BBC TELEVISION

A BRITISH

ENGINEERING

ACHIEVEMENT

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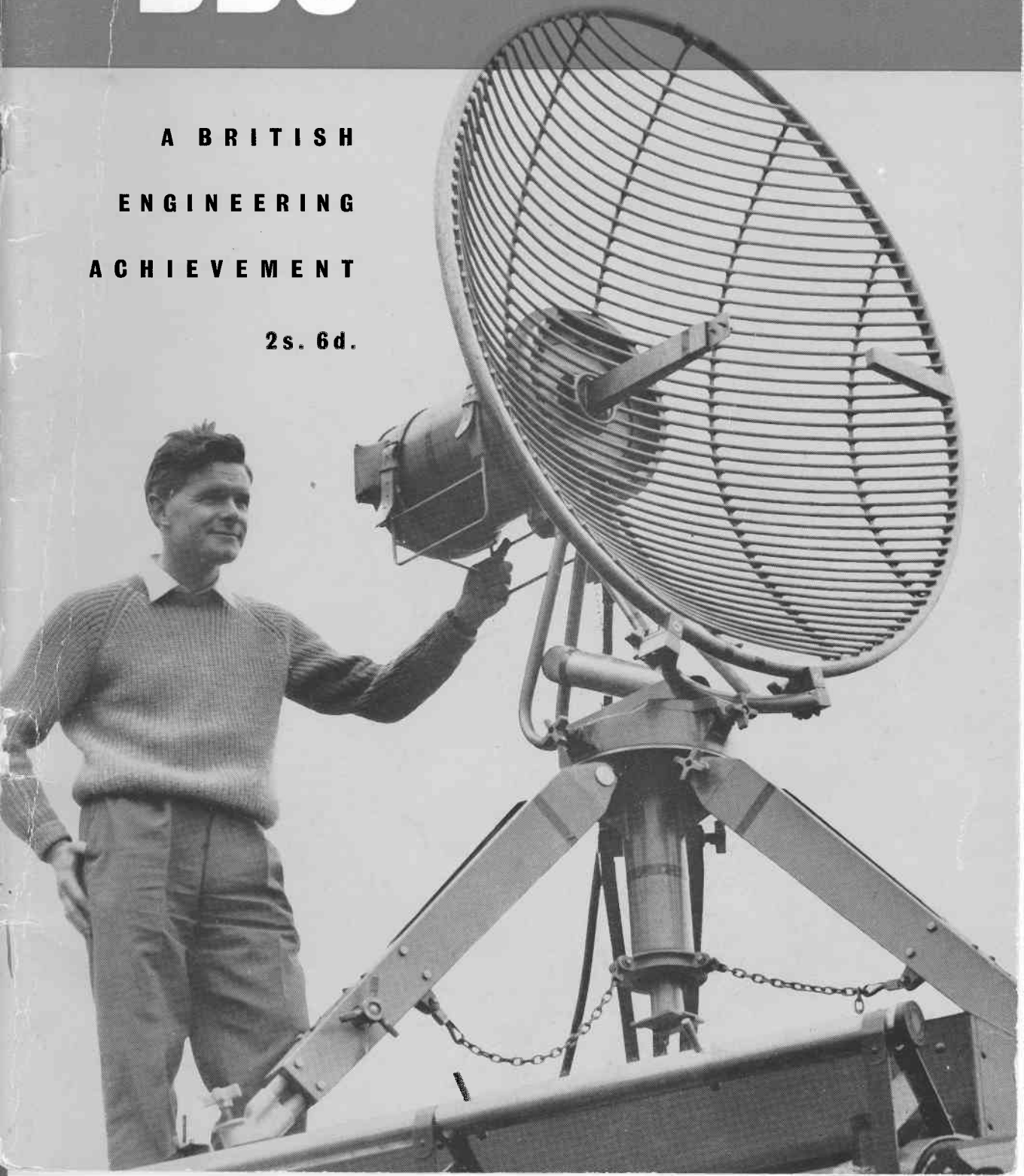

BBC TELEVISION

A British Engineering Achievement

1958

THE BRITISH BROADCASTING CORPORATION

The First Twenty-one Years

In 1957 THE BBC TELEVISION SERVICE celebrated its coming of age.

It was on 2 November 1936 that the world's first regular public service of high-definition television programmes was launched—BBC television from Alexandra Palace in London. The BBC is proud to have been the world pioneer in this field.

In this booklet the history of the development of the service is traced and a full description is given of the technical resources and coverage which the BBC has built up. BBC television has the most complete coverage of any television service in the world (more than ninety-eight per cent of the population of the United Kingdom in 1957). It has truly become 'The Network of the Nation'. In recording this outstanding achievement, the BBC is glad to acknowledge the continued co-operation of the British Radio Industry, who have provided most of the studio and transmitting equipment as well as more than eight million receivers. Since BBC stations are operated under licence from the Postmaster General, co-operation with the Post Office has also played an important part in these developments; the Post Office also provides vision and sound circuits linking together the various television studios and transmitters.

BBC engineers have always been pioneers. For twenty-one years they have occupied a position in the forefront of television development. In planning, design, and research they have achieved notable successes in the development of the BBC's Television Service. Much of this work has also been of great value to equipment manufacturers and to other broadcasting organizations. A description of this background effort and some of its more notable achievements to date are given in this booklet.

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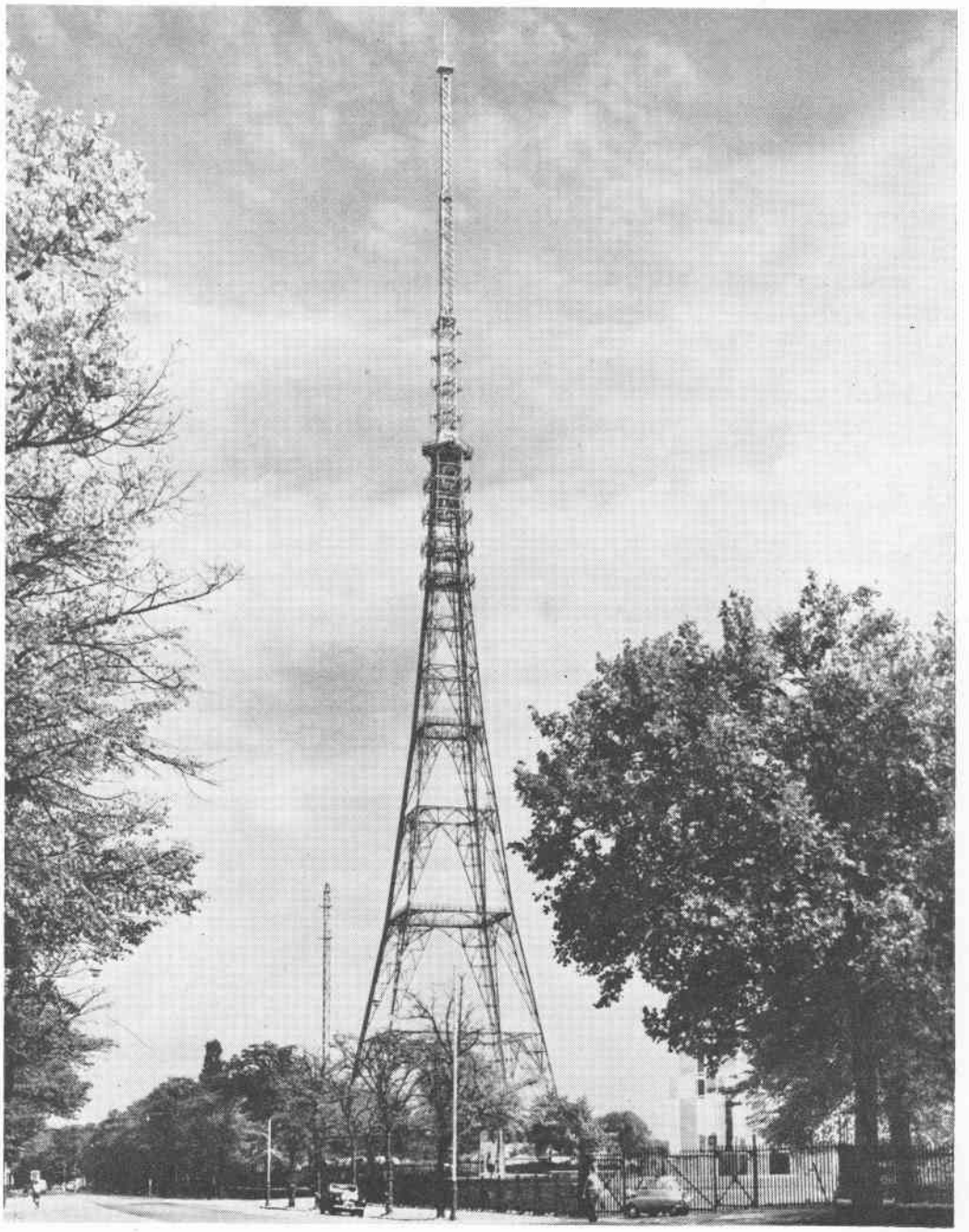


BBC Television Tower at Crystal Palace, London.

HOW TELEVISION WORKS—A BRIEF DESCRIPTION

THE GENERAL PROBLEMS

The many processes involved in television are too complex to be described fully here, but a simplified explanation of the basic principles is given for those interested.

It is necessary first to consider the action of the human eye. Basically this consists of a lens (the cornea) which focuses an image of the scene being observed on to a light-sensitive plate (the retina) at the back of the eye. The retina contains some millions of tiny elements each separate and distinct from its fellows, and each connected separately to the brain by an individual fibre in the optic nerve. The eye exercises keen discrimination, picking out minute details of the scene before it and conveying a perception of each detail separately and simultaneously to the brain. It does not combine the details together into a single impression as the ear does with sound; otherwise only an unintelligible blur would be seen.

In a television system it is therefore useless to send a mixture of detail—all the details of a scene must be transmitted separately, yet almost simultaneously. If the received picture is to be of good definition, something approaching a quarter of a million separate details must be transmitted.

In order to transmit these details, they must first be converted into electrical impulses; this can be done by a photo-electric cell, which reacts to light in a manner analagous to that of one element of the retina. The photo-electric cell can be made to produce an electrical impulse, large or small, according to the brightness of the light to which it is exposed. All television systems are based on its use. If a very large number of photo-electric cells is assembled on a small flat plate and an image of the scene to be transmitted is focused upon them by a lens, it is possible to obtain from each cell an electrical impulse—which is very small if that detail of the scene is dark but larger where the scene is bright. With a quarter of a million or so photo-electric cells we can obtain the necessary amount of detail, but it is impossible to use a quarter of a million transmitters to send the resulting electrical impulses over a distance. Somehow it must be arranged for these impulses to be sent one at a time so that a single transmitter and receiver can be used to convey the whole picture. This can be done quite readily by scanning.

Scanning is the process used by the eyes in reading a book. The text is divided into a series of horizontal lines and the eye moves from left to right along the first line reading word by word, moves quickly back to the left hand side and downwards to the start of the second line and so on. At the end of the last line the eyes return to the top and start a new page. Similarly, in television scanning, the picture to be transmitted is divided into a great many horizontal strips or lines by the scanning apparatus, which then reads off the detail along each line and passes it through the transmitting equipment to the receiver. The scanning apparatus also originates 'synchronizing signals' which tell the receiver when to start a new line and a new page. The 'page' in this case is one picture, that is, one scan of the whole scene. It is built up by the receiver detail by detail and line by line.

The essence of this process is speed. The received picture must be built up so rapidly that, because of 'persistence of vision' the brain is not conscious of anything but a continuous picture. This same principle of presenting a series of pictures very rapidly is used also in the cinema to create an illusion of smooth movement of the actors on the screen.

The standards of the television system used in the United Kingdom are based upon the transmission of twenty-five complete pictures each second, each composed of 405 lines. These standards represent a satisfactory compromise between picture quality and cost of equipment, but the presentation of twenty-five pictures per second is not sufficiently rapid to avoid flicker. A process called 'interlaced' scanning is therefore adopted. This means that lines 1, 3, 5, etc., are scanned first, followed by lines 2, 4, 6, 8, and so on. The scanning is performed at twice the normal speed and produces two coarse fields (of 202½ lines each), which are meshed together at the receiver to produce twenty-five complete pictures per second. Since the half-pictures or fields are presented at a rate of fifty per second there is no noticeable flicker.

DISSECTING THE PICTURE

In a modern television camera the scanning process is performed electronically. The camera lens throws an image of the scene to be televised on to a flat plate, which carries, in effect, a very large number of photo-electric cells, and is enclosed in an evacuated tube. The photo-electric cells turn the light and shade of the optical image produced by the lens into an electrical image. Also in the tube is an electron gun which produces a very thin beam of electrons; this beam is controlled by magnetic or electric fields and traces out the scanning lines in the manner already described. There are various types of camera tube. In one type the beam of electrons scans the photo-electric plate directly, but in others there is a second plate to which an 'electron image' is transferred from the first plate before the scanning is performed. In either case, the electron beam reads off the detail along each scanning line and produces a series of electrical impulses, which constitute the vision signal.

TRANSMITTING THE PICTURE

The electrical impulses which constitute the vision signal can be handled in a similar manner to the sound signals produced by a microphone. They can be sent over wires from the studio to the control room, from the control room through the distribution network to the transmitting stations in different parts of the country. At each of these stations, a further process is carried out to convert the vision signal into a radio transmission; in this form, the use of wires is no longer necessary and the signal can be broadcast, to be picked up by the aerials of individual viewers and conveyed to their television receivers.

REPRODUCING THE PICTURE

In the television receiver, the vision signal is separated out from the radio transmission and applied to a cathode-ray rube. This is an evacuated vessel which has a narrow neck containing an electron gun. As in the television camera, the electron gun produces a very fine beam of electrons, which is made to carry out the motions of scanning, and is directed on to a fluorescent screen at the other end of the tube, which is large and almost flat. This is the screen on which the picture is reproduced. The screen is coated with mineral salts having the special property of fluorescence; in other words, any part of the screen touched by the beam of electrons immediately glows and emits light. As the electron beam traces out the scanning lines, its strength is controlled by the signals originating in the television camera. This creates a pattern of light and shade which makes up the picture.

Finally, there are the synchronizing signals which are transmitted to keep the scanning beam in the receiver exactly in step with the one in the camera so that both the camera beam and the receiver beam start a new line and a new field at the same time.

THE EARLY DAYS

Experimental television transmissions by the BBC began in 1929 when facilities were granted to Baird Television, Ltd., to transmit programmes originating in their studios in Long Acre through the London Station transmitter in Oxford Street. These transmissions, which were subsequently referred to as 'low-definition', employed 30 scanning lines, and $12\frac{1}{2}$ pictures were transmitted per second. Vision only was transmitted, but in 1930 the transmissions were continued from the then new London Regional Station at Brookmans Park with the addition of sound. These 30-line transmissions were considered to be of sufficient technical interest for the BBC to equip a studio in Broadcasting House with Baird apparatus, and this was put into use in 1932.

At this time the development of improved standards of definition was proceeding rapidly. Baird Television, Ltd., and A. C. Cossor, Ltd., were experimenting with systems using 120 lines, the latter firm concentrating on a method known as 'velocity modulation'. Electric and Musical Industries, Ltd., and Scophony, Ltd., also had systems which were well advanced.

APPOINTMENT OF TELEVISION COMMITTEE

The question therefore arose whether a public service of 'high-definition' television was possible using very high frequencies (VHF) in order to accommodate the large band-width necessary for the transmission of such systems. In May 1934 the Postmaster General appointed a committee under the chairmanship of Lord Selsdon to report on the relative merits of the various systems and on the conditions under which a public service might be provided.

RECOMMENDATIONS OF THE TELEVISION COMMITTEE

The main recommendations of the Committee, whose report was issued in January 1935, were:—

(*a*) that a high-definition public service should be established at an early date and that VHF transmission should be used,

(*b*) that the BBC should be responsible for television as for sound broadcasting,

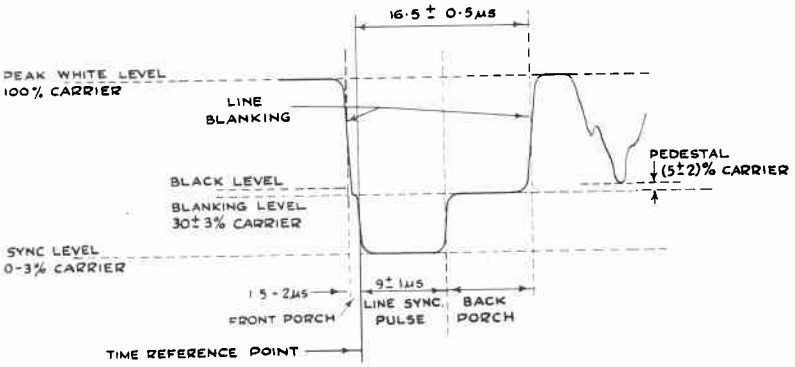
(*c*) that a standing Advisory Committee approved by the Postmaster General should be formed,

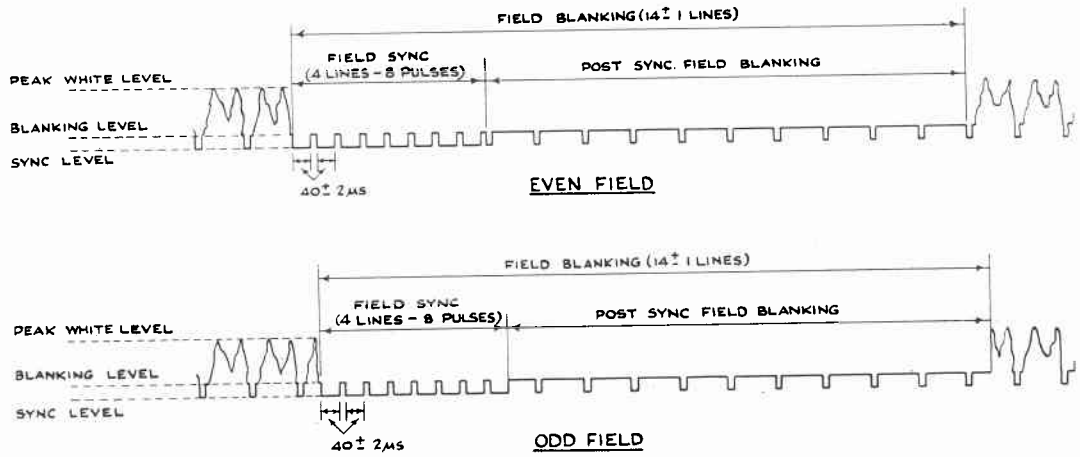
(*d*) that the first station should be in London and that the makers of the two selected systems, Baird and Marconi-E.M.I., should each supply their own apparatus for alternative operation,

(*e*) that the cost should be borne by the revenue obtained from the existing ten-shilling licence fee.

RECOMMENDATIONS OF THE ADVISORY COMMITTEE

The Advisory Committee recommended that the studios and transmitters should be at Alexandra Palace and that Baird Television, Ltd., and the Marconi-E.M.I. Television Co., Ltd., should be invited to tender for the supply of apparatus for their respective systems. Transmissions on wavelengths of approximately 6·7 metres for vision and 7·2 metres for sound





NOTES

(*a*) The drawing shows one half of the envelope of the modulated radio frequency carrier (i.e. the vision signal).

(*b*) Times of rise of leading and trailing edges of synchronising pulses (10–90% amplitude) not to exceed 0·25μs.

(*c*) Times of rise of leading and trailing edges of blanking pulses (10–90% amplitude) are between 0·25 and 0·5 μs.

(*d*) Time durations of the pulses are between the half maximum amplitude points.

(*e*) Field frequency is normally tied to frequency of mains.

(*f*) The blanking period prior to field sync has a duration of 1·5–50 μs.

BBC Vision Signal Waveform, 405-line 50-field Interlaced System.

(i.e. 45·0 and 41·5 Mc/s) were to be used, and the standards of picture transmission proposed by the two companies were accepted, namely:—

(*a*) Baird System: 240 lines, 25 pictures per second, sequential scanning.

(*b*) Marconi-E.M.I. System: 405 lines, 25 pictures per second with interlaced scanning giving 50 fields per second.

A VHF sound transmitter manufactured by Marconi's Wireless Telegraph Co., Ltd., was provided by the BBC for use with either system.

