BBC

SOUND BROADCASTING

ITS ENGINEERING DEVELOPMENT

PRICE 5s.

BBC
SOUND BROADCASTING

Its Engineering Development

PUBLISHED TO MARK THE 40TH ANNIVERSARY
OF THE BBC

AUGUST 1962

THE BRITISH BROADCASTING CORPORATION

Forty Years of BBC Sound Broadcasting

Regular public service sound broadcasting was started in the United Kingdom by the British Broadcasting Company, later to become the British Broadcasting Corporation, on 14 November 1922. The publication of this booklet describing the engineering development of the service marks the fortieth anniversary of that occasion. From the modest but enthusiastic beginnings in 1922, with equipment that was not specifically designed for broadcasting, BBC engineers and the British Radio Industry have made continuous progress in the development of the modern equipment and techniques now used for the BBC's programme services for listeners in this country and for the world-wide transmissions of its External Services.

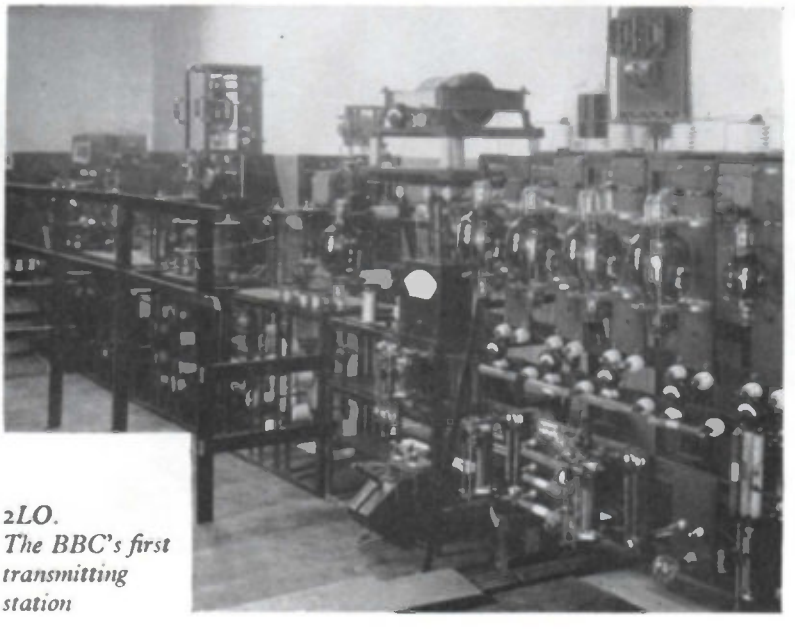
CONTENTS

THE BEGINNING OF BROADCASTING IN THE UNITED KINGDOM (UP TO 1939)

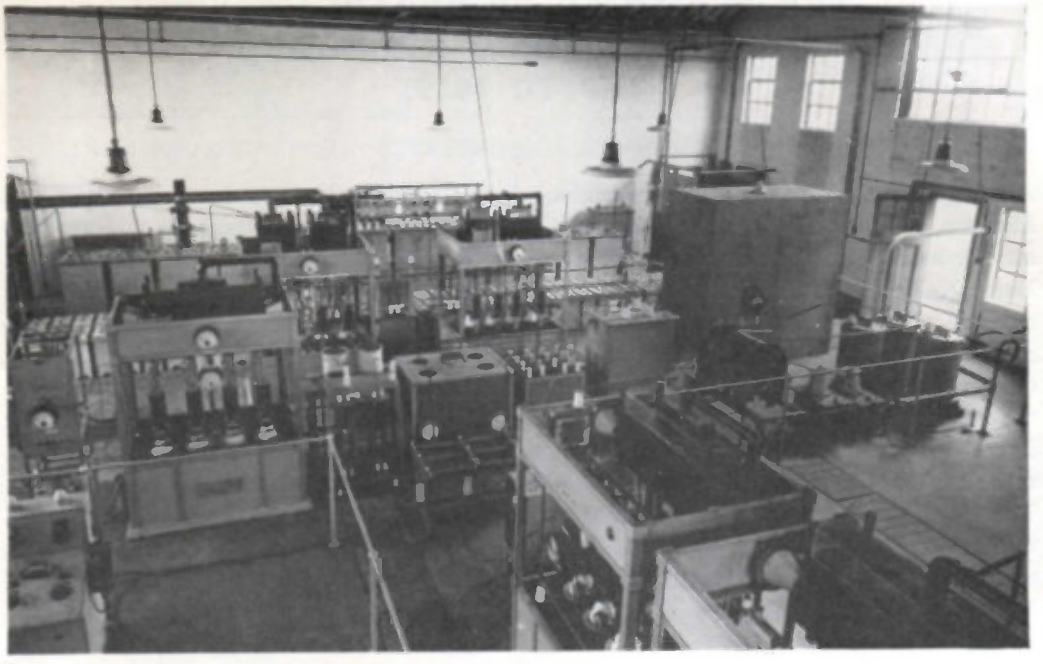
Although nightly experimental transmissions from Chelmsford were carried out by W. T. Ditcham, of Marconi's Wireless Telegraph Company, as early as 1919, perhaps 15 June 1920 may be looked upon as the real beginning of British broadcasting. It was on that date that Dame Nellie Melba broadcast from Chelmsford—it was claimed that the transmission was received as far away as St. John's, Newfoundland. During 1921 many representations, arguments and counter-arguments for permission to broadcast were made to the Postmaster General by amateurs, radio societies, and manufacturers of radio equipment. On 13 January 1922 the Postmaster General authorized Marconi's to include fifteen minutes of speech and music in the weekly transmission from their station 2MT (known affectionately as '2 Emma Toc') at Writtle near Chelmsford and the first regular British broadcasts started on the following day. The station was operated by a team of enthusiastic engineers, headed by Capt. P. P. Eckersley, who also produced the programmes. Other radio equipment manufacturing organizations, together with a few scientific amateurs, had also been carrying out research in the field of broadcasting.

THE BRITISH BROADCASTING COMPANY

To provide a regular service for the growing number of listeners the Postmaster General granted a licence to the British Broadcasting Company, which was formed by a number of



2LO. The BBC's first transmitting station



Daventry 5XX. The BBC's first long-wave station built in 1925 *and in regular use up to October* 1934

BBC London Transmitter on the roof of the Selfridge building in Oxford Street (1925)

radio manufacturers. Programmes began on 14 November 1922 from London (2LO) and the next day from Birmingham (5IT) and Manchester (2ZY). Within the next year stations were also opened at Newcastle, Cardiff, Glasgow, Aberdeen, and Bournemouth. A station in Belfast was opened in 1924. Each of these nine 1½-kW stations could be heard during daytime over a range of twenty miles or so by listeners with crystal sets and headphones and over considerably greater distances after dark. The Company's income was derived from royalties on receiving equipment (discontinued in 1924) and money from receiving licence fees.

The station staffs were real pioneers working long hours often under very difficult conditions and with equipment that had not been specifically designed for broadcasting. Nevertheless, within a few months 4½ hours of programme were transmitted daily to an audience of some tens of thousands of listeners and in December 1922 for the first time—regularly from May 1923—interlinking lines rented from the Post Office enabled News Bulletins read in London to be broadcast simultaneously from the other stations. The delays caused by sending the news items to each of the stations separately and reading them locally were thus eliminated.

Ten low-power (¼ kW) relay stations each linked to a main station were opened during 1924 and by then 60 to 70 per cent of the United Kingdom population was within reach of the transmissions. A further stride in achieving better coverage was made on 27 July 1925 when a 25-kW long-wave transmitter (5XX) was brought into operation at Daventry. This transmitter carried an alternative programme, which included weather forecasts and gale warnings, and increased to about 80 per cent the total population within reach of a BBC transmitter.

On 6 April 1925 the London transmitter (2LO), which until that time was in Marconi House, was replaced by one of higher power operating from the roof of the Selfridge building in Oxford Street.

THE BRITISH BROADCASTING CORPORATION

During 1926 two important events occurred which were to have far-reaching effects upon the future of British broadcasting: the Report of the Crawford Committee on Broadcasting was published and the International Broadcasting Union in its Geneva Wavelength Plan reduced the number of wavelengths available to the British Broadcasting Company. The Report of the Crawford Committee was taken into account in the formulation of the Royal Charter and Licence and of the Agreement under which the Company's successor—the British Broadcasting Corporation—was to continue and develop broadcasting from 1927 onwards. One of the effects of the reduction in the number of wavelengths was to stimulate efforts to greater economy in the use of the available channels. This was achieved in 1926 by operating more than one transmitter on the same wavelength. The licence of the British Broadcasting Company expired on 31 December 1926 and the Company was dissolved. On 1 January 1927 the British Broadcasting Corporation was constituted under a Royal Charter for ten years.

STUDIO DEVELOPMENT

After the move in May 1923 to Savoy Hill from Marconi House where there had been only one studio, the studio facilities were steadily increased. By the end of 1923 there were two studios in use with a small control room. During the next three years further general purpose and small news-reading studios were opened bringing the total number to nine.

The early studios, at Marconi House and at Savoy Hill, were usually treated acoustically

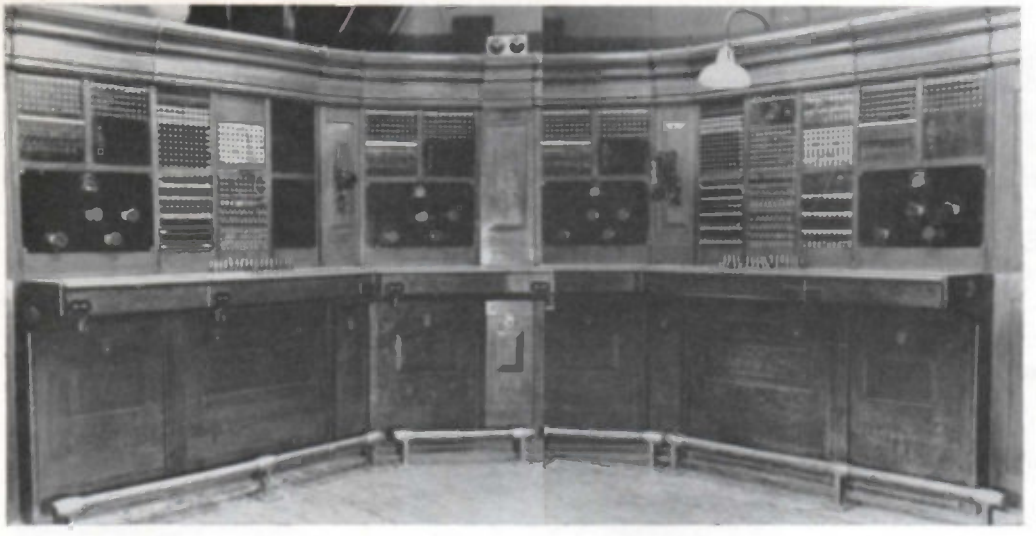
No. 1 Studio at Savoy Hill showing the 'acoustic treatment' by draping with curtain material. In the corner of the studio is the 'silence' booth for announcements

by draping with several layers of heavy curtains so as to 'deaden' them. It was not until the London studio activities were transferred to Broadcasting House in 1932 that new materials and techniques were introduced to control the acoustic qualities of studios to make them suitable for the various types of programme; the treatment for a talks studio needs to be quite different from that for an orchestral or drama production studio.

During 1923 and 1924 the centres which had been opened in Manchester, Birmingham, etc., were developed to have in most cases a fairly large main studio measuring approximately 20–30 ft × 10–15 ft together with one or two small studios at the bigger centres. The main control room was adjacent to the principal studio at each centre and an observation window was provided between the two areas. The associated transmitters were conveniently situated near to the studios.

STUDIO CONTROL FACILITIES

In these early days of broadcasting all the technical equipment, including amplifiers, at each studio centre was grouped together in the main control room, there being no control cubicles,



Sound control room, Broadcasting House, Manchester, installed in 1929

in the present sense, associated with individual studios although some of the studios did have a 'silence' booth from which announcements could be made.

BROADCASTING HOUSE STUDIOS

On 15 May 1932 the BBC's new headquarters at Broadcasting House, Portland Place, London, were brought into operational use. The building was designed as a sound studio centre, as well as an administrative centre, and there were twenty-two studios instead of the nine at Savoy Hill.

The special requirements of the many types of programme could now be met by having studios specially designed for each. For dramatic productions there were ten studios which could be used either singly or in groups according to the complexity of the production. A Dramatic Control Room combined the outputs of the individual studios under the direction of the producer. Provision was made for inserts from gramophone records, for special effects and for the addition of artificial reverberation from echo rooms. 'Balance and Control' staff were responsible for positioning microphones and controlling the level of the programmes delivered to the lines feeding the transmitters; the control was exercised in acoustically treated rooms equipped with loudspeakers.

The most important property of a studio from the acoustic point of view is its reverberation time; this is the time taken for the sound intensity, from the moment the source ceases to emit sound, to fall to one millionth of its original intensity—in effect the time the sound takes to die away and become inaudible. The appropriate reverberation characteristic is essential to the creation of the right atmosphere for the listener. For orchestral works, the listener will expect to 'feel' that the performance is coming from a concert hall, which would be characterized by a relatively long reverberation time, whereas for a talk or a news bulletin the impression of the speaker being in the listener's room will only be created if there is little or no reverberant

sound in the studio, the acoustic quality of the reproduction being governed almost entirely by the acoustics of the listener's own room. Thus, the provision of the correct reverberation time for each studio according to its intended functions is an essential part of the design of a studio centre.

Not only must the reverberation time be controlled in general terms, but its variation with musical pitch must be kept within defined limits. To achieve this the floors, walls, and ceilings of the new Broadcasting House studios were treated with sound absorbent materials to produce the appropriate absorption of sound energy for the particular purpose for which each studio was to be used.

All this resulted from the experience gained in the early days at Savoy Hill and from measurements made by BBC engineers of the acoustic properties of existing studios and concert halls. This development resulted in the provision of studios in Broadcasting House having greatly improved acoustic properties compared with those at Savoy Hill, but, by present-day standards, there was room for much further improvement which over the intervening years has been realized. Research and development in the art of providing good acoustic conditions is still continuing without any sign of finality having been reached.

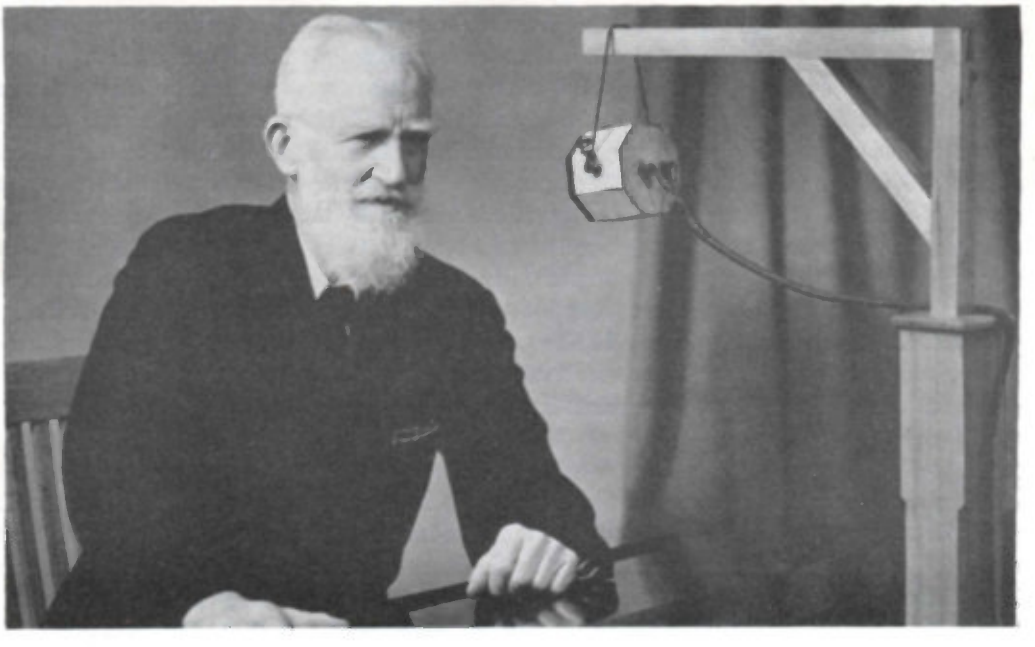
MICROPHONES AND ACOUSTICS

A close link exists between the development of studio acoustics and of microphones for broadcasting. This will be clearly understood when it is realized that, in the early days, to obtain a reasonably high output in relation to unwanted noise it was necessary for artists to be placed very close to the carbon granule type of microphones used at that time, each performer requiring a separate microphone. There was thus little indirect or reverberant sound (the nature and level of which was dependent upon the studio acoustics) compared with the direct sound from the performer. Thus studio acoustics contributed little to the output from a studio. There was, of course, no alternative to using more distantly placed microphones for broadcasting orchestral works. However, with the development of more sensitive microphones, which could be used from a range of several feet, the acoustics of the studio became of greater importance because of the increase in the proportion of reflected or reverberant energy picked up by the microphone. The headphones used by listeners were being replaced by loudspeakers, so that the acoustic effects of the rooms in listeners' homes also had to be taken into account.

The first microphones to be used in British broadcasting had performances which were very poor by present-day standards. Some of the earliest broadcasts were made using telephone-type carbon microphones fitted with conical mouth-pieces. In 1922 an American double button type of carbon microphone was first used but this was replaced in 1923 by the Round-Sykes microphone which was mounted in a cage-like structure on a very large stand and was referred to as a 'magnetophone'. The design of this was based on the 'moving coil' principle, the coil being the actual microphone diaphragm and taking the form of a flat spiral of aluminium wire held precariously in the field of a large electronmagnet by pads of cotton wool covered with grease. The instrument was heavy and clumsy and the electrical output required much correction to give a passable frequency response. Nevertheless, this equipment was very important in marking the first step towards the transmission of programme material for its aesthetic value rather than as a scientific curiosity.

The increased working distance which became possible with the magnetophone made necessary some kind of acoustic treatment to the studios as already mentioned. In 1926 the

A 'magnetophone' microphone in one of the Savoy Hill Studios



A Reisz transverse current microphone being used by the late Mr. George Bernard Shaw

carbon microphone was re-introduced in a more refined form, known as the Reisz transverse-current type. This was robust in construction, had a relatively high output and, by the standards of those days, had a good frequency response. This type of microphone was the mainstay of the Broadcasting Service up to the early thirties, although others were tried and many rejected. In particular, condenser microphones were used for a short period but were discarded because of operational difficulties and unreliability (these difficulties have since been overcome and the electrostatic type of microphone has returned to favour, see page 45).

Permanent magnet moving-coil microphones also returned in a form much smaller in size than the magnetophone. These were robust and could withstand exposure to weather and, remarkably, some designs utilized the principle of the 'reflex enclosure' to improve the low frequency response in the same way as it is used nowadays for loudspeakers and in moving-coil microphones.

A great step forward was taken in the early 1930s by the introduction of 'velocity' ribbon microphones, the performance of which was superior in several respects to earlier microphones. In particular, their directional properties could be used to discriminate against sources of unwanted sound and their response was more uniform at high frequencies than that of the 'pressure' microphones of that time. Because the directional properties varied less with frequency, these microphones gave much more faithful reproduction of the reverberant sound. The effect therefore of the introduction of the ribbon microphone was a noteworthy improvement in the quality of music transmissions. The BBC ribbon microphone was introduced in 1934 and during 1935–6 became the standard studio microphone.

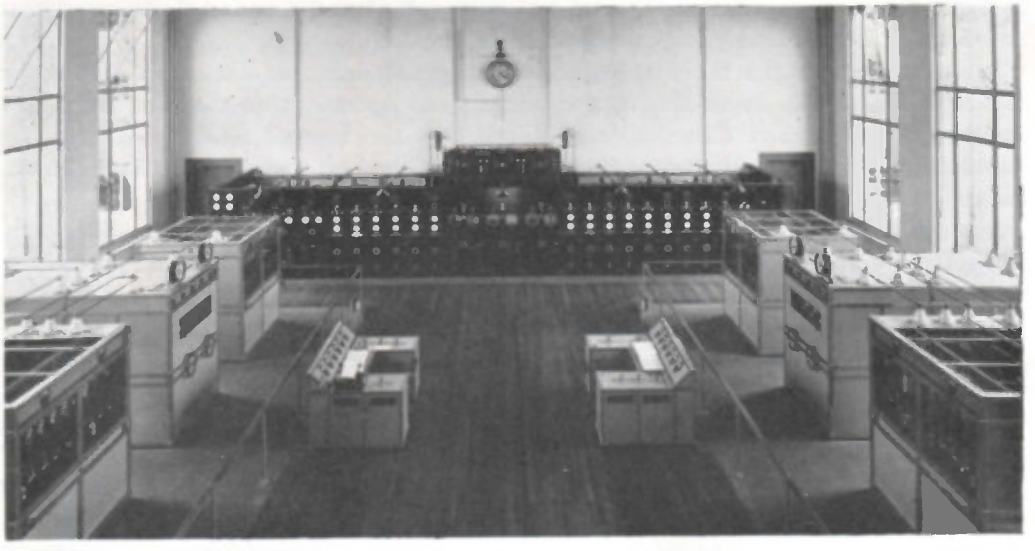
PROGRAMME DISTRIBUTION

During the early years of broadcasting the distribution of programmes between studio centres and to the transmitters was carried out by overhead Post Office lines. These did not require the use of repeaters between BBC centres and the necessary electrical correction, or equalization, of frequency response was fairly simple to achieve. However, although a satisfactorily wide range of frequencies was transmitted, these lines were subject to mechanical failure and variation in electrical performance with the weather. They also introduced noise and cross-talk. Underground cables were therefore adopted by the Post Office for the national telephone network and came into general use in 1930–1. The main cables included one or more programme circuits each consisting of a screened pair of wires 'loaded' with inductances every 1,000 or 2,000 yards and with amplifiers, or repeaters, every fifty miles. Such circuits provided stable performance, high reliability, and low cross-talk although a satisfactory frequency response, up to about 8,000 c/s, could be achieved only by the use of more complex equalizers than those needed for overhead lines.

THE REGIONAL SCHEME

The period from the formation of the British Broadcasting Corporation up to the outbreak of war in 1939 was one of rapid development in the broadcasting art and it was during this time that the now familiar pattern of British sound broadcasting took shape. From the largely independent local centres which came into being so rapidly after the introduction of broadcasting in 1922, centralization of studio facilities in main regional centres was developed.

New transmitting stations were built and many of these included twin high-power transmitters—50 kW instead of 1½ kW—one of which transmitted the National Programme



The transmitter hall of the Brookmans Park station

originating principally from London whilst the other radiated the Regional Programme. This regional type of transmitting station came into being with the completion towards the end of 1929 of the Brookmans Park station to serve the London area and south-east England. In March of the following year Daventry became the Midland Region station (5GB). In May of 1931 the North Region station at Moorside Edge, on the Pennines, was completed and similarly in Central Scotland, at Westerglen, near Falkirk, another twin-transmitter station was completed by mid-1932. A year later the West Region's station was completed and brought into operation at Washford, in Somerset. During 1934 the long-wave transmitter at Daventry (5XX) was superseded by a new higher-power long-wave transmitter at Droitwich which carried the National Programme and became one of the BBC's best-known stations. In February of the following year the Midland Regional Service was transferred from the Daventry 5GB transmitter to a new medium-wave transmitter at Droitwich. During 1936 two further regional stations were brought into operation—Lisnagarvey in Northern Ireland in March, and Burghead on the Moray Firth in October. The service to North Wales and Anglesey was improved when a medium-power station at Penmon, Anglesey, was brought into operation in February 1937, and in July the West and Welsh Regional Services from Washford were separated. This dual medium-wave station previously had radiated a combined West of England/Welsh Programme and the National Programme. However, experience with the 150-kW long-wave transmitter at Droitwich had shown that it served the area covered by the Washford 'National' transmitter. Therefore, from July 1937 the National transmitter at Washford radiated the West of England and the other the Welsh Programme.

Coverage in the north-east of England was greatly improved in October 1937 by the new high-power station at Stagshaw which replaced the early low-power Newcastle station (5NO).

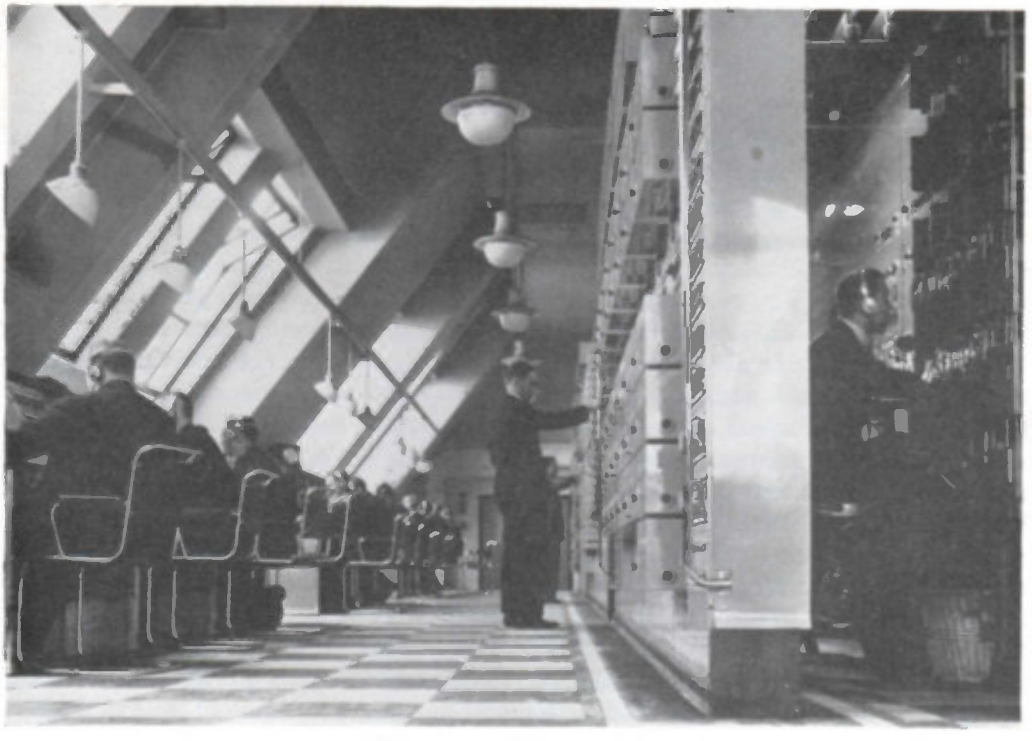
In September 1938 coverage in Scotland was improved when the station at Redmoss, near Aberdeen, replaced the early low-power station in Aberdeen.

In June 1939 coverage in the West Region was also greatly improved when a new high-power station at Start Point, South Devon, was brought into operation; on the same day a new medium-power station at Clevedon, near Bristol, was also brought into service. With the introduction of these two new transmitters, the West of England transmitter at Washford was withdrawn.

By 1939 the National Programme was being broadcast on 1500 metres by the long-wave Droitwich transmitter (approx. 200 kW) and by a group of three synchronized transmitters each of about 40-kW on 261 metres giving a population coverage of 93 per cent. The Regional Programmes were broadcast on ten wavelengths in the medium-wave band by twelve transmitters, three of 100 kW, six of 50 kW and three of about 20 kW, giving a population coverage of 89 per cent.

NEW STUDIO CENTRES

Simultaneously with the improvement in coverage brought about by the new transmitting stations, new studio centres were being built throughout the country. Broadcasting Houses, i.e. studio and administrative centres, were opened in Manchester (1929) and Edinburgh



Broadcasting House, London
Control Room showing amplifier racks and transmission position (1932)

(1930) and Broadcasting House London was completed in May 1932. On 14 May the 'End of Savoy Hill' programme was broadcast from Savoy Hill and the following day the new London Broadcasting House became the operational 'centre' of the BBC. Other studio centres were opened in Leeds (1933), Bristol (1934), and Glasgow and Aberdeen (1938). All of these were adapted from existing premises.

TECHNICAL CONTROL OF PROGRAMMES

With the availability of new studio premises came advances in technical equipment. In Broadcasting House, London, and similarly in the regional studio centres, the technical control of studio productions was carried out in the main control room itself or in control cubicles near to the main control room and remote from the studios. In London there were three control cubicles, one for the National Programme, one for the Regional Programme, and one spare. Provision of full technical control facilities in cubicles adjacent to each studio was only beginning at the outbreak of war in 1939, a change of technique which became fully developed during the war.

CONTROL ROOMS AND THEIR FUNCTIONS

In the earliest days 'balance and control' were effected by careful placing of the artists in relation to the microphone. Improvements in microphones soon made it necessary to use control cubicles to accommodate the technicians who controlled the volume and the amplifiers for feeding the programmes to the transmitters. A little later separate rooms with loudspeakers were provided for controlling programmes requiring a special knowledge of music.

As the service developed, broadcasting stations did not have to rely on their own resources for all their programmes and many were broadcast simultaneously from a number of transmitters. Thus the additional functions of programme co-ordination and routing and of 'network' operation were imposed on the control room and these responsibilities tended to obscure the original functions from which the name derives. The Control Room originally on the top floor of Broadcasting House, London, was an example of this phase, but even here separate cubicles were provided for the control of programmes of serious music and for handling complex programmes involving more than one studio or other source of material.

