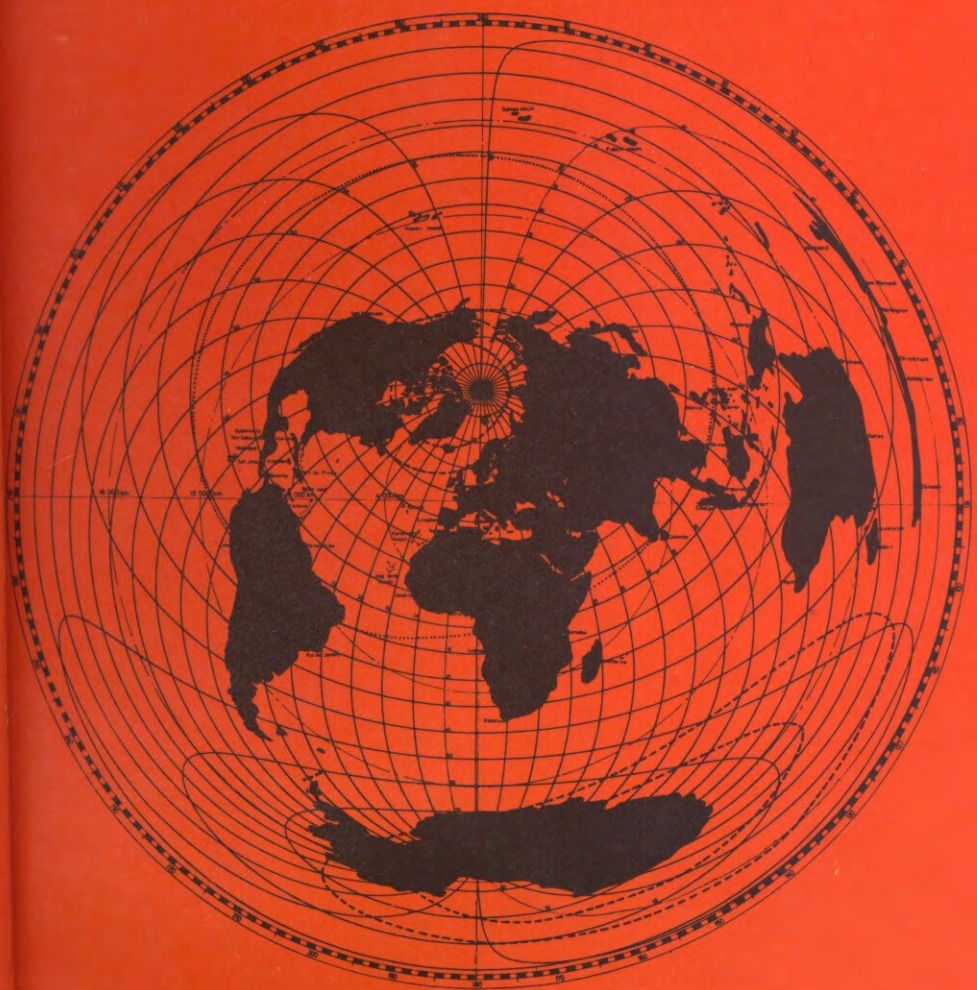
DEUTSCHE WELLE ENGINEERING

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The growth and development of short wave radio in Germany

The technical facilities of Deutsche Welle

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DEUTSCHE WELLE ENGINEERING

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Contents

Short Wave Broadcasting

During the past few decades, developments in the field of radio engineering as a whole have been extremely turbulent. Short wave broadcasting has acquired particular importance on account of the special propagation conditions and the large area it covers. These electromagnetic waves, forming part of the overall frequency spectrum of the radio frequency, enable long distances to be covered using only low-powered transmitters.

Unlike the long wave, the medium wave and the VHF-stations, whose coverage area is limited and for which frequency assignments only have to be effected once, the frequency application in the case of short wave has constantly to be adapted to existing ionospheric propagation conditions. To understand this it is necessary to explain the ionospheric wave propagation of a short wave signal.

The signal is radiated by the antenna in a vertical direction and at a small angle. It is reflected by one of the layers of the ionosphere (e.g. F_2 layer in approx. 320 km height) and returns to the earth at a point which is a long distance away from the transmitter. Thereafter, several reflections take place from the earth to the ionosphere and back during which the signal covers vast distances round the earth and at the same time loses more and more of its field strength. In addition, one has to consider the irregular behaviour of the reflecting layers, the height and density of which are liable to fluctuate. Other factors such as solar activity, the position of the sun and various other influences on the individual transmission paths as well as the overcrowding of the short wave bands, have an adverse effect on propagation conditions. In other words, short wave coverage is subject to constant fluctuations.

In order to ensure improved and stable reception, careful frequency planning and a world-wide decentralized network of relay stations are necessary. Only in this way can an acceptable short wave radio service be provided for listeners in all parts of the world.

The special tasks and demands imposed on the engineering department of the short wave broadcasting stations are naturally influencing the growth and development of short wave broadcasting, which must therefore be regarded as a highly specialized technical field.

The transmission medium employed by a broadcasting station therefore determines most clearly the kind of organization, the engineering systems and the technical facilities of the broadcasting house and the transmitting stations concerned.

The Historical Development of Short Wave Broadcasting in Germany

1924 The first German short wave radio contact with Argentina, using a 0.8 kW transmitter in the 4 MHz-range.

1926 Start of regular commercial short wave broadcasting from the Nauen radio station to the United States of America, South America and the former Dutch East Indies.
Start of short wave radio test broadcasts by the German Reichspost using a 0.15 kW transmitter at Königs Wusterhausen.

1927 A second test transmitter with a power of 5 kW goes into operation at Döberitz.

1928 The short wave test transmissions receive a positive echo at home and abroad.
At Zeesen near Königs Wusterhausen a world radio station is built for the Reichspost.

1929 Official opening in August of the first German short wave radio station with a power of 8 kW.

1932 Directional antennas used for the first time for the coverage of North America. A second short wave transmitter ready for operation.

1934 Commencement of transmissions by the German short wave station for Central America, South America, Africa and East Asia.

1935 A third short wave transmitter installed at Zeesen.

1936 With the event of the Olympic Games in Berlin comes the big breakthrough for German short wave broadcasting.
Eight "Olympia" transmitters with an output of 50 kW each and a second antenna system go into operation at Zeesen near Königs Wusterhausen.

1937 There are now a total of 263 short wave radio transmitters in the world.

1939 The two world radio transmitters of 5 and 8 kW are replaced by two 50 kW transmitters.

1943 At the short wave stations at Zeesen, Oebisfelde, Munich-Ismaning and Elmshorn a total of 22 transmitters with a power output ranging from 50 to 120 kW are put into operation.

1945 After the end of World War II, all short wave broadcasting in Germany is suspended.

1946 Low power short wave transmitters used by the broadcasting organizations of the German „Länder". These transmitters carry the medium wave programme alongside the actual medium wave transmissions.

1947 The North-West German Radio starts short wave broadcasts on the 49 meter-band from Elmshorn.

1952 Start of regular short wave test broadcasts by the North-West German Radio. The Norden/Osterloog transmitting station starts broadcasting overseas programmes on a 20 kW transmitter via reversible directional antennas to North America/Middle East, South America/East Asia as well as to Africa.

1953 The ARD (the organization comprising all the broadcasting stations in the Federal Republic of Germany) decides to found the DEUTSCHE WELLE under the sponsorship of the North-West German Radio.
Start of regular programmes in German.
A second 20 kW transmitter is put into operation.

1954 Commencement of the DX programme.

1955 July 2nd: laying of the foundation stone for the Jülich transmitting station.

1956 April 1st: The first 100 kW transmitter at Jülich commences operations. It is followed on August 26th, by the second 100 kW transmitter. Thus, by the end of 1956, all Deutsche Welle programmes can be transmitted by the Jülich station.

1957 One of the 20 kW transmitters from Osterloog installed at Jülich as a stand-by transmitter.

1958 The 20 kW stand-by transmitter also used for regular broadcasts whilst further transmitters are installed at Jülich.

1959 Two further 100 kW transmitters are put into operation.

1960 A fifth 100 kW transmitter ready for operation bringing the total number of transmitters available in Jülich to six.

Under the act governing the creation of broadcasting organizations under federal law, the DEUTSCHE WELLE is founded as a public corporation.

1961 As from September 1st, the Jülich station passes into the possession of the German Federal Postal Authorities, which also assume responsibility for the upkeep and maintenance of the transmitting facilities in Germany.

1962 Deutsche Welle moves from the premises of the West German Radio to a new building in Brüderstrasse. Here there are 3 broadcasting centres, 5 recording channels, 11 continuity studios with recording channels and a central control room.
Completion of a sixth 100 kW transmitter to be used as a stand-by transmitter.

1963 A seventh 100 kW short wave transmitter is in operation. The 20 kW transmitter closes down as it no longer meets requirements.
On March 15th, the Republic of Rwanda agrees to conclude a license agreement with Deutsche Welle. Only 5 months later, a test transmitter with an output of 0.5 kW goes into operation at the first DW relay station in Kigali.

1964 The measuring and monitoring station at Bockhacken becomes operative on February 1st.
At Jülich, the eighth 100 kW transmitter is ready for operation so that for the DW programmes 7 transmitters are available with a power of 100 kW each, whilst the eighth transmitter serves as a stand-by.

1965 October 26th: official opening of the Kigali relay station. The first transmitter of 250 kW goes into operation.
The antennas used at Kigali are directional aerials with screen reflector for two separate transmission directions and two-band quadrant antennas for omnidirectional transmission.

1966 By December 31st, seven transmitters are in operation in Jülich with 100 kW each, whilst a further transmitter of the same power output serves as a stand-by. For the transmission of the DW programmes, 26 reversible curtain antennas and three vertical cage antennas with omnidirectional characteristics are used. The curtain antennas are furthermore equipped with slew switches so that one directional antenna can be used for three different horizontal angles of radiation or, taking reversibility into consideration, for six different angles of radiation.

1967 Four additional reversible antenna arrays are set up at Jülich. At the same time, commencement of the change-over from antenna selector switches to coaxial switches. As a result of the compact construction method, a large number of switches can be accommodated in a very small space.

1968 Final completion of construction work in Jülich. With the start-up of 2 fully automatic transmitters of 100 kW each, nine operational transmitters and one stand-by transmitter, all of 100 kW, are available. For these transmitters drive units with decimal setting are used.
The feeding of the curtain antennas is effected via coaxial antenna selector switches and then over coaxial feeders to the balancing and transformation lines (STL) and from there via symmetrical feeders to the feed-in point of the antennas. Most of the 30 existing curtain antennas can be slewed by appropriate slew switches in the horizontal angle of radiation. This means that with one antenna several different coverage areas in the azimuth can be reached. Some of the existing curtain antennas also permit different angles of elevation for the transmissions.
The antennas are suspended between 34 masts, some of which are over 100 metres high. In addition to the curtain antennas, there are three vertical cage antennas at Jülich, two of which can be used for frequencies of between 6 and 21 MHz and one for frequencies ranging from 3.95 to 4.0 MHz; furthermore, there are two log-periodic antennas.
Operation of the automatic transmission control is effected at the broadcasting house in Cologne whereby one technician can handle three transmissions simultaneously.