EXPERIMENTAL HIGH-DEFINITION TRANSMISSIONS

Experimental public transmissions by both systems were radiated from Alexandra Palace during the Radio Exhibition at Olympia in August 1936, after which the transmissions were discontinued until October when a series of trial programmes was radiated for two hours daily.

ALEXANDRA PALACE STATION OPENED

The Alexandra Palace Station was formally opened by the Postmaster General on 2 November 1936, and a public service for two hours daily came into being on this date, the two systems being used during alternate weeks.

SINGLE STANDARD ADOPTED

On 5 February 1937 the Postmaster General announced that, as a result of the experience gained with the transmissions from Alexandra Palace, the television Advisory Committee recommended that a single set of standards should be adopted for transmissions from the Alexandra Palace Station. These were as follows:—

Number of lines per picture—405 interlaced

Number of fields per second—50

Ratio of synchronizing impulses to picture—30:70.

Accordingly, from 6 February 1937, the Marconi-E.M.I. system alone was used at Alexandra Palace with positive modulation of the vision signal. Both sound and vision transmissions were amplitude modulated and vertically polarized. It is interesting to recall here that the basis of this system was suggested as long ago as 1908 by A. A. Campbell-Swinton, who put forward in a letter to *Nature* an idea for the use of cathode-ray tubes at both transmitter and receiver. This idea he greatly amplified in a presidential address to the Röntgen Society in 1911, envisaging a special type of cathode-ray tube at the transmitter, which was the forerunner of the cameras in use today. The far-sightedness of this idea of nearly fifty years ago is remarkable, for it required only the application of modern technique to develop into the system now used by the BBC.

At this point, credit should be given to a team of E.M.I. research workers led by Mr. Isaac Shoenberg for translating Campbell-Swinton's theory into a workable television system. That team included such men as A. D. Blumlein and C. O. Browne, who both lost their lives in an air accident during the war, and Dr. McGee, now a professor at the Imperial College of Science and Technology in London.

When the service started there was a single transmitting station at Alexandra Palace in North London. The transmitter developed a peak white output of approximately 17 kW and was of the

high-power modulated type. Separate aerials were used for the vision and sound transmitters, each having a gain of 3 db. The power of the sound transmitter was 3 kW.

Two studios only were available, situated at Alexandra Palace in the same building as the transmitters. Each studio measured 70′ long by 30′ wide by 23′ high (21 × 9 × 7 metres) and was equipped with three cameras of the Emitron (Iconoscope) type. About 100 kW of lighting was available in each studio, part AC and part DC.

Equipment was provided at Alexandra Palace for televising standard cinema films, such as newsreels, cartoons, and other features, and 'outside shots' for incorporation in studio programmes. The equipment consisted of continuous-motion Mechau film projectors throwing an image directly on to the photo-sensitive mosaic of an Emitron camera.

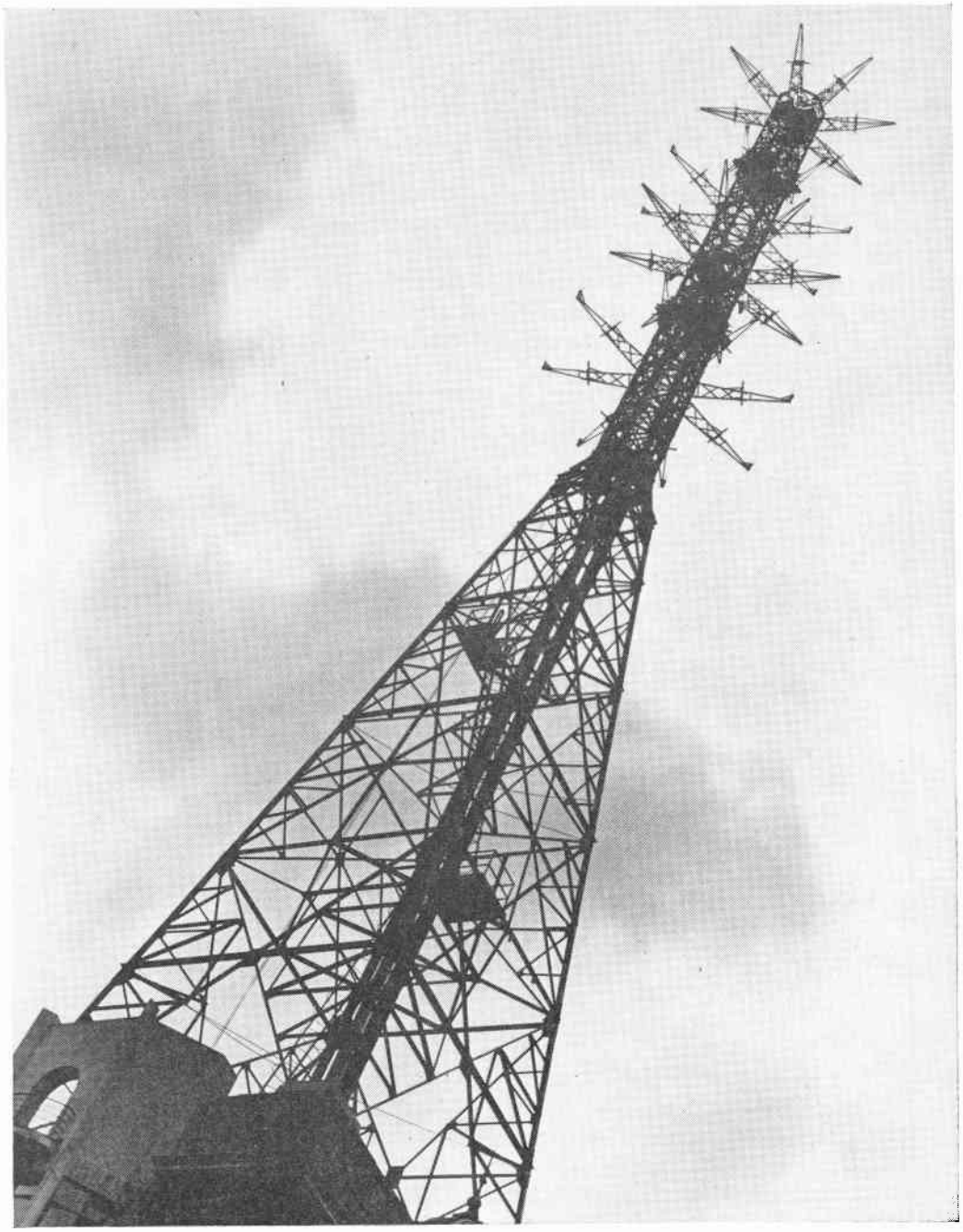
From the start it was realized that outside broadcasts, that is, programmes originating from outside the Alexandra Palace studios, would contribute a great deal to the television programmes. At first, such broadcasts were limited to the precincts of Alexandra Palace because the greatest length of camera cable that could be used was approximately 1,000 ft. (305 metres), but early in 1937 the Post Office installed a balanced-pair cable vision circuit between Alexandra Palace and central London, and it was by means of this that the first outside broadcast to be undertaken at a distance from Alexandra Palace was carried out. This was of the Coronation Procession of H.M. King George VI in May 1937. To enable outside broadcast programmes to be televised from places at a greater distance from Alexandra Palace, the BBC purchased two mobile transmitters (working in Band I with a vision transmitter output of 1 kW), which had a range of some twenty miles (32 kilometres) and could be used to convey the vision signals to Alexandra Palace for transmission in the normal way. Two mobile control rooms containing equipment for the control of three cameras were also obtained. Regular programmes were transmitted for about two hours each evening and 1½ hours each afternoon up to the outbreak of war in September 1939 when the television service closed down.

THE POST-WAR YEARS

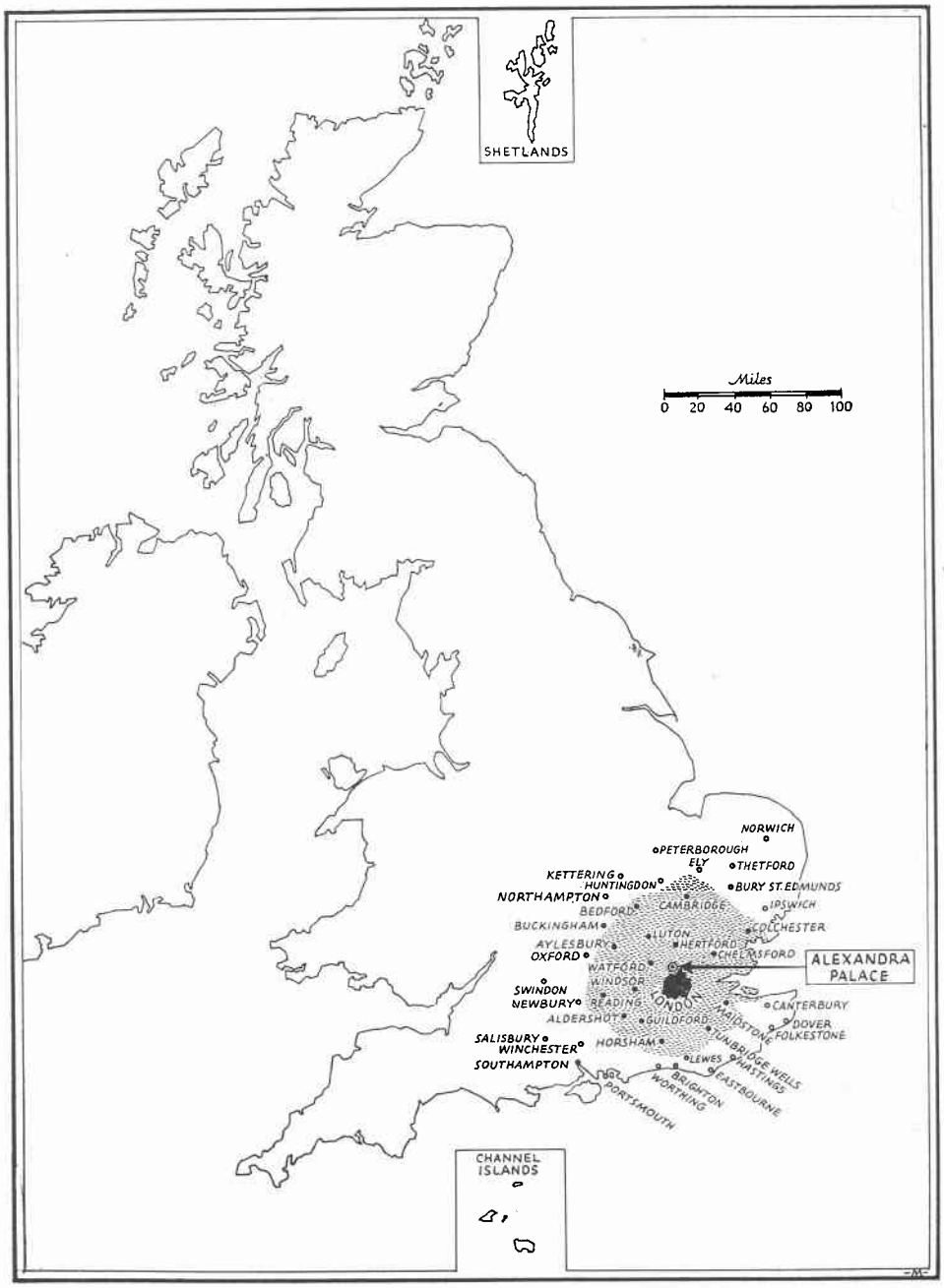
BRINGING TELEVISION TO THE WHOLE NATION

THE QUESTION OF STANDARDS REVIEWED

Towards the end of the war, a committee appointed by the Government under the Chairmanship of Lord Hankey recommended that when the service started again after the war, the pre-war standards of transmission should be used. The service was accordingly re-opened on 7 June 1946. The fundamental question of standards was reviewed during the ensuing two years and in 1948 it was decided by the Government that no change should be made. A new system, using a number of scanning lines in excess of 405 would have offered some increase in vertical definition of the received picture, but the horizontal definition would still have been restricted by the need to limit the bandwidth of the transmissions, in order to accommodate all the projected transmitting stations within the frequency band likely to be available. It has been found in practice that the BBC standard of 405 lines is capable of giving excellent pictures in



The 300-ft. mast and aerial at the Alexandra Palace station in service between 1936 and 1956.



Coverage of the original Alexandra Palace station amounted to 12,402,000 people, or twenty-seven per cent of the population of the United Kingdom. By 1939, when the service was suspended on the outbreak of war, some 20,000 receivers were in use. The map on page 25 shows the coverage that had been reached by the end of 1957.

the home at considerably lower cost than is possible with other standards, while at the same time making the best use of the limited frequency band available.

NEW TRANSMITTING STATIONS

Once the question of standards had been settled, it became possible to develop a plan for extending the television service beyond the area served by Alexandra Palace. A plan for nation-wide coverage was prepared and approved by the Postmaster General. The plan envisaged five high-power transmitting stations serving respectively the London area and south-east England, the Midlands, the industrial North of England, central Scotland and South Wales with part of the West of England. The major centres of population lying between the areas covered by these five stations were to be covered by five medium-power stations, leaving the more outlying areas to be served by other stations of lower power.

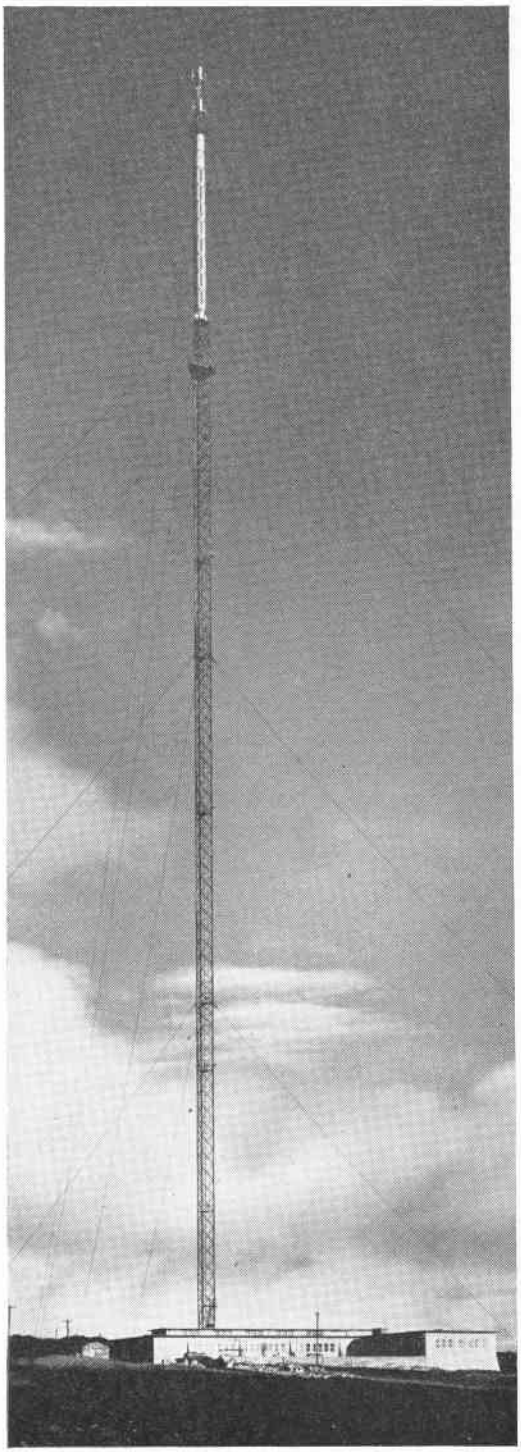
These stations had to be accommodated within the band of frequencies (41–68 Mc/s) allocated to broadcasting in 1947 by the Atlantic City Conference of the International Telecommunication Union. It was, therefore, decided that they should all use the vestigial sideband system of transmission to reduce the total bandwidth required—apart from the London station at Alexandra Palace which, being of much earlier design, had always used the double sideband system. By this means five independent frequency channels were obtained and it was decided that they should be shared on the basis of one high-power station, one medium-power station, and one or more low-power stations in each channel.

The first of the high-power stations outside London was opened in December 1949 at Sutton Coldfield, near Birmingham, and all four of the new high-power stations were completed by August 1952. Construction of the medium-power stations was delayed because, on account of the economic situation, the Government introduced restrictions on capital expenditure in March 1951 and authorization to proceed with them was not received until 1953. In the early part of that year a special effort was made to increase the coverage to the maximum possible in time for the Coronation in June of Her Majesty Queen Elizabeth II. Temporary stations were built with all speed at Glencairn, near Belfast; at Pontop Pike, covering the heavily populated Tyneside area, and at Truleigh Hill, near Brighton.

Construction of the five permanent medium-power stations was started in July 1953 and completed in June 1956. Meanwhile a temporary low-power station had been brought into operation in the Isle of Man and further stations had been authorized to cover East Anglia, the Channel Islands, part of the North of Scotland, the Londonderry area of Northern Ireland, North-west England, and West Wales. All these stations were completed before the end of 1957 and the BBC Television Service was then available to some 49,570,000 people—more than ninety-eight per cent of the population of the United Kingdom. All these stations have been accommodated in the five frequency channels of Band I.

There are three further bands of frequencies allocated by international agreement for television services in the United Kingdom; these are known as Bands III, IV, and V*. At the present time, techniques for using Bands IV and V are not yet fully developed in this country and the BBC's request to the Government for permission to use channels in Band III has not so far been granted.

**Band I extends from 41– 68 Mc/s, Band III from 174–216 Mc/s, Band IV from 470–585 Mc/s, and Band V from 610–960 Mc/s.*



In March 1956, the original Alexandra Palace transmitters were closed down and the service was transferred to a new transmitting station on the site of the Crystal Palace, in South London. The Crystal Palace vision transmitter was designed to provide, in conjunction with a higher gain aerial, an e.r.p. of 200 kW, using the vestigial sideband system of transmission. Unfortunately, it was not possible immediately to use the full power of 200 kW; construction of the top section of the supporting tower, on which the aerials were to be mounted, was delayed following the BBC's undertaking to make provision on the tower for aerials for other services, which involved redesigning and strengthening the top section. The service was, therefore, started using a temporary 250 ft (76 m.) mast and aerial and an e.r.p. of 60 kW. In September 1956, the service was transferred to a temporary aerial mounted at a mean height of 380 ft (116 m.) on the main tower and the e.r.p. was increased to 120 kW. The permanent aerial was completed and the full e.r.p. of 200 kW attained by the end of 1957.

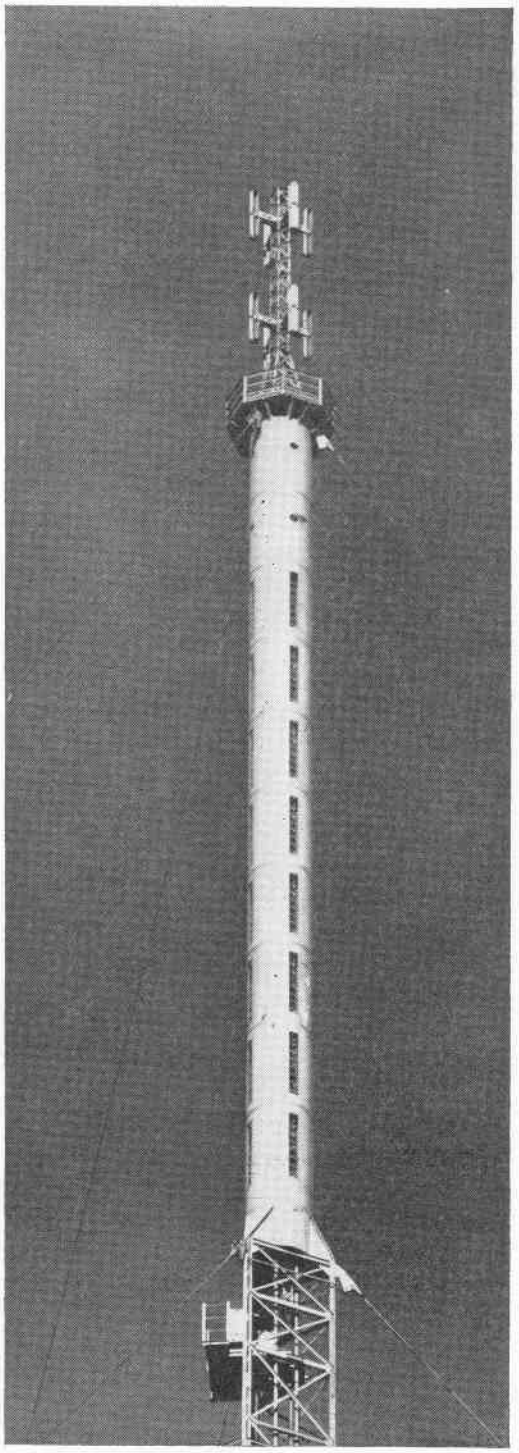
When the time came to design the first of the new high-power stations to be installed

Holme Moss, one of the BBC's high-power television stations. The main mast is 750 ft (228 m) high and incorporates a slot aerial for VHF sound broadcasting below the television aerial.

