrument is rotated and elevated.

As was the case with *Telstar*, orbital information for steering the aerial is obtained over a teleprinter circuit from the Goddard Space Flight Centre in the United States and fed into a computer which turns it into second-by-second tracking instructions.

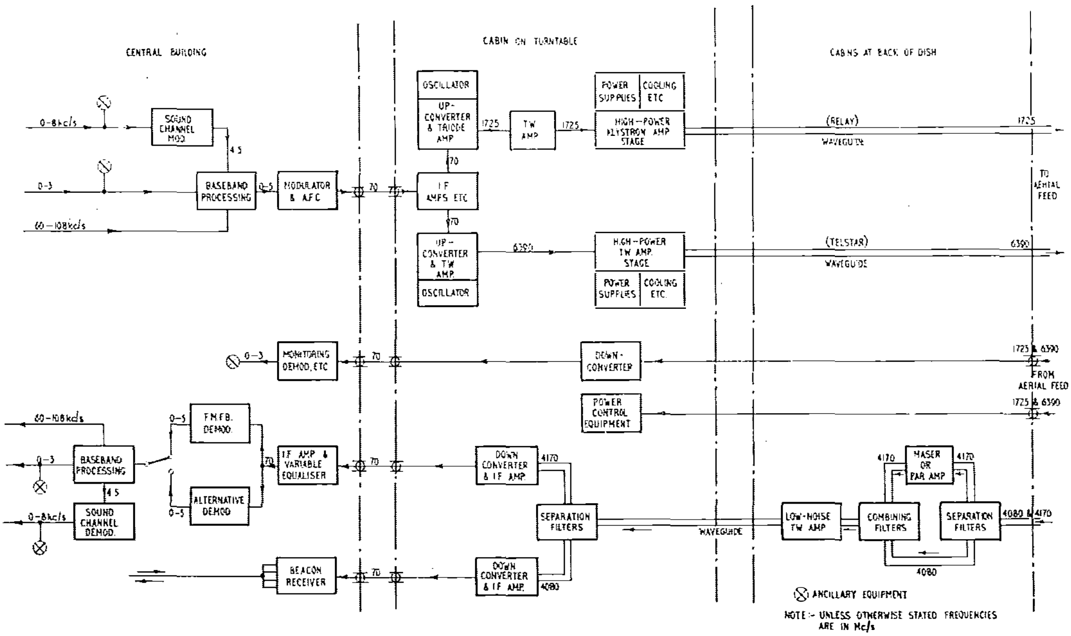
Because the signals from the satellite are very weak—less than one millionth of a millionth of a watt—they must be amplified many times. This is done by a travelling-wave "maser" amplifier fitted into a cabinet at the back of the dish aerial. The "maser", part of which is an artificial ruby, operates at 4,170 Mc/s and to be efficient must be kept at a temperature of only a few degrees above absolute zero with liquid helium and liquid nitrogen. The evaporated helium is recovered, compressed and stored for further use. The "maser" amplifier has a gain in excess of 25 db and a bandwidth of more than 25 Mc/s. Initially, it has a permanent magnet but this will be replaced by an electro-magnet using super-conduction.

In a cabin behind the reflector are filters for separating the beacon signal (4,080 Mc/s) from the communication signal (4,170 Mc/s) so that the latter can be amplified separately in the "maser".

Complex waveguide assemblies, with rotary and flexible joints, connect the feed at the focus of the reflector with equipment in the cabins and on the aerial turntable. On the turntable is an apparatus room accommodating two high-power transmitters —one 10 kW, 1,725 Mc/s, the other 5 kW, 6,390 Mc/s—the low-power drive equipment for them and some of the frequency shifting equipment. The turntable itself rotates only up to plus or minus 250 degrees so that cable loops can be used instead of slip rings.

The aerial has two separate feeds, each for simultaneous transmission and reception, mounted at the focus in the aperture plane of the dish. Both are designed for circular wave polarisation. One was used for the *Telstar* tests and the other will be used for tracking the satellite *Relay* when it is launched later this year. The feeds are mechanically movable so that the direction of the beam can be adjusted in addition to the adjustments achieved by moving the whole dish. A diplexer combines the 6,390 Mc/s transmitter output and the 4,170 Mc/s receiver input for connection to the *Telstar* aerial feed. So that its mechanical alignment

OVER



A simplified block diagram of the receivers and transmitters at the Post Office satellite ground station.

can be periodically checked, the aerial is fitted with a boresight telescope for ranging on to local and distance points whose bearings are accurately known.

A quarter of a mile away from the giant aerial and connected to it by a mass of cables and wires contained in a conduit, is the Control Room, topped by a tower in which an engineer, sitting in front of a battery of instruments and dials, keeps watch over the whole of the station site. Though the aerial steering is fully automatic, the operator is there to observe faults, to apply corrections and, if necessary, over-ride the automatic system.

Below the Control Tower are the rooms, separated by glass partitions so that visitors may see what is happening without interfering with the operators, which form the brain of the system. In one, a Controller and his staff, all provided with consoles, carry out such tasks as aerial steering and transmitter and receiver supervision. The room contains base-band and frequency-changing equipment, receivers for the "off-to-air" reception of television broadcast signals; measuring equipment; magnetic tape and other recorders; satellite beacon signal receivers and microwave, video and multi-channel telephony terminals. A wide range of measurements and subjective tests can be made with the measuring equipment on the transmission of multi-channel telephony, television, telegraphy and data signals and scientific experiments can be carried out to determine the variation of propagation characteristics, changes of noise temperature with the bearing of the radio beam and the physical conditions in the troposphere. Automatic equipment is available for recording and processing data in conjunction with the computer.

The received signals reach the building as a wide deviation carrier centred on 70 Mc/s. The carrier-to-noise ratio is extremely low and the recovery of video and multi-channel telephony signals with a satisfactory signal-to-noise ratio has meant devising two alternative forms of demodulator One employs frequency-modulation negative feedback and the other a system of tracking the frequencies of maximum energy and varying the instantaneous band-width.

In the Telegraph Room separate teleprinters are provided for the reception, on a private wire basis, of the orbital prediction data from, and operational traffic with, the Goddard Space Flight Control Centre and the satellite ground station at Andover, Maine; for telex facilities; and for receiving meteorological information.

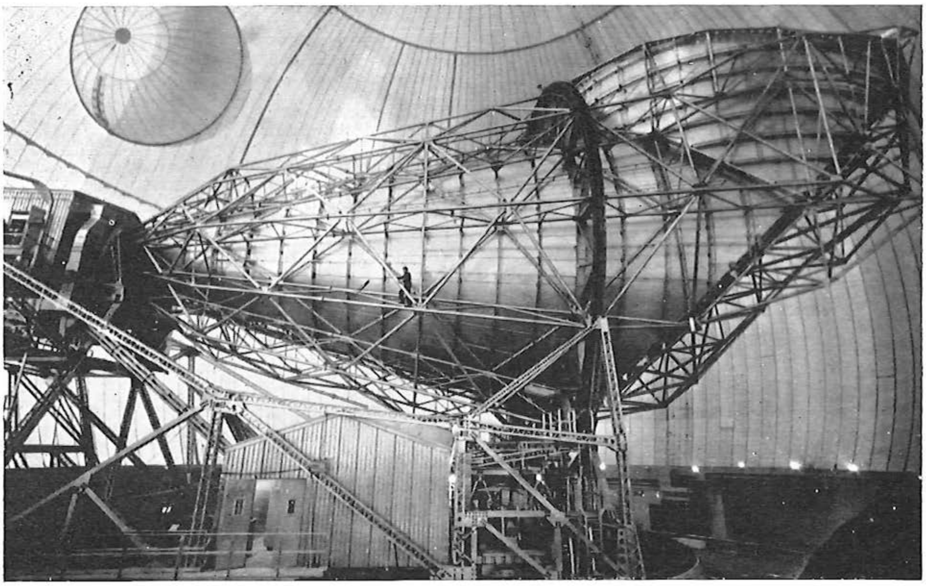
In another room, completely air-conditioned, is an electronic computer which processes the orbital prediction data into punched-tape aerial steering instructions, making allowances for changes of apparent satellite bearing due to atmospheric refraction and applying any other systematic corrections. Telegraph-type tape readers and data recording equipment are also provided for processing the orbital data and preparing the aerial steering tapes.

Instructions from the computer are passed into the aerial steering equipment in the form of punched paper tape which is "read" one second in advance, a second at a time, the tape-reading equipment positioning the tape for each reading operation from the "single cycle-start" hole which marks the beginning of each sequence. The time to which the start of each sequence refers is code-punched into the tape as hours, minutes and seconds. Then follow steering instructions, in binary code.

In the Aerial Steering Apparatus Room a comparison is made between the aerial steering input data in digital form and the digital signals derived from the read-out units on the aerial azimuth and elevation drives. This enables the servo feed-back loop to be completed. In a temperature-controlled annex are quartz-crystal oscillators of high accuracy which, in conjunction with time-signal radio receivers, provide a precise time source adjustable to Universal Time 2 (adjusted Greenwich Mean Time). Here, the steering tapes from the computer room to the aerial steering apparatus are received, the movement of the aerial depending on the synchronisation between the time recorded on the tape and that generated by the precise time source.

Before the Goonhilly station went into action in Project *Telstar*, it carried out a number of highly successful and comprehensive tests on a ground satellite set up at Leswidden, 20 miles from Goonhilly, to simulate a real satellite. The aerial was also beamed on the radio star Cassiopeia A to practise tracking signals.

AND THIS IS THE U.S. EAR



The Americans used this mammoth antenna—described as "the biggest ear in the world"—for transmitting and receiving signals during the recent tests with Telstar. *It weighs 340 tons, is 177-ft. long and is housed inside an enormous plastic bubble at Andover, Maine.*

Captain C. F. Booth, Deputy Engineer-in-Chief. He is in charge of the Satellite Communications project for the British Post Office.

BEFORE

IN THIS ARTICLE THE AUTHOR TELLS OF THE POST OFFICE STUDIES INTO SATELLITE COMMUNICATIONS SYSTEMS, DESCRIBES THE TWO TYPES OF SATELLITES AND THE ORBITS IN WHICH THEY CAN BE USED AND DISCUSSES THE POSSIBLE DEVELOPMENT OF AN INTER-CONTINENTAL SATELLITE COMMUNICATION SYSTEM OF THE FUTURE

AS *Telstar* triumphantly circles the earth and Britain takes the first steps into the space age of inter-continental communications by satellites let us, for a moment, look back.

Some two years or more ago the Post Office Engineering Department, in collaboration with the Ministry of Aviation and other Government departments, began a study of the potentialities of satellite communication systems providing "line-of-sight" paths between ground stations and satellites for which radio waves in the spectrum 1,000 to 10,000 Mc/s can be used for long-distance communications.

The transmission of these waves is independent of the ionosphere and of solar activity so that they are not subject to the fading and distortion frequently observed on long-distance radio circuits operating in the high frequency range, 3-30 Mc/s. In fact, frequencies between 1,000 and 10,000 Mc/s are used for conventional microwave radio relay systems in which signals are relayed from hilltop to hilltop, the relay stations being some 30 miles apart.

In a satellite communication system the relay point would be several hundreds, or even thousands, of miles above the earth, the signals spanning a correspondingly longer path between ground stations. To cover these long distances a very high power ground station and a highly directive aerial which is steered to track the satellites would be needed and the ground station receiver would have to be very sensitive and associated with a similar aerial to that used at the transmitter.

and AFTER TELSTAR

By CAPTAIN C. F. BOOTH, C.B.E.

A visit to the United States in 1960 confirmed the conclusion of the preliminary studies that a global system to provide several hundred telephone and telegraph circuits and a television channel was technically feasible and that the large potential capacity and flexibility of satellite communications might be of considerable value in meeting the increasing demand for world-wide communications. It was also concluded that it would be necessary to use active, rather than passive, satellites. An active satellite, like *Telstar* which was launched by the United States National Aeronautics and Space Administration (NASA) on 10 July last, contains electronic equipment which receives signals from the ground station, amplifies and re-transmits them to the distant ground receiving station. A passive satellite acts merely as a reflector of incident signals.

One example of a passive satellite is the metallised balloon, 100-ft. in diameter, launched by the Americans in Project *Echo* in August, 1960, into an orbit inclined to the equator and at a height of some 900 miles. Signals from a ground station

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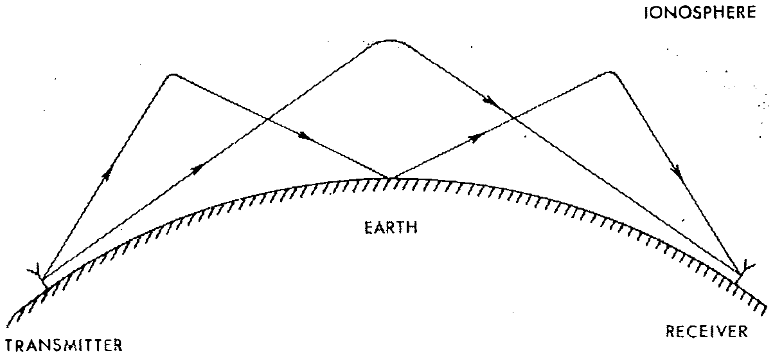
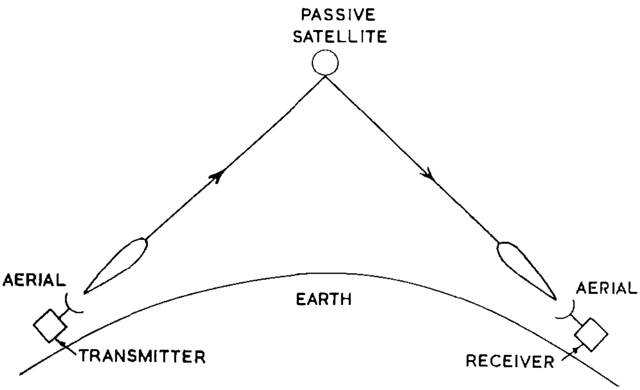
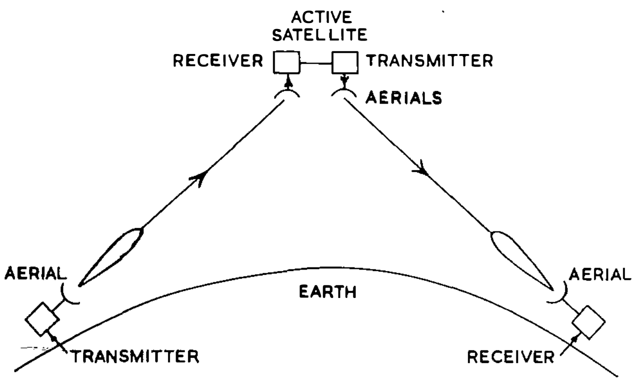


HIGH FREQUENCY RADIO TRANSMISSION VIA THE IONOSPHERE

This diagram shows how high-frequency radio signals are bounced back from the ionosphere. Over long distances, however, high-frequency circuits suffer from fading and distortion because the ionosphere is affected by solar activity.

GOONHILLY (Continued)





These two drawings illustrate the differences between an active and a passive satellite. The passive type merely reflects signals. The active satellite, fitted with a receiver and transmitter, picks up signals from a ground station, amplifies and re-transmits them.

transmitter on the eastern seaboard of the United States were bounced off the balloon when it was over mid-Atlantic and received at Malvern, England, on 19 August, 1960, by a team of Post Office and Royal Radar Establishment experts. The balloon is still circling the earth and can sometimes be seen at night, looking like a first-magnitude star.

The United States is also experimenting with another system of passive satellites in the form of a multitude of very fine metal needles, about half an inch long and as thick as a human hair, which will be sent up into the sky to act as a reflector, or artificial ionosphere, to incident microwave signals. The needles will be contained in a small canister and the material holding them together will volatilise when they reach orbital height, allowing them to scatter in a continuous belt around the earth. The first attempt to do this—Project *Westfall*—failed, but another is to be made. Some scientists have questioned the use of such belts of needles on the grounds that they may interfere with the work being done by optical, radio and radar astronomers.

The terminal station for an active satellite system in which a number of satellites move across the heavens would, like the one at Goonhilly, be on flat ground with an unobscured horizon. Information from an electronic computer would be fed with details of a satellite's orbit and converted into steering signals to operate the aerial control motors. As a satellite came into view of the two terminals of an inter-continental link the aerials would be steered automatically to point at it and follow it, signals being exchanged between the two ground stations through the satellite. Just before the satellite disappeared from view another would appear and a second aerial at each side would be directed on to it and would take over the circuit.

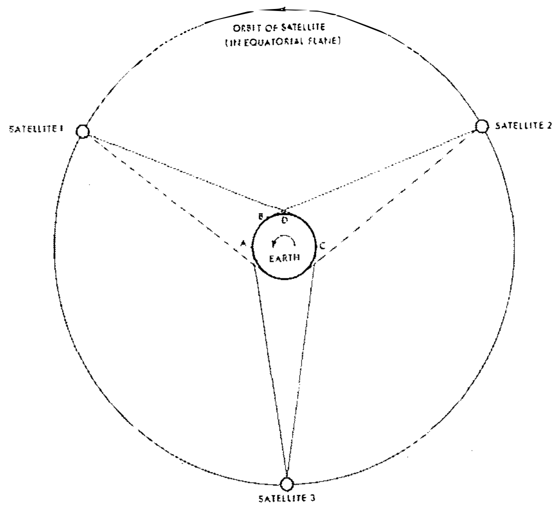
The type of orbit selected for the satellites decides the design and form of the system. There is a wide variety to choose from, including circular and elliptical orbits, in planes varying from polar to equatorial, and many have been suggested for use. It is thought that a system using a number of satellites in the equatorial plane would have many long-term advantages.

A special case is the circular orbit in the equatorial plane with the satellite some 22,300 miles above the earth and travelling in the same direction as the earth's rotation. The orbital period would be 24 hours so that the satellite would appear to hang stationary in the sky. It would "see" a large area of the earth and the ground station aerials would not need to be steered. If three such satellites were positioned at 120 degrees, one or other would be seen from most of the earth's surface, except the polar regions. Correction of the orbit and adjustment of the satellites' position in orbit would be necessary to ensure that they hung stationary. However, such a system might have serious disadvantages for multi-channel telephony because of the relatively long transmission time—more than half a second—from the ground station to the satellite and back. Tests have shown that this delay would cause difficulties for an appreciable number of telephone users but that it would not be troublesome for television and telegraph users.

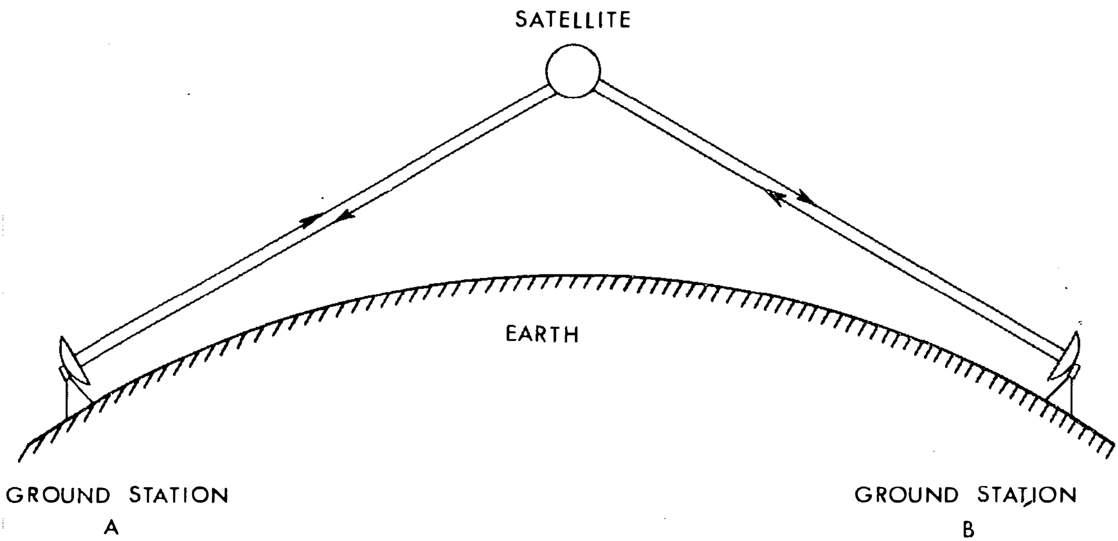
The time delay problem would be sensibly removed, however, by reducing the altitude of the satellites, for example from 22,300 to 8,600 statute miles, for which the orbital period would be 12 hours. In this system it would be necessary to increase the number of satellites from three to about 12 to achieve near-world coverage on a 24-hour basis. Each of the 12 satellites would have to be position and attitude stabilised, the latter probably requiring the satellites to have auxiliary jets to increase or decrease their speed. Each satellite

OVER

The system using three satellites in a 24-hour circular equatorial orbit. Each satellite would be 22,300 miles above the earth.