1969 A second 250 kW transmitter goes into operation in Kigali. At the same time, the antenna system is increased to 8 curtain antennas, suspended in pairs, each pair separated by a screen reflector. Two of the antennas are slewable. In addition, the Kigali relay station is equipped with three quadrant antennas which are used as omnidirectional antennas.
On August 26th, the foundation stone is laid at Wertachtal for a further Deutsche Welle transmission centre in Germany – exactly 40 years to the day since the German short wave radio station commenced transmission in 1929.

1970 On March 20th, the Director General of Deutsche Welle signs an agreement providing for the construction of a relay station in Malta.
On April 29th, a decision is reached on the building of a new broadcasting house. On the recommendation of the Director General, the Administrative Council of Deutsche Welle decides in favour of a design submitted by a Bonn group of architects.
On June 3rd, the relay of Deutsche Welle programmes starts via the transmitters at Sines in Portugal, where there are two transmitters with a power output of 250 kW. For these relay operations six slewable curtain antennas and one wide-band, vertically polarized, log-periodic antenna can be used.

1971 The first test broadcasts on the medium wave start in Malta on July 23rd, using a temporarily installed 20 kW transmitter.
On the 1st of August, the German language programme of DW is broadcast for the first time on two frequencies from Sackville in Canada in order to provide better coverage of North and Central America.

1972 At Wertachtal, the first transmitter with an output of 500 kW starts test broadcasts on April 10th, followed by the use of further transmitters on April 15th, July 10th and August 5th, 1972. At the start of the Olympic Games in Munich on August 26th, four transmitters are available. Also the first antennas for these transmitters go into operation.
In July building work commences on a new relay station in Malta.

1973 20th anniversary of the foundation of Deutsche Welle on May 3rd, 1953 at 1130 a. m. CET.

1974 March 28th: turning of the first sod, and June 28th: laying of the foundation stone for the new broadcasting house for Deutsche Welle and Deutschlandfunk in the south of the city of Cologne.
Further 500 kW transmitters are ready for operation at Wertachtal. Ultimately, a total of 74 antennas are planned here. They include five LP antennas and six quadrant antennas for the coverage of near and medium range areas, and 63 curtain antennas, 11 of them being available for close-range coverage and 52 for long-range. The curtain antennas are suspended in pairs, each being screened from the other by a screen reflector. Feeding is effected via coaxial antenna selector switches and coaxial feeders. Immediately in front of the antennas, the symmetrizing and transformation lines (STL) form the link between the coaxial and the symmetrical feeders. A special feature here is the horizontal slewing of the main direction of radiation of these antennas by $\pm$ 15° and $\pm$ 30°.
At the Malta relay station, three short wave transmitters go into operation with a power output of 250 kW each. For medium wave coverage a 600 kW transmitter is ready for operation. The Malta relay station is equipped with a three-mast medium wave antenna, six curtain antennas, four quadrant antennas and one rotatable log-periodic antenna.

1975 At Wertachtal, Deutsche Welle has 8 transmitters and 1 stand-by transmitter of 500 kW.

1975/1976 The relay project for Central America has been completed. It is divided into two stations: a large one in Antigua with four 250 kW short wave transmitters and a smaller one in Montserrat with two short wave transmitters of 50 kW and 15 kW respectively. The transmitter potential available in Central America is shared with the British Broadcasting Corporation.

1979 The joint broadcasting house for Deutsche Welle and Deutschlandfunk scheduled for completion.

The Historical Development of German Short Wave Broadcasting in Pictures

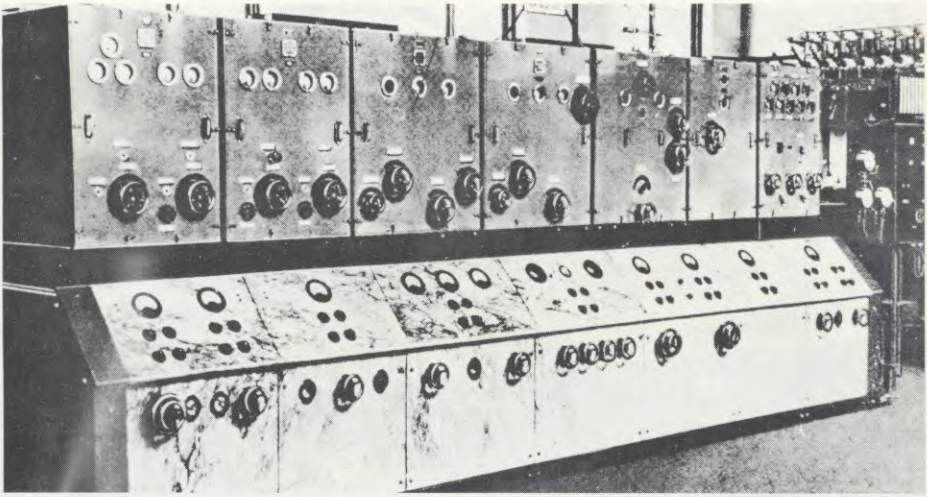
Left:
Transmitter building at Zeesen near
Königs Wusterhausen

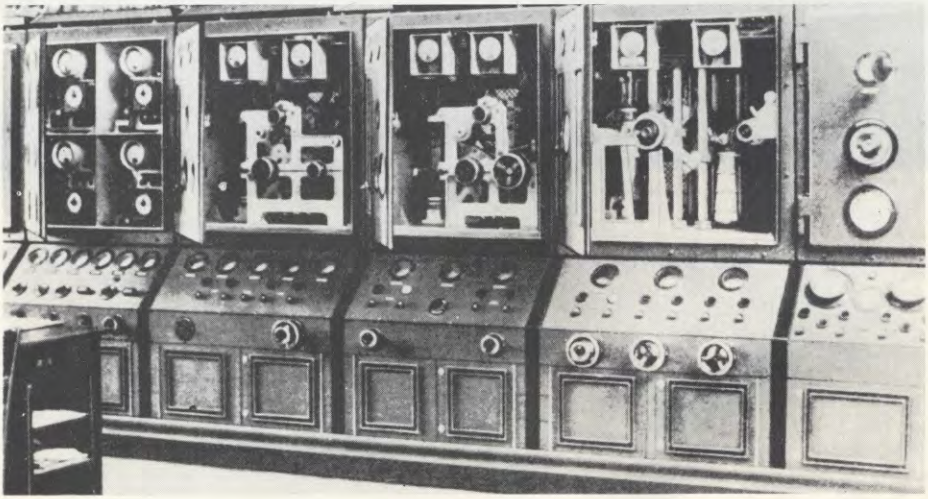
Bottom:
Transmitter hall 1929
On the extreme left the Weltrundfunk-
Kurzwellensender – the world radio short wave
transmitter –

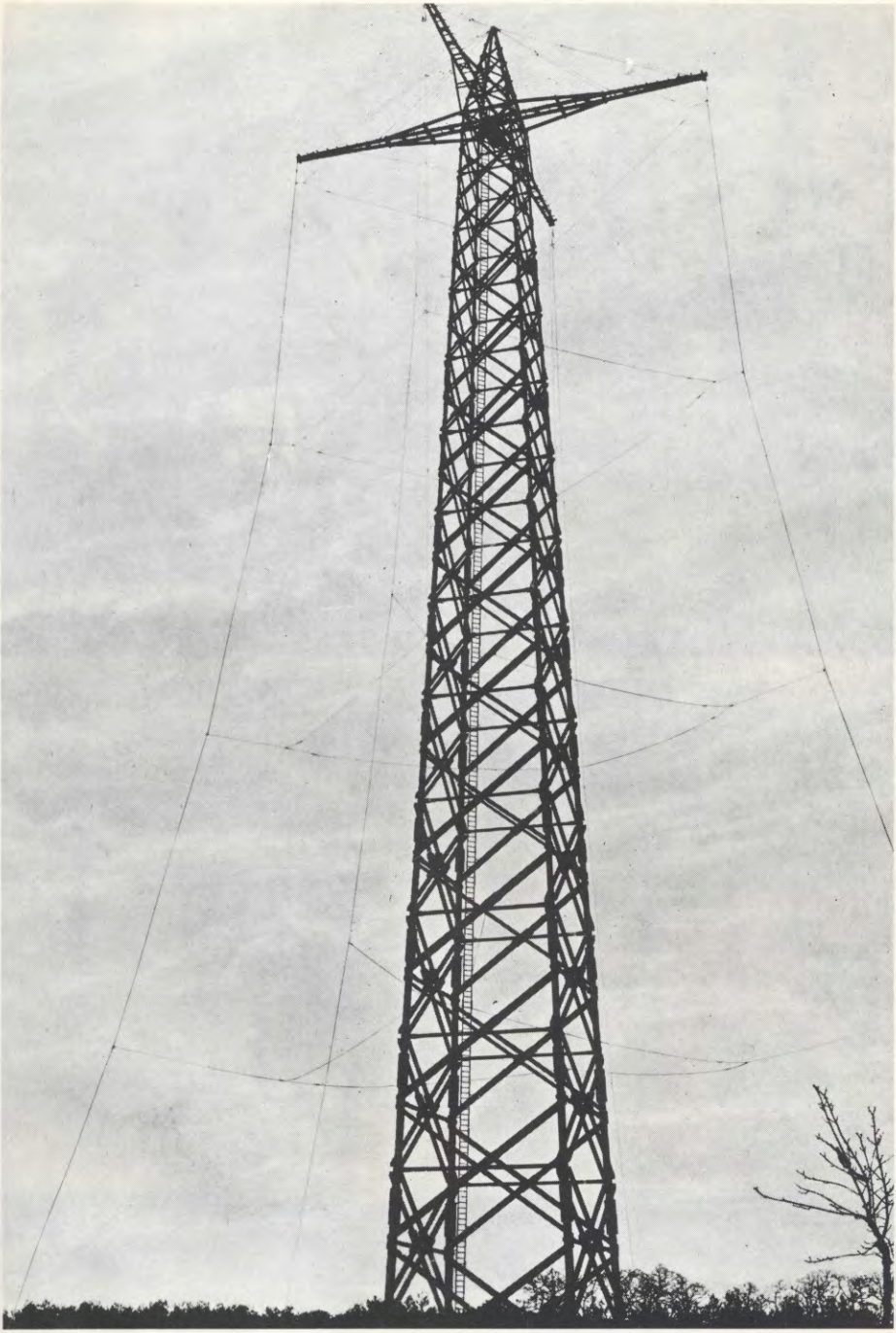
Top left:
The first world radio short wave transmitter 1929 with a power output of 8 kW