Holme Moss is built on the highest site used by the BBC and is 1700 ft. (518 m) above sea level. It was the second of the BBC's post-war stations and has an e.r.p. of 100 kW.

at Sutton Coldfield, improvements in circuit techniques and particularly in the design of transmitting valves had made it possible to obtain a peak white output from the transmitter of some 50 kW. This, in conjunction with a transmitting aerial having a power gain of two, gave an effective radiated power (e.r.p.) of approximately 100 kW. The four new high-power stations were, therefore, designed for this power. Sound transmitters of one-quarter the power, 12 kW unmodulated carrier, were provided.

The Sutton Coldfield vision transmitter is of the high-level modulated type, using earthed-grid valves in the final power amplifier. The Holme Moss transmitter is also high-level modulated but uses a neutralized earthed-cathode final power amplifier. The Kirk o'Shotts and Wenvoe transmitters are very different. They are low-level modulated at approximately the 600-watt level and the modulated signal is then amplified by three push-pull class B linear wide-band power amplifiers in cascade, using earthed-grid valves. It was decided to instal standby transmitters, both vision and sound, at each of these stations. For this purpose it was both convenient



The top section of the 750 ft (228 m) mast at Sutton Coldfield showing the two-tier television aerial and the slot aerial for VHF sound broadcasting.
Sutton Coldfield was the first television station to be built outside London and has an e.r.p. of 100 kW compared with 34 kW at the original Alexandra Palace station.

network is looked after by the BBC Lines Department who work in close co-operation with the Post Office; they also operate and maintain the BBC's television switching centres. Transmitting stations are the responsibility of the Superintendent Engineer, Transmitters, who controls also the transmitters used by the BBC's sound services.

The Television Operations and Maintenance department has two main parts, Studios and Outside Broadcasts. The studio section is responsible not only for operating and maintaining all the electronic equipment used at the studio centres, but also for technical operations (sound and vision mixing, sound balancing, lighting, telecine, and telerecording). The studio section also plays an important part in the planning of new studios and equipment.

SPECIALIST DEPARTMENTS

The Specialist Departments of the Engineering Division carry out research and development, provide the necessary buildings and equipment, and recruit and train staff. They deal with both sound and television engineering.

The Research Department carries out applied research over the whole field of broadcasting, but television has naturally demanded a major part of the available effort since the war. While concentrating mainly on future developments, this department has contributed much to the steady improvement in the present service: planning the location and power of new transmitting stations to give maximum coverage, site testing, transmitting aerial design, performance measurements, picture quality improvement, standards conversion, and improved telerecording systems are some of the immediate results of the department's work.

The Designs Department of the Engineering Division carries out design work over a very wide field and has been responsible for many new ideas in television. Its engineers have played a large part in breaking new ground on outside broadcasts. The Roving Eye, for example,

The two-camera version of the BBC's Roving Eye. Vision and sound signals can be transmitted to a convenient fixed point while the vehicle is on the move. Alternatively, the vehicle can be used as a two-camera static outside broadcast unit. When stationary, the radio link aerial can be raised to a height of 45 ft by means of a pneumatic ram giving greatly increased range.

and economical to use the same types of transmitters as those designed for the medium-power stations. These have an output of 5 kW and $1\frac{1}{4}$ kW for vision and sound respectively.

The Crystal Palace station is of radically different design. Both the vision and sound transmitters are divided into two units each of which contributes half the total power to the aerial system. If one unit should develop a fault, its 'twin' would maintain the service without interruption, though at reduced power.

There are duplicate feeders connected respectively to the upper and lower halves of the aerial system. Flexible switching arrangements are provided to enable the transmitter-feeder-aerial combination to be altered under fault conditions.

Maximum reliability is thus achieved in conjunction with duplicate drive units and low-power vision and sound equipment. The vision transmitters are grid-modulated at the final stage and air-cooled valves are used throughout. The vestigial sideband characteristic is produced by filters built into the transmitter units.

Vertical polarization is used at the five high-power transmitting stations, that is, the transmitting aerials are mounted vertically and receiving aerials must also be vertical. At Sutton Coldfield, Holme Moss, Kirk o'Shotts, and Wenvoe the aerial system consists of half-wave folded dipoles arranged in two tiers of four dipoles each, equally spaced around the top mast. The supporting mast in each case is 750 ft (228 m.) high, of lattice steel construction except for the top 110 ft (33·5 m.) which consists of a steel cylinder 6 ft (1·8 m.) in diameter. This cylinder, in which are cut thirty-two slots arranged in eight tiers of four, was built into each mast to provide a horizontally polarized transmitting aerial for future VHF sound broadcasting stations to be built on the same sites. These stations are now in operation.

At Crystal Palace, the aerial system is carried on a self-supporting tower. The tower is tapered to a height of 430 ft (131 m.) above which there are parallel-sided sections up to a height of 670 ft (204 m.) and then a top mast bringing the total height to 708 ft (216 m.). The upper half of the aerial system, mounted on a parallel-sided section, consists of four tiers of half-wave folded dipoles equally spaced around the mast. The lower half introduced serious problems of design because of the physical size of the tower and the fact that the tapering sides were not vertical. Eight dipoles are used in each tier of this section, arranged in pairs, two to each face of the tower. The aerial has an average power gain of 7·5 db.

No standby aerial is provided at Crystal Palace since the upper and lower sections can be driven separately by means of duplicate feeders. At the other high-power stations, standby aerials are provided, mounted on the main masts.

At some of the medium- and low-power stations, vertical polarization is used, as at the main stations, but others use horizontal polarization with the object of reducing co-channel interference, i.e. interference taking the form of a pattern of lines across the screen of a receiver which may result when two or more television transmitters in the United Kingdom are operated nominally on the same carrier frequency. An improvement of some 10 db can be achieved by this means. The effect of co-channel interference is further reduced by off-setting the frequencies of certain transmitters, i.e. by making them slightly different from the nominal values, either in a positive or a negative direction. The frequency off-set used is usually 6·75 kc/s ($\frac{2}{3}$ line frequency) for vision and 20 kc/s for sound.

Mast heights at the medium- and low-power stations mostly range from 300 ft to 750 ft (91 to 228 m.) and aerials are of the super turnstile or bat-wing types.

BBC TELEVISION STATIONS : 1958

Station	Channel	Frequencies Mc/s Sound	Frequencies Mc/s Vision	Polarization	Effective Radiated Vision Power kW	Gross Population Coverage
Crystal Palace	1	41·50	45·00	Vertical	200	14,548,000
Divis	1	41·50	45·00	Horizontal	12	1,297,000
*Wick	1	41·50	45·00	Vertical	—	—
Holme Moss	2	48·25	51·75	Vertical	100	17,907,000
North Hessary Tor	2	48·25	51·75	Vertical	1—15†	1,461,000
Rosemarkie	2	48·25	51·75	Horizontal	1	109,000
Londonderry	2	48·25	51·75	Horizontal	1	137,000
Dover	2	48·25	51·75	Vertical	0·25—4†	278,000
Truleigh Hill (Temporary Station)	2	48·25	51·75	Vertical	0·2	3,248,000
Rowridge	3	53·25	56·75	Vertical	1—32†	
Kirk o'Shotts	3	53·25	56·75	Vertical	100	4,155,000
Norwich	3	53·25	56·75	Horizontal	1—10†	809,000
Blaen-plwyf	3	53·25	56·75	Horizontal	1	71,000
Sutton Coldfield	4	58·25	61·75	Vertical	100	8,854,000
Meldrum	4	58·25	61·75	Horizontal	4—17†	463,000
Les Platons	4	58·25	61·75	Horizontal	1	99,000
Sandale	4	58·25	61·75	Horizontal	16	396,000
Folkestone	4	58·25	61·75	Horizontal	0·01	45,000
Wenvoe	5	63·25	66·75	Vertical	100	4,275,000
Pontop Pike	5	63·25	66·75	Horizontal	12	2,722,000
Isle of Man (Douglas)	5	63·25	66·75	Vertical	0·25—2·5†	45,000
*The Orkneys	5	63·25	66·75	Vertical	17	30,000
*Peterborough	5	63·25	66·75	Horizontal	—	—

*Projected stations. †Directional Aerial.

TELEVISION STUDIOS IN LONDON

Although considerable use is made of outside broadcasts and film, both for news items and other programmes, it is the studios that form the heart of a television service. It is also essential to have some central point from which the programmes distributed through the television network can be directed and controlled. This is most conveniently associated with a number of studios, forming what is known as a studio centre.

Before the war, the BBC had two studios only, small by modern standards, at Alexandra Palace in north London. When the television service was resumed after the war, the need for more studio space became urgent; furthermore, it became obvious that full use should be made of new technical equipment which had by then been developed, including new and more

sensitive types of cameras. These cameras had already been put into use for outside broadcasts and had demonstrated their marked advantages over the pre-war types.

LIME GROVE STUDIOS

At the beginning of 1950, the BBC bought a group of buildings at Shepherds Bush in West London known as the Lime Grove Studios, which had formerly been used for film production. These buildings contained five large studios suitable for conversion for television purposes as well as essential ancillary areas such as dressing-rooms, make-up and wardrobe rooms, and spaces adaptable for television film work. Four of these studios were converted and successively brought into use, a major operation because control rooms and technical apparatus rooms, not required in film-making had to be built and equipped. Additional ventilation had also to be provided on a considerable scale to keep the studio floor areas reasonably cool during long hours of continuous operation. The fifth and largest studio was used as a scenery store.

A rehearsal in progress in one of the BBC's most modern studios at Riverside, Hammersmith. The lighting battens, which can be raised or lowered electrically from a control desk on the studio floor, are clearly shown. The switching and dimming of the illuminators, individually or in groups, is performed by remote control from a lighting console adjacent to the Vision Control Room.

To enable the studios to be brought into use as quickly as possible, they were initially equipped with camera channels and related technical equipment designed and formerly used for outside broadcasts. A fifth small studio was added to serve as a programme presentation studio where announcements could be made, interviews conducted, and so on. This studio forms part of a Presentation Suite which includes a Central Control Room and a Central Apparatus Room. This area became the hub of the television network where programme items from all sources were marshalled for distribution to the network of transmitting stations that were springing up throughout the country.

Studios D and H were each equipped with three C.P.S. Emitron (Orthicon) cameras, Studio G with four Pye Photicon (Image Iconoscope) cameras, while Studio E was equipped with four Marconi Image Orthicon cameras using $4\frac{1}{2}$ ins. (11·4 cm) pick-up tubes. Studios D, G, and H have since been re-equipped with studio-type camera channels and associated apparatus, the cameras incorporating improved pick-up tubes developed from the C.P.S. Emitron type.

THE TELEVISION THEATRE

The BBC also acquired in 1953 a public theatre, formerly the Shepherds Bush Empire, mainly for the production of light entertainment shows before an audience of some 700 people. This theatre was equipped temporarily with three Photicon (Image Iconoscope) cameras

The Lighting Console in the apparatus room of Riverside Studio I. This controls remotely the lighting in the studio and provides 166 control channels each with its own dimmer.

removed from an Outside Broadcast Unit. In 1957, permanent studio equipment was installed, including Image Orthicon cameras using $4\frac{1}{2}$ ins. (11·4 cm) tubes.

RIVERSIDE STUDIOS

As the Television Centre would not be ready for some time and the hours of transmission were further extended to some fifty hours per week, it became necessary to acquire more studio space for immediate use. To meet this need, the BBC acquired the Riverside Film Studios at Hammersmith, some $1\frac{1}{2}$ miles (2·4 km) from Shepherds Bush, which contained two studios readily capable of conversion for television use.

In the conversion and equipping of these studios, the opportunity was taken to try out new techniques, in order to gain experience which could be applied to the design of the studios and their equipment at the new Television Centre. For example, a studio lighting system was installed that was quite new in the United Kingdom, and was designed to give greater flexibility in the production of programmes and improved picture quality. The illuminators are suspended in groups of four from horizontal battens distributed over the ceiling of the studio. The number of lighting battens is large enough in each studio to provide overhead lighting at any point on the studio floor simply by lowering the appropriate battens and swinging the illuminators in the correct direction. Each batten can be raised or lowered by an electric hoist and all the hoists are operated from a single control desk on the studio floor.

The illuminators can be switched or dimmed, individually or in groups from a lighting control console in, or adjacent to, the vision control room. In this way the lighting supervisor, working in close touch with the producer and vision control crew, can change the lighting effects as required during a programme.

In order to obtain experience of different methods of lighting control and thus help in planning the new Television Centre, Studio 1 was equipped with mechanical dimming, using auto-transformers and rheostats driven by electric motors through magnetic clutches, whereas Studio 2 has electronic dimming by means of thyratrons in series with the lamp filaments.

In Studio 1, there are 79 hoists and 344 lighting outlets giving a total available lighting load of 150 kW. Studio 2 has 62 hoists, 308 lighting outlets, and a total lighting load of 100 kW.

In converting these studios it became possible for the first time to group closely together the vision and sound control rooms and the vision apparatus room on the same floor level, an arrangement that has many advantages.

The camera equipment installed is Marconi Image Orthicon with $4\frac{1}{2}$ ins. tubes and there are four operational cameras in Studio 1 and three in Studio 2. Each studio is provided with a spare camera channel.

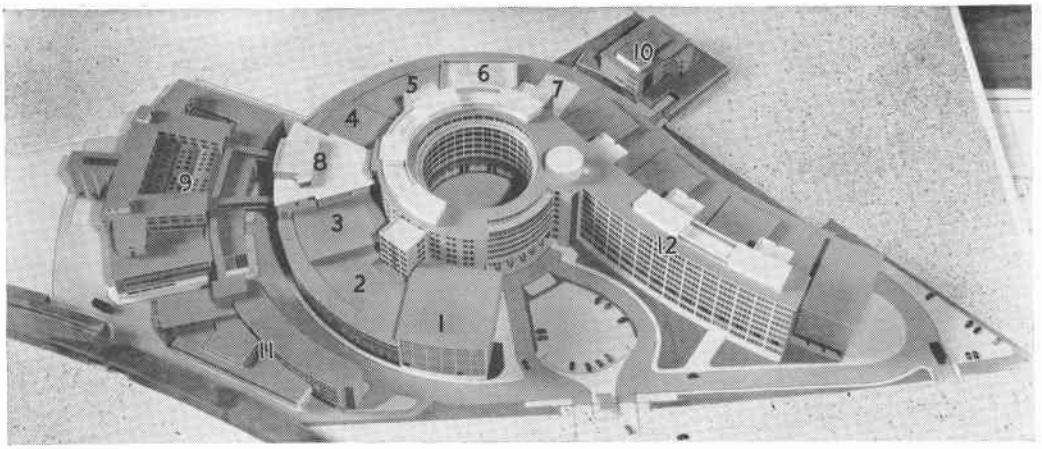
NEWS STUDIOS

The headquarters of BBC Television News is at Alexandra Palace and uses one of the two studios with which the television service began in 1936. There is also a news and interview studio in All Souls Hall adjacent to Broadcasting House, in central London, a small interview studio at London Airport and another in St. Stephen's House, near the Houses of Parliament.

St. Stephen's was the BBC's first unattended television studio and was brought into use in October 1957. It is used mainly for reports and interviews by the BBC's Parliamentary Correspondent. Here the television camera and other equipment is left set up ready for use and is switched on by remote control from Alexandra Palace when required. Work is in progress to convert the All Souls and London Airport studios to remote-controlled working.

THE NEW TELEVISION CENTRE

Plans had meanwhile been going ahead for the building of a completely new television centre. This will contain at least seven studios, full facilities for the construction and storage of scenery, and adequate space for all the technical and ancillary areas and for offices. A thirteen-acre (52,000 sq. m.) site for the new centre was acquired not far from the Lime Grove studios and construction was begun in 1951.



A Photograph of the Model of the New Television Centre.

1–7 Studios *8 Technical Control* *9 Scenery Block*
10 Restaurant Block *11 Works Block* *12 Future Extension*

The main block will be seen to consist of an inner ring which will be seven floors high, from which will radiate the studios and a 'central wedge'. A 40 ft (12 m.) wide ring road runs round the outer ends of the studios and on the outside of this are three more buildings, a Scenery Block, a Restaurant Block, and a Works Block. The studios are linked by an internal runway which allows scenery and properties to be conveyed from the Scenery Block direct to the outer ends of the studios; artists and staff will enter the studio from the inner ring.

It was decided to build the Scenery Block first so that it could be used immediately in conjunction with the Lime Grove Studios. This was completed and brought into use in 1954. It occupies approximately one acre (4,000 sq. m.). The Canteen Block was next completed and adapted for temporary use as offices and rehearsal rooms. Now, the foundations for the central ring are completed and a section of the superstructure containing seven studios is under construction. The installation of technical equipment for four of these studios will follow; one of them will be brought into use in 1960 and the remainder in 1961.

The architect for the work is Graham Dawbarn, C.B.E. (Norman and Dawbarn) in association with M. T. Tudsbery, C.B.E. (Consulting Civil Engineer to the BBC).

BBC TELEVISION STUDIO FACILITIES – LONDON AREA

MAIN PRODUCTION STUDIOS

Studio		*Area in*		*Camera Channels*	
		Sq. ft.	*Sq. m.*	*No.*	*Type*
Lime Grove	D	5,400	500	4	E.M.I. type 10764 Emitron
	E	4,800	446	4	M.W.T. 4½ in. Image Orthicon
	G	6,000	558	4	E.M.I. type 10764 Emitron
	H	2,800	260	3	E.M.I. type 10764 Emitron
	P	560	52	2	Pye P.E.S. Photicon
Riverside	1	6,000	558	4	M.W.T. 4½ in. Image Orthicon
	2	4,480	418	3	M.W.T. 4½ in. Image Orthicon
Television Theatre		2,000	186	4	M.W.T. 4½ in. Image Orthicon

TELEVISION NEWS STUDIOS

Alexandra Palace	B	2,100	195	3	Pye Photicon
				1	Caption scanner using Pye Staticon
London Airport				2	Peto Scott Vidicon
All Souls Hall				2	Peto Scott Vidicon
St. Stephen's House				1	Peto Scott Vidicon

Regional Studios are mentioned in the text below.

REGIONAL STUDIOS

The number and types of programmes contributed by the Regions to the national network, in addition to programmes transmitted for reception only in the Region itself, has made it necessary to provide Regional studios as well as the outside broadcasting units which have been in service for some time. Temporary or permanent studios are in service in Birmingham (the Midlands), Manchester (the north of England), Bristol (the West of England), Cardiff (S. Wales), and Glasgow and Edinburgh (Scotland). The long-term policy for equipping these centres is still under development, but the general aim is to equip each studio centre on the following lines:

1. A full-size studio with three operational cameras and a spare camera channel.

2. A separate interview studio with two cameras of the photo-conductive type.

3. Film scanning equipment, which will include a 'cross-fire' telecine capable of transmitting 35 mm and 16 mm films; in this layout there are two intermittent film projectors and two photo-conductive camera tubes, with each projector aiming directly at one of the camera tubes. The two projector-camera combinations are placed so that their light paths cross at right angles in the centre. This normally provides two independent telecine channels, but if either camera should break down, its projector can immediately be fed to the other camera tube by swinging a 45° mirror into position at the point where the light paths normally cross.

4. A film production unit equipped with 35 mm and 16 mm cameras, cutting and editing facilities and some film-processing equipment.