Signals can be exchanged between ground stations only when the satellite is visible to both.

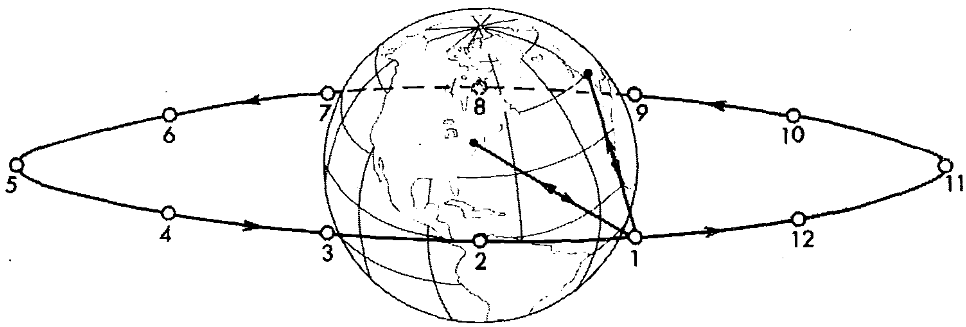


would be mutually visible to at least two ground stations in an inter-continental link and ground stations would track one for an hour and then switch to the next so that all 12 would be used each 12 hours. In this way continuous world-wide communications could be achieved from Latitude 57 North to Latitude 57 South and a system can be visualised which would provide 1,000 or more telephone circuits and two television channels.

It is not possible at present to specify the preferred type of system since more studies and the results of experimental tests are necessary. The British studies do, however, indicate that a system of active satellites, position and attitude stabilised and operating in circular orbits in the equatorial plane at a height of 8,600 miles may be a desirable objective, though many technical problems, some of them major ones, would have to be solved before it could be brought into being.

The early accumulation of experimental information on the performance of communication satellites is of extreme importance to the designers of a system for commercial use. To this end, in February, 1961, Britain and the United States reached a Memorandum of Understanding on collaboration between the British Post Office and NASA on the testing of experimental satellites launched by the latter for communication purposes. The first phase of the tests involve *Telstar* and *Relay*—both active satellites—and the next phase will cover Project *Rebound* (a passive satellite) and others. The understanding with the United States includes the interchange of technical information, makes clear that collaboration is in respect of experimental tests only and is not concerned with commercial exploitation. It does not preclude the use of the Post Office experimental ground station at Goonhilly for tests outside the co-operative projects outlined above. Similar agreements between the United States, France, the Federal Republic of Germany, Italy and Brazil have been approved.

The results achieved with *Telstar* have confirmed the technical feasibility of a global communication system to provide several hundred telephone and telegraph channels and one or two television

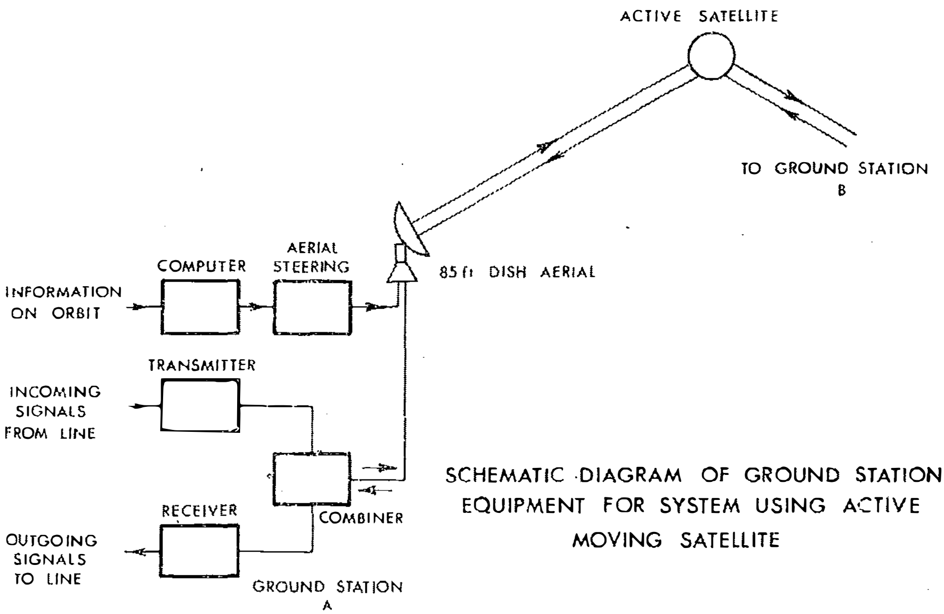


SYSTEM USING 12 EQUI-SPACED SATELLITES IN A CIRCULAR EQUATORIAL ORBIT, 7500 MILES

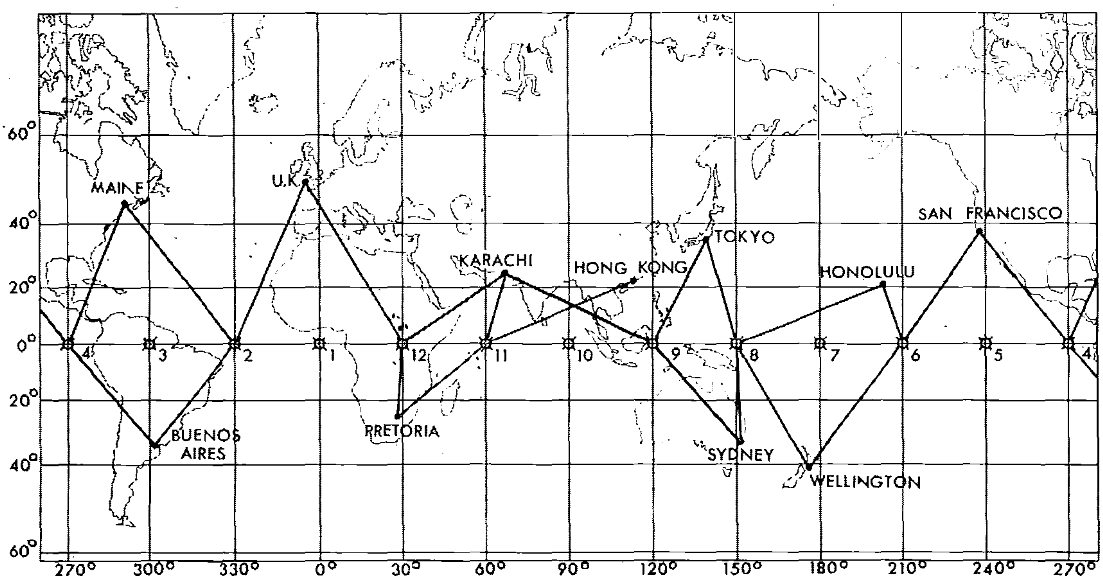
In this system, which solves the time delay problem, the 12 satellites would orbit the earth once every 12 hours and give near-world coverage. They would need to be position and attitude stabilised.

channels, using active earth satellites as relays. Engineers on both sides of the Atlantic are now busily engaged in testing the performance of *Telstar* and are looking forward to similar tests with *Relay*, which will be launched in the early autumn, and with others. The information they gain will be invaluable to them in their task of designing an operational system.

Much valuable experimental information has already been obtained but much more is needed before anyone can say with certainty what part a satellite system will eventually play. Nevertheless there are grounds for hoping that within the present decade satellites will provide a complementary means of reliable long-distance communications to that already given by submarine repeatered cables.



ABOVE: *A simple diagrammatic layout of the Goonhilly station.* BELOW: *The proposed communication links in a system of 12 equi-spaced satellites travelling in an equatorial orbit at a height of about 7,500 miles.*



This historic picture shows the cameraman making his final preparations for televising the Coronation Procession of King George VI from Hyde Park Corner.

TWENTY FIVE YEARS OF

TWENTY-FIVE years ago the BBC made world history by broadcasting on a public television service the first live outside broadcast pictures. The date was May 12, 1937, the place Hyde Park Corner and the occasion the Coronation Procession of King George VI.

The BBC's television service had been opened at Alexandra Palace on November 2, 1936, and it was obvious from the start that there was a need to venture outside the studio for programmes. To make this possible, the Post Office, early in 1936, laid a special balanced-pair cable connecting potential sources of outside broadcast programmes to Alexandra Palace. The cable was routed to provide a vision connection from Grosvenor House, Apsley House, London Pavilion, St. James's Palace, Buckingham Palace, Victoria Station, Horse Guards, the Cenotaph, St. Margaret's Church and Broadcasting House.

The Post Office has played—and continues to play—an important part in television outside broadcasting since the day in 1937 when the world's first live public television pictures were broadcast

The balanced-pair type of cable was chosen because its configuration minimises interference with a video signal from external sources at low frequencies, against which the lead sheath of the cable provides little screening effect. The diameter of the cable, including the lead sheath, is just under one inch and repeaters, capable of equalising and amplifying the vision signal after passing over up to eight miles of cable, were installed at Broadcasting House and Alexandra Palace.

For the first outside broadcast a 60 Mc/s radio link was set up by the BBC from Hyde Park Corner to Alexandra Palace and held in reserve in case the cable circuit failed. In the BBC's first camera the tube used (known as an Emitron, or iconoscope, pick-up tube and the best then available) was an awkward shape, which meant a bulky camera. It was also rather insensitive and required very bright illumination to give a satisfactory picture.

Each outside broadcasting unit was made up of four vehicles, each about the size of a large motor-coach. One vehicle was the mobile control room which contained the control and operation equipment of three cameras and accompanying sound facilities. The other three vehicles contained a diesel generator to provide the power supply when the local public supply was inadequate or unavailable, a vision radio-link transmitter, operating on a frequency of approximately 60 Mc/s with a peak power of 1 Kw, and an extending ladder to raise the transmitting aerial to a height of up to 80 feet.

TV OBs

by M. B. WILLIAMS, B.Sc (Eng.), A.M.I.E.E.

and J. B. SEWTER, A.M.I.E.E., M.T.S.

Pre-war developments

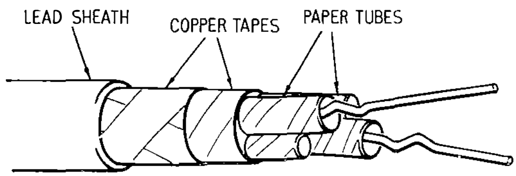
In November, 1937, cameras with the Super-Emitron, or image iconoscope pick-up tubes, were brought into service. This tube has a close family resemblance to the Emitron, but far less illumination is needed because its sensitivity is about ten times greater. From 1937 to 1939, great strides were made in improving television outside broadcast cameras and links and as a result picture quality improved, cameras and associated equipment became more portable and the outside broadcast coverage expanded to include the whole of the London area.

The BBC at first suffered severe interference with the reception of the radio-link signals at Alexandra Palace and early in 1938 a receiving station for radio links was set up at Swains Lane on Highgate Hill. The balanced-pair cable was intercepted so that vision signals received at Swains Lane could be relayed three miles to Alexandra Palace. The radio links had been chosen to operate at about 60 Mc/s because at that time this frequency was available for mobile links and gave the best chance of achieving satisfactory vision circuits from the fringe of London. The equipment was very bulky but did not need an optical path. The special balanced-pair cable provided an excellent vision circuit but the number of sources of programme within the range of its connection points—the cameras had cables which could only be extended up to 1000 feet—was very limited.

In early 1938, BBC engineers developed a technique for equalising pairs in ordinary telephone cables so that vision signals could be passed over them for limited distances. This allowed the balanced-pair cable to be exploited much more freely, because the mobile control room no longer had to be immediately adjacent to the balanced-pair connection point. The balanced-pair cable had been taken into only one telephone exchange, but, with the introduction of transmission over telephone pairs, spurs were provided into Mayfair and Gerrard exchanges.

The first broadcast using this form of transmission was on May 6, 1938, when an outside broadcast took place from news-film studios in Soho Square. The vision signal was relayed over about three-quarters of a mile of telephone pair in an ordinary subscribers distribution cable to Gerrard Telephone Exchange. Here, equalisation and amplification for the telephone pair was provided by the BBC, using a special repeater before connecting the balanced-pair cable to Alexandra Palace.

The summer of 1938 saw the addition of a number of extensions to the balanced-pair network,



The special balanced pair cable as used on the first television outside broadcast.

notably at Olympia, Earls Court and Fulham Telephone Exchange. An increasing number of broadcasts using telephone pair techniques was undertaken before the BBC Television Service closed on September 1, 1939. While only four broadcasts had used Post Office telephone cables from May, 1937 to September, 1938, more than 80 were made over varying lengths of telephone cable during the following 12 months.

Post-war Progress

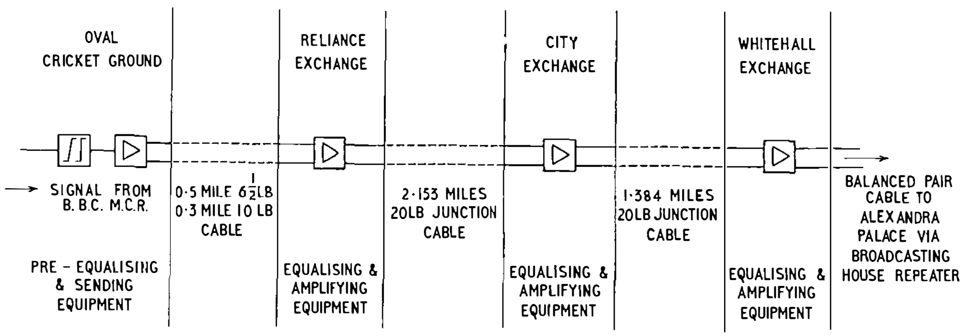
Before the BBC's Television Service was re-opened on June 7, 1946, it had been decided that the Post Office would increase the flexibility of the balanced-pair cable by providing new connection points or short spurs and repeaters for equalising and amplifying telephone pairs.

Additional outside broadcast links on new routes would be provided on coaxial cables to use new techniques of carrier transmission which were being developed. The BBC would continue to provide any temporary point-to-point radio links for television outside broadcasts and the Broadcasting House repeater equipment for the balanced pair cable, which had been destroyed by enemy action, was replaced.

When the Victory Parade was broadcast on June 8, 1946, the special balanced-pair cable had to be cut and extended to the BBC's mobile control room set opposite the saluting base in Pall Mall. The Post Office provided its first vision circuit on telephone pair for a broadcast from the Dorchester Hotel on June 21, 1946, when a telephone pair to Mayfair exchange was equalised and amplified, for connection to the balanced-pair cable. For the Test Match broadcasts from Lords in June, 1946, a length of single pair 0.375-inch coaxial cable was laid at short notice from Museum to Cunningham Telephone Exchange, with a spur from Cunningham to Lords cricket ground, so that a trial of 7 Mc/s double-sideband carrier transmission equipment could be made. The broadcast was a success and valuable experience was gained for the design of the television carrier equipment for coaxial cables.

For the Test Match from the Oval in August, 1946, the Post Office provided what was then considered an ambitious outside broadcast vision circuit. Three telephone pair sections were equalised and amplified before connection to the balanced-pair cable at Whitehall Exchange. A coaxial cable was laid later on this route, but the original method of provision on several types of telephone pair cables did much to confirm earlier tests which showed the value and capabilities of tandem connected sections of telephone pairs, each section being equipped with vision repeaters.

Post Office development of fully engineered carrier equipment for use on coaxial cables and variable equaliser-amplifiers (or repeaters) for telephone pairs proceeded steadily over the next few years. Meanwhile, the number of vision circuits provided by the Post Office on cables—including the balanced pair—in the London area gradually increased and from June, 1946, to June, 1949, the Post Office produced 140 of them. The vision circuits for the wedding of Princess Elizabeth in November, 1947, and for the silver wedding procession of King George VI and Queen Elizabeth in April, 1948, were provided mainly on the balanced-pair cable. On the former broadcast, two experimental cameras, fitted with the new cathode-potential stabilized Emitron tube were used. This tube was more sensitive than its two predecessors and although it could become unstable with bright flashes of light, it found some application in



This diagram illustrates the circuit arrangement adopted for televising the Test Match from the Oval in 1946.

outside broadcasts until the even more sensitive image-orthicon camera tube came into use in 1949.

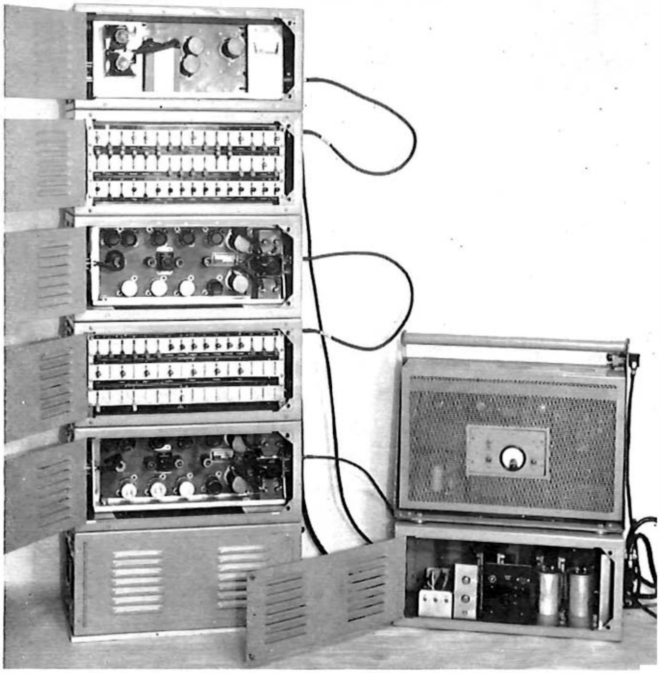
For the Olympic Games in July, 1948, a coaxial cable was laid from the Wembley Pool and Stadium to Wembley Exchange to connect with coaxial pairs through Elgar, Ladbrooke and Cunningham Telephone Exchanges to Museum. The first year in which the Boat Race broadcast involved Post Office vision cable links was 1949. The carrier equipment used on coaxial cables went through several stages of development but was finally produced in a form very similar to that adopted for main links.

On telephone pairs an unbalanced-to-balance send unit is required and repeaters are fitted at convenient points, such as exchanges, so long as the cable loss of a repeater section is not greater than about 60 db at 3 Mc/s—equivalent to about 0.75 miles of $6\frac{1}{2}$ lb conductor, or 1.0 miles of 10 lb or 1.5 miles of 20 lb. Considerable improvements were made between 1948-1952, and small wheeled racks were introduced to make the repeaters more transportable. Normally up to four repeaters of this type can be connected in tandem but sometimes up to eight have been used. The method introduced by the Post Office for adjusting telephone pair repeaters depends on the visual observation of the waveform response of the vision circuit. Pulses of known shape and repetition rate are transmitted over the telephone pair and through the repeater and are then displayed on a cathode-ray oscillograph. The repeater is adjusted to give a pulse at the output whose shape is as near as possible to that of the sent pulse. When several repeaters are connected in tandem, the observation and adjustment is carried out at each repeater in turn, beginning with the one nearest the sending end. This waveform technique greatly simplifies the lining up of vision circuits.

Mobile Control Rooms

Mobile Control Rooms brought into service by the BBC after World War Two were more compact than the two used before the war, and improvements in cameras have resulted in the image-orthicon becoming the accepted type of camera tube for outside broadcasts, except where space is at a premium and the smaller vidicon tube camera is used.

There have also been post-war developments in the outside broadcast radio links. As Band I became occupied by television stations and 60



An early type of Post Office telephone pair repeater.

Mc/s links more difficult to use, radio links operating on about 200 Mc/s were brought into service by the BBC. During 1948-1950, microwave radio links, which require line-of-sight paths and operate in the band 4400-4800 Mc/s, became available and the BBC began using them.

In December, 1949, with the opening of the BBC's Television transmitter at Sutton Coldfield and the introduction of a both-way television link between London and Birmingham, the field of outside broadcasts was extended to the Midlands. In 1951 and 1952, BBC television outside broadcasts expanded to the North, Wales and the West.