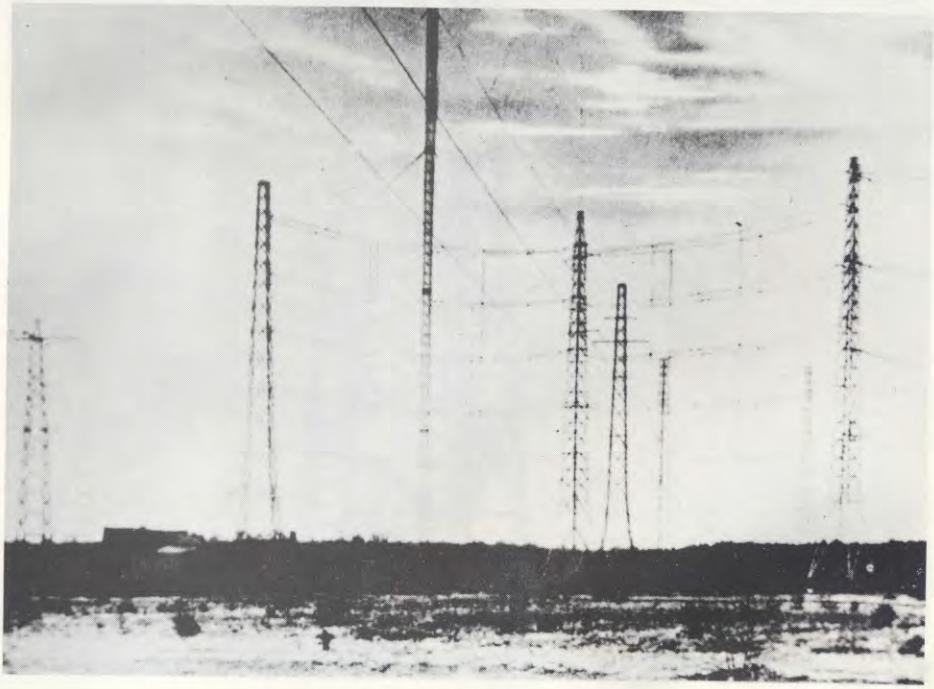
Bottom left:
The second short wave transmitter 1932 with a power output of 5 kW

Right:
Short wave omnidirectional antenna at the world radio short wave transmitter at Zeesen 1929







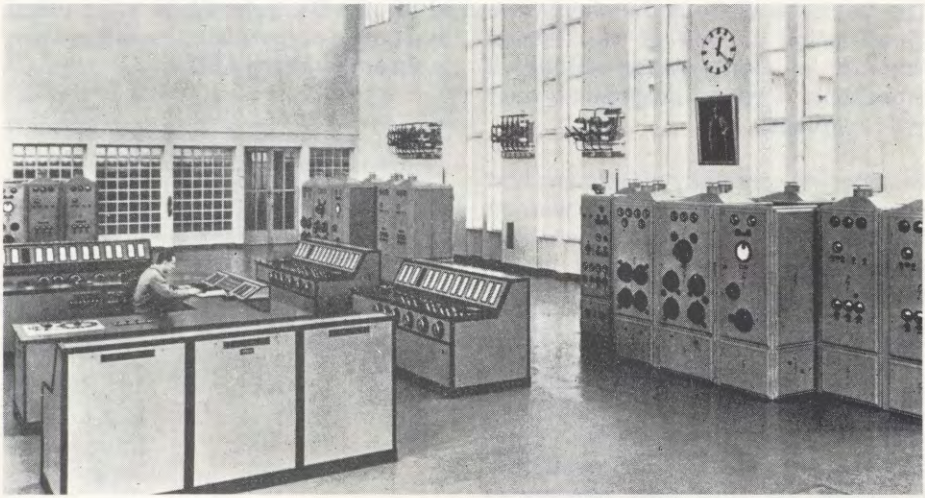


Top left:
Visitors from the USA preparing programme exchange with the German short wave station

Bottom left:
Antennas at the transmitting station in Zeesen:
Left – the short wave omnidirectional antenna
Right – a group of "Pine-tree" directional antennas

Top right:
50 kW "Olympia" transmitters at Zeesen 1936

Bottom right:
Transmitting station at Osterloog 1954



Deutsche Welle

The Deutsche Welle is the short wave broadcasting service of the Federal Republic of Germany for abroad. It broadcasts a varied programme daily in 34 languages.

The opening ceremony of German short wave broadcasting after the war on May 3rd, 1953, marked the commencement of regular programmes in the German language. In the treaty of March 27th, 1953, governing the establishment of a joint short wave programme by the regional broadcasting organizations united in the ARD*, it was stipulated that, under the name "Deutsche Welle", a programme should be broadcast via short wave network to abroad in order to give listeners there a comprehensive picture of the political, cultural and economic life in the Federal Republic as well as the German approaches to important problems.

On behalf of the other regional broadcasting organizations and with their full agreement, the North-West German Radio – the later West German Radio – in Cologne assumed responsibility for the Deutsche Welle short wave broadcasts.

Under the terms of the law of November 29th, 1960 on the establishment of broadcasting corporations under federal law, the Deutsche Welle was created as a public corporation. Deutsche Welle is a member of the ARD.

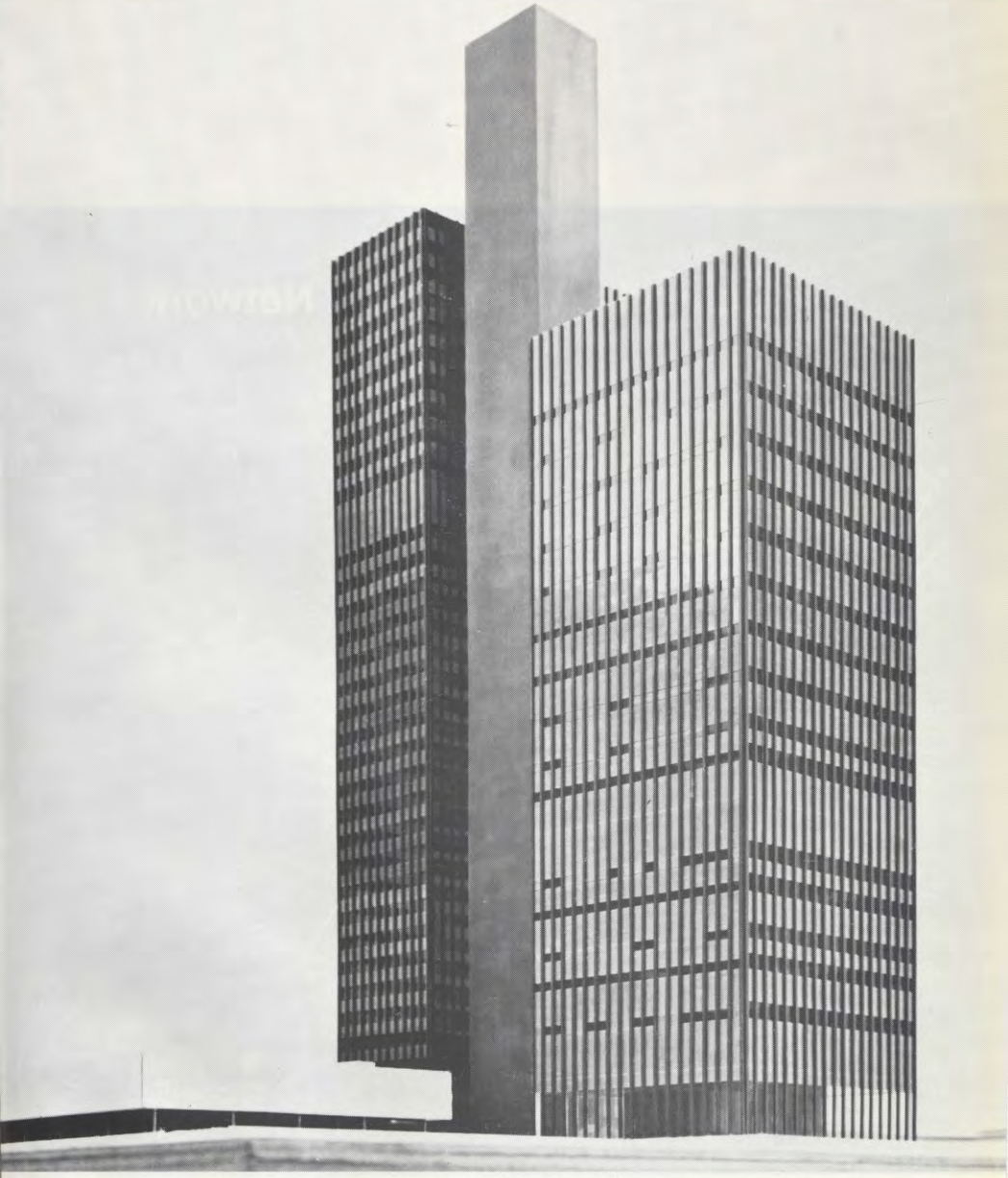
* Arbeitsgemeinschaft der öffentlich-rechtlichen Rundfunkanstalten der Bundesrepublik Deutschland

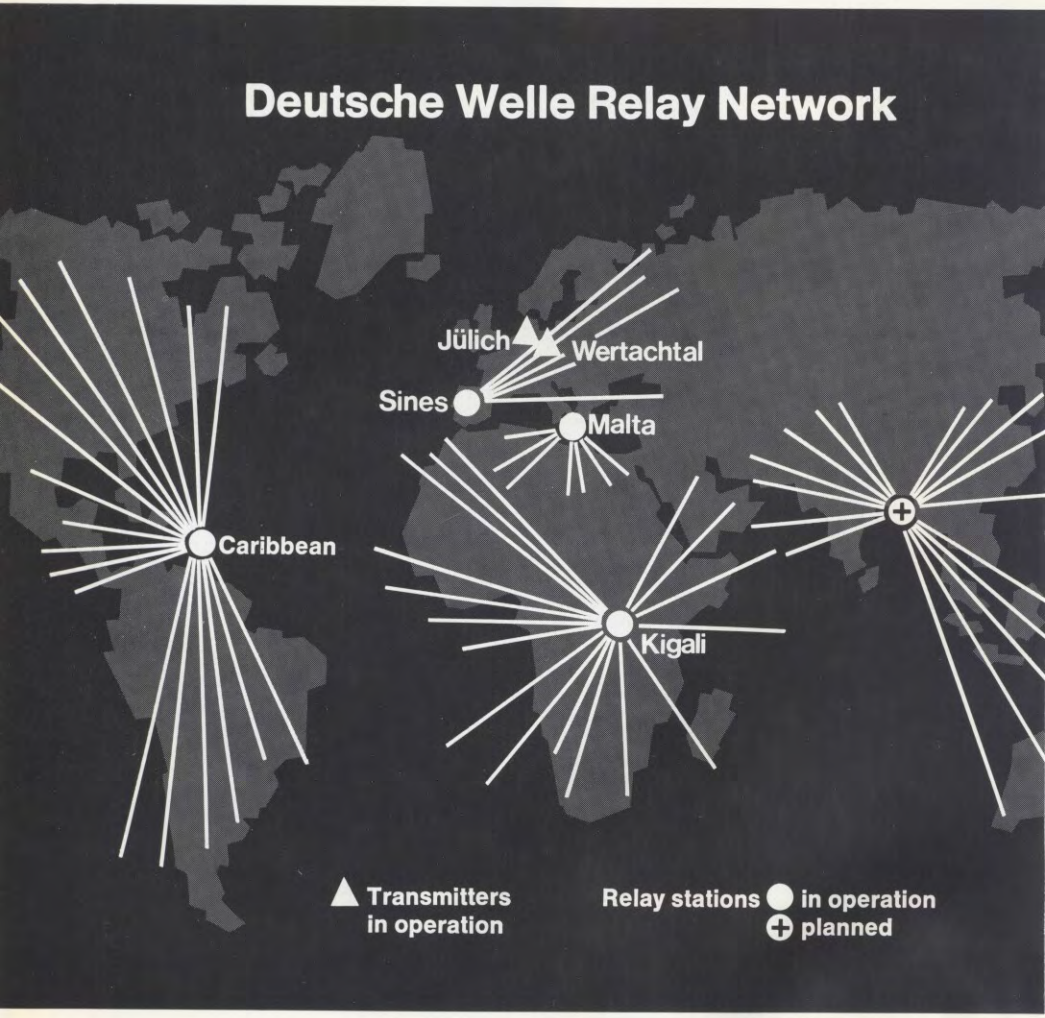
Picture right:
Since 1972, many DW departments have been housed in this high-rise block in Bonner Strasse, where they will remain until the new broadcasting house is completed