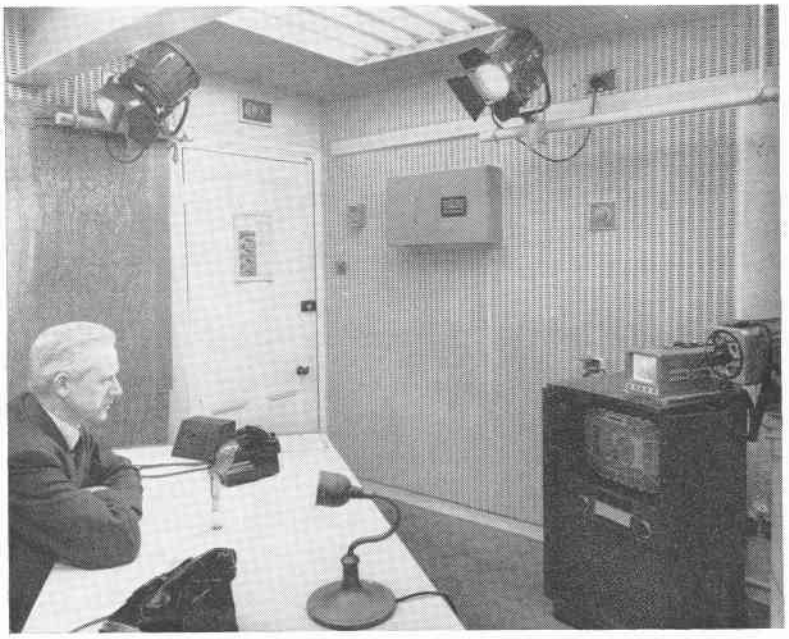
The outside broadcast units based in Birmingham, Manchester, Glasgow, Bristol, and Cardiff include mobile control rooms for the operation of three image-orthicon cameras, radio link vehicles which enable programmes originating in almost any part of the country to be fed into the local transmitting station or the national network, and vehicles equipped with diesel-alternator generating sets for use where a public mains supply is not available—a situation which is often met on isolated hill-tops which are ideal sites for radio link equipment.

LINKING THE STUDIOS AND TRANSMITTERS

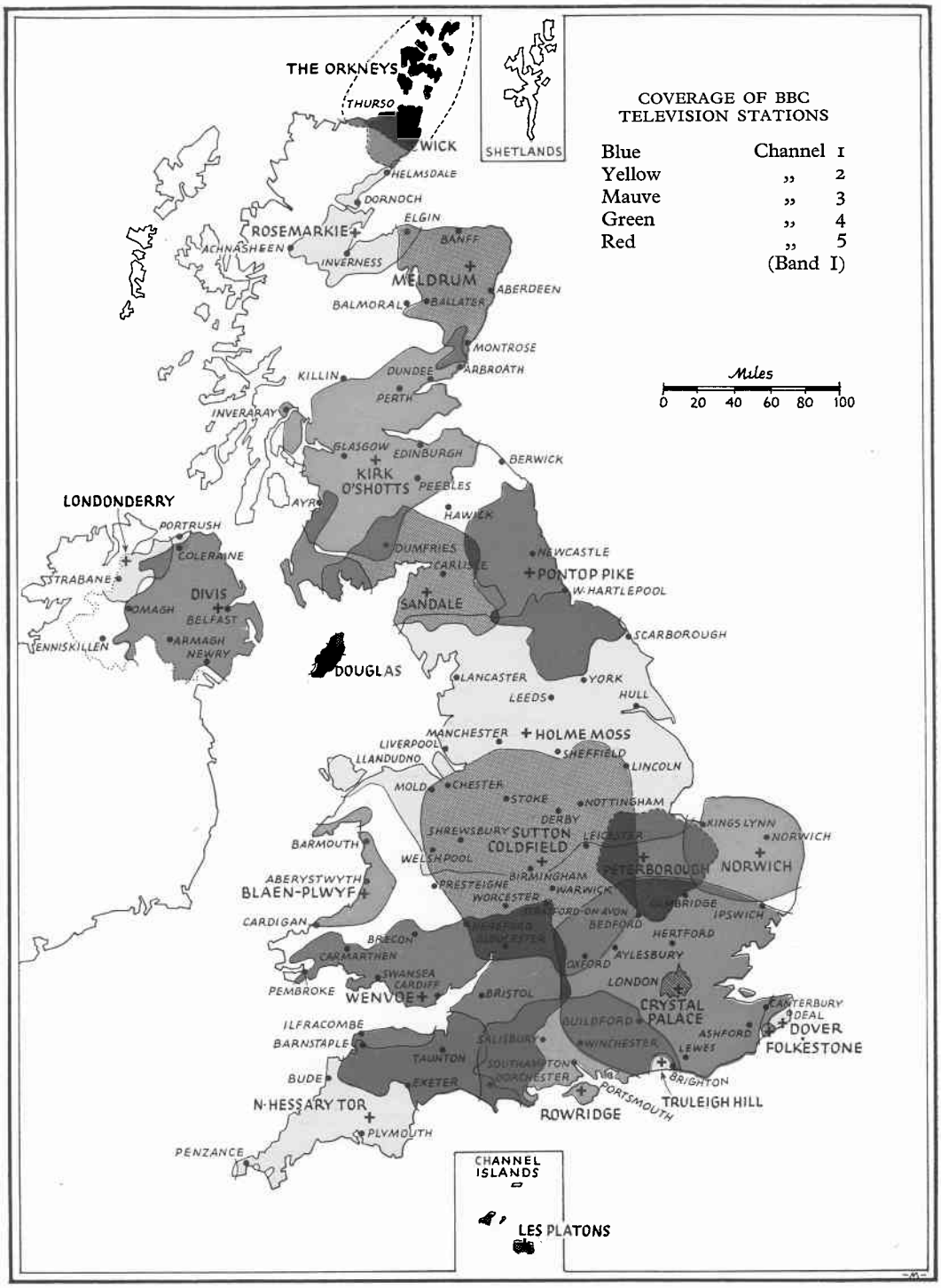
A network of vision and sound circuits has been provided by the Post Office. The main centre of programme production remains in London, but most of the network is duplicated so that vision and sound signals can be sent in both directions. This enables contributions from the Regions to the network programme to be routed to London, where they pass through the Central Control Room at Lime Grove which forms part of a programme Presentation Suite.

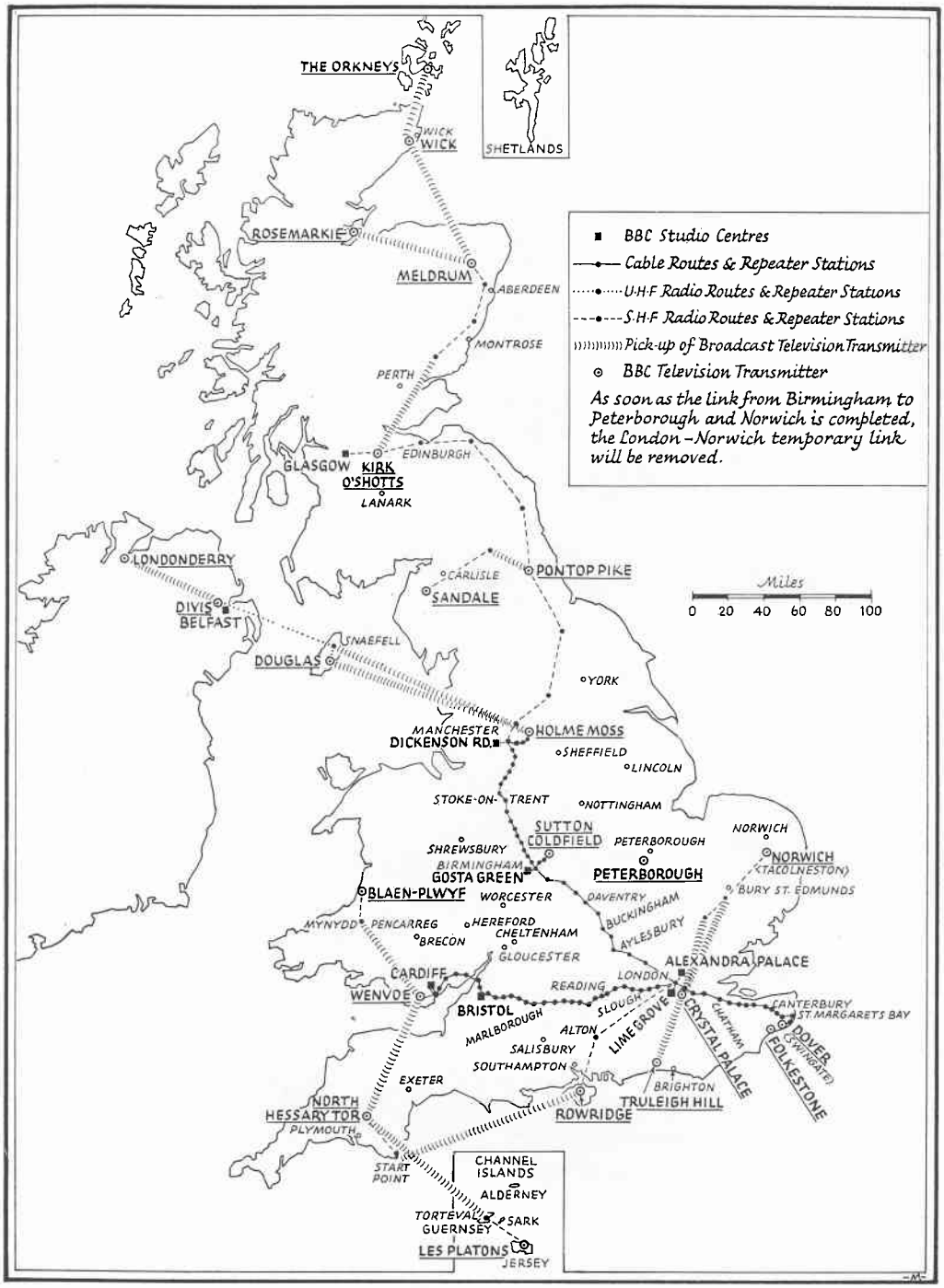
In planning these links, provision has been made for the Regions to transmit programmes different from those of the main network. For example, there are regular local news and sports reports for which the transmitting stations are split up into Regional groups.

Switching centres have been built at the main BBC studio centres to give control of the network programmes, programmes originated and transmitted locally, and outside broadcasts which may be fed into the network at intermediate points.



The BBC's first unattended television studio at St. Stephen's House: showing the small photoconductive - type camera and its monitor on which the Correspondent can check that his picture is satisfactory, a television set for checking the picture transmitted from the Crystal Palace television station, working and spare microphones, and fixed lighting.


COVERAGE OF BBC TELEVISION STATIONS
Blue Channel 1
Yellow ,, 2
Mauve ,, 3
Green ,, 4
Red ,, 5
(Band I)
Miles
0 20 40 60 80 100
THE ORKNEYS
THURSO
WICK
SHETLANDS
HELMSDALE
DORNOCH
ELGIN
ROSEMARKIE
BANFF
ACHNASHEEN
INVERNESS
MELDRUM
ABERDEEN
BALMORAL
BALLATER
MONTROSE
KILLIN
DUNDEE
ARBROATH
PERTH
INVERARAY
GLASGOW
EDINBURGH
BERWICK
KIRK O'SHOTTS
PEEBLES
AYR
HAWICK
LONDONDERRY
PORTRUSH
COLERAINE
DUMFRIES
NEWCASTLE
STRABANE
CARLISLE
PONTOP PIKE
W. HARTLEPOOL
DIVIS
SANDALE
OMAGH
BELFAST
SCARBOROUGH
ENNISKILLEN
ARMAGH
NEWRY
DOUGLAS
LANCASTER
YORK
LEEDS
HULL
MANCHESTER
HOLME MOSS
LIVERPOOL
SHEFFIELD
LLANDUDNO
LINCOLN
MOLD
CHESTER
STOKE
NOTTINGHAM
DERBY
KINGS LYNN
SHREWSBURY
SUTTON COLDFIELD
LEICESTER
NORWICH
BARMOUTH
WELSHPOOL
PETERBOROUGH
NORWICH
ABERYSTWYTH
PRESTEIGNE
BIRMINGHAM
BLAEN-PLWYF
WARWICK
WORCESTER
CAMBRIDGE
IPSWICH
CARDIGAN
BEDFORD
HERTFORD
BRECON
AYLESBURY
CARMARTHEN
OXFORD
SWANSEA
CARDIFF
LONDON
PEMBROKE
WENVOE
BRISTOL
CRYSTAL PALACE
CANTERBURY
DEAL
ILFRACOMBE
GUILDFORD
DOVER
ASHFORD
BARNSTAPLE
SALISBURY
WINCHESTER
FOLKESTONE
LEWES
TAUNTON
SOUTHAMPTON
BUDE
EXETER
DORCHESTER
BRIGHTON
PORTSMOUTH
N. HESSARY TOR
TRULEIGH HILL
ROWRIDGE
PLYMOUTH
PENZANCE
CHANNEL ISLANDS
LES PLATONS



Television Simultaneous Broadcast System.

The first of the vision circuits, between London and Sutton Coldfield was a radio link rented from the Post Office and operating on a frequency of some 900 Mc/s and having four intermediate repeater points. Later this link was replaced by a two-way coaxial cable circuit using 1 in. (2·54 cm) diameter tubes. A bandwidth of 3 Mc/s was obtained over both the radio and cable circuits, the latter operating on a carrier system between 3 and 7 Mc/s. A further coaxial cable circuit using $\frac{3}{8}$ in. (0·95 cm) diameter tubes was provided from Sutton Coldfield to Holme Moss. This is in accordance with standard coaxial cable practice, the cable channel occupying a frequency band from 0·5–4 Mc/s with the carrier frequency at 1 Mc/s. The extension of the network northwards to Scotland made use of an SHF radio link operating on a frequency of some 4000 Mc/s with seven intermediate repeater points. As the network of transmitting stations extended, use was also made of direct radio pick-up from an existing transmitting station in some areas, notably in Northern Ireland, South Devon, the Isle of Man, and the Channel Islands. A map showing the types of vision circuit used in different parts of the country appears on page 26.

TELEVISION PICTURES FROM FILM

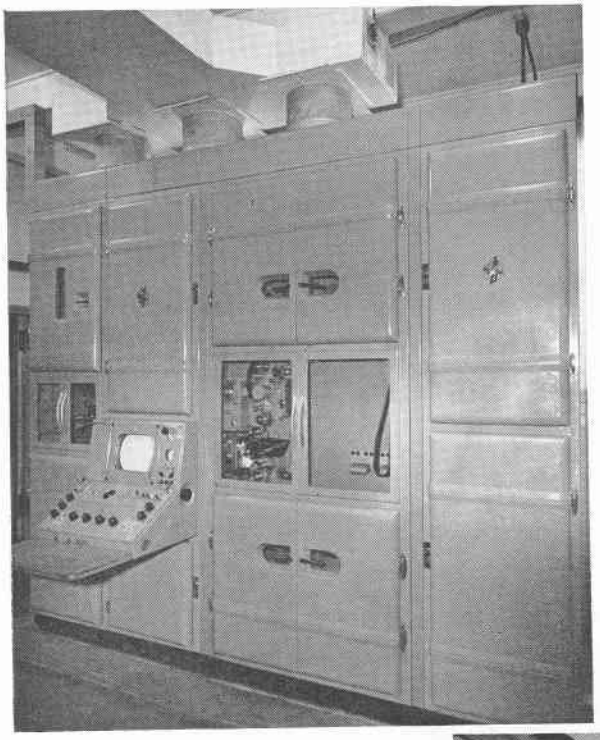
In order to transmit a film by television, it is necessary to scan each successive film frame and thus to obtain an electrical vision signal whose voltage varies with the density of the film along the scanning lines.

The preferred method of carrying out this film scanning is the flying-spot process, in which a cathode-ray tube provides a synchronized raster of uniform brightness and an image of this raster is passed through the moving film by a lens system. In this way, each point in the film frame is scanned by a moving beam of light. After it has passed through the film, the intensity of this light beam varies with the density of each portion of the film, and a photocell transforms this varying light intensity into an electrical voltage which varies correspondingly.

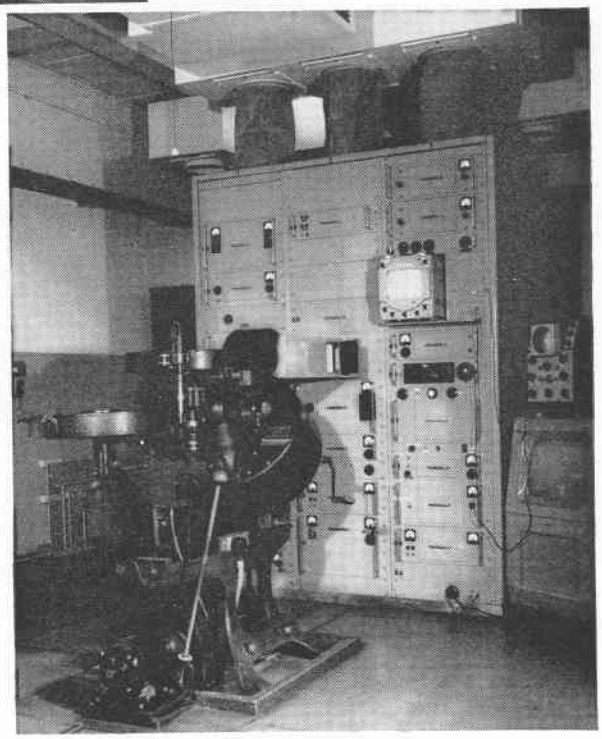
The flying-spot system produces vision signals of the highest quality obtainable in the present stage of telecine development.

A film transport mechanism of the normal intermittent type does not allow the film frame to remain stationary long enough for the scanning process to be completed. The earliest form of film scanning machine used by the BBC overcomes this difficulty by using a modified version of the pre-war German Mechau film projector. In this machine, the film moves continuously at a constant speed, and a system of mirrors moves the image of the scanning raster in such a way that it holds the image stationary relative to the moving film for the duration of a complete scanning cycle. This mechanism is now used in conjunction with a flying spot scanning system. Its main advantage is that it can transmit a picture when the film is out of synchronism with the television signal, or even when the film is stationary. There is thus no need for a waiting period to give the machine time to accelerate after it has been started up. This is important to the producer who has to insert film sequences into a live programme, since this is made much easier if he does not have to allow a time interval between 'cueing' the film and having it available for transmission. For this reason, the 'flying-spot Mechau' system (as it is called) is used for short film inserts into live programmes.

The flying-spot Mechau machine does not offer the best picture quality obtainable at present, since the mirror movement cannot be maintained entirely accurate in operation. The



Two examples of film scanning equipment using the flying-spot principle. In the equipment shown movement of the film is continuous. Other types of equipment use an intermittent film traction mechanism in conjunction with photo-conductive camera tubes.



best quality pictures are given by the twin-lens flying-spot machines. Three of the machines of this type handle 35 mm film only, while two others each deal with either 35 mm or 16 mm film, using two film traction mechanisms sharing common electronic equipment. In these machines, as with the Mechau, the film moves continuously, but in this case a double lens system focuses two images of the scanning raster (one image immediately below the other) on to the moving film. As each film frame passes the first image of the raster, the odd line field is scanned, and as the film moves on to the second image, the even line field is scanned. A mechanical shutter blacks out each raster image alternately while the other image is scanning the film, but there are no moving mirrors to cause deterioration of the transmitted picture. With these machines, the picture is not available for transmission until the mechanism has had time to accelerate up to synchronous speed, which normally takes about nine seconds, but their high picture quality is made use of whenever precise timing between live and film sequences is not required.

Experience has shown that it is more satisfactory to have all telecine machines in a central telecine suite provided that full liaison is maintained between producer and telecine operator. The central telecine suite is situated at Lime Grove but its output is available for use in conjunction with other studios such as Riverside or the Television Theatre.

The use of 16 mm film is increasing rapidly, and in order to increase the 16 mm handling capacity, two additional 16 mm channels, using photoconductive type camera tubes, have been installed as a temporary measure in the Lime Grove telecine suite. In this type of telecine machine, a standard type of film projector (using an intermittent film traction mechanism) projects a picture on to the signal plate of the photoconductive tube. The storage action of this type of tube maintains the picture signal during the short time interval when the blacking out of the projected picture (to allow film pull-down) overlaps the scanning period. The picture quality with this type of channel is limited by the inherent characteristics of the photoconductive tube, but it has the advantages of simplicity and relatively low cost. Telecine channels of this type are also used in the News and Newsreel studio at Alexandra Palace and in the Regional Television Centres.

All these types of equipment can reproduce sound either from an optical sound track on the same film as the picture, or from a magnetic recording on a separate film. The 16 mm sections of the dual 35 mm/16 mm machines are also equipped to deal with film which carries a thin 'stripe' of magnetic material for sound recording alongside the picture.