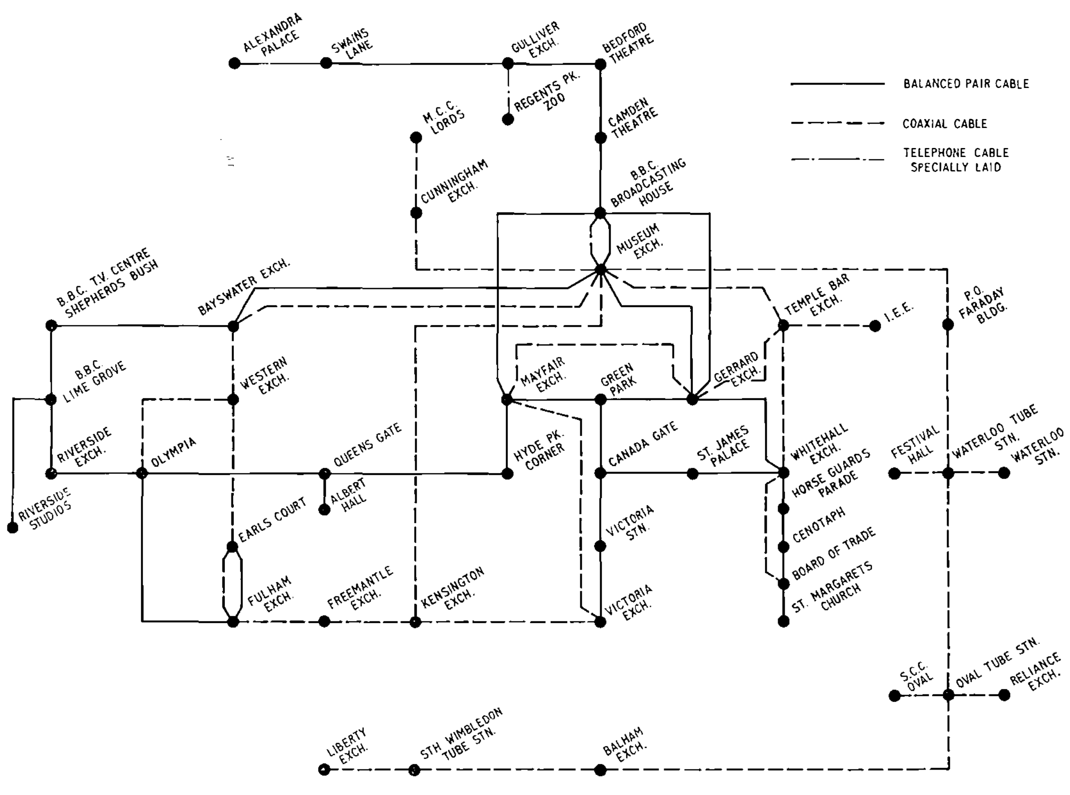
The Post Office initially met the BBC's requirements for outside broadcasts in the provinces by employing mobile and enthusiastic teams from London, but it was soon clear that more teams would be required as the network grew to give national coverage. So new Post Office teams were set up at Manchester and Cardiff and later at Edinburgh and Birmingham and new and more portable types of telephone pair repeaters were developed for their use. The development of cable and radio injection equipments to feed an outside broadcast signal into the transmission path at any intermediate repeater station on a main link proved a valuable addition to the methods of relaying outside broadcast signals. (An article in the Autumn, 1955, issue of this Journal described the setting up and equipping of the Post Office teams.)

The outstanding BBC television coverage for the Coronation of the Queen in June, 1953 and the subsequent royal tours of Scotland and Wales gave the Post Office teams the first chance to work together on one broadcast. Since then there have been many memorable television outside broadcasts in which the Post Office has been proud to take a part. Five which will long be remembered are the opening of Independent Television, in September, 1955; the opening of Parliament (October, 1958); the General Election broadcast (October, 1959); Princess Margaret's wedding from Westminster Abbey (May, 1960); and the Duke of Kent's wedding (June, 1961).

The introduction of an Independent Television Service in 1955 led to a sudden increased demand for outside broadcast vision circuits and the number of circuits provided by the Post Office rose to over 750 in 1958, but as the ITA's programme contractors and the BBC obtained more permanent studio facilities in the provinces and video tape recording of programmes became an accepted technique, the annual rate of provision has settled to an average of about 550.

Recent Developments

With the growth of the main television and telephony trunk networks, permanent reserve cable and protection radio channels, suitable for television transmission, have become available for



A diagram of the network of outside broadcast coaxial cables and the balanced pair cable as it is today, 25 years after the first outside broadcast.

part-time television use. These channels are now being used about 100 times a year for outside broadcasts and the channel from Belfast has made possible, for the first time, regular live outside broadcasts from Northern Ireland.

Since the first BBC broadcast from Calais in August, 1950, great strides have been made in exchanging television programmes on the Eurovision Network which now links 18 television services in 14 countries. Some of the more recent outside broadcast vision circuits have been arranged for television services in other countries when the BBC and ITA have not taken the programme.

The mobile control rooms have continued to get smaller and "roving eye" cameras are now in regular use. Mobile microwave links are operated by both the BBC and ITA, using frequencies in the band 7050 to 7300 Mc/s and the Post Office has provided radio links of this type for closed circuit television.

Although the television standard for Britain is at present 405 lines, 50 fields per second, monochrome, a number of television outside broadcast vision circuits are being ordered to other standards for recording programmes for export and for exhibitions and so on. Experimental repeaters for telephone pairs have been used for the transmission of 405 line colour, 525 line monochrome and 625 line monochrome and colour signals. Transistorised repeaters capable of transmitting 405, 525 or 625 line, monochrome or colour signals are also being developed. Recent developments by the Post Office in transmitting vision signals over coaxial pairs, without modulation of the signal to a higher band of frequencies, have been applied to outside broadcast circuits and it is unlikely that any more carrier equipment will be provided for these circuits on coaxial pairs.

The tall towers (such as the 520 ft. high Museum tower) and masts which the Post Office will be using in or outside the main cities for permanent radio links with the intermediate radio relay stations, will be valuable reception points for point-to-point microwave radio links using mobile equipment. In the past, the sound circuit associated with the vision circuit has normally been provided on Post Office telephone cables, but the increased demand for music quality plant is leading to a shortage of suitable cable circuits, especially on the main routes. In future the Post Office may also often have to arrange for the associated sound circuit to be routed over a radio link.

A No. 98A amplifier which was developed by the Post Office in the early 1950s. It was more portable than the previous type of telephone pair repeaters.

Reticent About Ringing

Why is the average number of telephone calls per person in Britain lower than in most other countries?

The answer, says The Guardian, *is that the British as a race are reticent. Not only do we not like speaking in railway carriages but, compared with Americans, Canadians, Australians and most Europeans, we are reluctant to pick up the telephone, too. Only the Germans and Belgians in a list of* 12 *countries made fewer calls per person in* 1960–61 *than the average of* 90.6 *made by the British.*

The most loquacious on the telephone are the Canadians who make an average of 538.4 *calls per person a year, with the Americans close runners-up with* 520. *Although the Italians have only* 7.8 *telephones per* 100 *people (Britain has* 16.2) *the average number of calls per person is* 121.

Telecommunications Statistics

In this issue we present some figures for the complete financial year to 31 March, 1962, compared with those for the two previous years.

	March 31*st* 1960	*March* 31*st* 1961	*March* 31*st* 1962
The Telephone Service at the end of the year			
Total telephones in service	7,856,000	8,280,000	8,624,000
Exclusive exchange connexions	3,652,000	3,894,000	4,084,000
Shared service connexions	1,132,000	1,142,000	1,126,000
Total exchange connexions	4,784,000	5,037,000	5,210,000
Call offices	73,700	73,900	74,300
Local automatic exchanges	5,088	5,190	5,277
Local manual exchanges	921	811	733
Orders on hand for exchange connexions	144,000	170,000	147,000
Work completed during the year			
Net increase in telephones	330,000	422,000	344,000
Net exchange connexions provided	430,000	490,000	459,000
Net increase in exchange connexions	178,000	253,000	173,000
Traffic			
Inland telephone trunk calls	383,000,000	422,000,000	475,000,000
Cheap rate inland telephone trunk calls	85,000,000	98,000,000	112,000,000
Overseas telephone calls:			
Outward	3,096,000	3,556,000	3,736,000
Inward	3,035,000	3,400,000	3,788,000
Transit	80,000	83,000	95,000
Inland telegrams (excluding Press and Railway) ...	13,000,000	12,000,000	12,000,000
Greetings telegrams	3,000,000	3,000,000	3,000,000
Overseas telegrams:			
Originating U.K. messages	6,421,000	6,369,000	6,477,000
Terminating U.K. messages	6,448,000	6,454,000	6,454,000
Transit messages	5,635,000	5,496,000	5,401,000
Inland telex calls*	4m. calls from manual and auto. exchanges; 8m. metered units from auto. exchanges.	2m. calls from manual and auto. exchanges; 37m. metered units from auto. exchanges.	77m. metered units; 10,000 manually handled calls.
Overseas telex calls:			
Originating (U.K. and Irish Republic)	2,429,000	2,948,000	4,304,000
Terminating (U.K. and Irish Republic) ...	31,000	105,000	80,000

**Conversion of the inland telex system to automatic working was completed in December,* 1960. *During the year ended March* 31, 1962, *the number of subscribers lines increased from* 7,089 *to* 8,765.

NOTES

During the year the telephone order list decreased from 169,800 *to* 147,200. *At the end of the year* 99,500 *applications for service were in process of being met and* 47,800 *were waiting cables or exchange equipment.*

The overseas telephone services were extended by opening service with British Honduras.

The CANTAT cable was inaugurated in December, 1961, *increasing the number of public telephone circuits to Canada and the United States to* 23 *and* 53 *respectively. The total number of cable calls to and from North America was* 500,655 *(excluding those on circuits leased to Continental countries for public traffic). During the year there was an increase of* 13 *per cent. in traffic with Canada and* 12 *per cent. with the United States, based on corresponding traffic figures for* 1960-61.

By March 31, 1962, *there were overseas telex services between Britain and* 64 *countries.*

The Art of Making Transistors

How, and under what conditions, are transistors made? This article traces the story of the general-purpose alloy junction transistor, in which a small wafer of pure germanium, doped with antimony, forms the base and the emitter and collector junctions are made by alloying indium pellets into it

ANTHONY P. PARSONS, A.M.Brit.I.R.E. and
R. A. HUBBLE, Graduate I.E.E., A.M.Brit.I.R.E.

THE characteristics of all transistors depend on their shape and size and the purity of their materials. In the general-purpose alloy junction transistor the impurity of the germanium must be less than one part in 100 million and since this purity is not found in commercial germanium the transistor manufacturer has to refine his own germanium several times over.

One method is "zone" refining in which germanium powder is placed in a 12-inch long graphite boat and passed down a slight incline through a series of radio-frequency heating coils. As the boat passes through the coils the germanium becomes red hot and impurities are forced to the upper end. The process is repeated several times until the finished ingot of germanium has all its impurities at one end. A purity test is made by measuring the resistivity of the germanium after the impure end has been removed. At this stage the germanium is converted into n-type material by adding antimony. This is achieved by placing the ingot, with a seed crystal, into a quartz boat and passing it once through a radio frequency coil. The seed crystal ensures that the resulting ingot has the required degree of doping and a uniform crystalline structure.

The ingot is then sliced into thin wafers. One method is to mount the ingot on a wax bed and slice it with a carborundum wire which moves like the blade of a band saw. The slices, now only approximately the thickness needed for making transistors, are then ground by machine and etched in an acid bath to achieve their final thickness of a few thousandths of an inch.

Slices cut from a bar of purified germanium are lapped to reduce their thickness. Later, the slices are etched in baths of acid.

After etching, the slices are washed and ready to be cut into the squares which form the bases of the transistors. For this operation each slice is mounted horizontally on a wax bed and lines in the form of a grid are scored on the surface. The germanium is so brittle that only a light tap is needed to break the slices into squares. As the slices are irregular in shape many pieces on the edges are not complete squares so these are placed on one side and later reclaimed to make germanium ingots. Separation is carried out by operators using fine camel hair brushes. Each slice produces about 40 squares all of which are potential transistors. So much depends on the correct thickness of the squares that each is gauged and graded.

The wafers are now ready to be alloyed with indium to form the emitter and collector p-n junctions and for this the materials are prepared by mounting the wafers in a jig so that an indium pellet touches it on each side (the emitter junction pellet is very much smaller than that for the collector junction). The loaded jigs are then heated to about 900 degrees Centigrade in an oven which has a hydrogen atmosphere to prevent oxidisation during the alloying process. This treatment alloys the two pellets into the wafer and gives the transistor an n-type material base with collector and emitter p-n junctions. The transistors are again chemically etched to remove from the surface surrounding the indium pellet any incompletely diffused indium which might otherwise provide a by-pass across the p-n junction. After etching, the transistor is washed, dried and mounted by its base wafer on to a larger nickel wafer subsequently fixed rigidly to one of three lead-out wires secured in a header. The other two lead-out wires are connected by fine wires to the collector and emitter areas where they are welded in position.

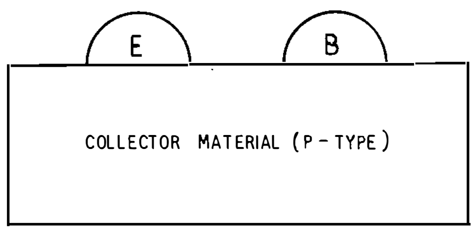
To ensure stable operating characteristics the transistor must be contained in a pure and stable atmosphere and the simplest, though not necessarily the easiest, way to ensure this is to enclose it in a hermetically-sealed envelope in a process known as encapsulation. This process presents many problems which manufacturers have attempted to solve in a variety of ways, one of which is to have the encapsulating body in two parts: the header and the envelope, both of which are kept in a dry atmosphere while the encapsulating process is carried out. The header is a flanged copper cylinder shaped like a top hat and in which is fixed a glass carrying the lead-out wires on which the transistor is mounted. The glass, lead-out wires and copper cylinder have identical co-efficients of expansion so that there is a perfect seal between the metal and the glass. The envelope, also made of copper and with a similar flange to that of the header, is placed over the transistor so that the flanges coincide and when pressed together form a cold weld.

The conditions under which transistors are made are of vital importance and elaborate precautions are taken to maintain clinical conditions in the factory, manufacturing and assembly areas.

What is a Transistor?

A TRANSISTOR is a three-layer device which behaves like a valve. Its two outer layers are either both of "p-type" or both of "n-type" material, the centre layer being of the opposite type. No current can flow between the outer layers because a barrier is formed by the junctions between the centre and outside layers. When a small current is passed into the centre layer this barrier is reduced, allowing a much larger current to flow between the outer layers than is injected in the centre. This phenomenon is known as amplification.

A semi-conductor does not readily conduct current and its ability so to do depends partly on impurities in the material. Since different impurities produce different kinds of conduction by introducing known impurities, "n-type" and "p-type" semi-conductors can be made. The former type contains an impurity whose atoms carry an extra electron and conduction takes place by the flow of electrons through the semiconductor. The "p-type" semi-conductor on the other hand has an impurity with one electron fewer and conduction takes place by electrons moving from hole to hole. The basis of most transistors is obtained by placing "n-type" and "p-type" material in the same crystal of a semi-conductor.



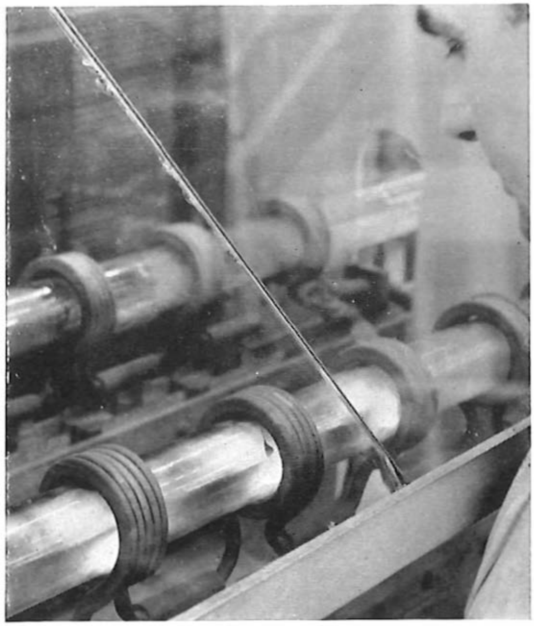
BASIC COMPONENTS OF ALLOY DIFFUSED TRANSISTOR BEFORE HEATING (NOT TO SCALE)

Ideally, factories should be in districts where the air is free from pollution but as this is generally impossible they are equipped with large air-conditioning plants which ensure that the air entering them is clean, dry and kept at a constant temperature. Air pressures inside "clean areas" are usually higher than those outside so that unclean air cannot penetrate through doorways, windows and other openings. A special mat with a sticky surface is often placed just outside doorways to remove dust and grit from the footwear of those entering clean areas.

Dry air in the factory is of paramount importance for moisture trapped on the active element of the transistor can cause serious deterioration in its performance. To prevent this, the final assembly of transistors is carried out inside a closely-controlled humidity cabinet containing extremely dry air. The operator sits outside the cabinet and assembles the transistor by inserting her hands into thin plastic gloves which are bonded to, and pushed through, two holes in the cabinet. She can see inside the cabinet through a glass viewing panel. Many assembly operations, such as fixing the lead-out wires to the active elements, are carried out with the aid of microscopes.

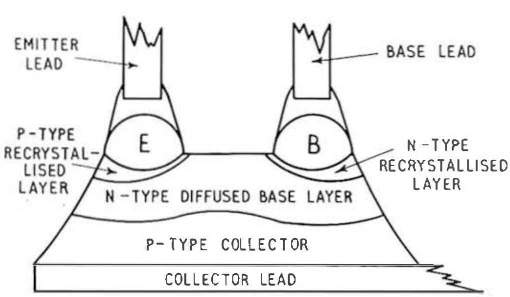
The operators—mainly girls because they have greater dexterity and ability to work for long periods on delicate and repetitive operations than men—wear nylon overalls and hats to reduce the likelihood of dust and fabric dropping into the assembly line. They take their tea breaks in areas away from the assembly lines and are not allowed to smoke at work.

In common with other mass production industries, transistor manufacturers use quality control checks on their production lines and keep detailed

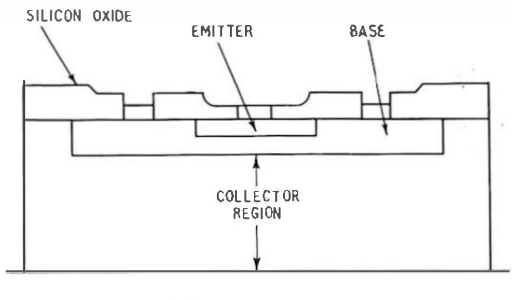


A close up view of a germanium zone-refining unit. Zone refining purifies the germanium to a degree higher than for any other manufactured article.

records of temperatures surrounding test equipment. At various stages during manufacture and assembly random samples are subjected to electrical and mechanical tests. Production stops if a large deviation from the accepted standard is discovered and the trouble is investigated. Electrical checks have a two-fold purpose: to test the working of the transistor and to grade them into voltage and current classifications. Mechanical tests include



SIMPLIFIED TRANSISTOR ASSEMBLY AFTER ALLOYING AND ETCHING



PLANAR TYPE

A girl operator at the Mullard works in Southampton assembles a transistor inside a dust-free humidity cabinet.

checking the hermetic seal and fragility of leads while vibration and shock tests seek out structural weaknesses not revealed by other means.

Quality control and exhaustive testing cannot, however, eliminate the inherent limiting characteristics of any type of transistor. One of these, in the alloy junction transistor, is its operating frequency. Many factors affect this, the most important being the base width which can be reduced only at the risk of melting the emitter and collector completely through the base during alloying. New manufacturing methods, notably the alloy diffusion technique which yields transistors with base thicknesses of a few microns (a micron is one-millionth of a metre) and high frequency characteristics, have been developed to overcome this problem. In the "mesa" transistor technique the wafer is made from collector (p-type) material, instead of alloying collector and emitter from each side of the base. Both base and emitter pellets (shown on page 127) are alloyed from one side only. Pellet B consists only of base (n-type) material while Pellet E is of both base and emitter material. During the alloying process the base material in both pellets diffuses through the collector material to form the base region. The manufacturing technique is so controlled that a base width of only a few microns is achieved. The base region reaches the crystal surface during alloying and is open to contamination from the atmosphere but this disadvantage is overcome in the planar transistor in which, with a wafer material of silicon, a silicon dioxide film is first deposited on the surface of the wafer. Both emitter and base are diffused through holes in the silicon oxide layer and the junctions are sealed below this to protect them from external contamination.