Top left:
Turning of the first sod for the new Deutsche Welle/Deutschlandfunk broadcasting house on March 28th, 1974

Bottom left:
Laying the foundation stone on June 28th, 1974

Right:
Model of the new DW broadcasting house




Deutsche Welle Relay Network
Jülich
Wertachtal
Sines
Malta
Caribbean
Kigali
Transmitters in operation
Relay stations in operation
planned

Survey of the Transmitting Stations and the Number of Transmitters

Jülich:	9 operational transmitters and 1 stand-by unit of 100 kW each
Wertachtal:	8 operational transmitters and 1 stand-by unit of 500 kW each

Relay Stations:

Kigali:	2 transmitters of 250 kW each
Sines:	2 transmitters of 250 kW each
Malta:	3 transmitters of 250 kW each and 1 medium wave transmitter of 600 kW
Antigua:	2 transmitters of 250 kW each
Montserrat:	1 transmitter of 50 kW and 1 transmitter of 15 kW

Other Stations:

Sackville:	In 1971, an exchange of transmission time was arranged with the Canadian Broadcasting Corporation (CBC). 2 short wave transmitters of 250 kW are available to DW for 4 hours per day.

From Broadcasting House to Listeners all over the World

The technical facilities available at the broadcasting house are designed to meet all the requirements of modern radio transmission.

The production, transmission and drama studios have been designed and built with special acoustic features and are so arranged as to provide for maximum efficiency in operation.

The same applies to the operation centre, which, as the central control room and junction point, controls and combines all lines inside the building and carries out all switching operations of out-going lines. The distribution network comprises a star-shaped arrangement of the production and live transmission studios, the recording channels and drama studios in the broadcasting house, the monitoring service, the measuring and monitoring station, the regional studios, transmitting stations etc. For the transmission of programme signals, high-grade cables are used.

Before a programme can be broadcast, before the signal can pass from the studio via the main control room to the transmitters and from there to its ultimate destination, namely the target area, many preparations have to be made. They start with programme planning and compiling, with pre-production right down to the actual broadcast which is composed, like a mosaic, of numerous individual contributions.

In the case of short wave programmes, the broadcasts consist largely of the spoken word. This is because in the relatively short transmission time for the various languages ranging from 20 to 230 minutes, a great deal of information and topical reports has to be accommodated.

The number of individual contributions to a programme, which are mostly pre-recorded, depends on the programme structure, transmission time and subject matter. The programme is supplemented by live contributions such as news, commentaries and reports from the presentation studio and by inserted recordings from outside. The lines for inserted contributions to the programme from inside and outside of the broadcasting house are connected up by the main control room. These lines connect the broadcasting studio with another studio in the building, with an outside studio, an OB van or with one of the regional German broadcasting corporations. In this way, various functions, presentations or interviews can be faded "live" into the broadcast and do not have to be pre-recorded. The moderators of topical programmes frequently make use of the telephone interview. Sometimes a pre-production of such conversations is necessary, e. g.

when the person to be interviewed, owing to other engagements, is unavailable while the programme is on the air. Another reason for such a pre-production is that telephone links over long distances may be known, in advance of the broadcasting time, to be impossible to establish owing to technical difficulties.

In addition to the broadcasting studios together with their recording channels and control rooms, there is also a large number of production studios at the broadcasting house which are used for the pre-recording of programme contributions in 34 languages. Each of these production studios is composed of a recording channel and a continuity studio complete with the necessary technical facilities. A studio is designed and constructed in accordance with special acoustic requirements. One characteristic feature here is the reverberation time (RT). Adequate sound insulation must also be provided to ensure undisturbed broadcasting. In addition to talk-back and signal installations, a control window in the wall separating the two rooms enables additional instructions to be given to the speaker or moderator in the studio. The studio manager for the corresponding programme division, together with the sound technician, direct the recording from the control room which is equipped with a control desk for the technical supervision and modulation of the recording as well as with several recording machines and in some cases also a record player. During production, the studio manager is responsible for programme presentation whilst the technician bears responsibility for the technical quality of the recording. Amongst other things, therefore, he has to make sure the microphones in the studio are in the right position, that the speaker gives a voice test, maintain the correct modulation of the recording during the entire production; he has to fade in and fade out music or spoken word contributions, cut out faults such as fluffs, clearing of the throat or excessively long pauses and he has to maintain the right tape speed. On average, these recordings have a duration of between five and twenty minutes and, according to the nature of the script, are recorded "dry" or they are mixed with music and sound effects as in the broadcast of radio plays. While production is in progress, one recording machine is switched to "recording", the others to "play-back" so that music and sound effects can be faded in or copied – these having previously been loaned from the archives.

On completion of production, the tapes, which are now ready for transmission,

either proceed straight to the live transmission studio or they are placed in the archives ready for broadcasting at a later date.

The well-known DW greetings and request programme called "Musik, die unsere Hörer wünschen" or "Music our listeners have asked for" has been selected here as a simplified example to illustrate the kind of pre-production mentioned above.

Members of the Music Department sort out the listeners' letters received together with the greetings and requests they contain and compile a selection for broadcasting. The production manager obtains the music requests from the tape archives. When extracts from longer pieces of music have been requested, it is necessary to compile a music insert tape. This means that the desired extracts are copied on tape in the required sequence, provision often having to be made for the fade-in or fade-out of the various extracts. The overall production consists of this insert tape, of other music titles obtained from the archives and of the speaker's continuity script.

In a further recording the music and the spoken word are mixed. For this, the speaker is in the studio where he reads out the listeners' requests in the required sequence and announces the corresponding music. This is then played in the recording channel either direct from the record, the tape or from the pre-produced insert tape. A further recording machine is switched to "recording" and makes a continuous recording of listeners' greetings and music.

On the broadcasting date planned, this tape proceeds to the broadcasting studio together with other contributions for the programme scheduled for that particular day.

Immediately before the start of the broadcast, the technician in the control room checks the individual recorded contributions with his running order as well as the live inserts planned for the programme and coming in from an outside studio or from the transmission studio (such as news, commentaries, announcements or programme preview). During the subsequent broadcasting time, the technician controls and supervises the programme. Converted into electric oscillations (AF-signals), the programme proceeds from the studio control room via the distribution circuit to the main control room and from there to the transmitters.

For the coverage of the target areas, several transmitters are used for each programme. These transmitters, which are connected to the antennas by feed-

ers, radiate the signal at high transmitting power as electro-magnetic waves. As a result of the reflection of these waves between the ionosphere and the earth's surface, they can reach listeners in all parts of the world whose short wave radio receivers convert them back into acoustic signals.
For the first broadcast by Deutsche Welle to overseas – a three hour programme in German – on May 3rd, 1953, only a few short wave transmitters were available at Osterloog in North Germany, with a maximum power of 20 kW. A larger transmitting centre was subsequently built at Jülich near Aachen with an extensive directional antenna system and went into operation in 1956. Today, this station uses nine 100 kW transmitters for the transmission of DW programmes. In 1961, the German Postal Authorities took over the Jülich station.
Although it is possible to cover enormous distances by short waves, the greater the distance the weaker and the more subject to disturbance the signal becomes. Short distances between transmitter and receiver result in greater field strength, less propagation disturbance and less interference by other stations on the same or on an adjacent channel. So really good coverage can only be achieved by using relay stations.
The first DW relay station to be set up was that at Kigali (Rwanda) in 1963. This was followed by the station at Sines in Portugal. A year later – in 1971 – a four hour programme exchange was arranged with the Canadian Broadcasting Corporation. What is at present the most modern short wave station in Europe was opened at Wertachtal in South Germany in 1972 with four 500 kW transmitters. After completion this station has now eight operational transmitters. A further relay station was opened on the Mediterranean island of Malta for the coverage of North Africa and the Middle East. This station operates with two 250 kW short wave and one 600 kW medium wave transmitters. In cooperation with the BBC, an additional relay station has been set up in the Caribbean with two short wave transmitters of 250 kW each. This station is broadcasting programmes destined for North and South America.
Yet another relay station is planned for Asia.

The rapid expansion of transmission potential was and still is necessary to achieve good reception in all parts of the world. Compared with the big short wave radio services operated by other countries, the ratio of programme hours to transmitter potential in the case of Deutsche Welle still leaves much to be desired.

The Structure and Functions of Deutsche Welle Engineering

The multifarious technical functions which Deutsche Welle has to carry out are spread over four special fields represented by the following departments:

High Frequency

Audio Frequency

Studio Operations and Engineering

Department for General Tasks

These four departments are headed by the Director of Engineering.

High Frequency Engineering

The High Frequency Department is responsible for the planning, equipment and upkeep of the transmitting stations. This includes work connected with the transmitting and the audibility of DW programmes as well as the reception of other broadcasting stations. The various fields of operations of this department are divided up as follows: High Frequency Operations together with Frequency Planning, Frequency Evaluation and Listeners' Technical Advisory Department; Transmitter Project Planning Department with the HF laboratory and workshops as well as the measuring and monitoring station at Bockhacken.

In the field of HF Operations, scientific surveys of propagation and reception conditions – which include the calculation and prognosis for the various propagation paths of the signal – are carried out. This work forms the basis for the selection of short wave bands and the use of the antennas at DW transmitting stations in Germany and abroad. Cooperation in international short wave radio organizations plays a major part in the work of the High Frequency Department. For instance, scientific contributions are made to the CCIR (Comité Consultatif International des Radio-Communications = International Radio Consultative Committee) or similiar organizations. Other functions of the High Frequency Department are assistance in transmitting station planning, sunspot numbers statistics and other ionospheric data, the production of azimuthal maps and dealing with international occupation of short wave bands.