EQUIPMENT FOR PRODUCING SPECIAL EFFECTS

A necessary part of any television studio production is a suitable background in front of which the action takes place. This takes many forms. The walls of a room, for example, may be built with wood, canvas, and other materials, real window-frames may be provided, bookshelves may contain real books, and so on. On the other hand, much of the background may be painted on a canvas backcloth which is a commonly-used method of depicting outdoor scenes.

BACK PROJECTION

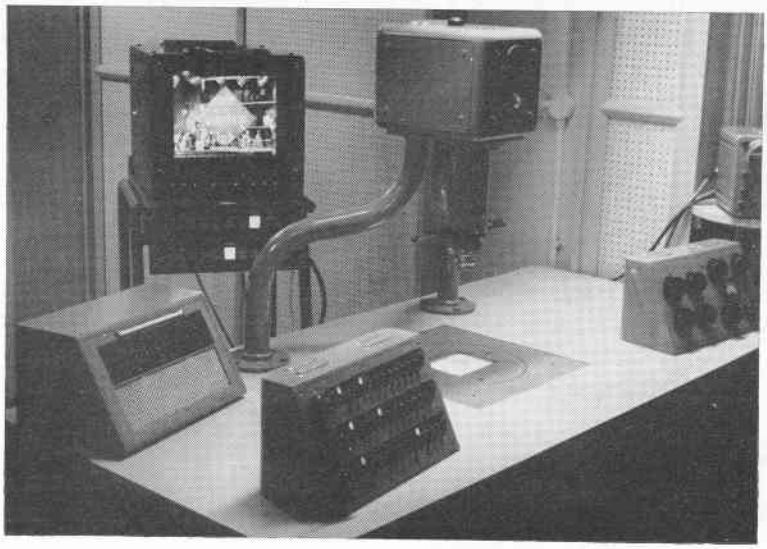
Another method of providing a background which is sometimes both convenient and economical is known as 'back projection', a process often used in the film industry. This means

that the action takes place in front of a large translucent screen on to the rear of which the required background is projected from a lantern slide. To the cameras this can appear entirely realistic if the relative illumination of the screen and of the 'live' artists is well balanced and if care is taken to get the perspective right. As well as this fixed or static back-projection the BBC successfully uses moving back-projection in which the image on the translucent screen is obtained from a film. As a typical example, this method can be used to convey the impression that the action is taking place in a train, the changing landscape on the screen as seen through the carriage window making it appear that the train is moving.

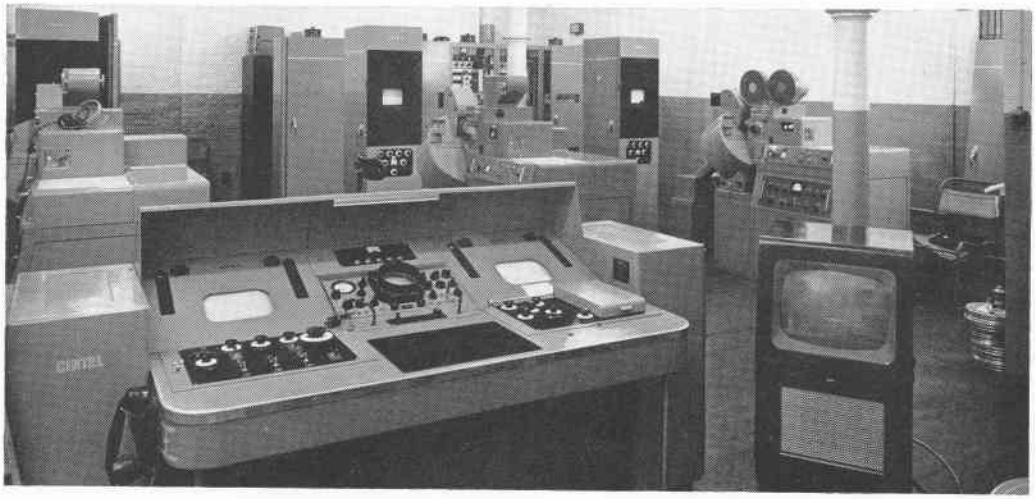
INLAY AND OVERLAY

A most versatile means of producing special effects is the Inlay/Overlay equipment developed by BBC engineers for the television service. This was introduced in mid-1953 and enables the effects to be obtained by electronic means.

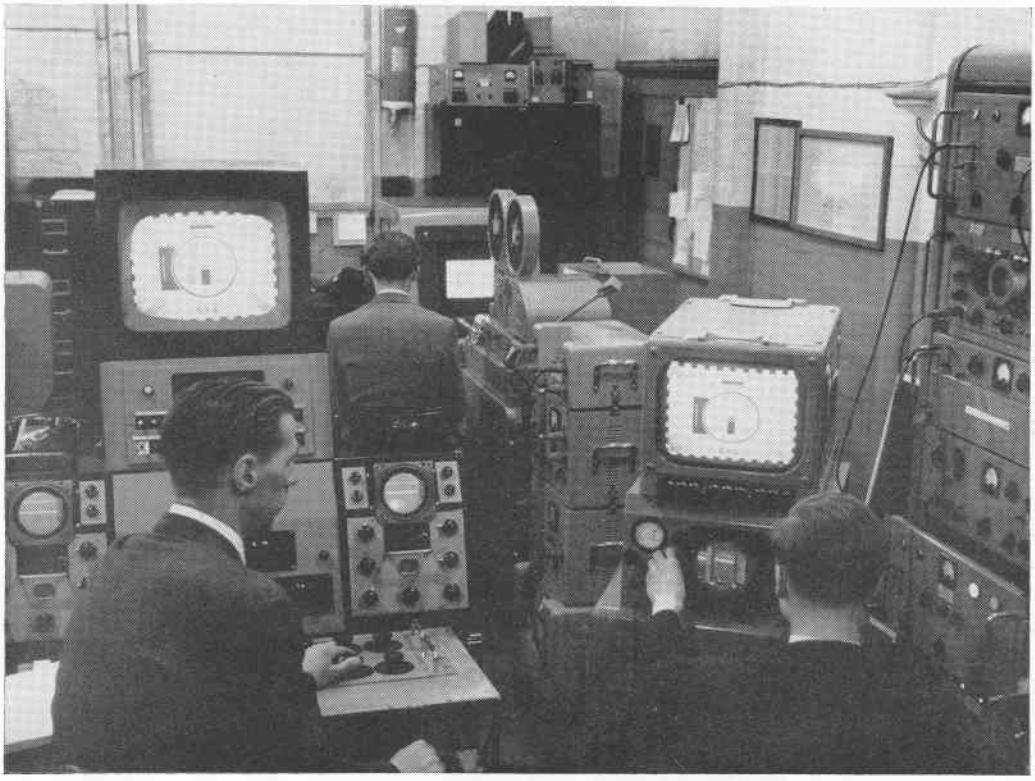
'Inlay' is a process whereby a portion of a television picture is suppressed (to black level), the shape and position of the suppressed portion being determined by an opaque mask placed over the raster of a flying-spot scanning apparatus. The area of the picture that is suppressed can then be filled by a picture from another source. The mask can be of any desired shape and moving masks can be used to produce such effects as 'wipes'; the screen can be divided into two so that two people at different places can be presented side by side, for example, for interview purposes and so on. In the 'Overlay' process, the shape and position of the suppressed part of the picture is determined by the shape and position of a selected part of the second picture which is to be 'overlaid'. The second picture can be a moving one, for example, a man in light clothes in front of a black background, and he can be made to appear as though he is walking across a room. An important feature is that the scale of the pictures from the two sources can be different. For instance, a dancer might be made to appear only two or three inches high and to be seen



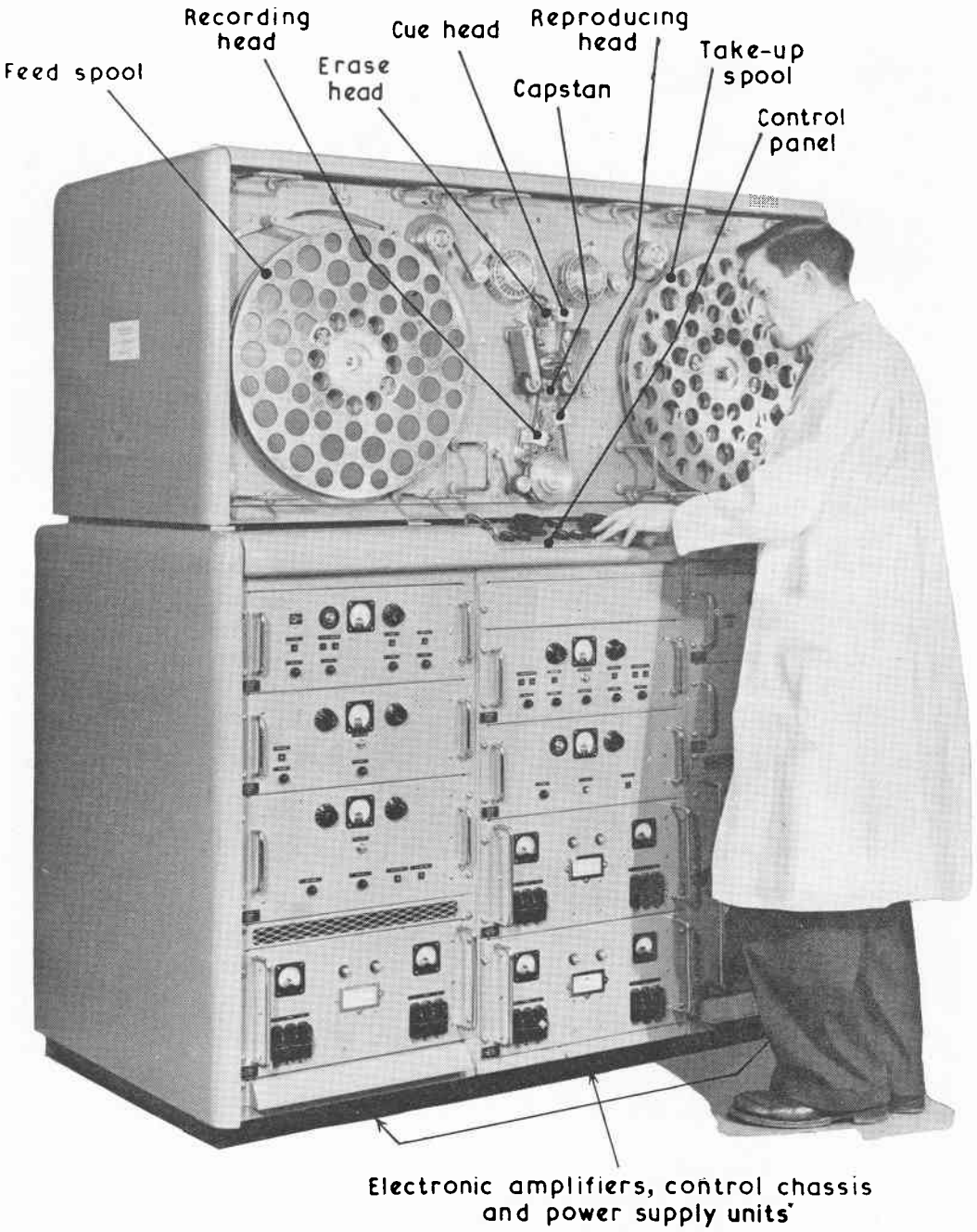
Inlay/Overlay equipment for the production of special effects. An example of its use is illustrated. A portion of the picture from one camera is blacked out by placing a diamond shaped mask over the raster from a flying spot scanner in the centre of the control desk. This space is filled with a caption from a second camera.



Mechau continuous film projector mechanism adapted and used in conjunction with a film camera for telerecording.



The suppressed field telerecording system developed by BBC engineers.



VERA (Vision Electronic Recording Apparatus) designed and built by BBC engineers for recording television programmes on magnetic tape.

picture on the end of a cathode-ray tube. In one of these systems, the Mechau projector mechanism described above (as used in some telecine channels) is made to work as part of a film camera, and serves to hold an image of the television picture stationary, relative to the moving film, for the duration of a complete television picture, i.e. for the duration of two fields.

In another system, known as the suppressed-field system, the picture on the cathode-ray tube is recorded by a normal intermittent type film camera which is run in synchronism with the television field frequency. Since this camera needs about half of each field period to complete the film pull-down and the film cannot be exposed during the pull-down period, it is necessary to suppress each alternate vertical scan (field) of the picture on the cathode-ray tube. The film pull-down takes place during this period of suppression. Thus the recorded picture has a nominal $202\frac{1}{2}$ lines instead of 405, but on the other hand the freedom from the optical inaccuracies of the Mechau projector used in the alternative system results in the two systems giving comparable picture quality.

The equipment described above is designed to use 35 mm film. New 16 mm telerecording equipment using the suppressed field system has been designed and installed by BBC engineers at the Lime Grove Studios.

A more recent method is the stored-field system in which all the lines are recorded. In this system, the alternate vertical scans, which take place during the pull-down period, are not suppressed. The afterglow of the cathode-ray tube is relied upon to store these lines until they are exposed at the same time as the lines which are scanned during the exposure period. It is necessary to provide circuitry which automatically increases the gain of the video amplifier during the scanning of the stored field, in order to compensate for the decay during storage and to ensure that the stored and direct fields have equal intensity when they are exposed together. Since this system records all the lines without the optical complication of the Mechau machine, it can produce recordings of very high quality.

Because of the limitations of the methods using photographic film, the BBC has devoted a great deal of technical effort to the problem of recording television pictures and the accompanying sound on magnetic tape by electrical means. As a result, the BBC Research Department has developed a method of magnetic recording which incorporates special features and has important advantages over other methods. The equipment has been successfully demonstrated in the laboratory and will shortly be put into service. It is known as VERA (Vision Electronic Recording Apparatus).

The picture information in the television system used by the BBC requires a band of frequencies some 3 Mc/s wide. To record television pictures on magnetic tape it is therefore necessary to run the tape across the magnetic recording head at a speed very much higher than that which suffices for normal sound recording. The BBC system uses a tape speed of 200 in/sec (508 cm/sec). The lower part of the frequency spectrum, from approximately 0–100 kc/s is recorded on one magnetic track, using frequency modulation, while the higher frequencies are recorded on a second track. The accompanying sound is recorded on a third track, again using frequency modulation. As the reproducing heads are separate from the recording heads, the machine has the important advantage that continuous monitoring of the picture recorded on the tape can be carried out while the recording is in progress. It also allows the recordings to be easily edited by cutting and joining the tape. A standard grade of magnetic tape $\frac{1}{2}$ in. (1·27 cm) in width is used.

FILM-MAKING FOR TELEVISION

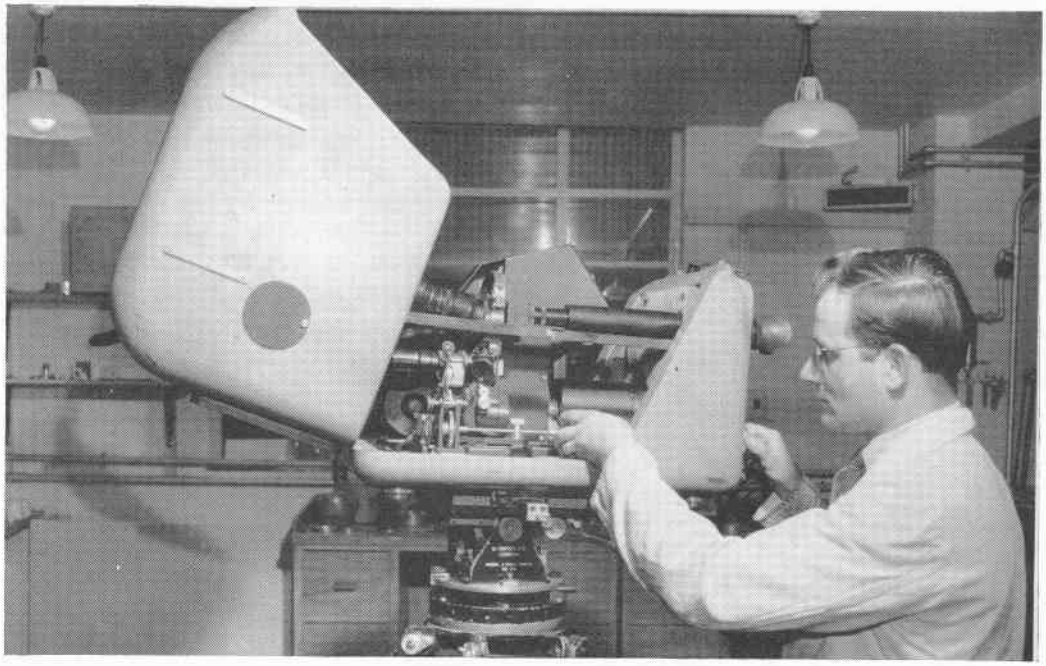
The use of film plays an important part in the BBC television programmes; it is extensively used in documentaries, for sequences inserted into 'live' programmes and, of course, for the News and Newsreel. The headquarters of the Film Department is at Ealing, where the BBC acquired in 1955 the former Ealing Film Studios.

In addition, each of the Regional centres has its own film unit. The Television News Department, which is a part of the News Division, is at present based at Alexandra Palace.

The Film Department normally uses 35 mm film in order to obtain the highest picture quality, but the News Department generally uses 16 mm film because of the need for light and more easily portable cameras. Each of these services is, however, equipped to handle film of either gauge.

The BBC uses some 120 film cameras of 16 different types. These are mostly commercial models, but one notable exception is a double camera developed by BBC engineers in collaboration with a manufacturer. This can expose either 35 mm or 16 mm film, has a reflex view-finder and is equipped for synchronous magnetic recording of sound on sprocketed film.

The Film Department has a need, at times, for light, portable cameras and sound recording equipment; this is met by a method of recording synchronized sound with a portable tape



A double film camera developed by BBC engineers in collaboration with a manufacturer. The camera can handle 35 mm or 16 mm film and is equipped for synchronous magnetic sound recording on sprocketed films.

recorder, using ordinary unsprocketed magnetic tape. In this system, a small 50-c/s alternator is built into the camera and coupled to its drive shaft. This produces an alternating voltage of about one volt which is recorded on the tape with its magnetic lines at right angles to those of the sound, thus providing a synchronizing signal which does not interfere with the recorded sound.

Although this equipment is easily portable, it is necessary to re-record the sound on sprocketed film before cutting and editing can be done. For this reason the News Department (to whom quick editing is important) prefer to record sound directly on the same film that carries the picture. As they often transmit the negative film (with electrical reversal) and a negative optical sound track is unsatisfactory, a magnetic 'stripe' on 16 mm film is generally used; this consists of a continuous thin band of magnetic material deposited on the film beside the picture.

Comprehensive facilities are available for cutting and editing film, some located at the Regional centres, and there are also dubbing and review theatres. The bulk of the film processing is done for the BBC by outside film laboratories.

FILM DUBBING

'Dubbing' is the process of transferring the sound accompaniment of a film from one of the many sound-recording media to another or for adding a commentary to silent parts of the film. This may be necessary for a wide variety of reasons. A documentary film, for example, may be made up of a mixture of interviews (with synchronized dialogue) and silent film shots (where the sound is filled in by a non-synchronous commentary, background music or sound effects).

Recording or reproducing machines for all the forms of sound recording involved in this process must be provided. There are at present some fourteen variations which may be encountered, embracing both 35 mm and 16 mm film. It is also necessary to provide the sound accompaniments of films for export in a wide variety of different forms; for example, although the BBC prefers to use magnetic sound recording on separate sprocketed film of the same gauge as the picture film, many broadcasting organizations abroad are equipped only to handle 16 mm film with an optical sound track combined with the picture film.

At present the different forms of recording and reproducing facilities are dispersed among different BBC premises, but a comprehensive Sound Transfer Suite is being built in the Television Film Studios at Ealing. This is a room containing equipment for recording and reproducing any of the forms of optical or magnetic sound tracks likely to be encountered by the BBC, together with disk reproducers and arrangements for running any combination of the machines in synchronism with one another.

A Film Dubbing Theatre must contain means for looking at a projected picture and recording a spoken commentary or other sound accompaniment at the appropriate moments. Thus the commentator must be provided with a microphone so placed that he can view the film in order to time his remarks accurately. The microphone must also be positioned so that it does not pick up unwanted sounds in the Dubbing Theatre. There must also be a control desk where sound signals from film, tape, disk or any other source can be faded up at the appropriate moments, and a position from which the producer can cue the commentator and the operators of the various sound reproducers.