Although the first transistor was made only 14 years ago the highly-specialised manufacturing industry has developed so rapidly that automation is now possible. Soon, too, such components as epitaxial planar transistors, four-terminal and multi-element devices will be in common use, and, looking farther ahead, transistors of the future may not require today's unwieldy encapsulation process.

The photographs illustrating this article are reproduced by courtesy of Mullard Limited.

With the aid of microscopes, operators attach the gold-plated connecting wires to the emitter and collector of germanium radio frequency transistors. Normally, the girls wear nylon hats—but this picture was posed.

The T and T Society's Lectures

The Post Office Telephone and Telegraph Society's 1962/63 programme of lectures will open on Tuesday, 9 October, with *Recording for Entertainment* by Mr. F. Woods, Promotions Manager of the World Record Club.

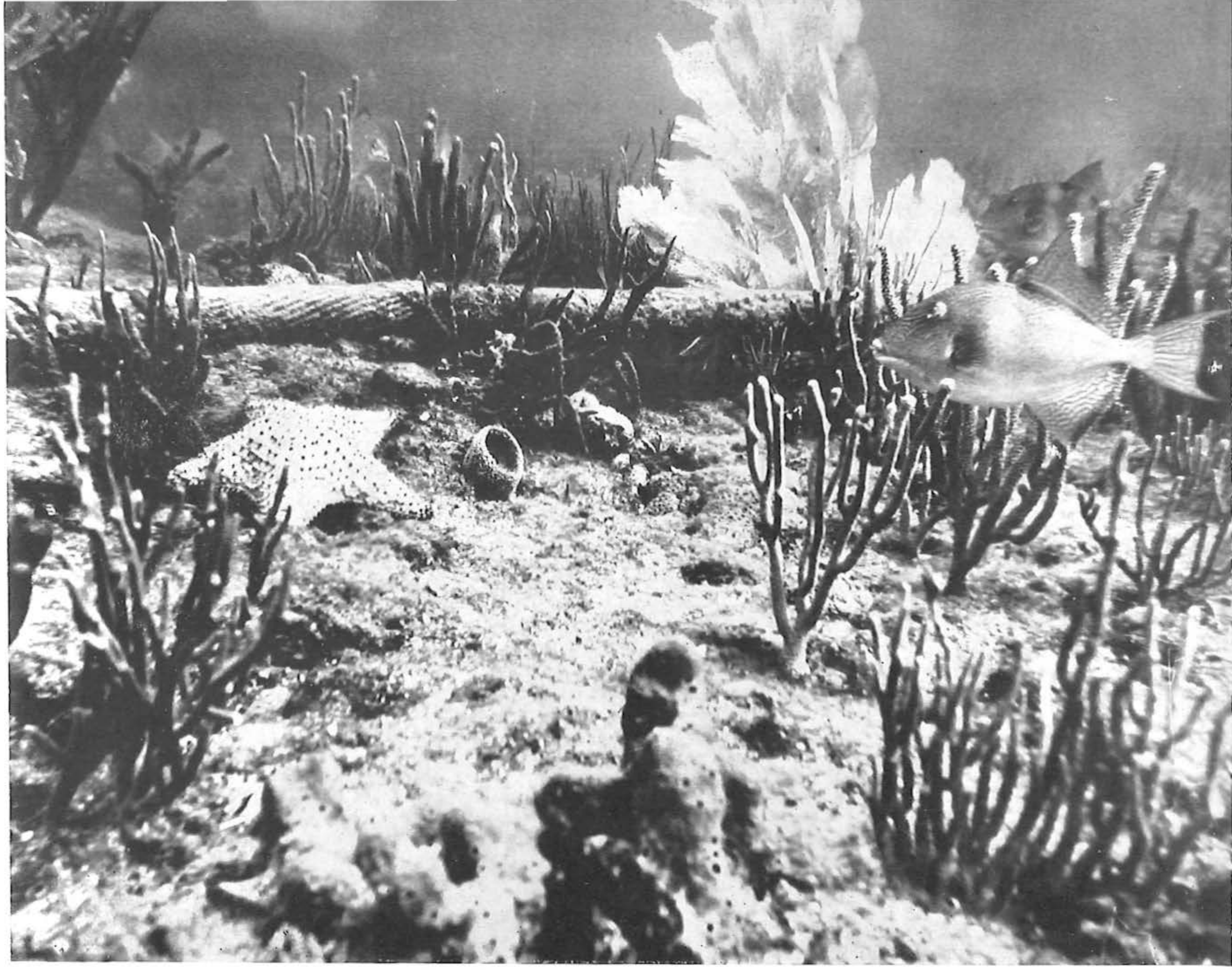
On 13 November Dr. A. R. A. Rendall, Head of Designs Department, BBC, will speak about *Developments in TV Techniques*, and on 11 December Mr. E. W. Shepherd, director, Finance and Accounts, GPO, will talk on *The Post Office in Business*.

Computers—What they are and What they will do will be the subject for Mr. C. R. Smith, O.B.E., Assistant Secretary, Central Organisation and Methods Branch on 15 January, 1963, and Mr. R. K. Pilsbury, Meteorologist, Meteorological Office speaks about *Weather Reporting* on 12 February, 1963.

The series will end on 12 March, 1963, with a talk by a senior officer of Pan-American World Airways on *Running an Air Line*.

All talks will begin at 5.15 p.m. in the Assembly Hall, Fleet Building, Farringdon Street, E.C.4.

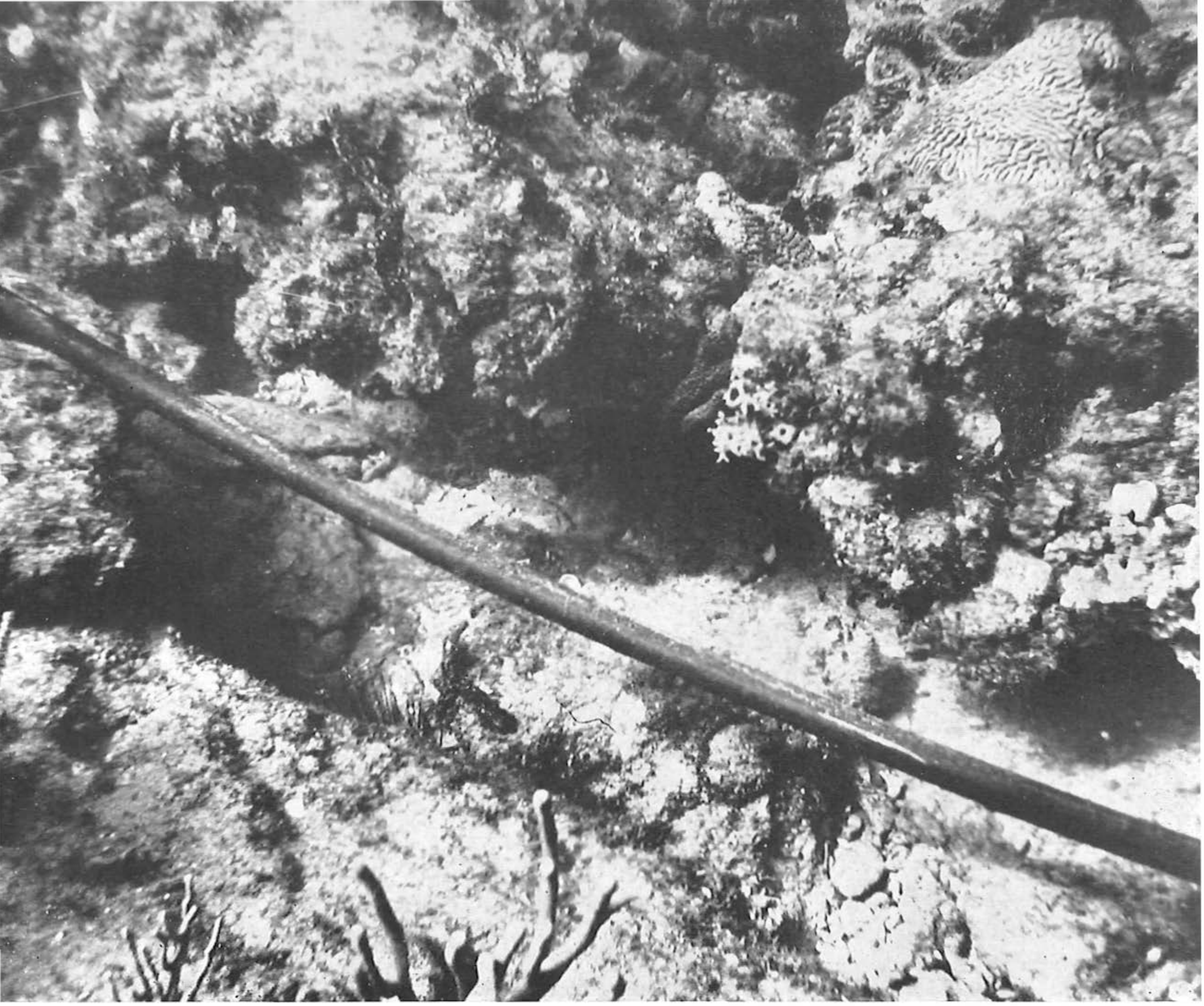
Membership of the Society is open to all Post Office staff and the staff of Cable & Wireless Limited, and the fee is still only 2s. 0d. a year. The Hon. Secretary is Mr. A. H. White, London Telecommunications Region HQ, Waterloo Bridge House, S.E.1, telephone number CITy 2000, Extension 513.



DOWN IN DAVY

UNTIL recently only the fish were able to see the trans-oceanic cables which span the seabeds and link the continents. But now the camera, too, takes a peep and in these remarkable pictures—two of the first underwater pictures of submarine cables—brings the fish's eye-view to man.

The astonished-looking, pop-eyed fish in the left-hand picture is staring at the Bell System armoured cable which links Florida with Puerto Rico. In the right-hand picture is seen part of the lightweight, armourless cable to be used in the Trans-Atlantic No. 3 Cable from Britain to the United States which will be laid



JONES'S LOCKER

by the autumn of 1963. Both pictures were taken off the Florida coast, the lightweight cable being under test.

The TAT 3 lightweight cable—only $1\frac{1}{4}$ inches in diameter and protected by polythene insulation—has been developed by the Bell Telephone Laboratories. TAT 3 will be the longest trans-oceanic cable ever laid. It will provide 128 more circuits, about half of which will be used for carrying traffic between Britain and the United States and the other half for service between Continental Europe and America.

** Photographs by courtesy of Bell News, Montreal and the Bell Telephone Laboratories, New York.*

Some of the members of the Pilkington Committee on Broadcasting which was set up in 1960 to consider the future of the broadcasting services in Britain. Sir Harry Pilkington, the chairman, is fourth from the right. On the extreme right is Billy Wright, the former England international footballer. "The importance of the issues, and the far-reaching nature of certain of the Committee's recommendations, make it wise to avoid precipitate decisions," says the Memorandum presented to Parliament by the Postmaster General.

The Future of Broadcasting

The Government will authorise a second television service for the BBC which will start in London by the middle of 1964 and be extended to the rest of the country later. Part of the new service will be in colour and all of it on 625 lines in ultra high frequency. Later, "there will be scope" for a second television programme under the Independent Television Authority, its shape and date of introduction depending on the future structure of ITA.

These are two of the Government's most important proposals contained in a "Memorandum on the Report of the Committee on Broadcasting" and presented to Parliament by the Postmaster General, Mr. Reginald Bevins, on 4 July, a few days after the Pilkington Committee report was published.

The Memorandum declares that there are obviously two opinions on whether the Pilkington Committee's arguments for a radical change in Independent television, structurally and financially, are valid and goes on to say that the practical difficulties presented by the Pilkington proposals have not been fully appreciated. "The evidence suggests that more people watch its programmes than those of the BBC. In some fields—for example, light theatre, news and religious broadcasting—it has undeniably contributed something of value to television and by bringing competition into the world of television exercised an enlivening effect on television in general."

After stating that the Government believes that an ultimate pattern of six television programmes should be kept in sight, the Memorandum agrees with the Pilkington Committee's view that educational programmes would best be provided as part of the general service programme and says the Government are prepared to authorise additional hours for both BBC and ITA television services, so long as they are used for programmes for adult education.

The Memorandum also proposes to authorise the BBC to provide a new transmitter as soon as possible to enable a distinctly Welsh television service to be given on a frequency in Band III to South Wales. Stations to serve North-east Wales and South-west Scotland would probably also be needed to implement the conception of self-contained national television services. The Government would discuss with the BBC and ITA the use of the remaining unallotted frequencies in Band III to improve the reception of existing programmes and to extend their coverage. Ultimately, a fully self-contained UHF television service for Wales, Scotland and Northern Ireland will be possible in Bands IV and V and when this is provided it will be possible to close down the special VHF services now to be provided as a short term measure.

On the question of local sound broadcasting, the Memorandum says that as there has been little evidence of any general public demand and the Government would be loath to create extra demand on resources which, at present, should be concentrated on national requirements, it would prefer to take cognisance of public reaction before reaching a decision.

FIFTY YEARS OF AUTOMATICS

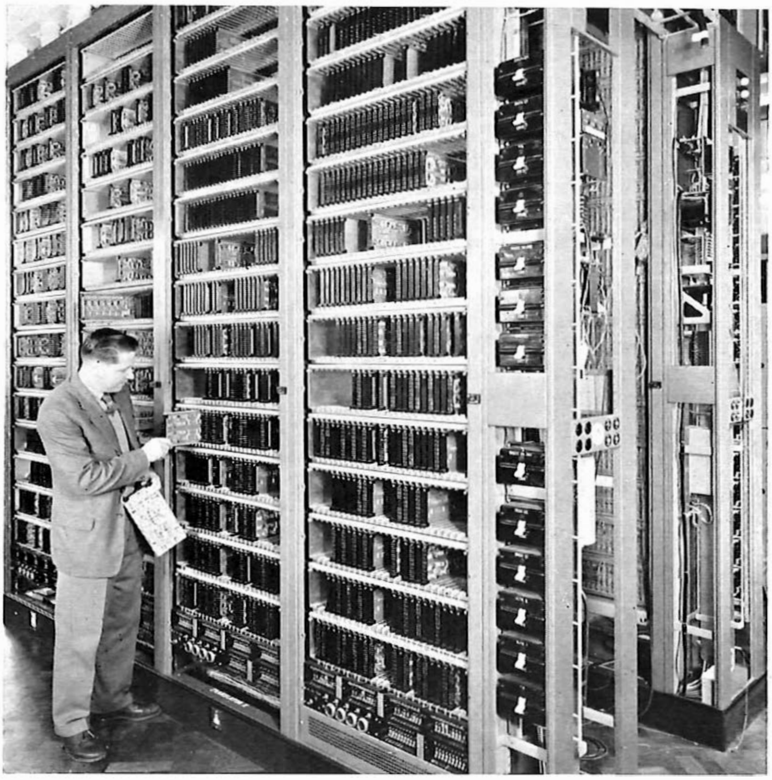
by J. A. LAWRENCE, T.D., M.I.E.E.

WHEN the first all-electronic automatic telephone exchange in Europe is brought into service at Highgate Wood, London, this autumn, the story of the first 50 years of automation in the Post Office will be completed.

The year 1912 was an historic date for it was then, after the unification of the telephone system in Britain, that the Post Office, free at last to plan ahead and unhampered by the uncertainties of the previous decade, embarked on automatic telephony.

On May 18, 1912, the first automatic telephone exchange in Britain was opened at Epsom,* to be followed almost immediately by a similar installation—later known as Official Switch—to serve Post Office Headquarters at St. Martin's-le-Grand, London. Both installations were based on the step-by-step system later called the Strowger system. They were to set the pattern for the

Half a century after the first automatic exchange in Britain was opened in 1912, the first electronic exchange in Europe is nearing completion. Here is the story of the developments in telephone exchange automation in those fifty years



Some of the equipment at the new electronic exchange at Highgate Wood which is planned to come into service this autumn. Work is already far advanced on new and improved systems of electronic switching.

* The automatic exchange at Epsom was experimental but it operated for 20 years. In 1932 it was replaced by a manual exchange which is now due to become automatic again by the first half of 1965.

future in Britain, though at the time this was not appreciated. The Post Office was following what was to become its traditional outlook on innovation—the new system of switching offered considerable improvements in service, reduced demands for accommodation and promised better use of capital resources. These were sufficient reasons in 1912 to justify a trial of automatic working under the critical eyes of the Engineering Department. Today—half a century later—the same approach to innovation is to be seen in the completion of the all-electronic exchange at Highgate Wood.

The choice of Strowger for Epsom was determined largely by its availability as a commercial system (several similar exchanges were already in service in the United States). The contract was placed with British Insulated and Helsby Cables—shortly to become the Automatic Telephone Manufacturing Company (the ATM of later years)—now the AT and E Company. The equipment was manufactured and installed by the Automatic Electric Company of Chicago.

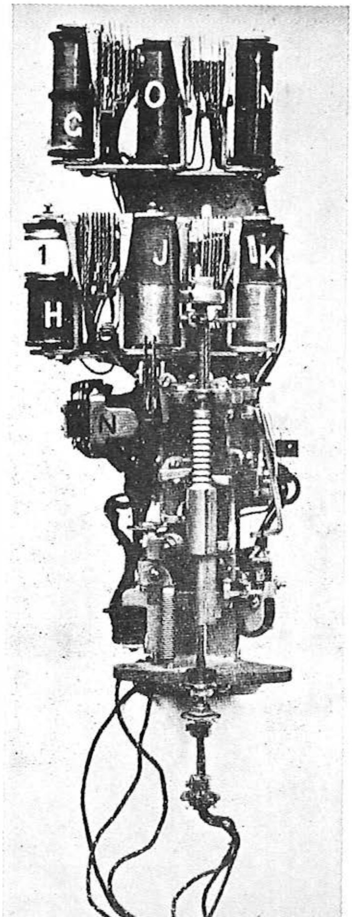
Only eight years earlier the invention of the Keith Line Switch had disposed of the economic problem of concentrating subscriber traffic on first selectors (formerly each subscriber had his own first selector). By 1912 the system's principles had largely taken on their present character: the familiar dial as the calling device, two-wire working between telephone and exchange, central battery operation and a trunking plan that permitted numbering plans of three, four or more digits. The apparatus was recognisably similar to much of the equipment still in service.

The exchange at Epsom provided 500 lines with 70 per cent. local traffic, a high proportion of which was considered essential to the success of automatic working. The facilities were basically those current in the United States, British variations being still in the future. Automatic metering for local calls excited considerable interest but the possibility of extending it to include non-local calls was not envisaged.

While Epsom was settling down to steady and satisfactory operation the Post Office was studying alternative systems and, in 1914, an entirely different system—the Lorimer—was opened for public service at Hereford. In many ways the Lorimer system, which lasted for eleven years, was in advance of its time. Some of its concepts are, in fact, reappearing in the electronic age and only now can its basic ideas be made to produce viable systems.

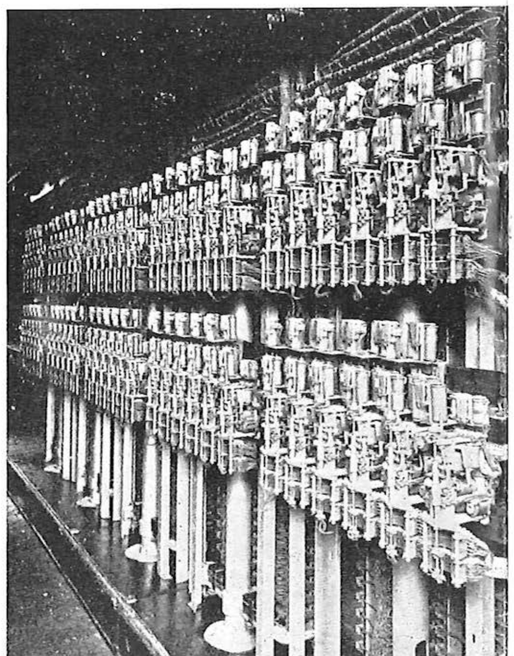
The Lorimer system was power driven, the selectors deriving their motion from a common motor drive through electro-mechanical clutches. The circuits were elegant and very economical of relays and circuit operation contained features which today would be thought of in the context of a wired programme control system.