In short wave radio, propagation conditions are extremely unstable and are likely to fluctuate within short spaces of time. Unlike the medium wave or FM, frequency selection has to be adapted to the state of the ionosphere whose reflecting and attenuating properties are influenced by solar activity and by the position of the sun and which, for their part, reveal a certain dependence on the sunspot numbers occurring at an 11 year cycle and on the time of day and year. Owing to the changing ionospheric propagation conditions and the varying influences on the individual transmission paths, the short wave frequencies have constantly to be reassigned. Transmission schedules can, therefore, only be drafted after careful examination of the frequencies for the target areas concerned. In order to ensure better frequency usage and to reduce interference, DW confers several times a year with the short wave stations of other countries to coordinate frequen-

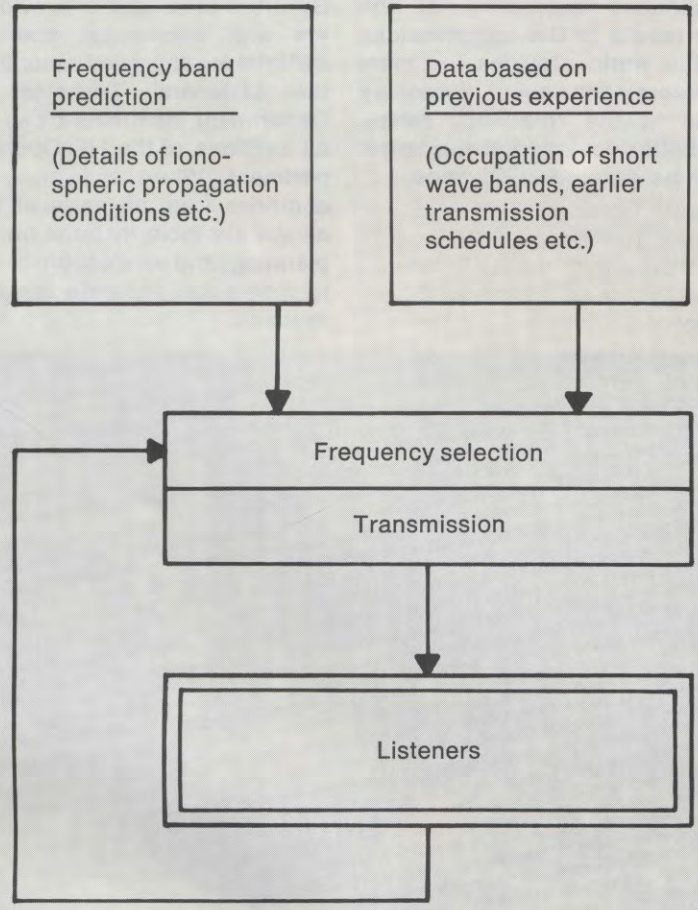
cies for the various transmission periods. In order to achieve agreement on the use of the various short wave bands or channels, the use of any given frequency is reported by the German Federal Postal Authorities – in accordance with the terms of Article 10 of "Radio Regulations" – to the International Frequency Registration board (IFRB) within the UIT (Union Internationale des Télécommunications) in Geneva.
Recommendations are made for the alteration of frequencies when interference is to be expected. Only when all this work has been completed can the final transmission schedule be drawn up in accordance with requirements and existing possibilities.

This shows what extensive preparations have to be made before a short wave programme can be broadcast on this or that frequency. Planning here calls for close cooperation not only within this one department but also with those organizations responsible for the care of the transmitters (e.g. for the stations in the Federal Republic of Germany – the Federal Postal Authorities), with similar departments at other radio stations and last not least with the listeners themselves who, by their reception reports, make a very useful contribution.

These reports, which are received daily, form the basis of all frequency planning and at the same time provide valuable assistance in the evaluation of reception conditions in the target areas. Moreover, the regular reception reports by other short wave stations are also taken into consideration (cf. Report on the DW measuring station at Bockhacken).

Illustration right:
Every day reception reports which also play an important part in the planning of frequencies are received from listeners in all parts of the world

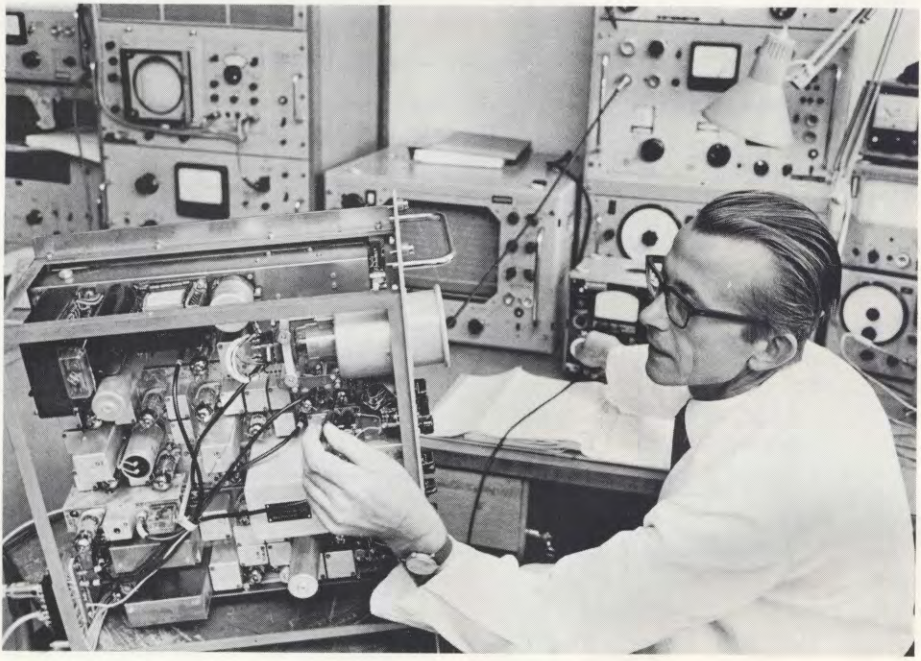
Simplified Diagram of Frequency Planning



The continuous monitoring of the reception results of DW transmissions all over the world provides the most reliable information about necessary alterations in the frequency range, whereby better coverage of the target areas can be assured in advance.

By virtue of its task of providing listeners with information and published material for improved reception quality, the Listeners' Technical Advisory Department maintains close links with all sections of the HF Operations Department. When answering listeners' enquiries from all parts of the world, all the available material on frequency planning and evaluation is consulted to ensure that accurate data is supplied to them.

HF laboratory



In the Transmitter Project Planning Department, the HF laboratory and the workshop carry out special developments in the field of transmitting and reception and the maintenance and repair of the technical installations. This naturally entails the constant and impartial study of all innovations in this field that appear on the market.

For the expansion of existing DW short wave stations and the establishment of further relay and receiving stations, the plans are drafted by engineers and their proper execution is supervised. Obviously, this necessitates harmonious cooperation with industry and a careful study of tenders submitted for the equipment of transmitters, antennas and receivers.

For the measurement and monitoring of propagation conditions, DW has its own measuring and monitoring station at Bockhacken. Here transmissions by DW and by foreign stations are monitored for interference and reception possibilities, and the frequency occupation of the short wave bands is regularly registered. In "round-the-clock" operations, the personnel here also deal with a multitude of other tasks, which are described in detail below.

The Measuring and Monitoring Station at Bockhacken

The modern DW measuring and monitoring station is situated on high ground about 317 m above sea level in the vicinity of Hückeswagen, some 40 km north-east of Cologne. It takes its name from the nearby village of Bockhacken.

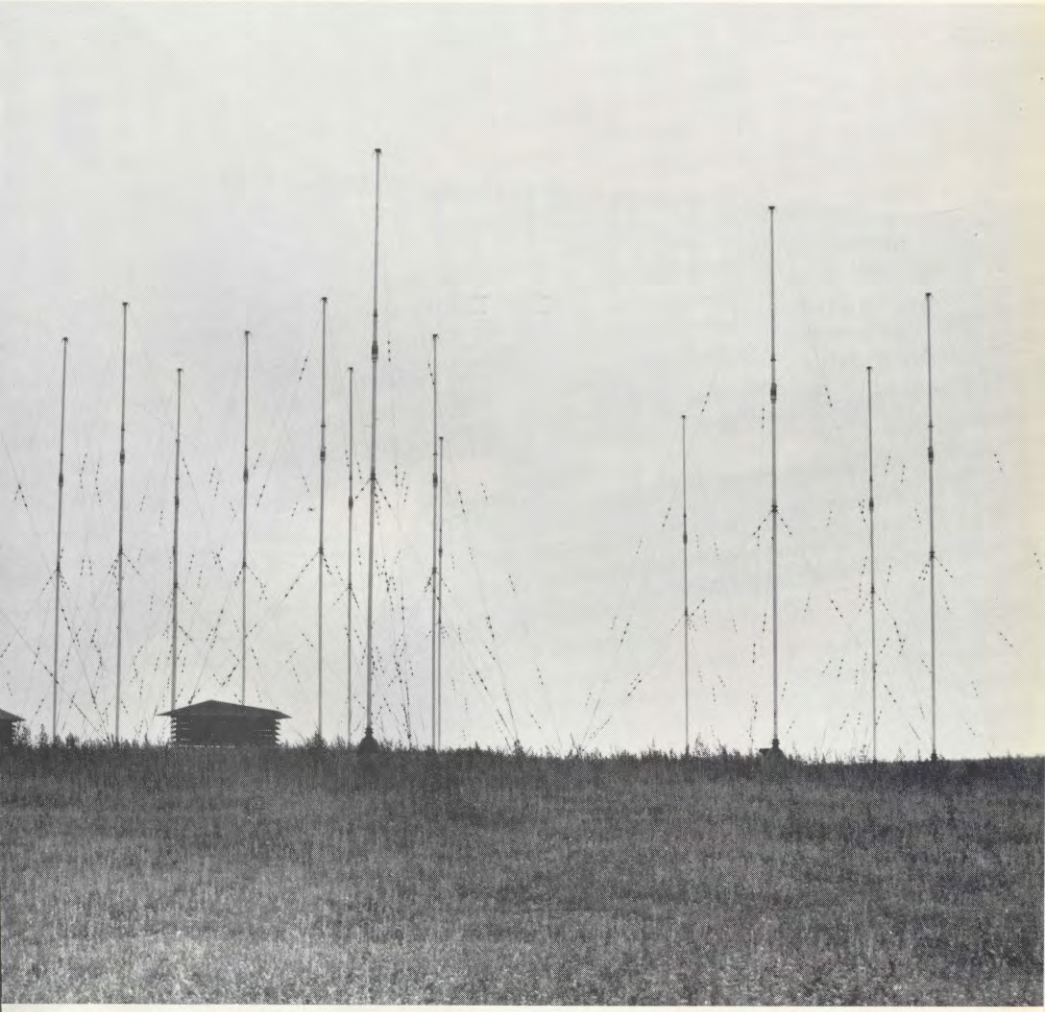
Here a constant check is kept on the short wave broadcasts and on their special propagation conditions. At the same time, newscasts by other radio stations and by news agencies are received for the DW Monitoring Service so that the general trend of foreign radio programmes beamed to the target area in question can be taken into account. The technical quality of other broadcasting organizations is also checked. In an exchange process, these stations also conduct similar observations of the DW programmes. The extensive field of operations of this receiving station also includes the conduct of measurement tests, the study of propagation conditions, the checking of the channels on the various short wave bands, the reception of teletype transmissions by the relay stations and distant teletype transmitters and the reception of trans-

The measuring and monitoring station at Bockhacken
Adcock antenna system
Frequency range: 1.5 – 28.0 MHz