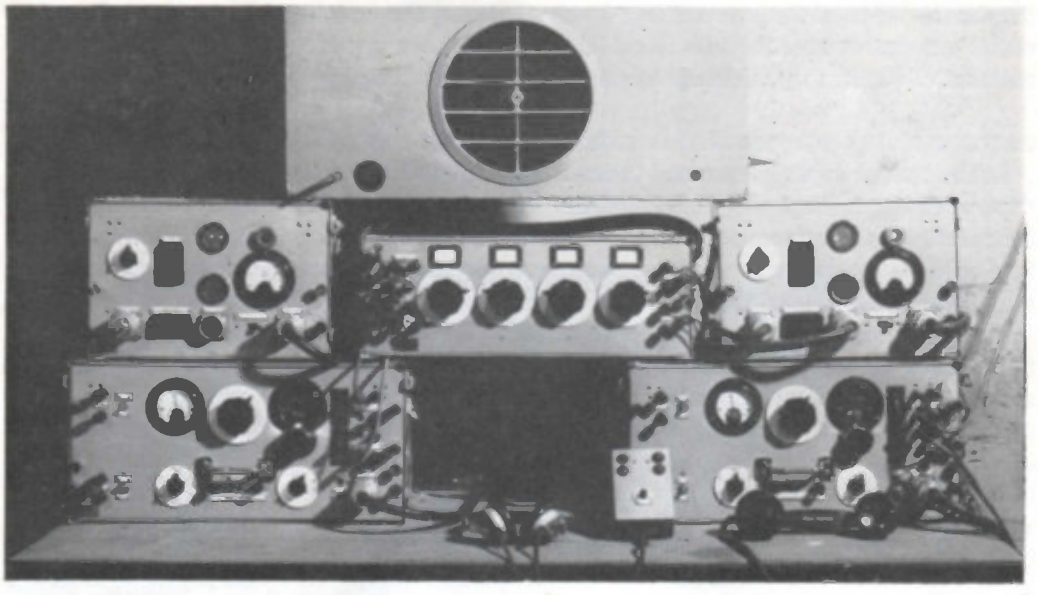
The introduction of mains-operated equipment obviated the need for centralizing all the amplifiers and their power supplies in studio centre control rooms and from about 1939 onwards a control cubicle was associated with each studio and separated from it by a sound-resisting window. The apparatus provided nearly all the facilities available in the earlier dramatic-control rooms and the control cubicles worked in conjunction with Continuity Suites from which the programme services were co-ordinated and presented. The Central Control Room was now devoted almost entirely to the operation of the networks feeding the transmitters, the testing and equalization of the Post Office lines between studio centres and transmitting stations and the handling of all the complicated technical routine inseparable from a large broadcasting organization. An example of this style of Central Control Room was that built during the war in the sub-basement of Broadcasting House, London, to replace the original, too-vulnerable, Control Room already mentioned (see page 40).

This principle proved so successful that future developments have been basically along these lines, although remotely controlled selector equipment similar to that used in automatic-telephone practice has now replaced the earlier plug-and-socket arrangements for programme selection and distribution.

OUTSIDE BROADCASTS

With the development of broadcasting, the number of outside broadcasts (O.Bs.), i.e. broadcasts from places other than BBC studios, steadily increased. Transmissions from performances given in concert halls were made from the beginning and broadcasts of outdoor events soon became an important feature of the programmes. The O.B. equipment of those days, which was battery operated, was bulky, heavy, and cumbersome.

In 1937 the BBC designed a new set of outside broadcasting equipment for operation from batteries or from the mains, which included portable microphone mixers, amplifiers, mains units and monitoring loudspeakers. This equipment was becoming available in quantity by the early part of 1939.



Outside Broadcast Equipment type OBA/8. The complete equipment comprises an amplifier, 4-channel mixer, monitoring loudspeaker, mains unit, and a communication unit for exchanging cue-light signals with the commentator's position. The amplifier and mains unit are duplicated as a precaution against failure

RECORDING

Initially, the BBC did not carry out any of its own recording but relied upon commercial companies producing the normal type of gramophone record. In 1930 the early steel tape magnetic recording system known as the 'Blattnerphone' was introduced but its use by the BBC did not become extensive. In 1933 direct disc recording was started by the BBC with the introduction of acetate discs. As a result of co-operation between the BBC and Marconi's a greatly improved magnetic recording system, known as the 'Marconi-Stille', was introduced in 1934 and although only a few of these large and heavy machines were made they remained in use until about 1940.

(left) *A Marconi-Stille tape machine in operation*
(right) *The Philips-Miller film recording equipment*

A sound-on-film, non-photographic, recording system was introduced in 1935. This, known as the Philips-Miller system, remained in use until the early 1940s. Basically, the system depended upon the variable width of track cut by a wide angle sapphire cutter in an opaque layer on a special type of film. As the method was mechanical rather than photographic, no processing was necessary, and the reproduction process was similar to that for photographic variable width recordings. Sound recording on photographic film is not well suited to broadcasting because of the time required for processing the recording before it is played back and because of the difficulty in achieving sufficiently good quality of reproduction.

WAR-TIME DEVELOPMENTS IN THE DOMESTIC SOUND SERVICES

THE NUMBER OF BROADCAST STUDIO CENTRES AND TRANSMITTERS IMMEDIATELY BEFORE THE WAR

In the period immediately preceding the outbreak of war in 1939 the BBC radiated the National Programme from one long-wave and three medium-wave transmitters and the Regional Programmes from twelve medium-wave transmitters. There were thirteen studio centres from which the programmes were originated and sent to the transmitters.

MEASURES TO AVOID GIVING NAVIGATIONAL ASSISTANCE TO ENEMY AIRCRAFT

As it was vitally important to keep broadcasting going during the war, it was necessary to use a method of transmitter operation that would prevent enemy aircraft from deriving navigational assistance from the transmissions.

Several high-power transmitters were grouped on the same wavelength so that enemy aircraft could not tune to an individual transmitter until they were relatively close, probably about twenty-five miles. But by this time the nearest transmitter would have closed down, thereby leaving the enemy guessing. Listeners in that area would still be able to hear the other transmitters on that frequency at least after dark when medium-wave transmissions can be received more strongly over long distances. The BBC medium-wave transmitters were therefore arranged in two wavelength groups, one in southern England and the other in northern England, Scotland, and Northern Ireland. Only once during the war were all these transmitters closed down simultaneously.

The single high-power long-wave Droitwich transmitter was closed down at the commencement of hostilities, but was re-opened in 1941 for broadcasting to Europe; a number of 'spoiler' transmitters operating on the same wavelength prevented its use by enemy aircraft as a navigational aid.

Operation of a number of transmitters on the same wavelength results in poor reception in areas remote from the individual transmitters because of mutual interference between the separate transmissions; the effect is much less if all the transmitters of the group radiate the same programme. The National and Regional programmes were therefore combined to produce a single programme—the 'Home Service'.

On Government instructions the BBC changed to group operation on 1 September 1939 and although adjustments were necessary to most of the transmitters all were ready for service within two hours. It was later learned from captured enemy documents that the object of confusing the enemy and preventing navigational aid to his aircraft was completely achieved.

OTHER PRECAUTIONARY MEASURES

Additional emergency premises throughout the country were acquired and equipped as studios and offices so that it would be possible to maintain a broadcasting service even under the worst conditions. One hundred and fifty war-time studios were brought into use. Complete mobile installations were also prepared for use in bomb damaged areas. These included transmitters, studio and recording equipment, and power generating equipment.

A new network of Post Office lines linked the old and the new premises and ensured that programmes, wherever originated, could be passed through a central point, usually London, for censoring and then on to the transmitters. Immediate contact was necessary with Fighter Command Headquarters, no matter what happened to BBC premises in London, so that any instructions from the R.A.F. for closing down transmitters in air raids could be quickly implemented. At the peak of the war over 30,000 miles of Post Office telephone circuits were in use throughout the country for broadcasting purposes.

TRANSMITTERS

In January 1940 a second programme was introduced for the Forces, at first only from 6 p.m. daily, but it was quickly extended to twelve hours daily and then again to include an early morning transmission.

To offset the closing down of transmitters during air raids and the effects of damage in the areas attacked, a large number of low-power transmitters, mostly of 100 or 250 watts, were built. Sixty of these were in service throughout the country by 1941, each with a range of five to ten miles. These stations did not have to close down unless the air raid 'alert' was given

within the area which it served. All sixty transmitters were synchronized on the same wavelength by the use of highly accurate crystal drive equipment.

IMPROVEMENTS IN TRANSMITTER FREQUENCY CONTROL

The development of high accuracy quartz crystal equipment for controlling the carrier frequencies of transmitters was continuing during the war and by 1942 equipment of greatly improved performance was becoming available and gradually replaced that of immediate pre-war design. The accuracy of these 'oscillators' was such that without adjustment over a period as long as three weeks the cumulative inaccuracy (in terms of the time error of a clock) would be less than one-fifth of one second, that is an error not exceeding one in ten million. This equipment was designed by BBC engineers and the quartz crystals were prepared and mounted in special high-precision stainless-steel holders designed by Post Office engineers.

To ensure that the transmitters of a synchronized group were keeping in step the frequency of each 'slave' transmitter was compared with that of the 'master' transmitter of each group. Later, an improved system was developed in which all transmitters relied upon a very accurate 1,000 cycles per second reference frequency distributed over lines from London. This system utilizes the fact that all BBC transmitter carrier frequencies are exact multiples of 1,000 cycles per second and the use of the highly accurate reference frequency not only ensures that the transmitters in a synchronized group can be kept closely in step with one another but also that the carrier frequencies have a high order of absolute accuracy. A later development enabled transmitting stations to utilize the extremely accurate carrier frequency of 200 kilocycles per second of the Droitwich long-wave transmitter as an alternative to the reference frequency distributed by line from London.

STUDIO CENTRES

The central control rooms in pre-war studio centres had highly reliable battery-operated equipment and were often situated on the upper floors of buildings where there was little restriction on the space. To give protection during air raids emergency duplicate control rooms, studios, and other essential services were built in basement areas. The space available in these was quite insufficient to house the bulky battery-operated equipment and it was therefore necessary to design more compact apparatus.

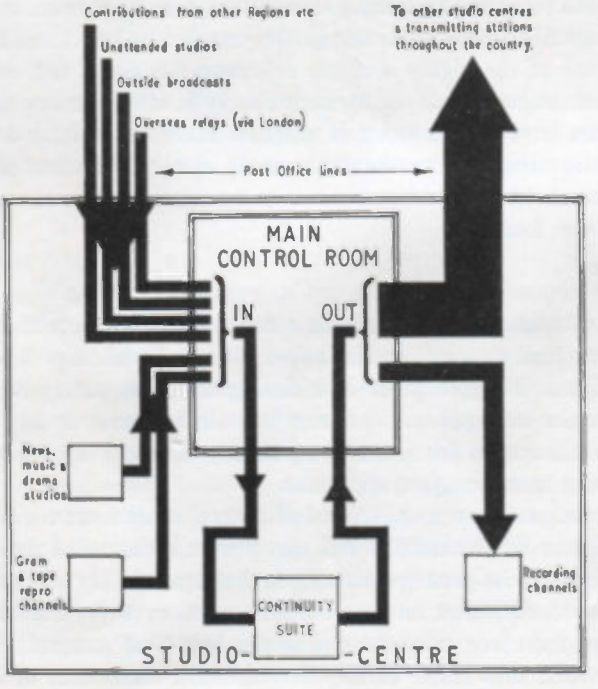
In 1937 the BBC designed new amplifying and control equipment which could be operated either from the mains or from batteries and was primarily intended for outside broadcasts. Among its advantages were its greater reliability and the possibility of conveniently mounting several items one above the other on metal frameworks, or bays, thus saving much space. This equipment was therefore used to equip the war-time control rooms and studios, which were also provided with either battery-driven motor-alternators or diesel-alternators as alternative sources of operating power with which to maintain the service in the event of failure of the mains supply. Every new studio was provided with a set of this 'outside broadcast' equipment, thus enabling rehearsals to be conducted without involving the equipment or staff in the central control room.

PROGRAMME PRESENTATION

A new method of programme presentation was being developed just before the war and BBC engineers were designing the equipment needed to provide the necessary technical facilities.

With this new system all contributions to any particular programme service are routed through a 'continuity suite' consisting of a control cubicle manned by a continuity operator and a presentation studio manned by a presentation announcer. The smooth running of the complete programme service thus becomes the responsibility of the presentation announcer: he decides if and when it is necessary to fade out a programme which is over-running or whether to interject announcements or play 'fill-up' gramophone records. For this purpose, he must carry out certain fading and switching operations. Other controls such as switching to and from the lines carrying the various programme contributions, the testing of circuits before transmission and checking programme volume are the responsibility of the continuity operator in the associated control cubicle.

The war-time requirements of the Overseas Services and later of the Home Programme Services made it necessary to introduce a war-time version of the continuity system, which is now an essential feature of programme control arrangements; the same basic conception has also been applied in the BBC's Television Service.



The Broadcasting Chain

ACOUSTIC TREATMENT OF STUDIOS

The acoustic treatment of the many war-time studios was necessarily of a makeshift nature. Nevertheless, in many cases results were very satisfactory and study of the reproduction quality obtained from war-time studios provided valuable information which was later successfully applied to the acoustic design of post-war studios.

OUTSIDE BROADCASTS

Outside broadcast equipment was permanently installed in several of the Royal residences and in many important Government offices. Programme material was gathered from military camps, places of entertainment and sporting events; the amount was no less than it had been during peace-time. Precautions such as duplication of equipment and lines were always taken to guard against possible breakdowns and a precautionary measure against extreme emergency conditions in London, which fortunately was never needed, was the construction of an exceptionally strong building, the 'stronghold', near Broadcasting House, to provide small studios, a control room, and a number of offices.

Frequent repairs were necessary to studios and control rooms in many parts of the country and a Repairs Section was therefore formed to deal with them quickly and effectively.

RECORDING

Up to a short time before the war the BBC's recording facilities were all concentrated at the Maida Vale studio centre in north-west London. The equipment then consisted of three 78 r.p.m. disc recording channels, three Marconi-Stille magnetic steel tape recording and reproducing machines, and two Philips-Miller film recording and reproducing machines. There were also six mobile recording units of various kinds, all based at Maida Vale.

During the war, the quantity of recording equipment was greatly increased and there was considerable adaptation of existing equipment and adjustment of operational methods to meet the changed and increasing programme demands for recordings. There was also a general improvement in the quality of recordings and of the reproduction from them.

STATIC RECORDING

The tremendous expansion of the BBC's Overseas and European Services required that a considerable percentage of the programmes should be recorded for subsequent repeat performances and to enable transmissions to be made at times when the broadcasting artists were not available. For the domestic services, programmes were often recorded during the daytime for evening transmissions to avoid calling people together at studio centres at times when air raids were likely. A reserve of recorded programmes was maintained and continuously kept up to date for use in the event of any main programme producing centre being put out of action. Many programmes were recorded instead of being broadcast live to give an effective means of censorship.

As more recording equipment became available, individual studio centres were made largely independent of one another by the installation of recording and reproducing equipment. The recording facilities in some cases were installed in a room immediately adjacent to a studio with visual communication through a large window in the common wall.

The provision of the considerable quantity of additional equipment for this expansion constituted a great problem in itself. For example, after increasing the Philips-Miller equipment to six channels by using all the equipment of this type available in the country, further expansion after the spring of 1940 became impossible because the equipment and the special film were manufactured in countries that by that time had been occupied by Germany. In consequence, it appeared that the disc system would be the most likely to be capable of forming the backbone of the recording facilities. Additional disc recording and reproducing equipment was obtained from the U.S.A. and this carried a high percentage of the increased load; the production of blank discs by British firms was increased to meet the peak requirement of 7,000 per week.

These discs consisted of a plastic coating on a metal base; the recordings could be reproduced several times, but if copies were required the discs were sent to a commercial firm for pressings to be made in the same form as that of ordinary gramophone records.

A major development was the introduction of larger discs with a diameter of 17½ inches which were recorded and played at 33⅓ r.p.m. so enabling complete 15-minute programmes to be recorded on a single side. However, this in turn necessitated the production of cutters for the recording process which would remain satisfactory for at least fifteen minutes of recording. Sapphire-tipped cutters were already in use in the U.S.A. but nothing suitable was available in this country. The BBC therefore decided to make its own and after some initial difficulties a satisfactory method of production was evolved and from that time the BBC has manufactured its own sapphire-tipped disc-recording cutters.

In 1942 it was decided to design and produce within the BBC a completely new disc recording equipment of high performance. After intensive development, installation of this new equipment began towards the end of 1944.

MOBILE RECORDING

To meet the great need for transportable recording equipment during the war a large number of an extremely robust battery-operated transportable type of disc-recording equipment, designed just before the war, were made and put into service; they proved invaluable.

High performance disc recording equipment, type D, designed and produced by the BBC

Most of the mobile recording work was naturally concerned with the reporting of the war at close quarters. Two mobile units were sent to France in 1939. Later, one unit covered the campaign in Eritrea and Ethiopia; later still, two units, and ultimately four, worked with the Forces throughout the campaign in North Africa. Each unit consisted of an Army vehicle adapted to carry the recording equipment and to act as a home on wheels for a team of two, reporter and recording engineer, both accredited war correspondents.

More complicated plans were made in preparation for D-day and a number of military-type four-wheel drive vehicles were fitted with recording equipment.

In order to obtain recordings of eye-witness reports by war correspondents during the initial period after the Normandy landings, 'midget' disc recorders were used. These weighed about thirty-five pounds complete. The design, production, and testing of these recorders was completed in six weeks; they were easy to operate and obviated the need for an engineer with each reporter. Although these 'midgets' did not provide the best quality they were satisfactory and enabled recordings to be made under conditions which precluded the use of the more elaborate vehicle-mounted equipment. As a result many recordings of considerable historical and documentary value were made which would otherwise not have been obtained. The recorded material was either telephoned back to this country or transmitted by a mobile transmitter, several of which were commissioned for the War Reporting Unit, and received at the BBC's Receiving Station at Tatsfield, near Westerham, Kent.

PROGRAMME AND COMMUNICATIONS CIRCUITS BETWEEN BBC CENTRES

In addition to the greatly expanded network of lines already mentioned, an extensive network was set up to feed a considerable number of small transmitting stations giving a programme service to American troops in this country while smaller programme distribution networks were set up for the Allied Expeditionary Force, Canadian Forces, the American Broadcasting Service in Europe, and for other purposes. Circuits were also needed for interconnecting strategic points in the broadcasting network with emergency premises and with the headquarters of Service and Government Departments. Elaborate precautions were taken to guard against the effects of disruptions in the programme distribution networks as a result of enemy action.

As all the main cables had to be brought together in the neighbourhood of each of the regional broadcasting centres, a number of emergency amplifying and switching centres were set up through which the programme circuits were arranged to pass on their way to the main regional centres. The emergency centres were located outside the vulnerable areas; they were connected to one another as well as to the regional centre so that if a number of main cable routes were interrupted inside the vulnerable area alternative circuits would be available between the outskirts of the city and the normal and reserve BBC premises within it. Some of these emergency switching centres were not staffed and the switching was then operated remotely, from other BBC premises.

A further precautionary arrangement was the routing of all lines from studios to transmitters via London with the provision of special switching arrangements so that if any one line became damaged or faulty the programme concerned could be re-routed over emergency lines. As an example of this type of precaution an elaborate automatic switching system for the large number of overseas programmes was set up at the External Services studio premises at Aldenham, near Elstree. Several alternative programme routes were provided between Aldenham, Broadcasting

(top) *BBC recording truck, as used by BBC War Correspondents, showing single-channel recording apparatus and associated equipment. A short-wave receiver can be seen on right with three-channel mixer and loudspeaker above*

(left) *BBC midget disc recorder*

House, and Bush House, London, and also between these premises and other emergency centres in London so that any one switching centre could, in an emergency, switch the programmes at another centre.

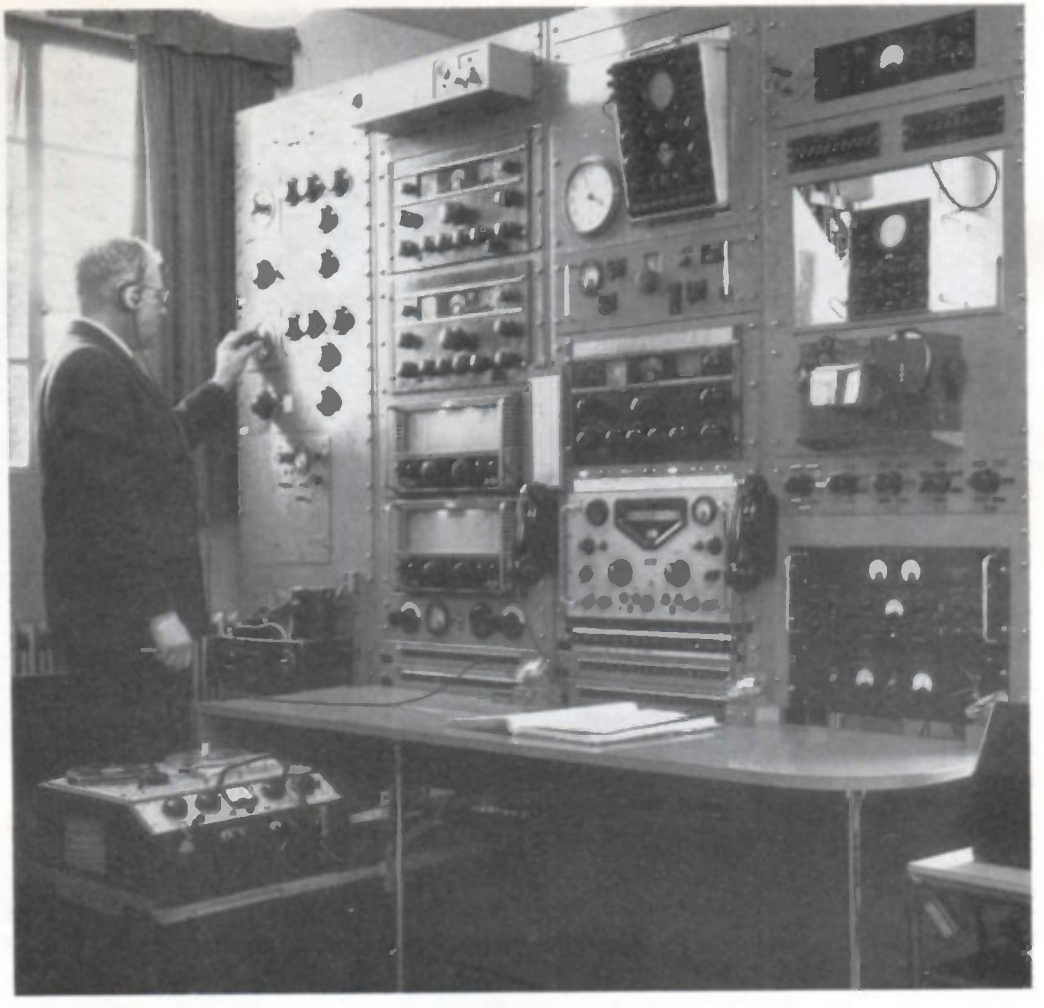
In addition to the circuits required for the distribution of the actual programmes a large number are needed for news and inter-office communication services and for administration and maintenance. Special systems were designed and built for use over emergency programme circuits to give sufficient speech and telegraphy channels between London and all the major regional centres. In addition, Post Office multi-channel telegraph systems for news and other services were installed in the London area feeding a ring cable round London as well as being connected to the headquarters of the BBC Monitoring Service near Reading. As described later, the Monitoring Service dealt with an enormous volume of material which was condensed and transmitted daily to Government Departments and other authorities in London. This was done by using a teleprinter 'broadcast' system installed in Broadcasting House in London and operated remotely from the Monitoring Service. This important contribution to the war effort was achieved by Post Office and BBC engineers working in co-operation to design the special equipment necessary, which is believed to have been the first of its kind.

A number of special systems for the transmission of speech and music over long distances by lines underwent considerable development under the stimulus of war-time conditions. One of these, the 'split-band' system, makes possible the use of ordinary telephone circuits for the transmission of speech and music of a quality that is acceptable for broadcasting purposes. Normally, special high quality line circuits are necessary. The split-band system utilizes two separate low-quality line circuits, the programme material being divided between them for transmission. The two halves are then put together again at the receiving end. The use of a number of portable equipments for carrying out this process made possible the first transmissions from European countries as they were liberated from enemy occupation.

THE BBC RECEIVING STATION AT TATSFIELD

This station was established in 1929 on a specially selected site on the Kent/Surrey county border at a point some 830 feet above sea level on the chalk hills of the North Downs. Before the war its work consisted of the reception by radio of programmes from abroad and the measurement of wavelengths, or frequencies, of BBC and foreign broadcasting stations. The accuracy of measurements was then limited to one part in ten million but this has since been increased to one part in 100 million, which is equivalent to measuring the distance from London to New York with an error not exceeding two inches. Special aerials and receivers were provided for reception from American and other overseas broadcasting stations for relaying and monitoring purposes.

When BBC broadcasting in Arabic started in 1938 at the request of the Government to counter hostile propaganda in that language from Italian stations it became necessary to know what was being said in the Arabic broadcasts from foreign stations. Arrangements were therefore made for the reception of this material at Tatsfield; it was then either recorded or sent direct to London by line. With the outbreak of war, this interception work increased enormously and could no longer be handled at Tatsfield. A separate Monitoring Service was therefore set up as described in the chapter on External Broadcasting. The big increase in the number of transmitters in the BBC's Home and Overseas Services resulted in a corresponding increase in the work of Tatsfield in checking the frequencies and other details of the transmissions.



The BBC Receiving Station, Tatsfield, Surrey. The senior engineer's operating position

Sources of interference to BBC transmissions had also to be investigated. In order to deal with this greatly increased volume of work the Tatsfield station was enlarged and the staff increased. The number of frequency measurements made each day rose to some 500, these being divided roughly equally between measurements of BBC transmissions and measurements of foreign transmissions. Another important aspect of the work of Tatsfield during the war was the accurate determination of the positions of enemy transmitters.

When an Italian station began to interject remarks during news bulletins on one of the BBC's Home Service frequencies, counter measures were taken. The enemy transmissions were picked up at Tatsfield and then inverted and mixed with the BBC's radiated programme. The result was that whenever the enemy transmission was received direct by listeners tuned to the

BBC Home Service on the same wavelength, the enemy speech was also received, in the inverted form, with the BBC programme. In consequence one cancelled the other—in fact the enemy jammed his own speech!

The reception at Tatsfield of broadcast transmissions for their programme content was also very greatly increased during the war because radio became the only means by which programme material could be collected from abroad, the whole of the European line telephone system having been interrupted. A noteworthy example of this work was the reception of the War Reporting Unit material from BBC mobile transmitters in the Mediterranean and in France and Germany right up to and including the Nuremberg trials.

The equipment at Tatsfield has recently been modernized and is extensively used for relaying programmes from abroad, for measuring the frequencies of BBC stations and foreign stations, and for measurements of signal strength and direction finding. On 5 October 1958 the signals from the first Russian earth satellite were recorded at Tatsfield, this being the first occasion on which such signals had been observed in this country.

BBC ENGINEERING STAFF DURING WAR-TIME

Over 500 of the BBC's 1,300 pre-war engineering staff became members of the Armed Forces during the war, either as a result of specific requests from the Government for specialists or as volunteers.

The loss of so many experienced staff created a very difficult problem. Not only had they to be replaced but a considerable increase in staff was necessary to man the greatly increased number of studios and transmitters. Because it was impossible to recruit trained engineers, untrained male and female staff were recruited.

The influx of raw recruits necessitated the provision of operational training facilities and an Engineering Division Training School was therefore set up to give instruction in general broadcasting operational practice followed by more specialized training in the particular type of work which each recruit would be called upon to carry out. This training was essentially in operational techniques and procedure. The results of this scheme were most successful very largely as a result of the enthusiasm which was shown by both training staff and the trainees. By the end of the war some 2,000 recruits had been trained and the number of war-time staff in the Engineering Division of the BBC reached the peak figure of 4,000.

REVIEW OF EUROPEAN WAVELENGTH SITUATION

At the outbreak of war European broadcasting stations were operating in accordance with the wavelength allocation plan established at the European Regional Conference at Lucerne in 1933 and brought into operation the following year. The Lucerne Plan was an attempt at rationing the use of the limited number of medium- and long-wave channels allocated for broadcasting in Europe. The European Regional Conference held in Montreux in 1939 produced a new wavelength rationing scheme which was to have come into force during 1940 but was never implemented. In consequence, the Lucerne Plan remained in force throughout the war years and although there were some departures from the official wavelength allocations to particular stations there was in general no attempt by the enemy to use wavelengths which had been allocated to this country.

In fact no new European broadcasting wavelength plan was introduced until the Copenhagen Plan of 1948 which was brought into operation in 1950.

THE POST-WAR PERIOD

THE POST-WAR PATTERN OF THE DOMESTIC SOUND SERVICES

When the post-war pattern of broadcasting was introduced on 29 July 1945 two alternative programmes were provided, the Home Service and the Light Programme. The latter set out to give British listeners a continuous service of information and entertainment distinctly different from the Home Services. Variations of the basic Home Service were radiated from the transmitters serving the different regions by the replacement of items in the Home Service originating in London with alternative programme items produced in the regions. The Third Programme was introduced in September 1946 and Network Three in September 1957, using the same technical facilities as the Third Programme but at different times of the day. The number of hours of sound broadcasting each week for listeners in the United Kingdom has increased from approximately 226 in 1945 to about 275 at the present time. The increase is mainly due to the Third Programme and Network Three, but there has also been an increase of some fifteen hours per week in the Light Programme hours.