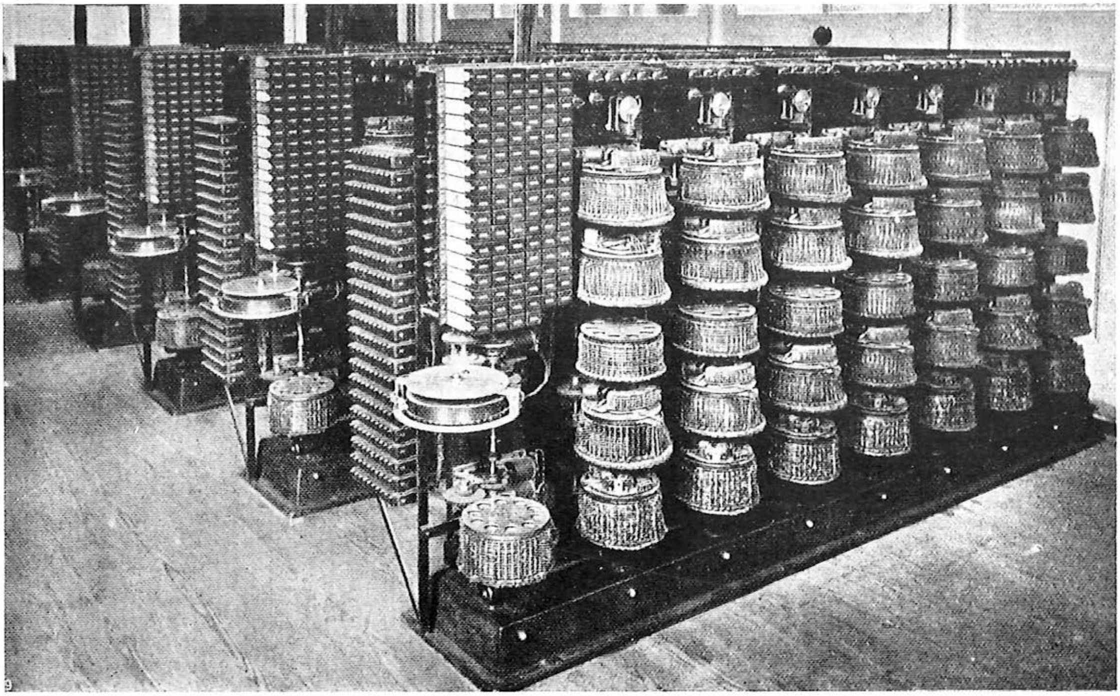
The Lorimer system did not use a dial as the calling device but four levers which were pre-set



LEFT: *A side view of a final selector mechanism in use in the early 1900s.*

BELOW: *The connector side of a line switchboard of the same period, showing five units with 12 connectors for each unit.*





Part of the Lorimer automatic equipment installed at Hereford in 1914. Like that at Epsom, it provided for 500 lines with 90 per cent. of local traffic.

to the wanted number and brought into operation by turning a handle.

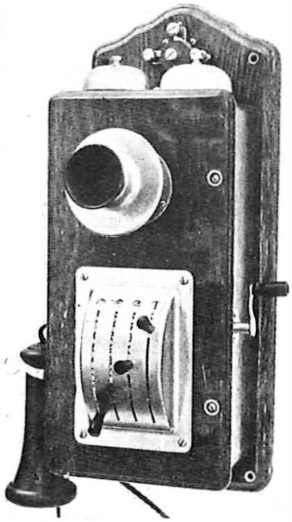
The typical wall telephone of the period was mechanically complicated and probably expensive but it had certain advantages for the user. It provided a visual check of the number being called and the number once set up could be recalled as often as desired merely by replacing and removing the receiver and turning the handle. A few years ago the Bell Laboratories produced an electronic system which had much in common with the Lorimer system, each subscriber's telephone being provided with its own lever-operated number register.

World War One did not stop progress in automation. Strowger working had not then developed its commanding position of later years and other systems required consideration.

The Western Rotary System which was now being manufactured in both the United States and Belgium was, like the Lorimer system, power-driven and used single motion switches. One novelty was a register, an essential part of all present systems.

The Post Office found much to commend the Western Rotary system and contracted for an installation for Darlington which came into service in 1914, providing for 2,800 lines with an initial capacity for 800. Today the Western Rotary system is world-wide—but it did not survive in Britain. By 1914 Strowger equipment was already being made at Liverpool. The Western Rotary system was slightly more complicated than Strowger, with which the Post Office was more familiar, and there were some misgivings about its dependence on common apparatus.

Despite the War, progress was rapid. Plans were laid in 1914 for full automatic working for Blackburn, using Strowger equipment, and the first small automatic exchange came under consideration for Chepstow. Economic considerations had so far limited automatic working to exchanges of more than 1,000 lines, with manual the preferred alternative. Its application to Chepstow with 65 lines was indeed an innovation described by a contemporary official as "a very interesting experiment—a proposal hailed with relief by the authorities concerned".



A Lorimer wall telephone in use in 1914. The required number was called by setting the hand-operated levers against the appropriate figures, in this case 9641.

By 1915 Siemens Brothers of Woolwich (now Associated Electrical Industries) who had been working on a variation of the Strowger system, had perfected a range of small exchanges based on line switches and Strowger-type final selectors and three of these exchanges were installed. That year also saw the beginning of the development of what was to become the British Strowger System, the American practice of the earlier system giving way to a modified practice better suited to Post Office requirements.

In 1916 Siemens completed the installation at Grimsby of an exchange after the Strowger pattern, except for the use of ten-contact first and second preselectors—in effect, primary and secondary uniselectors—which gave a higher traffic handling capacity despite the use of small capacity uniselectors.

In April, 1916, an ATM Strowger exchange was opened at Portsmouth. It replaced four manual exchanges and is recorded as exceeding in equipment "the total so far provided at all existing automatic exchanges in the country".

The second Western Rotary exchange opened at Dudley in September, 1916 and progress thereafter was steady. All new automatic exchanges were of the Strowger type until 1922 when the Post Office, although leaning heavily towards Strowger, opened an entirely new type of exchange at Fleetwood for 500 lines.

This exchange was all-relay and a remarkable development in the history of automatic working. It was in advance of its time and gave excellent service with a very small fault liability for many years. Its principles were complex by Strowger standards for it depended essentially on relay assemblies for switching and on registers with common control of switching, and although reasonably economic below 1,000 lines, increased disproportionately in cost as the number of lines increased above that figure. Only today are the principles being revived in the form of space division electronic exchanges. A close study of the relay automatic principles might well help to improve electronic systems. On page 139 is the trunking diagram for a 1,000-line exchange.

A 1922 review showed how great progress in automation had been in ten years. In that year 16 public and 13 private automatic exchanges were in operation, six public and ten private automatic exchanges under construction, 53 public exchanges in the specification stage and another 147 in the planning stage. The multi-office area had already arrived. Of the ten private exchanges under construction nine were of the relay automatic type—an ideal application for this system. The dominance of Strowger is well illustrated by the fact that of the 16 public exchanges in operation, eight were ATM Strowger, one Siemens' Strowger, one Lorimer, two Western Rotary and one Relay Automatic.

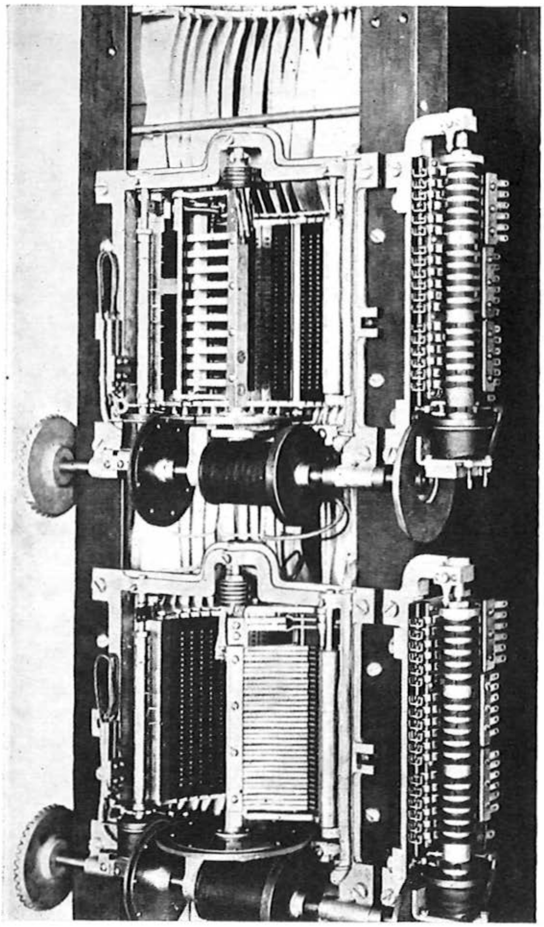
By 1923 rural automation had begun with Siemens' village automatic system, which provided for 20-59 lines and up to three junction groups, all on final selector levels, the digits for junction access being 01 to 00—typically 01, 04 and 07. This system, although providing the first practical and economic rural exchanges, did not survive in this form, largely because of its limited facilities, particularly for call charging. It did, however, lay the foundations for the extensive rural automatic system in Britain which today is probably as complete as any in the world.

This period also saw the entry of the General Electric Company as a British manufacturer of automatic equipment, purchasing manufacturing rights from the North Electric Company of Gallion, Ohio. Two trial exchanges, using imported apparatus assembled in this country, were opened at Dundee and Broughty Ferry and were the last experiments in new systems. The North Electric system was a step-by-step system but depended on two-motion selectors of a novel type. The selector banks were semi-circular but disposed with the contact arcs vertical. The wipers moved first horizontally under dial pulse drive and then vertically to select a free trunk to the next stage.

By 1923 the Post Office was firmly set on the road to automation and the decision to adopt Strowger as the future standard was virtually made. But the problem of London and other large cities remained unsolved. There were no clear indications that the Strowger system could satisfy the requirements. The Strowger multi-office area principle, with its inflexible trunking and numbering plans, although entirely satisfactory for cities such as Leeds, could not be contemplated for London which necessarily had to be converted over a number of years.

In 1919 Messrs. Laidlaw and Grinstead of Siemens proposed an ingenious solution for the London problem: the city would be split into nine regions, each designated by a single digit in the range one to nine, each region would serve up to 100,000 numbers and the name of each region would appear alongside the corresponding digit on the dial. Each region would also have a regional switching centre which would give access to its dependent exchanges and any caller anywhere would obtain direct access to the regional centre by dialling the regional name digit.

A pair of rotary group selectors used in the Western Rotary system which was installed at Darlington in 1914. The toothed wheels (left) provided the coupling to a common driving shaft which rotated continuously.

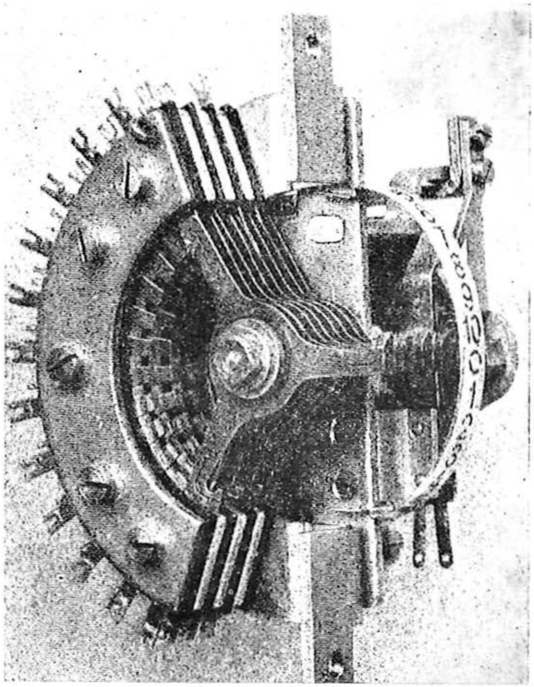


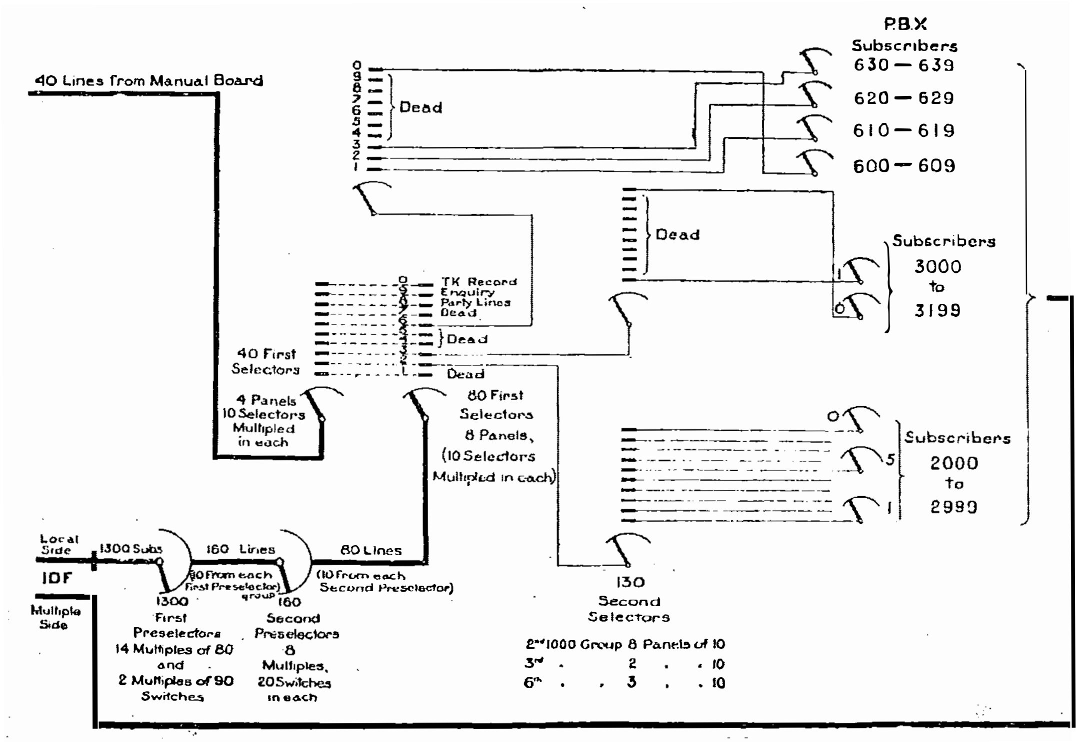
This proposal excited considerable interest but the Post Office was unable to accept its limitations—the rigid numbering plan, the inflexible junction plan, the limited number of possible exchanges and the enormous and intractable problem of transfers from manual to automatic working.

Meanwhile, the Western Electric Company of the United States had evolved a system known later as the Panel system. This was remarkable for its ingenious use of the code translation principle for area control of routing. The machine provided routing intelligence and for the first time made a rigid association between an area numbering plan, number of exchanges, exchange location and junction plan unnecessary. The system had been developed specifically as a solution to the Metropolitan area problem in the United States, and, as such, it was applicable to London.

Early in 1919, Mr. McQuarrie, of Western Electric, visited London and Colonel Purves, then Engineer-in-Chief to the Post Office, said later, "Mr. McQuarrie's description (of the Panel system) came to me as a veritable flash of light.

A ten-contact first pre-selector, part of the automatic equipment introduced at Grimsby in 1916.





This diagram of the circuit grouping arrangements for Grimsby in 1916 illustrates the beginnings of current practice in trunking diagrams.

It was at once apparent that, by the invention and application of the digit translators, numerical call indicators and so on which he described, most of the old bogies had been disposed of".

The success and detailed application of the translation principle is now well known. Why, then, was London not converted to Panel? Briefly, the Post Office found the Panel system expensive and complicated. It was in an early stage of development, much engineering and detailed design remained to be done and there was also the important question of whether the system could be manufactured in Britain. Nevertheless, it was the only known solution to the London problem, and had boundless possibilities.

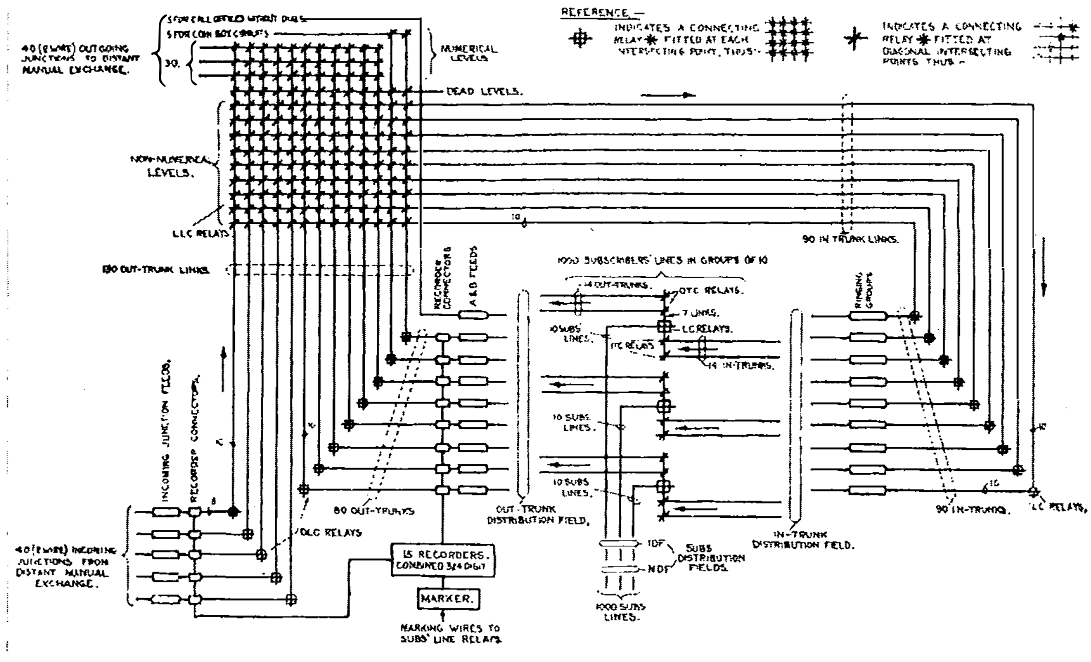
Preparations were, in fact, made for a Panel exchange at Blackfriars, London. The ATM Company reacted strongly by proposing a variant of the Strowger system which included code-translating facilities—soon to be known as the Director system. A working model was quickly constructed and installed for Post Office tests. A period of great activity and close co-operation between the engineers at Liverpool and in the Post Office followed—it is said that many of the circuits were worked out on the backs of menu cards in the dining car on the Liverpool train—and finally, in 1922, the Engineer-in-Chief of the Post Office recommended the adoption of the Director system. The compelling reasons for this recommendation were that the director system:

(*a*) had a lower first cost; (*b*) its circuits were simpler and already well known in Britain; (*c*) it used step-by-step two-motion switches and uniselectors; (*d*) it could be applied equally well to small and large exchanges; and (*e*) it could be manufactured entirely in Britain.

The first London director exchange opened at Holborn in 1927 and the conversion of the London network to automatic working proceeded steadily from that date. The same system was also used in the conversion of five other major cities to automatic working. Elsewhere the non-director system became standard practice.

By 1923 it was fast becoming obvious that close co-operation between the Post Office and the manufacturers was essential. A technical development committee was formed (the British Telephone Technical Development Committee) and over the next two decades or so standardisation, in the sense that each of the manufacturers could supply identical equipment to the same specification, was virtually accomplished. This did not mean that development and innovation ceased. On the contrary the BTTDC, under the Chairmanship of an Assistant Engineer-in-Chief of the Post Office, became responsible for modifying and extending the system to meet changing requirements, taking advantage of and developing technical improvements and encouraging innovations which promised future improvements. The success of their efforts is seen in such examples as the vast expansion of rural automatic working in the form of Unit Automatic Exchanges, the development of the Post Office 3000 type relay and the highly economical 2000 and 4000 type two-motion selectors, trunk mechanisation, the introduction of Subscriber Trunk Dialling and the development of electronic aids to the existing system—particularly register-translators.

The decade which ended in 1922 with the decision to convert London, was one of great importance to the Post Office and the British telephone industry. They were the formative years during which British practice in telephone automation developed along typically British lines. With the groundwork so firmly based progress after 1922 was steady and at times spectacular. Rural automation is a good example. In 1929 there were only nine rural automatic exchanges; by 1934 there were 1,139 serving 35,000 lines. The year 1924 saw the formation of the Telephone Development Association which, in conjunction with the Post Office, did much to promote the use of the telephone in Britain, particularly in the years following the depression. By 1932 the first suggestions for national dialling (now Subscriber



The Post Office introduced the first all-relay automatic exchange at Fleetwood in 1922. This diagram shows a typical trunking scheme for a 1,000-line relay automatic exchange.