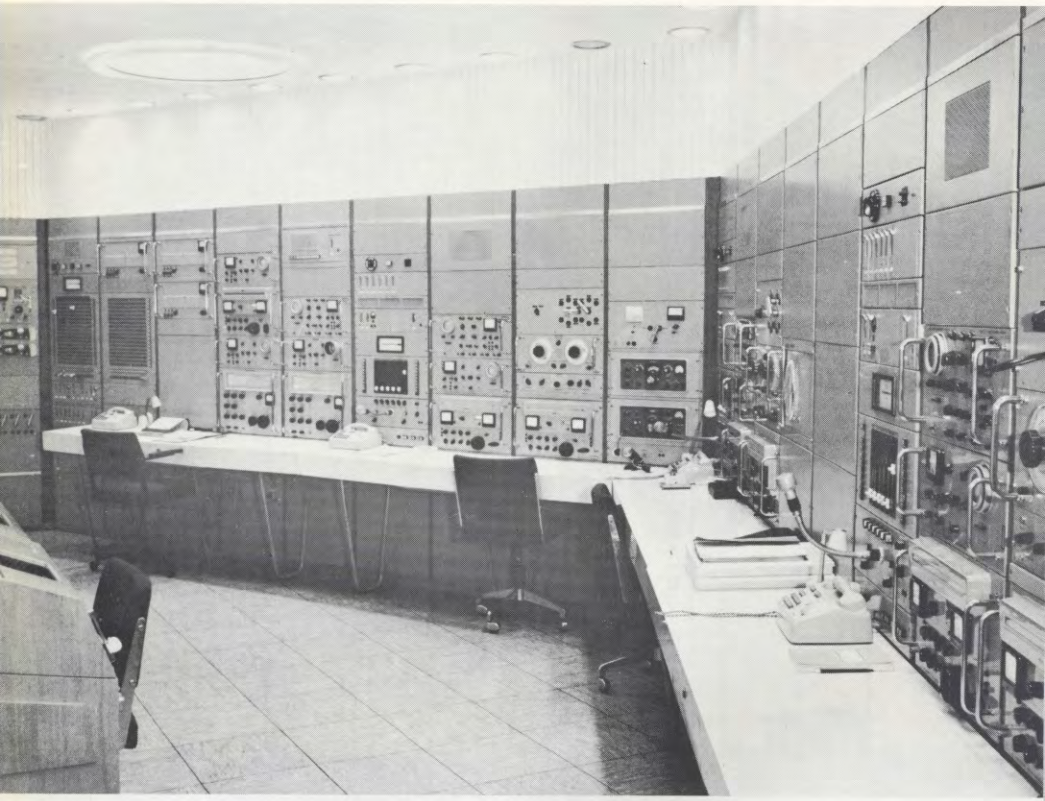
missions from other broadcasting stations, which, as contributions to DW programmes, are put through to the broadcasting house in Cologne. The variety of work to be done here calls for a well coordinated team which works day and night on a shift system.

A number of important factors had to be considered in selecting the location for this receiving station. As reception – especially of very weak signals – has to be as free from interference as possible, the station has to be situated well away from areas with a high noise level, i. e. from densely inhabited residential areas or industrial plants which cause considerable disturbances and produce screening effects. Moreover, it is necessary that the receiving station is erected well apart from a transmitting station, because in the immediate vicinity cross modulation might occur in the receiving apparatuses due to the high power-rate of the transmitter.

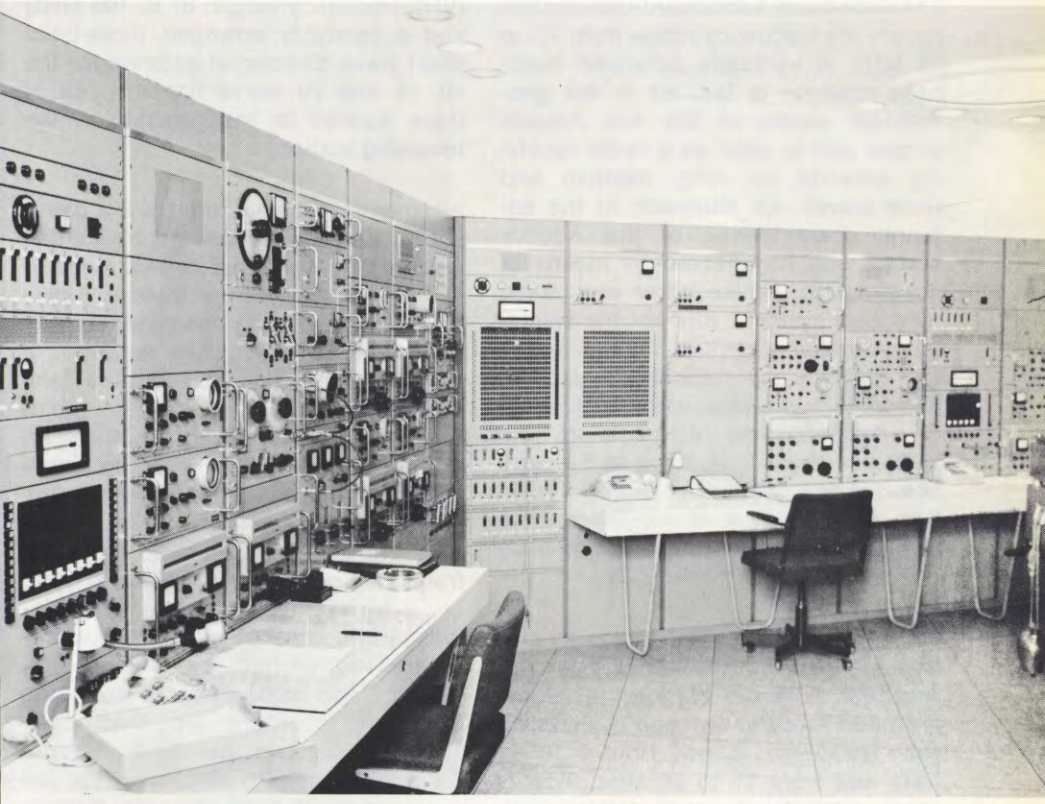
To ensure the trouble-free functioning of the Adcock antenna system, the station building was constructed underground. Above it, at ground level, in a circular area with a diameter of 28 metres, 18 vertically polarized antennas are arranged in two Adcock circles. With 6 and 12 antennas, respectively, they form an inner and outer antenna system. Each antenna is 8.5 m high.



Partial view of operating room



Partial view of operating room

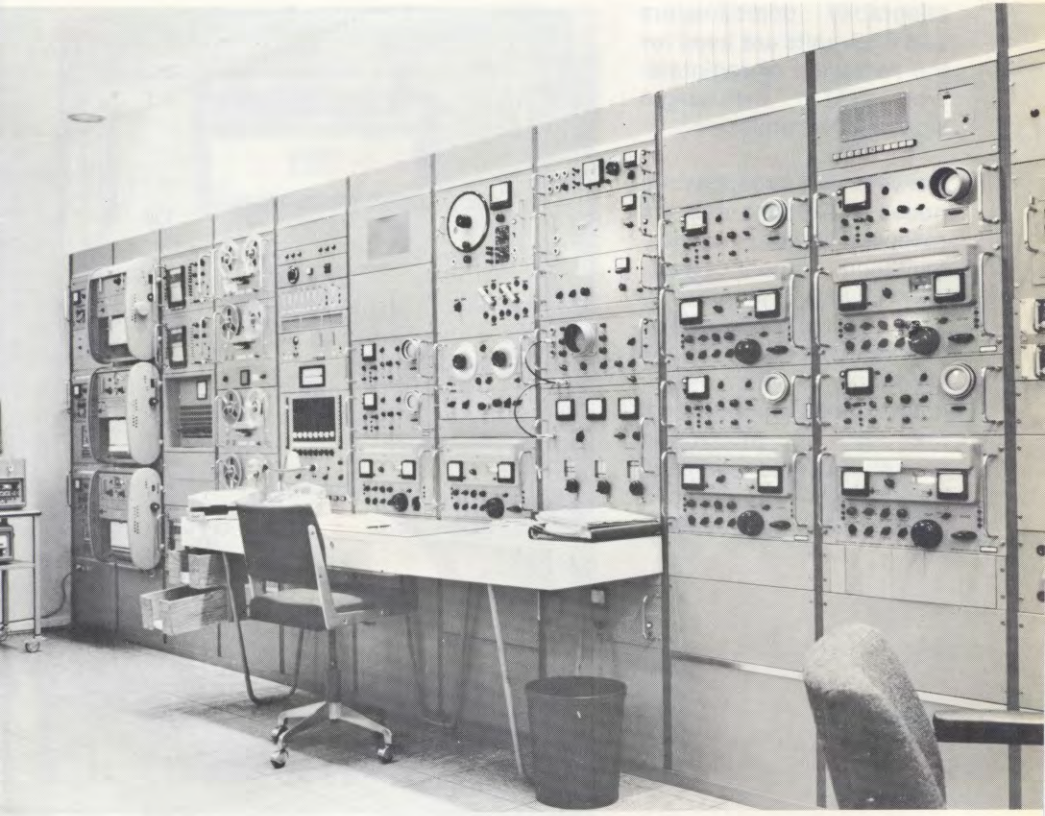


The wide-band Adcock antenna system covers the frequency range from 1.5 to 28 MHz. A vertically polarized multiband antenna is located in the geometrical centre of the two Adcock circles and is used as a radio receiving antenna for long, medium and short waves. An alteration of the antenna characteristic of the Adcock system can be effected by means of goniometers. Unlike other directional reception systems, it is not the selected reception direction that is amplified. Instead, the stations causing the interference are attenuated depending on their direction of incidence. The tune-out effect is as much as 50 decibels for any desired azimuth. In addition, the direction of incidence of a foreign station can be ascertained by a visual direction finder (IDF).

For communication with the relay station at Kigali in Rwanda and for the reception of radio stations in Africa, a double rhombic antenna is available with frequency ranges from 3 to 11 MHz and from 11 to 28 MHz. This is used mainly for the radio teletype link with the Kigali relay station and can be employed both as a transmitting and receiving antenna. Furthermore, there is a 230 metre long L-type antenna for long and medium wave reception, a rotatable FM-directional antenna (VHF-frequency range: 87 to 108 MHz) and a rotatably arranged three-band short wave directional antenna for the 10, 15 and 20 metre bands — all of them located in the grounds of the receiving station.

All antennas are connected via distribution amplifiers with the measuring and receiving set-ups so that multiple use of the antenna systems is possible. Each measuring and receiving set-up is equipped with two receivers, a single sideband attachment, a telegraphy demodulator (except measuring set-up 1) and a directional rejection goniometer with phase and amplitude control unit. The equipment here also includes a central frequency measuring system with radio and audio frequency generators of great accuracy, a high precision crystal clock installation controlled by a standard frequency transmitter, four remote-controlled tape machines, RF-spectrum analysing recorders, long-time registration recorders for field strength measurements, DC recorders for the registration of field strength fluctuations or a field strength spectograph respectively, a visual direction finder, FM, short, medium and long wave receivers for the DW monitoring service and extensive audio frequency equipment. Receivers connected to

Partial view of the rack-front
Left: Registration set-up
Centre: Measuring set-up
Right: Receiver for the monitoring service



Below:
Partial view of the visual direction finder (IDF)
Right:
Rotary FM antenna; the horizontal directivity characteristics are considerably improved by four parallel antennas

telegraphy demodulators and SSB-units are used for the reception of radiotele-type (RTTY) and single sideband transmission.

Between the broadcasting house in Cologne and the receiving station, there is a multitude of connections. They include 2 programme lines, 8 monitor lines, one line to the private branch exchange at the broad-casting house and a direct line to the monitoring service. The measuring and monitoring station also has its own telephone exchange line.

