From Marconi to Telstar

THE STORY OF RADIO

Norman Wymer

1724

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Associated companies, branches and representatives throughout the world

First published 1966

Printed in Great Britain by The Camelot Press Ltd, London and Southampton

Contents

List of Plates

We are indebted to the following for permission to use copyright photographs: Marconi Company Ltd. for plates facing pages 4, 5, 20, 21, between 44 and 45, and facing pages 53, 68, 69 (below), 84, 100 (below); British Broadcasting Corporation, 52, 85, 100 (above); United States Information Office, 101; Barnaby's Picture Library, 69 (above).

ACKNOWLEDGEMENTS

I wish to acknowledge the great assistance I have received in the writing of this book from the Marconi Company, the Marconi International Marine Company, the British Broadcasting Corporation and the General Post Office. These four sources, between them, supplied me with the bulk of the information contained in this book. The Marconi Company also very kindly checked the accuracy of the manuscript before publication, and the B.B.C. and G.P.O. also checked chapters relating to their respective activities.

Many years ago I interviewed John Logie Baird concerning his early experiments with television, and I have based my account of his struggles partly on information which he himself gave me at the time. I also interviewed Inspector Dew of Scotland Yard, in his retirement, and he related to me the story of his dramatic arrest at sea of Dr Crippen, through the medium of radio.

N. W.

I

Marconi's Experiments

Young Guglielmo Marconi dragged his mother by the hand to his secret hiding place in the garden of his parents' luxurious Italian villa near Bologna, and proudly showed her a weird-looking gadget which he had made up of scraps of metal and wire.

'Look, Mamma, at what I have made!' he exclaimed, beaming with delight. 'One day I shall be a famous inventor!'

It was a glorious summer day in 1887, and Marconi was then thirteen years old. Some seven or eight years later, when he was still only about twenty-one, Marconi invented the first practical system of wireless telegraphy—and his vow to be famous soon came true.

Extremely good-looking, with golden-brown hair and deep blue eyes, Guglielmo Marconi was a gay, adventurous and keenly intelligent boy whose lively spirit and winning ways captivated everybody. He began to show his inventive turn of mind at a very early age. Instead of playing with other boys, Guglielmo preferred to spend his time making odds and ends out of scrap materials and experimenting, as he called it, with jars of different coloured liquids.

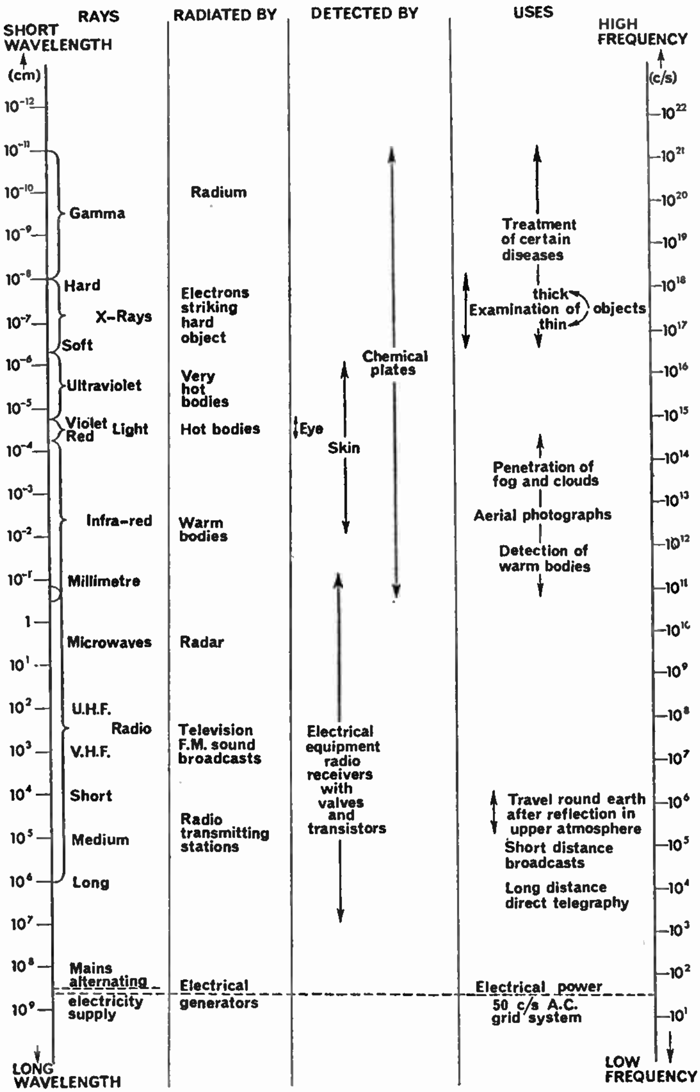
His mother, a warm-hearted woman of British descent, was pleased to see Guglielmo so happily occupied, but his father, a stern and practical Italian businessman who had made himself a fortune, had no patience with Guglielmo's 'experiments'. Signor Marconi considered his son an idler for wasting his time making useless gadgets. He sometimes grew so irritable that Guglielmo, to avoid his wrath, began to practise his hobbies behind some bushes, where nobody could see what he was doing, in a distant corner of the lovely spacious gardens, which overlooked vineyards and mountains.

Guglielmo would slink away to his hiding place without a word to anyone, so afraid was he that his father might find him. But then, on that summer day in 1887, he was so proud of his latest gadget that he could not resist showing it to someone. So he fetched his mother and let her into his secret.

Signora Marconi did not understand what the gadget was meant to be, but she thought that the boy showed great enterprise, and that he deserved to be encouraged in his hobbies. So, without telling her husband, Signora Marconi had a room in the attic of the villa cleared for him to use. It was in this attic that Guglielmo Marconi later invented his system of wireless telegraphy.

Naturally, Guglielmo was thrilled to have his own room. He called it his 'laboratory', and whenever he left the room he always took care to lock the door lest anyone—especially his father—should go in and discover or interfere with his precious jars and bits of apparatus. He gradually accumulated such a quantity of 'bits and pieces' that he had to line the walls with shelves to hold all the junk.

For seven years he toyed with a host of different ideas, but none of his experiments led to anything. He could find nothing to invent—nothing that was likely to bring him fame. Then, a few weeks before his twentieth birthday, he went for a mountaineering holiday to the Alps with his half-brother Luigi. One evening, feeling weary and footsore after a day in the mountains, Guglielmo sat down in the lounge of his hotel, picked up an old newspaper, and casually glanced through its pages. Suddenly he came upon an article about the work of a German physicist, Heinrich Hertz, who had

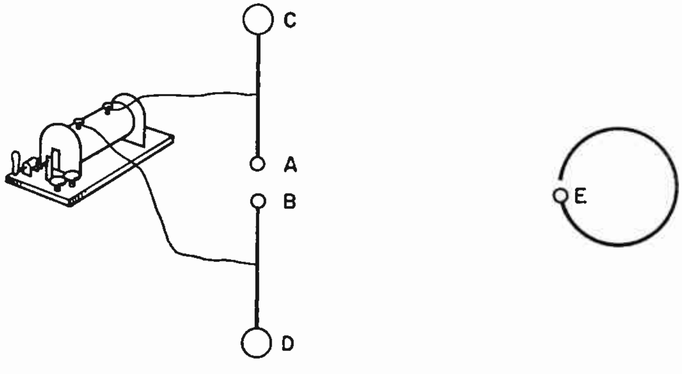


Electromagnetic waves

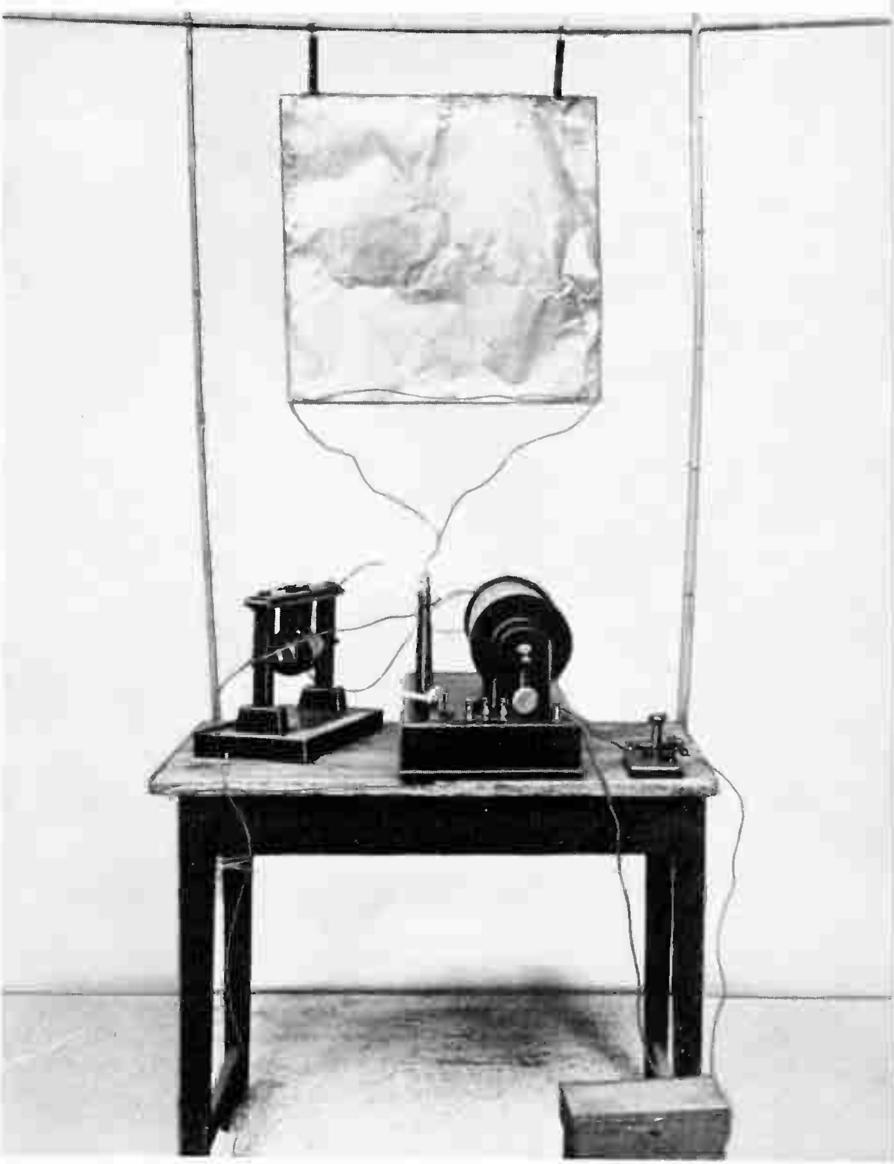
died a few months previously. That article gave him the inspiration he had been looking for.

The article reported that a few years before his death Hertz had discovered through a series of experiments that magnetic waves of electricity (termed 'electro-magnetic' or 'wireless' waves) travel through space at a speed of 186,000 miles a second (the equivalent of more than seven times round the world per second), the same speed as that of the waves which produce light. These wireless waves are not produced by scientific equipment; they are natural waves which have always been there and always will be there. The theory of the existence of wireless waves had been put forward in 1864 by a British physicist, James Clerk Maxwell, and Hertz had now proved Maxwell's theory.

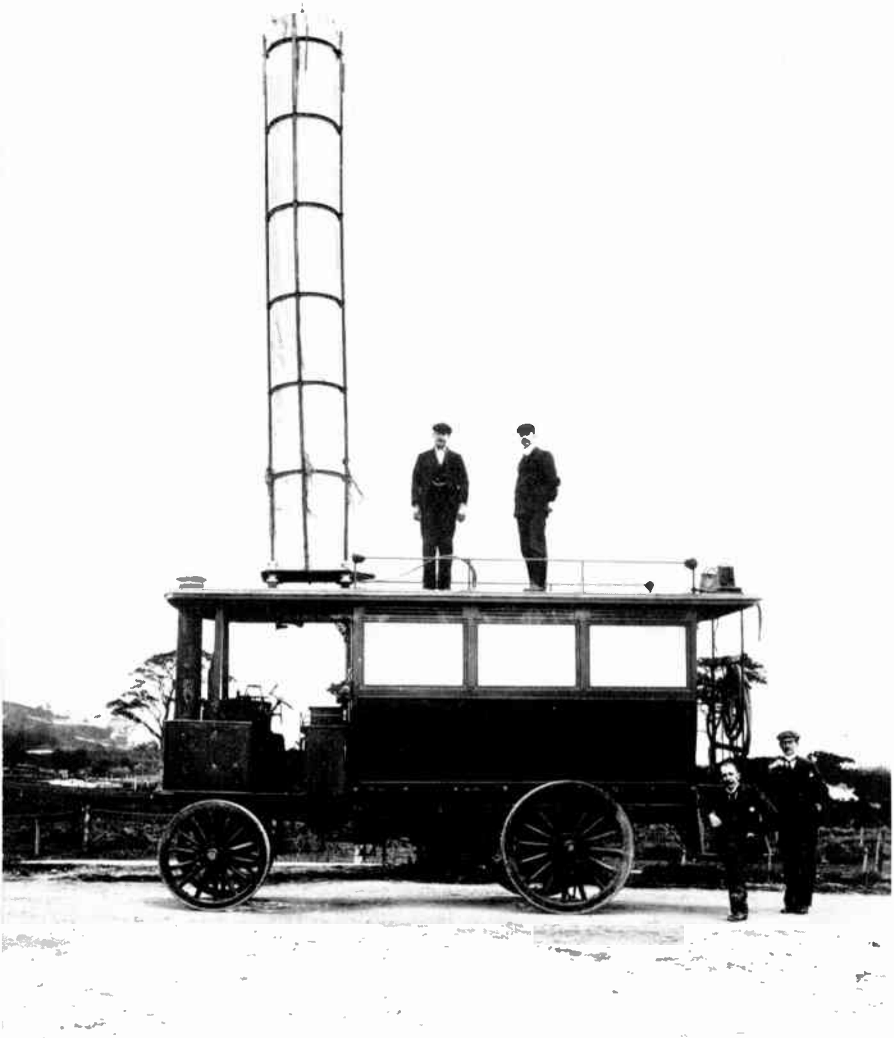
Hertz had produced positive proof by making an electric spark travel from a transmitting instrument to a metal ring, or receiver, a few feet away. For his transmitter, Hertz used a simple apparatus whose principal components were two metal balls on short arms (A and B). By applying an electric current, he produced a spark across the gap between these



Hertz's apparatus



A reconstruction of Marconi's original apparatus.



The first mobile wireless! Marconi (standing at the extreme right) used this steam wagon for experiments in 1901.

metal balls; almost simultaneously a second spark jumped across the opening in the metal ring (E). Hertz repeated this experiment many times, and the same thing happened on each occasion: a second spark echoed the first.

The transmitter which sent out the sparks and the ring which received and reproduced them were not connected by any wires; the two items of equipment were entirely separate. It was obvious, therefore, that the sparks must have been carried through space, from the transmitter to the metal ring, by natural forces—that is, by wireless waves.

Marconi read the newspaper article with intense interest; he had heard about the theory of electro-magnetic waves, but he did not know that their existence had actually been proved. He saw in a flash that these waves might be put to some useful purpose, and determined to try to invent some system (wireless telegraphy, in fact) for transmitting messages in the Morse Code of dots and dashes. Several scientists had conceived similar ideas and were already experimenting with the possibility of wireless telegraphy; it was to be a race between Marconi the amateur and the professional scientists as to who should succeed first. But Marconi was unaware of this.

On his return from his holiday, Marconi shut himself away in his attic and began to make a long and intensive series of experiments. He got up early each morning and worked until late at night, seldom going to bed before midnight. He became so absorbed in his experiments that he frequently refused even to appear for meals, and his good-natured mother, who was in his confidence, would take his food up to the attic on trays. Guglielmo's refusal to come down to the dining-room greatly angered his father. Signor Marconi had been informed by now that his son was using the attic, but he had not been told the purpose of these latest experiments. Still regarding his son as a boy, Signor Marconi assumed that Guglielmo was just toying with more stupid gadgets, and he stumped about the house grumbling impatiently:

'Disgraceful! Disgraceful! We never see Guglielmo these days. It would be nice if he would occasionally honour us with his presence!'

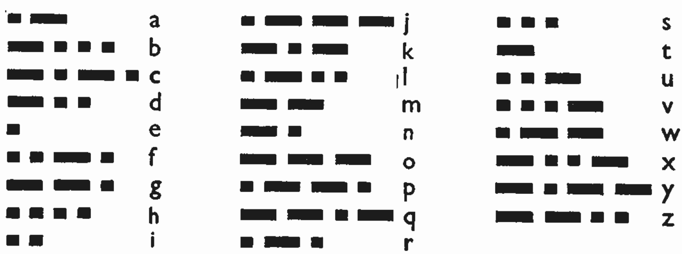
Marconi began his experiments by fitting up a simple gadget, similar to the apparatus used by Hertz, and trying to transmit a spark from one end of a table to a metal ring at the opposite end. Not being a trained scientist, he took a long time to discover how to do this, but, after many unsuccessful attempts, he eventually succeeded. Feeling very elated, Marconi then set to work designing and constructing a more powerful transmitter that would send out a larger spark over a greater distance. Again he had many failures and disappointments. He spent many weeks constructing and testing new gadgets, only to break them up again when they failed to do what he wanted. He was driven almost to despair; it seemed as if he would never succeed in the task he had set himself. However, he persevered, and, after numerous further experiments, he gradually increased the range of transmission, until finally he managed to send a spark the full length of the attic, a distance of about thirty feet.

Encouraged by this achievement, Marconi next attempted to make the wireless waves do something useful. He designed and constructed more complicated items of equipment, making many more fruitless experiments before he met with any success. Then one night when the rest of the family were asleep in bed, Marconi succeeded in making the wireless waves ring an electric bell in a room two floors below his attic.

Unable to restrain his excitement, Marconi bounded downstairs and woke up his mother to tell her his great news. Bursting into her bedroom, he exclaimed:

'Mamma, I've succeeded!'

Next morning, Guglielmo triumphantly demonstrated his successful experiment to his critical father. Signor Marconi complained that he could see little or no value in his son's accomplishment; there was no advantage in ringing a bell by wireless waves. But this was only a pose. Secretly, Signor Marconi was very impressed. He could not bring himself to



Modern Morse code

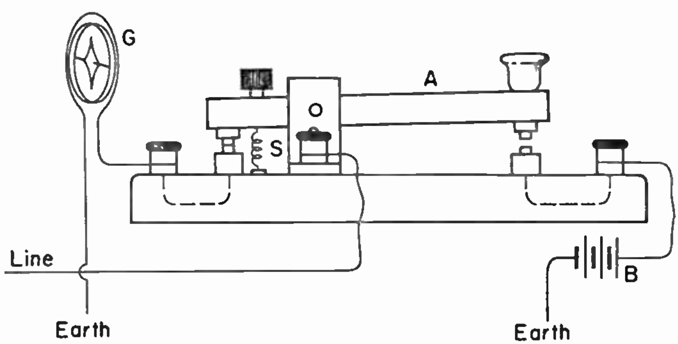
praise his son, but he showed his true feelings by giving Guglielmo a generous present—five thousand lire, the equivalent of nearly £250 in English money—to help him in his experiments.

Guglielmo was naturally most grateful for this gift. He used the money to buy materials which he had been unable to afford before, and with these he built better and more powerful equipment. He increased the power of his transmitter and receiver still further by fitting an aerial and earth to each instrument. Finally, Marconi made his first attempt to transmit signals in Morse Code by wireless waves.

Morse Code had been invented in 1837 by Samuel Morse, an American, for sending messages by electric telegraph, which in the 19th century was one of the principal means of communication. Morse, who became Superintendent of Telegraphs to the United States Government, devised an alphabet of dots and dashes, and invented a keyboard for tapping out messages in this code by breaking the electric circuit to produce short buzzes for the dots and longer buzzes for the dashes. His system proved highly successful and was adopted universally.

Marconi connected a Morse keyboard to his wireless transmitter, and, seated at one end of the attic, tapped out a few dots and dashes. His signals were carried down the room by the wireless waves, and almost immediately were picked up and repeated quite audibly by the receiver at the far end, thirty feet away. Marconi was delighted.

But this experiment, successful as it was, only proved that wireless waves could be used to send messages indoors. Marconi now had to discover whether the waves would operate with the same efficiency out of doors. So he enlisted the help of his elder brother Alfonso, nine years his senior, with some experiments in the garden.