THE NEW TELEVISION CENTRE

Perspective drawing by Frank A. Weemys of how the colonnade approach to the Main Block will appear on completion.

Drawing was shown at Royal Academy 1956, and at Paris Salon 1957 where it was awarded a Bronze Medal.

OUTSIDE BROADCASTS

Outside broadcasts (generally known as O.B.s) account for approximately one sixth of the BBC's television programme output. A figure like this does not give an adequate impression of the vast amount of effort required to organize and execute these broadcasts. A better idea can be gained by considering the last three months of 1957 during which there were 118 outside broadcast items originating from places as widespread as Brighton, Glasgow, Plymouth, and Dover. A considerable expansion in technical facilities has been needed to enable these broadcasts to be carried out and also to pioneer O.B.s from aeroplanes and helicopters, surface ships, and submarines. These facilities can be classified under two main headings.

(a) The equipment for generating signals embodying all the details (including sound) of the scene being televised.

(b) The means for conveying these signals to an appropriate point on the national network so that they can be broadcast either nationally or to a particular part of the country.

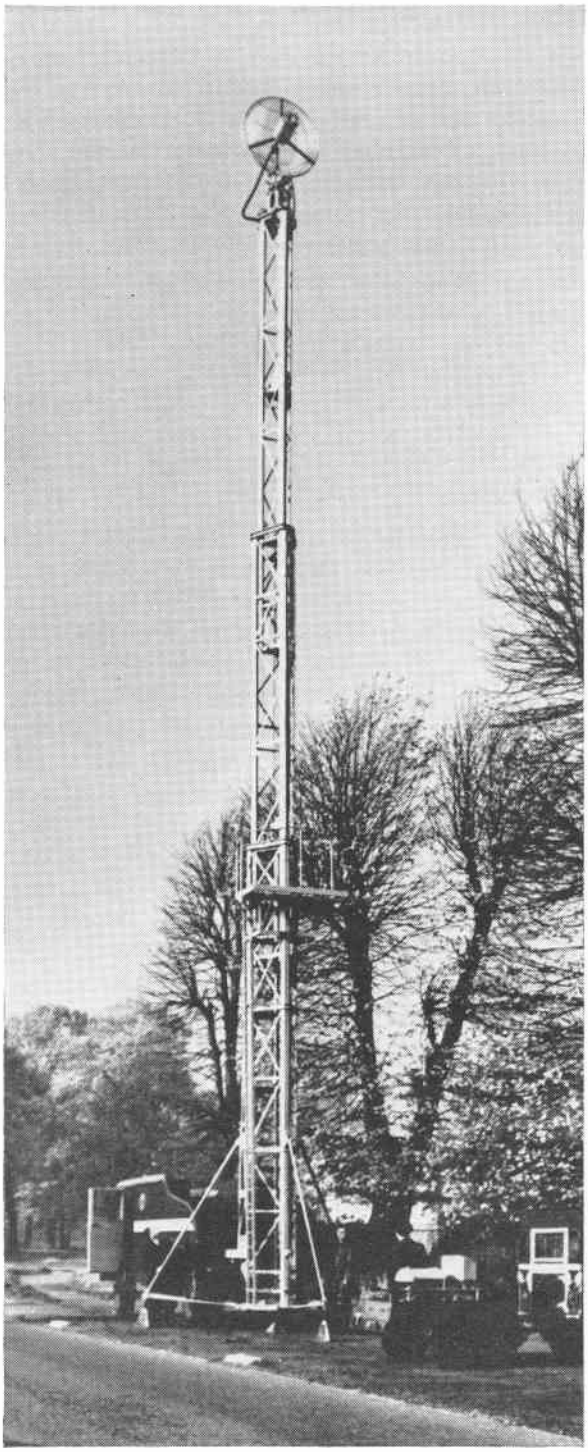
The television signal is generated by up to four cameras in conjunction with a mobile control room which is taken to the scene of the O.B. The mobile control room contains all the technical equipment needed for operating the cameras, including waveform generators, and also accommodates the producer of the programme and his staff as well as engineers. The number of cameras available is normally three and they can be operated away from the vehicle using camera cables up to 1,000 ft in length. The vision control equipment permits cutting, fading or mixing television cameras. Sound equipment is installed to accommodate ten microphones.

The cameras used with the mobile control rooms are exclusively of the Image Orthicon type. There are nine of these mobile units in service, four equipped with 3-inch image orthicon tubes and five with $4\frac{1}{2}$-inch tubes.

The cameras have turrets carrying a number of alternative lenses so that a lens of the desired focal length can be selected quickly. The turrets fitted to the more recent cameras will accommodate lenses of 2 ins. and 40 ins. focal lengths simultaneously as well as two others of intermediate focal length. The cameras also have a 'neutral density' filter with a range of 10 : 1, which, operated in conjunction with a remote iris control from the control vehicle allows scenes of widely different luminance to be televised, while simultaneously permitting control of the depth of field over a greater range of distances than was previously possible.

As an alternative to a lens turret, zoom lenses of various types are used. A zoom lens is one in which the focal length can be altered during transmission, either manually or by means of an electric motor. This changes the magnification of the lens and produces a remarkable subjective effect. For example, a wide-angle, general view of a scene can be changed progressively to a close-up of any selected detail without the picture becoming out of focus. This change can be made as slowly or as quickly as desired. A 5 : 1 range of variation in focal length is provided for; one type of lens provides alternative variations in focal length, either from 4 ins. to 20 ins. or from 8 ins. to 40 ins., the desired range being selected before the assembly is attached to the camera.

Although mobile control rooms are normally operated from the public power supply, mobile power supply vehicles are held in reserve to allow broadcasts to be made from points where no public supply is available. These are equipped with diesel-electric generating sets providing



an output of 18 kVA. Each diesel engine is fitted with an accurate governor for close automatic speed control and can run on full load without refuelling for $7\frac{1}{2}$ hours.

Vision signals from the mobile units are conveyed to the television network in various ways. Permanent vision cable circuits are rented from the Post Office in parts of central London, with extensions to certain places farther out from which O.B.s are frequently taken. Ordinary telephone lines are used for short distances of one or two miles either as 'spurs' to this cable or independently. Elsewhere BBC radio links are used, mostly operating in the Super High Frequency or centimetric band on frequencies of approximately 4,500 Mc/s. These can give a range of about 45 miles over an optical path with a power of 3 watts: greater distances are covered by using two or more links in tandem. The terminal receiving point of a radio link is normally the nearest convenient point on or near to the permanent network, which may, for example, be a tall building in the town where a regional centre is situated, a repeater station on the Post Office network or a BBC

When Radio Links are used for television outside broadcasts it is essential to be able to raise the transmitting and receiving aerials clear of local obstructions and in the minimum time. The Extending Tower vehicle shown lifts the aerial and transmitting equipment to a height of 60 ft.

A radio link vehicle used for television O.B.s. At the front of the vehicle is a VHF aerial receiving vision signals from the mobile unit at the source of the programme and at the rear a microwave transmitter and parabloid aerial re-transmitting the signals to a further receiving point. The Band I aerial receives the television programmes as broadcast for monitoring and cueing purposes.

television transmitting station, provided with SHF receiving aerials on its mast.

Mobile extending-tower aerial vehicles are used with the SHF links to gain height and to enable local obstructions to be avoided.

The transmitting and receiving paraboloid aerials and their associated electronic equipment can be raised by the telescopic extending towers to a maximum height of 60 ft. (18m.) above ground and orientated by remote control on to any required bearing with an error of less than $\pm\frac{1}{2}°$.

Mobile O.B. units are provided in London and in each of the BBC Regions except Northern

The Dover Lifeboat equipped with outside broadcast cameras visits the South Goodwins Lightship. One of the cameras used was of the photo-conductive type chosen for its comparatively small size and weight and seen here being carried aboard the Lightship.

Among the more unusual outside broadcasts was a series involving the transmission of television pictures from a helicopter. An Image Orthicon Camera Channel was used and the vision and sound signals were transmitted to a receiving point on the ground by VHF radio links.

Ireland where there is at present no vision link to the mainland. (A television interview studio has been provided in Belfast which is linked with the Northern Ireland transmitting stations at Divis and Londonderry.) In addition to the mobile control room itself, each unit has a number of auxiliary vehicles to carry cameras, microphones, cables, and radio link equipment.

The units described above constitute, so to speak, the main armament but other equipment is also used for O.B.s. In some circumstances, the equipment already described is too bulky to be accommodated at the site of an O.B. and takes too long to set up and bring into action. The BBC therefore designed a light-weight O.B. unit which became known as the 'Roving Eye'. This is a vehicle 18′ × 10′ × 6′ 9 ins. (5·8 × 3 × 2 m.) equipped with a single camera channel, the camera being mounted so that it can be raised by means of an electric motor through a circular opening in the roof and used while the vehicle is in motion. Radio transmitters working in the VHF Band are installed to convey the vision and sound signals to some convenient fixed point from which they can be taken to the television network in the usual way. The vehicle contains its own power supply equipment, consisting of an alternator driven by a petrol engine. VHF radio circuits are provided between the vehicle and the fixed receiving point for communication purposes; the base-to-vehicle link also carries a 50-c/s signal derived from the public power supply to which the waveform generator in the vehicle is locked. The vision transmitting aerial on the roof of the vehicle is controlled by a gyro-compass so that once the aerial is aligned in a given direction it remains so irrespective of the manoeuvres of the vehicle itself.

The success of the Roving Eye led to the design of a second similar unit equipped with two camera channels, which considerably increased its usefulness. The range of the radio link transmitters was greatly increased, when the unit was used at a fixed point, by the incorporation of a pneumatically operated telescopic mast which could raise the aerials to a height of 45 ft. (13·7 m.). Apart from its 'roving' function, the 2-camera vehicle is often used by itself when the use of the more cumbersome 3-camera O.B. unit (which may need four or more vehicles) is not justified or is inconvenient. It is also used to provide additional camera channels when required, in conjunction with a normal O.B. unit.

EUROVISION

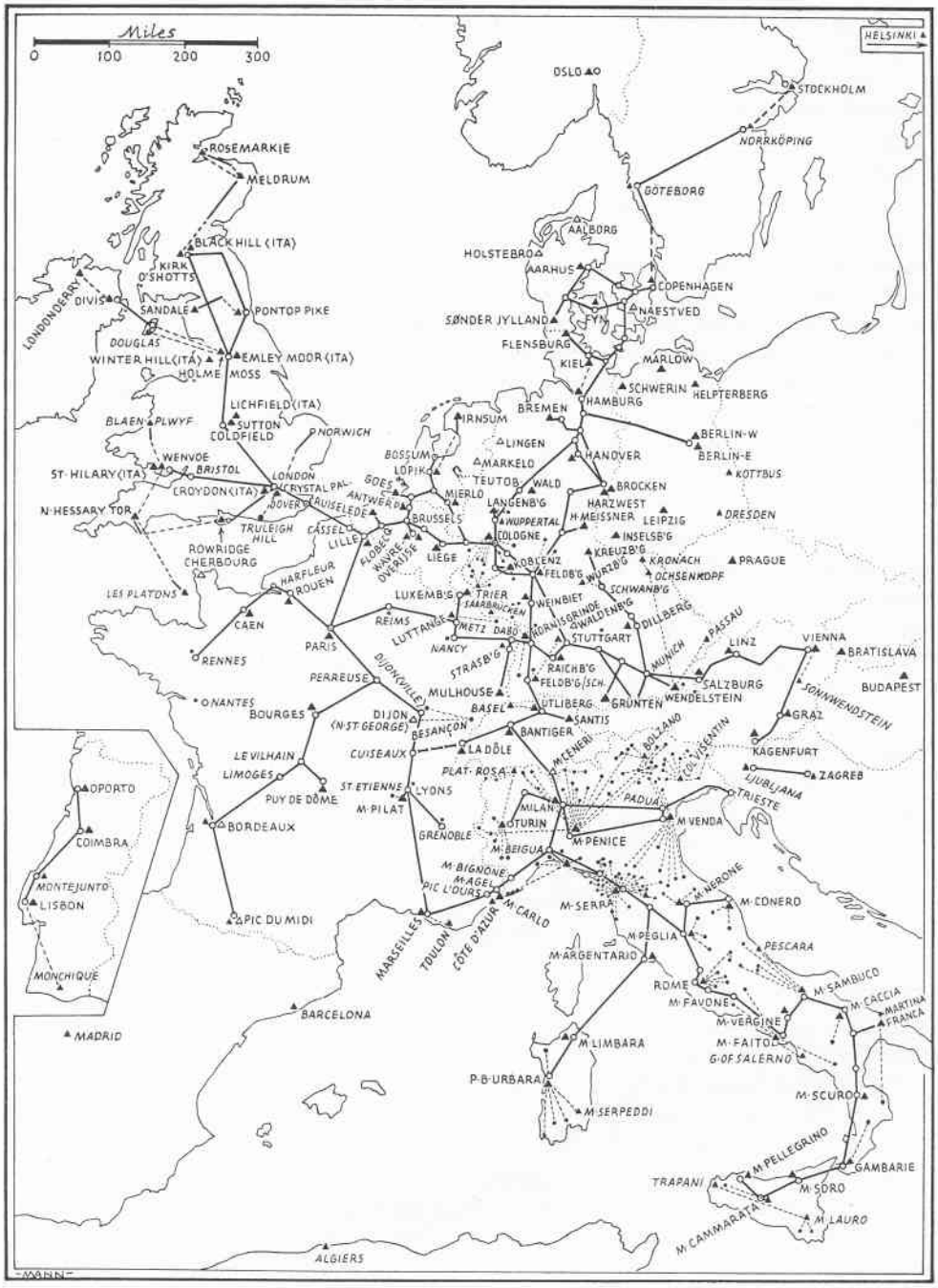
The exchange of television programmes between those European countries which have television services is now taken for granted. Yet only five years ago the Eurovision network did not exist.

In 1952, the BBC in conjunction with R.T.F. in France conceived the bold idea of presenting to viewers in Britain a series of programmes originating in Paris. The technical problems to be overcome were formidable. There was, of course, no circuit in existence capable of carrying vision signals from Paris to London although R.T.F. had an experimental radio link between Paris and Lille. Temporary radio links were set up by the BBC to carry the signals from Lille to the coast, across the English Channel and on to London. (The possibility of linking the French coast with London had previously been demonstrated in 1950, when a BBC Television O.B. unit was sent across the Channel for a programme originating in Calais.) This was the first occasion when a television programme had been transmitted live from one nation to another.

Then there was the problem of the different television standards used in the two countries. The BBC television service uses a 405-line standard while R.T.F. had a 441-line system in Paris and a new system using 819-lines in Paris and Lille. How to convert television signals from one standard to another exercised the minds of BBC research engineers and their French colleagues, but a solution was found on both sides of the Channel. A standards converter designed by the BBC Research Department was installed at Cassel, in northern France, to convert the French 819-line signals to 405-lines; and a French firm produced another which was installed in Paris so that the 441-line transmitter could be fed from the 819-line system. Converters have since been installed at other points in the Eurovision network.

The basic idea of the conversion process is simple; it is to display the picture with the number of lines used in the originating system, on the screen of a cathode-ray tube and to re-scan it with a television camera operating with the number of lines used at the receiving end of the circuit. In practice, much experimental work had to be done to produce a satisfactory converter. In the BBC converter, the tube on which the picture is displayed has a phosphor with a decay time comparable with the time taken to scan a single field of the television image. By this means the television camera is presented with a picture that is virtually continuous during one field. The scanning camera has an Image Orthicon tube.

The next big step forward was in June 1953, when television in Europe had grown to such an extent that viewers in France, Holland, and Western Germany were able to see live pictures from London of the Coronation of Her Majesty Queen Elizabeth II. The temporary linking circuits used at that time have now been replaced to a large extent by permanent networks and the number of countries taking part in the Eurovision exchanges has grown to twelve. In Britain, the Post Office installed in 1955 a two-way coaxial cable vision circuit between London and the coast near Dover, where the present terminal of the cross-channel radio link is situated. A permanent cross-Channel radio link is to be provided by 1958 in conjunction with the French P.T.T., but meanwhile a temporary link is being operated jointly by the BBC and R.T.F. Towards the end of 1957 the BBC installed new standards converters at the British end of the cross-Channel link. These use $4\frac{1}{2}$ inch Image Orthicon Tubes and have reduced to negligible proportions the loss of quality in the conversion process; one converts incoming signals from the 819-line or 625-line standard to 405-lines, the other converts outgoing signals from the 405-line standard to 625-lines.



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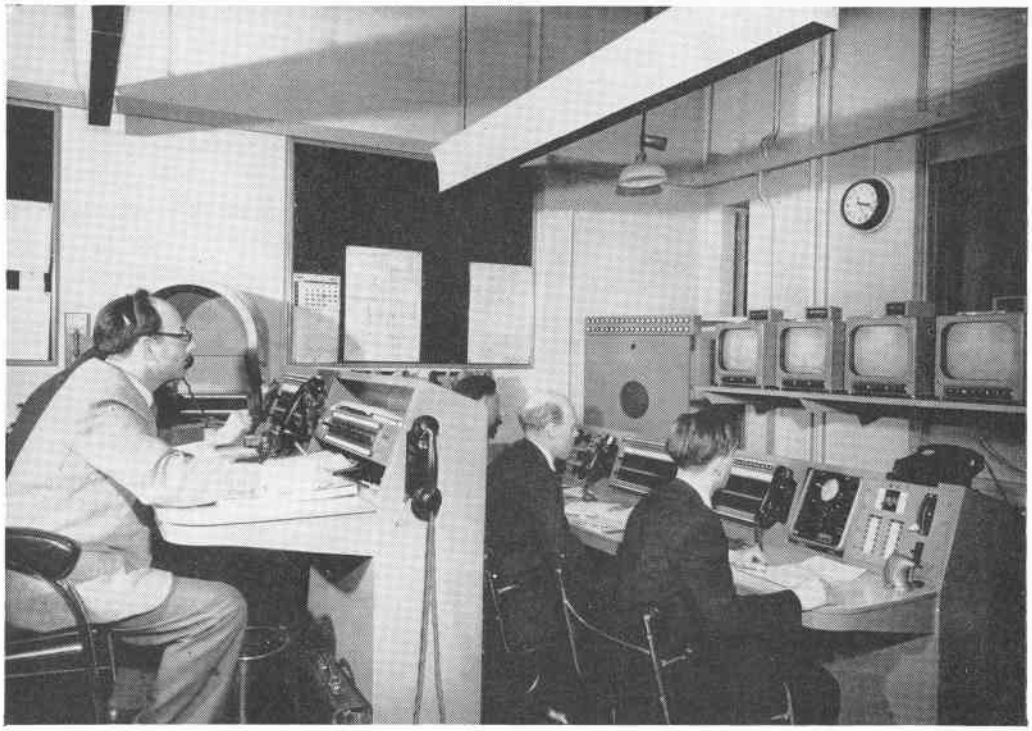
Television Stations in Europe and the Eurovision Network

▲ *Main Stations.* ● *Low-power or Satellite Stations.*



The Continental Control Point in Broadcasting House, London, through which pass the vision and sound signals of Eurovision programmes to and from the United Kingdom.

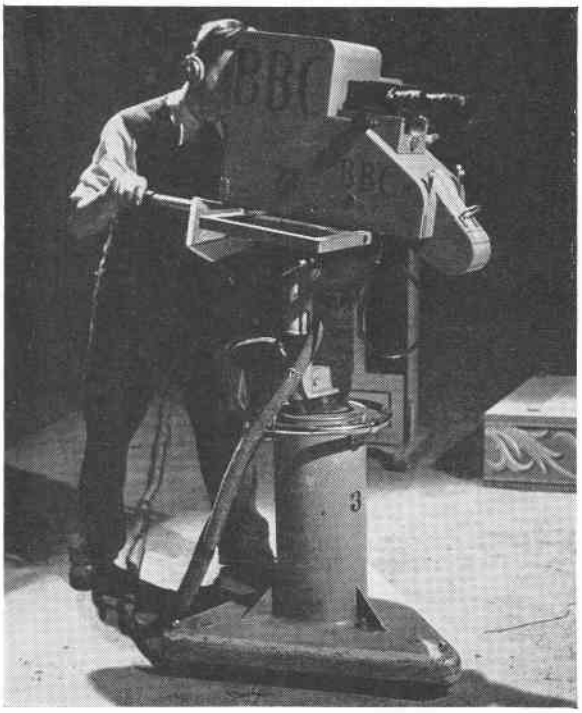
The increase in the number of participating countries and the likelihood of more frequent exchanges of programmes made it essential to have some central co-ordinating body; this function is fulfilled by the European Broadcasting Union. The E.B.U. has established a Eurovision Programme Unit at Geneva and a Eurovision Technical Co-ordination Centre in Brussels. When required, the latter centre, in addition to technical planning, undertakes the supervision and switching of the transmissions.