Reception Facilities at the Deutsche Welle Relay Stations

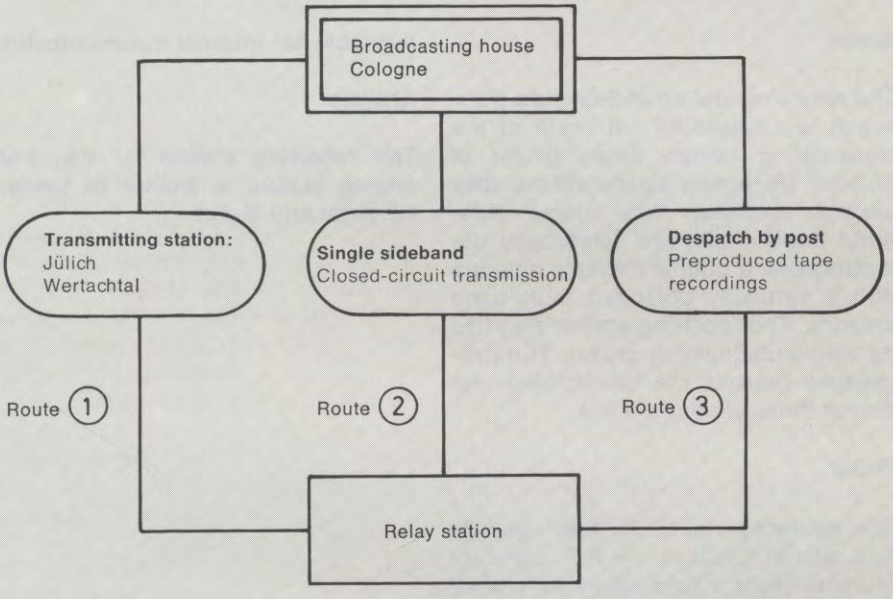
Basically, a relay station has two functions. It receives signals coming in from the broadcasting house in Cologne via the transmitters at Jülich and Wertachtal, amplifies them and rebroadcasts them at increased transmitting power. The relay station can also receive programme contributions by way of single sideband transmissions of the Federal Postal Authorities which are then rebroadcast by the transmitting stations at Kigali, Sines, Malta, Antigua etc. For these reasons, the appropriate reception facilities have been installed at these relay stations.

Kigali

The receiving station of Gasogi near Kigali, the capital of Rwanda in Africa, is situated about 10 km to the north of the transmitter building. This location was selected because the Rubungo Mountains provide an effective screening of the receiving station against the radiations of the transmitting station which is situated on the plateau of Mount Kinyinya. No personnel is required for the receiving station, as the receivers are remote-controlled from the studio in the transmitter building by way of a control cable. Receiving equipment includes a double rhombic antenna and several receivers which are equipped with single sideband attachments and telegraphy demodulators as there is also a radio teletype link with the broadcasting house in Cologne. In this way, operating instructions and information can be exchanged.

Two ways of programme transmission have already been mentioned. A third consists in the use of tape recordings which are preproduced at the broadcasting house in Cologne and then despatched to the relay station. For this reason, the relay stations have a broadcasting studio which enables a programme to be compiled from the material supplied in the various ways mentioned above (see chapter on Department for General Tasks). The individual programme items are preprogrammed on a keyboard of the control unit in the automatic studio which controls the transmission.

The various routes for programme transmission to the relay station



Illustration

Sines

The receiving station at Sesimbra (Portugal) is situated 64 km north of the transmitting station Sines (south of Lisbon). Reception equipment includes several receivers with single sideband attachments and telegraphy demodulators, a double rhombic antenna and a vertically polarized multi-band antenna. The receiving station also has its own broadcasting studio. The programme reaches the transmitting station at Sines via a radio link.

Malta

The receiving station for the transmitting site at Cyclops on the island of Malta is about 8 km west of the village of Nigret. An existing building there was taken over and after a suitable conversion, a broadcasting studio and a receiving station were installed there, equipped with the necessary apparatuses. Transmissions from Germany are received by means of a double rhombic antenna (100 metres wide and 170 m long). In addition, there is a vertically polarized multi-purpose receiving antenna for test and measurement use. The programme passes via radio link from the receiving station at Nigret to the transmitter modulation at Cyclops. A teletype transmitter is also available for internal communications.

Antigua

The receiving station for this transmitting station is similar to those in Portugal and Malta.

The essential part of any broadcasting station is formed by its transmitters. They are set up in one or two rows facing each other in the transmitter hall and their function is to impress the in-coming AF signals from the broadcasting house on the processed HF signal in the transmitter.
The radio programmes are then radiated with very high power via the transmitting antennas.

The large transmitter cabinets are installed for the complex technical apparatuses of the short wave transmitters. Here, in addition to the various stages of the transmitter, we find the HF amplifier, self-tuning devices, modulation amplifier, the valve cabinet for the final stages, anode tuned circuits, the power coupling circuit, low-pass filter together with the vapour cooling system and the systems for coils and air cooling.

In a second row behind – in the transmitter hall at Wertachtal – is the power supply of each of the transmitter amplifiers. The operating voltages for the transmitter valves and their auxiliary systems are delivered here. In three further cabinets, set up behind each transmitter on the outside walls of the transmitter hall, are to be found the mains transformers, filtering elements (capacitor, choke), the modulation transformer and the modulator choke etc., and in the 3rd cabinet are the fans with air filters, the ventilating system and the coil cooling system.

The heat exchangers with the steam condensers of the vapour cooling system are accommodated in the rooms above. The intense heat development with the high transmission power imposes special demands on the cooling systems for the power output valves, the coils of the HF final stage and for the transmitter housing.

A new generation in the field of transmitter engineering is formed by the 500 kW transmitters with fully automatic tuning which can be employed for the entire short wave frequency range. Moreover, like those at other stations, the transmitters must be suitable for frequency changes which often have to be made on account of short programme segments at the short wave broadcasting stations.

Basic Structure of a Transmitter

1. HF-Stages

A frequency-determining oscillator for the generation of the carrier frequency with multi-stage broadband HF amplifier, an HF output stage with vapour-

cooled, high power transmitting valves and the subsequent output circuits (anode tuned circuits, coupling and filter circuits) – these are for tuning, for power coupling and for the harmonic filtering over 40 MHz. The signal passes to the antennas via feeders.

2. AF Stages

The audio frequency arriving by the modulation circuit from the broadcasting house is processed in the multistage modulation amplifier and amplified. The output stage operates on the modulation transformer. For the AF output stage, vapourcooled, high power valves are likewise used. Modulation is effected on the anode of the HF high power output valves.

3. Power Supplies

An extensive supply of power is required for the necessary operating voltages. The entire system at Wertachtal has a daily power consumption of about 20 megawatts – equivalent to that of a small town.

4. Cooling Plants

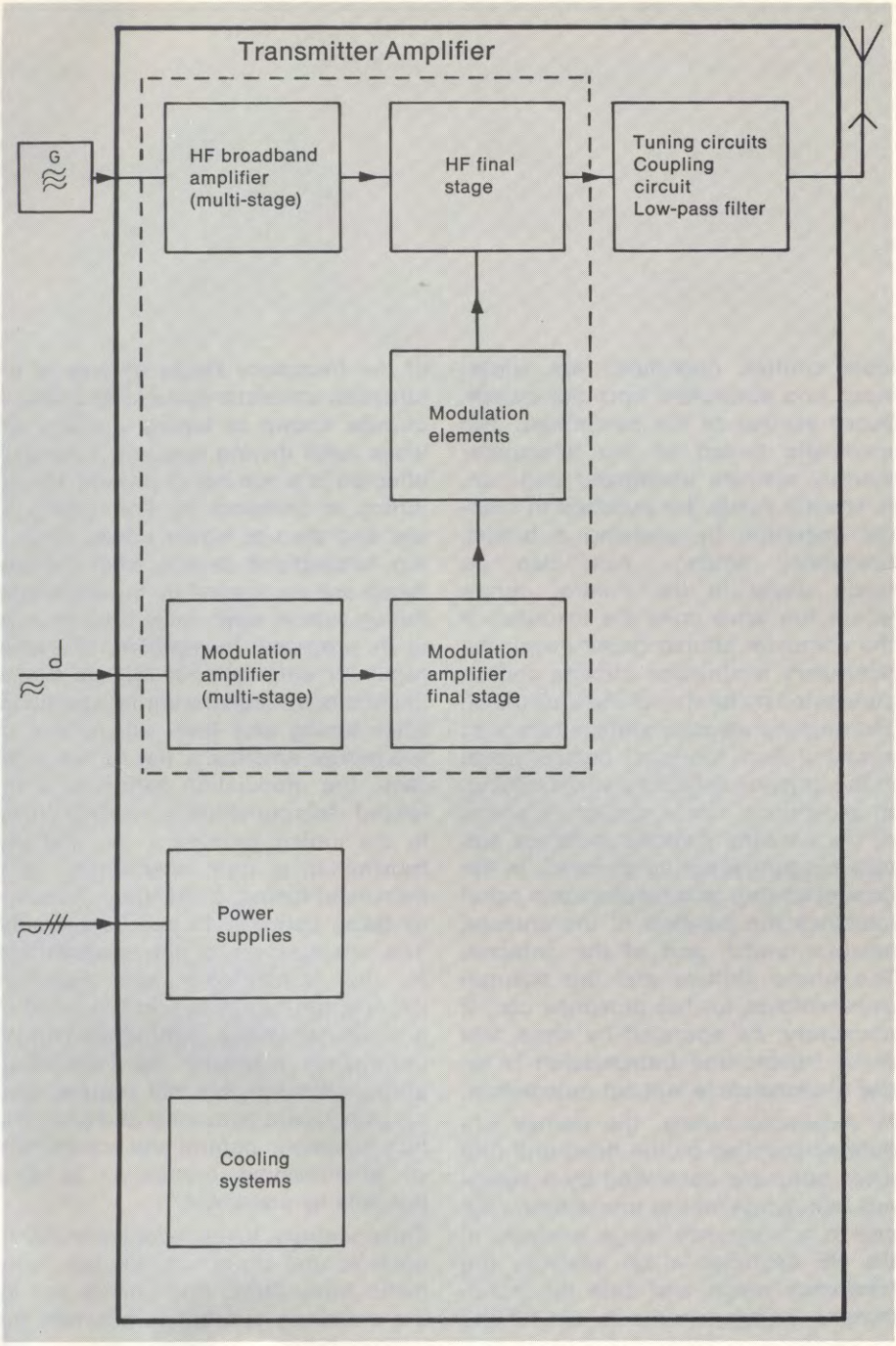
a) Vapour cooling plant for the high power valves.
b) Water cooling is provided for the resonant circuit coils, for the coils of the low-pass filter etc.

c) Air cooling for the transmitter cabinets with various units and systems.

The greater part of the heat is generated on the anodes of the vapour cooled HF and AF output valves and is discharged unpressurized as steam into a heat exchanger. Steam condensers have been additionally provided for. The coils of the anode tuning circuits, the low-pass filters and the load resistances of the short-circuited parts of the anode variometers are also water-cooled. In the case of the other sections of the transmitter as well as the output stage rectifiers, the heat is eliminated by cooling air.