Trunk Dialling) were heard. In 1933 automatic multi-coin boxes became available.

The rest of the story of the first fifty years of automation is well known. Immediately after World War Two a start was made on trunk mechanisation—the process by which trunk calls could be set up to any automatic exchange in the country by a single operator. This was the forerunner of STD. It provided much of the apparatus necessary for automatic switching of trunk circuits.

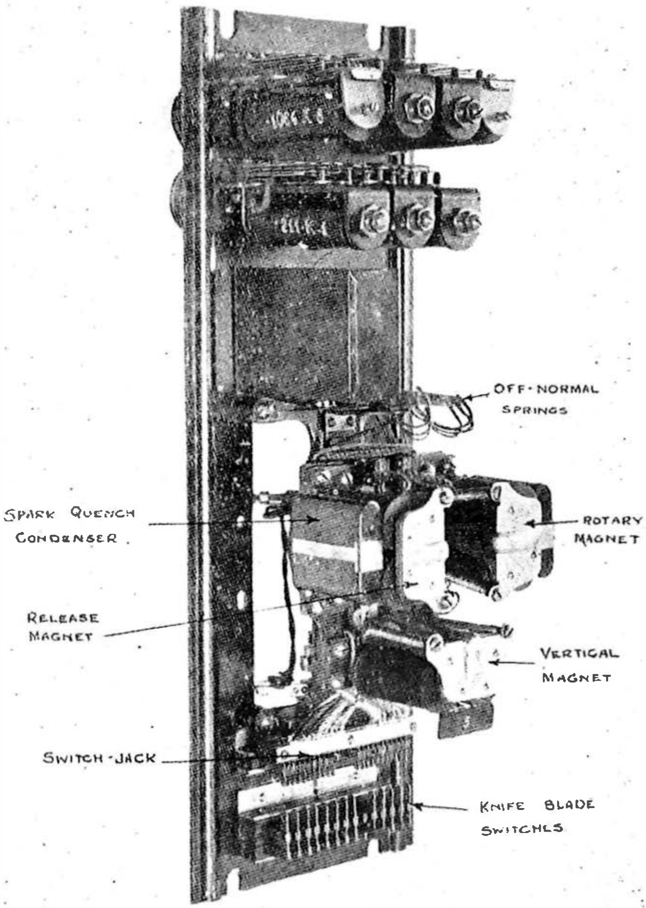
In 1949 a national dialling study group under the Chairmanship of Mr. D. A. Barron, CBE, now Deputy Engineer-in-Chief, published a report which showed conclusively that STD was practicable and almost certainly economically advantageous and proposed the broad technical lines on which the plan could be developed. Following a period of financial stringency, work began in 1954 on conversion to STD, culminating in December, 1958, in the opening by the Queen of the first STD installation at Bristol. Today about one and a half million trunk calls are being dialled by subscribers every week.

The Post Office was still pursuing its forward-looking policy on innovation. Work had been in progress since 1945 at the Post Office Research Station on electronic switching techniques. By 1950 this had progressed far enough to justify field trials of electronic aids to existing systems and, in 1952, the world's first electronic register translator in public service was opened at Richmond, Surrey. This work bore fruit in the development of centralised register-translators for STD. In 1956 the Post Office concluded a Joint Electronic Research Agreement with the five manufacturers to conduct research into electronic switching as a possible alternative to electro-mechanical switching. The first practical results of this joint effort are to be seen at Highgate Wood, London. Work on electronic switching is continuing and already vast improvements have been made and the development of the second generation electronic exchanges is far advanced.

In fifty years we have come from the first electro-mechanical exchange to the first electronic exchange. Epsom was preceded by about 12 years of experimental techniques and systems. Curiously, Highgate Wood also required about 12 years of experimental work, but whereas Epsom embodied the results of operational experience as well as successful experiment, Highgate Wood has yet to go into service.

Current opinion based on development capability holds the view that by 1972 trial electronic exchanges will have been in service for several years and production versions will be available—again a curious echo of the decade from 1912 to 1922. Will history repeat itself?

* There is a vast amount of material on which to draw and selection is inevitable. The Journal of the Institution of Post Office Electrical Engineers gives an admirably connected picture of events over the last fifty years and it is upon this source, supplemented by references to *The Story of the Telephone*, by J. H. Robertson, that most of this article is based.



A North Electric two-motion selector, less its bank. These selectors were employed in two trial exchanges—at Dundee and Broughty Ferry—in the 1920s.

All photographs illustrating this article, except that on page 133, are reproduced from the Journal of the Institution of Post Office Electrical Engineers.

MISCELLANY

Premium for Dr. Metson

Dr. G. H. Metson, MC, Deputy Director of Research at the Post Office Research Station, Dollis Hill, has added another Premium—the highest award made by the Institution of Electrical Engineers—to the four he was awarded in the 1950s for papers on the understanding of valve theory and manufacturing techniques.

This time, Dr. Metson won the premium for a paper on electrical engineering.

Dr. Metson, who served with the Royal Signals in World War II, reaching the rank of Colonel, joined the Post Office in 1925. He enjoys a world-wide reputation as a leading authority on the behaviour and causes of failure of oxide cathodes in valves.

*

Hooted out of Town

A Kentucky farmer named Nathan Stubblefield was publicly sending and receiving both voice and music by wireless years before Marconi won fame for sending and receiving wireless code signals, according to an article by Frank Edwards in the London *Evening News* of 16 June.

In 1892, says Edwards, Stubblefield successfully demonstrated with two disconnected telephones, how messages could be transmitted through the air without wires. But the crowd which heard Stubblefield and his son exchange a conversation in normal voices over a distance of about 100 yards, refused to believe him and "hooted him out of town".

Not until 1902, when he astonished American scientists by demonstrating how voice messages could be exchanged between a moving steamship in the Potomac and the Virginia shore was Stubblefield able to convince the sceptics. But by then Marconi had already succeeded.

A stone memorial on the courthouse lawn at Murray, Kentucky, now marks the spot where Stubblefield and his son carried out their first experiments.

*

Facts and Figures

There are now 65,000 European telex customers accessible by direct dialling from Britain, 40,000 of them in Western Germany. About 9,000 subscribers can dial their own calls direct to subscribers in Norway. A new telex service to the Republic of Sudan was opened on 1 August.

The number of combined television and sound radio licences in Great Britain and Northern Ireland increased in June this year by 54,774, bringing the total to 11,983,683. The number of sound only licences, including 509,685 for sets fitted in cars, was 3,495,834.

FLASHBACK TO 1884

Telephony has come a long way in the past 80 years or so and here, to illustrate the rapid advances that have been made, is a picture of the Croydon (Surrey) Telephone Exchange in 1884. The sewing-machine-like contraption in the centre with an untidy mass of wires hanging above it is the switchboard which is believed to have served fewer than a dozen lines. This exchange was owned by the National Telephone Company and was manually operated either by magneto or common battery signalling. The Company was taken over by the Post Office in 1912.

Towering over the Thames near Waterloo Bridge is a new building of considerable interest to the Post Office for inside it is the . . .

BIGGEST PABX IN BRITAIN

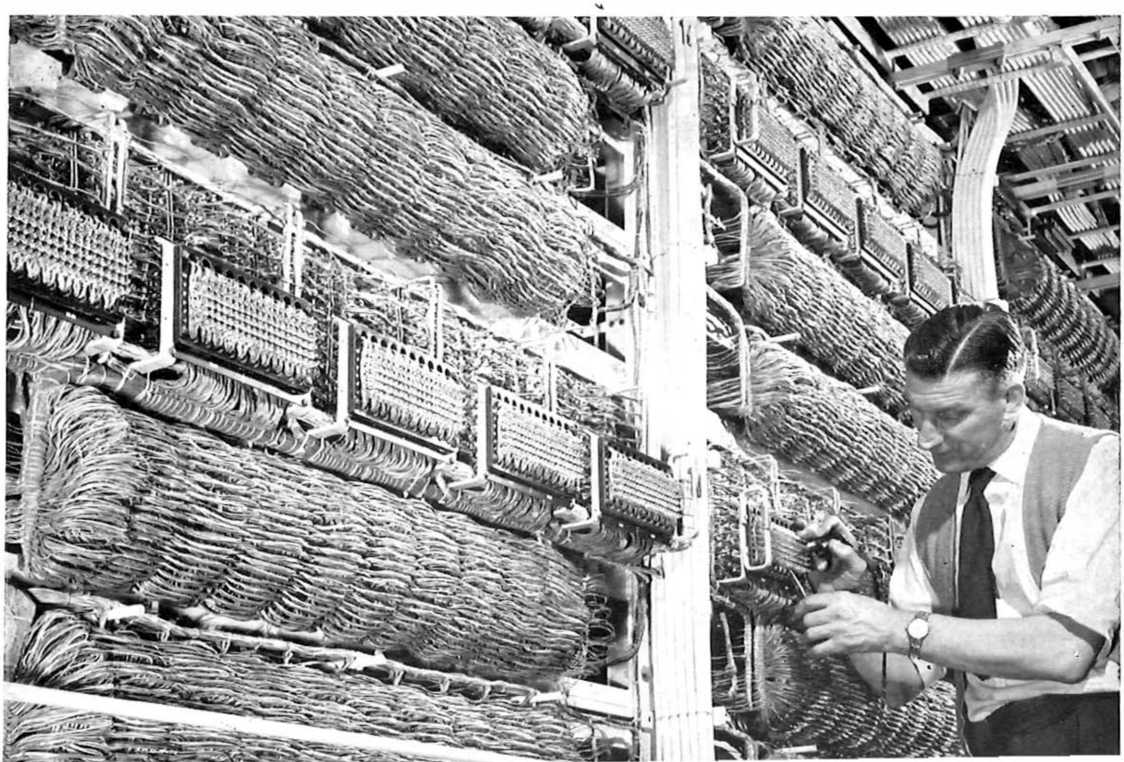
ON the South Bank of the Thames at Waterloo, scene of the Festival of Britain some 10 years age, now stands a remarkable building which houses the biggest and most comprehensive Private Automatic Branch Exchange in Britain.

It is the new, 26-storey London headquarters of the Shell International Petroleum Company. Its Cordless PABX can serve 4,500 extensions, increased if necessary to 7,000, has 240 exchange lines, and 130 private wires, external extensions and inter-switchboard lines, six of which give direct communication with the Hague.

After two years of site exploration the building of the new Shell offices began in August, 1957, and for a short while the 26-storey tower block was the tallest building in London. That record has now been relinquished, and indeed it will soon again be outstripped by the Museum Tower (described in the Winter, 1961, issue). But the Shell Centre has other outstanding features which have yet to be surpassed.

The quantities of materials used in the construction could seldom have been encountered before in a project of this nature: 14 million bricks; 2 million feet of scaffolding; 18,000 tons of reinforcement; 200,000 cubic feet of concrete; nearly half a million feet super of facing stone; 23 miles of plastic pipe and so on. New methods of construction were of necessity developed to cope with the problems which emerged during the building operation. Closed circuit television was used to inspect the deep holes which were excavated to contain the foundation piers, sand for the building was blown through pipes to the upper floors and then fed down again by gravity, concrete was pumped to a height of 350 ft. with booster stages at the 9th and 18th floors, and—a really modern

A rear view of the position racks showing the wiring of the selectors and the cables leading to other equipment in the Shell building.



By A. J. FORTY,
B.A. (Oxon), A.M.I.E.E.

Photographs:
Shell International Petroleum Company

technique—machinery and tanks for the top floor were flown in by helicopter.

The facilities to be enjoyed by the future occupants of the Centre (about 5,000 of them) will be unusually comprehensive. Both the 26-storey block and its flanking 10-storey building will be fully air conditioned with heating or cooling pipes in the ceilings which can be manually or thermostatically controlled, either individually or in groups. Windows are double glazed and mineral wool acoustic treatment has been given to partitions. Air tube mail distribution and tea and coffee conveyors serve all floors. A theatre and cinema, a swimming pool with electronic timing gear for racing events, a recreation area for badminton, table tennis and fencing, squash courts, a rifle range, changing cubicles, coffee lounges and a multiplicity of dining rooms are some of the amenities to be provided. There is even an entrance from the building to the Waterloo Underground Station on the Bakerloo line, so that the fortunate office worker has no need to brave the hazards of the London weather.

In recent years new designs of PABX have been introduced by manufacturers (to specifications approved by the Post Office) using cordless switchboards for the operators' positions. These cordless boards contain little more than keys and lamp indicators and, consequently, they can be designed with the pleasing lines of contemporary furniture. With the remainder of the PABX equipment relegated to the apparatus room it thus becomes possible for the operators to work in a room which has the appearance and the comfort of a modern office. Due in part to the switching techniques employed and also to the fact that they were developed at a later time, the modern cordless PABXs can offer facilities which are not provided by their predecessors. Shell has taken full advantage of these and of the improved appearance in the equipment which has been designed, made and installed for them by the Automatic Telephone and Electric Company.

The switchroom contains 19 operators' positions, a supervisor's desk and two inquiry desks. Deep carpeting and acoustic tiling on the ceiling give the

This is the switchroom in the Shell Centre PABX. It has 19 operators' positions, a supervisor's and two enquiry desks. Note the deep carpeting, acoustically-tiled ceiling and the glass viewing cubicle.

The 26-storey Shell Centre building by the Thames. It is connected by subways to the nearby block of ten storeys. The tower on the 25th floor has a public viewing gallery.

room excellent acoustic characteristics and this treatment, combined with the absence of the noise associated with cord-type switchboard operating, provides excellent working conditions for the staff. The switchboards, specially designed for this installation by Mr. Richard Huws, are of a novel pattern which has been approved by the Council of Industrial Design. Loudspeakers are fitted unobtrusively in the ceiling and the supervisor has a microphone by means of which she can broadcast instructions to her operators. The justifiable pride of the architect in the design of the switchroom is shown by the provision of a semicircular glazed cubicle from which the staff may be observed at work.

The apparatus room, which is more prosaic (though it has deep red walls and ceiling, black pillars and a buff coloured floor), is situated in the basement of the upstream building. Telephone cable risers connect with each floor of this building, while access to the downstream block is provided by way of a subway which also carries power cables, other services and pedestrian traffic. Under all floors of both blocks is a comprehensive system of trunking which enables outlets for individual extensions to be located virtually without restriction, thus providing full flexibility in the location of office furniture and of partitions.

The equipment provided at extension points varies in complexity from simple 700 type instruments, of which there are over 2,000, through plan extensions (150 plans 1A, 1,200 plans 2 and 400 plans 107) to special apparatus connected not only to the PABX but also to an independent key calling network. The key calling system provides rapid communication between members of groups of personnel who have a high community of interest. The main station of each group (called the "master" station) can make a call to any of its associated (or "side") stations merely by throwing a key. The "side" station may speak to its "master" in the same manner, and may in itself act as master to a series of lesser side stations. By operating more than one key at a "master" station conferences may be held.

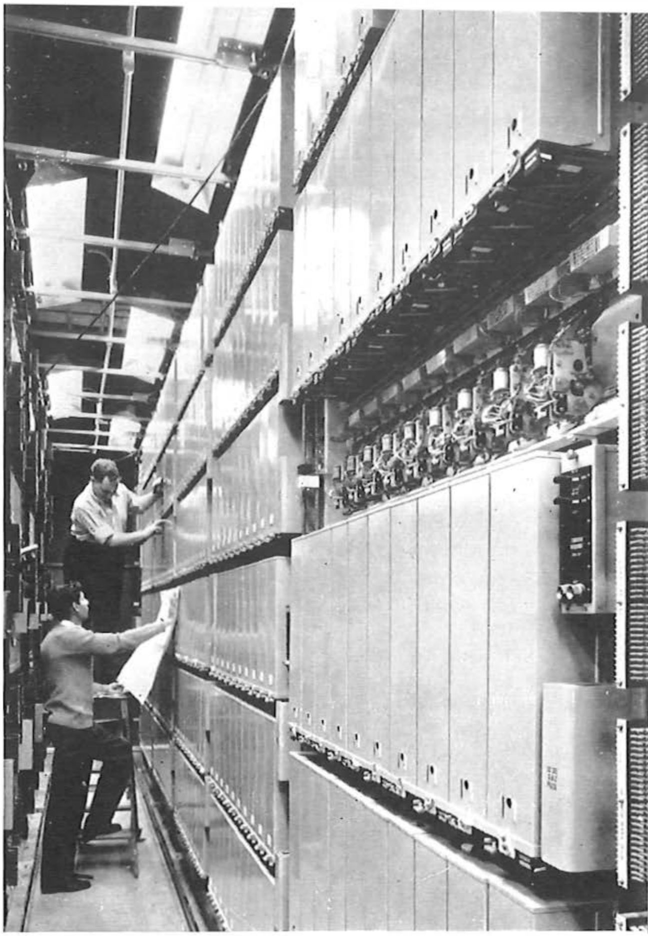
Each of the 110 "master" stations incorporates a loudspeaking telephone (it can be used optionally instead of the handset which is also provided) and keys which vary in number from 10 to 30, the whole of the equipment being housed in a cabinet specially designed for the Shell installation. The 632 side stations have no loudspeaking facilities, but also have their keys (20, 10 or 2) mounted in a specially designed cabinet. There is no central equipment required for this system: only multiple cable connects the various stations which are all mains operated.

Other well known methods of providing key calling at PABX extensions exist which use centralised switching equipment associated with the PABX for establishing the connections and thereby may prove more economical in initial capital outlay at the expense of flexibility. The independent system, however, was chosen by Shell because they require the answering of exchange calls to take priority over internal traffic, a view that the Post Office will endorse. By adopting the independent key calling system they have arranged that two connections, one from the PABX and one from the key calling network, are terminated on each extension instrument so that incoming exchange calls can be signalled at the extension even if the user is speaking on the other network.

The Shell Organisation has paid special attention to the problems relating to exchange access. The 240 exchange lines are connected to Waterloo exchange which has been converted to STD working. It was decided that access to the trunk network should be possible only through an operator and that auxiliary services normally available by a local call should not be allowed to extension users. This embargo also covers the 999 call since Shell Centre has its own local emergency service. The following grouping of exchange lines thus emerge: 103 are allocated for incoming calls only, 97 are used for outgoing calls only, but have barring equipment located at the PABX which forbids the use of 0, 100, 999, INF and TEL and other similar codes, while the remaining 40 are full facility lines for use on trunk calls only, with access only through the operator (by dialling 87). By means of facility discriminators which are seized whenever an extension telephone handset is lifted the class of service allowed at each station can be varied in accordance with the status of the extension. For example, cleaners, office boys and the like are allowed only extension to extension calls and are barred all exchange access.

For technical reasons all trunk calls obtained through the operator on large cordless PABXs are "reverted", that is, the extension user calls the operator, requests the call and then hangs up his handset. The operator then obtains the required number and rings the calling extension in order to connect the call. This procedure is adapted in the Shell installation for giving a record of trunk calls for accounting purposes in the following manner. Associated with each exchange line of the full facility type is a recording meter which prints figures on a continuous roll of paper tape. When the operator keys the digits to obtain a trunk call the corresponding numbers are recorded on the meter tape. The operator then keys the extension number to revert the call and this number also is recorded. For the duration of the call the meter responds to the STD pulses received from the exchange and when the call ends their total is added to the record. The tape then automatically steps on to leave a space in readiness for the next recording.

These arrangements give the Shell Organisation full control of trunk calls and comprehensive accounting information relating to them, but special arrangements have to be made to provide service when the manual positions are not staffed. For this purpose each of the 200 restricted exchange lines has teed to it at Waterloo Exchange a second line, the number of which is published for night service. When the night service key is operated on the Supervisor's desk in the switchroom, the 200 exchange lines are connected through to 200 selected extensions which can then receive incoming exchange calls from the teed night service numbers.