A Morse keyboard. Signals are sent by pushing down A. Incoming signals are shown by the indicator G

Guglielmo rigged up a receiver with an aerial on a patch of ground a short distance from the villa and requested Alfonso to listen-in at this receiver while he transmitted some signals from the house. Instructing his brother to wave a red flag if he picked up the signals, he hurried back to the attic to tap out a message in Morse Code. Standing by the window, craning his neck to keep his eye on Alfonso down the garden, Guglielmo flashed out a few dots and dashes—and in a matter of seconds, to his great joy, he saw his brother racing towards the house wildly waving the red flag.

With Alfonso's help, Guglielmo now made a second open-air experiment to discover whether the wireless waves would carry signals from one side of a hill to the other. The two brothers took up positions on opposite sides of one of the foothills to the mountains beyond the garden. As before, Guglielmo operated the transmitter while Alfonso listened-in at the receiver, but since, of course, they could not see each other, it was arranged that this time Alfonso should fire a gun if he received the message. Guglielmo tapped out his signals—and again they came through perfectly.

By these and other experiments, Marconi proved that wireless waves were capable of carrying messages across either flat or hilly country, and probably for any distance. After experimenting for little more than nine months, he had invented a practical system of wireless telegraphy. With only the scantiest knowledge of science, Marconi had won the race against the trained scientists.

He spent several more months improving his equipment. Finally, in the autumn of 1895, at the age of twenty-one, Marconi offered his invention to the Italian Government as an alternative and cheaper communications system than the electric telegraph for transmitting messages in Morse Code. But, to Marconi's bitter disappointment, the Italian

Government rejected his offer. Since Marconi was not a scientist, the Italians refused to believe that his invention was practicable; indeed, they ridiculed his ideas, treating him almost as if he were a crank.

'Don't lose heart,' his mother encouraged him. 'You may have a better chance in England.'

Signora Marconi, who still had many relations and friends in England, suggested that they should go to London together and try to obtain an introduction to some department of the British Government. Guglielmo adopted her suggestion.

2

Marconi in England

Marconi, accompanied by his mother, landed in England in February 1896. He brought with him two large trunks of wireless equipment, and these immediately got him into difficulties with the Customs officials at the port.

When a Customs Officer came to examine his luggage and found the trunks packed with a mass of weird apparatus, he became deeply suspicious. Suspecting that Marconi might be an Italian spy, he interrogated him closely about his reasons for visiting England. Marconi explained his purpose, but the Customs Officer, never having heard of wireless telegraphy, was not convinced by his statement. He dismantled and closely inspected the various gadgets, but, of course, this led him nowhere. Eventually, with some hesitation, he let the luggage pass.

Signora Marconi spent the first few weeks in England scouting round to find someone with influence who might help her son to get his invention taken up by the British Government. After contacting numerous people, her efforts were finally rewarded. Marconi was given a personal introduction to the Chief Engineer of the General Post Office, William Preece.

A genial man with a beard, moustache and side-whiskers, Preece was sixty-two—some forty years older than Marconi —but no one was better qualified to judge the merits of his invention, or in a better position to assist in getting it adopted by the British Government.

Preece had led a most distinguished career at the General Post Office. He was constantly exploring new ideas for improving or expanding the G.P.O.'s communications network. It was Preece who introduced the telephone into England. An ardent research worker, he had made a life-long study of many branches of electricity, and it happened that for some years he had been conducting some personal experiments with wireless waves. Preece, who subsequently received a knighthood, was therefore most interested to learn of Marconi's invention, and one day towards the end of June he invited the young Italian to call at the head office of the G.P.O. in St Martin's-le-Grand to demonstrate his apparatus.

Marconi reported for his interview with his two trunks and proudly unpacked their contents on to Preece's desk. Preece was amazed by the weird assortment of rods, wire, brass knobs and bottles of metal filings. The collection looked so gimcrack—just so much junk—that it seemed inconceivable that the apparatus would work. However, Preece reserved judgement, and requested Marconi to assemble his equipment and proceed with his demonstration.

Marconi rigged up his transmitter on the roof of the G.P.O. and installed his receiver on the roof-top of another building some 300 yards away. In the scorching heat of the summer sun, Marconi then flashed a message in Morse Code from the G.P.O. to the second building—and his signals were received perfectly.

Only a few men employed by the G.P.O. witnessed the demonstration—the first public demonstration of wireless telegraphy to be given anywhere in the world. The people in the streets below went about their business in their usual way, unaware that history was being made above their heads—that a new scientific development was taking place which in time would transform their leisure hours.

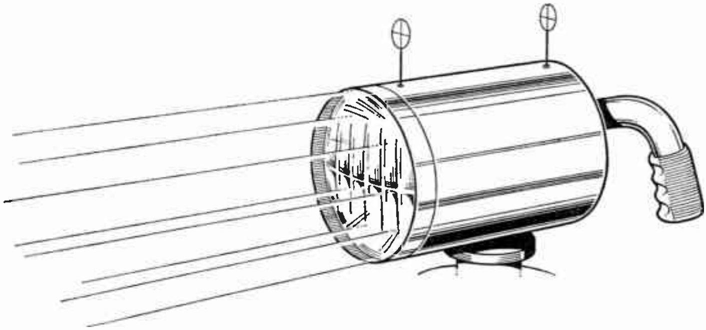
Preece was so impressed with Marconi's invention that he immediately brought it to the notice of the British Government, with the result that Marconi was asked to give some further demonstrations on Salisbury Plain, in Wiltshire, to a group of government officials and high-ranking army and naval officers.

This was a most important occasion for Marconi, who could not adequately express his gratitude to Preece for using his influence to bring this about. Marconi's whole future might depend upon the success or failure of these demonstrations. If he could convince this distinguished company that his ideas were practical, his invention might be widely adopted, bringing him both fame and fortune. On the other hand, if his demonstration should fail, he might never achieve recognition. So much hinged upon the results of these demonstrations that Marconi took extra pains with his preparations, overhauling every item of equipment and testing it again and again to make absolutely certain that everything was in perfect working order.

Marconi gave a number of demonstrations on Salisbury Plain, over distances ranging from just under two to just over four miles, and every one was successful.

The distinguished spectators were delighted with the results, and warmly congratulated Marconi. The naval officers were especially delighted, and they asked Marconi whether the wireless waves would cross water. Their reason for asking this was that they believed that wireless telegraphy could be of great value to ships at sea, whose communication system at that time was restricted to lamps and flags, only visible at short range.

A ship beyond sight of land or of other shipping had no means of sending out a distress signal if she ran into difficulties. If a ship struck an iceberg in the open sea, or if her engines broke down and she needed a tow, her captain could summon help only if there happened to be another vessel in the vicinity near enough to receive a signal by flag or lamp. If there was no such vessel in the vicinity, the ship was left to the mercy of the cruel sea. Consequently, numerous

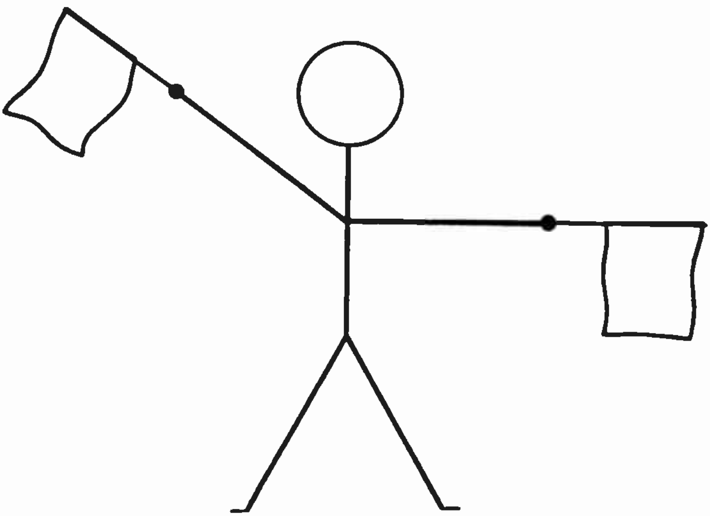


An Aldis lamp

shipping disasters, many with tragic loss of life, occurred every year. It was estimated that at one period in the last century the annual number of shipwrecks topped 2,000 and that, on an average, more than 3,000 seamen lost their lives at sea in a single year. Many of these disasters could have been greatly minimised or perhaps even avoided if only the ships had possessed the means to signal for help. The naval officers believed that wireless telegraphy might fill this urgent need for an improvement in shipping communications—*if* the wireless waves would cross water.

Marconi had never tested his equipment on water, but he immediately volunteered to do so. In May 1897 he gave a series of demonstrations across the Bristol Channel before a larger company of spectators which included, in addition to the government officials and service chiefs, one or two foreign observers and newspaper reporters. Preece, who also attended, was so anxious for these tests to succeed that he arranged for one of his most experienced assistants at the G.P.O., George Kemp, to assist Marconi in these experiments.

Marconi gave his demonstrations in two stages at intervals of a week. Setting up his transmitter at Lavernock Point, near Penarth, in Glamorgan, Marconi first flashed a number of messages in Morse Code to a small island in the Bristol Channel, a distance of about three and a half miles. This test proved successful. So a week later Marconi flashed a second series of signals right across the Bristol Channel to Brean Down, in Somerset, a distance of between eight and nine miles. This test was equally successful.



Flags used for semaphore signalling

By thus proving that wireless waves could in fact be used across water as well as over land, Marconi triumphantly passed the turning-point between possible failure and eventual success. His achievement, besides delighting the spectators, was widely reported in the newspapers and aroused great general interest both at home and abroad. Wireless became a principal topic of conversation, and Marconi began to achieve fame almost overnight.

The Italian Government, who had treated Marconi with such scorn, now had second thoughts about their wisdom in rejecting his invention. Pocketing their pride, the Italians made an urgent appeal to Marconi to return to Italy to demonstrate his system of wireless telegraphy at the important Italian naval base of La Spezia.

Marconi, loyal to his own country, immediately went back to Italy, where he was received like royalty. Installing his equipment at La Spezia, he transmitted a series of signals to ships outside the port and succeeded in establishing radio communication with ships as much as twelve miles out at sea, thereby carrying his marine experiments a stage farther to give positive proof that wireless could be of practical value to shipping. The delighted Italians celebrated this memorable occasion by giving a special banquet, attended by all the principal ministers of the government, in Marconi's honour.

The Italians tried to persuade Marconi to stay and continue his work in Italy, but, although gratified to be treated as a hero, he refused their requests and tempting offers. After completing his demonstrations at La Spezia, he returned to England—the country which had given him his opportunity—and there, in July 1897, he formed a company with the object of developing his invention and establishing a chain of regular wireless telegraph services for shipping and other purposes.

Marconi opened a research laboratory and workshops at Chelmsford, in Essex (still the company's headquarters), and he employed a small but highly skilled team of scientists and electrical engineers to explore and experiment with new techniques and to manufacture the wireless equipment.

Preece, his stalwart champion, by now had such complete confidence in Marconi's system that he offered to dispense with the services of George Kemp at the G.P.O. and to allow him to work for Marconi permanently. Marconi accepted Preece's offer with profound gratitude, and, with Kemp's assistance, he spent the next three to four years conducting a chain of spectacular experiments designed to test the scope of wireless waves and to increase the power and range of transmission and reception.

Only a few weeks after forming his company, Marconi built the world's first wireless transmission station at the Needles, in the Isle of Wight. He then erected a second wireless station in the grounds of a private house at Bournemouth, between fourteen and fifteen miles away, and established permanent radio communication between these two centres. Regular experimental transmissions between the Needles and Bournemouth were then conducted daily, under Marconi's supervision, over a long period, and from time to time signals were also flashed from these stations to shipping in the English Channel.

With an eye to publicity—so important to an inventor—Marconi invited the general public to visit the wireless stations to watch some of these experiments; indeed, he even allowed a number of the visitors to send their own messages. Twice a day special demonstrations were staged for the benefit of the general public, and these aroused intense interest and enthusiasm. People came from near and far to witness the experiments, and they marvelled at Marconi's mysterious instruments flashing and receiving the dots and dashes through the ether.

The following summer, 1898, Marconi caused further excitement by giving a wireless commentary on an important Irish yachting regatta. He followed the yachts in a tug and radioed a running commentary of the races in Morse Code to the offices of a Dublin newspaper—and his reports were then printed in special editions of that newspaper, which were on sale in the streets while the regatta was still in progress.

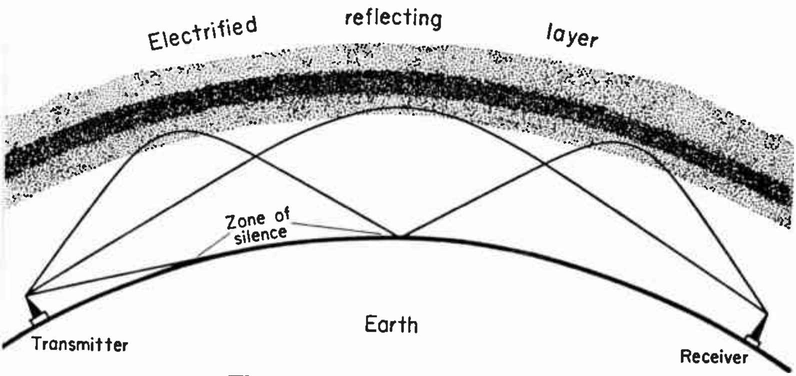
A year later, in the summer of 1899, Marconi caused a far greater sensation by spanning the English Channel. He set up a transmitter and receiver at Dover, on the English coast, and a second transmitter and receiver at Boulogne, on the French coast, and inaugurated a two-way wireless telegraph service between England and France. For the first time radio communication between two separate countries was thus established; the first thread of the radio network which now links the nations of the world had been spun.

'Nothing in the previous history of wireless telegraphy,' it is recorded, 'aroused such keen interest as the spanning of the Channel. It set the scientific world talking and filled the newspapers with descriptions, comments and prophecies.'

'Marconi will be sending messages across the Atlantic next,' the prophets declared.

'Impossible!' retorted the scientists. 'The curvature of the earth will prevent that.' The scientists argued that, as the world is round and not flat, the wireless waves would have to travel in a circular course to reach America from England. They did not know about the reflecting layers above the earth which bounce back wireless waves, and they assumed that the waves would travel off in a straight line into space when they reached the horizon. On this assumption, they predicted that the curvature of the earth's surface would inevitably cause any wireless signals sent from England to disappear into the sky at some point above the ocean, perhaps less than half-way across the Atlantic.

Many of the leading scientists of the day held this theory; but Marconi, with no scientific education or qualifications, felt convinced that the experts were wrong—and he determined to prove them so. He resolved to try to establish transatlantic wireless communication between some spot in Cornwall and a point on the coast of America, a distance of about 2,000 miles. Marconi, who had inherited a family fortune, was now a rich young man in his middle twenties; he spent some £50,000 on these ambitious experiments.



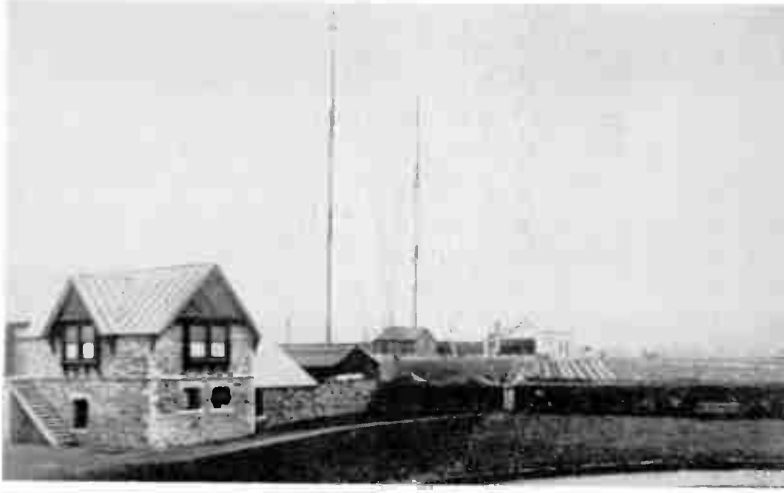
The reflection of wireless waves

With the assistance of George Kemp and a small but carefully selected team of technicians, Marconi designed special equipment for this great test. Realising his own limitations, he enlisted the services of Sir Ambrose Fleming, professor of electrical engineering at University College, London, as his scientific adviser; and Fleming designed a transmitter one hundred times more powerful than the instruments previously used by Marconi.

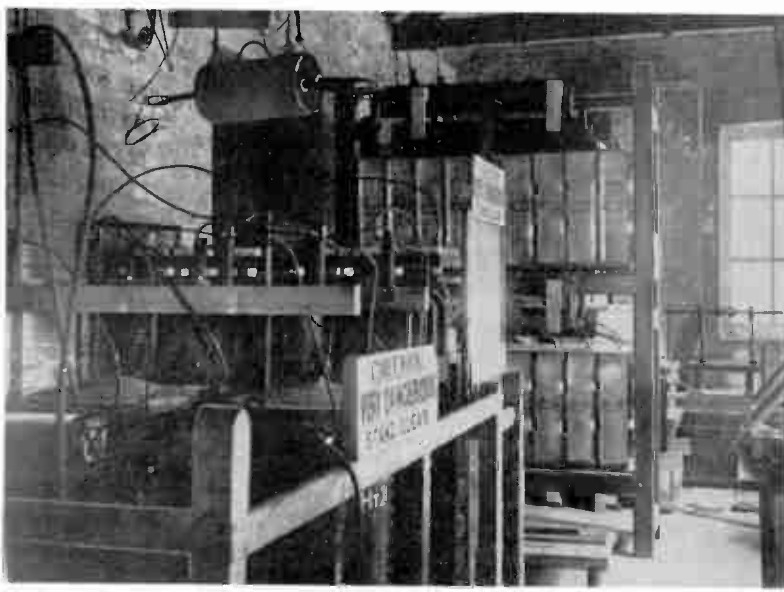
While the giant transmitter was under construction, Marconi and Kemp went down to Cornwall to choose a suitable site for the transmitting station. After exploring quite a wide area of the county, they chose a remote spot on the south coast called Poldhu, high above the cliffs near Mullion—a few miles from the modern Telstar station used to pick up and relay signals from the television satellites (see Chapter 10).

Work on the construction of the Poldhu station began in October 1900; the building was completed and the splendid new plant installed the following January. Marconi then spent several months testing and experimenting to find ways of improving the performance of the equipment. He made countless adjustments and then tested and re-tested until he was completely satisfied with the efficiency and reliability of every item of equipment. He left nothing to chance.

In November 1901 Marconi and Kemp, accompanied by another engineer named Paget, sailed for America to choose a site for their second wireless station. Marconi decided to erect this at Cape Cod, on the sandy peninsula of Massachusetts. He intended to set up both a transmitter and a receiver and to establish two-way wireless communication across the Atlantic, but the weather suddenly worsened, and the massive circular aerial array for the transmitter blew down almost as soon as it was erected. After this mishap, Marconi gave up all idea of sending signals from America, and decided instead to set up a station simply for receiving signals from Poldhu. In view of the adverse weather conditions, Marconi and his team now abandoned Cape Cod and moved on to Newfoundland. Finally they selected a place called St John's for their receiving station—a most desolate spot with not a shrub or a tree, more lonely even than Poldhu.



Poldhu wireless station in 1901.



Part of the transmitting apparatus at Poldhu.

Marconi (centre) with Kemp (left) and Paget on their arrival in Newfoundland for the first trans-Atlantic wireless tests.

Raising the kite aerial at Signal Hill.

They set up their receiver in a deserted building. Then again the weather changed. A fierce gale blew up, and the team found it impossible to put up the high masts for the receiver aerials.

'For a couple of days I battled with the elements,' Paget, who was in charge of the aerials, tells us. 'I tried to elevate the aerials by means of two large balloons, but one of my balloons was carried away by the gale, which snapped the heavy mooring rope like a piece of cotton.'

As the weather was deteriorating rapidly, it looked as if the tests would have to be abandoned. However, the party had also brought with them six kites. So Paget harnessed 600 feet of aerial wire from the receiver to one of these kites, and, after an exhausting struggle in the teeth of the gale, he eventually managed to fly this kite to a height of 400 feet.

Not wishing to waste any more time, Marconi went straight to the post office and sent a cable to his team at Poldhu instructing them to transmit the three Morse Code dots representing the letter S at frequent intervals daily, starting on 11 December.

Shortly after midday on that date Marconi, dressed in a tweed coat and knickerbockers, and his two assistants took up their positions in a small, dark room of the derelict building—and waited. With the wind howling outside, Kemp sat at the simple receiver and took the first turn at listening for the signals from Poldhu. Marconi drank a cup of cocoa before taking over from Kemp. Paget squatted on a packing-case, anxiously wondering about his aerial. No signal came through on that first day.

Next morning, calamity; the gale, stronger than ever, blew away the kite supporting the aerial. Failure now seemed certain. However, after another fierce struggle, Paget succeeded in launching a second kite.