TRANSMITTING STATIONS

COVERAGE

The population coverage on long and medium waves is 93 per cent for the Home Service, 99 per cent for the Light Programme, and 70 per cent for the Third Programme/Network Three. These figures refer to reception after dark and indicate the percentage of the population for which reception is free from fading and distortion but they do not take into account the effects of the often severe interference from foreign stations. This type of interference does greatly reduce the satisfactory coverage on medium waves in many parts of the United Kingdom, particularly on Home Service wavelengths.

INTERNATIONAL WAVELENGTH PLANS

During the post-war years the long- and medium-wave bands became severely congested as a result of the rapid growth in the number and power of the stations operating. In an endeavour to rationalize the use of these bands in the European zone a new allocation plan was worked out in Copenhagen in 1948 and came into force in March 1950. This plan made provision for the BBC to use one long wavelength and thirteen medium wavelengths, including one international common wavelength, for its domestic Sound Services. It succeeded for a time in arresting further deterioration but a great deal of additional mutual interference between stations in different countries has since developed. This is mainly because the plan was not adhered to by all European broadcasting organizations; in fact it was not accepted by several of these, including the occupying powers in Germany. The overcrowded conditions which now exist in these wavebands result from the great increase in the number of European stations from some 520 for which provision was made in the Copenhagen Plan to about 1,000 at present in operation. In consequence, there is serious mutual interference especially after dark and this has been the main factor leading to the BBC's development of sound broadcasting on very high frequencies. Extensive VHF sound broadcasting services are now in operation

in a number of European countries, notably in Germany and Italy as well as in the United Kingdom.

MEDIUM- AND LONG-WAVE TRANSMITTING STATIONS: LIMITATION OF USABLE POWER

It might appear that a simple solution to the problem of interference to BBC transmissions would be to increase the powers radiated. However, there are two reasons why this cannot be done. First, the maximum power that can be radiated by each station is laid down in the Copenhagen Plan to which the United Kingdom was a signatory and the BBC is already using these maximum powers. Secondly, there is a practical limit to the maximum power that can be effectively used by medium-frequency broadcasting stations and it is for this reason that there are relatively few stations with powers exceeding 150 kW. The reason for this limitation is that the radiation from the aerial of a medium-wave transmitter travels outwards from the aerial not only parallel with the earth's surface (ground wave) but also upwards at an angle to the earth's surface (sky wave). By virtue of the bending effect of the earth upon the waves that are propagated close to its surface, the waves are enabled to follow the general curvature and to a large extent the irregularities of the earth's surface. As the energy spreads more and more widely it naturally becomes weaker and, in addition, energy is absorbed in the earth itself. These factors limit the range of the ground wave of a medium-wave transmitter; with radiated powers of the order of 100–150 kW this range may be about 100 miles, the precise value being determined by the frequency of the wave (the relationship between frequency and wavelength is explained on p.81) and the nature of the earth's surface over which it travels. During daylight the skyward radiation is absorbed in the upper atmosphere but after dark it is reflected by the electrically conductive regions which exist above a height of about fifty miles above the earth's surface and is returned to the earth's surface at distances from the transmitter governed by the angle of the skywards radiation. At distances sufficiently remote from the transmitter, direct ground radiation and indirect sky waves will therefore be received together after dark. The sky waves, which are reflected at a continually varying height, interfere with the ground waves so that in areas where the strengths of the two signals are comparable severe fading and distortion occurs and reception is spoilt. This effect with high-power transmissions occurs at distances of approximately 100 miles from the transmitter and the useful range cannot be increased by increasing the transmitter power because the strengths of both rays would be equally increased.

This effect is very much less marked with transmissions in the long waveband and since such transmissions lose their energy to the earth much less rapidly than do medium-wave transmissions they are suitable for operation with higher transmitter powers and do give satisfactory reception over greater distances than do medium-wave transmissions. This explains why it is worth while to operate the BBC's long-wave Light Programme transmitter at Droitwich with an output power of 400 kW, which enables it to provide a satisfactory service to the greater part of the United Kingdom.

SPECIAL TRANSMITTING AERIALS

As the range of high-power medium-wave transmitters is limited after dark by interaction between the ground wave and sky wave, one method of increasing the useful range of the ground wave is to use transmitting aerials which limit to a minimum the energy radiated skywards. Much work has been done on the development of this type of aerial and the results

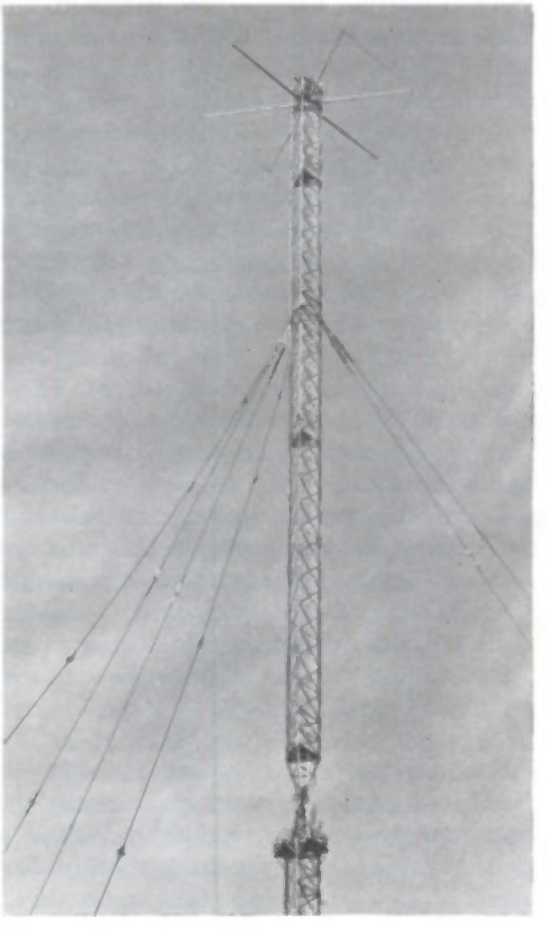
have been incorporated in the new anti-fading mast radiators now used at a number of BBC stations. These have materially improved reception in the outer parts of the areas served.

A further limited improvement in coverage was achieved by the use of directional transmitting aerials which are able to concentrate the radiated energy in the directions where it is most needed.

OPERATION OF TRANSMITTERS IN SYNCHRONIZED GROUPS

The allocation to the BBC of insufficient channels under the Copenhagen Plan for each of its transmitters to have the exclusive use of a separate channel necessitated the operation of many BBC transmitters in synchronized groups. For example, there are four Welsh Home Service transmitters operating on the same frequency and in Scotland there are also four Home Service transmitters operating in a common-frequency group. For the Light Programme there is a group of ten medium-wave transmitters and for the Third Programme there are two groups of five and thirteen transmitters each. Although the radiation of a common programme by all the transmitters in a synchronized group greatly reduces the interference between them there is still a severe reduction in the size of the areas that can be satisfactorily served compared with the coverage which is possible when each transmitter has its own unshared frequency.

The increase in the application of synchronized group operation which was successfully used during the war was greatly assisted by the development of quartz crystal transmitter frequency control equipment that was very much smaller and less expensive than the equipment developed during the war but which had a comparable performance. Improvements were also effected in the equipment used in checking the accuracy of the frequencies of transmitting stations.



Anti-fading mast radiator of Third Programme transmitter at Daventry. The top section of the 725-foot mast is fed by an inductor across an insulator at the 460-foot level. The base of the mast is insulated from the ground and the radial spokes at the top increase the capacitance to ground

ADDITIONAL HOME SERVICE TRANSMITTERS

The increasing interference from foreign broadcasting stations continued to reduce the effective coverage of BBC transmitters after dark. To offset this and also to give improved reception in poorly served areas twelve additional low-power Home Service transmitters were built in the years 1951–4. These provided improved reception for about a million people. However, no new frequency channels were available and so each of these additional low-power stations had to be operated on frequencies already in use by other BBC Home Service transmitters. This resulted in some of the new stations having to radiate a regional variant of the Home Service inappropriate to the area being served, because an additional transmitter on the fringe of the area served by an existing transmitter must use a different frequency so as to avoid interference and must therefore broadcast a different programme from that of the main station in the area. This explains why, for example, the low-power transmitters on the south coast at Bexhill and Folkestone radiate the West of England Home Service instead of the London Home Service.

The numbers and total powers of the transmitters now used, a list of which is given on pp. 88 and 89, are as follows:—

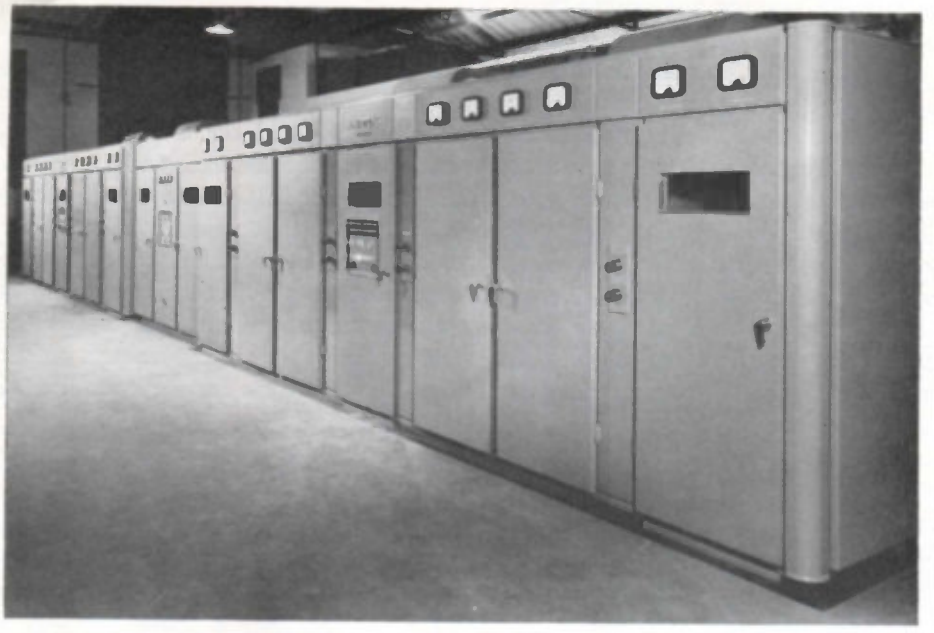
Home Service	28 transmitters	1139 kilowatts total output
Light Programme	11 transmitters	586 kilowatts total output
Third Programme/Network Three	18 transmitters	167 kilowatts total output

DEVELOPMENTS IN THE DESIGN OF MEDIUM-WAVE TRANSMITTERS

There have been important developments in transmitter design since the war. The high-power class 'B' modulated transmitters with output powers of about 100 kW and with efficiencies of between 30 and 40 per cent, introduced in the years immediately preceding the war, were followed in the post-war years by transmitters of higher efficiency. By 1954 high-power transmitters of 150-kW output power using air-cooled valves with thoriated filaments requiring less filament heating power were common and efficiencies of 40–50 per cent were realized.

A number of post-war developments are well illustrated by the design of the BBC high-power Third Programme/Network Three medium-wave transmitter at Daventry which was brought into service on 8 April 1951 replacing a temporary installation that had been in use at Daventry since March 1950. The new transmitter was installed in a separate building at the BBC's short-wave station at Daventry and the output is radiated from a 725-ft anti-fading mast radiator at Dodford nearly one and a half miles away, the transmitter and aerial being connected by a long open-wire feeder. This was necessary to avoid interference between the medium-wave transmissions and the short-wave transmissions from Daventry.

This transmitter consists of two identical 100 kW units capable of independent operation. Normally, the two halves are operated together at somewhat reduced power and give 150 kW output to the aerial, this being the maximum permitted in the Copenhagen Plan. Should a fault develop in either half of the transmitter the service is maintained, but at reduced power, by the other half. This gives a worth-while increase in reliability without the wasteful installation of spare equipment, which would be required only on the rare occasions when faults occur in the main transmitting equipment. The transmitter uses air-cooled valves throughout. Previously, the practice had been to cool the high-power valves of transmitters by circulating water. This requires complicated arrangements for the insulation of the high-voltage sections and for the exchange of the heat generated between the distilled water circulated around the valves and the



The Third Programme unattended transmitter station at Daventry consists of two identical units, each complete in itself and capable of an unmodulated carrier output power of 100 kilowatts. The transmitter is remotely controlled by the equipment shown on the left which is installed in another building

secondary cooling circuit containing ordinary water which itself requires outdoor cooling equipment.

A further departure from previous practice was the use in this transmitter of alternating current for heating the valve filaments. Previously, direct current was necessary and was generated from the alternating current supply by rotary converters. The generation of the high-tension direct-current supplies for the valves is also carried out without the use of large rotary converters, as in earlier designs, by the use of mercury arc rectifiers. Thus no rotary machinery is involved except for the small motors in the cooling air blowers. The transmitter is designed for remote and unattended operation, being operated from another building at the Daventry station. The effect of these innovations is a substantial increase in efficiency resulting in considerable saving in operating costs.

Although this is still the only high-power medium-wave transmitter in the BBC to be remotely operated, the principle of remote control and of automatic operation controlled by time switches, without staff in attendance, has been extended to a large number of lower-power BBC transmitters. At the present time there are fourteen Home Service, four Light Programme, and fifteen Third Programme/Network Three medium-wave transmitters operated in this way. Maintenance of these transmitters is carried out by mobile teams of engineers.

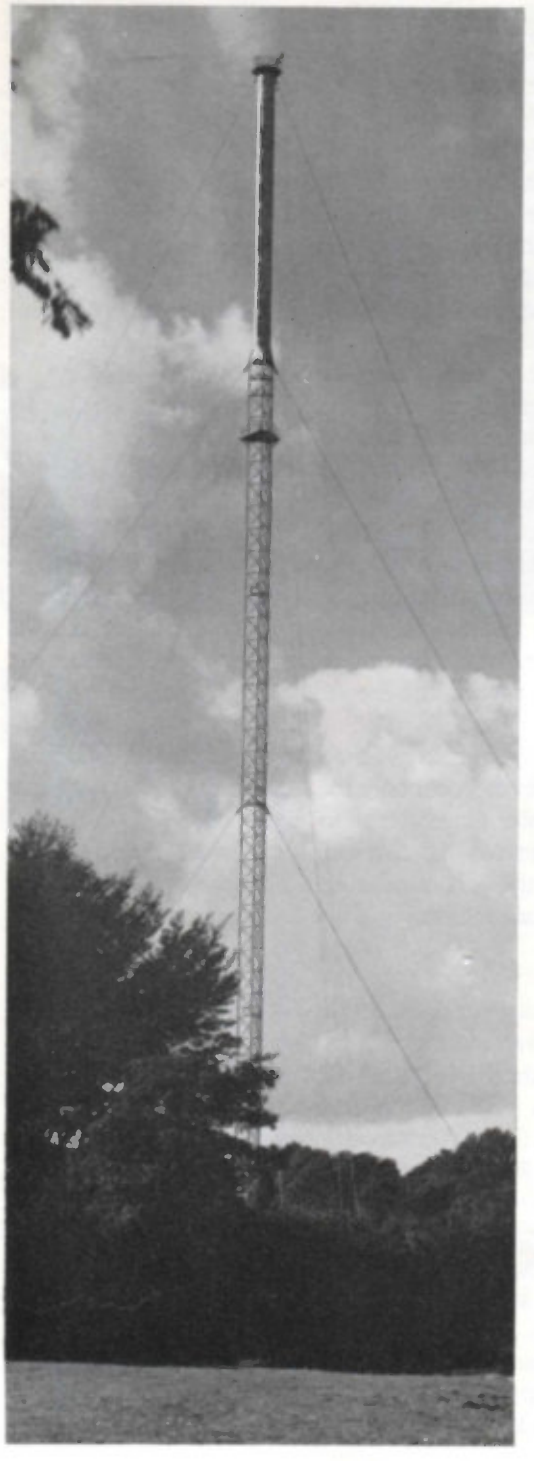
The satisfactory introduction of unattended transmitter operation necessitated the development by BBC engineers of automatic monitoring and alarm equipment so that warning of failure or incorrect operation of a transmitter can be automatically given at a manned BBC centre and corrective action immediately taken. In the case of some types of fault, automatic equipment at the transmitter either simply switches out the faulty section or changes to a standby unit.

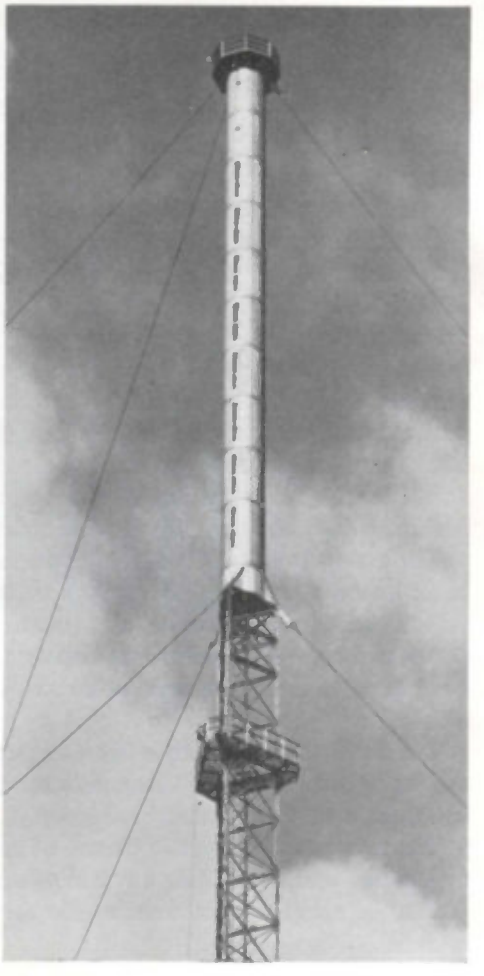
The multiple-unit principle has also been used in many of the low-power unattended transmitters so that on the rare occasions when faults do occur only the faulty unit ceases to operate and there is only a temporary reduction in power but no break in the service.

The remote and automatic control of transmitters has resulted in a substantial economy in operational staff and in this way has reduced the cost of running the service and has enabled staff to be released from routine jobs for more interesting work for which skilled staff are essential.

VERY HIGH FREQUENCY SOUND BROADCASTING

Foreseeing the difficulty of improving or even maintaining the population coverage of the sound services on medium and long waves, the BBC started during the war to explore the possibility of using the very high frequencies which had so far not been exploited for sound broadcasting. The portion of the VHF band (Band II) which by international agreement is allocated to sound broadcasting extends from 87·5 to 100 megacycles per second (Mc/s). The wavelengths are very short—about 3 metres—but in this country only about half of this band (88–95 Mc/s) has so far been allocated to broadcasting, the remainder being used by other services. Low-power transmitters using frequency modulation (f.m.) and amplitude modulation (a.m.) working in this band (Band II) were installed experimentally at the BBC's London Television Station at Alexandra Palace in 1945. This trial was followed in 1949 by the building at Wrotham in Kent of a high-power experimental station containing one f.m. transmitter and one a.m. transmitter each with an output power of about 20 kilowatts. The output of these transmitters was fed simultaneously to a BBC-designed wide-band cylindrical slot aerial





VHF sound transmitting station mast and cylindrical slot aerial at Wrotham, Kent.

At combined television and VHF sound stations the two aerials are mounted on the same mast with the television aerial normally at the top

110 ft long mounted on a 470 ft mast, which concentrated the radiation in the vertical sense so as to achieve the maximum range that could reasonably be accomplished. The effective radiated power was 120 kW. Extensive tests were carried out on the characteristics of the a.m. and the f.m. transmissions so as to assess the relative merits of the two systems.

This full-scale experiment proved that f.m. offered some definite advantages over a.m. and a plan for national coverage of the BBC domestic sound programmes using frequency modulated VHF transmitters was submitted to the Government early in 1951. Unfortunately, restrictions on capital expenditure prevented immediate adoption of the BBC plan. It was not until July 1953 that the Government felt able to give its approval in principle to the introduction of VHF sound broadcasting and a decision on whether this should use the a.m. or f.m. system had still to be made. The Television Advisory Committee, which was charged with the responsibility of making recommendations to the Government on VHF sound broadcasting, recommended in December 1953 the adoption of the f.m. system. The Government accepted this recommendation in February 1954 and in July 1954 the BBC was authorized to begin the construction of the first of the new sound broadcasting stations.

An additional transmitter was installed at Wrotham and the existing a.m. transmitter modified for f.m. and on 2 May 1955 this station was brought into full service radiating the Home, Light, and Third Programmes. This alternative sound broadcasting service was free from the foreign interference experienced on the medium-frequency transmissions after dark. There were also other advantages. Coverage of all three BBC sound programmes could be extended to areas where one or more could not be well received from the medium- and low-frequency transmissions. Moreover, medium- and long-wave receivers need to be designed so as to minimize the effects of foreign interference. This inevitably restricts the quality of reproduction from such receivers. But these restrictions do not exist in the case of VHF receivers. A marked improvement in the quality of reproduction thus became possible with the introduction of the new service. VHF/FM transmissions are also comparatively free from most kinds of electrical interference. Listeners are becoming aware of these advantages and at present nearly one in three has a VHF receiver.

New VHF sound transmitting stations were built and brought into operation throughout the United Kingdom, the great majority of them being on the same sites as existing BBC television stations. This co-siting policy permitted the use of the same masts for the transmitting aerials as were already in use for the television transmissions and facilitated the rapid construction of the new stations because of the existence of facilities such as access roads and electricity and water supplies. It also enabled considerable economies of operating staff to be achieved. This has resulted from the use of BBC designed automatic monitoring and alarm equipment, which has permitted the VHF sound transmitters to be operated without staff in attendance but with the safeguard of the associated television station staff being close at hand. These factors made possible the very rapid extension of the VHF sound broadcasting service and its operation in the most economic manner. By May 1962 twenty-six VHF sound stations had been completed and these make available to more than 98 per cent of the United Kingdom population the Home Service, the Light Programme, and the Third Programme with Network Three.

The new VHF sound stations have also been designed and equipped to provide the most reliable operation. Twin transmitters are operated in parallel for each programme service so that if a fault should develop in either half the service will be maintained on reduced power by the

VHF sound station at Sandale, Cumberland: transmitter hall. This station radiates the North of England and the Scottish Home Services as well as the Light Programme and the Third Programme with Network Three. Each programme is radiated by a pair of transmitters, eight in all; four are shown on each side of the transmitter hall and beyond them are the programme input, drive, phasing, and automatic monitoring equipments. (Most VHF sound stations radiate three programmes and are therefore equipped with six transmitters)

other. In addition, the outputs of the transmitters are combined into two independent similar groups, each including the output from one half of each of the three (or four) double transmitters. The two grouped outputs are fed to separate halves of the transmitting aerial by separate feeder cables. Thus a breakdown in one of the feeder cables or in either half of the transmitting aerial would result only in a temporary reduction in power until the fault had been rectified; there would be no break in the service.

Should a fault occur in the transmitting equipment in the VHF sound station an indication of the fault and an alarm are given in the adjacent manned television station. Staff answering the alarm are given a clear indication by the automatic monitoring equipment of the part of the transmitting equipment which has become faulty. The fault may thus be speedily located and the transmission restored to full power with the minimum delay.

A start has already been made on the task of bringing the service to as many as possible of the unserved 2 per cent of the population by building a number of low-power relay stations designed for operation without staff in continuous attendance. Government approval has been

given for the construction of the first thirty-nine of these stations of which some are already in operation. Consideration is being given to the needs of other localities where it is hoped that it will be possible to build further low-power VHF sound relay stations.

For use at these low-power stations the BBC has designed a type of transmitter known as a 'translator', which receives the programme by radio from a parent station and re-transmits it, after amplification, on another channel in the same band. At each site it is necessary to use three sets of combined receiving and transmitting equipment for the three programmes and in many cases there will be television translators on the same sites. This type of equipment is relatively cheap and simple to install and operates unattended, but it can be used only in places where the signals from the parent station can be reliably received for re-transmission to local listeners. By choosing a site that is well placed both for reception and for transmission and by using directional aerials on 60-foot or 100-foot masts, the BBC can offer a service considerably better than is possible by direct reception in listeners' homes.

PROGRAMME AND STUDIO DEVELOPMENTS

STUDIO DESIGN

Many of the advances in this field have resulted from developments in equipment and in presentation methods and production techniques. A general improvement in studio acoustics followed from extensive laboratory studies based on new methods of acoustic measurement, from experience in the design of studios, and from the availability of new materials.

Changes in studio design have followed from the trend towards the use, for dramatic productions, of large studios with several microphones and locally modified acoustics, instead of several smaller studios, each with distinct acoustic properties, linked by a Dramatic Control Panel. The use of studios in groups originated from the time Broadcasting House became an operational studio centre in 1932. The emphasis since the war has moved towards medium-sized general purpose studios, each with two or more areas having radically different acoustic treatment. Studios are now often built with non-parallel facing walls and, in the larger studios, with the ceiling surfaces broken up or 'coffered'.

Research into the desirable acoustic properties of concert halls and large orchestral studios has resulted in the successful introduction of porous and resonant absorbers and architectural features designed to scatter reflected sound. Notable examples of these techniques are the large orchestral studio at Maida Vale, London, and the rebuilt studio premises at Swansea.

The expansion in the daily programme output has necessitated a considerable increase in the number of permanent sound broadcasting studios. The total number of studios in use immediately before the war was ninety-five and this has now increased to over two hundred, of which thirty-six are used for the External Services.

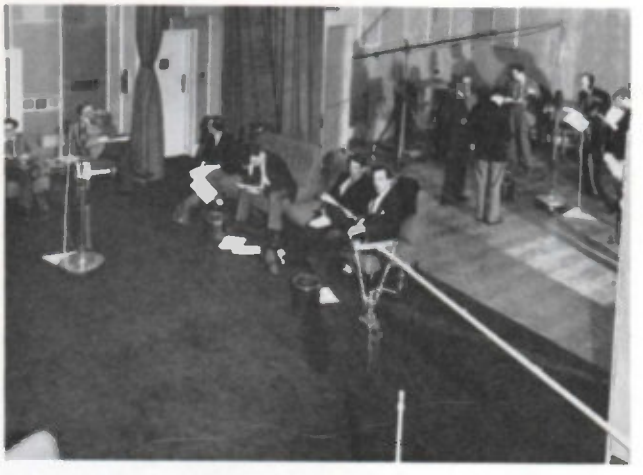
The use of general purpose studios and the development of the self-contained studio unit have several advantages—particularly in relation to rehearsals. Originally, the central control room at a studio centre handled rehearsals as well as the live transmissions, which added considerably to the operational load. All the technical facilities needed for rehearsal are now provided in the local studio control cubicle. Rehearsals can therefore be conducted without the central control room being involved.