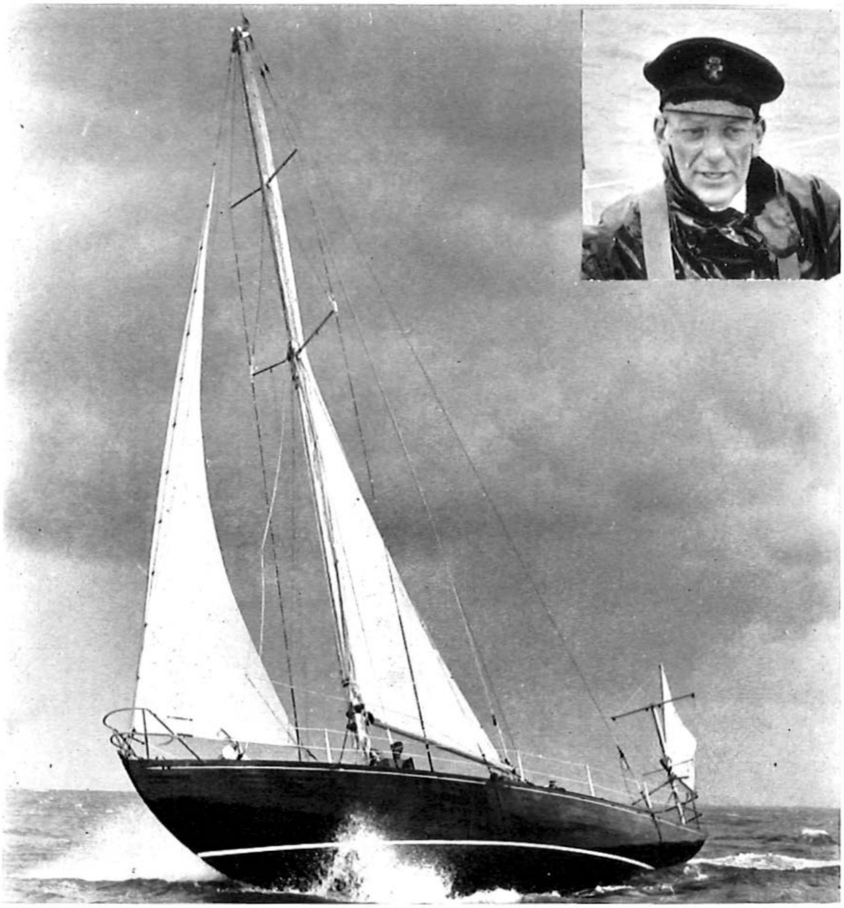


Technicians at work in the apparatus room in the upstream building. The subway which joins the two buildings carries power cables, pedestrian traffic and other services.

To enable the selected 200 extensions to make outgoing calls, 20 of the 40 full facility exchange lines are switched, together with their recording meters, to level 87 of the PABX, and access to them is obtained by dialling these digits as for operator assistance during the day. When the extension hears the exchange dialling tone the required number is dialled and this, with the metered units, is duly recorded as before. Since, however, there is no reversion of the call under night service conditions, special arrangements have to be made to record the number of the calling extension. This is done by Calling Line Identification equipment which, at the end of an outgoing exchange call hunts for the extension and passes

Continued on Page 147

ALONE ACROSS THE ATLANTIC



Photographs by Courtesy of The Guardian

WHEN 61-year-old Francis Chichester sailed his yacht "Gipsy Moth III" into New York Harbour on the night of July 4 he set up a remarkable record. He had sailed 3,000 miles across the Atlantic single-handed in 33 days and 15 hours—six days and 21 hours better than his previous record crossing two years ago.

The Post Office took more than a passing interest in Mr. Chichester's feat for it played a not unimportant part in helping him to plot his course, warning him of weather conditions and keeping him in touch with the outside world on his lonely voyage.

The story goes back to early this year when Mr. Chichester asked the Wireless Telegraph Section of the Post Office Radio Services Department for a licence to install and operate a small radio telephone on board "Gipsy Moth III" during his Atlantic crossing. Then, in March, the *Guardian* asked WTS and the External Telecommunications Executive if they could help maintain a daily radio-telephone service from the yacht to the *Guardian*, using a low-power, 75 watt radio transmitter.

The Post Office provides a radio-telephone service for large passenger liners and other ships but these usually have transmitters of some 500 watts and more efficient aerials than can be erected on a small yacht. Ships within 200 miles of the

British coast are served by coast stations operating in the 2 Mc/s frequency band but ships at greater distances by transmitters and receivers located at Rugby and Baldock and operating in the higher frequency bands. The calls are normally connected over the inland telephone network to the land subscriber.

In spite of the difficulties the Post Office agreed that it might be possible to maintain contact with the yacht so long as radio conditions were good and that at least four frequencies—one in each of the 2, 4, 8 and 12 Mc/s bands—were used.

Shortly afterwards, Marconi's Wireless Telegraph Company installed a "Kestrel" battery-operated transmitter with an output of 75 watts on the yacht, together with a suitable receiver, and adapted one of the stainless steel mast stays of "Gipsy Moth III" for use as an aerial. A petrol-driven generator was provided for re-charging the battery. Meanwhile, the Post Office made special arrangements for handling calls to and from the yacht since the low-power transmitter on board would not have given a good enough signal to be treated in the normal way through the inland telephone network. Arrangements were also made for a *Guardian* reporter to be present at the Brent Radio Telephony Terminal during the exchange of calls so that engineering facilities for improving the intelligibility of signals could be used to best advantage.

When "Gipsy Moth III" sailed from Plymouth on June 1, daily radio contact was maintained until June 7 by the Land's End coast station and calls passed to the *Guardian* reporter at Brent. After that, the high frequency transmissions from Rugby came into range and were used daily. Conversations were consistently satisfactory and the *Guardian* reporter had no difficulty receiving day to day progress reports from Mr. Chichester and passing to him weather and ice-floe reports. Only once did communications fail—when the petrol generator temporarily packed up—but rapid team work by engineers from the Post Office and the Marconi Marine and Coventry Victor Engine companies devised a method of overcoming the problem.

Recordings of Mr. Chichester's conversations with the *Guardian* were made by the BBC on several occasions and on June 8 an extremely satisfactory two-way live programme was broadcast on the "To-night" television spot.

D. J. WITHERS

Birthday Honours for the Staff

Mr. N. F. Sephton, Telecommunications Controller, North Eastern Region and Mr. H. G. Dean, Telephone Manager, Exeter, were awarded the O.B.E. in the recent Queen's Birthday List, and Mr. C. J. Cameron, Assistant Staff Engineer, Stores Liaison Section, Engineering Department, received the I.S.O.

Mr. J. E. Haworth, Senior Executive Engineer, LMP Branch, Engineering Department, and Mr. C. Riley, Area Engineer, Cambridge received the M.B.E.

The British Empire Medal was awarded to Miss D. Ryder, Chief Supervisor, Leeds; Miss N. E. Hoard, Chief Supervisor, Slough; Miss N. C. Gallagher, Supervisor, Douglas, Isle of Man; Mr. G. L. Chilton, Inspector, North West Area, London Telecommunications Region; Miss L. A. Billiet, Chief Supervisor, Continental Exchange, and Mr. W. A. C. Emmans, OT Supervisor, International Telex Exchange.

★★★★★★★★★★★★★★★★★★★★★★★★★★

BIGGEST PABX (Continued)

the required information into the recorder before the call is released.

This review of the Shell installation has necessarily been incomplete and facilities such as operator recall, enquiry and transfer and so on, which are common practice in large cordless PABXs, can only be mentioned in passing. It should, however, be said that from the start of the project discussions have been held between the Inland Telecommunications Department, the Engineering Department, the Regional and Area Staff, the contractor and the Shell management, and there is no doubt that this co-operation has contributed largely to a satisfactory interpretation of the complex requirements of the customer and to the successful completion of the project.

This, then, is the PABX at Shell Centre. There is no doubt that it will adequately fulfil the present requirements of the Shell Organisation and will set the pattern for some time to come.

OUR CONTRIBUTORS

C. F. BOOTH (*Before and After Telstar*) has been Deputy Engineer-in-Chief since 1960 and is in charge of the Communications Satellite project for the Post Office.

A. J. FORTY (*Biggest PABX in Britain*) is an Assistant Staff Engineer in charge of PBX development in the Subscribers Apparatus and Miscellaneous Services Branch of the Engineering Department. He was born in Oxford in 1915, educated at the City of Oxford School and at The Queen's College, Oxford, where he obtained a first-class honours degree in engineering. He joined the Post Office as a Probationary Assistant Engineer in 1938. In 1956 he contributed *Reduction of Acoustic Noise* published in the Spring issue.

R. A. HUBBLE (joint author, *The Art of Making Transistors*) is an Assistant Engineer in the Telephone Electronic Exchange Systems Development Branch of the Engineering Department. He joined London Telecommunications Region in 1940 and was employed on automatic exchange maintenance in City Area and precision testing of cables at Regional Headquarters. On promotion to his present rank in 1957 and until May of this year, he was concerned with the standardisation and approval of valves and transistors in the Subscribers Apparatus and Miscellaneous Services Branch.

A. P. PARSONS, (joint author, *The Art of Making Transistors*) joined the Post Office in 1941 as a Youth-in-Training in the Oxford Telephone Area. In 1951 he was a Limited Competition entrant to the Engineering Department as Assistant Engineer and in 1956 became an Executive Engineer in "S" Branch by Limited Competition. The article stems from work on standardisation of transistors within the Post Office which involves close liaison with manufacturers and users. He has two children aged 14 and 11 who like fishing and says he enjoys towing his caravan to remote places. The major part of his contribution to the article was written in the caravan while the boys fished!

J. A. LAWRENCE (*Fifty Years of Automatics*) is Staff Engineer in charge of the Telephone Electronic Exchange Systems Development Branch in the Engineering Department. He has written several articles for the *Journal*, the last one, *Problems of Electronic Exchanges*, being published in the Spring, 1961, issue.

J. B. SEWTER (joint author, *Twenty Five Years of TV OBs*) is a Senior Executive Engineer in the Main Lines Development and Maintenance Branch, Engineering Department. He joined Bedford Telephone Area in 1942 and was transferred to Training Branch, Engineering Department in 1945 as an instructor on Automatic Telephony. Since 1951 he has been in the Main Lines Development and Maintenance Branch where he has been engaged on the maintenance and operation of the television networks, the development and operation of outside broadcast equipment and the laying and maintenance of submarine cable systems.

M. B. WILLIAMS (joint author, *Twenty Five Years of TV OBs*) is an Assistant Staff Engineer in the Main Lines Development and Maintenance Branch, Engineering Department. He contributed *The Post Office Television Outside Broadcast Service* to the Autumn, 1955 *Journal* and his career is outlined in that issue.

D. J. WITHERS (*Alone Across the Atlantic*) is a Senior Executive Engineer in charge of the Radio Utilisation Section, Engineering Branch, External Telecommunications Executive.

★★★★★★★★★★★★★★★★★★★★★★★★★★

CORRESPONDENCE

Bouquets for the G.P.O.

ON the day after the first television picture was received from America by way of *Telstar*, the Postmaster General received the following letters :—

Dear Mr. Bevins,

On behalf of ITN I would like to express our congratulations on the magnificent achievement of the General Post Office in establishing the Goonhilly Downs link. The Telstar *operation has brought us in close contact with the Post Office at a wide range of different levels, and we have encountered throughout an attitude of co-operation and efficiency which we greatly admire . . . I only wish your engineers at Goonhilly could have heard the cheer in our control room when this morning's excellent pictures came up on the line from Cornwall.*

Yours sincerely,
Geoffrey Cox, Editor,
Independent Television News Ltd.

Dear Mr. Bevins,

I was privileged last night to see the result of the remarkable work of your scientists in receiving television programmes via Telstar. *You and all your technicians are to be most warmly congratulated.*

Yours sincerely,
*Samual Salmon, Cadby Hall, London, W.*14.

....

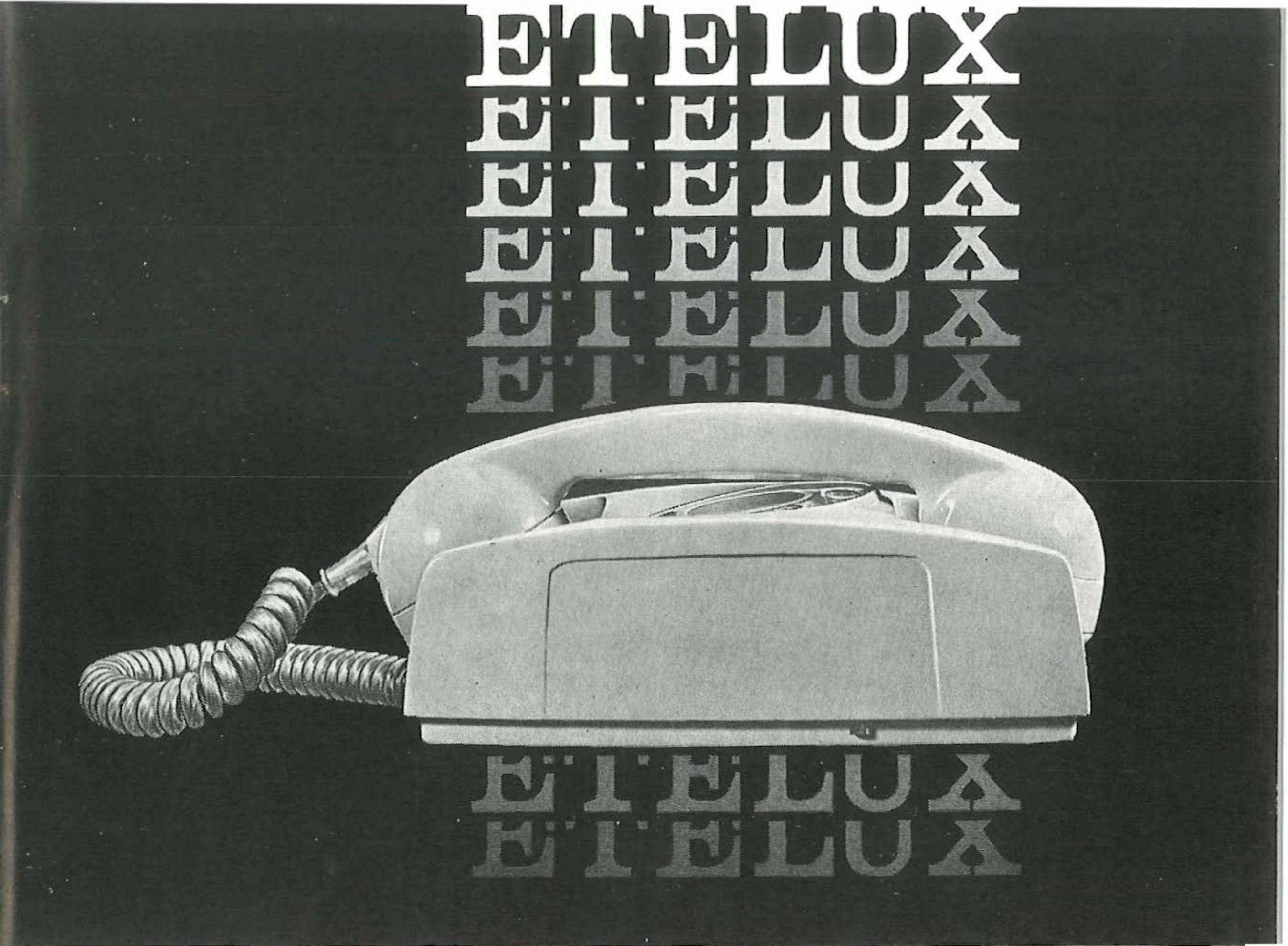
Mr. E. M. Gleadle-Richards, Senior Executive Engineer, LTR, writes to the *Journal:*

On page 91 *of your Summer issue you say that the last Faraday lecture by a Post Office official before* 1961 *was in* 1938–39. *I seem to remember, however, that the late Sir Stanley Angwin gave the Faraday Lecture in* 1947 *or* 1948 *at the Caxton Hall.*

✱ The *Journal* was correct. The Faraday lecture has been given only twice by Post Office officials—the 1938–39 one by Captain B. S. Cohen, OBE, a Staff Engineer who retired in December, 1938; and in 1961–62 by Mr. D. A. Barron, CBE, MSc.

✱

*Readers' letters should be sent to the Editor, Telecommunications Journal, Headquarters GPO, St. Martin's-le-Grand, London, E.C.*1.



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ESSAY COMPETITION RESULTS

The Institution Certificate and prize of £6 6s. has been awarded to R. Bayfield, Technical Officer, Brighton, in the 1961-62 Essay Competition held by the Institution of Post Office Electrical Engineers.

The essays were judged by E. W. Anderson, W. B. Jago and C. Grant.

The following (with the titles of their essays) have won prizes of three guineas each and Institution Certificates:—

K. Hounsell, Technical Officer, Folkestone (Home Countics Region), *A Look at Eurovision.*

R. J. Thorogood, Leading Technical Officer, Muswell Hill (London Telecommunications Region), *The Highgate Wood Experiment.*

D. A. Hill, Technical Officer, Skegness (North Eastern Region), *Maintenance and its Organisation.*

E. R. Harrington, Technical Officer, Engineering Department, I Branch, *Inspection of the Lightweight Submarine Telephone Cable.*

Institution Certificates of Merit have been awarded to:—

P. Morrison, Technician I, Bletchley Park (Home Counties Region), *Engineering—Recruiting and Training.*

F. E. Butler, Technical Officer, Rotherham (North Eastern Region), *The Economic Nature of the Post Office Engineering Department in the framework of Postwar Commerce.*

F. C. Reading, Technician I, Dial House, London (London Telecommunications Region), *Subscriber Trunk Dialling.*

D. W. J. Smith, Technician I, Bletchley Park (Home Counties Region), *Pinus Sylvestris.*

R. J. Boon, Technical Officer, Cardiff (Wales and Border Counties), *Abetting the Bookmakers.*

Particulars of the next competition, entry for which closes on 31 December, 1962, may be obtained from the Institution of Post Office Electrical Engineers, GPO, 2-12 Gresham Street, London, E.C.2.

Publication and Price. The *Journal* is published in February, May, August and November, price 1/6. The annual postal subscription rate is 6/6 to any address at home or overseas.

Contributions. The Editorial Board will be glad to consider articles of general interest within the telecommunications field. No guarantee of publication can be given. The ideal length of such articles would be 750, 1,500 or 2,000 words. The views of contributors are not necessarily those of the Board or of the Department.

Communications. Communications should be addressed to the Editor, Post Office Telecommunications Journal, Public Relations Department, Headquarters, G.P.O., London, E.C.1. Telephone: HEAdquarters 4345. Remittances should be made payable to "The Postmaster General" and should be crossed "& Co."

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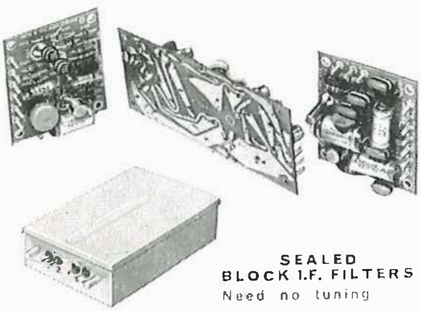

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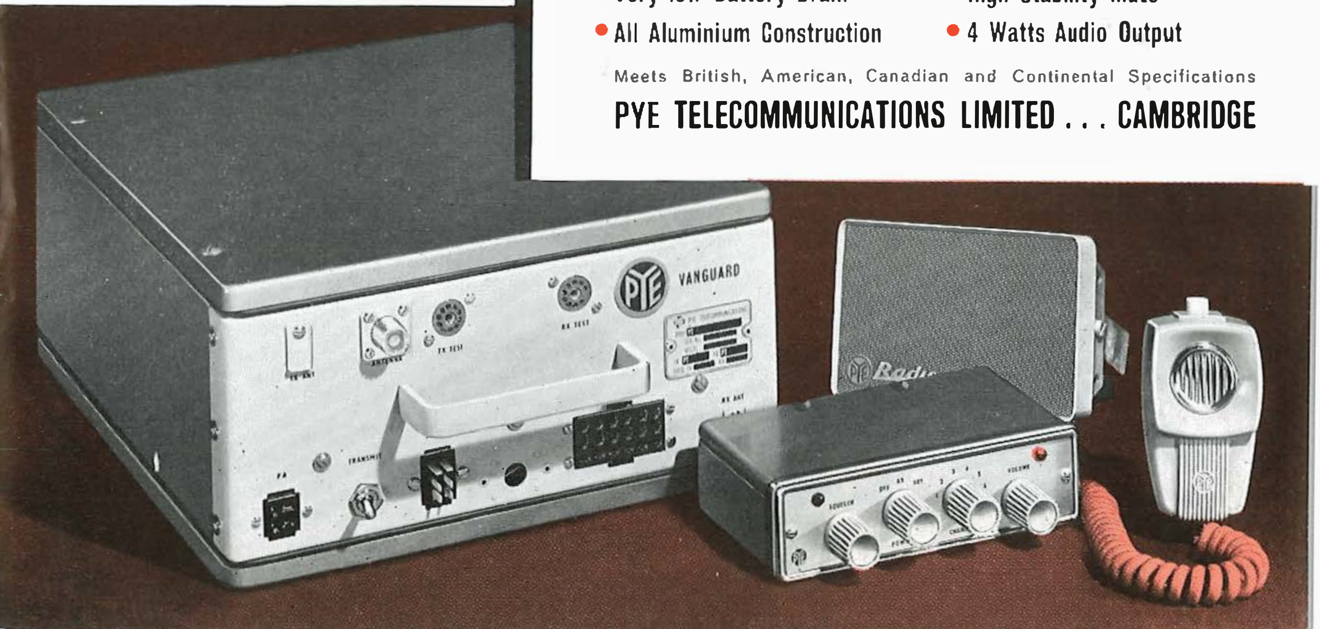

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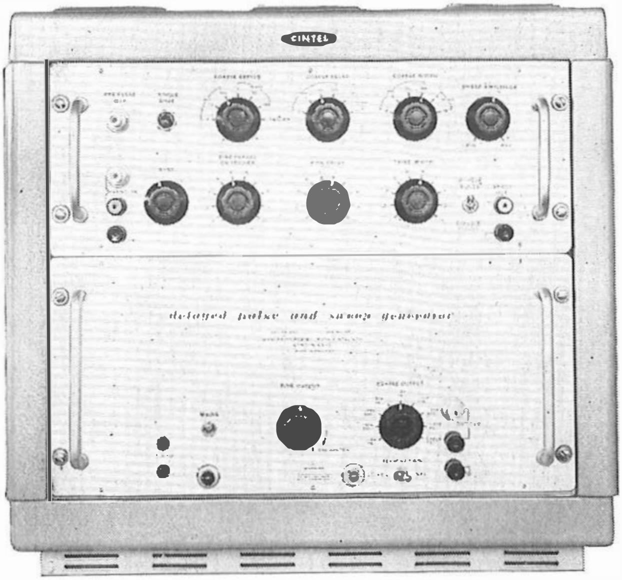

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Main pulse

Width: Variable from 0·09μsec to 105msec ±5%.