Then, at 12.30 in the afternoon, when Marconi himself was listening-in, the signal upon which so much depended was received. Very faintly—so faintly that he had to strain to catch the sounds—Marconi heard the magic dots of the letters S: pip, pip, pip . . . pip, pip, pip . . .

'Listen to this, Kemp!' Marconi almost shouted. 'Quick—take the headphone! . . . Can you hear anything?'

'Yes, yes—that's the signal! That's it!' Kemp replied excitedly.

'The letter S?'

'Yes—no doubt about it!'

Marconi had scored his greatest triumph. He had established trans-Atlantic radio communication, which the scientists had declared to be impossible. By this magnificent achievement, he had finally proved that there was an almost limitless field for the development of radio.

'I now felt absolutely certain that the day would come,' he said later, 'when mankind would be able to send messages without wires, not only across the Atlantic, but between the furthermost ends of the earth.'

3

Radio for Ships and Aircraft

While all these successful experiments were taking place, a start had been made in developing wireless as a practical aid to shipping. In 1898—the year after Marconi formed his company—wireless telegraphy was established between the South Foreland and East Goodwin lightships, near the mouth of the River Thames.

This area off the coast of Kent was notoriously dangerous for shipping, and within only a few weeks of the wireless equipment being installed a German steamer collided with the East Goodwin lightship in a fog. Immediately distress signals were flashed by radio in Morse Code to South Foreland. Lifeboats were launched in record time, and in a daring sea rescue, with visibility down to only a few yards, all lives were saved. If there had been no wireless, the steamer might have sunk and everyone aboard been drowned.

During the next few years the great seafaring nations of the world slowly began to equip their ships with wireless, and radio shore stations were built for communication with the ships at sea. The first shore stations were erected along the coasts of Britain and Ireland. Others were then built along the coasts of France, Belgium and Germany. By 1901—the year when Marconi conducted his trans-Atlantic experiments—new stations were springing up all over the world. More than 100 radio shore stations had been built or were in the course of construction, and over 200 ships carried wireless.

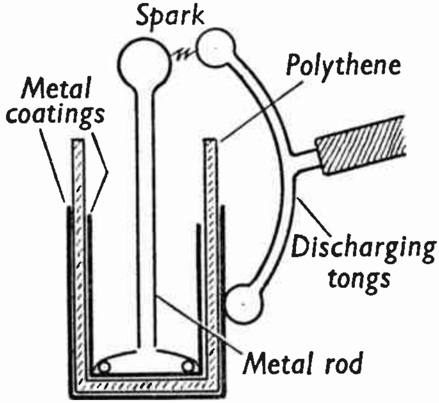
The radio room in the average ship of those early days was very small and primitive. The radio 'department' in the first British merchant ship to carry wireless, the *Lake Champlain*, was housed in a miserable cabin which cost a paltry £5 to rig up. Very little larger than a cupboard, it was only four feet six inches long and three feet six inches wide. It was constructed of match-boarding, with the iron bulkhead forming one of the walls. There were no windows, and consequently the room was pitch dark and airless. The wireless operators had to leave the door open in order to see, or indeed to breathe!

The wireless equipment was mounted on a table covered with green baize. The accumulators stood on the floor, and the lamp resistance for charging the cells was screwed on to one wall. The operator on duty sat on an old wooden box to transmit and receive his messages.

The old Morse keyboards used for transmitting messages were heavy and cumbersome, and both tricky and tiring to operate.

'The maximum speed we could handle,' a ship's wireless operator of those times later recalled, 'was about ten words a minute. And even at that slow rate of transmission operators would soon tire. We suffered mostly from strain in the arm as the key worked like a pump and required considerable expenditure of energy for operation. If we went faster the thing failed to function.' Failure of equipment for one reason or another was by no means uncommon. 'I remember an occasion,' the same operator recollected, 'when the entire bank of Leyden jar condensers broke down. Not having any spares, I pasted tin foil on both sides of several jam jars—and the idea worked quite well!' (The Leyden jar is a glass jar, coated inside and outside with tin foil, for storing electric charge. It was invented in 1745 at Leyden University, in Holland.)

The wireless operators constantly had to improvise. Yet, in spite of the limitations of the equipment, the introduction of radio soon helped to reduce the number of shipping accidents and the heavy loss of life at sea. As more and more ships were equipped with wireless, the number of accidents at sea dropped dramatically. During the period from 1901 to 1910 more than 6,000,000 passengers crossed the Atlantic with the loss of only nine lives. And similar improvements were recorded on other sea routes.



The Leyden jar condenser

In the summer of 1910 wireless telegraphy was used at sea for a different purpose—to catch a murderer, the notorious Dr Crippen. Dr Crippen, who had a practice in Camden Town, in London, was charged with the murder of his wife, whose mutilated body had been found in the cellar of his house; and his secretary, Ethel le Neve, was charged as an accessory to the crime. Warrants had been issued for their arrest, but a nation-wide search by the police had failed to find the couple.

Crippen and his secretary were fleeing from justice aboard the steamship *Montrose*, bound for Quebec. Crippen had shaved off his moustache and discarded his spectacles, and Ethel le Neve was disguised as a boy; they were travelling as 'Mr Robinson and son'. Their photographs and descriptions were published in all the newspapers, with an appeal from Scotland Yard for any information that might lead to the discovery of their whereabouts. But Crippen and his secretary felt quite safe in their disguises. In any case, their arrest at sea, so they thought, would be impossible.

However, their strange behaviour soon aroused the suspicions of the ship's captain, Captain Kendall. He had just been reading a newspaper report about the search for Crippen and his secretary when, chancing to glance through the porthole of his cabin, he noticed on deck two 'men' affectionately holding hands and looking lovingly into each other's eyes.

Captain Kendall sauntered on deck for a closer inspection of his two mysterious passengers. He engaged them in casual conversation and was impressed by the 'boy's' feminine voice and complexion. He observed, too, that 'Mr Robinson' had a strained look about the eyes and that the bridge of his nose was red and indented as though he was accustomed to wearing glasses. He had obviously shaved off his moustache and was now growing a beard.

The captain returned to his cabin and picked up his newspaper again. Later, when the 'Robinsons' went down to lunch, he nipped into their cabin and quickly rummaged through their possessions. He found a woman's bust bodice and one or two other articles that required explanation. Captain Kendall thereafter kept his two passengers under close observation and bided his time until he could be more certain of their identity.

Two days later, when Crippen was strolling on deck with his companion, a sudden gust of wind blew his coat-tails into the air, and Captain Kendall, who was shadowing him, observed a revolver in the hip-pocket of Crippen's trousers.

The captain now took action. He radioed the following message to England for Scotland Yard: '130 miles west of Lizard . . . Have strong suspicions that Crippen, London cellar murderer, and accomplice, are amongst saloon passengers. Moustache taken off, growing beard. Accomplice dressed as a boy. Voice, manner and build undoubtedly a girl . . .'

Crippen, basking on deck in the sun, heard the message being tapped out in Morse Code and was greatly curious. He considered wireless a most fascinating invention. Little did he know the contents of the message!

As soon as it was received in England a detective from Scotland Yard, Inspector Dew, sailed by the next ship to cross the Atlantic. A number of messages arranging a plan of campaign for the arrest at sea of Crippen and Ethel le Neve were radioed between Inspector Dew and Captain Kendall from their respective ships. Finally, the *Montrose* dropped anchor five miles off Father Point in the St Lawrence River, and Inspector Dew, disguised as a ship's pilot, boarded her from a cutter.

'Good morning, Dr Crippen,' said the detective, whipping off his pilot's cap. 'I'm Inspector Dew from Scotland Yard.' He grasped Crippen's hands and slipped on the handcuffs. And so the arrests were made. Crippen was subsequently convicted and hanged, but his secretary, Ethel le Neve, was acquitted.

This sensational arrest of a criminal at sea through the medium of wireless telegraphy captured the imagination of the entire world. During the next two or three years a number of dramatic sea rescues, made possible by wireless, gave further proof of the value of radio to shipping.

Finally, in 1913, every deep-sea ship carrying fifty or more persons was bound by law to carry radio. This law resulted from the sinking of the liner *Titanic* the previous year. While sailing on her maiden voyage, the *Titanic* struck an iceberg and sank with the loss of 1,470 of her 2,200 personnel and passengers. After this appalling calamity the seafaring nations of the world held an international conference in London and framed a comprehensive set of safety regulations for shipping, covering every department from the construction of a ship in the builder's yard to her navigation on the high seas. These numerous safety precautions finally made it compulsory for certain ships to be equipped with radio. These regulations have been extended from time to time until today all ships of 500 tons or more must carry either radio-telephone or radio-telegraph equipment.

Today the radio department of a large ship such as an ocean liner is spacious and streamlined and contains a bewildering array of the most modern radio and electronic equipment for both wireless telegraphy and wireless telephony—very different from the poky cabin of the *Lake Champlain*, the first British merchant ship to carry wireless.

Most liners have from three to six radio officers, but some have as many as ten or twelve. During a voyage they maintain a 'listening watch' by day and night. They keep in constant wireless communication with the shore stations along their route, and they listen-in for messages and distress signals from other shipping in their area. A ship may send out a distress signal for any number of reasons—because she has struck a rock and is in danger of sinking, because her engines have broken down and she needs a tow, or perhaps because she has sickness aboard and, having no medical staff of her own, she requires a doctor from another ship. On picking up an SOS message, the radio officer must immediately inform his captain, who, if his ship is within reach of the vessel in distress, will at once alter course and go to her aid.

At regular intervals throughout the twenty-four hours, the radio officers listen-in to the time signals, news bulletins and weather forecasts which are broadcast from the land stations for the benefit of shipping.

These weather forecasts are of immense importance to the captain. A radio warning of a storm ahead may enable him to alter course and skirt round instead of running into the storm. At the same time, if the liner should herself encounter bad or abnormal weather conditions, the captain will instruct one of his radio officers to transmit a warning to the nearest shore station. The general weather forecasts are built up largely from the reports of ships at sea.

In addition to their 'listening watch', the radio officers transmit and receive a stream of messages for the captain to and from the offices of the shipping company and the various ports of call and final port of destination. They also handle numerous messages for the passengers.

And, of course, radio is no longer used only for communications. Today both ships and aeroplanes are equipped with highly scientific radio and electronic instruments to assist in their actual navigation. The radio aids in a ship include radar (described in Chapter 7) to help the captain to navigate his ship in safety in a fog or poor visibility, direction-finders to help him to keep to course, and echo-sounders to tell him the depth of water beneath his ship. Many fishing vessels are equipped with echo-sounders and other devices to help the fishermen to detect the shoals of fish.

The pilots of aircraft rely very largely on radio to guide them on their journeys across the world. Aeroplanes carry numerous radio aids to navigation, operated from panels of switches in their cockpits; and the pilots receive flying instructions by radio from Air Traffic Control Centres along their route.

Aeroplanes fly along 'air corridors' or 'airways' which, although of course invisible, are mapped out in the sky at different heights with a safety separation of 1,000 feet between each corridor. At intervals along each air route there are Air Traffic Control Centres, each of which is responsible for all aircraft flying within its zone. And between these control centres, many of which are sited at important airports, are other land radio stations which continuously transmit radio signals into the sky.

When an aeroplane takes off, the pilot is directed on his ascent by radio from a controller at the airport. As soon as he is airborne, he signs in to the next control centre. He tells the controller by radio telephone the type and call sign of his aircraft and the details of his flight. The controller then gives the pilot any flying instructions that may be necessary and tells him the frequencies of the radio signals or 'beams' to follow. The pilot tunes-in to the first of these beams and flies towards it with the aid of his instruments. He then flies on to the next beam. As he passes out of that control zone, the pilot signs in to the next Air Traffic Control Centre and goes through the same procedure. This is repeated at every control centre throughout the journey. Finally, on reaching his destination, the pilot calls up the controllers at the airport who give him his landing instructions. The controller responsible for bringing down the aeroplane follows the course of the aircraft on a radar screen, and, if visibility is poor, he may use radio to assist the pilot in his descent.

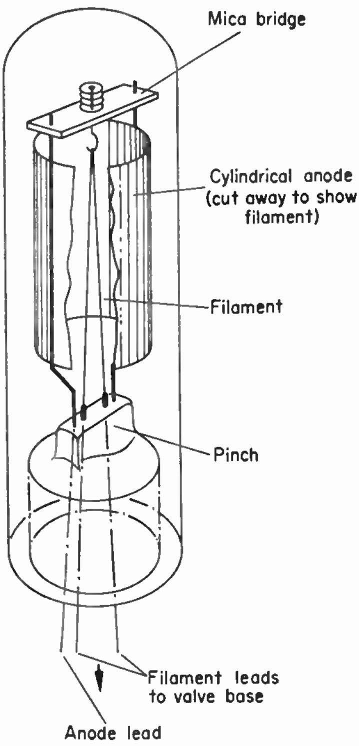
At every stage of a flight, from take-off to landing, the crew of an aircraft is in constant radio communication with the ground.

Radio has revolutionised both sea and air travel. And it has all developed from those experiments on the Bristol Channel when, only about seventy years ago, Marconi flashed the first signals across water by wireless telegraphy. At that time wireless telephony was still a dream of the future.

4

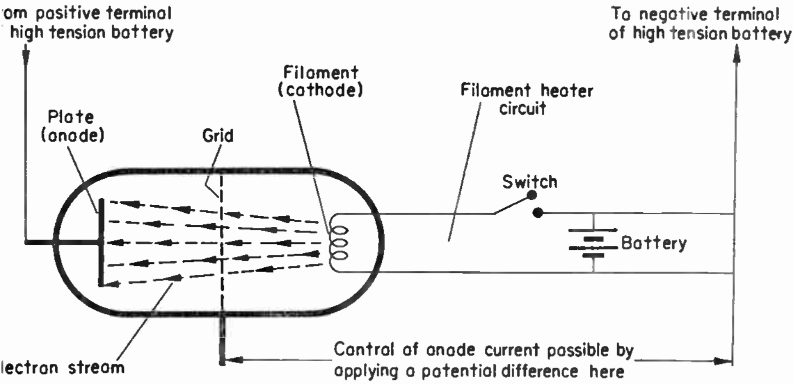
The Start of Broadcasting

In the early years of this century electrical engineers and scientists in many countries, including Marconi's own research team at Chelmsford, began to conduct experiments to find some means to use wireless waves to reproduce speech and music instead of just the dots and dashes of Morse Code.



The diode valve

Many people were instrumental in developingwireless telephony. The first great contribution was made by Sir Ambrose Fleming, who had designed the Poldhu transmitter for Marconi's trans-Atlantic broadcast. After long and painstaking research, Fleming produced the first radio valve: the diode valve, forerunner of the thermionic valves of the present day. This valve served as a detector. An American, Lee de Forest, then carried this invention a stage farther by designing a more sensitive valve—the triode valve—which could be used in addition for amplification. Some years later it was discovered that this triode valve also had the ability to generate oscillations. These two major inventions opened up the way to further important discoveries and technical developments, and thus, a practical system of wireless telephony gradually was devised.



A diagram of the triode valve. The grid between the anode and the cathode is used to regulate the current

The first successful attempts at transmitting the human voice and music were made by a Canadian electrical engineer named R. A. Fessenden in 1906, just ten years after Marconi came to London. A few days before Christmas in the year 1906 wireless operators in a number of ships at sea were listening-in through their headphones for the familiar dots and dashes of Morse Code messages to shipping when, to their amazement, they heard distorted strains of music which they recognised as the unmelodious scraping of a violin. When the music stopped, a voice came on the air requesting anyone who might have heard the solo to write to a given address and record the fact. Using a high-frequency alternator, Fessenden succeeded in transmitting speech and music from the continent of America over a distance of about 200 miles.

Although this was a remarkable achievement, many more years of research and experiment were necessary before wireless telephony could be put to practical use. The system was used for the first time during the First World War (1914-18) to give instructions to pilots of aircraft engaged in the war in Europe. Many an air battle against the Germans was fought and won with the help of wireless telephony. Great secrecy was maintained, and probably very few people outside government and military circles and the manufacturers of the equipment were aware that wireless telephony had reached this advanced state, yet wireless was soon to transform the home life of millions of people all over the world.

Shortly after the end of the First World War radio began to be used for home entertainment. Early in 1919 the Marconi Company conducted an experiment to test the range and scope of wireless telephony. They set up a transmitter at Ballybunnion, in Ireland, and a receiver at Louisberg, in Nova Scotia, and broadcast the human voice across the Atlantic.

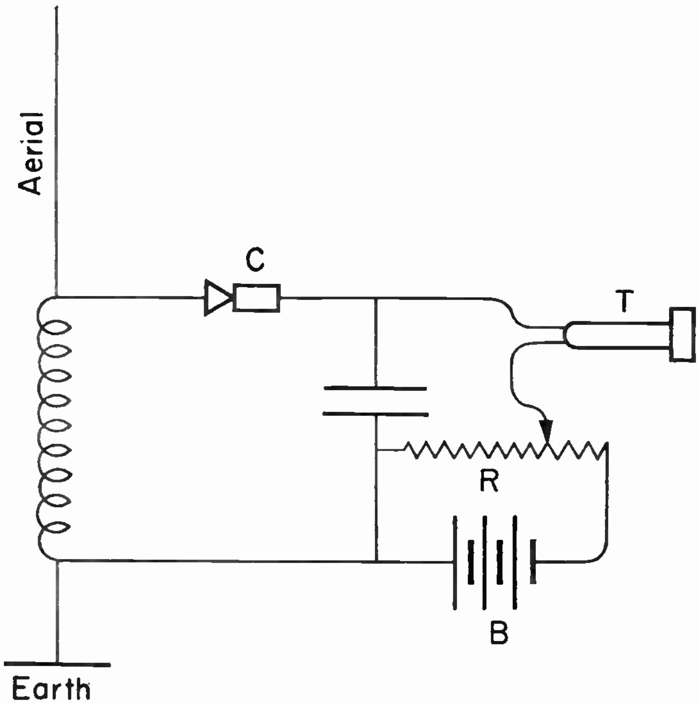
Some months later the Marconi Company obtained the rather grudging sanction of the Postmaster-General (whose department controls all radio licences in Britain) to conduct regular experimental transmissions from their works at Chelmsford. The Postmaster-General was not very enthusiastic about radio; although he appreciated its importance for ships and aircraft, he doubted—as did many people at that time—whether wireless would prove a desirable form of entertainment. However, as a great concession, he allowed the company to broadcast their experimental transmissions to the public on condition that the programmes were first submitted to his department for official approval. And that is how broadcasting began.

The Marconi Company gave their first public broadcast on 23 February 1920. The programme, being designed primarily for experimental purposes, was not very inspiring; it consisted of a news bulletin and one or two rather indifferent musical items. But nobody minded about the contents or quality of the programme. Radio was new—an adventure! The few people who possessed a wireless set and were able to listen-in were greatly excited. They marvelled at this wonderful new invention which brought entertainment into their homes.

The broadcast created such a stir that many people began to build themselves wireless sets to listen-in to future programmes. This required little or no knowledge of radio and very little skill. Any handiman or intelligent schoolboy could rig himself up a receiver quite cheaply. Apart from the headphones—for there were not many loud-speakers in those days—there was practically nothing to buy that cost more than a few pence.

All that was needed was to make a cylinder of cardboard and wind the correct number of turns of wire around it. A small piece of carborundum or some other cheap mineral, known as a 'crystal' was attached to one end of the wire. A thin metal thread, called a 'cat's whisker', rested on the crystal and was connected to the other end of the coil through a pair of headphones. An arrangement made out of an old tobacco or cocoa tin served as a tuning condenser. Finally, the set was earthed by wiring it to a water tap in the kitchen, and a second long wire was carried down the garden or backyard and hitched to a branch of a tree or a pole to serve as the aerial.

The old crystal sets were usually very unreliable. They squeaked, crackled and made irritating noises, and from time to time the 'cat's whisker' would slip, causing the programme to fade out completely. (This generally seemed to happen during the best part.) However, with a little juggling and perhaps a few sharp taps, it was usually possible to restore



A crystal set. The resistance (R) and battery (B) permitted more accurate tuning than with the elementary set. The headphones are marked (T) and the crystal (C).

reception without too much delay. Reception was appalling by modern standards. Both speech and music were often badly distorted, and sometimes scarcely audible. And yet people derived immense pleasure from listening-in to the programmes from Chelmsford on these sets.

Twice daily the Marconi Company broadcast a short programme, half an hour of news and music. The programmes were still not very exciting. But then, on 15 June 1920, the company gave their listeners entertainment of a much higher quality. They brought the world-famous Australian singer Dame Nellie Melba to the microphone.

When Melba arrived at the Chelmsford works to make her broadcast, one of the engineers proudly pointed up to the two great masts, towering to a height of 470 feet, from which the aerial was suspended.