BEHIND THE SCENES

ORGANIZATION

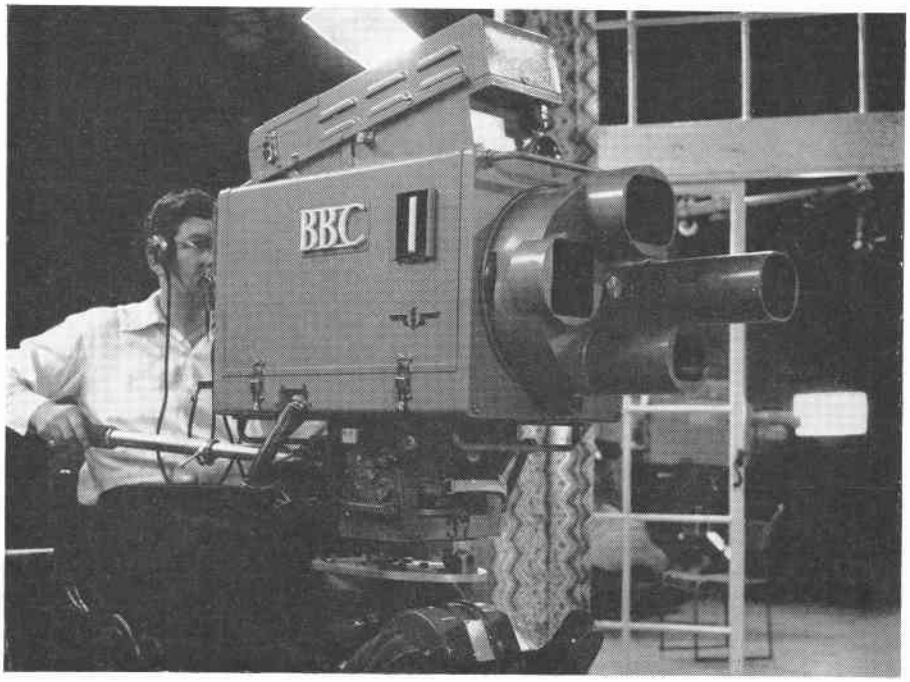
Television studios and transmitting stations are owned and operated by the BBC. Permanent line networks are owned by the Post Office who rent them to the BBC together with temporary lines for outside broadcasts. Radio links used for outside broadcasts are owned and operated by the BBC under licence from the Postmaster General.

Responsibility for the day-to-day operation and maintenance of all the equipment used in originating a programme, that is, studio, telecine, telerecording, and outside broadcasting equipment rests with the Controller, Television Service Engineering, under the technical direction of the BBC's Director of Engineering. The distribution of programmes over the line



An example of a pre-war camera fitted with a single lens and optical viewfinder.

One type of modern camera showing the rotating lens turret, fitted with four lenses of different focal lengths, and an electronic viewfinder.



network is looked after by the BBC Lines Department who work in close co-operation with the Post Office; they also operate and maintain the BBC's television switching centres. Transmitting stations are the responsibility of the Superintendent Engineer, Transmitters, who controls also the transmitters used by the BBC's sound services.

The Television Operations and Maintenance department has two main parts, Studios and Outside Broadcasts. The studio section is responsible not only for operating and maintaining all the electronic equipment used at the studio centres, but also for technical operations (sound and vision mixing, sound balancing, lighting, telecine, and telerecording). The studio section also plays an important part in the planning of new studios and equipment.

SPECIALIST DEPARTMENTS

The Specialist Departments of the Engineering Division carry out research and development, provide the necessary buildings and equipment, and recruit and train staff. They deal with both sound and television engineering.

The Research Department carries out applied research over the whole field of broadcasting, but television has naturally demanded a major part of the available effort since the war. While concentrating mainly on future developments, this department has contributed much to the steady improvement in the present service: planning the location and power of new transmitting stations to give maximum coverage, site testing, transmitting aerial design, performance measurements, picture quality improvement, standards conversion, and improved telerecording systems are some of the immediate results of the department's work.

The Designs Department of the Engineering Division carries out design work over a very wide field and has been responsible for many new ideas in television. Its engineers have played a large part in breaking new ground on outside broadcasts. The Roving Eye, for example,

The two-camera version of the BBC's Roving Eye. Vision and sound signals can be transmitted to a convenient fixed point while the vehicle is on the move. Alternatively, the vehicle can be used as a two-camera static outside broadcast unit. When stationary, the radio link aerial can be raised to a height of 45 ft by means of a pneumatic ram giving greatly increased range.

was a Designs Department product and the department was responsible for the experimental work and adaptation of equipment in connexion with transmissions from aircraft and helicopters in flight, from ships at sea, and from a submerged submarine.

The design and construction of the first inlay and overlay equipment was another of the department's contributions as was the radio microphone. This department has also been concerned with the development of new techniques and equipment for the equalization of television line circuits, involving new pulse-testing methods and the introduction of time-function correction in place of frequency-response equalization.

The Planning and Installation Department is concerned, in the television field, with the technical planning, equipping, and commissioning of television studios, outside broadcast bases, and transmitting stations. This involves the preparation of cost estimates, the handling of contracts, and continuous close technical liaison with manufacturers.

The Equipment Department is responsible for the supply of much of the technical equipment used by the Engineering Division, exceptions being heavy transmitter plant and television camera and control equipment which are the responsibility of the Planning and Installation Department who obtain the equipment from the manufacturers. Most of this equipment is manufactured by outside firms, but where urgency is the keynote, or only a small number of items is required, the construction is undertaken in the Equipment Department, whose workshops are also used for routine maintenance and repair work. The department maintains a Test Room through which new or repaired equipment passes before it is issued. The department is also responsible for the operation of the BBC's transport fleet, which includes many vehicles specially equipped for television work.

The Building Department is responsible for all structural and civil engineering work, and has to interpret requirements for transmitting stations, studios, offices, and other premises, and to provide an economic solution to the problems of relating technical and other needs to aesthetic considerations and site conditions.

The department prepares plans, elevations, and specifications for buildings, draws up specifications for associated services such as lifts, heating, and ventilating systems, etc., and arranges and supervises contracts for carrying out the work. Outside professional advice and assistance is engaged where works are of a size and importance likely to attract wide public interest, and the advice of the Corporation's Consulting Civil Engineer is available in all cases.

The department also prepares specifications for high masts and towers, and arranges contracts for their supply and erection. The maintenance of these buildings, services, and masts are also among the responsibilities of Building Department.

It is important that viewers and listeners should be aware of new developments in the various BBC services so that they can take full advantage of the services available and of technical improvements as they are introduced. The Engineering Information Department therefore provides a service of technical publicity both to the listener or viewer direct and to the press, deals with listeners' and viewers' queries and gives advice on reception problems. The department also arranges with the Post Office for relays of important programmes to and from the United Kingdom all over the world including the sound accompaniment in Eurovision programmes.

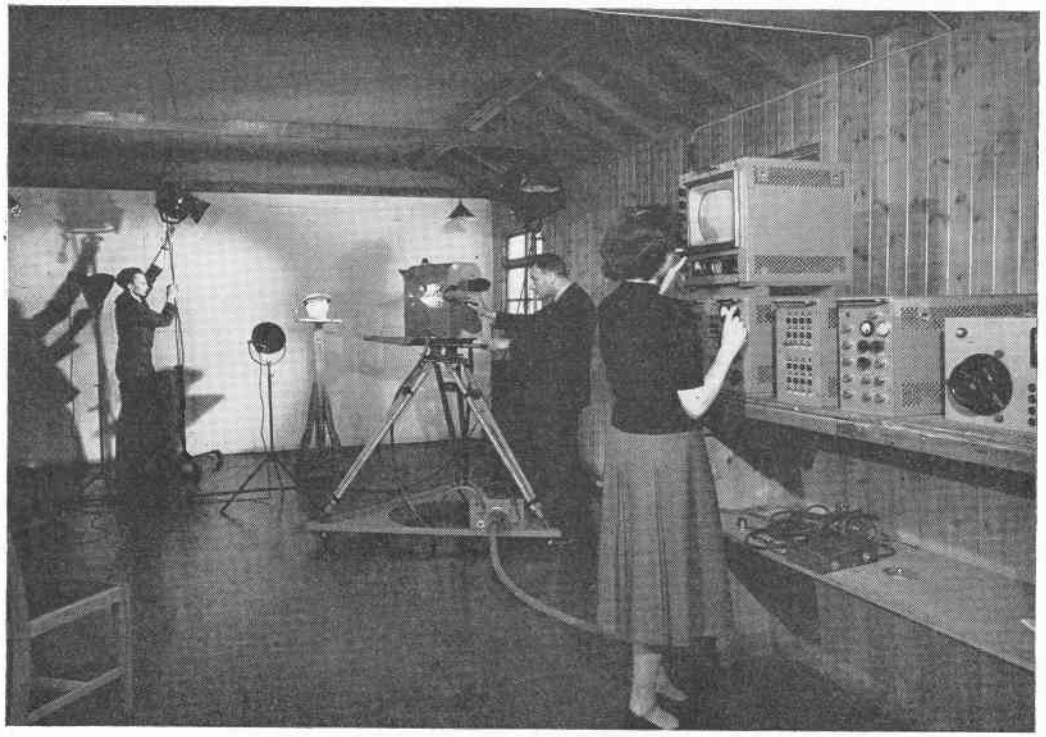
Representation of BBC technical interests is provided by this department both at international conferences and on technical committees and close liaison is maintained with the radio industry, its trade organizations and the Post Office. The department also includes the BBC

Receiving Station at Tatsfield which is responsible for measuring the frequencies of BBC and foreign transmitters, receiving items broadcast from overseas for inclusion in BBC sound programmes, and for watching transmission and reception conditions.

The staff of the Engineering Division is administered by the Engineering Establishment Department. This department is responsible for recruitment and for internal transfers of staff in conjunction with the engineering departments concerned. It is also concerned with co-ordinating the training of staff and with their general welfare, progress, and working conditions.

Technical staff recruited for the Television Service from outside the BBC usually start either as Probationary Technical Assistants or Probationary Technical Operators. After two years service, which is intended to be primarily a training period, there is the possibility of promotion either into the Technical Operator grade or to Technical Assistant and then to the junior engineering grades. Initially, promotion is dependent upon ability, academic progress, and on operational experience; subsequently more senior posts are filled by competition at appointment boards. There is also provision for direct recruitment into the engineering grades by outside candidates possessing the required qualifications, e.g. university graduates.

The training of new staff is achieved partly through practical experience and work under supervision and partly by means of training courses at the BBC's Engineering Training Depart-



Students at the BBC's Engineering Training School receiving instruction in television lighting. Various lighting arrangements are tried out on the model head, on which the camera is trained and the resulting picture is examined on the monitor.

ment. All staff during their first year's service are required to attend a course of training at the Engineering Training School, a fully residential establishment situated near Evesham, Worcestershire. This department provides training in the highly-specialized subject of broadcasting engineering at various levels, from elementary courses for newly-recruited technical assistants and operators to more advanced courses for technicians and graduate engineers. It also runs conversion courses for staff transferred from the sound service and is responsible for writing technical instructions and training supplements, mainly for the use of staff on the operations and maintenance side.

THE CONTINUATION OF TECHNICAL PROGRESS

In the very nature of television there is always something new to do, new problems to be solved, improvements and new developments to be worked out. A lively background organization is, therefore, needed to feed in new ideas and to plan for the future. The BBC has built up such an organization on a considerable scale to ensure that its leading position in the television field is maintained. The senior staff of both the Specialist and the Operations and Maintenance Departments are concerned with this part of the BBC's work.

Technical improvements in television owe much to continuous liaison between the BBC's engineers and the manufacturers of technical equipment used in the Television Service, including makers of television receivers and aerials. In order that manufacturers may gain from the BBC's experience, information is given to them about the behaviour of equipment in service, and specifications are issued covering new designs of equipment. Since the war, manufacturers have enormously improved the design of cameras, introduced lens turrets, and zoom lenses, and improved camera dollies and cranes. The power available from vision transmitters has been trebled, and the e.r.p. increased many times through improved designs of aerial. Temporary radio link equipment used for outside broadcasts has been enormously improved both in range and performance and in reduced size and weight.

The bulk and weight of the conventional television camera is always a disadvantage and particularly so in outside broadcasts. The BBC has, therefore, made use on a number of occasions of industrial cameras using photo-conductive (Vidicon) tubes where the technical quality of the picture is secondary to the need for a physically small and light camera. Outside broadcasts from a submarine and from a lifeboat and lightship are typical examples.

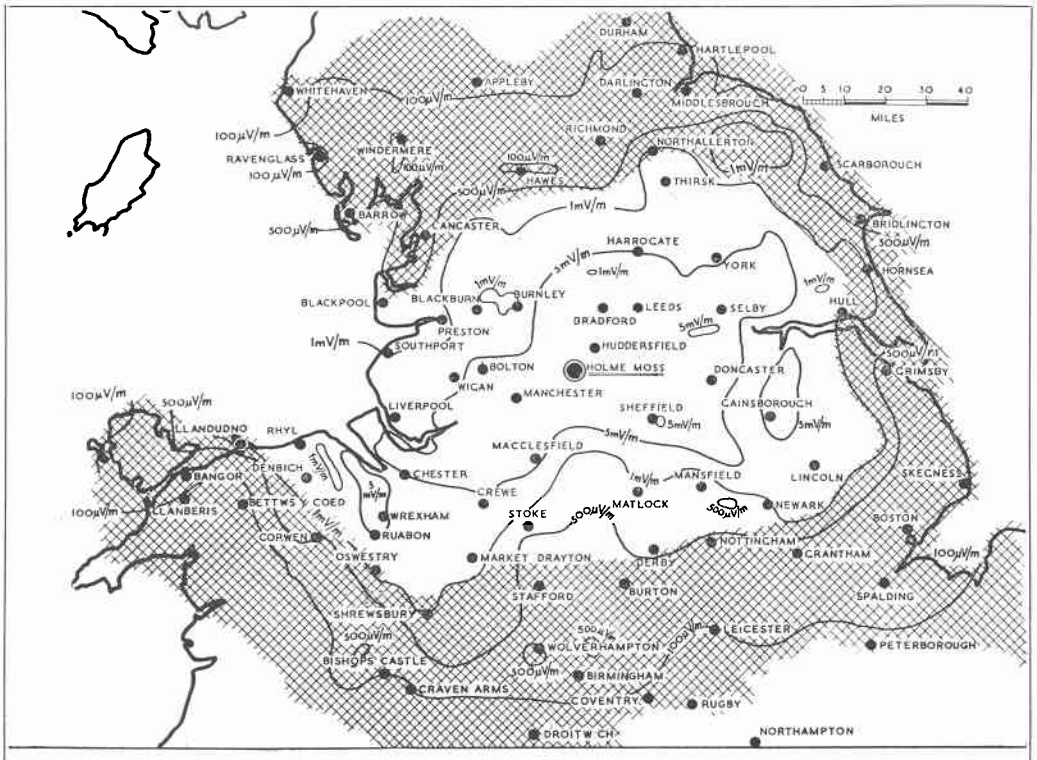
Another feature of this type of camera equipment is the short warm-up period. The equipment is ready for operation within a minute or so of switching on and it is thus eminently suitable for use in remotely-controlled and unattended studios.

Notable improvements in picture quality and presentation have resulted, not only from the use of improved cameras, but also from new equipment and techniques developed by BBC engineers. To quote just two examples, the development and introduction into service of a derivative equalizer, which provides variable correction of both frequency and phase responses, has contributed considerably to picture-sharpening. Equipment has been developed which enables synchronization to be ensured between the pictures from two widely-separated sources, for example, a studio and an outside broadcast. This makes it possible to fade from one service to the other without frame slips or other objectionable effects, to superimpose the two pictures or to use split-screen working in which one half of the screen is occupied by the local picture and the other half by the remote one.

COVERAGE

It is the aim of the BBC to provide a television service covering, as far as possible, all parts of the United Kingdom. This entails the provision of an adequate number of transmitting stations of sufficient power and the means of conveying the television signals to them. It is also important that receivers and aerials should be suitably designed and chosen to suit local conditions; the BBC is in constant touch with the radio industry and the trade on these points.

Already some 98 per cent of the population are within range of the service and this figure will be raised to about 98·2 per cent when additional stations already announced and under construction are completed. To extend the service to the remaining 2 per cent or so presents a very serious economic problem because these people are distributed over a large area, mostly



APPROXIMATE FIELD-STRENGTH CONTOURS
OF THE HOLME MOSS TELEVISION TRANSMITTING STATION

Carrier Frequency = 51·75 Mc/s
Peak White Power = 50·kW (e.r.p. 100 kW)
Receiving Aerial Height 30 ft.

The Field Strength at any given place may differ over a range of ±10 db from the value indicated by the contours, which represent average values. Considerable fading may be experienced in the shaded area.

A typical BBC television field strength map.

in small communities, e.g. in mid-Wales and the Scottish Highlands and outlying islands. A large number of low-power transmitters would be necessary to serve these areas and the cost of building and maintaining them together with the links connecting them to the main network would indeed be formidable. Furthermore, the number of additional transmitters that can be accommodated in Band I without causing interference in areas served by the existing transmitters is very limited. As a possible solution to this problem the BBC is developing an unattended transmitter of very low power which could be used to serve small communities and so to fill in pockets of poor reception.

A series of maps published by the BBC shows the areas covered by the various stations in the form of field strength contours which are of particular interest to the radio industry and trade. First class reception can be expected within the 500 μV/m contour. The outer contour line, representing a field strength of 100 μV/m, indicates approximately the maximum distance from the transmitting station at which satisfactory reception can be expected, but at these greater distances much depends on local conditions. The very high frequencies (very short wavelengths) used for television broadcasting behave in many respects like light waves; that is, they travel more or less in straight lines and cannot penetrate solid obstructions such as hills. Furthermore, just as the beam from a lighthouse cannot be seen beyond the horizon, so the transmissions from a television station tend to be cut off at the radio horizon, which is roughly the distance that can be 'seen' from the transmitting aerial. For this reason, television stations are built wherever possible on high ground and their aerials are supported on tall masts, often as high as 750 ft. (228 m.). This extends the radio horizon and diminishes the shadows cast by hills and man-made obstructions such as gasholders, as well as increasing the field strength.

The radio horizon is not however a rigid barrier beyond which reception is impossible. Some 'bending' of the radiated waves takes place in the atmosphere so that the horizon is effectively extended. The strength at which the transmission can be received at such distances does however vary with atmospheric changes; temperature changes, pressure, and humidity all have an effect and such comparatively long-distance reception is, therefore, characterized by its variability. Sometimes for days at a time, reception may be much weaker or much stronger than normal and short-term fluctuations in strength (fading) are likely. At such times too there may be interference from other stations which are normally too far away to interfere, including BBC television stations in other parts of the country sharing the same frequency channel. The areas in which such variable reception occurs are commonly referred to as fringe areas.

INTERFERENCE

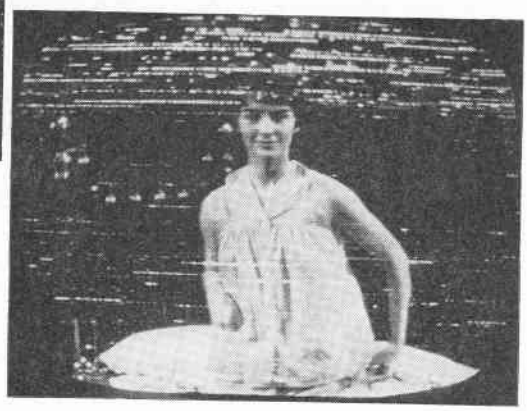
Interference of various kinds may affect television reception. Probably the most widespread form of interference is that caused by the ignition systems of motor vehicles. In the United Kingdom regulations were introduced making it obligatory for all vehicles sold after 1 July 1953 to be fitted with interference suppressors. Older cars are exempt from these regulations, but there have been several publicity campaigns, in which the BBC has taken part, designed to persuade motorists to fit suppressors, in the interest of viewers.