Broadcasting House, London, showing the Extension on the left in which new technical and programme facilities have been provided. These were brought into use progressively during 1961

CONTROL ROOMS

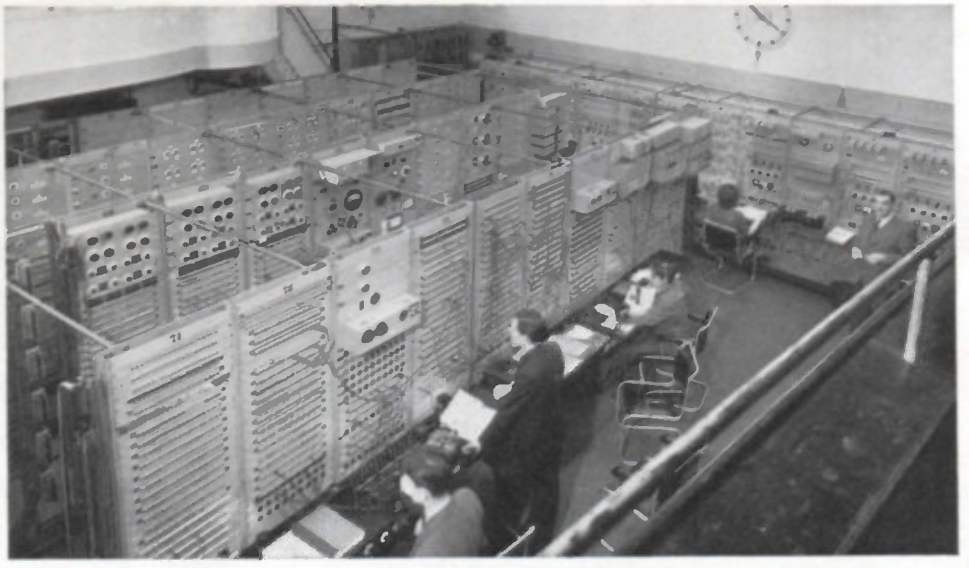
In 1939 all control rooms at BBC studio centres were equipped with remotely-controlled relay switching for routing the programmes. The rapid war-time growth in the number of sources and destinations that had to be switched made this system impracticable because of the physical bulk of the equipment, even if sufficiently reliable operation of the tremendous numbers of relays needed could have been guaranteed. Furthermore, with changing presentation requirements a more flexible arrangement was needed. These requirements were met by using a simple plug-and-jack system with flexible cords for interconnecting programme sources and destination lines. This method has now been largely replaced by a greatly improved system using remotely operated motor uniselector switching for the simultaneous selection in one operation of programme circuits with the associated cue, control, and signalling circuits. Very large numbers of sources and destinations can thereby be controlled from a single control position without operational complexity. The latest example of this technique is the new control room in the extension to Broadcasting House, London. Many of the main control rooms at the

A studio in which different acoustic treatment has been given to each of the two areas



Studio 1, Maida Vale, showing acoustic treatment

Studio 1, Swansea, showing cavity absorbers



(above) *War-time Control Room, showing the plug-and-jack system with flexible cords for interconnecting programme sources with destination lines*

CONTROL ROOMS, BROADCASTING HOUSE, LONDON

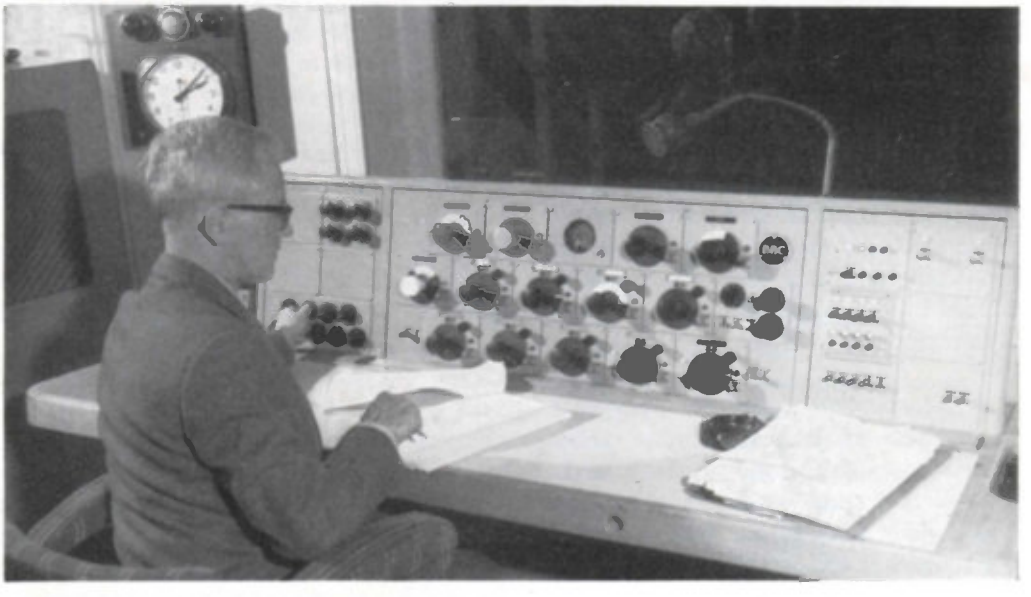
(below) *The new Control Room in the Extension brought into operation in* 1961. *The main control desk shown includes facilities for the remote control of motorized selector switches by which any of* 200 *programme sources can be selected and connected to any of* 130 *destination lines. Over the desk is a large panel which indicates the source-to-destination connections in use*

regional centres have already been modernized and re-equipped with uniselector switching and this work is continuing.

STUDIO EQUIPMENT

New studio equipment designed by BBC engineers is radically different from that used before and during the war. A separate amplifier is provided in the studio control cubicle for each microphone, and the microphone outputs are mixed after this initial amplification. Equipment introduced in 1947 consists essentially of two main items, a control desk and an apparatus cabinet. The desk, in the studio control cubicle, has faders for smoothly adjusting the volume from each microphone or other source, talkback microphones for production staff to talk to artists in the studio, artificial reverberation (or echo) facilities, switches for changing to spare amplifiers, programme meters for measuring programme volume, telephone instruments, and signalling equipment. The apparatus cabinet houses all the amplifiers, power supply units, relays, and other technical apparatus and may be installed in any convenient space not necessarily in the control cubicle. All items in the cabinet are connected to the permanent wiring by plugs and sockets for easy removal for maintenance or repair.

Another type of studio equipment has since been developed by the BBC and was introduced into service in 1954. This is less costly than the earlier equipment while still providing all the facilities required, including those demanded by recent changes in programme production technique. The new equipment has been designed on the modular principle and comprises three standard amplifier types with the necessary mains supply units, standard panels con-



Modern studio control equipment (type B) showing the modular construction enabling a wide range of combinations of units to be mounted according to the facilities needed in any particular studio

New Mixer Suite, 1A, Broadcasting House Extension, London, provides facilities for building up programmes from a large number of sources. From the studio, seen through the double-glazed window, the linking and explanatory commentary is made; at the desk on the extreme left, up to seven programme sources can be selected and made available to the Studio Manager at the Control Desk. These seven sources plus the outputs from the studio microphones and from tape and disc reproducers in the cubicle are used by the Studio Manager to compile the composite programme. The television monitors are part of the closed circuit link to the News Room for giving late news flashes, e.g. during sports programmes

taining faders, switches for giving cues to artists by light signals in the studio, indicators and similar apparatus, all of which can be assembled in the number and variety appropriate to the needs of any particular studio according to its functions.

The amplifiers used in control rooms were all battery-operated up to the beginning of the war. These have since been superseded by mains-operated types which have steadily been reduced in size. Experimental amplifiers incorporating transistors have been designed and given extended service trials and are being introduced where their use offers advantages.

UNATTENDED SOUND STUDIOS

In the last ten years unattended studios have been established, supplementing the more extensively equipped regional centres and sub-centres. These unattended studios serve news and topicality requirements, enabling reports to be broadcast without the necessity for the speakers journeying to the main centres, which may well be some forty or fifty miles away. The equipment and technical arrangements are such that no engineer need be present—hence the term 'unattended'. The studios are about 20 ft × 16 ft in size, with an adjacent room housing the control equipment. Arrangements have been made so that such studios can also be used for more elaborate transmissions with a producer and engineer present in the adjacent control room. There are now twenty-four of these studios in service throughout the country.

THE CONTINUITY SUITE

The technique of using continuity suites as described on page 20 for assembling programme items into a smooth-running programme service has become a basic feature in the production of sound programmes.

Continuity Suite, Broadcasting House Extension, London
This is one of four interchangeable suites, one each for Home, Light, and Third/Network Three programmes with one spare suite

Control Cubicle: The desk is designed for two operators, one to select and control the programme, the other for setting up and selecting the tape machines for reproducing recorded material and generally assisting the main operator. High-grade monitoring loudspeakers, headphones, and peak programme meters enable visual and aural watch to be maintained on the outgoing programme

Studio: Through the double-glazed window can be seen the Continuity Studio. The announcer in the studio has two 3-speed record reproducers, microphone, cue and indicating lights, and switches and faders enabling him to make continuity announcements and play records. There are talkback facilities to the adjacent cubicle and programme sources. Cue light signalling to any source studio is also provided

[*See also front cover*]

AUTOMATIC MONITORING EQUIPMENT

The shortage of skilled staff and the need for further economy led the BBC to develop automatic equipment for monitoring transmitters and the lines between studio premises and transmitters. This has already been mentioned in connection with the transmitters for the VHF sound service. The increasing use of equipment of this type has enabled the monitoring of the domestic programmes to be achieved with a more economical use of technical manpower than

otherwise would have been practicable, at the same time releasing technical staff from much routine work and making them available for more interesting tasks.

MICROPHONES

Developments in microphones have included substantial improvements in the performance, and a considerable reduction in the size and weight, of the ribbon microphone, and the reappearance of the electrostatic microphone which had previously been abandoned because of operational difficulties and the unreliability of pre-war models.

Advances in design and performance have resulted from increased understanding of the basic principles and the availability of improved magnetic and other materials.

In 1939, the ribbon microphone known as Type A was the standard for studio use. This was modified in 1943 by the addition of a new type of ribbon and balanced wiring, and was designated Type AXB. In 1944 the permanent magnet system was altered and a Ticonal magnet substituted, giving improved sensitivity; microphones of this type were known as Type AXBT.

The demand for smaller and lighter high-quality microphones led to considerable research and to the trial of many different types. One new type introduced into service in 1952 is known as the PGS ribbon microphone, developed by the BBC Research Department and now manufactured by a commercial firm. It is considerably smaller and therefore much less obtrusive than the Type AXBT and has only one-third of the weight. A marked improvement in quality has been achieved, especially in the response at the higher frequencies.

There is considerable demand for microphones possessing directional characteristics other than the 'figure of eight' of the ribbon microphone, which causes it to respond most strongly

(left) *Ribbon microphones—type PGS and AXBT to same scale*
(right) *Noise-cancelling lip microphone, type L2*

to sounds arriving from directly in front and behind but with little pick-up from the sides. Microphones are needed that will pick up sound from the front only (cardioid) and from all directions (omni-directional). Hence it has been necessary to make increasing use of electrostatic microphones which, because of the small size of their working parts, can readily be designed to have any, or in some cases all, of the required directional characteristics over sensibly the whole of the audio frequency range. In particular, the cardioid type is essential for outside broadcast use in the footlights of theatres and opera houses in order to obtain the maximum pick-up from the stage without picking up too much sound from the orchestra immediately behind the microphone.

The BBC Research Department designed a close-talking microphone of the pressure-gradient type for use where there is a high level of background noise, for example for commentaries on sporting events. The original design was introduced in 1937 and became known as the lip microphone, type L1; an improved version, type L2, was produced in 1951 and was until recently the only 'noise-cancelling' microphone of its kind in the world. The lip microphone, when held close to the commentator's mouth, gives a high degree of discrimination between the wanted speech and the background noise. When so used, however, speech tends to sound unnatural and both acoustic and electrical compensation of the frequency response have been introduced. A microphone, based on the BBC design, is now manufactured by a commercial company.

Microphones having special characteristics are required, for example, where special directional properties or robustness are needed or where there is a need for microphones to be held in the hand or worn on the person. The BBC maintains an acoustics laboratory with advanced facilities for the calibration and testing of microphones produced by the Industry.

LOUDSPEAKERS

The critical aural monitoring of programmes, which is carried out at several points in the broadcasting chain, demands a high-quality loudspeaker used under suitable conditions to show up any unwanted noises, distortion or other programme faults. It must also reproduce sound with a high degree of fidelity so as to enable a balance to be obtained that is acceptable when the programme is heard over a wide variety of reproducing equipment and not merely over other loudspeakers of the same type.

The design of a high-quality loudspeaker is a frustrating task since the characteristics required have so far defied attempts to reduce them to a precise specification. The performance of the final product has to be assessed by ear but, unless the subjective judgment is arrived at under carefully controlled conditions, it is easy to obtain contradictory results. To provide itself with loudspeakers of the necessary high standard of performance the BBC has made, in addition to laboratory tests, direct comparisons between the reproduced sound from a loudspeaker and the original sound in the studio, employing for the purpose its own experienced staff. In this way, the performance of new commercial designs is rigorously assessed. The BBC also designs its own loudspeaker assemblies by combining units from different manufacturers.

A loudspeaker designed for monitoring purposes by the BBC uses a commercial 15-inch low-frequency unit mounted in a vented cabinet in conjunction with high-frequency units and suitable cross-over networks. A smaller and lighter transportable adaptation of this design has been produced for use on outside broadcasts. Tests have also been conducted with modern commercial versions of a wide-range electrostatic loudspeaker.

OUTSIDE BROADCASTING EQUIPMENT

The standard BBC equipment for outside broadcasts which was designed just before the war was used extensively both for its original purpose and in equipping the very large number of additional studios which were opened during the war. Little progress was possible in the design of new equipment during the war, although the requirements for outside broadcast operation had become more complex. In order to provide the additional facilities required in post-war years, the existing unsuitable and—by modern standards—rather cumbersome equipment had to be pressed into service with the result that the number of units to be transported and interconnected at outside broadcast points became very unwieldy.

In consequence a new type of amplifier with its auxiliaries was developed to provide equipment as small and light as possible without sacrificing reliability, yet having a general technical performance similar to, or better than, the earlier equipment. Ease of transport and, if necessary, dismantling, were considered important and provision was made for carrying subsidiary items such as microphone cables, cue lights, telephones, etc.

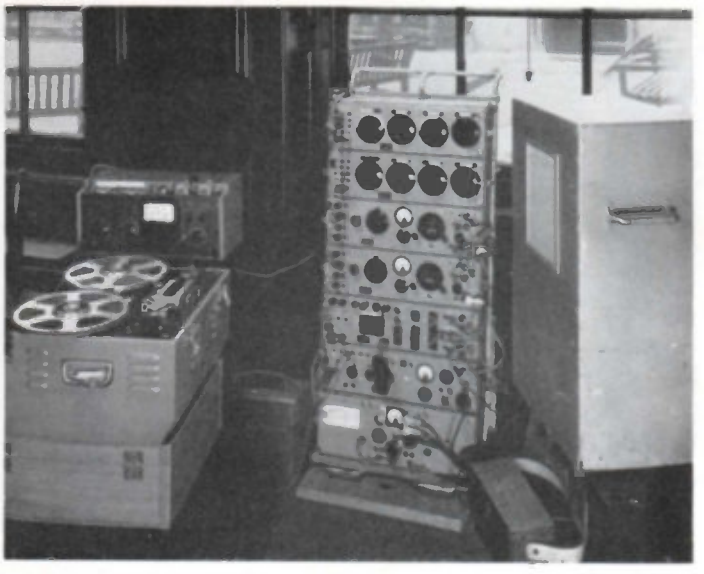
Each set of the resulting equipment is mounted in a stack on a hand trolley to facilitate its movement. A set consists of seven units of five types; two mixer units for controlling up to eight separate programme contributions from different microphones or other sources, two combined amplifiers and meters for measuring programme volume (the amplifiers can also be used for calibrating the programme meters), a distribution and general control unit, a loudspeaker and isolating amplifier unit, and a power supply unit. The equipment can be operated from the mains or from dry batteries contained in the power supply unit. It is designed so that these seven units can be operated without dismantling, or alternatively they may be removed from the trolley and, by the addition of a suitable number of similar units, extended to deal with the more complex programmes. Mounted at the back of the trolley are drums each containing 150 ft of screened microphone cable. Additional items, separately transported, are a portable loudspeaker, communications units for lamp signalling between the control point and the microphone sites, and a box of spare components and other miscellaneous items.

In designing this equipment full advantage has been taken of the availability of small valves and other components so as to keep size and weight to a minimum. A transistorized version of the amplifier has now been produced and has had successful service trials in the Sound and Television Services. Its lightness, low power consumption, and freedom from microphony are particularly valuable.

Both the war-time and the later version of the sound outside broadcast equipment were used during the Coronation broadcasts in 1953, for which 1,300 additional sound circuits were required to link the eleven temporary control rooms and more than eighty control positions with the permanent BBC control rooms in the London area. Five main sound networks covered broadcasts and recordings for U.K. listeners, BBC European and Overseas listeners, and transmissions by other broadcasting organizations in Europe and in other parts of the world. There were more than a hundred commentators speaking in forty-two languages. A similar large-scale operation was undertaken for the wedding of H.R.H. Princess Margaret in 1960.

Equipment of the same types has been used for the Royal Tours of Nigeria, Canada, South Africa, Southern Rhodesia, Australia, New Zealand, India, and Pakistan.

A new development in the outside broadcast field is the 'suitcase' apparatus for simple programmes, which is designed for one-man operation by a commentator or reporter without



OBA/9 trolley-mounted equipment designed by BBC engineers for outside broadcasts. It is here shown together with transportable tape recording equipment and a high-quality transportable loudspeaker

an engineer. The complete equipment is contained in a small suitcase measuring only $15\frac{1}{2} \times 9\frac{1}{2} \times 5\frac{3}{4}$ inches and the total weight is 15 lbs. Transistors are used in the microphone amplifier and also in the very small radio receiver which can be used for programme cues, by tuning to one of the broadcast transmissions of the programme taking the report or commentary. A crystal microphone is provided and telephone ringing and speaking facilities are included so that the commentator can establish contact with the BBC centre that will receive his contribution. The user connects his equipment to the appropriate Post Office line circuit simply by inserting a single plug into a socket provided at each established outside broadcast point.

Another BBC development, used mainly in outside broadcasts, is a radio microphone, which was designed to relieve commentators of the encumbrance of a long cable connecting the microphone to the control position. The radio microphone was introduced in July 1955 and is used by the BBC's Sound and Television Services. It consists of a miniaturized VHF frequency modulated transmitter and a separate battery-pack. Each of these is approximately the size of a packet of twenty cigarettes. A pair of miniature microphones may be worn by the commentator or a hand-held type may be used for interviewing. The aerial consists of a length of flexible wire concealed in the user's clothing. The transmitter operates on frequencies in Band I with a power output of about $\frac{1}{4}$ watt. It is believed to be the smallest high-quality transmitter of its kind at present available for this particular purpose. The range of the transmitter depends upon conditions, but in the open can exceed half a mile.

Recent additions to the fleet of special outside broadcast vehicles are two Mobile Studios and Control Rooms fully equipped for large-scale programmes from events such as the Brussels Universal and International Exhibition in 1958 and many of the bigger Agricultural, County, and Horse Shows. In the later version the control room equipment can handle a total of twenty-three programme contributions. These are derived from microphones in the vehicle's own

(left) '*Suit-case*' *outside broadcast equipment*

(right) *BBC Radio Microphone, showing the transmitter being slipped into a pocket. The battery-pack is of similar size, the aerial is concealed in the clothing and the miniature microphone can be replaced by a hand-held type for interviewing*

Mobile Studio and Control Room for BBC Outside Broadcasts. The control position (centre) *and the producer's position. Part of the studio may be seen through the open door*

studio, the output of a bank of four disc-reproducing turntables and the outputs of receivers which pick up programme items from portable transmitters carried by commentators who may be operating some distance from the mobile control room.

Sound programmes are usually brought from an outside broadcast to a convenient point on the main network by means of lines temporarily rented from the Post Office; these are tested and electrically corrected by the BBC to give good programme quality. Where the outside broadcast is mobile or suitable lines are not available, radio links are used.

INTERNATIONAL PROGRAMME EXCHANGES

The number of programmes exchanged between the BBC and other countries rapidly increased during the post-war period. There are several ways in which such exchanges may be effected. The programmes can be sent direct by high-quality line, by radio-telephone, or by direct reception of broadcast transmissions from the originating country or, alternatively, by the exchange of recordings. All these methods are used between the broadcasting authorities in the Western World and by 1961 live relays from other countries to the BBC had increased to 19,894 (571 in 1939) while the number of BBC programmes taken by other countries had increased to 5,555 (886 in 1939).

PROGRAMME DISTRIBUTION AND COMMUNICATIONS FACILITIES

The permanent network of lines connecting the studios with the transmitters, for conveying the programmes and for communications purposes, is supplied and maintained by the Post Office. BBC engineers co-operate with those of the Post Office in setting up the programme lines to the high standard required and carry out routine tests to ensure that the specified technical characteristics are maintained. The standards aimed at are at least equal to those laid down by the Comité Consultatif International Télégraphique et Téléphonique (C.C.I.T.T.). Electrical correction is applied at BBC centres to compensate for any residual distortion on lines forming part of the permanent network; for this purpose equalizers with 'tailor-made' characteristics are used, whereas variable equalizers are used for temporary lines. For long programme circuits it has been found necessary to introduce additional correction to compensate for the effects of changes in temperature.

The expansion of the BBC's various services has demanded improved communications facilities. The comprehensive communications system that has been built up now provides inter-office telephone communication and engineering control facilities between all the regional centres and transmitting stations throughout the network; it also provides teleprinter facilities between London and the main centres. Most of the communications circuits are provided by three- or four-channel carrier systems each using two Post Office music circuits, the teleprinter channels being interleaved with the speech communication channels. In some cases the pro-

gramme circuits can be used for inter-regional communication at times when they are not needed for programme production purposes.

The BBC now rents from the Post Office about 25,000 miles of programme circuits for sound, including those used for the sound component of the television programme, and 7,000 miles of control and communications circuits.

The programme networks comprise a distribution system for carrying each of the programmes from the continuity centre to the transmitting stations and a contribution network bringing programmes from remote parts of the system to the continuity centre. The main networks are set up in programme chains, e.g. Home, Light, Third/Network Three, and Television Sound, and they are normally subjected to periodic routine testing, the test signals being originated at the London end and readings being taken manually at intermediate studio centres and transmitters. Contribution circuits are similarly tested in chains. This method, however, does mean that a number of engineers are engaged simultaneously on the tests, which take about thirty minutes for each chain. Automatic sending apparatus has now been introduced for these tests on the main programme distribution chains, thereby reducing the time to 5–6 minutes. Apparatus has also been designed to reduce this time still further to 3–4 minutes by the use of automatic synchronized receiving apparatus, which makes a record of the test results. It is intended to use this apparatus also for the adjustment of 'topping up' correctors on long chains of three or four links so as to iron out the accumulated variations in performance.

SOUND RECORDING

THE INTRODUCTION OF MAGNETIC-TAPE RECORDING

The post-war development in sound recording has seen the introduction on an ever-increasing scale of magnetic-tape systems. As already mentioned there was a great increase in the use of recorded programmes in this country during the war. This was also true of other countries and especially of Germany where almost the whole of the German home programmes were recorded. The Germans concentrated on a magnetic recorder known as the Magnetophon, in which the recording medium was a plastic tape impregnated or coated with a magnetic powder. Apart from the high quality it provided, this equipment had the advantage of a playing time of more than twenty minutes for a single reel of tape so that a long recording time could be accommodated in a very small volume.

Magnetic-tape recording has now been developed to a high degree of perfection and is used the world over. The speed at which the tape runs past the recording and reproducing heads is of great importance and, in addition to being accurately maintained during recording and replaying, obviously needs to be standardized if tape recordings are to be interchangeable both within the BBC and with other broadcasting organizations. For recordings of first-class quality, a tape speed of 15 in./sec. is used, but equipment is also available giving speeds of 30, 7½, and 3¾ in./sec. A ¼ in. wide plastic tape is used, coated with iron oxide. International agreement has been reached on the standardization of the essential characteristics of recording and reproducing equipment necessary for the international exchange of recorded programmes.

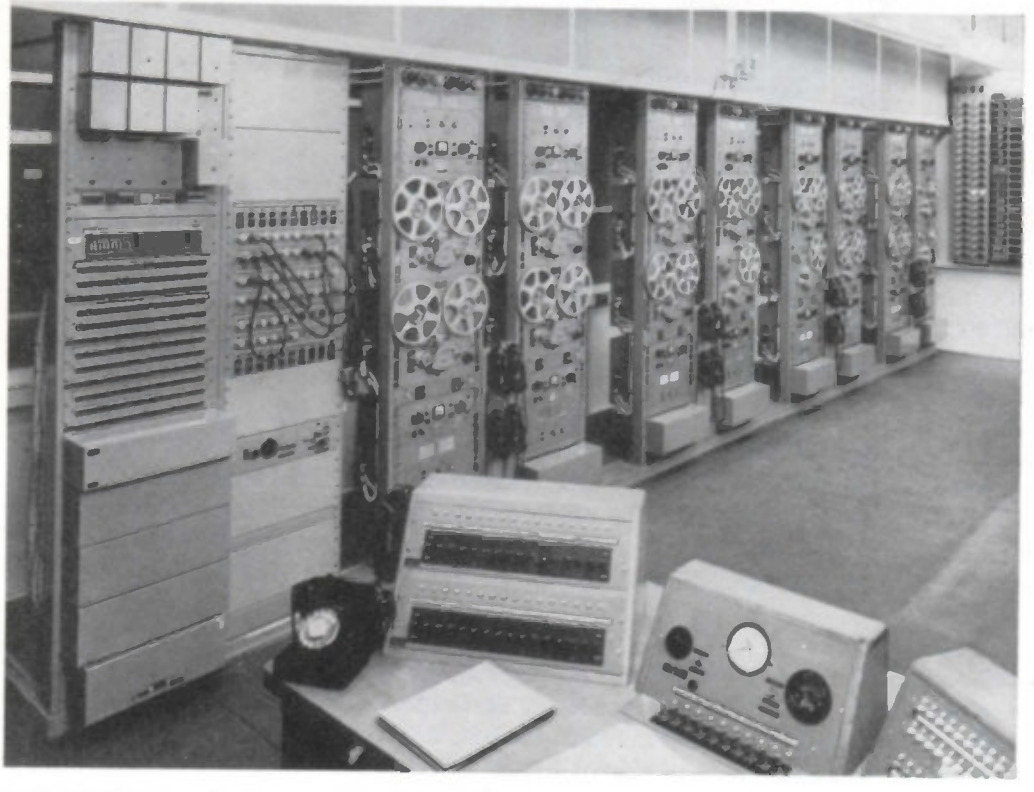
During recent years the BBC has expanded very greatly its facilities for recording programmes

on magnetic tape. The majority of recordings are now made on magnetic tape, but direct disc recording is still used for some purposes, for example, for news reports where speed and ease of editing are essential requirements. The present proportion is approximately 80 per cent tape and 20 per cent disc, and the use of discs continues to decrease.

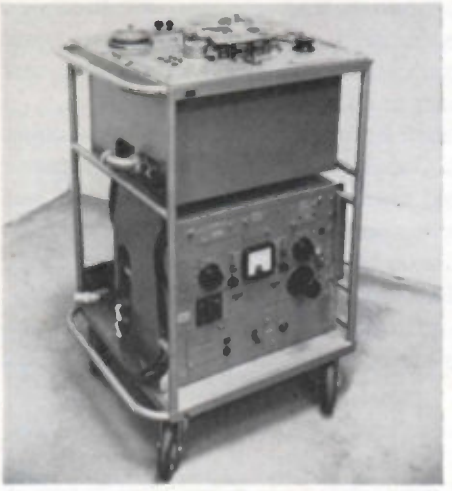
There have been two recent developments of importance brought about by the sheer number of tape recording channels that has become essential. One is the establishment of a separate recording room where numerous machines are grouped together, thus saving both space and operating staff. Machines are also equipped for remote operation so that once they are set up they can be started or stopped by pressing a button on the control panel of any studio or other area equipped with this facility. The second development is the trolley-mounted type of tape machine which can be easily transported to any area where recording or reproduction is required; the technical characteristics of this equipment are identical with those of the rack-mounted type.

MOBILE RECORDING EQUIPMENT

In addition to the permanently-installed recording channels at BBC studio centres, mobile tape recording equipment has been produced and installed in saloon cars and there are also



The Central Tape Recording Room, Broadcasting House, London



(left) *Trolley-mounted tape recording equipment enables recording and reproducing facilities to be easily and quickly provided in areas where these facilities are not permanently required*

(right) *A transistorized tape recorder used extensively by BBC correspondents*

portable and midget recorders. The midget recorders are of particular interest—they measure 15¼ in. × 7½ in. × 8¼ in. and weigh only 14½ lbs including batteries. These single speed recorders, which use tape speeds of 3¾ in./sec. or 7½ in./sec., are suitable for recording speech and are supplied to BBC foreign news correspondents overseas, as well as being widely used by the BBC throughout the United Kingdom. The amplifier used in these portable recorders has recently been re-designed, the valves being replaced by transistors. The space so saved has been used to improve the play-back facilities by accommodating a loudspeaker with its associated transistorized amplifier.

Other machines comparable in size with this recorder have now been produced which although rather more expensive can be switched to any of three speeds at the highest of which, 15 inches per second, the performance is comparable with that of the large static machines.

For interview work a smaller, lighter and much less expensive machine has recently become available which measures only 9⅝ × 5 × 2½ inches and has a weight of only 4 lbs. The use of this type of machine is rapidly increasing.

FINE-GROOVE DISCS

The introduction of fine-groove (long-playing) discs for speeds of 33⅓ and 45 r.p.m. made it necessary for the BBC to design reproducing desks specifically for these recordings. These incorporate a number of special features. In the BBC it is comparatively rare for a fine-groove recording to be reproduced in its entirety, but quite common for short excerpts to be used. It must therefore be possible to find a passage quickly and to start reproduction on a chosen word or note. Some form of groove-locating and a quick-starting device that will not result

BBC disc reproducing desk, type RP2/1. The equipment can be used at speeds of 33⅓, 45, and 78 r.p.m. and includes groove-location and quick starting facilities

in damage to the recording or to the reproducing stylus are therefore required and these facilities have been incorporated in the design of these equipments.

RECORDING STATISTICS

The BBC is probably unique among large broadcasting organizations for the high percentage of live transmissions in its programmes; less than 50 per cent of the BBC's programme output is recorded. Nevertheless during 1961 recordings were made on 58,000 discs and 122,000 reels of magnetic tape; this was in addition to 70,000 disc recordings made for the Transcription Service, which distributes recordings of BBC programmes to overseas broadcasting organizations.

RECLAIMING USED MAGNETIC TAPE

One of the advantages of magnetic recording is, of course, that the tape can be used again once the existing recording is no longer required. The BBC has therefore established a tape reclamation unit for testing and repairing tapes; it reconditions and returns to service some 450 miles of tape each week.

LOCAL BROADCASTING

At the time of writing it is not known whether the Government will decide in favour of the introduction of local broadcasting, i.e. the production and transmission of programmes of local interest in cities and large towns throughout the country. The BBC is ready to undertake this task and has made preliminary plans for the setting up of local stations, each with its own studio and outside broadcast facilities capable of producing several hours of programme material each day. The transmitters would operate on VHF, but might in some cases be supplemented by medium-wave transmitters during the daytime.