'From up there, Dame Nellie,' he said in the hope of impressing her, 'your voice will go out and be heard over most of Europe.'

Melba, having no knowledge of wireless, thought that she was expected to broadcast from the aerial! Looking up in horror, she exclaimed:

'Young man, if you think I'm going to climb up there, you're mistaken!'

The engineer, somewhat abashed, hastened to reassure the great prima donna and led her to the studio, a miserable room with a cold concrete floor—very different from the fine concert halls where Melba was accustomed to singing. In an effort to make the place a little more cheerful, a rich pile carpet had been spread over the floor, but for some reason Melba, temperamental by nature, objected to this.

'First of all we'll get rid of this thing,' she said with a sniff. Digging her foot under one edge of the carpet, she promptly proceeded to roll it up.

However, apart from this little difficulty over the carpet, Melba made light of the inconveniences and accepted them with good humour. She sang four songs: the National Anthem, 'Home, Sweet Home', a French song, and an aria from Puccini's opera *La Bohème*, which she sang in Italian. Her songs were heard quite clearly throughout the British Isles, in many parts of Europe, and as far away as Newfoundland; and although the poor quality of the microphones and receivers hardly did justice to Melba's lovely soprano voice, listeners everywhere were enchanted.

After this popular programme, it might have been assumed that broadcasting would expand rapidly. But in fact the reverse happened. A few weeks later the Postmaster-General, without warning and for no sound reason, suddenly clamped down and banned any further experimental transmissions to the general public.

His astonishing action, which was supported by the Government, was extremely short-sighted and could hardly have been worse timed. For while Britain closed down, other countries were opening up. America had opened her first broadcasting station—KDKA—at East Pittsburg. Holland had begun to broadcast concerts from The Hague. France was broadcasting from the Eiffel Tower in Paris, and soon one or two other countries in Europe also began to transmit programmes of entertainment. The network of world radio, which now covers every corner of the globe, was slowly beginning to spread. And yet Britain, where so much had been done to develop broadcasting, had no broadcasting station.

People in Britain began to listen to the programmes from abroad. They were able to tune-in to the foreign stations quite easily on their crystal sets. They enjoyed these programmes; the concerts from Holland were especially popular.

Nevertheless, listeners resented the fact that Britain provided no broadcasting service of her own.

For more than a year British listeners contented themselves with listening to the foreign programmes. Then, in December 1921, a deputation of listeners petitioned the Postmaster-General to sanction a broadcasting service without delay. The Postmaster-General refused to do this. The listeners petitioned again, and eventually, after much badgering, the Postmaster-General gave in. Realising that public opinion was against him, he reluctantly allowed the Marconi Company to start a limited broadcasting service to the public, subject to numerous petty restrictions.

Instead of transmitting purely for experimental purposes, the Marconi Company was now allowed for the first time to broadcast programmes specifically designed for the entertainment of the public—a great step forward. The company hastily rigged up an old army hut at their radio development centre at Writtle, in Essex, as their broadcasting station, hired a piano for the studio from a local shop, and on 14 February 1922 they 'went on the air'.

For some strange reason—possibly for fear of antagonising the Press who might fear competition from this new medium of entertainment—the company were not permitted to advertise their programmes. So they compiled a register of their listeners by appealing to them to send in their names and addresses, and they then sent them postcards advising them about their programmes. They were compelled to behave almost like a secret society—as though there was something to be ashamed of in broadcasting.

The number of listeners, which at first totalled about 6,000, quickly increased, with the result that after a few weeks the Postmaster-General, now a little less worried, was prevailed upon to allow the Marconi Company to open a second broadcasting station, in London. This station was housed on the seventh floor of a building in the Strand, and its call-sign was 2LO—a name that was soon to ring throughout Britain and beyond the seas.

After the opening of 2LO the number of listeners quickly multiplied to 20,000 and 30,000. To meet the increasing demand for wireless, a number of electrical firms had by now turned over to manufacturing radio sets. They made not only crystal but also valve sets. Their receivers ranged from tiny crystal sets in a matchbox, which could be bought for a shilling, to large valve sets in splendid mahogany cabinets, which cost many pounds. These wireless sets, in the words of of the G.P.O., 'had one thing in common—they appeared to contain enough wire, if uncoiled, to connect you direct to the station to which you wished to listen!'

In the early summer of 1922 six of the radio manufacturers, headed by the Marconi Company, came to a business agreement. They joined forces and formed a new company for the purpose of providing a regular daily broadcasting service in Britain. They obtained a licence to broadcast from the Postmaster-General, and they called their new company the British Broadcasting Company Limited. (Later the Company became a corporation, the British Broadcasting Corporation.)

5

The Rise of the B.B.C.

On the evening of 14 November 1922, listeners in Britain put on their headphones, tuned-in their wireless sets, and waited with a feeling of expectancy. The receivers crackled and spluttered, as was their habit. Other strange noises from the studio followed. Then the announcer came on the air and opened the programme with these words: 'Hallo! Hallo! . . . 2LO calling . . . 2LO calling . . . This is the British Broadcasting Company . . . 2LO . . . Stand by for one minute, please. . . .'

And so, from the seventh floor room of Marconi House in the Strand, London, the voice of the B.B.C. was heard for the first time.

The programme which followed was uncommonly dull. The main items were a scanty news bulletin and a dreary weather report stating that London was blanketed in fog —as a great many of the listeners already knew only too well! There was no fanfare of trumpets—no special attraction to mark the importance of the occasion.

The second evening, however, had more to offer. The country was in the throes of a General Election, and throughout the day people had been voting at the polling booths. That evening two regional stations were opened, at Manchester and Birmingham, and the infant B.B.C. made history by broadcasting the first election results from London and the two new regions. People living within range of these three stations who possessed wireless sets invited their friends and relations to their homes to listen-in to the results. As many as forty and fifty people crammed into some of the larger houses. Many of these listeners had no special interest in politics; some probably did not care a hoot which party was returned to power, the reigning Coalition party led by Lloyd George or the Conservatives led by Bonar Law. But one result caused quite a stir among all listeners—the sensational defeat of Winston Churchill, then a Cabinet Minister of nearly forty-eight.

During the first few months broadcasting hours were irregular. On some evenings broadcasting would begin as early as five o'clock whereas on other evenings the start might be delayed until as late as eight o'clock. The stations usually closed down at between 10 and 10.30 p.m., although this too was variable.

The hours of broadcasting were governed to a certain extent by the material available for the programmes. These still consisted mainly of news bulletins, weather reports and musical items. At the end of a programme the friendly announcer would often round off with the words: 'I hope you all heard that as well as we did in the studio'—a hope that was by no means always realised. Sometimes, when atmospheric conditions were bad, listeners hardly heard a word.

The studio of the London broadcasting station—2LO—was a small drab room, furnished with a faded green carpet, a dilapidated sofa with the stuffing peeping through, and a grand piano. To improve the acoustics, the walls were draped with muslin curtains.

One evening in the middle of a broadcast these curtains caught fire, and the programme was brought to an abrupt halt while everyone broke off and frantically endeavoured to put out the flames. One man grabbed the only fire extinguisher, to find that it was broken. Finally, after all other efforts had failed, the broadcasters ripped the curtains from the walls, flung open the window, and threw them out into the street. The breathless announcer then mumbled an apology for the interruption into the microphone, and the programme continued.

Incidents of this nature were not uncommon in the early days of broadcasting. From time to time the microphones caused embarrassment. The early microphones, unlike those of today, could not be adjusted to suit the height of the speaker or singer. A tall man had to stoop to speak or sing into the microphone, while a short man had to stand on a pile of books to reach it. To balance on a rickety pile of books requires some skill and concentration. The idea worked quite satisfactorily provided that the artist remembered how delicately he was poised, but, if he became lost in his part and forgot, the consequences could be most unfortunate. One evening in the Manchester studio a singer, without thinking, boldly threw out his chest and took a step backwards to reach a high note—and lost his balance. The pile of books slid from under his feet, and he collapsed under the piano with a resounding thud.

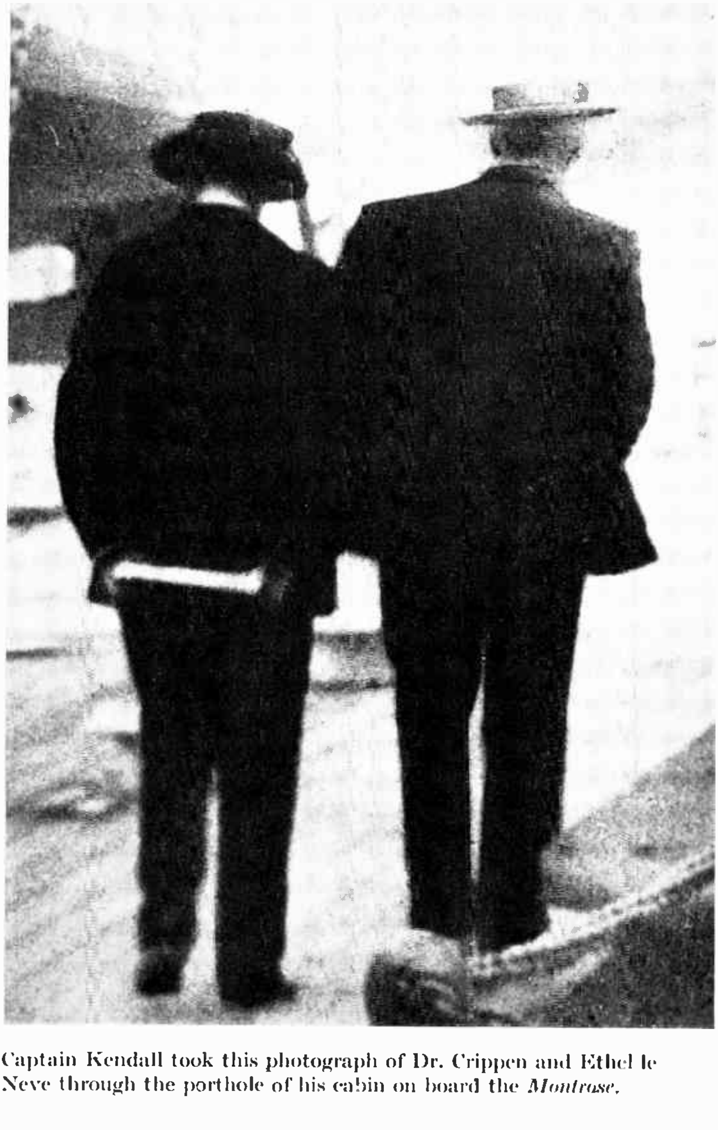
Programmes were frequently interrupted by some 'technical hitch'—the expression used to explain away any little difficulty, mechanical or otherwise. And at the end of a musical item the announcer would request listeners to: 'Wait one minute, please, while we move the piano.' Whereupon there would be the sounds of scraping, shuffling and heavy breathing as the piano was heaved and shoved to one side.

Broadcasting was conducted in the most chaotic conditions, with little or no system. Indeed, it was miraculous that any programme ever went on the air. But then a young Scotsman named John Reith (now Lord Reith) was appointed general

Lord Reith

An early radio installation in a passenger liner before the First World War.

A modern installation in the logistics ship *Sir Lancelot.*



Captain Kendall took this photograph of Dr. Crippen and Ethel le Neve through the porthole of his cabin on board the *Montrose*.

Dame Nellie Melba at the microphone.

A studio scene at Marconi House, London, in 1922, when regular broadcasting first began in Britain.

manager of the B.B.C., and he very soon began to improve conditions.

The circumstances of Reith's appointment were rather curious. Reith, who was then in his early thirties, was an engineer by profession, but he had recently given up his good job as manager of an important engineering group in Scotland in order to find himself some other post of greater scope and opportunity. An ambitious man with immense drive and determination, and also deeply religious, Reith had the firm conviction, as he wrote in his diary, that 'there is some great work for me to do in the world'. He had no idea what form that work would take, but one day shortly before the start of official broadcasting he was scanning the Appointments columns of the old *Morning Post* when his eye alighted on an advertisement for a general manager for the new B.B.C.

Reith had absolutely no knowledge of broadcasting; indeed, he was not even entirely clear as to what the word meant. But his interest was aroused, and he decided to apply for the post. A month later he was interviewed and given the appointment. Even after his interview Reith still had no clear picture of broadcasting. So, before taking up his new duties, he invited one or two people in the radio world to lunch with him, 'with intent', as he tells us in his autobiography, 'to discover, without disclosing my ignorance, what I had become general manager of'!

John Reith took up his appointment on 30 December 1922. Although still hazy about the technicalities of broadcasting, he fully appreciated its future importance to the community; and he resolved from the outset to build up the B.B.C. into an efficient public service of the highest possible standard. In this he met with spectacular success.

One of Reith's first acts was to transfer the London broadcasting station to slightly better and less cramped quarters in Savoy Hill, a street leading down from the Strand to the Thames Embankment.

Reith started with a regular staff of only four people, the porter, an office boy and a charwoman, but he soon recruited a splendid team of producers, announcers and technicians to present and put the programmes on the air.

Gradually over the course of the next few years the programmes improved in quality, variety and scope. Religious services, talks, orchestral concerts, variety, 'Children's Hour', 'Woman's Hour', school broadcasting, and many other successful programmes were introduced. As early as 1923 outside broadcasting began with the relaying of Mozart's opera *The Magic Flute* from the Royal Opera House at Covent Garden. The following year the voice of King George V was heard on the air when he opened the Empire Exhibition at Wembley—the first time a sovereign had ever spoken to his subjects by radio.

Little by little, the hours of broadcasting were extended and made more regular. New regional broadcasting stations were opened in many parts of the British Isles to bring radio within the range of nearly every home in the land. At the same time immense improvements were effected on the technical side. More powerful transmitters and receivers were designed, by gradual degrees the equipment generally was brought up to an altogether higher standard, and valve radio sets with loud-speakers gradually supplanted the unreliable crystal sets with headphones. The whole tone and quality of production steadily improved. These technical developments were brought about by the combined efforts of the radio manufacturers and the B.B.C.'s first Chief Engineer, P. P. Eckersley, who was appointed to his post two months after Reith became general manager. As Eckersley humorously remarked, 'I must have been the Chief because I was the *only* engineer at that time!'

With remarkable speed and efficiency, John Reith built up the B.B.C. into the finest radio system in the world. But he did not achieve success without a struggle. He was faced with many problems which required all his skill and determination to solve. He had to contend with interference from various quarters, notably from government officials, and he was constantly attacked by the Press.

As the standard and range of broadcasting improved, the number of listeners rose rapidly, and this caused the Press considerable alarm. The editors of the national newspapers were afraid, quite understandably, that people who listened to the news on the wireless might give up buying their newspapers. They could not risk losing sales, and so, in self-defence, they furiously attacked the B.B.C. in their columns. They criticised the programmes and found fault in everything that Reith was doing.

'The programmes at present sent out are miserably poor and have been growing worse every day,' wailed the *Daily Express*. Contemptuously referring to the B.B.C. as 'this broadcasting company', the *Evening Standard* expressed the opinion that the average listener would soon 'treat the thing as a discarded toy and give up interest in wireless altogether'. Most of the newspapers joined in the sniping. With one voice they declared in so many words: 'There is no future for radio.'

But Reith was undismayed, and eventually the newspaper editors, seeing that in fact their sales were not adversely affected by radio, ceased their almost daily criticism of the B.B.C. Indeed, one or two newspapers turned about and even began to praise the B.B.C.

In 1927, after five years in operation as a limited company, the B.B.C. was established as a public corporation under a

Royal Charter, and became the British Broadcasting Corporation.

The next five years brought further all-round expansion. By 1932, the end of broadcasting's first decade, the number of people holding wireless licences had risen to nearly 4,500,000 (as compared with the 20,000 to 30,000 when the B.B.C was founded), and the original staff of four had multiplied to close on 1,200.

The premises at Savoy Hill were bursting at the seams. Extra rooms had been rented in other buildings to accommodate the growing staff, and several new studios had been fitted up, one of these being in an old rat-infested warehouse. But these were only makeshift arrangements. Splendid new premises were in the course of construction in Portland Place—Broadcasting House.

To erect this building, some 43,000 tons of earth had to be excavated, and nearly 3,000,000 blocks of Portland stone were imported from Dorset. People came from near and far to watch this imposing edifice rise, storey by storey, to a height of 112 feet above street level. Few building operations within living memory had aroused so much interest.

It took three years to build Broadcasting House. With mixed feelings, their pleasure tinged with a certain sadness at leaving Savoy Hill, which despite the congestion had become like a home to them, the staff of the B.B.C. moved to their new headquarters in the spring of 1932, and the following July Broadcasting House was officially opened by King George V and Queen Mary.

Today, little more than thirty years later, the staff of the B.B.C. (including those employed on television) numbers over 18,000—and Broadcasting House is no longer adequate. Although Broadcasting House is the headquarters only for sound radio, it became necessary some years ago to take over other buildings, including a large hotel, to house various departments concerned with this side of broadcasting.

The B.B.C. now have over 200 sound broadcasting studios —very different from the one miserable little room in the Strand with the faded green carpet and muslin curtains draping the walls. Some of the studios are very small—not much larger than a good single bedroom in a private house. These are used primarily for talks. Other studios are very much larger. Some are as large as a gymnasium, and these are used for concerts and other programmes requiring plenty of floor space. All the studios, regardless of size, are air-conditioned and designed to produce the best possible tone and quality of sound.

Broadcasting is a science. Unlike the early slap-happy days when nobody ever quite knew how things would turn out, today teams of experts plan the programmes and put them on the air. The number of people involved in an individual broadcast varies according to the type of programme; a play with a large cast naturally requires a larger team than a straight talk. But for every broadcast there will be a producer, one or more studio managers, an announcer, and engineers to transmit the programme.

A studio is equipped with a number of microphones by each of which is a green light, used to 'cue' the artist so that he knows when to say his lines. In one wall of the studio is a long double-glazed window beyond which is a soundproof 'control cubicle' containing a mass of technical apparatus, operated from a panel of switches by the window overlooking the studio. There are switches to flash the microphone lights on and off; faders for adjusting the volume from each microphone; meters for measuring the volume of sound; an instrument to distort the voice to make an actor sound as if he is speaking on the telephone from a distance; and many other devices. The cubicle is also equipped with tape-recorders or record-players for producing music and sound effects.

During a broadcast the producer and his studio managers direct and control the performance from this cubicle. The producer, who is in charge, sits by the window and listens with a critical ear. The senior studio manager sits at the panel of switches and operates the various instruments. And one or two other studio managers stand by the tape-recorders or record-players and 'swing in' with the music or sound effects at the appropriate moments.

Since the cubicle is soundproof, the producer can give his studio managers any instructions that may be necessary without his words being picked up by the microphones outside. He cannot, of course, speak to the artists, but he can signal simple instructions to them by flashing the lights by their microphones. If, for example, an actor is speaking too fast the producer may instruct the studio manager at the panel to give him a signal on his light to slow down his diction a little. Likewise, if an actor is speaking too slowly, he can signal to him speak a little faster.

Let us picture the scene in a studio when a play is broadcast. Weeks of preparation have gone into the production. The cast has been carefully chosen after many auditions. Lines have been hacked out of the script or re-written to smooth out words and sentences that do not fall easily from the tongue. The play has been rehearsed again and again, and at the final rehearsal every part was timed with a stop-watch to ensure that the performance will not overrun by so much as one minute. Now, as the moment for the broadcast draws near, the actors and actresses stand by their microphones in the studio, scripts in hand; and the producer and studio managers take up their respective positions in the control cubicle.

A few seconds before the broadcast is due to begin, the engineers flicker a red light in the studio. Immediately there is complete silence. The atmosphere is tense. Even the artists with long experience of broadcasting feel a little on edge. Everyone anxiously watches the flickering light. The seconds seem like hours. Then the red light comes on permanently. The engineers have connected the studio to the 'network', and the studio is 'alive'.

From a different studio in some other part of the building, the announcer introduces the programme. There is a pause. Then the studio manager at the control panel flashes on a green light by one of the microphones to cue the first actor to say his lines. And the play begins.

Following the play with the script, the senior studio manager, who never leaves the panel for one instant, flicks on first one switch and then another. As each artist completes his lines, the studio manager allows a pause of a few seconds and then brings in the next artist. He fades down one microphone and brings up the volume of a second.

From time to time the studio manager by the record-player swings in some music and then gradually fades it out again. Another studio manager may introduce various sound effects by other means. He may empty jugs of water into a pail to represent a running stream. Or, if the play is an historical one and somebody is beheaded, he may slash a large, fat cabbage in half with a guillotine.

Meanwhile, throughout the play, the producer listens and watches and issues any instructions that he may consider necessary to improve the performance.