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5V max in	75Ω rise time	10mμsec
10V max in	150Ω rise time	<20mμsec
25V max in	600Ω rise time	<40mμsec
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Polarity: Positive or negative going.

Accuracy: ±2%.

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Conclusion of pre-pulse to advent of main pulse, delay variable from 0·09μsec to 105msec. Accuracy ±5%.

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D.C. coupled negative going sawtooth same width and delay as main pulse.
15V peak max.

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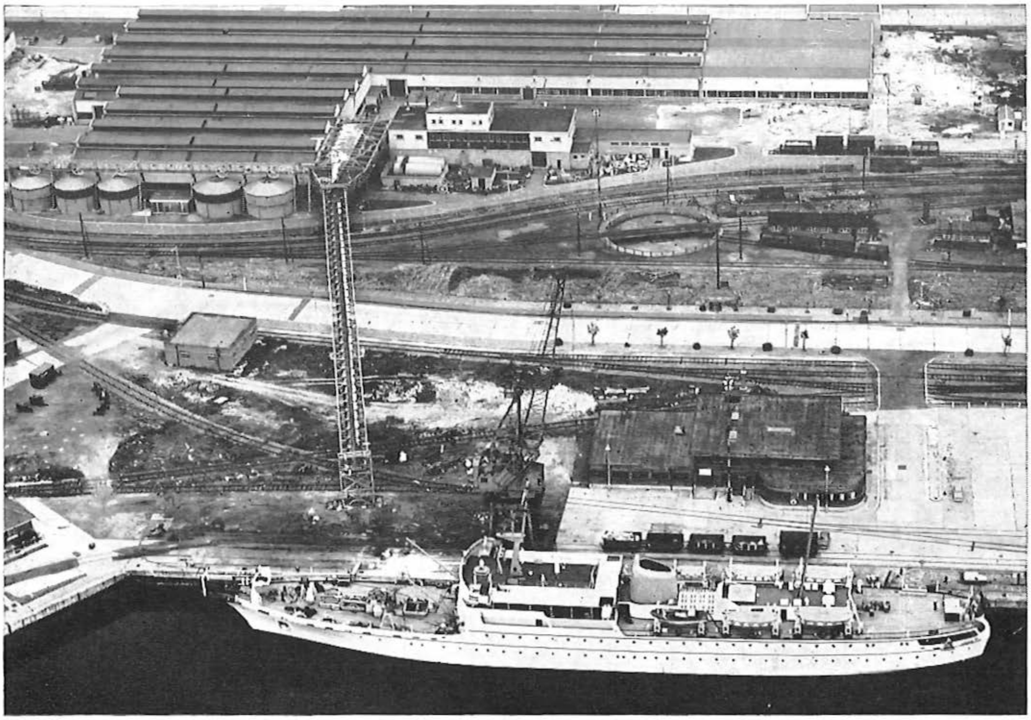

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UK—Sweden	536	
UK—Denmark	315	
UK—Germany No 2	253	
UK—Germany No 1	250	
Bournemouth—Channel Islands	140	
Wales—Morecambe Bay	75	
Wales—Isle of Man	66	
UK—Belgium	61	

STC ENGINEER AND MANUFACTURE ALL TYPES OF SUBMARINE TELEPHONE AND TELEGRAPH CABLE.

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TMC

Extensible Line Connector

The TMC Extensible Line Connector provides complete telephone service to ten subscribers using only one exchange line, and is extensible to accommodate twenty-two subscribers using four lines. Thus four pairs out of a cable free the remaining pairs either for new subscribers or for connection to other TMC Extensible Line Connectors, permitting further groups of ten to twenty-two subscribers to be given service.

The equipment is designed around three types of jack-in relay set so that very simple stage-by-stage extension may be made from 10 subscribers working over only one pair to 22 subscribers working over four pairs. It consists of two units—very simple to instal and maintain. The compact Subscriber Unit is supplied as a fully wired framework for wall or rack mounting and a weatherproof case, suitable for wall or pole mounting, is available as an optional extra. No battery or power is required at the Subscriber Unit, and no control pairs are needed. The Exchange Unit is also a small framework fully wired.

Tell us of your immediate requirements and your plans for future development, and we will submit quotations and recommendations.

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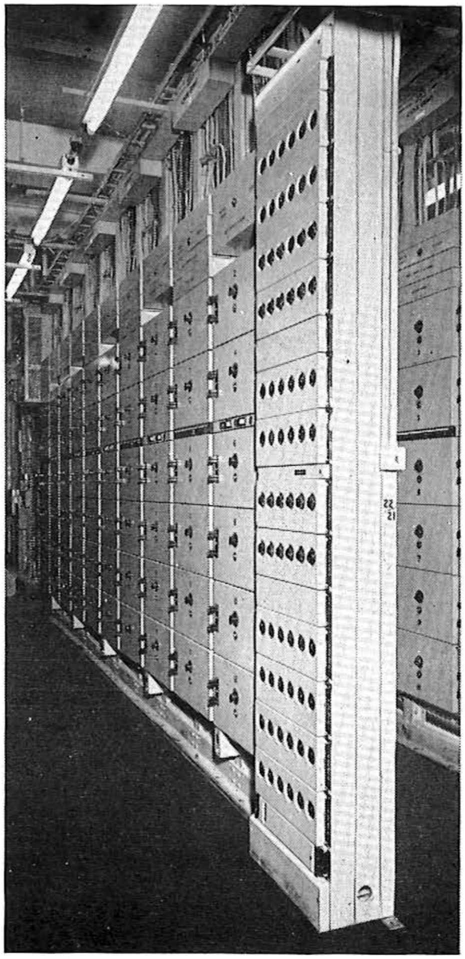
STC 56-TYPE CHANNEL EQUIPMENT

head of the line



STC transistor channel equipment has been chosen by the British General Post Office (G.P.O.) for use in main-line wide-band telephony systems. Some 13,000 channel ends have already been ordered by the G.P.O.

72 CHANNELS PER RACKSIDE

Each rackside mounts 6 groups of 12 channels designed for use with separate signalling equipment.

ECONOMY OF SPACE AND POWER

The use of transistors and modern components has reduced the size to approximately one third that of previous G.P.O standard channel equipment, and the power consumption to one eighth

STC are also supplying a quantity of transistor group translation equipment.

A single transistor-type channel rackside installed in a G.P.O. station beside a suite of older type STC equipment that provides only 6 channels on each rackside. STC have 30 years experience in the manufacture of channel equipment.

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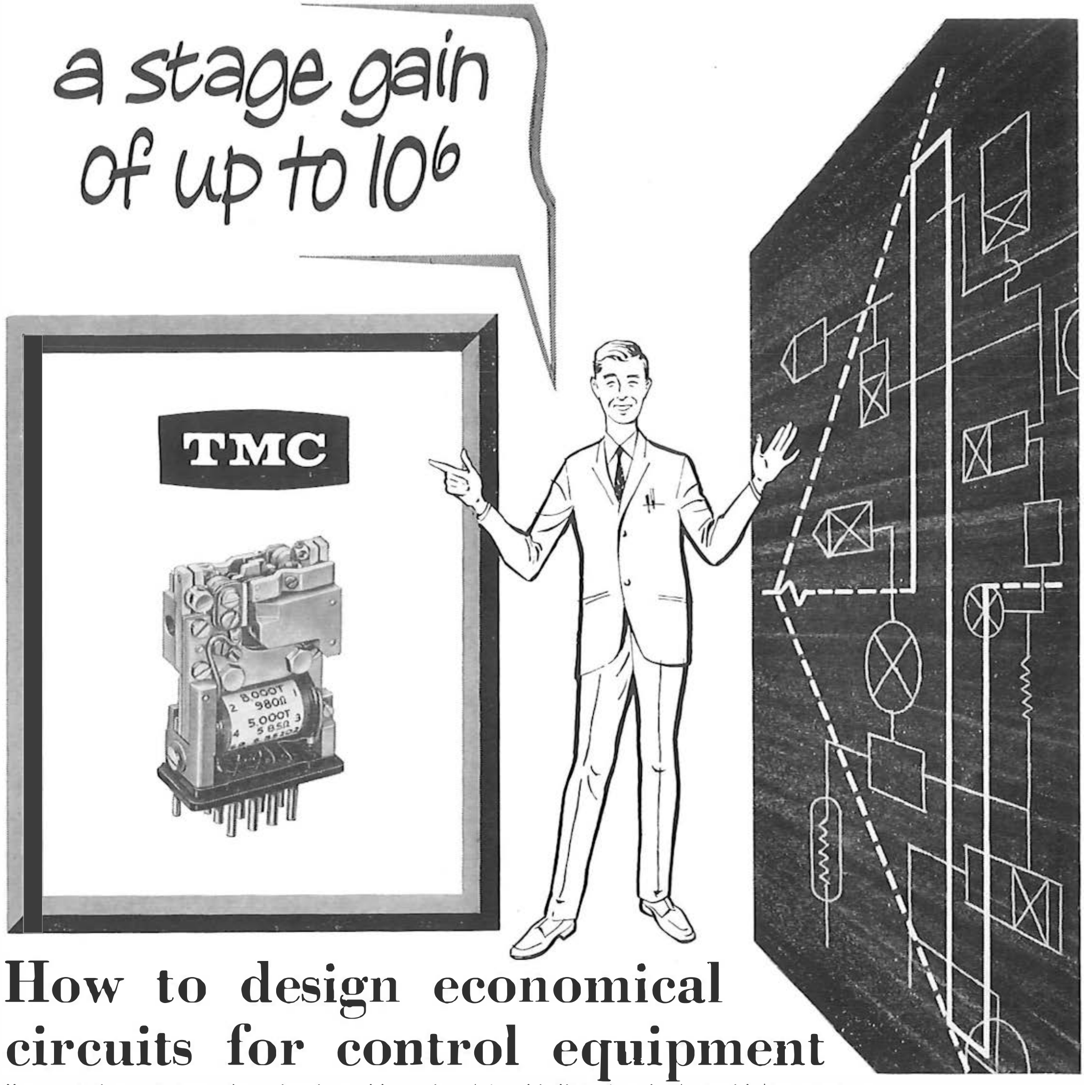

How to design economical circuits for control equipment

Every engineer knows that circuit problems involving bi-directional, sinusoidal or square-wave signals will find a neat and compact solution among the distinguished range of TMC Carpenter polarised relays. But the full significance of their outstanding sensitivity and high operating speeds may not be fully realised in these days of low level signal techniques involving miniature non-thermionic devices. For real economy in remote or automatic control functions the sensitive Type 51 TMC Carpenter relay, which will operate from signals of a fraction of a mA to control high wattage circuits, can effect a single-stage gain of up to 10^6.

A highly efficient magnetic circuit, compliant contact damping free from bounce, high operating speeds, high contact pressure and the absence of bias distortion are a few of their outstanding characteristics. Most are available in each-side stable, one-side stable or centre-stable adjustment.

The TMC advisory service is prepared to evaluate your own relay problems and recommend suitable types for any application.

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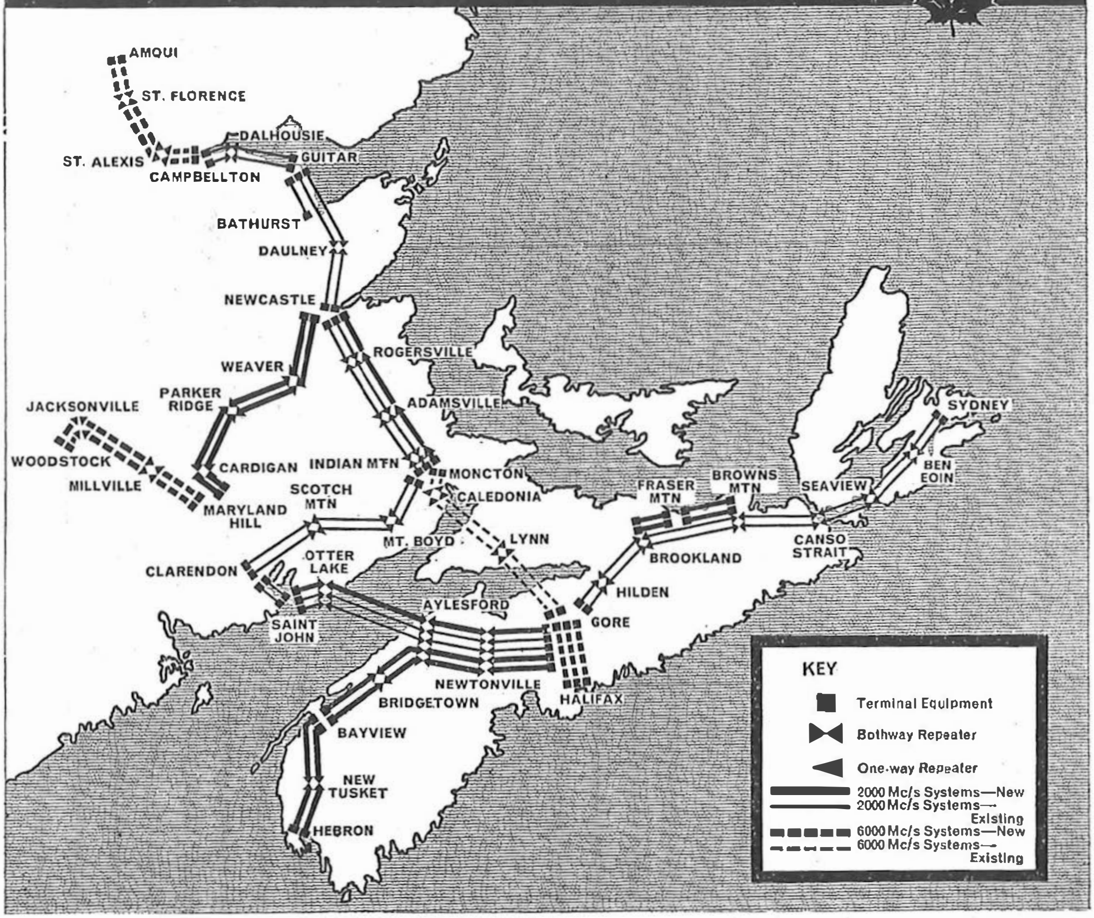
FURTHER ADDITIONS TO THE MICROWAVE COMPLEX IN EASTERN CANADA



Expansion of the networks operated by The New Brunswick Telephone Company, the Maritime Telegraph and Telephone Company and the Quebec Telephone Company has resulted in further large orders for both UHF and SHF radio relay and the associated voice multiplex equipments. The extensions now on order will provide the network with additional 360 television channel/miles and 230,000 speech circuit/miles.

The radio and multiplexing equipments used will be manufactured by G.E.C. (Telecommunications) Ltd and supplied and installed by Canadian General Electric Company.

The new extensions will employ customer proven G.E.C. microwave equipments operating in the 2000 Mc/s and 6000 Mc/s frequency bands, and transistored multiplex equipment.

For further information on the radio and multiplexing equipments please write for Standard Specifications SPO 5555, SPO 5502 and SPO 1372

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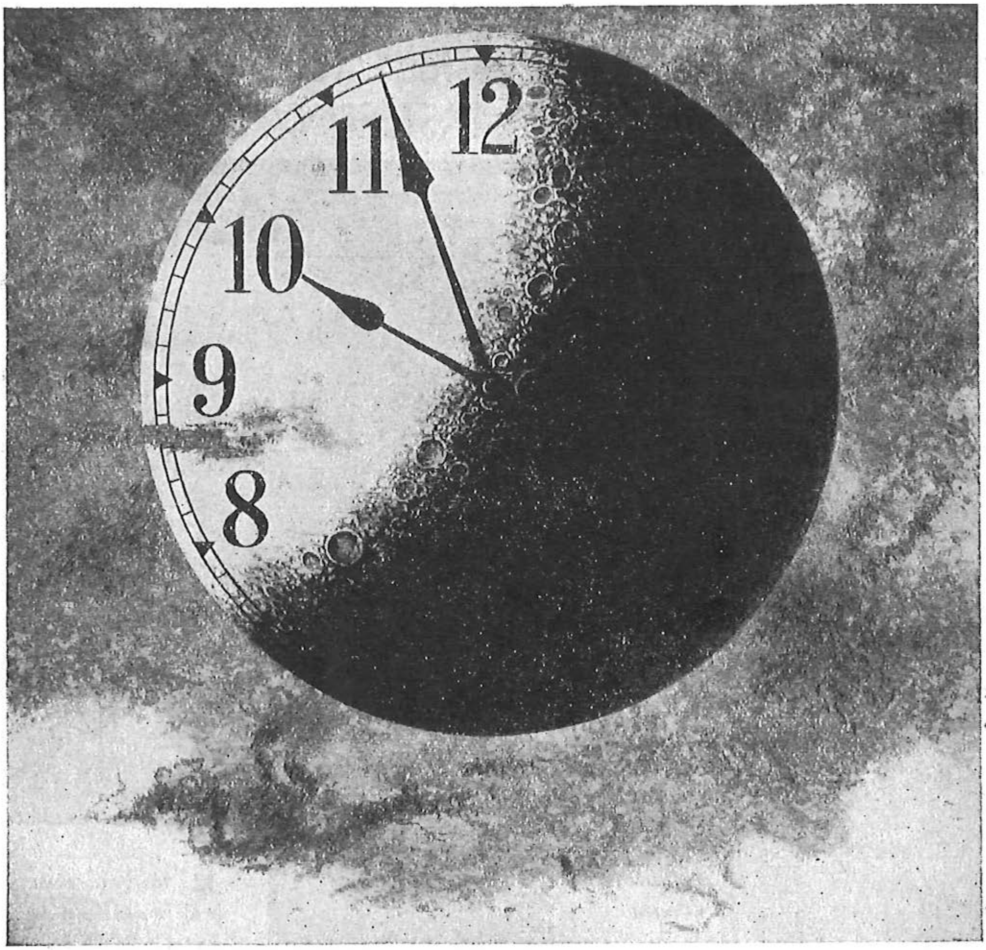

Time and Space

In the art of telecommunication time and space have assumed a new importance and significance. The conquest of time and space in the universal sense is being made possible by researches in telecommunication based upon the maximum utilization of the minutest fractions of time—measured in milli-microseconds—and space measured in micro-inches.

New techniques in electronics enable us to scan thousands of telephone subscribers' lines, store, read and act upon information—itself measured in millions of "bits" of data—in micro-seconds. New investigations in components and their assembly are leading to the conception of molecular arrangement of material to create the behaviour pattern of conventional resistors, capacitors, etc. in infinitely small compass.

In the laboratories of the A.T.E. Group new techniques, new materials and new ideas are being shaped to anticipate the telecommunication of tomorrow and of the future.

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