STEREOPHONIC BROADCASTING

A stereophonic sound system is one in which two or more channels are used so as to give the listener an impression of the relative positions in space of a number of sources of sound. Such a system demands more equipment, both for the broadcasting authority and for the listener, than an ordinary monophonic system, but it is capable of giving greater realism, depth, and clarity to many types of broadcast programme and to the reproduction of gramophone records.

In 1958 the BBC began experimental stereophonic transmissions outside normal programme hours using two separate channels from the studios up to and including the transmitters. These transmissions are still continuing in 1962 on alternate Saturday mornings, the two transmission channels throughout the country being via the sound transmitters of television stations for the right-hand channel and the Third Programme/Network Three transmitters (medium-wave and VHF) for the left-hand channel. The use of two transmission channels in this way necessitates the use of two receivers and would not be practicable for stereophonic broadcasting as a regular service. Moreover, it would not be possible to free two transmitters to serve each area during normal programme hours. If a regular stereophonic service is introduced, it must employ a transmission system in which the left- and right-hand signals are transmitted simultaneously from a single transmitter and received by a single receiver. It is essential that the stereophonic transmissions should be 'compatible', i.e. that they should give satisfactory monophonic reception when heard on receivers of the types already in general use.

The idea of using two or more microphones, each connected to a separate loudspeaker, was conceived many years ago. Early investigations into binaural hearing using two microphones connected separately to left and right earphones were described by Lord Rayleigh in 1896 and an experiment on these lines was carried out in the Paris Opera House in 1881. However,

it was not until the 1930s that any significant progress was made. Most of the early stereophonic systems were developed for the cinema using a technique employing a number of microphones placed across the sound 'stage'. The outputs from these microphones are recorded on separate sound tracks reproduced by separate loudspeakers. These are spaced across the cinema similarly to the placing of the original microphones. Although there are refinements to this basic arrangement it is clear that this will provide the impression of different relative positions of the various sources of sound and that as these move across the scene the impression of this movement will be re-created in the cinema as the sounds are transferred smoothly from one loudspeaker to another.

Attention was directed towards the development of a system better suited to domestic conditions; the basic principles for such an arrangement were laid down as early as 1931 by A. D. Blumlein, who realized that only two channels are necessary to convey the complete stereophonic information. Blumlein's ideas included an arrangement for recording the left- and right-hand channel information in the single groove of gramophone records, but because of practical difficulties at that time this was not then a commercial proposition.

There have since been two great advances in recording techniques and systems. During the immediate post-war period magnetic recording on tape was rapidly developed and this opened the way for the simultaneous recording on separate tracks on the same tape of the information from the left- and right-hand microphones. The other and more recent development has been in disc recording and processing, which have made it possible to implement the original proposals of Blumlein in what is now known as the '45/45' system. Long-playing stereophonic discs are now in commercial production and general agreement has been reached throughout the recording industry regarding the technical standards to be adopted. The improvement in realism apparent on quite inexpensive reproducing equipment makes it likely that interest in stereophony will not be confined to a relatively small number of enthusiasts.

For stereophonic broadcasting, two microphones are placed very close together; so that they interfere with one another's performance as little as possible it is customary to mount one microphone immediately above the other. The arrangement is referred to as the 'coincident microphone' technique the use of which results in sounds over the whole of the required sound stage width being intercepted by the two microphones. In one such arrangement, sounds from the extreme left are picked up only by the left-hand microphone and sounds from the extreme right are picked up by the right-hand microphone only. Sounds originating from positions between these two extremes are picked up by both microphones—equally when the sound comes from the centre, progressively more by the left and less by the right as the source moves towards the left-hand side, and, of course, more by the right and less by the left as the source moves towards the right.

When the electrical outputs from the two microphones are separately transmitted over similar chains of equipment and are reproduced by two separate loudspeakers, one on the left and the other on the right, then the relative positions and the movement of the sound sources can be reproduced—provided that the two loudspeakers are similar and provided that the listener is at about the same distance from each of them. This arrangement not only gives an impression of position and movement but results in greater clarity, or separation, between the various instruments and artists compared with monophonic transmission.

The fortnightly experimental stereophonic transmissions by the BBC have served a dual function. They enable listeners in most parts of the country who possess both a television

receiver and either a medium-wave or a VHF sound receiver to assess the kind of reproduction which becomes possible from stereophonic transmissions. In addition, the transmissions enable experience to be gained by the BBC in the production of stereophonic programmes and of the special technical equipment required.

A number of systems have been proposed for stereophonic broadcasting and the BBC is continuing its investigations to assess the advantages and disadvantages of each. This work is being carried out in co-operation with other members of the European Broadcasting Union in an endeavour to discover a system that will meet the many exacting requirements for an acceptable stereophonic broadcasting service.

Early in 1962 the European Broadcasting Union recommended to its Members the adoption of the stereophonic system developed in the U.S.A. and known as the Zenith-GE system. This enables the two channels to be transmitted by a single VHF transmitter and to be received on relatively simple equipment; it has the disadvantage, in common with other practicable systems, that the range of each station is reduced for stereophonic reception, but it is hoped that developments in technique will at least partially restore the loss in coverage.

EXTERNAL BROADCASTING

TRANSMITTING STATIONS

EARLY EXPERIMENTAL TRANSMISSIONS

A series of experimental transmissions was started in November 1927 from a 10 kW short-wave transmitter working on 24 metres (12·5 Mc/s) at the Chelmsford works of Marconi's Wireless Telegraph Co. Ltd. These transmissions showed that a short-wave transmitter operating in England on a single wavelength could provide intelligible reception to almost every British Dominion and Colony. Clearly, the use of two transmitters working simultaneously on different wavelengths would materially increase the periods of good reception. In addition, it seemed desirable for the transmitters to be capable of adjustment to wavelengths in each of the wave-bands from 13 to 50 metres internationally allocated to broadcasting. It was also clear that the substitution of directional transmitting aerials for the omnidirectional aerial used for the experimental transmissions would increase the signal strength in the areas for which particular transmissions were intended, thus necessitating a number of separate directional aerials for transmissions to various parts of the world.

THE BBC EMPIRE SERVICE

The inauguration of the 'Empire Service' from the BBC Daventry station on 19 December 1932 represented a considerable step forward from the single wavelength transmitter of 1927. From non-directional transmissions of random excerpts of the domestic programmes on one wavelength, without regard to the suitability of the times for the listening audience overseas, the service had grown to simultaneous directional transmissions from two 15-kW transmitters, on wavelengths chosen to suit the propagation conditions, of programmes specially arranged for

reception at times most suitable to audiences in (1) Australasia, (2) India, (3) South and East Africa, (4) West Africa, (5) Canada and the Caribbean Zone.

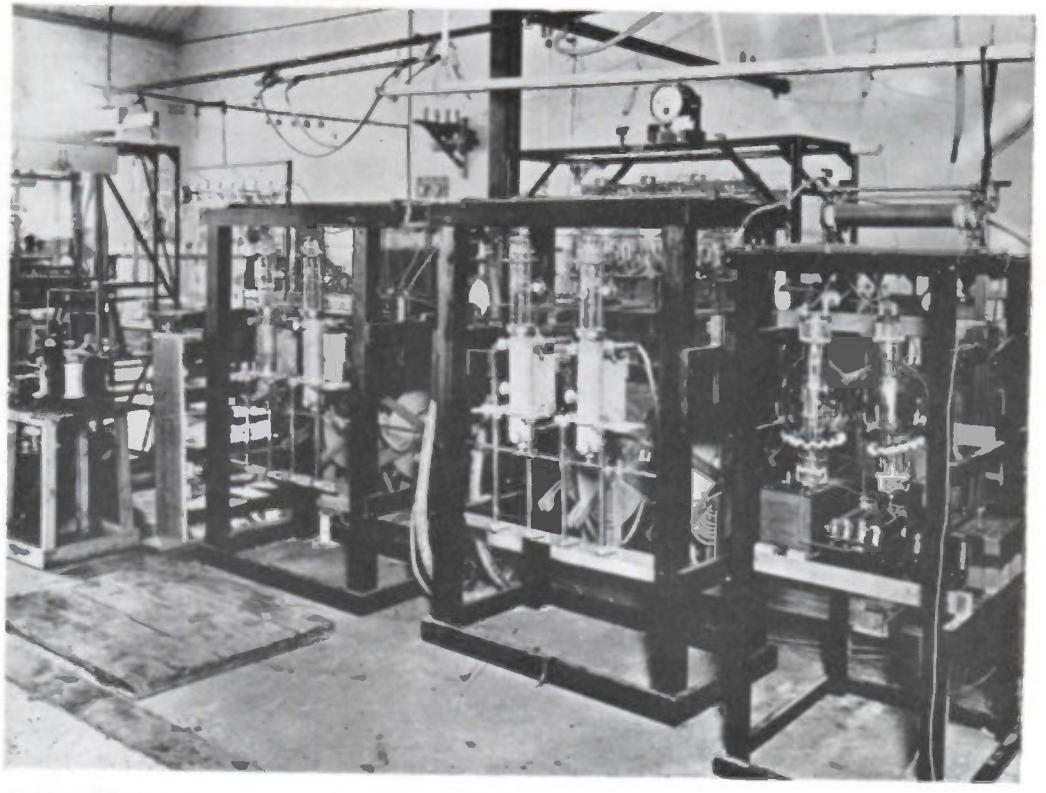
To improve the overall percentage of good reception, changes in timing and additions to the schedule were made in October 1933. A sixth transmission was added in 1935 primarily for evening listening in Western Canada but also serving North America generally and giving an early morning service to India.

RECEPTION REPORTS

A useful system was soon instituted whereby selected listeners reported on reception conditions in the various areas and countries served; this was later supplemented by a weekly cable reporting scheme by a small number of contacts in various parts of the Empire.

EARLY AERIAL DEVELOPMENTS

To improve the strength of the received signals a major scheme was started to provide a greater number of more highly directional aerials. The original twelve directional and six omnidirectional aerials were replaced by aerials with transmission direction bearings as follows:—44° (3), 68° (3), 248° (3), 80° (6), 126° (2), 135° (1), 160° (4), 175° (1), 224° (5), 260° (6),



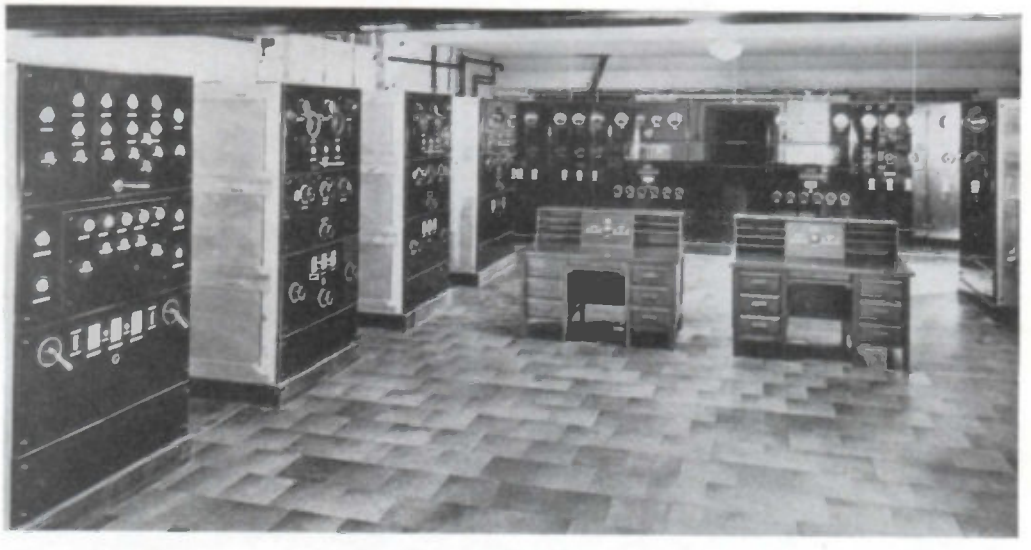
The Chelmsford transmitter, 5SW (1927)

294° (6), 306° (6), 315° (3), 324° (3), the figures in brackets being the number of aerials on each bearing. Physically separate aerials were not necessary for all these directions because of their reversibility (as between 44° and 224° for example) and the possibility of electrically 'slewing' the direction of the main radiation beam of an aerial over an angle of about ± 15° by suitably controlling the relative phases of the currents fed to different sections.

EXPANSION OF THE DAVENTRY STATION

The original pair of transmitters were supplemented by the transfer to Daventry of the experimental (5SW) transmitter from Chelmsford modified to give an output of 20 kW and to work on a number of wavelengths. This was housed in a small separate structure near the original building.

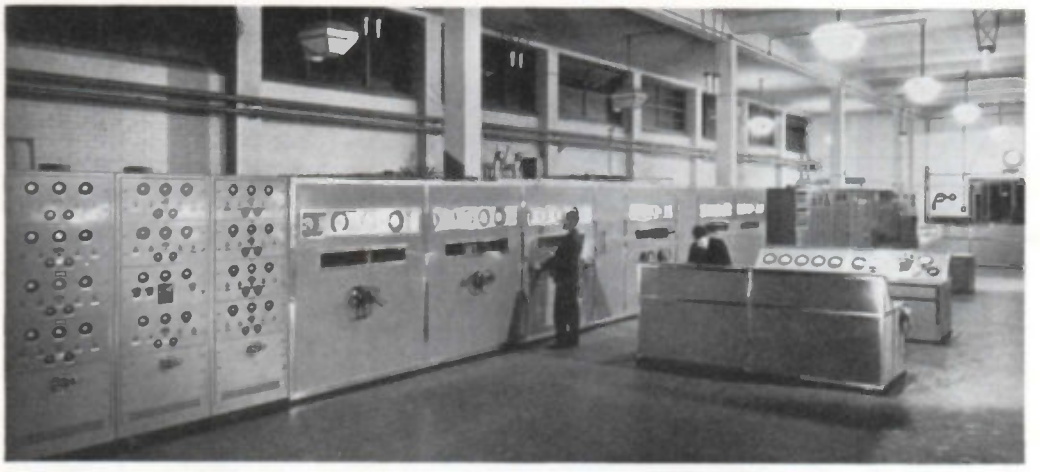
In 1936, work was started on a new building large enough to accommodate four transmitters of considerably greater power output. By the time this was completed early in 1938, however, a further extension was required as a result of the decision to broadcast in foreign languages. The capacity of the new building was therefore increased to house a total of eight high-powered transmitters; one of these was capable of operating either on a single wavelength or at reduced power on two wavelengths simultaneously.



The transmitter hall at Daventry in 1932

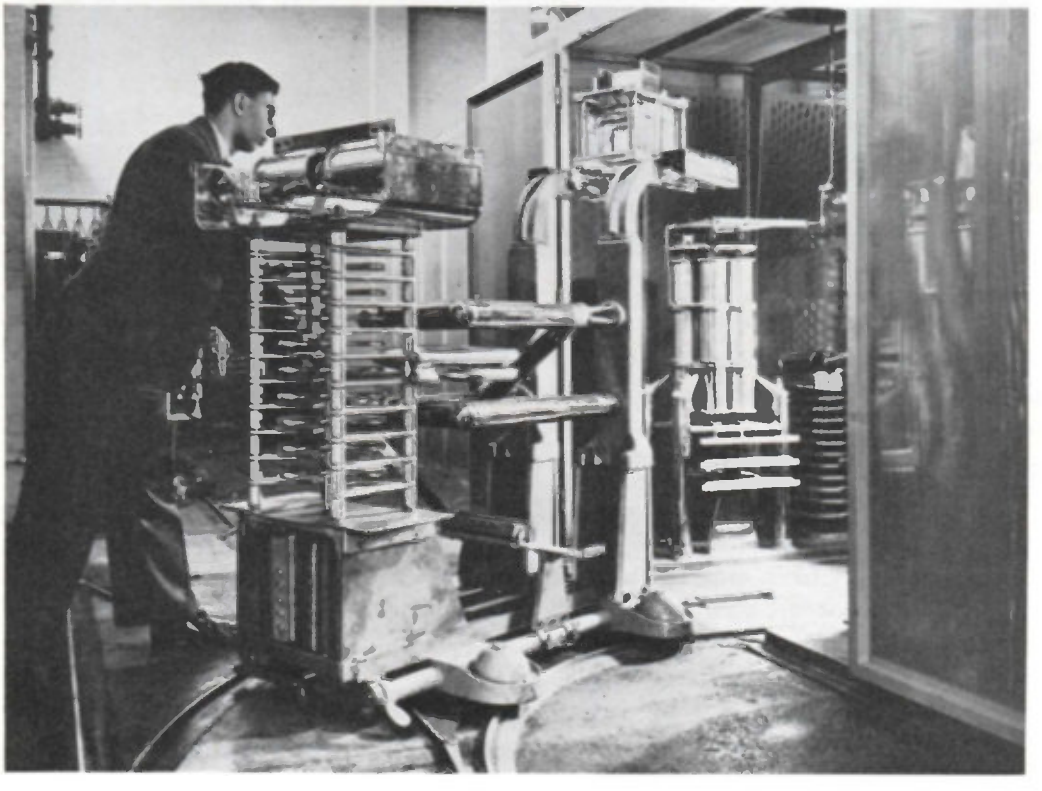
NEW TRANSMITTERS

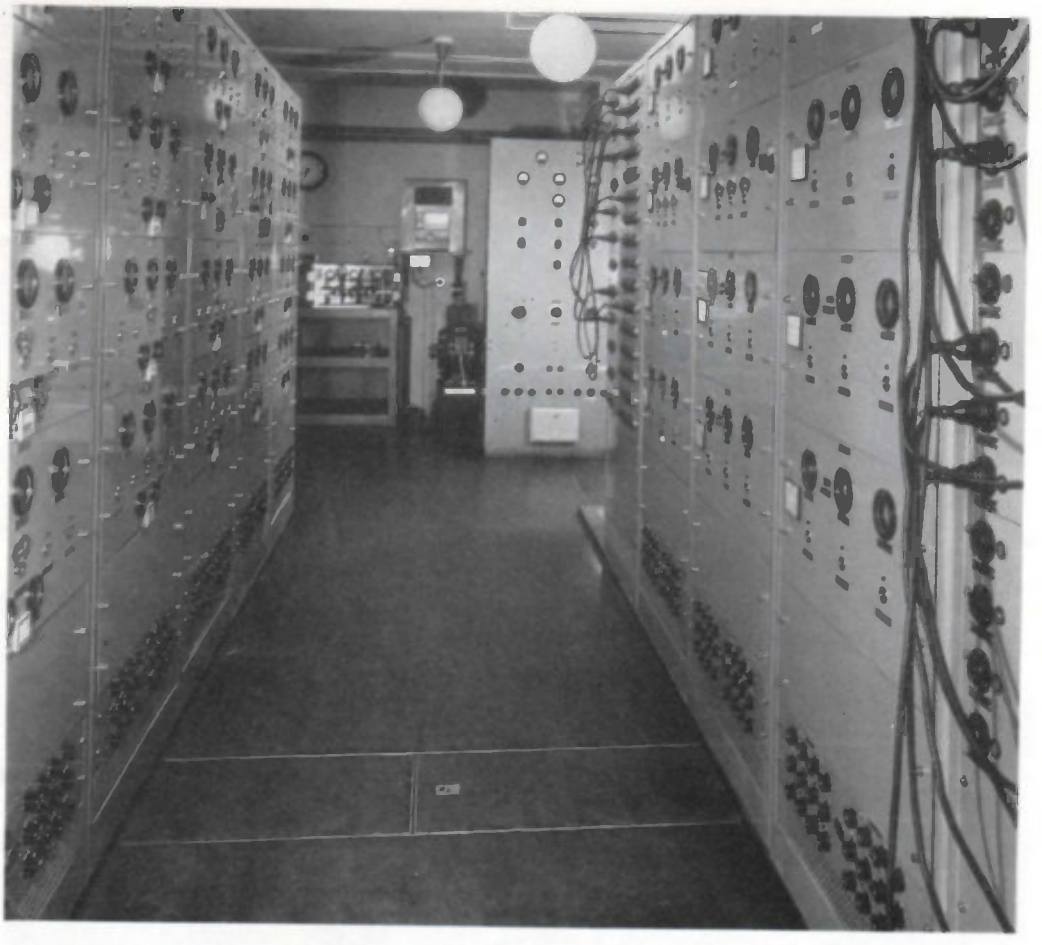
Although at that time the highest-power short-wave broadcast transmitters commercially available were capable of output powers of 40–50 kW, it was considered that this figure would be inadequate for the future and that higher-power transmitters would be necessary. After consultation with the manufacturers, transmitters were ordered for the new station at Daventry with power outputs of 100 kW.



(above) *Two of the high-power transmitters at Daventry in* 1938

(below) *Truck-mounted tuning circuits of one type of new short-wave transmitter at Daventry enabled more rapid wave-changing to be achieved* (1938)





Centralized drive room at Daventry for the generation of all the transmitter carrier frequencies (1939)

To meet the special needs of the BBC's much expanded short-wave broadcasting services, these new transmitters were required to meet the following specification:—

Power outputs of 80 to 100 kW over the range 13·5 to 80 metres.

All tuned circuits to be capable of rapid adjustment to four predetermined wavebands with the number of adjustments to be kept to a minimum and to be uncritical.

The transmissions to have a frequency stability to within 10 c/s per Mc/s by using quartz crystal control in conjunction with harmonic generators for deriving the final output frequencies. Continuously-variable oscillators were to cover frequencies not available by crystal control but the stability of these was to be within 40 c/s per Mc/s.

The harmonic distortion of the programme was to be kept to a specified low level and the response was to be maintained over the audio-frequency range 50–8,000 c/s with little permissible variation (± 2 db).

It became obvious at an early stage in the development of the Daventry station that centralization of the drive equipment for controlling the carrier frequencies of the various transmitters would be advisable. These facilities were, therefore, provided in a room set apart for the purpose, thus enabling more accurate control of the crystal operating temperatures to be maintained. This improved the frequency stability of the radiated carriers and facilitated the operation of more than one transmitter from a common drive, all transmitters on the site being connected to the Drive Room by radio-frequency cables, which were fed from the outputs of the harmonic generators at carrier frequencies. Selection facilities enabled any harmonic generator to feed up to four transmitters and any oscillator to be coupled to any harmonic generator.

FURTHER AERIAL DEVELOPMENTS

Work on a new aerial system was also started in 1936 after the results of a long series of tests (from May 1933 to March 1935) had shown that horizontally polarized aerials were better than vertical, that more than four vertical tiers were not needed in each aerial array, and that for long-distance transmissions the bottom tier should not, in general, be less than one wavelength above the ground.

Considerable mechanical and electrical design work was necessary for the aerial-support masts, the aerial-array rigging, and the feeder system, including the feeder-to-aerial switching arrangements.

WORLD-WIDE RECEPTION ACHIEVED

Reception tests on the performance of the completed Daventry station showed that only on comparatively rare occasions of exceptionally disturbed ionospheric conditions was it impossible to receive the news bulletins, on a reasonably good receiver, in practically any part of the world, at least once in twenty-four hours.

Additional transmitters and aerials were added to enable the foreign language broadcasts, previously mentioned, to be introduced in 1938.

WAR-TIME EXPANSION

The need for great increases in the broadcasts to overseas countries, which gathered momentum during 1939 and continued throughout the early years of the war, necessitated the building of a considerable number of additional high-power transmitters, in particular to enable the broadcasts to occupied countries to be radiated on more wavelengths and at great strength. The necessary facilities were provided by the following measures:—

(i) A new station was built at Rampisham, in Dorset, which came into service early in 1941 with four 100-kW short-wave transmitters.

(ii) Three more high-power transmitters were added at Daventry.

(iii) A new station was built at Skelton, near Penrith, containing twelve transmitters, six of them twin-channel, giving a total of up to eighteen high-power transmissions simultaneously from a selection of fifty-one aerials.

(iv) A new station was built at Woofferton, in Shropshire, equipped with six 50-kW short-wave transmitters.

(v) A new 100-kW transmitter was added at each of two existing medium-wave stations.

(vi) A medium-wave station was converted to work on short waves.

(vii) In 1942 a new medium- and long-wave station was built at Ottringham, near Hull, with a maximum power output of 800 kW.

The greatly expanded Empire Service became known in 1943 as the BBC Overseas Services. These, together with the European Services, became the BBC External Services the growth of which is shown by the following:—

Year	*Number of short-wave transmitters*	*Total output power (kilowatts)*
1932	2	30
1935	3	50
1937	6	170
1938	6	250
1939	8	450
1940	14	840
1941	19	1340
1942	20	1400
1943	44	3020

At the peak another 2000 kW were available from medium- and long-wave transmitters. The programme networks grew from one in 1937 to twelve in 1943–44 and the number of languages rose to forty-five with a total of 132 daily programme hours. At the present time the number of languages is thirty-nine with a total of about eighty-four programme hours per day.

WORLD-WIDE AUDIENCES

At the end of the war it was estimated that in Europe alone 200 million people listened to BBC transmissions. The European and the world audiences continued to be very large after the war. For the Coronation of H.M. Queen Elizabeth II on 2 June 1953, the amount of world rebroadcasting was probably greater than for any other single event. All or part of the special programmes were rebroadcast by some 450 stations in the Commonwealth and Colonies, by 2,000 in the United States of America, and by 400 in other parts of the world.

THE NEED FOR EXTERNAL BROADCASTING AFTER THE WAR

The future of the BBC's External Broadcasting was clearly of great importance to the country. Recommendations were made in the report of the Drogheda Committee, in 1953, on the pattern of British overseas broadcasting and on the development of technical facilities. Considerable efforts have been made by the BBC in recent years to overcome the increasingly difficult problem of providing reliable services to virtually all parts of the world. These efforts include the improvement in performances of short-wave transmitting aerials, the replacement of the early transmitters by up-to-date equipment of higher power and efficiency, and the development of short-wave and medium-wave relay stations overseas.

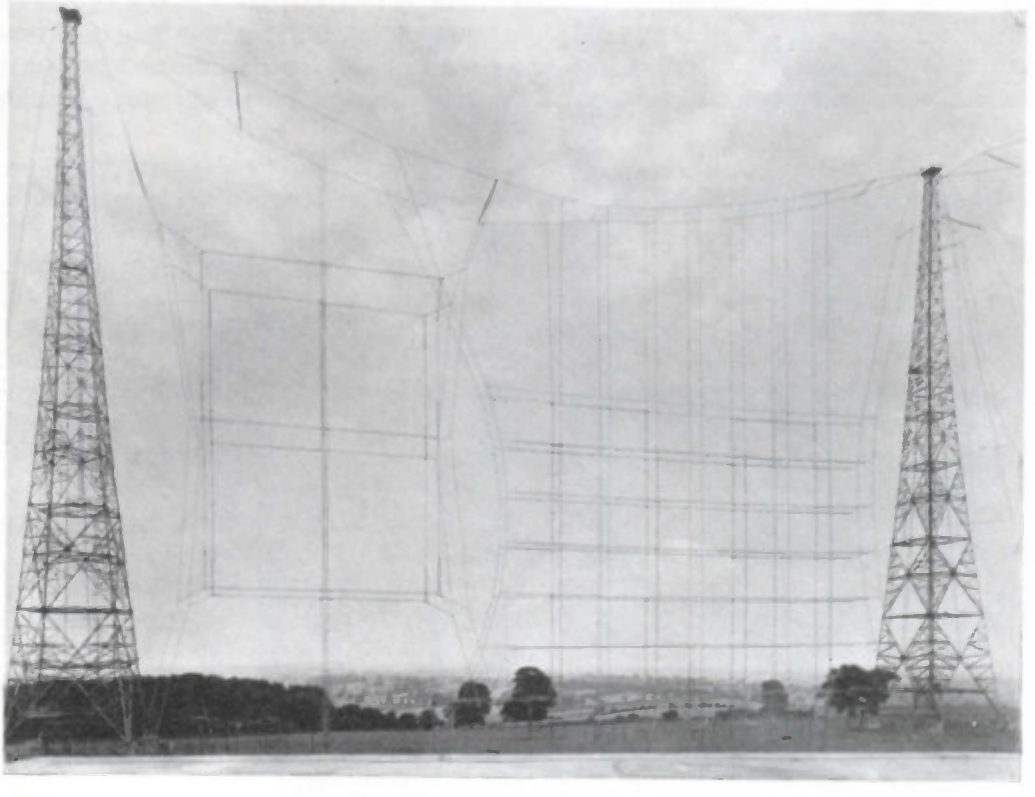
SHORTAGE OF CHANNELS IN THE SHORT-WAVE BANDS

One of the most serious problems is that of finding transmission channels clear of co-channel or adjacent-channel interference. In addition, severe interference to BBC transmissions is often caused by deliberate jamming which, although not always aimed at those transmissions, frequently spreads from nearby channels.

The technique of increasing the power of transmissions by operating more than one short-wave transmitter on the same wavelength using the same aerial has been successfully developed by the BBC and this, together with increased aerial gains, has enabled stronger and clearer signals to be received in remote parts of the world. Economy in wavelengths has been achieved by radiating the same programme in two or three directions simultaneously on the same wavelength, from either the same or different sites.

POST-WAR AERIAL IMPROVEMENTS

Continuous attention has been given since the war to the improvement of the BBC's short-wave transmitting aerials as these are a key factor in providing the best possible reception in the intended service areas.



Two of the self-supporting aerial towers at the Daventry short-wave station between which are supported a 49-metre (left) *and a 16-metre transmitting aerial array*

Not only have these aerials to be designed to give the strongest signals in the wanted areas but it is very desirable that as little as possible of the available transmitter output power should be radiated in unwanted directions, both from the point of view of minimizing waste and also to avoid interfering with other broadcasters.