After the last lines have been spoken, there is another pause. The announcer closes the programme. The engineers disconnect the studio, and the red light goes off.

The play is over, and the studio 'dead'.

6

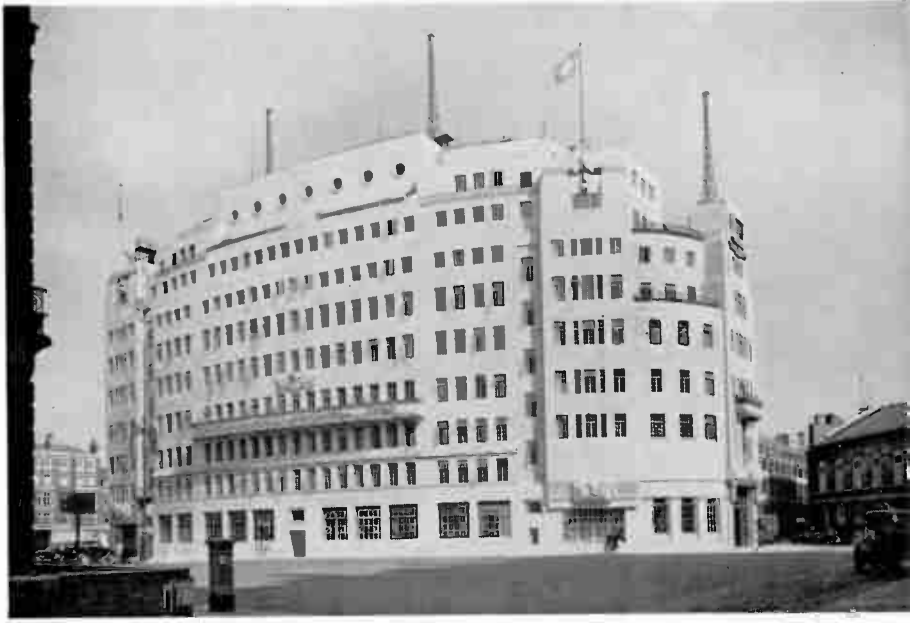
The Birth of Television

While John Reith was building up the B.B.C. another Scotsman, John Logie Baird, was making the first successful experiments with television.

Baird, who was born in 1888, was the son of a Scottish minister, as also was Reith. Dogged by ill health all his life, Baird gave the impression of being a lethargic sort of man with little or no ambition. He was careless about his appearance: his clothes were usually shabby and he was lax about having his hair cut. Always short of money, he drifted from one idea to another in the hope of finding some way to make his fortune. It was in a desperate effort to make ends meet that he eventually turned to the idea of television.

Baird began to show his inventive turn of mind as a schoolboy. Inspired by the aviation experiments of the Wright brothers, conducted at the beginning of this century, he decided to try his hand at building himself a 'flying machine'. He built a contraption out of various odds and ends and launched it from the roof of a building, but it disintegrated in the air, and Baird, who was hurled to the ground, was lucky not to break his neck. Later, he rigged up a home-made telephone with overhead wires, but a storm blew down the wires just as a coach was passing along the road, and the coachman was torn from his seat and injured.

Baird went to three schools, and he was not really happy at any of them. Like Reith, he then went on to the Royal Technical College in Glasgow to train as an engineer. After



Broadcasting House, London.

Radio Newsreel: in the studio a few minutes before going on the air.

An early television 'studio'. A Nipkow scanning disc can be seen just below, and to the left of, the panel with three meters on it.

A Marconi Cathode Ray television receiver (1934).

obtaining an engineering diploma, he took a science degree at Glasgow University. At the age of twenty-six he was given an engineering post with the Clyde Valley Electricity Company at a salary of thirty shillings a week.

It was a miserable job, and Baird disliked it intensely. He had to turn out at night in all weathers to deal with mechanical breakdowns, and the strain soon began to tell on his health. So after a short time Baird began to look around for some other way to earn his living.

Before giving up his job, he experimented with various ideas in his spare time. One of his first 'brainwaves' was to manufacture artificial diamonds by electrically exploding carbon rods in concrete. One evening he conducted an experiment on these lines at the electricity station; he embedded some rods of carbon in a bucket of concrete and connected them to the station's main power output. Immediately there was a tremendous explosion—and the entire power supply for the district was cut off.

Baird finally conceived the idea of making an undersock for people who, like himself, suffered from cold feet. He devised a kind of thermostatic hose impregnated with borax which would be both warm in winter and cool in summer. He made and sold a number of pairs and earned himself some welcome pocket money. Convinced that this was the idea he had been looking for, Baird then resigned his engineering post, rented a cheap room in Glasgow and, with a capital of only £10, he proceeded to manufacture his new patent undersocks in commercial quantity.

At first business was disappointingly slow. However, Baird visited the principal stores and persuaded the buyers to stock his product. He then employed an army of women to go round the city advertising his undersocks on sandwich boards. Sales quickly began to mount, and in twelve months

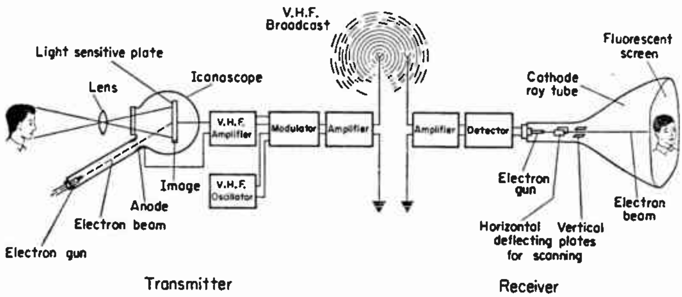
Baird made no less than £1,600. But then his health broke down again, and he was compelled to give up his promising business.

Baird emigrated to the West Indies in the hope that the warmer climate might improve his health. He started a jam factory in a hut in Trinidad, but nobody would buy his jam. So he sold his factory for a paltry £5 and returned home. During the next few years he tried to scratch a living by selling fertilisers, honey and soap. He invented a pneumatic sole for shoes, but the first time he tested a pair one of the soles burst and he fell over. He then invented a glass safety razor which proved equally useless. Baird began to grow desperate.

Then in 1923—the year after the B.B.C. was founded—Baird, now thirty-five, with no income and almost penniless, went to Hastings, in Sussex, to stay with an old school friend, Guy Robertson, whom he nicknamed 'Mephy'. One day during his visit he went for a walk along the cliffs, and in the course of that walk he had the sudden inspiration of trying to invent a practical system for television.

Before describing Baird's experiments, let us consider how television functions today. The basic principle of television is an extension of sound broadcasting. Sound broadcasting is achieved by turning sounds into electrical impulses by means of a microphone, amplifying these the requisite amount and superimposing them on a radio wave which is shot out into space to travel considerable distances. At the receiving end, this composite wave is picked up on the aerial and amplified, and the two component waveforms are separated. The ones corresponding to the original sound waves are then fed into a loud-speaker, which reverses the function of the microphone by reconstituting the electrical impulses as sounds.

In the case of television, light as well as sound is handled in this way. Light reflected from the televised scene is converted into equivalent electrical impulses, transmitted on a radio wave, disentangled at the receiver, and reconstituted as light for benefit of the viewer.

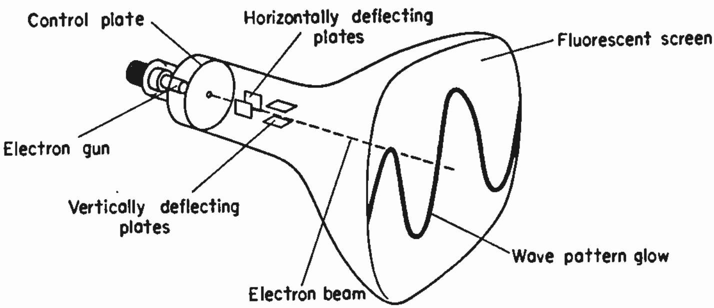


The transmission and reception of a picture by television

The pictures are televised as a series of still pictures, or 'frames', by means of electronic beams, photo-electric cells and other light-sensitive devices. Immensely complicated electronic equipment is used. The photographs are taken by breaking down the image (the subject televised) into thousands of spots of light of different degrees of intensity by a scanning process.

A light-sensitive pick-up tube in the television camera scans the image with an electron beam. This beam scans the image in lines from left to right, working down the subject from top to bottom. The electrical impulse which results at any one instant represents the light emanating from one small spot on the picture at that exact instant. If the camera tube is scanning a bright portion of the picture, the electrical impulse it produces will be a strong one. If it is scanning a dark portion, it will produce a weak impulse.

While the scene is being televised these electrical impulses, produced in rapid succession, are transmitted on a radio wave to a receiver, where another electron beam in a cathode ray tube operates in synchronisation with the camera tube and converts the impulses back into light. The beam in the cathode ray tube scans a fluorescent coating on the back of the face of the tube in exact synchronisation with the scanning process at the transmitter. The strength of this beam is controlled by the strength of the output from the camera pick-up tube, a strong impulse producing a bright spot of light on the fluorescent coating and a weak impulse producing a dull spot. In this way a faithful picture of the image is reproduced by the receiver simultaneously with the taking of the picture.



The cathode ray tube

Viewed at close range, the picture appears on the television screen as a series of lines, but at normal viewing distance these lines are lost to the eye, and the viewer sees a clear picture in all its detail. Although the picture on the screen appears to be in motion, this is really an optical illusion. This illusion of movement is produced by transmitting the thousands of separate frames at the rate of about twenty-five pictures a second. At this tremendous speed the human eye is unable to detect the breaks in the sequence, and consequently vision is uninterrupted.

The possibility of television had been realised for some time before Baird appeared on the scene. Even before Marconi began his first experiments with radio waves, in the latter half of the last century, ways were found to transmit pictures by means of electrical impulses conveyed by wires. A telephone operator employed on the Atlantic cable service, Joseph May, first discovered by accident that selenium is sensitive to light. An American, C. R. Carey, then worked out a system for transmitting pictures by means of a series of selenium cells. His system proved impractical, as it was found that about a quarter of a million cells would be required for transmission, but a Frenchman, Maurice Leblanc, later found a way out of this difficulty by conceiving the idea of breaking up a picture into numerous spots of light. Finally, a German engineer, Dr Paul Nipkow, invented a mechanical scanning device for doing this. By their various discoveries and inventions, these men and a number of others all helped to lay the foundations for television before the days of radio.

Thus Baird's idea of 'seeing by wireless', as he described it, was by no means original. The spectacular development of wireless telephony had made it obvious to many people that radio waves could be used for vision as well as for sound. In fact, unknown to Baird, an American, Charles Francis Jenkins, was already experimenting with television in the United States. It was to be a race between the two men as to who would first succeed in producing a practical system for television, Baird or Jenkins.

When Baird returned from his walk along the cliffs and told Mephy of his plan, his friend refused to take him seriously.

'You don't know what you're attempting,' he said. 'You'll never succeed!'

But Baird refused to be put off. During his walk he had worked out in his head a detailed system, and he was determined to put his ideas to the test. Having practically no money to buy equipment, he had to improvise. He bought some radio valves and a selenium cell and scratched around for 'bargains' for the other items he required. He got hold of a crude combined transmitter-receiver, unearthed an old electric-fan motor from a pile of junk in the backyard of an electrical shop, and procured a cheap projection lamp which he fitted with a bull's-eye lens obtained from a cycle shop for a few pence. He tracked down some obsolete wireless telegraphy equipment that was being sold for next to nothing, begged a tea chest and a biscuit tin from a grocer and a hat box from a milliner, and bought a couple of torch batteries, several yards of wire, some darning needles, and one or two other odds and ends.

With the aid of glue, sealing wax and string, Baird then rigged up a makeshift apparatus in his bedroom at Mephy's home. He made a revolving scanner based on Nipkow's idea by cutting a circle of cardboard from the hatbox, piercing it with a series of holes, and mounting the disc on the spindle of the old fan motor. The holes were designed to serve the same purpose as the modern electron beam; as the scanner revolved, spots of light from the image to be televised would pass through these holes and be converted into electrical impulses. For his image, Baird cut out another piece of cardboard in the shape of a Maltese cross.

Having set his various items of equipment in position, Baird placed the cardboard cross in a pool of electric light on one side of his scanner, started up his motor, and attempted to televise this image. To his intense delight, he succeeded, after several attempts, in transmitting a shadow of the cross a distance of two or three feet. It was not a proper picture, only a flickering shadow. But this simple experiment with junky apparatus convinced Baird that his ideas were practical.

Feeling greatly elated, Baird demonstrated his successful experiment to some newspaper reporters in the hope that the resultant Press publicity might be instrumental in bringing him in some cash to enable him to buy better equipment and extend his experiments. The reaction of the readers was most disappointing, but Baird's father, who was unaware of his son's latest venture, happened to see a copy of one newspaper report, and he sent him a cheque for £50—a most welcome surprise.

Baird now rented a small room above a shop in Queen's Arcade, Hastings, bought himself a separate transmitter and receiver and various other items of equipment, and set about developing his system. Denying himself all but the barest necessities and often going short of food, he worked into the early hours of the morning night after night for many weeks conducting his experiments. Gradually he began to achieve better results; his shadow pictures assumed more definite shape and grew a little clearer. But they were still no more than shadows.

To obtain a proper picture, Baird needed still better equipment—and by now his funds had run out again. He decided to appeal to the readers of *The Times* to help him out. He employed a little guile. Thinking that he might stand a better chance of obtaining financial assistance by appearing not to be seeking it, he inserted the following advertisement in *The Times*: 'Seeing by Wireless—Inventor of apparatus wishes to hear from someone else who will assist (not financially) in making working models.' This did the trick. A small London wireless dealer by the name of Day came forward and paid Baird £200 in return for a third share in his invention.

This was hardly good business from Baird's point of view, but he needed the money urgently. He now built a much more powerful apparatus, but before he made any headway with this he had an accident which nearly cost him his life. He connected several hundred flash-lamp batteries together in series to produce a high-tension supply of 2,000 volts—and then absentmindedly placed his hands on the two ends of this powerful assembly of batteries. He nearly electrocuted himself, but luckily he fell to the ground and broke the circuit.

Unfortunately, the Press heard of the accident and reported that the house had nearly been blown up. The landlord read these exaggerated reports, took fright, and sent Baird a terse letter instructing him to cease his experiments forthwith or quit. Baird threw the letter in the wastepaper basket and took no notice. This led to a row with the landlord, and Baird was forced to pack up his equipment and leave.

Baird now went to London and rented an attic room in Soho. Soon after coming to London, he ran out of money again. Dispirited and feeling far from well, he went round the newspaper offices in Fleet Street trying to seek further publicity, but the newspaper editors regarded him as a crank and refused to publish his story. Baird then called on a number of radio manufacturers in the hope that they might assist him, but they, too, were unhelpful. Nobody had any confidence in Baird's invention.

Then one day in March 1925, Baird received an unexpected visitor: Gordon Selfridge. Selfridge was planning to stage some special festivities at his famous store for a period of three weeks, and, having heard of Baird's experiments, he came round to his lodgings to see what they were all about.

Selfridge was impressed. Believing that this would provide an interesting novelty for shoppers, he engaged Baird to give three demonstrations daily for a fee of £25 a week.

The shoppers at Selfridge's were fascinated by this new idea of 'seeing by wireless'. But one or two were a little alarmed. They mistrusted the mysterious apparatus and were afraid that it might have the power to see into their homes and expose their private lives! 'Is it sufficient, Mr Baird,' one old lady asked, 'to draw the curtains in my bathroom to be safe from your invention?'

These demonstrations, besides bringing in money, gave Baird the publicity he needed. People who mattered began to take greater interest in his invention, and one of the radio manufacturers, the General Electric Company, volunteered assistance by making Baird a gift of radio valves to the value of £200.

Baird now made further technical improvements and experimented with televising a ventriloquist's dummy. At first he produced only the usual shadow. Then at last, on 2 October 1925, he succeeded in transmitting a picture that showed up the dummy's facial features.

Greatly excited, Baird resolved to try without further delay to televise a real person. With tousled hair, he bounded downstairs in his open-neck shirt and carpet slippers, grabbed hold of an office boy, William Taynton, from the floor below, and set him in front of the transmitter in place of the dummy.

Scared by the blinding light, young Taynton backed away, but Baird persuaded him to stay with a bribe of half a crown. He set his transmitter in operation and then dashed over to his receiver to see what was happening. As the scanner revolved on its spindle, the face of William Taynton—the first person in the world to be televised—appeared on the small television screen. The picture flickered and was of poor quality, but the boy's features were quite visible. It was a definite television picture.

John Logie Baird had won the race against the American, Charles Francis Jenkins, in producing the first practical system for television. He achieved this by only a narrow, margin, for only a few weeks later Jenkins scored a similar triumph in the United States. Baird's system, however, was the first in the world to be used.

In January 1926 Baird gave a television demonstration in public which was equally successful. This was widely reported by the Press, with the result that Baird, who had struggled for so long in obscurity, became world-famous almost overnight.

He had no difficulty in finding financial backers now. He formed a company, established well-equipped workshops and laboratories, and employed a team of engineers and scientists to assist him in developing his system.

Although still faced with many problems, Baird began to extend the range of transmission and improve the quality of production. He devised techniques for televising out of doors. He even succeeded in transmitting pictures in colour, and also in three dimensions. He spent about three years trying out new ideas and introducing improvements to his system. Then in 1928, Baird made history by transmitting television pictures across the Atlantic, from London to New York.

After this achievement, Baird endeavoured to persuade the B.B.C. to start experimental television broadcasting by his system. This proved a long and formidable task. Baird's pictures, although a great improvement on his original experiments, were still indifferent—very poor by modern standards—and the B.B.C. did not consider the time ripe to introduce television, even experimentally, until good-quality high-definition pictures could be achieved. However, after a great deal of badgering, with endless interviews and correspondence, the B.B.C. eventually yielded.

The first experimental television broadcast in the world took place at 11 o'clock on the morning of 30 September 1929. The programme took the form of a discussion between two speakers, and it was not a very impressive exhibition. There was no separate sound channel, and so the speakers first spoke into a microphone and then self-consciously faced the camera in silence.

After the opening of Broadcasting House, in 1932, the B.B.C. started a limited service of four experimental television programmes a week. These were normally broadcast from the basement of Broadcasting House, and they usually began at midnight. The reason for this was that it was difficult to spare the staff to handle a television programme until sound broadcasting had closed down for the night. The fact that most people were in bed by midnight was of little consequence because there were no more than a hundred or so viewers in possession of television sets.

The first television programmes were very limited in scope; they were confined mainly to interviews, musical items, cabaret turns and performing animals. A fixed camera was used—very different from the easily-operated mobile cameras of today—and the person to be televised was required to stand in front of a fierce light that came through a hole in the wall. The artists had to be heavily made up to prevent their features disappearing under this brilliant light; their noses were outlined in black and their lips painted a vicious purple colour. As one commentator of those early days put it, 'They looked like a cross between a ghost and a clown.'

Some people found it almost impossible to concentrate in this hot blinding light. One famous personality ignored most of his interviewer's questions. Shading his eyes with his hand and blinking incessantly, he exclaimed: 'I say, this light is terrible! You'll really have to do something about it. I'm so dazzled I can't even think!' And the viewers had waited up until after midnight to watch this interview!

Little by little, these and other technical problems were overcome and standards improved. Yet all this was only an episode in the history of television. As events were to prove, Baird—in spite of the great work he had done—had from the beginning followed a fruitless path. The reason was simply that Baird's television system, based on the Nipkow discs, was purely a mechanical one, and therefore could never approach the flexibility of an all-electronic system such as by this time had been developed in America, notably by Vladimir Zworykin, an engineer of Russian birth. This is the system in universal use today, and it is interesting to note that a British engineer, Campbell Swinton, outlined the theory of it as early as 1908.

For some years electrical engineers in America, as in many other countries, had been conducting intensive research in the field of television. In 1929 Zworykin gave a public demonstration of his 'Iconoscope' camera tube. Meanwhile, in Britain the Marconi Company were solving many of the problems to do with the transmission of high-definition pictures. Then in 1932 another British firm, Electrical and Musical Industries (E.M.I.), introduced their 'Emitron' camera tube for beam scanning (described on pages 55-56). Two years later the Marconi Company and E.M.I. joined forces.

When, therefore, the B.B.C. came to inaugurate their high-definition television service—the world's first public television service—on 2 November 1936, they had to decide which of the two systems to adopt, the Baird or the Marconi-

E.M.I. system. A government committee set up two years previously to examine all aspects of television recommended that both systems be given a trial before a final decision was made. Accordingly, the B.B.C. rented part of Alexandra Palace, commonly known as 'Ally Pally', for its new television service and fitted up two separate studios, one for each system.