Another common cause of interference is that from domestic and industrial electrical appliances such as refrigerators, sewing machines, hairdryers, and vacuum cleaners; electric light bulbs with faulty filaments can also cause serious interference. In 1955 regulations were introduced to control interference from refrigerators and from domestic and industrial appliances driven by small electric motors. Wherever possible the Post Office persuade the user of an

Motor car ignition interference

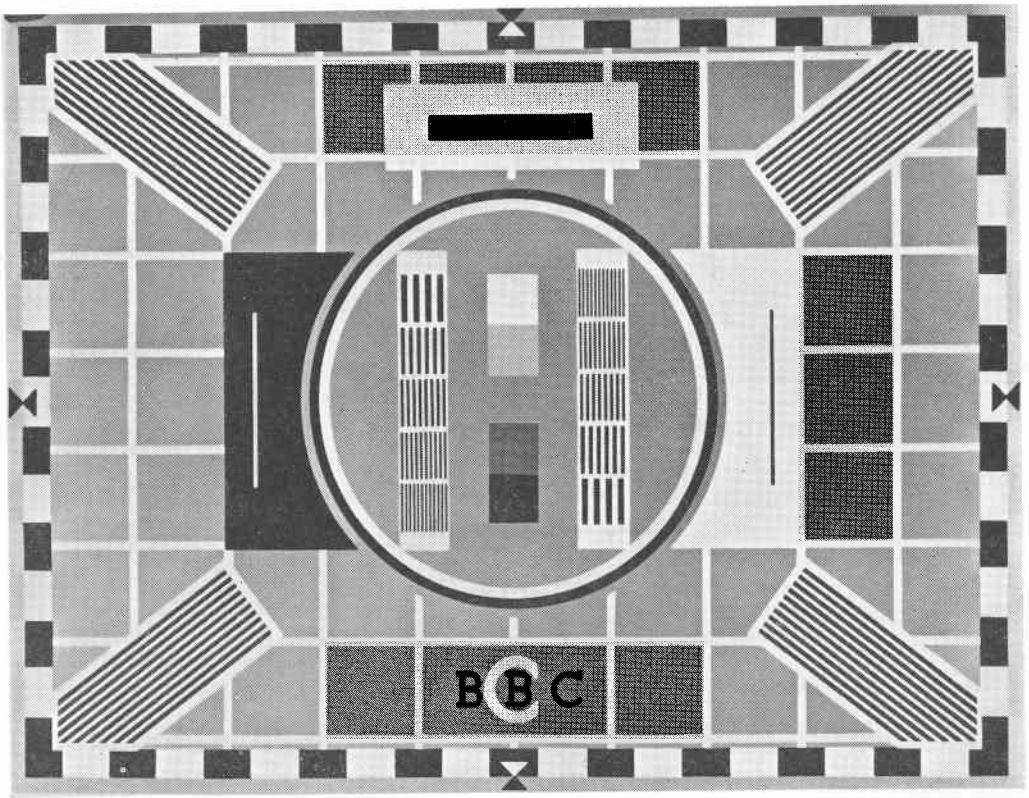
Radio-frequency interference from another transmitting station

Severe 'ghosting' (multi-path reception)



Interference from an electric motor (hairdryer)

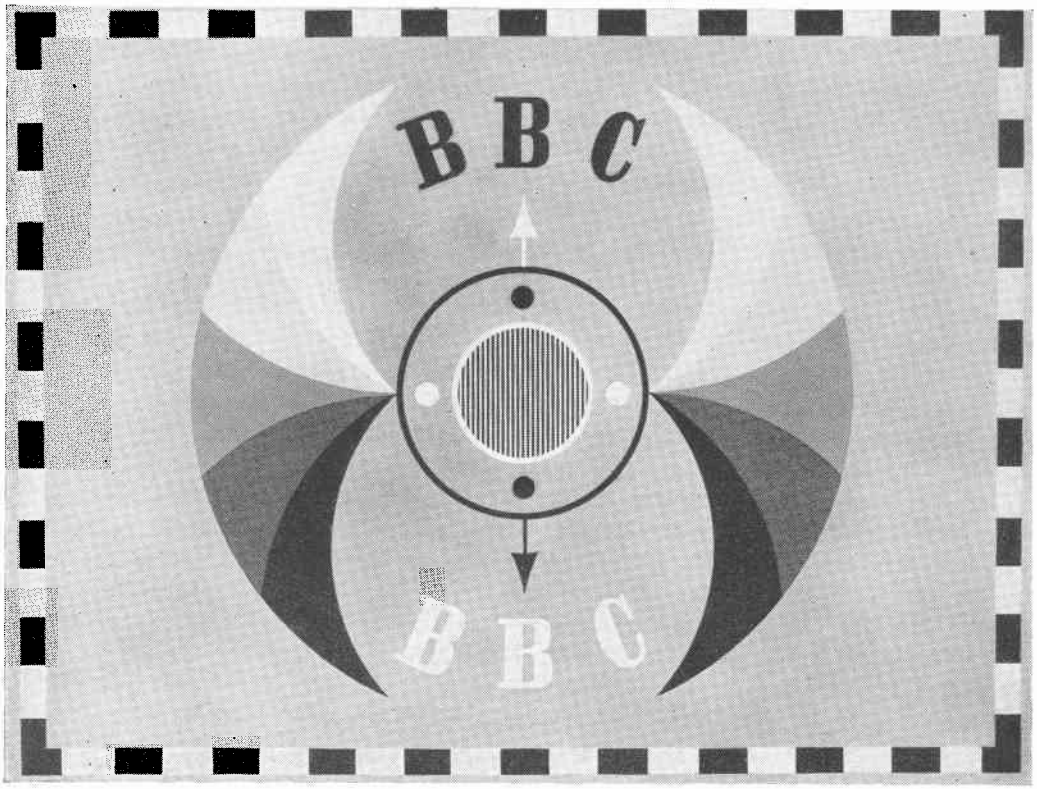
Some examples of interference photographed from the screen of a television receiver.



Test Card 'C' which is radiated each week-day for the benefit of the Radio Industry and Trade.

interfering appliance to have suppressors fitted; only if he refuses to do so are penalties invoked. Interference is also experienced in certain districts from high-voltage overhead power lines.

Another type of interference which is particularly serious in fringe areas is radio-frequency interference due to other transmitting stations, industrial and electro-medical apparatus, or radiation from nearby radio or television receivers. These produce a pattern on the screen, as distinct from the spots caused by most other types of interference. Included in this category is long-distance interference propagated via the ionosphere. During 1957 and 1958 in particular, solar activity reached an extremely high level resulting in ionospheric propagation at unusually high frequencies; as a result many local radio services in the U.S.A. were received at considerable strength in the United Kingdom. Some of these services operate on frequencies falling within the BBC's Channel I and severe interference was experienced both on sound and vision in some areas. Another source of serious interference was the 'forward scatter' transmissions, used as a means of communication between other countries and the United Kingdom. These stations operate on frequencies close to those adopted by most manufacturers for the Intermediate Frequencies of television receivers.



The BBC Tuning Signal which is radiated at the start of each programme period to help viewers in adjusting their receivers.

In general there are three things that the viewer can do if his reception is seriously marred by interference:

Most television receivers incorporate interference limiters in both the sound and vision circuits, the vision limiter usually being adjustable as a 'pre-set' control. By turning the appropriate knob the interference can be reduced considerably, but a point will be reached beyond which the quality of the picture will be spoiled. Just short of this point is usually the optimum setting.

The use of an efficient outdoor aerial will almost always improve the signal to noise ratio and a highly directional type may give considerable relief when interference comes mainly from a direction different from that of the television station being received. Interfering radio-frequency signals are not necessarily confined to the channel to which the receiver is tuned. They may, for instance, enter the receiver at the intermediate frequency and, as with all receivers of the superheterodyne type, there is also the possibility of second-channel interference. Such interference can often be eliminated by the use of an appropriate filter connected to the aerial socket of the receiver.

When all reasonable steps have been taken by the viewer and interference from electrical apparatus is still severe, the aid of the Post Office Interference Investigation Branch may be obtained by completing a form (No. T113W) obtainable at most main Post Offices. The service which the Post Office provides aims at locating the source of the interference and if possible having interference suppressors fitted to the offending equipment. Advice is also given to the viewer on steps he himself can take to reduce the interference.

ADJUSTING THE RECEIVER

The radio retailer when installing a new receiver should carry out all the initial adjustments and leave the set in first-class operational condition. Adjustments which the viewer will be called upon to carry out should, therefore, be confined to those needed in the normal operation of the receiver, with perhaps minor adjustments to the pre-set controls over a long period. The purpose of the various controls is usually explained fully in the manufacturers' instruction booklet, but where the viewer is in difficulty, he should seek the advice of his radio dealer.

The BBC is anxious that viewers should obtain the best possible reception of its programmes, and the Engineering Information Department is always willing to give advice through the medium of correspondence. The BBC also transmits a tuning signal at the start of each transmission period to help viewers in adjusting their receivers; a free leaflet is available explaining how to use the Tuning Signal when carrying out adjustments.

For the benefit of the Radio Industry and Trade, a more complex text pattern known as Test Card 'C' is transmitted for considerable periods each week-day; a leaflet explaining the significance of the various patterns is also available on application.

Viewers who live in areas where reception is difficult should seek the advice of an experienced radio retailer when having a new television receiver installed. Some modern receivers are particularly suitable for use in such areas, incorporating automatic picture control and 'flywheel' synchronization which help to keep the picture steady under adverse conditions. The use of a multi-element aerial erected as high as possible above ground will increase the available signal at the receiver input and decrease 'noise' on the picture as well as reducing outside interference. Echoes or 'ghost-images' can also be reduced or eliminated by careful positioning and alignment of a directional aerial. If the aerial is some distance from the receiver there may be a noticeable loss of signal in the feeder cable between the aerial and the receiver. The expense of a low-loss type of feeder cable may then be well justified because of the improvement in signal-to-noise ratio.

LOOKING TO THE FUTURE

THE NEW TELEVISION CENTRE

One of the major projects on which the BBC is engaged is the new Television Centre now under construction near Shepherds Bush in West London. This development has already been described on page 22 together with a photograph of a model showing how the Centre will look when completed. Provision has been made in the studios under construction and planned for possible future developments such as the introduction of a second BBC programme and the transmission of colour.

COLOUR TELEVISION

The BBC has done a great deal of preparatory work on colour television starting as long ago as 1946, in the laboratories of the Research Department. Close liaison has been maintained throughout these experiments with the Television Advisory Committee (a committee appointed by the Postmaster General to advise him on the development of television and sound broadcasting at frequencies above 30 Mc/s) and with the Post Office and the Radio Industry. Since

BBC Experimental Colour Television transmissions. A view of the studio at Alexandra Palace showing the two three-tube colour cameras.

1955, the Research and Designs Departments have collaborated in a series of experimental transmissions, begun on the BBC's initiative, first from Alexandra Palace and latterly from the new high-power station at Crystal Palace. To enable these test transmissions to be carried out, the BBC has equipped a colour television studio at Alexandra Palace. This studio and its control room contain all the apparatus necessary for the origination of a colour picture using a 16-mm scanning equipment for films or slides built by the BBC, a 35-mm commercial film scanner, and a colour camera channel with two studio cameras.

The colour television system which is being used for these tests is a modified form of the N.T.S.C. (National Television Systems Committee) system now in use for public service in the United States of America. As the system has been adapted to the British 405-line television standards the experimental transmissions can be made by a transmitter which is used for the normal monochrome service without changing its frequency channel. The purpose of these transmissions is:—

1. To provide a source of high-grade colour picture signals so as to permit colour receiver development work to continue.
2. To enable further experience to be gained in the operation of a colour studio and other colour television equipment.
3. To obtain further knowledge of the compatibility of the modified N.T.S.C. system.
4. To investigate further the problems of receiving and transmitting colour pictures.

The data obtained from these experiments are being made available to the Television Advisory Committee. The tests of the compatability of the system began in October 1955 and those involving also an appreciation of the colour picture itself in November 1956. In April 1956, the BBC in co-operation with the Post Office and the Radio Industry, arranged for a visit of Study Group XI of the C.C.I.R. (Comité Consultatif International des Radiocommunications) which is making an international appraisal of progress in colour television. At the request of the Postmaster General the BBC arranged in January 1957 a demonstration of colour television reception for Members of both Houses of Parliament. The experiments continue.

A detailed analysis and appreciation of the results so far obtained has been published as a BBC Engineering Division Monograph, No. 18, which has been brought to the attention of the Television Advisory Committee and of the C.C.I.R. It is also on sale to the public.

TELEVISION IN THE ULTRA-HIGH FREQUENCY BANDS

In the United Kingdom, television broadcasting is at present restricted to Bands I and III and Band I is already overcrowded with stations. In order to examine the practicability of using higher frequency bands in the future, the BBC has carried out extensive work in the laboratory followed in 1955 by a first series of U.H.F. propagation experiments. These were directed towards the investigation of propagation on frequencies between 470 and 960 Mc/s over distances representing a normal service area, and over longer distances to obtain data necessary for the evaluation of co-channel interference.

Low-power transmitters modulated with square waves or pulses, were used for these experiments. Although the transmitters themselves have been obtained from outside manufacturers it has been necessary for the BBC to design and make a variety of the equipment needed, including transmitting and receiving aerials, receivers and measuring equipment. The long-distance propagation experiments are continuing.

Part of the Colour Control Room which also contains colour film and slide scanners.

The information obtained about the service area to be expected from a U.H.F. transmitter has been completed and the results are being studied. The information collected in this way was, however, insufficient to determine fully the suitability or otherwise of Bands IV (470–585 Mc/s) and V (610–960 Mc/s) for television broadcasting in the United Kingdom. Early in 1957, the BBC, at the request of the Television Advisory Committee, decided to embark on a more ambitious series of experiments using high-power transmitters radiating both vision and sound signals, initially on 405-lines and later on 625-lines (C.C.I.R. standard) for comparison purposes. These tests have been planned by the BBC in co-operation with the Television Advisory Committee and the Radio Industry. A 10-kW peak-white vision transmitter and a $2\frac{1}{2}$-kW sound transmitter have been installed at the Crystal Palace television station for the purpose together with a helical aerial at the top of the 708-ft tower producing an e.r.p. (vision) of 125 kW.

Comprehensive studies of the received pictures have been organized both at fixed points and in specially equipped vehicles. The tests began on 11 November 1957.

So the BBC looks to the future. It is our constant endeavour to improve the technical quality of the existing service, to ease reception problems where they still exist and to provide those whose task it is to conceive and produce the programmes with the best technical facilities that can be devised. BBC Television never stands still. Who knows what possibilities will be opened up by engineering research and development in the next twenty-one years?

SOME IMPORTANT DATES

IN THE DEVELOPMENT OF BBC TELEVISION

1936	2 NOV	High-definition television service officially inaugurated from Alexandra Palace. The Baird system and the Marconi-E.M.I. system were used on alternate weeks. Coverage, 25 per cent of the population of the United Kingdom.
1937	5 FEB	The Postmaster General announced that a single set of standards (those of the Marconi-E.M.I. system) would be used from then on.
	12 MAY	First television Outside Broadcast: Coronation Procession of King George VI.
1939	1 SEP	Television Service closed down prior to outbreak of war.
1946	1 JUN	Broadcast receiving licence increased to £1 for sound; licence for television and sound introduced at £2.
	7 JUN	Television Service resumed, using pre-war system with 405-lines.
1947	4 JUN	BBC announced acquisition of site for first television transmitting station outside London, at Sutton Coldfield near Birmingham.
1948	24 AUG	The Postmaster General announced that the existing 405-line system would be used for the Sutton Coldfield transmissions and would continue to be used at Alexandra Palace for a number of years.
1949	17 DEC	Sutton Coldfield television station opened. Coverage increased to 46·5 per cent of the population.
1950	3 APR	Aspect ratio of transmitted picture changed from 5 : 4 to 4 : 3 to bring it into conformity with standards adopted elsewhere.
	17 MAY	BBC announced acquisition of 13-acre site at the White City, Shepherds Bush, for a television and sound broadcasting centre.
	21 MAY	Lime Grove Studio Centre brought into use.
	27 AUG	First BBC television Outside Broadcast from outside the United Kingdom (Calais).
	30 SEP	First 'live' air to ground television broadcast (from an aircraft in flight).
1951	14 MAR	The Assistant Postmaster General announced the postponement of the five medium-power television stations planned for N.E. England and the Aberdeen, Belfast, Plymouth, and Southampton districts.
	12 OCT	Holme Moss television station opened. Television coverage increased to 65 per cent of the population.
1952	14 MAR	Kirk o'Shotts television station opened.
	8 JUL	First public transmission in the United Kingdom of television from Paris.
	15 AUG	Wenvoe television station opened. Television coverage increased to 81 per cent of the population.

1953	1 MAY	Pontop Pike and Glencairn (Belfast) temporary television stations opened.
	9 MAY	Truleigh Hill temporary television station opened.
	2 JUN	Coronation Ceremony televised for first time. Also seen by viewers in France, Netherlands, and Western Germany.
	15 JUN	First television relay from ship at sea (Royal Naval Review, Spithead).
	15 OCT	Television Theatre brought into service (formerly Shepherds Bush Empire).
	20 DEC	Douglas, Isle of Man, temporary television station opened.
		Television coverage increased to 86 per cent of the population.
1954	27 JAN	Television Centre (Scenery Block) brought into use.
	1 JUN	Television and sound combined licence increased to £3.
	6 JUN–4 JUL	First European exchange of television programmes with eight countries taking part (United Kingdom, Belgium, Denmark, France, Netherlands, Italy, Switzerland, and Western Germany).
	12 NOV	Rowridge temporary television station opened.
	14 DEC	Redmoss temporary television station opened.
	17 DEC	North Hessary Tor temporary television station opened.
		Television coverage increased to 91 per cent of the population.
1955	1 FEB	Norwich television transmitting station opened. (Temporarily on reduced power.)
	21 JUL	Divis television transmitting station opened (replacing Glencairn in Northern Ireland) (see 1.5.53).
	15 SEP	First section of permanent two-way television link with Continent completed (between London and St. Margaret's Bay).
	3 OCT	Les Platons (Channel Islands) television transmitting station opened.
	10 OCT	Colour television test transmissions began from Alexandra Palace.
	12 OCT	Meldrum television transmitting station opened (replacing Redmoss, near Aberdeen). (See 14.12.54.)
	15 NOV	Pontop Pike television transmitting station completed. (See 1.5.53.)
	25 NOV	First 'live' television broadcasts from Ireland (Belfast and Dublin).
		Television coverage increased to 93·5 per cent of the population.
1956	28 MAR	Crystal Palace television transmitting station opened (replacing Alexandra Palace).
	22 MAY	North Hessary Tor television transmitting station completed. (See 17.12.54.)
	4 JUN	First transmission from Riverside, Hammersmith, television studios.
	11 JUN	Rowridge television transmitting station completed. (See 12.11.54.)
	16 JUN	First 'live' television broadcast from a submarine at sea.
	4 AUG	First television transmission from a helicopter.
	5 NOV	The first series of experimental colour television transmissions to include 'live' pictures from Alexandra Palace studios and Crystal Palace transmitter began.

	5 NOV	Sandale temporary television transmitting station opened. Television coverage increased to 97·5 per cent of the population.
1957	30 and 31 JAN	Demonstration of colour television transmission to Members of both Houses of Parliament.
	29 APR	Blaen-plwyf television station opened.
	1 AUG	Sound and television combined licence raised to £4 (i.e. £3 plus £1 excise duty).
	16 AUG	Rosemarkie television transmitting station opened.
	29 OCT	First BBC unattended television studio brought into use at St. Stephen's House, opposite the House of Commons.
	11 NOV	Experimental television transmissions started in Band V on 405 lines, from Crystal Palace.
	12 DEC	Douglas, Isle of Man television transmitting station completed. (See 20.12.53.)
	18 DEC	Londonderry television transmitting station opened. Television coverage increased to 98 per cent of the population.
1958	14 APR	First use of VERA (Vision Electronic Recording Apparatus) for magnetic recording of television pictures.
	21 APR	Dover television transmitting station opened.
	5 MAY	Experimental television transmissions started in Band V on 625-lines, from Crystal Palace.

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