During the years 1951–61 some 160 aerials were constructed, either to replace existing ones or to cater for changing propagation conditions or network requirements.

THE DEVELOPMENT OF SHORT-WAVE RELAY STATIONS

Because of the great distances involved and the inherent difficulties of the propagation paths to certain areas of the world, the use of intermediate relay bases is sometimes the only practicable solution to the problem of providing a satisfactory service.

One such area is Asia, particularly the Far East, and the British Far Eastern Broadcasting Service was set up in Singapore in 1945/6 to replace the war-time use of All India Radio facilities. At first, BFEBS relayed the BBC's Services on four low-power short-wave transmitters at Jurong, near Singapore, and the temporary use was also obtained for 8½ hours per day of one high-power and one low-power transmitter belonging to Radio Ceylon.

In the meantime, a new short-wave transmitting station was being built by the BBC at Tebrau, in Malaya, to be fed with programmes picked up from the BBC's normal services to the area at a receiving station at Woodleigh on Singapore Island. This relay base came into service on Christmas Day 1950, two high-power and four low-power transmitters being the ultimate complement there. It has proved of the utmost value in providing strong signals in

(1)

BBC Far Eastern Station

(2)

(1) *BBC Transmitting Station at Tebrau, Malaya*

(2) *Receiving Station, Woodleigh: the aerial field*

the Far East, South and South-east Asia, and Australasia: it is particularly valuable as a link with Australia on special occasions such as Christmas Broadcasts and Cricket Tests.

Regular relays via Radio Ceylon continued until about the middle of 1951 when, as a result of the change of that station from a public service to a commercial organization, they were much reduced.

DELIBERATE JAMMING OF BROADCAST TRANSMISSIONS

Radio jamming consists of radiating unpleasant noises, morse or alternative programmes of music or speech, on the same wavelengths as the jammed broadcast with the intention of making it unintelligible to listeners in selected areas.

This process was first employed in the early 1930s and was widely used throughout the war. Post-war jamming has been employed by many countries, notably those of the Communist bloc and, so far as the BBC is concerned, it began with the U.S.S.R.'s jamming of the Russian Service in April 1949. Since then, our services in Hungarian, Rumanian, Bulgarian, Polish, Albanian, Kuoyu, Cantonese, Czech, Slovak, German, Finnish, Greek, Turkish, Hebrew, Persian, Yugoslav, Slovene, and Spanish have all been attacked. Since early in 1960, the Russian Service has been jammed spasmodically for weekly average periods amounting to about one-quarter to three-quarters of the total broadcasting time in that language.

In spite of the tremendous efforts made by the jamming organizations to obliterate the jammed language services in the service areas, there is ample evidence to show that listeners there can still receive the programmes with varying degrees of intelligibility.

POST-WAR WAVELENGTH PLANS AND FREQUENCY ALLOCATIONS

In 1950, the implementing of the Copenhagen Wavelength Plan resulted in the reduction of the coverage of the European Services of the BBC because of the withdrawal of the long wavelength (167 kc/s) from BBC use. Although this loss was partly made good by the use of two medium-wave channels (1,295 kc/s and 1,340 kc/s), it became necessary to augment this service by the use of the BBC high-power Third Programme transmitter at Daventry (647 kc/s) outside Third Programme hours. Three months later, further reinforcement was provided during the early morning period by using the high-power long-wave (200 kc/s) Light Programme transmitter at Droitwich up to a quarter of an hour before it was required for the Light Programme.

The possibilities of formulating a workable short-wave allocation plan were extensively but fruitlessly explored in a series of international conferences starting in Mexico City in September 1948 and continuing there until April 1949. A second conference was held in Paris from June to December 1949 and yet a third in Florence in March 1950. Finally, again in Florence and then in Rapallo a fourth attempt failed and was abandoned in April, 1950. As a result of this failure to reach an internationally agreed plan on the allocation of channels in the short-wave bands the serious shortage of channels available to the BBC continued, and a number of 'out-of-band' channels had to be used.

During 1953, a survey by Commonwealth countries showed that the ratio of the number of short-wave stations operating to the number of channels available was well over three in the 6 Mc/s band, over four in the 7 Mc/s band, and nearly three in the 9 Mc/s band. An investigation of conditions in the lower frequency bands early in 1953 showed that, of fifty-five simultaneous transmissions in the 49-metre band (6 Mc/s), not more than six were intelligible at times because of mutual interference.

In February 1953 the high-power overseas transmitting station at Ottringham, near Hull, was closed. Simultaneously, the medium-wave transmissions on 1,295 kc/s which this station had been carrying in the European Services were transferred to a station at Norden in West Germany. This station had previously been used on another frequency for the European Services from 1946 to 1950. Reinforcement of the coverage in East Germany was provided during the same year by using a medium wave and a VHF transmitter in Berlin. This arrangement continued until 31 March 1962, when it became necessary, as an economy measure, to stop using the Norden station.

In 1957, after consideration of the recommendations made by the Drogheda Committee in 1953, the Government decided that the Portuguese, Dutch, Norwegian, Swedish, and Danish services should be discontinued; the French and Italian services were reduced and the Austrian and German services integrated.

ADMINISTRATIVE RADIO CONFERENCE, GENEVA, 18 AUGUST–22 DECEMBER 1959

This Conference, at which the BBC was represented, reviewed and modified the Radio Regulations and the Frequency Allocation Table drawn up at the 1947 Atlantic City Conference. The position of the Broadcasting Services was not greatly affected by the changes. In spite of the general recognition of the unsatisfactory situation in the short-wave bands there was little support for their extension. Agreement was secured, however, on a new procedure whereby seasonal schedules are now voluntarily submitted by broadcasting organizations to the International Frequency Registration Board in Geneva well in advance of the implementation dates which occur four times each year. This has been named 'Frequency Management Procedure' and, although it cannot be called a 'plan', it can fairly be looked upon as a first step in this direction. Introduced for the first time in September 1960, it appears to have worked smoothly enough from a procedural point of view, but it cannot of itself prevent the worst effects of gross overcrowding in the short-wave bands.

MEDIUM-WAVE RELAY STATIONS

The advantages of relaying its External Services on medium waves has long been apparent to the BBC. Its use of medium-wave transmitting facilities belonging to other organizations started during the war, when it made use of a Government-owned transmitter situated in the United Kingdom for some of its programmes for Europe as early as November, 1942; it still uses this station today.

When the war ended, British occupation of part of Austria allowed the BBC to make use of a powerful medium-wave transmitter at Dobl, near Graz. This station picked up the normal short-wave broadcasts to the area and rebroadcast them on 1025 kc/s. When propagation conditions were particularly difficult—during Winter, sunspot minimum, conditions—the programme material had to be fed from London by line for part of each day. It was of the greatest use for supplementing reception in South-eastern Europe. These relays started in 1949 and ended when Austria regained her independence in the middle of 1955.

The next opportunity for the BBC to use a medium-wave outlet occurred in November 1956 when, shortly after the Suez incident, the facilities previously operated by the Middle East Broadcasting Service in Cyprus became available. These comprised initially one 100-kW medium-wave and four lower-powered short-wave transmitters, to which was added in July 1958 another 100-kW transmitter. Since then, these facilities have relayed the whole of the

One of the two new 100-kW twin radio-frequency channel transmitters brought into service at Rampisham, Dorset, in 1961

Arabic Service and parts of the General Overseas Service, thereby greatly improving audibility in the Middle East.

Two more medium-wave relay stations, installed by the Diplomatic Wireless Service, were brought into operation towards the end of 1960. A 10-kW transmitter on the south coast of Malta relays the whole of the BBC's Arabic Service, giving good coverage in Libya and Tunisia. The other station, at Berbera, on the north coast of the Somali Republic, relays almost the whole of the BBC's Arabic Service, the Swahili Services and some General Overseas Service and transcription material. The very high power of this station gives it a night-time range of around 1,000 miles. This, with the coverage of the medium-wave transmitters in Cyprus and Malta, makes the BBC vernacular programmes easily receivable on the cheapest types of receiver in use throughout the greater part of the Arab world.

IMPROVEMENTS IN TRANSMITTING EQUIPMENT

Early in 1961, two new short-wave transmitters (100 kW each) were brought into operation at the Rampisham station. These have twin radio-frequency channels of which either can be in

use at any time while the other is being adjusted for use on another wavelength. At the appropriate time, such as a programme change, a rapid changeover within a few seconds can be effected from one channel to the other without loss of transmission time. The channel which has just been taken off transmission can then be adjusted for use on the next wavelength required, and so on. These transmitters also incorporate water-vapour cooling for the high-power valves: this system is more compact and less costly than water cooling as used in previous transmitters. These two new transmitters replaced two of the oldest transmitters which had been in use at Daventry since 1932.

At Daventry itself two new transmitters (100 kW each)—similar to those installed at Rampisham—came into service in 1962 replacing two obsolescent 50-kW transmitters which had been in service since 1937.

The high-power short-wave transmitters recently produced by the Industry have important advantages over the older types. They consume less power for a given output and are in other respects more efficient. The older transmitters are gradually being replaced under an extensive modernization programme, which will result in better reception of BBC programmes throughout the world.

RAPID AERIAL SWITCHING

Much potentially valuable time has been lost in the past in switching the connections between aerials and transmitters. These changes have necessitated the transmitters being idle for periods of 15 minutes when such changes are necessary, but newly developed switching equipment, remotely-controlled from the transmitter buildings, is now avoiding much of the time wastage, the switching being carried out during the few seconds gap between the end of one transmission and the beginning of the next.

PROPAGATION CONDITIONS

Reception of broadcast programmes on short waves is very much dependent on propagation conditions, which vary from year to year, from season to season, and throughout each day. These conditions depend on the electrical state of the ionosphere, which comprises a series of layers of electrically charged particles of gas at heights of between fifty and two hundred miles above the earth. The frequency used for transmission to a particular part of the world at a particular time must be chosen to suit the propagation conditions: if it is too low the signals will be absorbed before they reach their destination; if it is too high they will pass through the ionosphere instead of being reflected back to earth. It is therefore essential to have a system of forecasting the optimum frequency for each transmission for each season of the year. A number of stations throughout the world co-operate in providing the data from which such forecasts can be made, the co-ordinating authority in the United Kingdom being the Department of Scientific and Industrial Research. From these forecasts BBC engineers prepare schedules of the frequencies to be used. The optimum frequency for any given service depends, among other things, on the eleven-year cycle of solar activity which passed through a maximum early in 1958. Near the minimum of the cycle the highest-frequency short-wave bands become much less useful than during the maximum phase and this aggravates the congestion in the lower-frequency bands. During the International Geophysical Year (1957–8) a great many special observations were made of phenomena affecting radio propagation and the BBC's receiving station at Tatsfield acted as one of the centres for making these observations.

PROGRAMME AND STUDIO DEVELOPMENTS

PRE-WAR DEVELOPMENT

When the original Empire Service in English was opened on 19 December 1932 using two 15 kW transmitters at Daventry, only a single programme was radiated at any one time for periods totalling ten hours per day. The times of the separate transmissions were arranged to take into account the differences in local time in the various parts of the Dominions and Colonies for which the transmissions were intended. It was thus necessary to have only a single programme line from London to Daventry. Many of the items were radiated as simultaneous broadcasts from the Domestic Sound Services.

A large number of programmes were also recorded at the time of the 'live' broadcasts so that they could be transmitted later to different areas in which the peak local listening times varied widely in Greenwich Mean Time. This necessitated considerable expansion of the recording and reproducing facilities. Much experimental work was undertaken, for example, on the Marconi-Stille magnetic steel tape and the Philips-Miller optical film systems referred to under 'Recording' on page 16. Facilities were also provided for additional news bulletins.

Broadcasting to foreign countries in languages other than English was introduced with the deteriorating international situation in 1938. These additional transmissions, mainly of news bulletins, required extra studio space which initially was provided in Broadcasting House, London.

WAR-TIME EXPANSION

By the end of 1939, bulletins in several more languages had been added and separate Empire and European Services were envisaged. Existing studio premises at Maida Vale in north-west London were utilized to provide the new facilities which had now become urgently necessary. During 1940 the number of foreign language transmissions increased to a total of forty-three. This, of course, necessitated a great increase in studio facilities, and during the years 1939 and 1940 the major part of the Empire Service staff and studio operations were transferred to a large estate at Wood Norton, near Evesham, in Worcestershire. The European Service was provided with centralized studio facilities at Bush House, Aldwych, London. Even then additional premises became necessary and further accommodation was acquired near Evesham.

The necessarily close association and co-operation between studio centre control room staff and the studio staff during this difficult and important period was to develop into the form of continuity suite working which was later to be adopted for most of the External Services transmissions and indeed also throughout the BBC's Domestic Sound and Television Services.

The extent of the expansion is shown by the fact that ultimately the Empire Service provided a World Service in English for twenty hours a day divided into four main transmission periods, and more specialized regional services in English for about 8½ hours a day for the Commonwealth countries. The European Service provided transmissions mainly in Central European languages, for about eighteen hours a day, and transmissions mainly in the Balkan languages, for about 8½ hours a day.

With the ever-increasing pressure on studio requirements plus the threat of enemy bombing, further expansion became necessary and premises were utilized for the Empire Service at Aldenham, in Hertfordshire, from December 1941, and a converted large departmental store

at 200 Oxford Street, London, from May 1942. For the European Service, the Bush House facilities were extended towards the end of 1942.

PROGRAMME DISTRIBUTION

The great increase in the number of programmes in many languages naturally gave rise to many technical problems concerning the operation of the studios, the transmitters and the interconnecting programme circuits. A simple programme network colour-coding system did

Programme distribution switching at the External Services centre at Aldenham, Hertfordshire (1943 *to* 1952)

much to simplify the operational procedure and was introduced during 1939. The number of programme lines to each of the transmitter sites situated in different parts of the country was governed by the number of networks to be radiated simultaneously. The duration of programmes was standardized at multiples of one-quarter hour. The separate language programmes became contributions to the 'colour networks'. Each individual chain of programme lines was scheduled to carry one or more 'colour networks' in succession, and at the transmitter sites each chain had to be connected to the correct transmitter(s).

In May 1943 all programmes for the External Services were routed through Aldenham. The time available for switching at each quarter-hour being only a few seconds, it was necessary to use some form of pre-setting arrangement for all chains which could then be switched simultaneously. This was achieved by fitting two duplicate sets of sockets for the programme contributions (the colours) and the programme lines to the transmitters (the chains). These two sets were referred to as X and Y but only one set at a time could be connected; if X was on transmission, then Y was available for interconnecting the appropriate colours and chains by cords and plugs according to the pattern for the subsequent quarter-hour period. It was then only necessary at the appropriate instant to operate a single switch which simultaneously changed over all the connections from the X to the Y sockets, thus releasing the X set to be set up for the next quarter-hour period.

At the transmitters, the switching between the programme chains and individual transmitters was carried out manually each quarter-hour as required; automatic switching has now replaced the manual switching at some transmitters. As already mentioned, new switching equipment has also resulted in much quicker changes in the connections between the transmitters and aerials.

POST-WAR CONCENTRATION

As soon as possible after the war ended, all the Overseas Services studios and associated facilities were concentrated at Bush House and Oxford Street; by May 1952 the studios at Aldenham and Wood Norton were closed down, the programme-to-line switching equipment having been transferred to Bush House. Programmes originating in Oxford Street were sent to Bush House for distribution to the various transmitters.

In June 1954 a specification was produced for a new control room and associated areas in the Centre Block at Bush House. New studios, also in the Centre Block, were designed together with recording facilities and continuity suites to which reference is made later. These were commissioned in November 1957, use of 200 Oxford Street being given up in December 1957.

BUSH HOUSE SWITCHING AND CONTROL ROOM

Although the original plug and socket method of programme switching provided complete flexibility with low initial cost, this method is untidy and uneconomical in the number of operating staff required for a large installation, and provides no safeguard against human error. In designing the new control room the motor uniselector system, as used in automatic telephone exchanges, was incorporated. This method provides a ready means for switching simultaneously with each programme circuit such ancillaries as the engineering control lines and cueing facilities. Source switches connect any selected programme source to a channel through the switching system while route switches connect a selected channel to a destination, viz. the

transmitter. This double selection method, for a system as complex as that of the External Services, permits all the necessary selection of sources to destinations with considerably fewer selector switches than would be needed for direct source-to-destination switching.

An automatic switching unit enables a twenty-four-hour pattern of colour-networks-to-chains to be set up in advance and the appropriate switching operations take place automatically at every quarter-hour under the control of a master clock. Units known as marking code selectors have 'combs' inserted which control, via relay circuits, the connections which are made to the destination switches. Each colour programme has a comb with a particular arrangement of contacts and, depending upon the arrangement of the combs in the selectors, the destination switches rotate to their predetermined positions at each quarter-hour when operating pulses are applied under the control of the master clock. Twenty-four selectors control the destination switches for twenty-four chains. Any necessary changes in the switching pattern are made by replacing existing combs by others with different contacts.

The main operating position in the control room itself consists of a large desk with a main and a supplementary indicator panel. The main panel shows visually all the source-to-channel and the channel-to-destination connections, while the supplementary indicator shows, by operation of a channel key, the source connected to it (if any) and the destination (if any), thereby avoiding the need to search the large area of the main panel to ascertain the source and destination connected to a particular channel. The display on the supplementary panel is cancelled when another channel key is operated—only one display can appear at a time in contrast to the full display of the main indicator.

Provision is made for manually overriding the pre-set automatic switching to cover last-minute schedule changes, fault conditions, etc. Extensive monitoring and communications facilities are provided.

CONTINUITY WORKING

Reference was made earlier to continuity suites. Continuity working, now used throughout the BBC, takes two different forms in the External Services. Where a network is continuously broadcast to the same group or groups of countries the programme material will come from a variety of sources and a continuity suite consisting of a studio and control cubicle is used. The programme contributions from all sources are fed into the control cubicle, together with linking announcements from the associated continuity studio, to form a continuous programme.

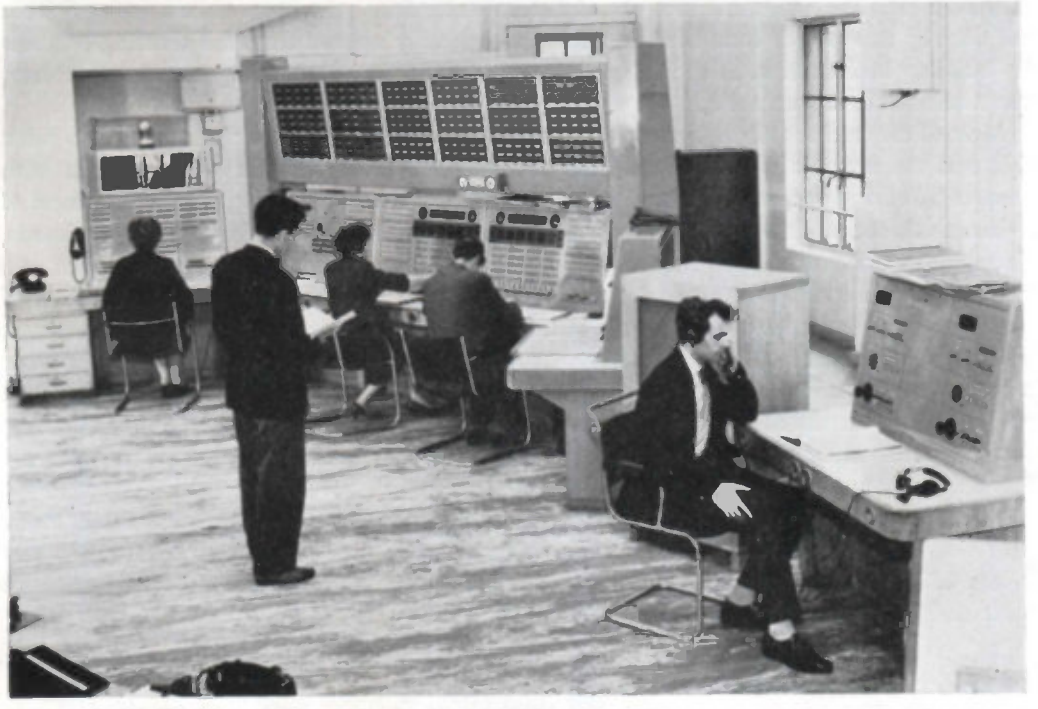
In other cases a network consists of a number of short programmes, each directed to a different part of the world, and in this case the continuity control cubicle simply assembles the network from the individual items without linking announcements.

In addition to three main continuity suites, there are continuity cubicles, adjacent to the control room, for the networks comprising a number of independent programmes.

OTHER PROGRAMME DESTINATIONS

The main technical functions of Bush House are to assemble the complete networks in the various continuity positions and to distribute them to the chains feeding the transmitters by means of the automatic switching unit.

In addition to being distributed to the transmitters, programme material is required for a variety of purposes such as sending to other countries, sometimes as part of a two-way programme; for recording for subsequent transmission; for distribution within the Bush House



The Bush House Control Room. In the centre is the main operating position over which is the main source-to-channel indicator panel

area for programme checking and listening; and to feed a selector system that enables the BBC's technical monitoring station at Tatsfield to dial any network and so to compare, via a direct line, the programme originating from Bush House with that radiated by the transmitters and monitored by radio at Tatsfield.

Facilities are also provided for dealing with additional material such as news despatches and items received by radio at Tatsfield for use either live or recorded for later transmission, and artificial 'echo' facilities are available.

BUSH HOUSE STUDIOS

There are now thirty-six studios, including eleven new ones, three continuity suites and a special studio for announcements to countries joining or leaving the General Overseas Service. The latest designs of studio apparatus have been installed; in several of the original studios the earlier equipments have been suitably modified to take advantage of the new control room facilities. The normal equipment for each studio cubicle consists of a modern control desk, plus gramophone reproducing facilities at 78, 45, and 33⅓ r.p.m. and tape reproducing facilities.

Strict precautions were necessary to ensure sound insulation between the studio suites and the rest of the building. Floating floors, constructed in lightweight concrete, rest on mattresses

of glass fibre. The wall structures are of two separate skins; the inner skin is isolated from the floor by one inch of cork, the outer being additionally isolated from the abutting columns by building board strips. A sponge rubber underlay in the surrounding corridors insulates the studios from impact noise.

Most of the studios and their associated control cubicles have a volume of about 3,000 cubic feet and the acoustic treatment was designed to give a reverberation time, constant with frequency, of 0·35 seconds. The acoustic treatment is of two types. First, porous absorbers of 1-inch thick rockwool were used which absorbed well at frequencies from 500 c/s upwards. Secondly, membrane resonators, evolved by the BBC Research Department, were used and these consist of roofing felt enclosing air spaces. After adjustment, made by the addition of shallow roofing felt units to increase the absorption within the range 250–700 c/s, the acoustic conditions were found to be satisfactory. However, there appeared to be more absorption at 1,000 c/s than was expected and this was thought to be due to a combination of the efficient absorption by carpets at this frequency and to the effect of the perforated decorative covers to the acoustic material. As a result an 'anti-carpet' absorber has been designed which absorbs less efficiently at frequencies near 1,000 c/s.

Since solid hardboard was considered aesthetically unacceptable for covering the acoustic absorbers in the studios, curtain fabric was either draped or used as stretched panels. The colour of the fabric was used as the dominant colour around which the decorative schemes were designed for each studio suite.

RECORDING AND REPRODUCING FACILITIES

Extensive magnetic tape recording and reproducing facilities have been provided. These include two central tape rooms with facilities for remotely-controlling the recording or reproduction of twenty programmes simultaneously. Eleven separate tape channels, with remote-control facilities, are available for recording, editing, and dubbing. Recording channel operators can themselves select the required programme sources without involving the main control room.

ECONOMY IN ENGINEERING STAFF

The centralized working in the new control room resulted in a saving of 12 per cent in engineering staff. Further savings resulted from experience in the operation of the technical areas, so that now there is about 17 per cent saving in staff in spite of increasing commitments. The reliability of the equipment proved to be excellent, so that similar installations were adopted for the Television Centre, which became operational from June 1960, and in the Broadcasting House Extension that was brought into operation in 1961.

THE SOUND TRANSCRIPTION SERVICE

During the war the BBC took over the activities of the Joint Broadcasting Committee. These included the major responsibility for recording selected programmes on discs, which were then processed and copies distributed to Allied and neutral countries for use by their broadcasting services. This service was complementary to the direct reception and rebroadcasting in overseas countries of the BBC short-wave programmes. Thus came into being the BBC's Sound Transcription Service (of which the Transcription Recording Unit comes under Engineering Division). This Service rapidly expanded and still continues on an ever-increasing scale. The

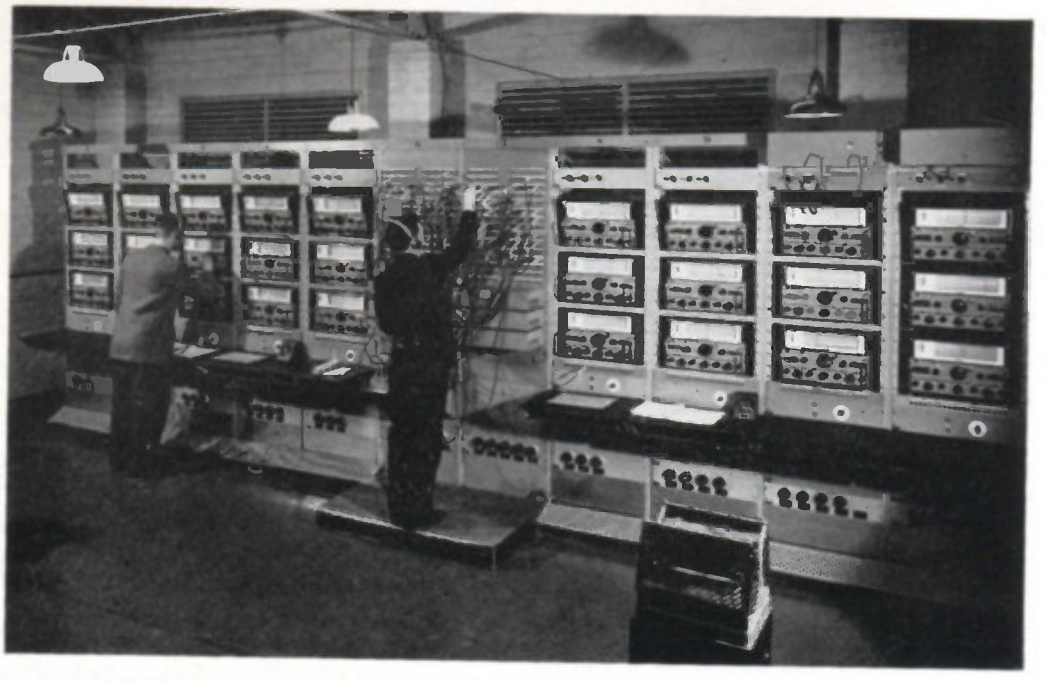
building up of the Transcription Service during the war involved the development of a comparatively small amount of equipment to an exacting specification. With the exception of some of the mechanical parts, all this equipment was designed and built within the BBC. Although a considerable number of the recordings are now on magnetic tape, many recipients still prefer discs and a large quantity of discs therefore continues to be sent overseas. During the year 1960–61 over 900 different programmes, amounting to some 70,000 records, were despatched.

THE MONITORING SERVICE

Listening to broadcast transmissions for the purpose of committing them to paper and distributing the information so obtained became known as 'monitoring' and the simple language monitoring, which was started at Tatsfield (the BBC's technical monitoring station), just before the war, developed very rapidly and became a separate unit initially set up at Wood Norton, near Evesham, in 1939. It outgrew the accommodation available there and was finally established in April 1943 at Caversham, near Reading, where the total number of staff employed exceeded 1,000, of which 650 were engaged directly in the operation of the service. At the peak, 1½ million words were listened to in each twenty-four hours, 300,000 words were transcribed and 100,000 words were circulated as a duplicated 'Daily Digest'. 24,000 words were sent daily as 'flash' material over teleprinter circuits.

The technical facilities of the Monitoring Service consisted of a series of omnidirectional aerials feeding, through a system of wide-band amplifiers and special distribution circuits, some 100 broadcast or communications receivers which were operated by the language monitors themselves. The monitors made notes of what was heard and recorded the broadcasts on dictating machines. At the conclusion of a broadcast, the monitor concerned transcribed the report in greater or less detail as necessary. For the reception of the weaker stations, a remote receiving site was set up. This occupies some 250 acres at Crowsley Park, four miles away from the headquarters at Caversham. At Crowsley the installation includes a number of directional aerials of the rhombic and Beverage types, and some fifty communications receivers operated by engineers. The outputs of the receivers at Crowsley are connected by lines to the reception rooms at Caversham where each monitor switches his headphones either to his own local receiver or to the line connected to the appropriate receiver at Crowsley. The site at Crowsley was chosen with special care so as to secure the lowest possible electrical noise level in the district, and the general neighbourhood of Reading and Caversham was chosen because it was reasonably remote from all high-power transmitters—a condition necessary to reduce to a minimum the production of intermodulation products in the wide-band amplifiers. It had, moreover, good communications with London and was considered to be reasonably immune from air attack. The arrangements made to distribute by teleprinter circuits to Government Departments the information picked up at Caversham have already been mentioned on page 23 under 'Programme and Communications Circuits between BBC Centres'. Special arrangements were made to secure immediate 'stop press' transmission of very important items.