For a period of three months, programmes of two hours' duration were televised on alternate days by each system. Then in February 1937 judgement was passed. It was decided that the Marconi-E.M.I. system was greatly superior to Baird's both in picture quality and in terms of studio techniques. This was a cruel blow for Baird. The B.B.C. adopted the Marconi-E.M.I. system exclusively, and poor Baird, who died nine years later, was eclipsed.

On 12 May 1937 the Coronation of King George VI and Queen Elizabeth was televised. Although it was drizzling with rain and visibility was poor this first outside television broadcast (other than those from the grounds of Alexandra Palace) was a triumph. About 10,000 people watched this historic event, the Coronation, on television, and the broadcast made a great impact.

During the next two years the number of viewers began to mount steadily, until by the summer of 1939 more than 20,000 people in Britain owned television sets, as compared with a mere 300 three years previously. But then in September 1939 the Second World War broke out—and there were no television transmissions in Britain for seven long years.

7

Radar

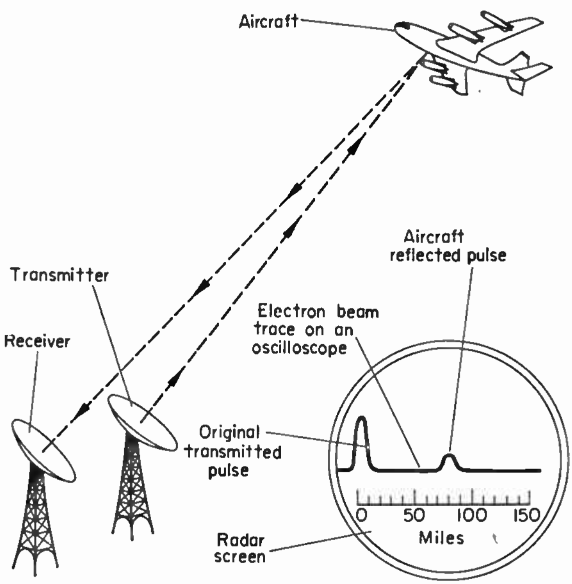
Although the war caused a temporary suspension of television broadcasting, it also brought another development in the field of radio which today is of inestimable importance —radar.

The name 'radar' stands for Radio Detection and Ranging. By means of radar it is possible to track down and establish the exact position and distance of objects which the human eye may not be able to see, and to record the direction and speed of moving objects, such as ships and aeroplanes. Radar can pick out objects more than a hundred miles away in the worst weather conditions, when visibility may be down to perhaps only a hundred yards, or less.

Radar works in this way. Powerful transmitters send out a stream of radio waves called 'pulses' at the rate of perhaps one thousand every second. These pulses shoot through the air at a speed of 186,000 miles a second until they hit an object—perhaps a ship, an aeroplane, a building, or a hill. These pulses cannot go through that object; and so they immediately shoot back at the same speed, in the opposite direction, and hit the aerial of the radar. The moment this happens a 'blip' of light appears on the radar screen, showing the position and distance of the object.

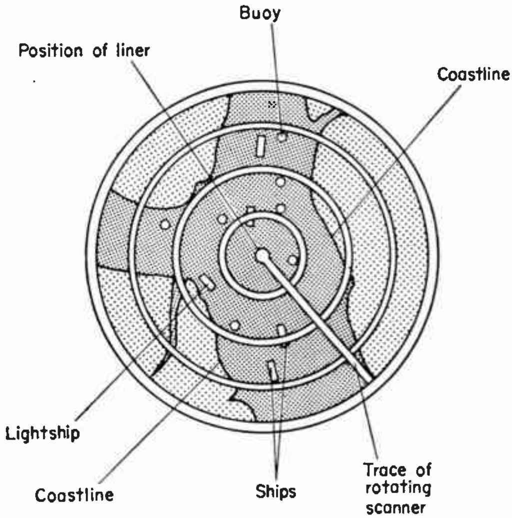
The size of the light gives an idea of the size and form of the object. If the pulses hit a ship or an aeroplane, for example, they will produce only a very small light; but if they hit land they may produce several lines of light, showing the shape of the land almost as clearly as in a drawing. The strength of the light is also a guide: land, water, and materials such as wood and metal all produce different degrees of brightness. The water in a lake or river will show only a dull light whereas the buildings of a town will give a bright light.

The radio waves very often strike many objects of different kinds, and all these appear on the screen as separate lights. The screen then becomes like a map. But there is one great difference between this radar map and the ordinary map of places; as the ship or aircraft moves along, the picture is constantly changing. The lights from the moving objects keep jumping forward by a fraction of an inch: every time that new radio pulses hit these objects their lights on the



A radar set tracking the approach of an aircraft screen give a little jump. This may happen three or four times a second.

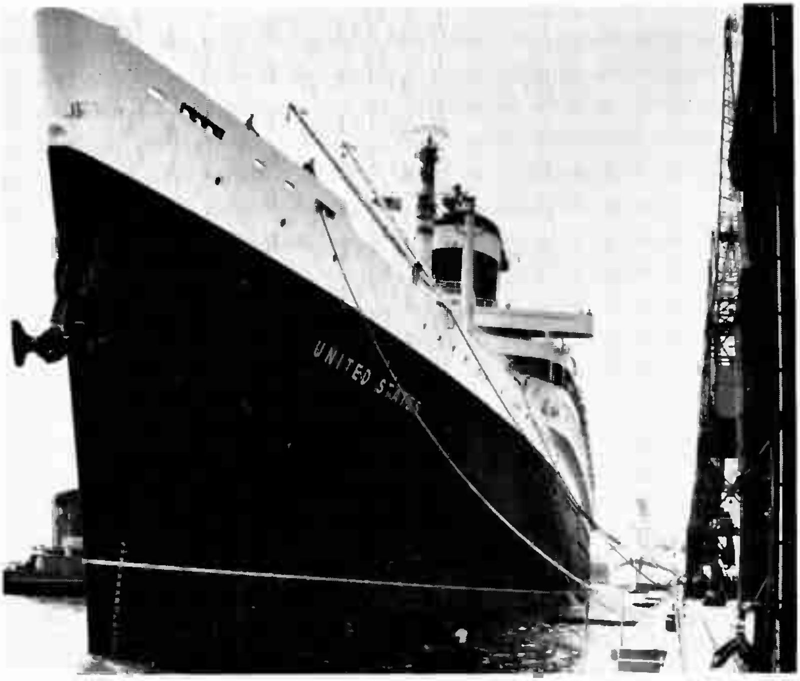
Different types of screen are used to record all this information. One screen shows the position and the speed and direction of movement; another screen shows the heights of the objects. The distance is measured by the length of time the radio pulses take to reach the radar aerial after they have been transmitted; this information is worked out by radio circuits and on a cathode ray tube.

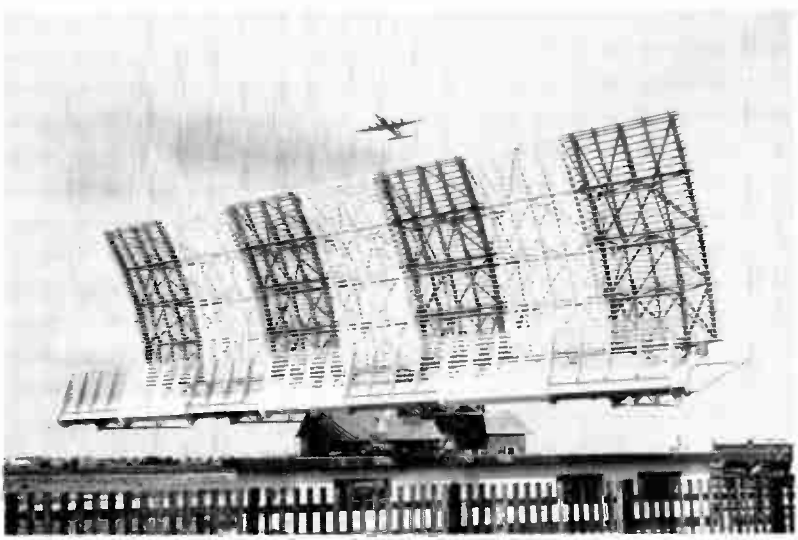


The radar screen of a liner in the Solent

The early work which ultimately led to the conception of radar was carried out by scientists in various countries in the course of investigations into the behaviour of the ionosphere (a layer of the earth's upper atmosphere). In Britain these investigations led Robert Watson-Watt—a Scot, like

A harbour entrance and its image on a radar screen.





Radar scanners: *above*, on a ship's mast, *below*, at London airport.

Reith and Baird—to the idea that somewhat similar techniques might be used for the detection and location of aircraft.

Watson-Watt, who was knighted for his important work, was born in 1892. His father was a carpenter, and he wanted Robert to follow the same trade. But a teacher at Robert's school said that he was not suited to manual work; he should use his brains, not his hands. Robert was a clever but lazy boy; he worked hard only at subjects that interested him. At first he was interested in extremely few subjects. He liked English, and, as he was good at writing, his headmaster suggested that he should earn his living as a newspaper reporter.

Robert was quite attracted to this suggestion, but later he became more interested in science and decided to become an electrical engineer instead. His headmaster considered this a most unwise decision because Robert was so bad at mathematics. He told the boy: 'You will never pass your examinations!' He tried to persuade Robert to change his mind, but Robert never wavered. He worked especially hard at his mathematics and passed all his examinations well. He won a scholarship to University College, Dundee, where he obtained a first-class science degree.

A year or two later the First World War (1914-18) began, and Robert Watson-Watt tried to find himself a scientific post connected with the war. At first nobody seemed to want him. But then in 1915 he was employed by the British Government to study weather conditions and report likely changes in the weather. His primary duty was to discover when thunderstorms were expected. These forecasts were needed for planning air battles against Germany.

Watson-Watt worked in an old wooden building in the most difficult conditions. He had hardly enough room to move, his instruments were of poor quality, and he had no one to help him. His wife, who had no knowledge of science, helped with some of the donkey-work and taught herself to mend his instruments when they kept breaking down.

In spite of the difficulties, Robert Watson-Watt did his job well. After the war the Government gave him a post at a new research station at Slough, where, under much better conditions, he continued his studies. He had in 1916 evolved a method of locating lightning flashes at long range by means of conventional direction-finding techniques, but with the innovation of a cathode ray tube as the method of presentation. Concurrently with this, investigations were going on in several countries into means of determining the height of the ionosphere by using radio techniques. Notable among the workers in this field were the British scientists Appleton and Barnet. Now Watson-Watt also became involved.

Appleton and Barnet, in common with most other investigators, were using continuous radio waves for their experiments, and a curious phenomenon was commonly experienced; whenever an aeroplane was flying in the vicinity of the radio apparatus the intricate measurements which were being carried out were upset. For the most part this was just treated as a nuisance.

Watson-Watt was among the first to realise that this effect, although a hindrance to ionospheric research, might well be used for aircraft location. At this time the only warning systems against aircraft attack were acoustic and visual. The acoustic system took the form of a huge ear-trumpet mounted on the coast to detect the sound of engines, and the visual system was the old-established one of a human observer equipped with binoculars. Both methods were patently very limited in range and tended to become less and less effective as the speed and numerical strength of

Robert Watson-Watt

air forces increased. Some better method, giving a much longer warning period, would be urgently needed in time of war.

In contrast to the more conventional continuous-wave technique in use for ionospheric research, Robert Watson-Watt had, between 1926 and 1931, been experimenting with sending out pulses of radio waves as a probe, and the idea came to him that, by using a cathode ray tube as a measuring device, the 'nuisance' echoes which were returning from an aircraft could be timed, and the distance of the aircraft from the ground station read off in miles from a scale on the cathode ray tube. The bearing of the aircraft could be obtained by applying direction-finding methods.

He immediately set to work on such a device as a side-line to his ionospheric investigations. It was indeed fortunate that he did so, for in 1935 came a critical and rather strange turning-point in his career. The British Government approached Watson-Watt with a request that he should invent a device which he did not consider possible. So he offered the Government his radiolocation system instead.

The Government were worried about the size and power of the German air force—the *Luftwaffe*—which at that time was numerically greatly superior to the Royal Air Force. They were afraid that, if war should break out, which seemed to be extremely probable, the *Luftwaffe* would attack Britain in great strength, and that the R.A.F. would be too weak to hold off the attacks. So Watson-Watt was asked whether he could devise some way to destroy the German aeroplanes in the air by means of radio waves.

Fantastic as this suggestion may sound today, many people —including a number of eminent scientists—believed at that time that there was a powerful radio wave called a 'death ray' that was capable of almost anything. Indeed, there were rumours that one or two countries in Europe had already discovered and actually used the death ray for several different purposes. It was reported from one country that this ray had been tested on a highway and that it had suddenly stopped all the engines of a long line of vehicles on a busy road. Far more alarming, a German scientist claimed that he had developed a ray which could kill people, destroy machines and devastate buildings; but this was only typical Nazi propaganda.

Robert Watson-Watt did not believe any of these reports and rumours. He told the Government that in his opinion no radio waves were powerful enough to destroy aeroplanes. But he expressed the belief that radio waves could be used for another purpose: to give notice when enemy aeroplanes were preparing to attack Britain. Watson-Watt believed that he could devise a radio instrument—radar—to keep a watch on the sky and give a continuous picture of the position and movement of all aircraft flying towards Britain. This picture would show the aeroplanes long before it was possible to see them from the English coast, and this would enable the R.A.F. to fly out to sea and try to drive back the *Luftwaffe* before they reached the coast.

Watson-Watt mentioned this idea quite casually in a sentence or two at the end of his letter; he did not really expect the Government to take much notice of his suggestion. However, the Government saw at once that radar might help to protect Britain against air attacks, and they immediately asked Watson-Watt for more information about his ideas.

Watson-Watt sat down, did some quick mathematics, and then drafted a short report, explaining how radar would work. He spent very little time on his report; he did not even trouble to make proper drawings. Surely no man can ever have written a report on such an important subject so quickly or with so little effort.

The Government, convinced that his ideas were practical, commissioned Watson-Watt to begin work on developing radar immediately, and appointed a small team of electrical engineers to assist him with his researches and experiments. The Government ordered the scientists to keep their work a close secret; they must not tell even their own families what they were doing.

So much was by now known about very short wireless waves—the basis of radar—that there was a danger that scientists in other countries might also start to experiment in this field. The Government were afraid that the German scientists, whom they greatly respected, might succeed in developing radar before the British scientists. It was a race between the British and the Germans.

Owing to this vital need for secrecy, Watson-Watt and his team went to the remote village of Orfordness, near the east coast of England, to conduct their experiments. Nobody took much notice of them at first, but people soon began to talk and ask questions when their research station was erected. 'What are they doing?' they asked one another. 'They must be searching for oil!' one man decided.

The scientists were amused. Then one evening, in an attempt to put the villagers off the scent, one of the party told a woman at their hotel: 'We are experimenting with death rays—radio waves that can stop cars!' He then added confidentially: 'This is a secret. So don't tell anyone else!' Of course, she told everyone she met. The people in the village believed the story and asked no more questions!

Watson-Watt and his team made very quick progress, producing a successful radar instrument after experimenting for only about five or six weeks. They fitted this instrument, with its transmitter and aerial, into a van, and drove to a lonely part of the countryside to test it. An aeroplane flew towards them from an aerodrome many miles away, and the engineers endeavoured to detect it with their radar. The radio waves hit the aeroplane at a distance of about seventeen miles, and simultaneously a small blip of light appeared on their screen.

The delighted men immediately tried to improve upon this result by increasing the range of detection; they also tried to work out some way to discover the height of the aeroplanes. For their first experiments they used a transmitter of very low power and an aerial only seventy feet high. They now built a much more powerful transmitter and increased the height of their aerial to over 200 feet. Their new equipment, which weighed many tons, gave them much better results. At their first attempt, the engineers tracked an aeroplane about thirty miles away; they then gradually extended this distance to forty, fifty and sixty miles. Finally, they tracked an aeroplane seventy-five miles away. By then they had also discovered a way to tell the heights of the aircraft.

Within the space of only four months Watson-Watt and his team had developed radar to a stage where it could be put to practical use in a war. The British Government ordered a chain of radar stations to be constructed without delay along the east and south coasts of England for the purpose of keeping a watch on the sky and giving early notice of aeroplanes flying towards England from Germany, or from any country in Europe which might fight on the side of Germany in a war.

While these stations were being built, Watson-Watt developed his system and produced a very small radar instrument, weighing only a few pounds, to fit into the cockpit of an aeroplane. The main purpose of this instrument was to help the R.A.F. pilots to detect German aircraft in the dark, if the *Luftwaffe* should attack Britain at night.

Some eighteen months or so before the Second World War the British Government had a scare. British agents in Europe reported that enormous radio aerials of a most unusual type were being erected in one or two places in Germany. These reports came as a great shock to the Government. Had the Germans also developed radar? This fear was always in their minds.

The Government determined to inquire forthwith into the purpose of these aerials, but they did not know whom they could trust to make these investigations. They did not dare to reveal the vital secret about radar even to their own agents. Finally, the Government decided to send Watson-Watt himself to Germany to make the inquiry.

Watson-Watt went to Germany with his wife. Posing as holiday-makers, they dressed in country clothes and went for long walks in the districts where the aerials had been built. They pretended to be interested in old churches. Whenever they came to a church with a high tower, Watson-Watt would climb to the top, take a small telescope out of his pocket and look across the fields, searching for the aerials.

He discovered the aerials, but came to the conclusion that they had no connection with radar. He believed that they belonged to a new sound radio station. But, in fact, they were radar aerials. Germany had also begun to experiment with radar, but her scientists had made very little progress, and had not yet produced any satisfactory radar equipment. The British scientists still had a long lead in the race.

In 1938, the year of the Munich crisis, the manufacture of radar instruments began on a large scale in Britain in preparation for war. This caused another problem. The Government could not tell the manufacturers what they were making in case they should give away the secret of radar. This meant that no one firm could make a complete instrument. Different parts of the instruments were made by different manufacturers, and these were then assembled in secret by scientists. The next task was to train men and women in the use of these instruments. This was also done in secret.

When the Second World War began, in September 1939, the east coast of Britain was well protected by radar. Here land radar stations could track aeroplanes as far as 100 miles away. Soon the R.A.F. had radar instruments in many of their fighter aircraft; the Army anti-aircraft units defending the shores of Britain were equipped with radar to help them to aim their guns; ships of the Royal Navy were also fitted with radar. Germany was still experimenting.

Radar was used for the first time in the Battle of Britain, in the summer of 1940. France had capitulated, and the British Army had been driven out of Europe. Germany had conquered practically the whole of Europe, but she still had to beat Britain to win the war. She tried to force Britain to surrender by attacking her from the air. The powerful *Luftwaffe*, then the strongest air force in the world, attacked Britain nearly every day over a period of several weeks. It did not seem possible for the weaker R.A.F. to give battle against such heavy odds. But Britain had radar.

Without radar, it would have been necessary for the R.A.F. to patrol the sky for German aeroplanes by day and night with never a break—and there were not enough machines or pilots to spare for this. But radar searched the sky and gave notice when an attack was imminent. The courageous R.A.F. pilots—the famous 'Few', as Winston Churchill called them—then 'scrambled' into their aeroplanes and flew out to sea to engage the enemy. With the help of radar the pilots were guided straight to the attackers, and, as a result, they were often able to shoot down the German machines before the Germans saw them. This gave the R.A.F. a great advantage which helped to make up for their inferiority in numbers. It was estimated that in good weather conditions one British aeroplane with radar assistance was equal to five German aeroplanes without, while in bad weather conditions it was equal to perhaps fifty.

On 15 September 1940 the *Luftwaffe* attacked Britain in immense strength—and were driven back with the loss of about 100 aircraft. After this crippling loss, the Germans changed their tactics and began to attack British towns and cities by night instead of by day. These night attacks, which continued for many months, killed thousands of people and destroyed thousands of buildings; the death and destruction were terrible. But still Britain was not beaten. Radar again helped to save her.

After the Battle of Britain was won, radar was used by the Allies in every major battle on land, at sea and in the air for the rest of the war. British and American ships equipped with radar were able to search for and often to destroy German warships and U-boats while the enemy ships were preparing to attack. An epic sea victory was the destruction of the famous German battleship *Scharnhorst* with the help of radar.

On 26 December 1943—Boxing Day—a number of British merchant ships were sailing in convoy in the icy Arctic Ocean with valuable war supplies for Russia, and the *Scharnhorst* was preparing to attack the convoy. If the *Scharnhorst* could get near enough to fire on them, she would almost certainly sink every merchant ship.