The wide-band amplifier equipment used at Caversham was specially designed by BBC engineers. It relies essentially for its success on special types of wide-band transformers, used in the distribution of the amplified aerial signals to the receivers, which are capable of covering



Monitoring Service: Crowsley Park Receiving Station. Communications-type receivers, aerial-signal distribution system, and wide-band amplifiers

the band of frequencies from 50 kc/s to 40 Mc/s with an attenuation, inside the pass-band, of not more than 2 db. The range of frequencies covered by the distribution system is 100 kc/s to 27 Mc/s. This range is subdivided into seven octaves and one near-octave. The distribution arrangements avoid interference from any first-order combination terms produced in the aerial amplifiers and also provide over 40 db attenuation between receivers connected to the system.

Post-war developments have included the replacement of the original octave amplifier system at Crowsley Park by six push-pull wide-band amplifiers having a high degree of linearity, each covering the frequency range from 100 kc/s to 25 Mc/s and having ten radio frequency outputs; the replacement of the original, American, communications receivers by British receivers of improved performance; and the use of very-long-wave converters in which morse signals in the frequency range 15–150 kc/s are made to key a radio-frequency oscillator to produce an output within the tuning range of normal receivers.

The Main Listening Room at Caversham has been almost completely re-equipped with modern British communications-type receivers. Remotely-started plastic belt recording machines, replacing the earlier wax-cylinder machines, are installed so that items can be recorded for subsequent replay on transcription machines. The recording machines are arranged in groups and electrical 'booking' facilities at each monitoring position enable any recorder which is not already booked or in use to be reserved for instant use when required. Radio-teletype transmissions have now largely superseded Hellschreiber (facsimile telegraphy) transmissions

and are either received at Crowsley and fed to Caversham or, in the case of the long-wave signals, are received direct at Caversham.

The programme lines from Crowsley Park are switched in the Listening Room at Caversham to the appropriate monitoring positions at the supervisory control position. Here a BBC-designed console provides such facilities as push-button monitoring-line routing, supervisory monitoring of all monitors' listening positions, and two communications-type receivers for use by the supervisor.

The monitors now cover broadcasts from more than thirty-five countries in nearly as many languages. From the total intake, the Monitoring News Bureau selects and processes news and other urgent information for transmission by teleprinter to the BBC's news departments and to the Foreign Office. Part of this service is also supplied to subscribing news agencies. A number of publications are produced daily, or at less frequent intervals, chiefly for Government Departments, but are available also to other organizations.

INTERNATIONAL CO-OPERATION

In the field of international relations, the BBC participates in the work of a number of organizations, and is represented on numerous committees and study groups. International co-operation can naturally assist in the solution of many problems in broadcasting; for some of them it is indispensable. Many links with organizations overseas were broken by the war and have since been re-established. The International Broadcasting Union, formed by the broadcasting organizations in Europe in 1925, could not be maintained after the war as a single comprehensive union of all the broadcasting organizations in the European region, on account of political difficulties. In Western Europe, the European Broadcasting Union founded in 1950 has replaced the I.B.U.; it is an organization embracing the whole field of sound and television broadcasting, including programme and legal matters as well as technical ones. The then Director-General of the BBC was elected President of the Union in 1950 and was re-elected to that office from 1955 to 1960. A member of the Engineering Division of the BBC has been Chairman of the Technical Committee since 1952. The E.B.U. has its headquarters in Geneva; the Technical Centre is in Brussels with a monitoring and measuring station at Jurbise, in the south-west of Belgium. In Eastern Europe there is a separate union known as the International Organization of Radio and Television (O.I.R.T.), which has its headquarters in Prague and includes among its members most of the countries of Eastern Europe and others in the Far East. There is some exchange of information and co-operation between the two Unions on technical matters.

The E.B.U. operates in Brussels an international control centre for Eurovision, through which pass the vision, sound, and control lines connecting together sixteen countries in Western Europe. On 1 January 1962 a permanent network of sound and control lines was set up, linking eight of these countries together; although this network was established primarily for use in connection with television, it is available also for sound broadcasts relayed from one country to another.

The BBC also participates in the work of the International Telecommunication Union (I.T.U.) and in that of its two permanent consultative committees—the International Telegraph

and Telephone Consultative Committee (C.C.I.T.T.) and the International Radio Consultative Committee (C.C.I.R.). These organize studies and issue recommendations and information on technical and operating problems. Whenever broadcasting interests are involved, the BBC sends representatives to the conferences, either as members of a United Kingdom delegation or as independent observers.

The BBC is also represented on the U.K. committee of the International Special Committee on Radio Interference (C.I.S.P.R.) organized by the International Electrotechnical Commission (I.E.C.); the latter body is concerned with standards for all electrical equipment, and the former with the measurement, control, and suppression of electrical interference caused by such equipment.

CO-OPERATION IN THE BRITISH COMMONWEALTH

Broadcasting has steadily grown throughout the Commonwealth countries and there has been a rapid development of broadcasting in the Colonies, particularly since 1949 when the British Government decided to make funds available for this purpose under the Colonial Development and Welfare Act.

All the Commonwealth countries and thirty-two Colonial territories now have sound broadcasting services.

In 1945 the first Commonwealth Broadcasting Conference was held in London; it was called in order that the major broadcasting organizations of the United Kingdom, Australia, Canada, New Zealand, South Africa, and India should be able to review their co-operation during the war years and to consult with each other how best this co-operation could be continued and developed in time of peace. Parallel with the meetings of the main Conference a technical committee covered the same field on the engineering and scientific side. The success of this Conference led to the holding of another, also in London, in 1952, and a third in Sydney, Australia, in 1956. A further similar Conference was held in New Delhi in January 1960. These Conferences have provided a valuable means of exchanging information and have proposed a number of practical steps to ensure still closer co-operation and mutual assistance in all fields of broadcasting.

Since the war, Colonial broadcasting has created a growing need for experienced broadcasters and engineers to help in establishing and running the new services until trained replacements are available. The BBC has assisted in these projects by seconding staff, on request from the Colonial Office, and by accepting suitable staff from the Colonies and from the newer Commonwealth countries for training by the BBC. Assistance has also been given in surveying the various territories in the planning stage in order to provide expert advice on the creation and expansion of a broadcasting service.

In 1962 the number of BBC staff on secondment to overseas broadcasting organizations totalled forty-three, comprising twenty-three technical and twenty programme and administrative staff.

This rapid and large-scale development has helped to create an important market for British manufacturers of broadcasting equipment of all kinds ranging from complete transmitting stations and studio centres to recording equipment and receivers.

ENGINEERING RECRUITMENT AND TRAINING

The technical requirements of the various BBC services have continued to expand, particularly in television and VHF sound broadcasting. This has created a need for additional staff in the engineer and technician grades; inevitably, there have also been losses of fully-trained staff to other organizations and an increasing rate of normal retirements. Engineering recruitment and training therefore form an important part of the BBC's activities.

Recruitment of technical staff into the Engineering Division is normally made into one of the following five categories—Engineers, Graduate Apprentices, Technical Assistants, Technical Operators, and Technical Trainees.

The number of qualified Engineers required has increased at a greater rate than that of Technical Assistants. It is therefore difficult to obtain the requisite number of Engineers by promotion of experienced Technical Assistants, and it is necessary to recruit fully trained Engineers in the face of intense competition from industry and from other public services. Engineers with suitable academic qualifications are recruited either direct from university or technical college, or after having obtained some experience in industry. During their first year's service, which is considered as a specialized training period, they are given practical training 'on the job' and in addition attend an engineering course at the Engineering Training Department lasting about three months.

The Engineering Division also accepts engineers and physicists with university degrees for graduate apprenticeships. These apprenticeships last two years and include attachment to various Engineering departments and a short course in the Engineering Training Department; most of the graduate apprentices are appointed to one of the Specialist Departments, e.g. Research or Designs, at the end of their training.

Recruits to the Technical Assistant and Technical Operator grades now come mainly from the ranks of school-leavers at about eighteen years of age who have spent the last two school years in the sixth form. Care is taken to ensure that boys recruited will be suitable, after appropriate experience and training, for promotion to the grade of Engineer or Senior Technical Operator. Technical Operators normally work under the guidance of Senior Technical Operators as members of a team testing and operating studio, control room, and recording equipment. Technical Assistants, who work under the guidance of Engineers, are concerned with the maintenance of this equipment or with the operation and maintenance of equipment at transmitting stations and for line communications. In addition to 'on-station' training, Technical Operators and Assistants attend full-time courses at the Engineering Training Department during the early years of their service.

Sandwich courses, or technical traineeships, are provided for a limited number of boys leaving school with the General Certificate of Education at Advanced Level, the Scottish Certificate of Education on the higher grade, or the Northern Ireland Senior Certificate, in mathematics and physics. During these courses alternate periods of six months are spent in various Engineering departments and at a technical college. The courses last three years and lead to the Higher National Diploma in electrical engineering and to graduate membership of the British Institution of Radio Engineers. Trainees who are outstanding in the final Diploma examinations and in their training with the BBC are considered for an extension of this course by a further period of attendance at a technical college for graduate membership of the Institution of Electrical Engineers.

Further particulars of employment of the categories of staff mentioned are available by writing to the Engineering Recruitment Officer, Broadcasting House, London, W.1.

Reference has already been made on page 27 to the measures taken during war-time to train the large number of new recruits needed by the Engineering Division. In 1946 the training was concentrated at a central Training School near Evesham.

The Engineering Training Department provides training in broadcasting engineering for all types and grades of technical staff. Attention is focused on the application of basic principles to the equipment and methods used by the BBC, without attempting to duplicate the basic training in electrical engineering given by the universities and technical colleges.

The training courses are planned and revised as necessary to meet the requirements of the sound and television services, which vary as technical development proceeds. A feature of the training technique that has aroused considerable interest outside the BBC is the presentation of highly technical information in such a way that it can be readily understood by staff without advanced technical knowledge or mathematics. Seventeen different types of training courses are now given, ranging from the basic courses for new recruits in the Technical Assistant and Operator grades to specialized refresher courses for established engineers. Courses, followed by an examination, are also held for staff wishing to qualify for transfer from the Technical Assistant to Engineer grades.

An important feature of the Engineering Training School is that it is fully residential (with accommodation for 240 students), thus enabling trainees from different parts of the organization to meet and discuss their problems and their work. Trainees have also been accepted from overseas broadcasting organizations, mainly those of the Commonwealth countries.

ELECTRICAL INTERFERENCE

The BBC is vitally concerned with all kinds of interference which may spoil reception of the programmes by its public, the listeners and viewers. The enormous growth in the number of electrical appliances used in the home, in addition to greatly increased use of industrial and electro-medical apparatus, has made local electrical interference a major hazard to reception, particularly since the war. In some areas, severe interference is also experienced from overhead power lines. The BBC is therefore intimately concerned with the technical investigation of this problem and works in close collaboration with the Post Office, the Institution of Electrical Engineers, the British Standards Institution, and other interested organizations, including the C.I.S.P.R. (International Committee on Radio Interference).

It is satisfying to be able to record that, as a result of careful technical investigations and consultation, the Postmaster General has been able to make Regulations under the Wireless Telegraph Act, 1949, for the control of interference caused by the ignition systems of motor vehicles and stationary installations using internal combustion engines (1953) and by small electric motors and refrigerators (1955). Interference from electro-medical and industrial heating equipment is under consideration by the Postmaster General's Advisory Committee.

Unfortunately, the fitting of ignition-interference suppressors to older (pre-1953) vehicles has not been made compulsory, and these vehicles, though diminishing in numbers, continue to cause serious interference to television and VHF sound broadcasting, particularly in areas of low signal strength.

The investigation of complaints of electrical interference is undertaken by the Post Office; the number of complaints of interference with sound broadcasting investigated has steadily fallen as shown by the following figures:—

1957	135,994
1958	123,331
1959	107,877
1960	106,200
1961	91,756

This reduction is no doubt due partly to the increased use of VHF transmissions, which are much less susceptible to interference than long-wave and medium-wave transmissions. It is also partly due to the increased popularity of portable receivers, which are less susceptible to mains-borne interference than mains-operated receivers, and partly to a transfer of public interest to television. It seems likely, however, that some part of the welcome reduction in the number of complaints is a result of the introduction of the regulations and of the greater awareness of the problem among manufacturers and users of electrical appliances.

WAVEBANDS AND FREQUENCIES ALLOCATED TO SOUND BROADCASTING IN THE UNITED KINGDOM

Band	*Frequencies**	*Remarks*
Long wave	150–285 kc/s (2,000–1,053 m.)	One frequency (200 kc/s) available to BBC
Medium wave	525–1,605 kc/s (571–187 m.)	12 frequencies for Home, Light, and Third Programmes and two for European Services, plus two international common frequencies, of which one is at present in use
Short wave	3,950–4,000 kc/s (75 m. band) 5,950–6,200 kc/s (49 m. band) 7,100–7,300 kc/s (41 m. band) 9,500–9,775 kc/s (31 m. band) 11,700–11,975 kc/s (25 m. band) 15,100–15,450 kc/s (19 m. band) 17,700–17,900 kc/s (16 m. band) 21,450–21,750 kc/s (13 m. band) 25,600–26,100 kc/s (11 m. band)	Frequencies in these bands are agreed for use as requested by the BBC External Services
Band II (VHF)	87·5–100 Mc/s	Frequencies at present mainly restricted to 88–95 Mc/s, used for BBC VHF Sound Services

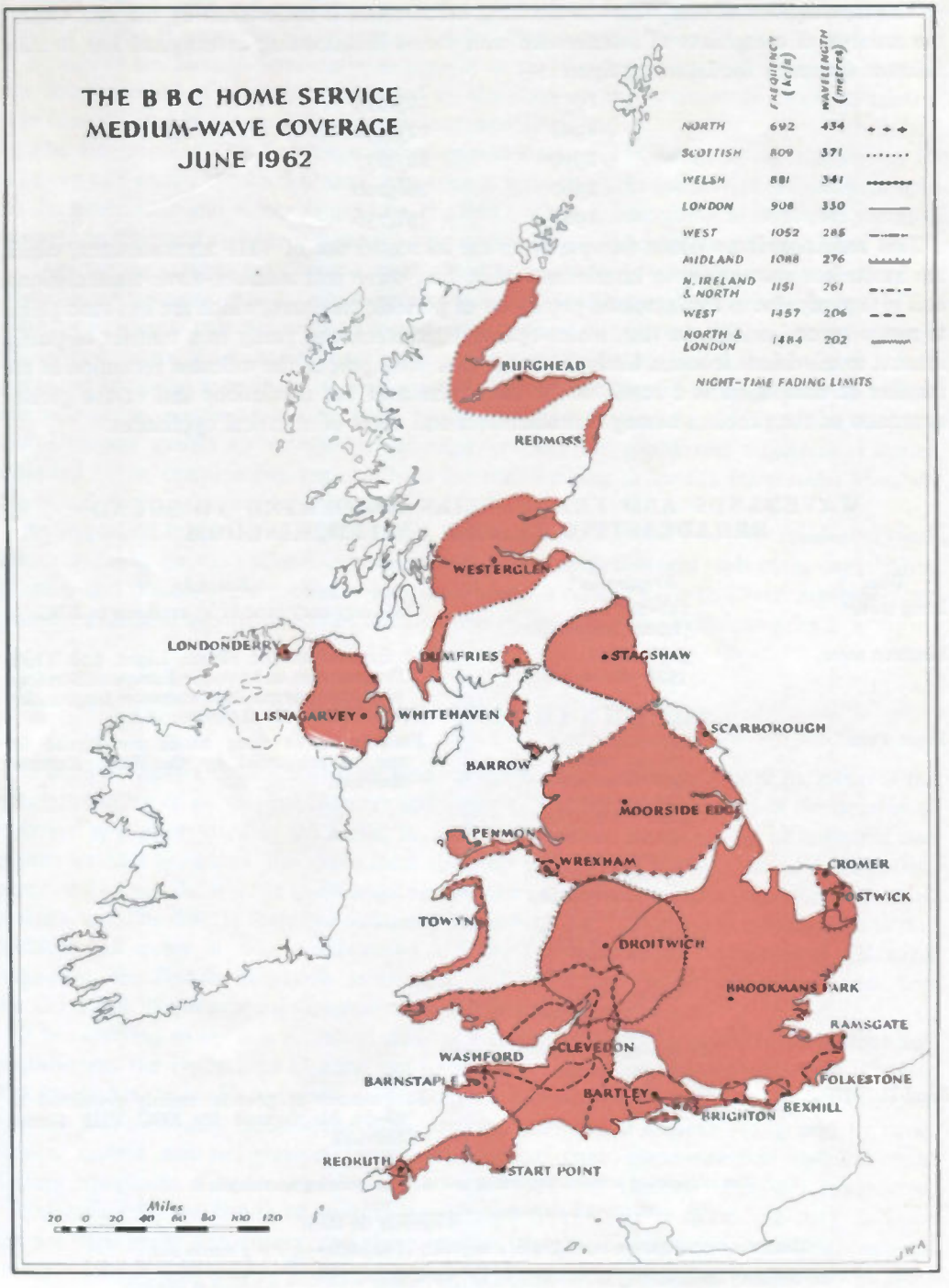
* The relationship between frequencies and the corresponding wavelengths is

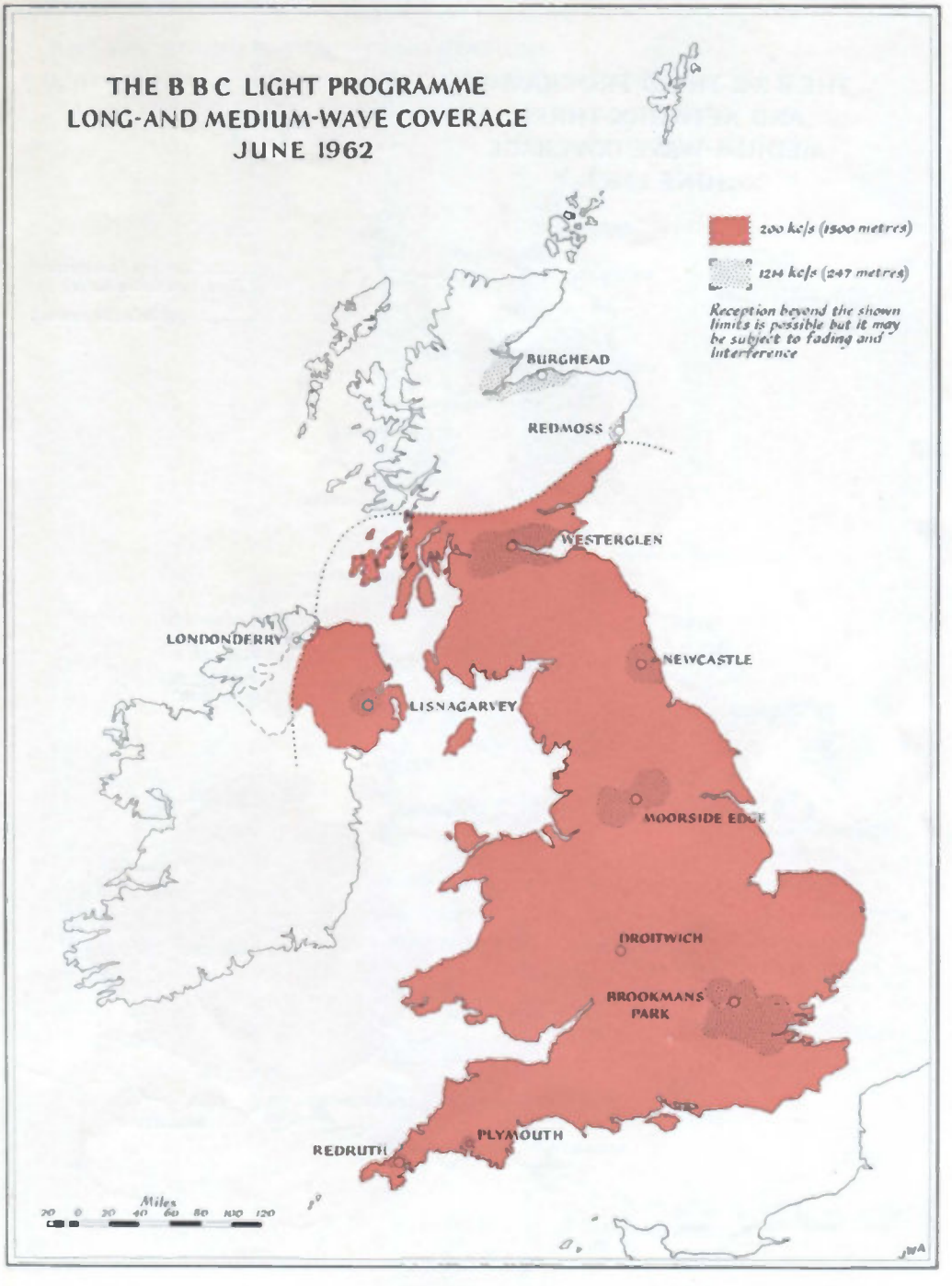
$$\text{Wavelength (in metres)} = \frac{300}{\text{Frequency (in Mc/s)}}$$

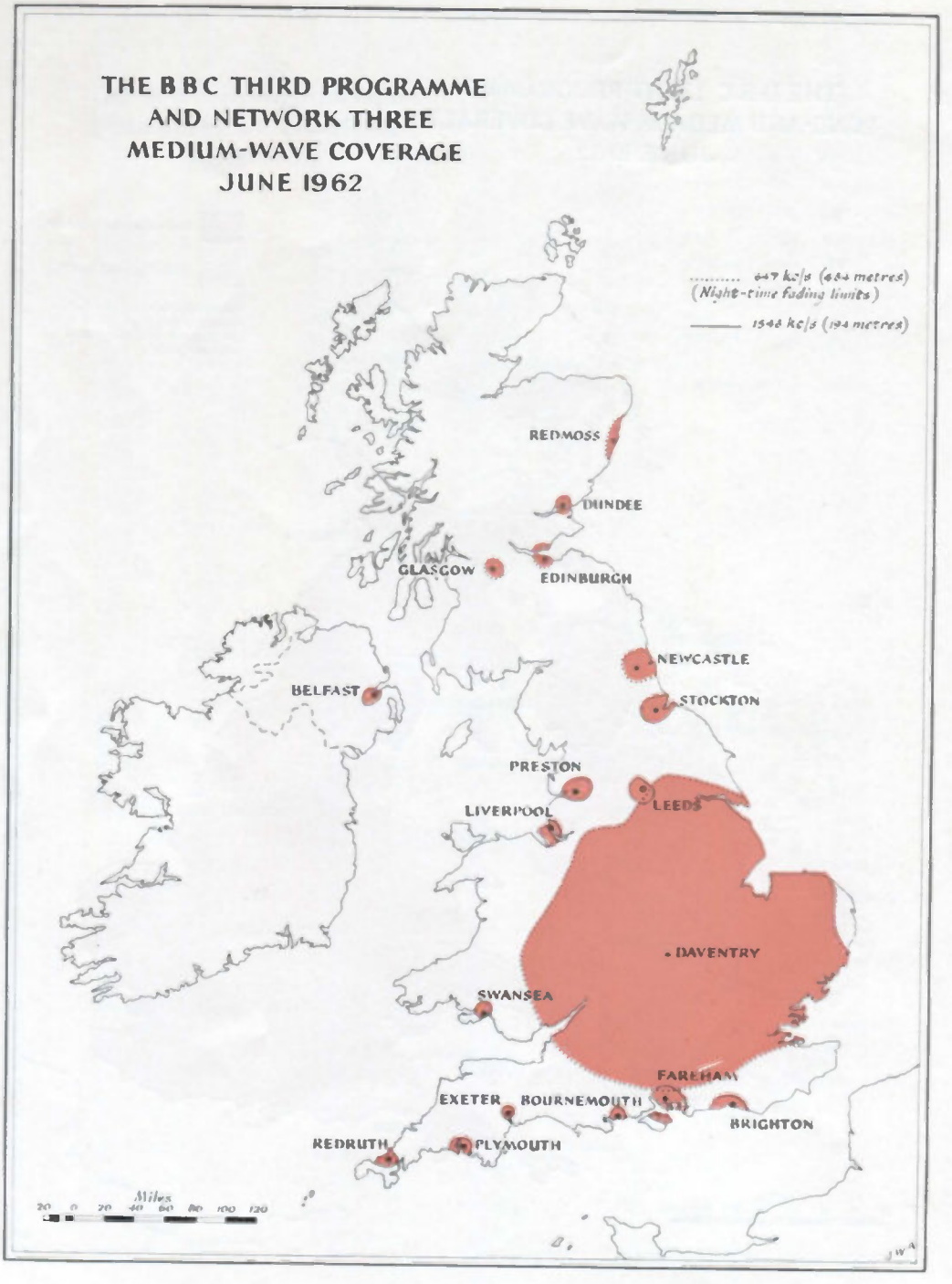
Thus, the wavelength corresponding to a frequency of 60 Mc/s $= \frac{300}{60} = 5$ metres and

the frequency corresponding to a wavelength of 1,500 metres $= \frac{300}{1{,}500} = 0{\cdot}2$ Mc/s or 200 kc/s

(1 Mc/s = 1,000 kc/s)


THE B B C HOME SERVICE
MEDIUM-WAVE COVERAGE
JUNE 1962
FREQUENCY (kc/s)
WAVELENGTH (metres)
NORTH 692 434
SCOTTISH 809 371
WELSH 881 341
LONDON 908 330
WEST 1052 285
MIDLAND 1088 276
N. IRELAND & NORTH 1151 261
WEST 1457 206
NORTH & LONDON 1484 202
NIGHT-TIME FADING LIMITS
BURGHEAD
REDMOSS
WESTERGLEN
LONDONDERRY
DUMFRIES
STAGSHAW
LISNAGARVEY
WHITEHAVEN
SCARBOROUGH
BARROW
MOORSIDE EDGE
PENMON
WREXHAM
CROMER
OSTWICK
TOWYN
DROITWICH
BROOKMANS PARK
RAMSGATE
WASHFORD
CLEVEDON
BARNSTAPLE
FOLKESTONE
BARTLEY
BRIGHTON
BEXHILL
REDRUTH
START POINT
Miles
20 0 20 40 60 80 100 120


THE B B C LIGHT PROGRAMME
LONG-AND MEDIUM-WAVE COVERAGE
JUNE 1962
200 kc/s (1500 metres)
1214 kc/s (247 metres)
Reception beyond the shown limits is possible but it may be subject to fading and interference
BURGHEAD
REDMOSS
WESTERGLEN
LONDONDERRY
NEWCASTLE
LISNAGARVEY
MOORSIDE EDGE
DROITWICH
BROOKMANS PARK
PLYMOUTH
REDRUTH
Miles
20 0 20 40 60 80 100 120


THE BBC THIRD PROGRAMME
AND NETWORK THREE
MEDIUM-WAVE COVERAGE
JUNE 1962
647 kc/s (464 metres)
(Night-time fading limits)
1548 kc/s (194 metres)
REDMOSS
DUNDEE
GLASGOW
EDINBURGH
NEWCASTLE
BELFAST
STOCKTON
PRESTON
LEEDS
LIVERPOOL
DAVENTRY
SWANSEA
FAREHAM
EXETER
BOURNEMOUTH
BRIGHTON
REDRUTH
PLYMOUTH
Miles
20 0 20 40 60 80 100 120


BBC VHF SOUND BROADCASTING STATIONS AND COVERAGE HOME, LIGHT, THIRD AND NETWORK THREE PROGRAMMES JUNE 1962
SHETLAND
EXISTING MAIN STATIONS
RELAY STATIONS IN OPERATION
RELAY STATIONS PLANNED OR UNDER CONSTRUCTION
AREAS COVERED
ORKNEY
THRUMSTER
LEWIS
SEMARKIE
SKYE
MELDRUM
GRANTOWN-ON-SPEY
FORT WILLIAM
PITLOCHRY
KINLOCHLEVEN
FORFAR
OBAN
PERTH
KIRK O SHOTTS
ROTHESAY/LARGS
ERWICK-UPON-TWEED
ASHKIRK
SOUTH-WEST SCOTLAND
LONDONDERRY
LARNE
PONTOP PIKE
SANDALE
ENNISKILLEN
DIVIS
NEWRY
DAL
SCARBOROUGH
DOUGLAS
BARROW
HOLME MOSS
LLANDDONA
SHEFFIELD
EAST LINCOLNSHIRE
LLANGOLLEN
SUTTON COLDFIELD
MACHYNLLETH
PETERBOROUGH
TALCONESTON
BLAEN-PLWYF
NORTHAMPTON
CAMBRIDGE
LLANDRINDOD WELLS
HEREFORD
PEMBROKE
CHELTENHAM/GLOUCESTER
BRECON
CARMARTHEN
OXFORD
WENVOE
BATH
WROTHAM
DOVER
HARNSTAPLE
BRIGHTON
OKEHAMPTON
NORTH HESSARY TOR
ROWRIDGE
REDRUTH
Miles
20 0 20 40 60 80 100 120
LES PLATONS


BBC CENTRES AND
REGIONAL BOUNDARIES
JUNE 1962
STUDIO CENTRES
SOUND TRANSMITTING STATIONS :-
Domestic Long & Medium Wave (A.M.)
Domestic Very High Frequency (F.M.)
External Services
TELEVISION TRANSMITTING STATIONS
REGIONAL BOUNDARIES
ORKNEY
THRUMSTER
BURGHEAD
ROSEMARKIE
MELDRUM
ABERDEEN
REDMOSS
DUNDEE
WESTERGLEN
GLASGOW
EDINBURGH
KIRK O' SHOTTS
LONDONDERRY
DUMFRIES
STAGSHAW
NEWCASTLE
PONTOP PIKE
SANDALE
SKELTON
STOCKTON
DIVIS
BELFAST
LISNAGARVEY
WHITEHAVEN
SCARBOROUGH
BARROW
DOUGLAS
LEEDS
PRESTON
MOORSIDE EDGE
MANCHESTER
HOLME MOSS
SHEFFIELD
LLANDDONA
PENMON
LIVERPOOL
BANGOR
WREXHAM
LLANGOLLEN
NOTTINGHAM
CROMER
SUTTON COLDFIELD
TOWYN
POSTWICK
PETERBOROUGH
NORWICH
BIRMINGHAM
WOOFFERTON
TACOLNESTON
BLAEN-PLWYF
DROITWICH
LLANDRINDOD WELLS
DAVENTRY
MANNINGTREE
OXFORD
BROOKMANS PARK
SWANSEA
CARDIFF
LONDON
RAMSGATE
BRISTOL
CRYSTAL PALACE
WENVOE
CLEVEDON
WROTHAM
DOVER
BARNSTAPLE
WASHFORD
HASTINGS
FOLKESTONE
BARTLEY
FAREHAM
RAMPISHAM
REXHILL
EXETER
SOUTHAMPTON
BRIGHTON
NORTH HESSARY TOR
BOURNEMOUTH
ROWRIDGE
PLYMOUTH
REDRUTH
START POINT
Miles
20 0 20 40 60 80 100 120
LES PLATONS

BBC TRANSMITTING STATIONS AND STUDIOS

Domestic Services Transmitting Stations	
Long- and medium-wave. (These contain 57 transmitters in service plus 27 installed reserves)	43
VHF sound. (These contain 160 transmitters in service plus 2 installed reserves)	26
External Services Transmitting Stations	
Short-wave in United Kingdom. (These contain 37 high-power (with powers of 50 kW and over) and 2 lower-power transmitters (with powers of less than 50 kW))	4
Short-wave overseas (Tebrau). (This contains 2 high-power and 4 lower-power transmitters)	1
Medium-wave station in Europe (Berlin)	1
VHF station in Europe (Berlin)	1
East Mediterranean relay station (2 medium-wave, 4 short-wave transmitters)	1
Malta medium-wave relay station	1
Berbera medium-wave relay station	1
Total number of transmitting stations	10
Total number of transmitters in service	55

Domestic Sound Studios	Attended	Unattended
London	58	7
Regions	83	17
Total	141	24

External Services Studios	
London	36

BBC VHF RELAY STATIONS FOR THE HOME, LIGHT AND THIRD PROGRAMMES

Stage I

Fort William
Ashkirk (Galashiels)
Berwick-on-Tweed
*Llandrindod Wells
Kinlochleven
Oban
*Oxford (four sound programmes)
*Redruth
*Les Platons, Channel Islands
*Londonderry

Stage II

Forfar, Angus
Grantown-on-Spey
Lewis
Pitlochry
Shetland
Skye
East Lincolnshire
Enniskillen
Pembroke
Sheffield
South-West Scotland

* Already in operation

Stage III

Cheltenham/Gloucester
Cambridge
Hereford
Northampton
Kendal
Larne
Newry
Rothesay/Largs
Perth
Carmarthen
Machynlleth
Okehampton
Bath
Barnstaple
Scarborough
Barrow
Brecon
Brighton

Until sites have been chosen and technical operating conditions agreed, it is not possible to predict exactly the improvements in coverage which the above stations will achieve. It is estimated, however, that the thirty-nine VHF stations will increase the coverage by some 1,120,000 and give improved service for a further 1,700,000 people, bringing the coverage of all three programmes on VHF to 99·4 per cent of the population of the United Kingdom.