The merchant ships were unaware of their danger, but a Royal Naval patrol tracked the *Scharnhorst* on their radar screens just in time to prevent this disaster. Darkness had fallen, the sea was rough, and a strong wind was blowing. In the inky black the naval vessels followed the *Scharnhorst* with their radar for nearly four hours without actually sighting her. They still could not see the German battleship when they came within firing range. So the British ships trained their guns on her by radar—and scored several direct hits. The *Scharnhorst* fought back, but she was at a disadvantage, and after a short battle she was finally destroyed. The merchant ships, which were not even damaged, sailed on and delivered the war supplies to Russia.

Although the Germans succeeded in developing radar quite early in the war, they could not catch up with the British.

'We succeeded with radar too late, and that undoubtedly contributed to our defeat,' a German officer said after the war had ended.

Today radar—developed far beyond the wartime models—is used for many peaceful purposes all over the world. As we have seen in a previous chapter, modern ships of all nations carry radar to help them to sail safely in bad weather, when visibility is poor; and radar also helps to guide aeroplanes across the world. In many countries police use radar to check and control the speed of motor vehicles on roads carrying a speed limit.

Radar is used to forecast the weather, and to study the moon and the stars. Powerful radio-telescopes using radar techniques can find stars which are too distant to detect through an ordinary telescope. These radio-telescopes are also used to study the American and Russian scientific experiments in outer space. Scientists in Britain, America and Russia watch and report the progress of the manned satellites as they circle round the globe.

Almost every year some new use is found for radar.

8

Broadcasting to the World

While radar was of inestimable value for military purposes during the Second World War, sound radio likewise played an immensely important part on the home front, helping to keep up the morale, not only of the people of Britain, but also of all the countries occupied by the enemy or in danger of being over-run.

Television broadcasting closed down for the duration of the war because there was a grave danger of its strong signals being picked up by German bombers and helping to guide the *Luftwaffe* pilots to their targets in Britain. Similar dangers applied to a lesser degree in sound broadcasting, but there it was possible to overcome this problem by grouping several transmitters on one wavelength, thereby making it impossible for enemy aircraft to tune to any individual transmitter until they were almost within visual range. Thus, while television closed down, sound broadcasting continued to develop. The hours of broadcasting were greatly extended, and there was an all-round expansion of both the home and overseas services.

The B.B.C. played a vital role in the war, and the strictest precautions were taken from the outset against the risk of spies and saboteurs—'Fifth Columnists'—attempting to put transmitters and receivers out of action. Broadcasting House was guarded by squads of police by day and night, as were the many other buildings occupied by the B.B.C., and no one was admitted without a pass.

Elaborate emergency arrangements were also made to enable the B.B.C. to continue their services uninterrupted in the event of Broadcasting House being destroyed during the bombing of London. An old, disused railway shaft deep under the City of Bristol (headquarters of the West Region) was converted into an emergency broadcasting station—an immense feat of civil engineering. Engineers converted the shaft into a tunnel of four chambers, one above the other; and these four rooms, starting from the bottom level, were equipped respectively as a control room, recording room, studio, and transmitting room. There were also three smaller chambers near ground level. The tunnel was made immune from any form of aerial attack.

This remarkable emergency broadcasting station was manned day and night throughout the war, ready to take over at a moment's notice, but fortunately the need to bring it into operation never occurred. Broadcasting House received several direct hits during the air attacks on London, and on one occasion several members of the B.B.C. staff were killed, but the building survived the bombing with no interruption to the services.

The development of their overseas services, which had started in a small way in 1932, was perhaps the B.B.C.'s greatest contribution to the war effort. The B.B.C. broadcast special programmes to the British and Allied forces serving overseas, and built up a comprehensive news service for the people of the occupied countries.

Several times a day, at set hours, the B.B.C. broadcast news bulletins to the different countries in Europe—including to Germany and her ally, Italy—in their own languages; their accurate reporting of war news soon won the universal respect of all freedom-loving people, and the bitter hatred of the Nazi war leaders. The B.B.C. became the voice of freedom and a powerful weapon against the lying Nazi propaganda of the German Press and radio.

The German radio, under Nazi control, pursued a deliberate campaign of deceit, with the aim of instilling a general hatred of the British and their Allies, turning the people of Europe against their own leaders, spreading alarm, despondency, and panic. The Nazis twisted and distorted the news to their own advantage, grossly exaggerating every German victory and ignoring every setback. They told the most fantastic lies—sometimes reporting incidents that had never occurred—and they repeated these stories frequently on the principle that a lie oft-repeated may eventually be accepted as the truth.

The B.B.C. made it their policy always to present the true facts, however grave the situation might be, and in this way inspired immense confidence. The people of Europe, like the people of Britain, thrived on the truth and drew courage from these broadcasts from Britain. From time to time members of the Governments of German-occupied territories, who had come to London to continue the fight for freedom, took part in these broadcasts: they told their people how to conduct themselves during the Nazi occupation and promised them eventual liberation by the Allies. Naturally, this did much to bolster morale.

The Nazis tried to jam these broadcasts by radiating Morse signals, speech, music and various unpleasant noises on the same wavelength so as to make the programmes unintelligible to listeners in Europe, but without success. They made it a crime, punishable by imprisonment or death, to listen to the B.B.C. broadcasts. Immense risks were taken by these clandestine listeners in the occupied countries of Europe. Men and women of all ages risked their lives daily to hear the truth from the B.B.C. Crouching in dark cellars, shutting themselves up in the lavatory or bathroom, or in any other reasonably safe place, they listened on smuggled wireless sets while some members of the family or a friend kept watch for the approach of the secret police.

The news was passed on to their friends and neighbours who had no wireless sets. In many towns and villages of Europe organised listening groups printed and circulated news sheets. In Norway a vast group prepared a regular news sheet of several pages called the *Radio Post*, and a member of this group who later escaped to England gave a graphic description in a B.B.C. broadcast of how they set about this dangerous task.

'At this very hour,' this Norwegian told listeners in Britain 'the secret journalists are at their underground work. The day's work has finished on the farms and in the factories and offices. Now the more important part of the day has come. In a cellar somewhere in my snow-covered country a girl is crouching in front of a muffled loud-speaker taking shorthand notes of the B.B.C. news. In his lodgings a student is typing the stencils for tomorrow's *Radio Post*. In a boat-house a young factory worker turns the handle of the duplicator. In a deserted office three young clerks are pinning the sheets together, folding the finished papers, and putting them into envelopes. Or they may be walking the streets and roads in the black-out, dropping envelopes into pillar-boxes, or delivering small bundles of papers at houses as they go along. Hundreds and hundreds of people are at work just now, producing and distributing the illegal papers in my country, and before midday tomorrow their duplicated papers, bringing the latest war news, will have covered the greater part of Norway.'

In 1941 the B.B.C., in addition to broadcasting the news, began to incite the people of Europe to bait their German oppressors by starting the famous 'V for Victory' campaign. Since V is the initial letter of the word meaning Victory in most European languages, a Belgian working for the B.B.C. suggested that this letter be adopted as a symbol of freedom —a 'rallying emblem' for all true patriots—and in a broadcast to Belgium launching the campaign he urged the Belgians to chalk up Vs all over the country as a sign that one day Belgium would rise again.

Next day, as if by magic, rudely chalked V signs mysteriously appeared on walls, pavements, lamps and trees in every town and village of Belgium. Like a forest fire, the campaign quickly spread throughout Europe.

The B.B.C. now made a practice of opening their broadcasts to Europe with a signature tune comprising the three dots and single dash of the Morse signal for V · · · — . Very often they played the opening bars of Beethoven's Fifth Symphony, in which the rhythm of the music seems to take the form of the V sign repeated · · · — · · · — . As most Germans regard Beethoven as their greatest composer this insult to their pride infuriated the Nazis.

It was from the ranks of this V Army, rallied by radio from London, that the great underground Resistance movements of Europe were recruited. Long before D-Day—the day for the return of the Allied armies to liberate Europe from the Nazis—passive resistance gave way to active resistance.

Plans were carefully prepared by Resistance headquarters in London in collaboration with the fighting services, and streams of instructions were broadcast from London to individual groups of Resistance workers in the different countries, telling them to blow up arms dumps, mine bridges and roads, set booby traps, and perform various other acts

Alexandra Palace.

A television studio.

of sabotage. These instructions were broadcast daily at appointed hours in the form of pre-arranged coded messages which would be quite unintelligible to the Germans.

This was a two-way service. Every Resistance group had a wireless operator with a portable transmitter whose job was to maintain radio contact with the B.B.C. and send back reports for Resistance headquarters in London. When a mission was successfully completed, when anything went wrong and fresh instructions were required, or when new information was gleaned concerning German troop movements, the radio operator of the group would conceal himself in an attic, a country barn, or some other hiding place reasonably safe from the dreaded Gestapo, and transmit a message to London.

By their many acts of bravery, the Resistance workers of Europe paved the way for the liberation of their countries. And all this was brought about with the help of radio.

Since the war all the great nations have steadily expanded their overseas services until today the radio network covers the entire world. Britain, America, Russia and several other nations broadcast regular services to numerous foreign countries in many different languages. Their programmes go out across the world by day and night.

Every twenty-four hours, day in and day out, the B.B.C. broadcast to widely scattered parts of the world in English and in about forty foreign languages. All these foreign broadcasts are sent out from Bush House, a large building lying between the Strand and the Aldwych, scarcely more than a stone's throw from the cramped little studio with the faded green carpet from which the B.B.C. made their first broadcasts in 1922.

There is a strangely cosmopolitan atmosphere about Bush

House, with men and women from nearly every corner of the globe housed under the one roof. They are there to work on the programmes for their own particular countries. They produce a large number of the programmes, and they undertake all the broadcasting in the foreign languages. The French at Bush House broadcast to France; the Germans to Germany; the Israelis to Israel; and the Arabs to the Arab countries of the Middle East. Japanese broadcast to Japan, and Indians to India. Exiles from Russia, China and other countries in the Communist bloc broadcast to the countries behind the Iron Curtain. The programmes in English are, of course, produced by British producers, and they also supervise many of the foreign programmes.

The programmes from Bush House cover a wide field—news bulletins, talks on numerous subjects, music and recordings of some of the popular programmes previously broadcast in the home services. The news is drawn from the leading news agencies of the world, from the B.B.C. monitoring organisation which listens to and summarises the world's broadcasts, and from the despatches of the B.B.C.'s own reporters and correspondents, stationed in various countries.

The Communist countries, like the Nazis during the war, dislike their people listening to the broadcasts from Britain and America as they are afraid that these programmes about the British and American ways of life, so much freer than their own, may make them discontented. For a very long time the countries behind the Iron Curtain made a practice of jamming programmes to make them unintelligible. Many Communist countries still do this, but recently Russia has called a truce in this 'radio war', and it is to be hoped that before long others will follow suit.

People all over the world listen to the broadcasts from Britain, America and Russia, and also from others countries, every day. Rich men in homes as grand as palaces listen-in on expensive radio sets. Poor men in dirty villages of mud huts, who cannot read a newspaper, tune-in on cheap transistor sets to hear what is happening in the world. Men camping in tents in the bleak deserts of North Africa listen to the news bulletins from their own countries, and then often tune-in to London to check the truth of what they heard. All have learnt to respect the voice of the B.B.C.

From time to time B.B.C. films and telerecordings of television programmes—which started up again a year after the end of the war—are now also sent out to some foreign countries; and this side is likely to expand considerably in the next few years.

9

Television Today

At 3 o'clock on the afternoon of 7 June 1946 a woman announcer, Jasmine Bligh, walked towards an Emitron camera on the terrace of Alexandra Palace, smiled into the lens, and made the first television announcement in Britain for nearly seven years. She introduced the Postmaster-General, who, in a simple inaugural ceremony, briefly outlined the great technical developments since pre-war days and confidentally predicted a bright future for television in the years ahead—a prediction that has since been justified in full measure.

The following afternoon the B.B.C. Television Service reopened in glory by televising the great Victory Parade in St James's Park in London. Television cameras were mounted on a stand in The Mall, and viewers in their homes saw on their television screens every phase of the ceremony. They saw the arrival of King George VI and Queen Elizabeth; and they watched the long procession of service men and women, and representatives of the many civilian bodies that had played a part in bringing about this great victory, march past the saluting base. They even had a view of part of the fly-past overhead by aircraft of the R.A.F., some of which were piloted by survivors of the gallant 'Few' who, with the help of radar, had won the Battle of Britain in the darkest days of the war.

Since only about 7,500 people possessed a television set, the ceremony was watched by probably no more than 25,000 to 30,000 viewers at the most. But they were delighted by the performance, and many of the viewers who had watched the ceremony on their friends' sets afterwards went out and bought sets of their own.

And so the public interest in television began to grow. By the end of that year, 1946, the number of people in possession of television sets had risen to 30,000, and within five years, by 1951, the number had topped a million.

Then came the Coronation of Queen Elizabeth II, on 2 June 1953. The B.B.C. televised this historic event almost in its entirety—the processions along the route to Westminster Abbey of royalty, cabinet ministers and other dignitaries, and of foreign kings, queens and heads of state; the panorama in the Abbey while the arrival of the Queen was awaited; the crowning of the Queen; her return in splendour to Buckingham Palace in a glass coach, wearing her robes and crown and holding the sceptre; and all the rest of the glorious pageantry. This television performance, by far the grandest ever attempted, was superb throughout.

Some 20,000,000 people watched the ceremony on television. Viewing parties were held in private houses with an average of seven people clustering round each set. Many people who had no television set hired one for the occasion. Others bought tickets and watched the event on television screens set up in hotels, clubs, cinemas, shops, offices and other public places. A large number of the viewers had never seen television before, but the great majority were now intrigued by it.

From that day popular enthusiasm for television mounted rapidly, the number of licence holders increasing at the rate of about a million a year. Television aerials began to sprout from the roofs of the humblest homes—and some people who could not afford to buy or rent a television set stuck up an aerial none the less, so as to 'keep up with the Joneses'!

During the 1950s work began on the construction, at a cost of £12,000,000, of a new television centre for the B.B.C. at the White City. An enormous seven-tiered circular building, shaped rather like a wedding cake, this is now the largest television centre in Europe and the most up-to-date in the world. It is from this building, not yet completed when this book was written, that most of the B.B.C. television programmes from London are now transmitted—a great contrast to the cramped room in the basement of Broadcasting House where the programmes of pre-war days were broadcast.

But the B.B.C. no longer has the monopoly in television. In 1955 the Independent Television Authority was set up to provide commercial television—programmes produced by a number of 'contracting companies' who draw their revenue by inserting in their programmes advertisements for which high fees are charged. Although this periodic interruption of a programme to advertise different brands of soap, chocolates and other commodities irritates some viewers, the I.T.A., whose headquarters are in Kingsway, London, today commands a vast and ever-growing audience.

The B.B.C. and I.T.A. operate in close competition, with each trying to capture the largest audience. Television is continually expanding. In 1964 the B.B.C. opened a second television channel—B.B.C.2. The next development will probably be the introduction of colour television. For many years research teams have been engaged in working out techniques for producing television pictures in faithful colours. Now, at last, they have achieved the results they were aiming for, and colour television is likely to be introduced in the near future. Indeed, a start has already been made by one or two American broadcasting companies.

Today well over 15,000,000 people in Britain own or rent a television set, and the number of viewers is probably three or four times that number. Although most viewers watch television in moderation, this medium of entertainment practically rules the home life of many families. They never go out in the evenings, and their friends scarcely ever dare to drop in.

Let us now go behind the scenes and see how a television programme—say, a play—is produced and broadcast. A television play, running for an hour and a half, usually takes about a month to six weeks to produce, and a large team of men and women, experts in various fields, will be involved in the production.

After a television script has been prepared by a script-writer and a producer for the play selected, a sum of money is allocated for the production. The amount will be governed by the type and length of the play, the quality and number of the cast, the length of time likely to be needed for rehearsals, whether any filming will be required, and by various other factors. The cost of producing a play varies considerably. An average figure is about £5,000 for a 75-minute play, but a major production might well be greatly in excess of this sum.

When the producer knows how much money he may spend, he holds a 'planning meeting' with various departments concerned in the production and works out how to obtain the best results. After formulating a general scheme, the producer, who can apportion the money in any way he pleases, discusses with the designer the scenery arrangements.

The designer studies the script carefully, forms a mental picture of the type of scenery best suited to the production, and makes a series of sketches of the sets that he feels should be included. He calculates the approximate cost of constructing and painting such scenery and submits his sketches to the producer for his approval.

The scenery suggested may cost more than the producer feels justified in spending out of his financial allocation. In which case he may decide to dispense with one or two of the sets and to substitute 'back-projections'—life-size pictures which are thrown on to a back-cloth behind the stage by means of enormous lanterns. If the play is set out of doors as well as indoors, the producer will have to decide whether to go to the expense of having the exterior scenes filmed instead of constructing sets. These and many other points will be discussed by the producer and designer.

The designs, when finally approved, are reproduced life-size by scenic artists, who then pass on their paintings to skilled carpenters to construct the sets in plywood. The sets are built in sections, and as each set is finished it is painted and decorated by the artists. Finally, the completed scenery is transported to the television studios.

The designer, meanwhile, makes a 'property plot' of the furniture and fitments required, and property men search for the necessary articles from various sources. The B.B.C. has a vast 'prop store' which supplies nearly 200,000 props a year for their television plays. Even so, they cannot always supply all needs, and the property men may have to go round the bric-à-brac shops to unearth some of the more unusual items.

Meanwhile, the producer will have held auditions with actors and actresses and done his casting.

As soon as he has selected his artists, he visits the wardrobe department and makes arrangements about the costumes to be worn—another matter requiring a great deal of thought and discussion. The women's dresses must both suit their figures and tone with the scenery, and, although the pictures will be in monochrome, care must be taken to avoid introducing colours that become either insipid or too brilliant when photographed. The television camera is unsympathetic to bright reds, for example, and the contrast between black and pure white is likewise too startling. If the actors are to wear evening dress, their white shirts must be dusted with a light buff powder to reduce the dazzle.

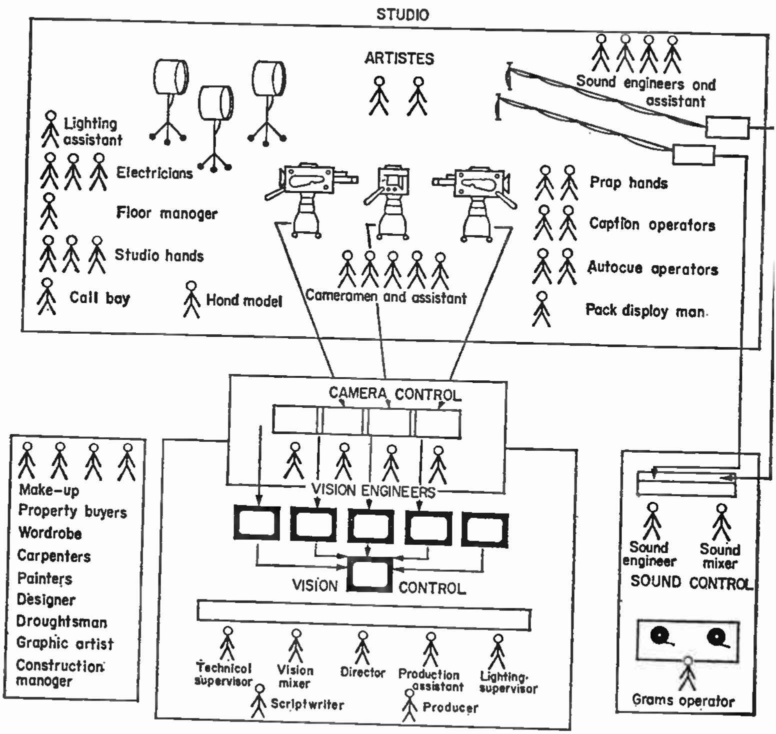
When these details have been settled, the wardrobe department sets to work on the costumes, and the producer proceeds to introduce the actors and actresses to their parts by holding informal 'script readings' at which the cast sit together round a table and read their parts aloud without attempting to act them. In this friendly way, they gradually become familiar with their lines and begin to develop a unity.

Rehearsals now begin. The first rehearsals are held in a bare room—usually a drill hall or an old church hall—with no scenery or cameras. The floor is marked with numerous chalk lines and squiggles to denote where the scenery and furniture ought to be.

These early rehearsals almost invariably reveal a number of weaknesses in the script. A line that appeared witty when read may sound neither clever nor funny when acted. Or an actor may find difficulty in laying the correct emphasis on certain words when he has to synchronise those words with a dramatic or awkward movement across the stage. All kinds of snags may crop up. The producer endeavours to iron out these problems by holding 'editing sessions' with the cast during these rehearsals. He will re-word lines that have not come over well, delete entire passages that have been badly 'fluffed', and perhaps slightly alter the timing here and there.

Sometimes a producer has to be quite ruthless with a script.

After rehearsing for perhaps five days a week for two or three weeks in a bare, uninspiring room, full-scale rehearsals with scenery and cameras are held in a studio.



The organisation of a television studio

A television studio is designed on the same principle as a studio for sound broadcasting, although it is very much larger proportionately and far more elaborately equipped. Overlooking the studio is a large sound-proof 'control gallery' with glass windows, which is equipped with a series of television screens and a mass of complicated electronic apparatus controlled by switches. From this gallery the producer and his team control the performance and send out the pictures to the network for transmission.

Three, four, or perhaps as many as six cameras may be used to televise a play. These cameras are equipped with lenses to give different angles of vision, and some are mounted on mobile platforms with rubber-tyred wheels, called 'dollies', which move silently across the studio floor, swivelling this way and that. Each camera bears a number, and the producer is able to address the cameramen during a performance, without his words being picked up by the microphone, by means of an 'intercom' system. The producer may instruct the operator of the second camera to move to the left if he is not quite happy about his picture composition. 'Two, pan left,' he will say.

All the cameras, whatever the number, are in continuous operation throughout the performance. If, for example, there are four cameras in use, all four will be taking photographs from different positions in the studio simultaneously. But, of course, only one out of the four pictures taken at any one time will actually be transmitted. The picture for transmission is selected by the producer, and this is done by means of the television screens in the control gallery.

Each camera is linked to a screen bearing a corresponding number. As the play is televised, the output from the four cameras appears on their respective screens. The producer watches the four screens continuously with a critical eye and selects the most suitable picture for transmission. This is then thrown on to another screen by a member of the team known as the 'vision-mixer', and it is this picture which is transmitted.

The shots to be taken by the cameramen are pre-arranged by the producer during rehearsals. A special camera script is prepared outlining each scene to the cameramen, giving them an approximate idea of the placing of their cameras and the type of shots to be taken—whether, for example, pictures in a particular scene are to be close-ups or long-shots, and so on. Thus, when they move into the studio for rehearsals, each cameraman will have some idea of what is required of him. The producer will then hold a special rehearsal for the benefit of the cameramen at which the camera script will either be agreed as it stands or adjusted as necessary.

The studio itself is in the charge of a 'production assistant', and throughout the play the producer will be in constant communication with him by 'intercom,' issuing any directions that may be necessary for the improvement of the performance. From time to time the producer may request the production assistant to give some instruction to an actor or actress in a way that can be neither seen nor heard by the viewers.

The production assistant is responsible for all the studio arrangements from the moment the first rehearsals are held in the studio. He supervises the erection of the scenery, the dressing of the stage, the positioning of lights and microphones, the arrangements for incidental music and sound effects, and many other vitally important details. It is his job to see that the producer's ideas and wishes are executed in the studio in as efficient, practical and artistic a manner as possible.

At last, after weeks of preparation, the time arrives for the play to go on the air. The set for the first scene is dressed and lit. The artists to make the first appearance are in position on the set and the others are standing by. The cameras are poised. Dressers, make-up girls, property men, stage hands, firemen and various technicians are in attendance. There may be as many as twenty or thirty people, apart from the actors and actresses, on the studio floor. The floor itself is strewn with cables and a mass of other paraphernalia, and from all corners, it seems, lights shine forth and microphones dangle.

The producer has a final word with his production assistant and then climbs the steel steps to the sound-proof control gallery from which he will direct the performance with his team of assistants.

A red light in the studio flickers, and the production assistant calls for silence. Immediately there is a deathly hush. A few seconds later two signs light up to denote that the studio is connected to the network—'Sound On—Vision On'. The producer instructs the production assistant over the 'intercom' to 'cue artists'—and the play begins.

As the play proceeds, the cameramen swivel their cameras silently around the studio floor shooting their pictures, now moving in for a close-up and then withdrawing again, panning to the left and then panning to the right, and periodically changing their lenses. In the course of the performance the cameramen will take thousands of shots, and, as they are taken, they simultaneously appear on the screens in the control gallery.

The producer selects the sequence for transmission in the way already described. He dodges from camera to camera selecting the most suitable shots; and, if the outdoor scenes have been filmed, he will also have to bring in the film on the 'telecinė' at the appropriate places.

Farther along the gallery sound engineers control the volume of voice reproduction. Electricians control the lights. 'Gram-players' bring in the incidental music and sound effects.

And away in another part of the building, some distance from the studio, the engineers on the network transmit the programme. As the separate electrical impulses for sound and vision are received at the transmitting station from the studio control gallery, the two sets of signals are monitored, amplified, groomed and controlled by passing them through a series of electronic devices collectively known as the 'programme input equipment'.

The sound and vision signals are then transmitted along separate paths on slightly different radio frequencies to a special unit, where they are combined and fed to a common aerial system to be thrown out through space.

A small portion of these signals from this composite waveform is picked up by the domestic television aerial and fed into the receiver. The sound and vision electrical impulses are disentangled and reconstituted, the light signals being fed to the cathode ray tube behind the television screen and the sound signals being amplified and fed to the loud-speaker.

And so, by a highly complex process, the television play is brought to the viewer.

Outside television programmes are broadcast on the same lines as a studio production. Mobile units with three or more cameras are employed, and special vehicles, equipped with the same series of screens and other technical apparatus, contain the producer's control room. The pictures are fed through this mobile control room and sent by radio or special cables to a main transmitting station, whence they are relayed to viewers in their homes.

In recent years great developments have been taking place in a different field of television: closed-circuit television. In this system the range is restricted to a limited area—perhaps to a building or a ship—and a cable is used for transmission.

Closed-circuit television is used as a visual aid. It is used extensively in industry for inspection and research purposes: indeed, it is often referred to as 'industrial television'. In the aircraft industry, for example, television cameras are employed to detect faults in aircraft in concealed places which the human eye cannot probe. Tyre manufacturers use these cameras to watch certain dangerous tests where it would not be safe for people to be present. Closed-circuit television is used in teaching hospitals to give medical students a close-up view of surgical operations. It is also used in medicine for diagnostic purposes: before performing an abdominal operation, a surgeon may decide to study the functioning of his patient's stomach with a television camera. Closed-circuit television cameras are often sited inside nuclear reactors to enable scientists to study activities which they coud not witness in any other way.

The system is used for sundry purposes, and the field is expanding every year.

10

Telstar

Now experimental satellites for television and radio communications are in orbit in outer space—a revolutionary development which began with the launching of the satellite Telstar from Cape Canaveral (now Cape Kennedy), in America, in the summer of 1962.

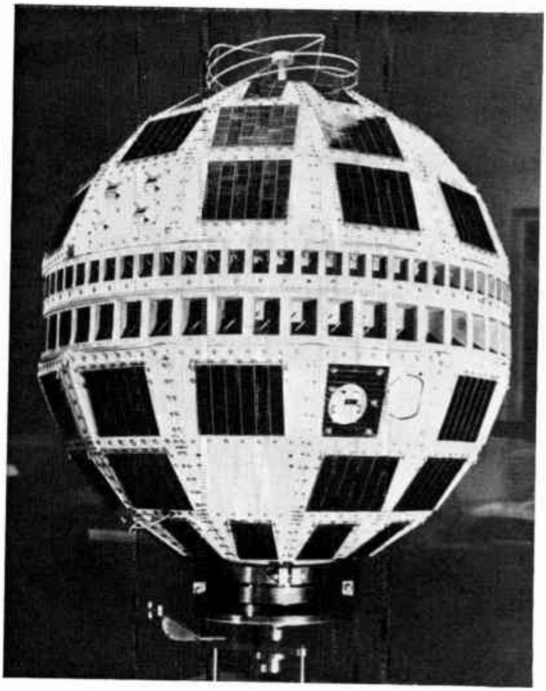
There are two main types of satellite: 'active' and 'passive'. An active satellite is a small but highly complex piece of electronic equipment which, on its journey through space, receives signals from the ground, amplifies them, and then re-transmits these signals to land receiving stations, which may be hundreds or thousands of miles away in different parts of the world. A passive satellite is of very much simpler construction and merely acts as a reflector for bouncing signals back to earth. It is the active satellite on which the present experiments are concentrated.

Telstar, the first active satellite, is a little under thirty-five inches in diameter and weighs no more than 170 pounds, but contains over 15,000 electronic parts, including more than 1,000 transistors. Mounted on the surface of the sphere are 3,600 solar cells and batteries which convert sunlight into electricity to provide the power for the electronic equipment.

Although an active satellite contains such a vast number of components, its system of operation is really quite simple. Telstar circles the earth at a speed of 15,000 miles an hour in an elliptical path, its nearest distance from the earth at any one time being about 500 miles and its greatest distance

An outside broadcast: the Tall Ships' Race.

Colour television experiments.



Above: Telstar. *Below:* Telstar model.

about 3,000 to 3,500 miles. On its journey it sends out tracking signals to enable the ground stations to follow its course. These ground stations are equipped with a mass of highly complex radio and electronic equipment, and the tracking, transmitting and receiving operations are performed from a central control building similar in character to the control centre of an airport. So highly developed is the system that if a fault occurs while a satellite is in flight it may be possible in certain conditions to correct it from the ground.

Engineers at the transmitting station track the satellite and send out signals by means of a narrow beam, only a fifth of a degree in width, in a massive radio-telescope aerial, which can also be used for receiving signals; because of the narrowness of this beam, the aerial has to be pointed at the satellite with absolute precision.

Signals sent out to Telstar for re-transmission reach the satellite when it is in the region of 2,000 to 3,000 miles out in space. Owing to the immense distance, the signals, when received, are very weak, but they are immediately amplified by the electronic equipment. As the signals are received from the ground, the solar cells capture the energy of the sun and feed power to the batteries, and the satellite amplifies the signals ten million times and re-transmits them back to the ground.

Engineers at the receiving station track the satellite with a similar beam and pick up the signals in a large collecting area of their enormous aerial. By the time they reach the receiving station the signals, having travelled a similar immense distance on their return to earth, are again very weak. So they are amplified once more. Finally, the signals are relayed to the networks—to the networks of the B.B.C. and I.T.V. in the case of Britain—and the television programme, carried by the satellite, is re-broadcast to viewers at home simultaneously with the broadcast in the country where the actual performance is being televised.

Telstar was designed purely for experimental purposes—to test the feasibility of using satellites for television and radio communications, to explore the advantages and disadvantages of such a system, and to glean information for future technical developments in this field. The satellite was developed and constructed in America by the Bell Telephone Laboratories. Years of research and experiment went into the project, and before the satellite was launched it was subjected to a long series of laboratory tests in a thermal-vacuum chamber which scientifically simulates conditions in space. Meanwhile, ground stations for transmitting and receiving the signals were built in America, Britain and France.

The Americans built their station at Andover, Maine, where they erected an enormous horn-shaped aerial, 177 feet long with an aperture sixty feet square. This vast aerial runs on circular tracks for elevation adjustment, and is mounted in a pressurised radome resembling a gigantic bubble to give protection against wind, snow and ice. It cost the Americans about £2,000,000 to build their ground station.

The French built their station at Lannion, in Brittany, and adopted an aerial system of similar design.

The site selected for the British ground station was the Goonhilly Downs, a wild stretch of moorland on the Lizard Peninsula, in Cornwall, only a few miles from Poldhu, scene of the first trans-Atlantic experiments with wireless telegraphy little more than sixty years before. Here, at a cost of about £800,000, engineers of the G.P.O. erected a huge dish-shaped aerial of their own design, some eighty-five feet in diameter. This aerial, which can be rotated and tilted to different angles, is connected by a mass of cables in a conduit to a central control building and is operated from a panel of dials and switches mounted under an observation window in the control tower.

The Telstar tests, conducted across the Atlantic Ocean, had to be timed very carefully. A satellite can only pick up and re-transmit signals when it is within the line of sight of both ground stations—the transmitting and receiving stations—at the same time. Telstar, speeding over the Atlantic at a height of between 2,000 and 3,000 miles and at a velocity of about 15,000 miles an hour, came within range of the American ground station at Andover and of the British and French ground stations in Europe for a period varying from about twenty to thirty minutes during a circuit round the globe. The satellite normally took about three hours to complete a circuit; it then reappeared over the Atlantic for another twenty to thirty minutes, and was lost again. Thus, all the tests had to be conducted in these brief periods, and the position was complicated by the fact that the satellite was not visible on every circuit.

The first series of tests with Telstar began on 12 July 1962, when, for the first time in history attempts were made to carry live television programmes across the Atlantic, in both directions, between the continents of America and Europe by means of a satellite. The experiments aroused world-wide interest.

On the morning of 10 July Telstar was launched from Cape Canaveral in the nose of a Thor-Delta rocket. The rocket roared up into the sky, and a few minutes later Telstar was hurled into an elliptical orbit round the earth exactly according to plan.

For most of that day Telstar circled round the southern hemisphere out of the line of sight, and the engineers at the

American, British and French ground stations spent their time checking and testing their complex radio and electronic equipment—making sure that their transmitters could run up to full power, that their receivers were functioning properly, that their massive aerials were tracking correctly, and that everything was in perfect working order and in complete readiness for 'the great night'.

In the evening of 10 July, about twelve hours after the launching, Telstar appeared over the Atlantic, and the Americans at Andover made an initial engineering test by transmitting some television signals to the satellite. The engineers at the British ground station at Goonhilly then attempted to track Telstar and pick up these signals. It took them some time to establish contact with the satellite, and when eventually they succeeded in this the signals they received were very weak and the pictures extremely poor—badly broken up and quite unrecognizable. The disappointment of the engineers was acute.

By now Telstar had passed out of range. So the engineers at the American and British stations waited until the early hours of the morning and repeated the experiment on Telstar's next passage over the Atlantic. This time the signals received were a little stronger, but the pictures were still miserably poor in quality. Something was obviously wrong.

The engineers at Goonhilly spent the rest of the night and the greater part of the following day investigating the trouble. After an intensive investigation they came to the conclusion that the fault lay in the aerial, and they set to work making various adjustments. They completed these at about five o'clock in the evening and then waited anxiously for Telstar's next circuit to see if the troubles had been remedied.

The experiment was repeated yet again, and this test was a complete success; a strong signal and a good picture were received at Goonhilly. Intense was the relief of the engineers at Goonhilly when they saw the picture of a man from the other side of the Atlantic appear in clear detail on their monitoring screens. It was also a moment of triumph, for, although this was only a preliminary test, they had received the first television pictures ever to be carried by a satellite.

The following evening, 12 July, the first public tests began. These were conducted in two parts. On the first circuit of Telstar live television programmes from America were transmitted to Europe, with the French station at Lannion acting as the receiving station. On the second circuit television programmes from Europe were transmitted to America by the British ground station at Goonhilly.

Shortly before eight o'clock by British Summer Time the American engineers at Andover established contact with Telstar and proceeded to transmit the first television pictures from America, and the French engineers at Lannion endeavoured to pick up the signals from the satellite and relay the pictures to the television networks of the European countries.

In sixteen countries of Europe an audience totalling some 200,000,000 people sat facing their television screens, watching and waiting. There were a few minutes of agonising tension when nothing seemed to be going right. A commentator appeared on the screen, but although his mouth opened and closed no words came. Several weird things happened. At two minutes to eight a shadowy picture of the Statue of Liberty, in New York, flickered to one side of the screen—and then suddenly the picture brightened, and from that moment everything went with a swing.

Viewers in Europe first saw part of a baseball match in Chicago. From there the scene quickly shifted to the White House, in Washington, where the late President Kennedy was holding a Press conference to inaugurate this historic broadcast. Next came scenes and interviews from Cape Canaveral where Telstar was launched. There then followed a rapid succession of television pictures showing life in many different parts of the American continent—festivities in Quebec, and glimpses of a performance of *Macbeth* at Stratford, Ontario; pictures of the World Fair at Seattle; scenes from the United Nations building in New York; views of the Niagara Falls. . . . Finally, just before Telstar finished its circuit, viewers were brought back to the Statue of Liberty.

The broadcast lasted exactly eighteen minutes, and, although from time to time the pictures momentarily broke up into a kaleidoscopic pattern and there were interfering noises, the quality of both pictures and sound was in the main very good. Most of the countries of Europe reported excellent reception.

Shortly before eleven o'clock, on Telstar's next circuit, the second part of the evening's tests began. Opening with a picture of Big Ben and various scenes from London, television pictures from nine European countries were linked together in a composite programme and were transmitted to America by the British ground station at Goonhilly. This programme, which was seen in millions of American homes in all parts of that vast continent, was probably the most difficult ever handled, but the results were excellent. The only disappointment was that the broadcast was cut short by a minute or two because Telstar went out of range before the programme was completed. Never before had it been possible to broadcast a television programme live on both sides of the Atlantic simultaneously.

These and subsequent tests opened up a new field for the future, proving that satellites have an important part to play, not only in television, but also, and more important, in radio-telephonic and radio-telegraphic communications. As later tests have shown, a satellite that can carry television pictures may equally well be able to carry telephone calls, telegrams and teleprinter messages. On its circuit over the Atlantic Telstar might well be capable of handling as many as 600 telephone calls and an even greater number of telegraphic messages between the continents of Europe and America.

A satellite system of radio-telephonic and radio-telegraphic communications embracing the world, to supplement the inadequate land and submarine systems at present in use, would be of immense benefit to every country. How can scientists and engineers achieve this?

The question of how best to use satellites for communications purposes is a difficult one, involving many factors, not least of which is cost. Two problems which have to be resolved are the choice of the orbital path—whether it should be elliptical or circular—and the height at which the vehicle should be in orbit—on this question there is considerable controversy.

Height is a critical factor because the physical laws which determine the behaviour of electro-magnetic waves demand that an optical path must simultaneously exist between each of the ground stations and the satellite before communication can take place. This is what the communications engineer terms the 'line of sight' conditions, already referred to (page 103).

A satellite in orbit at a height of 6,500 miles remains within the line of sight for a much longer period than a satellite such as Telstar, circuiting at 3,000 miles; it stays within range for about two hours. A satellite in orbit at a height of 12,500 miles could be used for communications for about four and a half hours, as against Telstar's twenty to thirty minutes.

The nearer the satellite is to the earth, the shorter must the distance be between the ground stations, and the shorter the time interval during which both are in line of sight with the vehicle. The between-stations distance must be shorter because the curvature of the earth limits the line of sight path; the time interval is shorter because the nearer the satellite is to the earth the more orbits it must do in a given time in order to maintain its position in space. It follows from this that, in order to provide a 24-hours communication service between the ground stations, a number of low-altitude satellites would have to travel in procession. This is one suggestion which is under consideration.

Another possibility might be to arrange for a satellite to be in orbit at a very great height so that ground stations over half the earth's hemisphere could 'see' it simultaneously. By this system two or three satellites could effectively cover the world. This might appear to be an easy solution, but, in fact, it is not so simple as it sounds. The cost of putting such satellites into orbit would be extremely high, not only from the launching aspect, but because higher-power transmitters would be necessary in the space vehicles on account of the greater path length. The reason for this is that the signals pass through the earth's atmosphere which is liable to play tricks with the signals and to introduce losses in strength which can be quite severe. Then again, the long distances involved in the transmission make the time delay quite significant, and this would have the effect of causing pauses in telephone conversations. There are numbers of technical difficulties.

Yet another scheme is to put a satellite in orbit at a height of about 23,000 miles. At this height, if the orbit is an equatorial one, the satellite's speed is such that it keeps station over a given part of the earth's surface. That is to say, it is permanently within the line of sight; it does not disappear over the horizon like the low-altitude satellites, and so is always available.

Many orbits and different types of satellite have been proposed. There are numerous possibilities, but they all have various technical advantages and disadvantages which must be thoroughly explored by the space experts and telephone engineers before there can be a final assessment of the the most suitable satellite and orbit for a permanent communications system.

The satellite tests are likely to continue for a long time.

Meanwhile, other countries in addition to America, Britain and France are beginning to play a part in these tests. Ground stations for transmitting and receiving signals to and from the satellites have been built or are in the course of construction in a number of countries in different parts of the world. An international pattern is gradually emerging.

Eventually the scientists will have gleaned all the information they require, and there can be little doubt that one day, perhaps by the early 1970s, there will be a world network of satellites for television and radio communications in orbit in outer space.

* * * *

Since this book went to press an experimental high-altitude satellite, Early Bird, has been launched and has taken the place of Telstar, although the latter is still in flight. A very much larger satellite, Early Bird, which was launched in 1965, has 600 cells. It hovers above the Atlantic at a height of 22,300 miles and is within the line of sight of the American and European ground stations simultaneously throughout the twenty-four hours. It can thus be used at any time and for as long a period as may be required—a great advantage over Telstar's periods in range of only twenty to thirty minutes.

But Early Bird is still only an experimental satellite. The tests continue, and probably another satellite will be launched before long.

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