Stage I is due to be completed during 1963; construction of the stations in Stage II is proceeding concurrently and it is expected that most of these will be completed by the end of 1963 and the remainder, including Stage III stations, in 1964.

STATIONS TRANSMITTING THE HOME, LIGHT, THIRD AND NETWORK THREE PROGRAMMES ON LONG AND MEDIUM WAVELENGTHS

HOME SERVICE

Programme and Station	Frequency (kc/s)	Wavelength (metres)	Power (kW)	Main Areas Served
London				
Brookmans Park	908	330	140	London and S.E. England
Ramsgate	1,484	202	2	Ramsgate District
North of England				
Moorside Edge	692	434	150	Lancashire, Yorkshire, Cheshire, Flint, N. Nottinghamshire, N. Derbyshire, N. Lincolnshire
Whitehaven			2	Whitehaven District
Cromer			2	N.E. Norfolk
Barrow	1,484	202	2	Barrow District
Midland				
Droitwich	1,088	276	150	Midland Counties
Postwick			7·5	Norwich Area
West of England				
Start Point	1,052	285	120	S. Cornwall, S. Devon, Dorset, Isle of Wight, S. Coast
Barnstaple			2	Barnstaple–Bideford Area
Bartley	1,457	206	10	S. Hampshire, S. Wiltshire
Brighton			2	Brighton District
Clevedon			20	Somerset, S. Gloucestershire
Folkestone			1	Folkestone District
Bexhill			2	Hastings and Eastbourne District
Redruth			2	Camborne and Redruth District
Scottish	809	371		Scotland
Burghead			100	
Redmoss			5	
Westerglen			100	
Dumfries			2	
Welsh	881	341		Wales
Penmon			8	
Towyn			5	
Washford			100	
Wrexham			2	
N. Ireland/N.E. England	1,151	261		
Lisnagarvey			100	Northern Ireland
Londonderry			0·25	Londonderry District
Scarborough			2	Scarborough District
Stagshaw			100	N.E. England, Scottish Border

LIGHT PROGRAMME

Station	Frequency (kc/s)	Wavelength (metres)	Power (kW)	Main Areas Served
Main Transmission:				
Droitwich	200	1,500	400	British Isles
Auxiliary Service:				
Brookmans Park	1,214	247	50	London
Burghead			20	Moray Firth area of Scotland
Lisnagarvey			10	Parts of Northern Ireland
Londonderry			0·25	
Moorside Edge			50	S. Lancashire and S.W. Yorkshire
Newcastle			2	Tyneside
Plymouth			0·25	Plymouth
Redmoss			2	Aberdeen
Redruth			2	Redruth (Cornwall)
Westerglen			50	Edinburgh and Glasgow

THIRD PROGRAMME AND NETWORK THREE

Station	Frequency (kc/s)	Wavelength (metres)	Power (kW)	Main Areas Served
Daventry	647	464	150	Within a radius of approximately 100 miles of Daventry, Northamptonshire
Edinburgh			2	
Glasgow			2	
Newcastle			2	
Redmoss			2	
Belfast	1,546	194	Between 0·25 and 1	Local Districts
Bournemouth				
Brighton				
Dundee				
Exeter				
Farcham				
Leeds				
Liverpool				
Plymouth				
Preston				
Redruth				
Stockton-on-Tees				
Swansea				

VHF STATIONS TRANSMITTING THE HOME, LIGHT,

Station	FREQUENCY (Mc/s)			Effective Radiated Power (kW each programme)	Main Areas Covered
	Light	Third/ Network 3	Home		
Blaen-plwyf	88·7	90·9	93·1	60	Cardigan Bay area
Divis	90·1	92·3	94·5	60	N. Ireland to the borders of Eire, to Omagh in the west, Coleraine in the north, and to the coast on the east
Douglas (I.O.M.)	88·4	90·6	92·8	3·3	Most of the Isle of Man
Dover	90·0	92·4	94·4	0·5–6·5*	East Kent
Holme Moss	89·3	91·5	93·7	120	The area bounded on the north by a line from Barrow to Bridlington and on the south by a line from Anglesey, via Montgomery and Stafford, to Cleethorpes
Kirk o'Shotts	89·9	92·1	94·3	120	Central Scotland
Les Platons	91·1	94·7†	97·1	0·8	Channel Islands
Llanddona	89·6	91·8	94·0	3–12*	Anglesey and parts of Caernarvonshire and Denbighshire
Llandrindod Wells	89·1	91·3	93·5	1·4	Llandrindod Wells area including Rhayader and Builth Wells
Llangollen	88·9	91·1	93·3	5–11*	Flint and parts of Denbighshire, Merioneth, Montgomeryshire, Cheshire, Lancashire and Shropshire
Londonderry	88·3	90·55	92·7	2–12*	Parts of the counties of Londonderry and Tyrone
Meldrum	88·7	90·9	93·1	60	N.E. Scotland east of a line running roughly from Elgin to Montrose
North Hessary Tor	88·1	90·3	92·5	60	Devon and Cornwall (except for small areas in N.E. Devon and W. Cornwall), parts of Somerset and Dorset
Orkney	89·3	91·5	93·7	3–20*	Orkney and N. Caithness
Oxford	89·5	91·7	93·9 (Midland) 95·85 (West)	6–20*	Includes Oxford, Bicester, Witney, Swindon, Wantage and Aylesbury

* Directional aerial

† 94·45Mc/s until 1.11.62.

For relay station details see page 87

THIRD AND NETWORK THREE PROGRAMMES

Station	FREQUENCIES (Mc/s)			Effective Radiated Power (kW each programme)	Main Areas Covered
	Light	Third/ Network 3	Home		
Peterborough	90·1	92·3	94·5	1–21*	Rutland, Huntingdonshire and Cambridgeshire, most of Bedfordshire and parts of Lincolnshire, Northamptonshire, Leicestershire, Buckinghamshire, Essex, Suffolk and Norfolk
Pontop Pike	88·5	90·7	92·9	60	County of Durham and North Riding of Yorkshire, most of Northumberland and parts of Cumberland
Redruth	89·7	91·1	94·1	1–9*	West Cornwall
Rosemarkie	89·6	91·8	94·0	3–12*	Moray Firth area, including most of Nairn and Morayshire; parts of Inverness-shire, Ross and Cromarty, and Sutherland
Rowridge	88·5	90·7	92·9	60	Hampshire and the Isle of Wight, Dorset, S. Wiltshire, West Sussex, S. Berkshire and S.W. Surrey
Sandale (Carlisle)	88·1	90·3	94·7 (North) 92·5 (Scottish)	120	N.W. England, part of S.W. Scotland
Sutton Coldfield	88·3	90·5	92·7	120	An area extending to Chester and Worksop in the north, Gloucester in the south, Welshpool in the west, and Grantham in the east
Tacolneston (Norwich)	89·7	91·9	94·1	120	Norfolk and Suffolk and parts of Lincolnshire, Huntingdonshire, Cambridgeshire and Essex
Thrumster	90·1	92·3	94·5	0·1–10*	Most of Caithness
Wenvoe	89·95	96·8	94·3 (Welsh) 92·125 (West)	120	S. Wales and Monmouthshire; Somerset and parts of Dorset, Devon, Wiltshire and Gloucestershire
Wrotham	89·1	91·3	93·5	120	S.E. England, including the London area

* Directional aerial

For relay station details see page 87

IMPORTANT DATES

IN THE DEVELOPMENT OF BBC SOUND BROADCASTING

1922	14 NOV	Daily broadcasting started from London station (2LO) (Marconi House) of British Broadcasting Company—news bulletins and weather reports
	15 NOV	Manchester (2ZY) station opened
	15 NOV	Birmingham (5IT) station opened
	16 NOV	First BBC printed programme on record
	24 DEC	Newcastle (5NO) station opened
1923	8 JAN	First outside broadcast (excerpts from 'The Magic Flute'—Covent Garden)
	13 FEB	Cardiff (5WA) station opened
	1 MAR	First Radio Exhibition—as part of Ideal Home Exhibition (organized by National Association of Radio Manufacturers)
	6 MAR	Glasgow (5SC) station opened
	1 MAY	Opening of Savoy Hill Studios
	1 OCT	Publication of Report of Sykes Committee on Broadcasting
	10 OCT	Aberdeen (2DB) station opened
	17 OCT	Bournemouth (6BM) station opened
	16 NOV	Sheffield (2FL) station opened—first relay station
	30 DEC	First continental programme contributed by line from Radiola, Paris
	31 DEC	First broadcast of chimes of Big Ben, to usher in New Year
1924	5 FEB	Greenwich time signal inaugurated
	17 FEB	Big Ben daily time signal introduced
	28 MAR	Plymouth relay (5PY) station opened
	1 MAY	Edinburgh (2EH) relay station opened
	11 JUN	Liverpool (6LV) relay station opened
	1 JUL	Cessation of payment of royalties by receiving equipment manufacturers. Substitution of a single 10s. receiving licence for the broadcast (10s.), constructors (15s.), experimenters (10s.) and interim (15s.) licences.
	8 JUL	Leeds–Bradford (2LS) relay station opened
	21 JUL	Chelmsford (5XX) high-power long-wave station opened for experimental purposes
	15 AUG	Hull relay station (6KH) opened
	14 SEP	Belfast (2BE) station opened
	16 SEP	Nottingham (5NG) relay station opened
	12 NOV	Dundee (2DE) relay station opened
	21 NOV	Stoke-on-Trent (6ST) relay station opened
	12 DEC	Swansea (5SX) relay station opened
1925	18 MAR	First international conference on broadcasting convened in London by British Broadcasting Company. International Broadcasting Union formed
	3 APR	British Broadcasting Company represented by Admiral Carpendale at First General Assembly of I.B.U. at Geneva
	6 APR	2LO moved to Oxford Street—power increased
	27 JUL	Chelmsford (5XX) transferred to Daventry (first BBC long-wave transmitter)
1926	5 MAR	Publication of Report of Crawford Committee on Broadcasting
	14 NOV	Geneva Plan drawn up by I.B.U. reduced number of wavelengths available to B.B.Co.
1927	1 JAN	British Broadcasting Corporation constituted under Royal Charter for ten years
	1 JAN	Mr. J. C. W. Reith became first Director-General of BBC
	21 AUG	Daventry (5GB) experimental high-power transmitting station, carried alternative programme for Midlands
	11 NOV	Chelmsford (5SW) short-wave station opened for experimental broadcasts to Empire
1929	29 APR	Broadcasting House Manchester opened
	21 OCT	Brookmans Park transmitting station opened. This station was designed for twin high-power transmitters and thus marked the beginning of the Regional Scheme

1930	9 MAR	Alternative programmes for London and Home Counties from London Regional Station began with opening of second transmitter at Brookmans Park
	9 MAR	Daventry (5GB) became Midland Regional Station
	29 NOV	Broadcasting House, Edinburgh, opened
1931	17 MAY	North Regional Station at Moorside Edge opened (first alternative programme service 12.7.31)
1932	2 MAY	Broadcasting House, London, opened
	15 MAY	Move to Portland Place. New Broadcasting House became Headquarters of BBC
	12 JUN	Scottish Regional transmitting station opened at Westerglen (first alternative programme 25.9.32)
	17 DEC	Chelmsford experimental station (5SW) closed down
	19 DEC	Empire service on short waves inaugurated from Daventry
	25 DEC	First Round-the-Empire Christmas Day programme and broadcast message by King George V
1933	18 JAN	Broadcasting House, Leeds, opened
	28 MAY	West Regional transmitting station opened at Washford
1934	15 JAN	Lucerne Plan, drawn up by the European Broadcasting Convention, put into operation. BBC retained its one long wavelength. Its ten medium wavelengths increased to eleven
	18 SEP	Broadcasting House, Bristol, opened
	7 OCT	Daventry (5XX) superseded by Droitwich high-power transmitter, which broadcast the National Programme
1935	17 FEB	Droitwich Midland Regional transmitter opened
1936	16 MAR	Publication of Report of Ullswater Committee on Broadcasting
	20 MAR	Lisnagarvey transmitting station opened
	12 OCT	Burghead transmitting station opened
1937	1 JAN	New Royal Charter and Licence came into force for ten years
	1 FEB	Penmon transmitting station opened
	4 JUL	West of England and Welsh regional services separated
	19 OCT	Stagshaw transmitting station opened, replacing Newcastle (5NO)
1938	3 JAN	First foreign language service started (Arabic)
	15 MAR	Latin American Service started (Spanish and Portuguese)
	30 JUN	Resignation of first BBC Director-General—Sir John Reith
	9 SEP	Redmoss took over service from Aberdeen transmitter
	27 SEP	First service in European languages began (French, German, Italian)
	18 NOV	Glasgow Broadcasting House opened
	9 DEC	Aberdeen Broadcasting House opened
1939	13 JUN	Plymouth relay station closed
	14 JUN	Start Point transmitting station opened
	14 JUN	Clevedon transmitting station opened
	1 SEP	Home Service replaced National and Regional Services. Supplementary service in foreign languages started for listeners in European countries
1940	7 JAN	Start of special programme for Forces from 6 p.m. nightly
	3 MAY	Plymouth Home Service transmitter opened (see 13.6.39)
	29 DEC	Bartley transmitter opened
1941	24 JAN	Norwich transmitter opened
	16 FEB	Rampisham short-wave station opened
	5 MAY	Engineering Training began at Maida Vale, London
	5 MAY	Belfast Broadcasting House opened

1943	12 FEB	Ottringham high-power medium- and long-wave station opened near Hull for broadcasting to Europe
	15 APR	Skelton short-wave station opened near Penrith
	14 AUG	Plymouth Home Service transmitter closed (see 3.5.40)
	15 SEP	Skelton short-wave station—separate, second section, opened (see 15.4.43)
	17 OCT	Woofferton short-wave station opened, near Ludlow
	5 DEC	Plymouth Forces transmitter opened (see 14.8.43)
1944	22 DEC	Londonderry transmitter opened
1945	29 JUL	Light Programme began from Brookmans Park, Burghead, Droitwich, Londonderry, Moorside Edge, Redmoss, Redruth, and Westerglen transmitting stations
1946	17 FEB	Plymouth Light Programme transmitter opened
	5 MAR	Wrexham transmitting station opened
	29 SEP	Third Programme began from transmitters at Belfast, Bournemouth, Brighton, Dundee, Edinburgh, Fareham, Glasgow, Leeds, Liverpool, Newcastle, Plymouth, Preston, Redmoss and Stockton
1947	1 JAN	New Licence and Agreement came into force for five years
	11 FEB	Daventry (5XX) closed down after re-opening during war
	26 FEB	Exeter Third Programme transmitter opened
	29 JUN	Redruth Third Programme transmitter opened
1948	10 DEC	Publication of Agreement between Postmaster General and BBC on Broadcasting in Far East
1949	6 JUN	Postwick transmitting station replaced Norwich
1950	15 MAR	Copenhagen Wavelength Plan implemented
	15 MAR	Light Programme transmitters opened at Newcastle and Lisnagarvey
	30 NOV	Nottingham unattended sound studio opened
1951	18 JAN	Publication of Report of Beveridge Committee on Broadcasting
	1 MAR	Liverpool unattended sound studio opened
	8 APR	Daventry high-power Third Programme transmitter opened
	16 SEP	Hastings (later Bexhill) West of England Home Service transmitter opened
	16 SEP	Brighton West of England Home Service transmitter opened
	16 SEP	Ramsgate Home Service transmitter opened
	7 OCT	Barrow North Home Service transmitter opened
	11 NOV	Scarborough Northern Ireland/N.E. England Home Service transmitter opened
	1 DEC	Publication of the Royal Charter and Licence and Agreement for the continuance of the BBC
	23 DEC	Folkestone West of England Home Service transmitter opened
1952	1 JAN	Supplementary Charter for six months came into force
	9 MAR	Barnstaple West of England Home Service transmitter opened
	1 JUL	New Charter came into force for ten years
1953	14 FEB	Towyn Welsh Home Service transmitter opened
	24 FEB	Dumfries Scottish Home Service transmitter opened
	2 JUN	Coronation Ceremony of Her Majesty Queen Elizabeth II broadcast from Westminster Abbey
	18 OCT	Redruth West of England Home Service transmitter opened
	8 NOV	Bexhill West of England Home Service transmitter opened, replacing Hastings (see 16.9.51)
	26 DEC	Cromer North Home Service transmitter opened

1954	18 JAN	Publication of Second Report of the Television Advisory Committee, 1952 (on VHF Sound Broadcasting)
	10 FEB	Government approved adoption of frequency modulation for VHF Sound Broadcasting
	19 DEC	Swansea Third Programme transmitter opened
1955	2 MAY	VHF Sound Broadcasting Service began with regular transmissions from the Wrotham (Kent) station serving London and S.E. England
	25 AUG	Hull unattended sound studio opened
	2 OCT	Penmon temporary VHF transmitting station opened (Welsh Home Service only)
	20 DEC	Pontop Pike VHF transmitting station opened
	20 DEC	Wenvoe VHF transmitting station opened (temporarily Welsh Home Service only)
1956	18 MAR	Divis VHF transmitting station opened
	29 MAR	Meldrum VHF transmitting station opened
	29 APR	Wrotham VHF station. Automatic monitor and control equipment brought into use
	23/24 MAY	Manchester new sound control room brought into operation
	3/6 JUL	New Mobile Sound Studio and Control Room for Sound Outside Broadcasts used for first time at Royal Show at Newcastle-on-Tyne
	7 AUG	London—St. Stephen's House unattended sound studio opened
	7 AUG	North Hessary Tor VHF station opened
	27 AUG	London Airport Queen's Building unattended sound studio opened
	10 SEP	Norwich sub-regional headquarters brought into use
	25 SEP	Transatlantic Telephone Cable (T.A.T.): inauguration ceremony broadcast
	14 OCT	Blaen-plwyf VHF station opened (temporarily Welsh Home Service only)
	7 NOV	First direct live sound transmission broadcast from Shackleton Base of Commonwealth Transantarctic Expedition
	10 DEC	Holme Moss VHF station opened
	20 DEC	Sutton Coldfield VHF station began test transmissions on reduced power
	22 DEC	Wenvoe permanent VHF station began test transmissions on reduced power
	22 DEC	Tacolneston (Norwich) VHF station began test transmissions on reduced power
1957	19 FEB	Douglas unattended sound studio brought into service
	4 MAR	Oxford unattended sound studio opened (temporary premises). Transferred to permanent premises 15.3.58
	21 MAR	Exeter unattended sound studio brought into service
	16 APR	Carlisle unattended sound studio brought into service
	29 APR	Blaen-plwyf television and permanent VHF station opened (see 14.10.56)
	30 APR	Sutton Coldfield VHF station came into full service (see 20.12.56)
	30 APR	Tacolneston (Norwich) VHF station came into full service (see 22.12.56)
	26 MAY	Cardiff low-power (1484 kc/s) Welsh Home Service transmitter transferred to Third Programme service
	4 JUN	Rowridge VHF transmitting station opened
	30 SEP	Start of Network Three
	13 OCT	Transfer of Overseas Services to Bush House from 200 Oxford Street (completed 3.11.57)
	28 OCT	Bristol temporary VHF station opened (Third Programme only)
	30 NOV	Kirk o'Shotts VHF station opened
1958	13/14 JAN	Stereophonic test transmissions from London transmitters (11 and 17 May from transmitters throughout U.K.)
	9 MAR	Douglas (Isle of Man) VHF station opened (temporarily North Home Service only). Operated on experimental basis from 20.12.57
	14 APR	Radiophonic Unit came into operation
	23 APR	Mobile Sound Studio and Control Room sent to Brussels Exhibition
	11 and 17 MAY	First scheduled stereophonic experimental sound broadcasts took place as part of special Gramophone Record Week programmes (from transmitters throughout the U.K.)
	18/26 JUL	Empire and Commonwealth Games at Cardiff
	18 AUG	Sandale VHF transmitting station opened
	12 OCT	Rosemarkie VHF station opened
	18 OCT	First series of regular stereo experimental transmissions began (alternate Saturday mornings)
	27 NOV	Cambridge unattended sound studio opened
	20 DEC	Llangollen VHF station opened
	20 DEC	Llanddona VHF station opened
	22 DEC	Orkney VHF station opened (temporarily Scottish Home Service only)

1959	28 FEB	Bristol temporary VHF Third Programme and Network Three transmitter closed
	1 MAR	Wenvoe VHF Third Programme and Network Three transmitter opened
	20 MAY	Brighton unattended sound studio opened
	8 JUN	Portsmouth unattended sound studio opened
	15 JUN	Douglas (Isle of Man) VHF permanent station opened (*see* 9.3.58)
	24 JUN	Postmaster General's announcement of his approval in principle of the BBC's first stage of its plan for extending and improving coverage of the television service and the three sound services on VHF by low-power relay stations (fourteen television and ten VHF sound)
	5 OCT	Peterborough television and VHF sound transmitting station opened
	22 OCT	Gatwick Airport unattended sound studio opened
1960	1 MAR	Thrumster permanent television and VHF sound transmitting station opened
	31 MAR	Cardiff Third Programme transmitter (1484 kc/s) closed
	20 MAY	Announcement by Postmaster General of approval in principle of second stage of BBC's plans for extending and improving coverage of the television service and of the three sound services on VHF by low-power relay stations (ten television and eleven VHF)
	8 SEP	Announcement by Postmaster General of Appointment of Committee to inquire into the Future of Sound and Television Broadcasting (Pilkington Committee)
	30 NOV	Cheltenham unattended sound studio opened
	16 DEC	Sheffield unattended sound studio opened
1961	5 MAR	Rampisham: new twin-channel sender (35) brought into operation (see 24.4.61)
	24 APR	Rampisham: second of twin-channel senders (36) brought into operation (see also 5.3.61), replacing two of the early Daventry senders
	26 APR	Truro unattended sound studio opened
	8 MAY	Paris (France). New and larger BBC sound studio with extended facilities came into operation in BBC's Paris Office premises, 59 avenue Hoche
	26 MAY 23 JUN	European Broadcasting Conference, Stockholm
	21 JUN	Canterbury unattended sound studio brought into operation
	10 JUL	First section of new London Control Room in Broadcasting House Extension came into operation (Sound Outside Broadcast Position)
	24 JUL	Second unattended studio at St. Stephen's House came into operation—for sound only
	8 AUG	Dover VHF sound station brought into service
	21 SEP	Poole unattended sound studio brought into operation
	16 OCT	Third Programme Continuity transferred to new suite adjacent to new London Control Room in Broadcasting House Extension, followed by transfer of Home and Light Continuities
	16 OCT	Les Platons, Jersey, VHF sound broadcasting station brought into service
	23 OCT	Londonderry VHF sound broadcasting station brought into service
	4 DEC	Llandrindod Wells television and VHF sound relay station came into operation
1962	22 FEB	Leicester unattended sound studio brought into operation
	26 FEB	Redruth VHF sound and television relay station came into operation
	24 MAY	Announcement by Postmaster General of approval in principle of third stage of BBC's plans for extending and improving coverage of the television service and of the sound services on VHF by low-power relay stations (23 television and 18 VHF)
	28 MAY	Oxford (Beckley) VHF sound station brought into service
	27 JUN	Publication of the Report of the Pilkington Committee on Broadcasting

BBC ENGINEERING DIVISION MONOGRAPHS

A series of Engineering Monographs is published by the BBC, describing work that has been done by the Engineering Division and including, where appropriate, a survey of earlier work on the same subject.

The series should be of interest and value to engineers engaged in the fields of broadcasting and of telecommunications generally.

Individual copies cost 5s. post free, while the annual subscription is £1 post free. About six monographs are produced every year and they may be obtained from newsagents and booksellers or direct from BBC PUBLICATIONS, 35 MARYLEBONE HIGH STREET, LONDON, W.1.

The following monographs dealing with sound broadcasting subjects have so far been published:—

No.	Title	Date
2.	*Absolute Measurements in Magnetic Recording*	SEPTEMBER 1955
4.	*The Design of a Ribbon Type Pressure-gradient Microphone for Broadcast Transmission*	DECEMBER 1955
5.	*Reproducing Equipment for Fine-groove Records*	FEBRUARY 1956
7.	*The Design of a High-quality Commentator's Microphone Insensitive to Ambient Noise*	JUNE 1956
8.	*An Automatic Integrator for Determining the Mean Spherical Response of Loudspeakers and Microphones*	AUGUST 1956
9.	*The Application of Phase-coherent Detection and Correlation Methods to Room Acoustics*	NOVEMBER 1956
11.	*Engineering Training in the BBC*	MARCH 1957
16.	*Analysis and Measurement of Programme Levels*	MARCH 1958
20.	*The BBC's Mark II Mobile Studio and Control Room for the Sound Broadcasting Service*	AUGUST 1958
22.	*The Engineering Facilities of the BBC Monitoring Service*	DECEMBER 1958
25.	*A Quality-checking Receiver for VHF/FM Sound Broadcasting*	JUNE 1959
26.	*Transistor Amplifiers for Sound Broadcasting*	AUGUST 1959
28.	*Programme Switching, Control, and Monitoring in Sound Broadcasting*	FEBRUARY 1960
29.	*A Summary of the Present Position of Stereophonic Broadcasting*	APRIL 1960
31.	*The Power Gain of Multi-tiered VHF Transmitting Aerials*	JULY 1960
35.	*Tables of Horizontal Radiation Patterns of Dipoles Mounted on Cylinders*	FEBRUARY 1961
38.	*Operational Research on Microphone and Studio Techniques in Stereophony*	SEPTEMBER 1961
42.	*Apparatus for Television and Sound Relay Stations*	JULY 1962
43.	*Propagational Factors in Short-wave Broadcasting Reception*	AUGUST 1962