The fully automatic transmitting operations at the Wertachtal station are computer-controlled. From the control centre, which is equipped with all the indicator and operating facilities for supervision and control, the transmitters can be remote-controlled with the commands "out of function", "ready for operation", "in operation". For

Simplified block diagram of a short wave transmitter


Transmitter Amplifier
G
HF broadband amplifier (multi-stage)
HF final stage
Tuning circuits Coupling circuit Low-pass filter
Modulation elements
Modulation amplifier (multi-stage)
Modulation amplifier final stage
Power supplies
Cooling systems

local control, operations are supervised and controlled from the switchboard section of the transmitter. The automatic tuning of the transmitter thereby remains unaffected and can, in special cases, be switched to manual operation by pressing a button. Frequency settings can also be made direct in the control centre where the drive units are installed. If the computer should break down, the necessary modulation circuits can be connected up by way of the jack panel. The antenna selector switches are then actuated from the local control panel in the antenna selector switch building. In exceptional cases, the cross points of the antenna selector switches can also be connected up by hand. In the control centre, an indicator lamp panel indicates the position of the antenna selector switch and of the antenna. The phase shifters and the change-over-switches for the antennas can, if necessary, be operated by hand. But really trouble-free transmission is today inconceivable without automation.

In automatic tuning, the carrier frequency supplied by the drive unit (the drive units are controlled by a standard frequency) for the transmitter, passes to a frequency range analyser in the HF amplifier which analyses the frequency range and sets the transmitter's tuning circuits to the middle of the frequency range by way of instruction translater systems and control circuits known as tuning auxiliary devices (with driving motors). Tuning is effected in a number of phases. Rough tuning is followed by fine tuning at low and then at higher power. Matching fluctuations arising from the antenna are readjusted by the automatic tuning system even while transmission is in progress. In addition, the level regulator automatically adjusts power fluctuations occurring during operation. After tuning and level adjustment of the carrier amplitude, the AF amplifier resp. the modulation amplifier is released - this constituting a further phase in the tuning process — so that the transmitter is now operational. With automatic tuning, a change in frequency takes between 10 and 60 seconds. The change-over of the programmes to the transmitters and antennas is computer-controlled. In the event of a computer failure, operations can be controlled manually as described above although this will require considerably more personnel and time. The fully automatic control and supervision of broadcasting operations is only possible by computer.

The computer, being installed in Jülich, controls and supervises the two automatic transmitters and carries out all the switching operations between the

transmitters and the antennas that are necessary for transmitting operations. The basic structure of the Jülich transmitting station can be compared to that of the Wertachtal station.

At the Kigali relay station, at Sines and in the case of some of the transmitters at Jülich, tuning is done by hand which means that for every change in frequency between 1 and 5 minutes are required in order to tune all the transmitter's frequency-determining circuits. The automatic transmitters at the Malta relay station are tuned by means of tuning auxiliary devices. Operation and control are carried out from the transmitter's switchboard. A fully automatic transmission operation like that at Wertachtal and Jülich is possible. At the relay stations, the antenna selector and the slew switches are remote-controlled from the control desk in the transmitter hall. From the transmitter, the HF power passes to the antenna selector switch system which, on account of the great space required at Wertachtal, has been accommodated in an adjacent building. The switching system, set up like a crossbar distributor, occupies an enormous space.

Depending on the transmitters with symmetrical or coaxial output used at the individual stations, the feeders as well as the antenna selector switches have, for matching reasons, been set up symmetrically or coaxially with the corresponding feeders.

The change-over from the one system to the other is effected by means of symmetrizing and transformation lines (STL). Additional transformation lines (TL) serve to ensure the passage of HF power to the antenna with as little loss as possible.

At the Wertachtal station, the coaxial HF feeders have been laid in space-saving cable ducts to the symmetrizing and transformation lines in front of the antennas. The symmetrizing and transformation lines or STL's, as they are called, symmetrize the voltage and effect a matching to the characteristic impedance of the symmetrical feeders which branch out via the phase shifters to the feed-in points of the antennas. In Jülich, the change-over from the coaxial to the symmetrizing feeders takes place immediately outside the station building. In Kigali and Sines, on account of the symmetrical transmitter outputs there, both the antenna selector switches and the feeders are symmetrical. The system employed in Malta is similar to that in Jülich.

The Short Wave Antenna Systems at the Transmitting Stations

Short wave radio programmes can be broadcast over long distances and can thus provide coverage of vast areas of the same language and living habits.

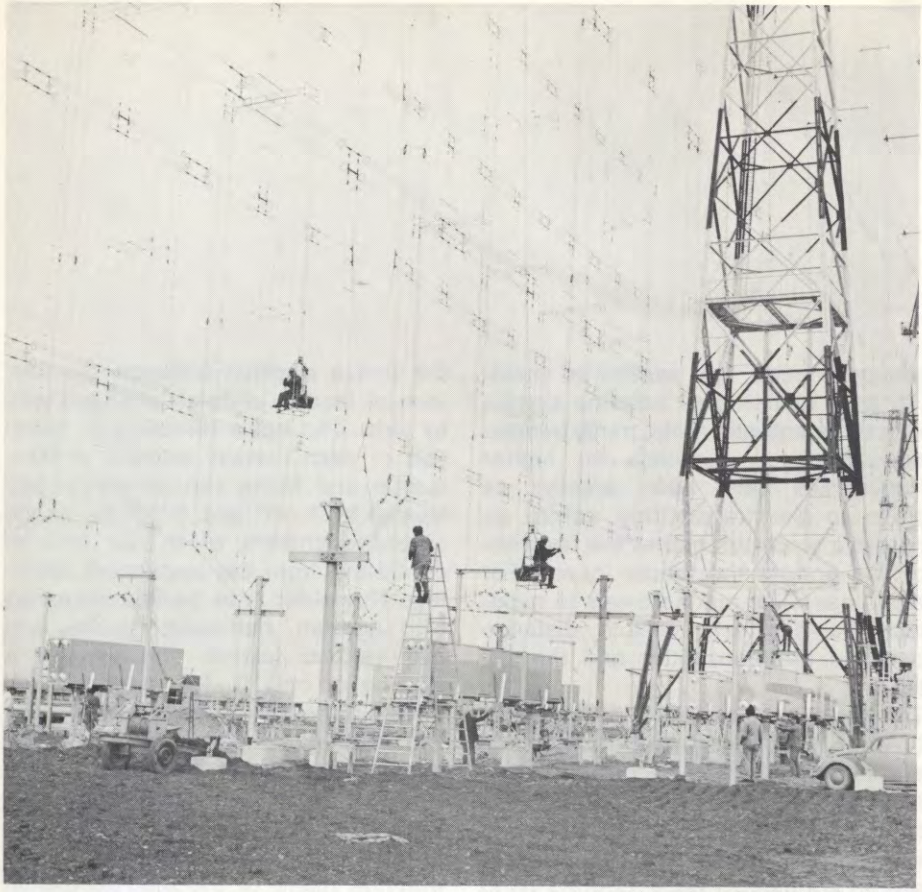
What kind of antenna system is chosen for the required frequency range will depend on the size of the target area and on the length of the transmission path. For the location of their antennas, short wave stations need a relatively large, flat area because mainly directional antennas are used, which are erected as horizontally polarized dipole curtains. Moreover, the antennas must be so located as to ensure a sufficiently great decoupling of the antennas and unhindered radiation. The latter also applies to the area in front of the antennas. When the antennas have an elevation angle of only 5°, the smallest angle of radiation should not be obstructed by buildings, rising ground, power lines or bridges etc. Other necessary conditions are good ground conductivity and a sufficiently long distance from local airports. The arrangement and grouping of the antennas is dependent on the geographical location of the transmitter in relation to the target areas to be served. On account of the fluctuating propagation conditions, antennas of the various short wave frequency ranges are allocated to each main coverage direction. In addition, with the vast majority of modern antennas (like those at the Wertachtal station for instance), the direction of maximum radiation can be electrically slewed from its basic direction in a range of max. ± 30°. According to the electrical slewing range of the direction of maximum radiation and the half power beamwidth (the horizontal beamwidth of the antenna), the main radiation lobe of the antenna covers an angle of approximately 90°. This means that, by using several antennas, any desired transmitting concentrations can be formed for every coverage area. It is likewise possible, using one antenna, to cover successively several azimuthally adjacent target areas.

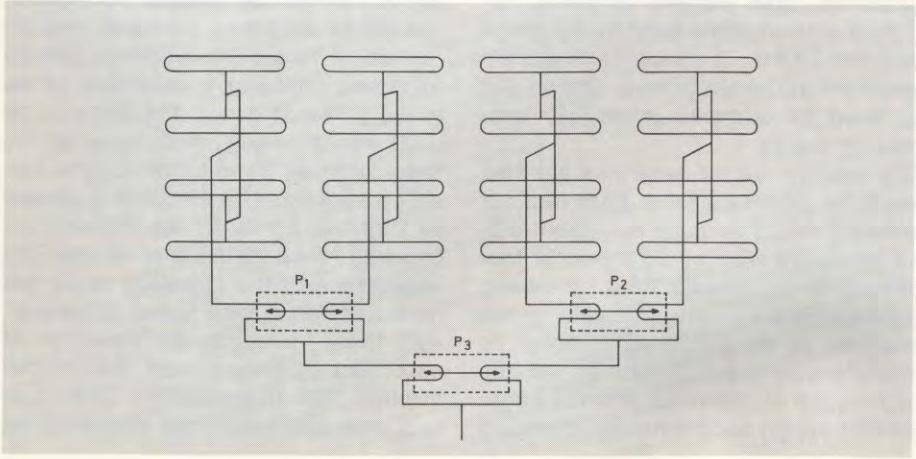
In the case of extensive target areas which occur as a rule, it is necessary, owing to the highly directional antenna systems, to confine transmissions to a limited reception area. However, by the simultaneous use of several antennas of varying radiation angles (azimuth), it is possible to achieve a fanwise coverage of a large area. By way of an antenna selector switch system, each antenna can be connected to the existing transmitters and maximum interchangeability is possible. At Jülich and Wertachtal, the directional antennas have been combined to form antenna arrays for the different main directions of radiation and are

grouped round the transmitter building as a star-shaped antenna system with three antenna arms, partly bended several times. Antennas for higher frequencies have been erected as close to the transmitting centre as possible since the higher the frequency the greater the feeder losses. For this reason, the aim here was to maintain the shortest possible distance between the transmitter and the antenna.

The directional antennas used for the broadcast of programmes to overseas are highly directional curtain antennas. They are multi-band antennas for two, three and four successive short wave bands. At the Jülich station there are, in addition to two and three-band antennas, also curtain antennas for only one short wave band in the range of 6 and 7 MHz. The wide-band curtain antennas at the Malta relay station can be used for a maximum of four successive bands.

The modern curtain antennas are also known as dipole curtains. Each radiator consists of horizontally polarized folded half-wave dipoles arranged in four bays and four stacks. The wide-band characteristic is made possible by the erection of the individual dipoles as multiple-wire cages. Compared with the older types of antennas, a much larger slewing range is obtained by changing the phase position between the four vertical feed-in systems arranged side by side. The basic direction of radiation of each curtain antenna at Wertachtal and Malta can be electrically slewed by $\pm$ 15° and $\pm$ 30° by means of phase shifters which are remote-controlled from the transmitter building. The older type curtain antennas with end-fed, half-wave dipoles and two vertical feed-in lines permit a slewing of only $\pm$ 10°. At the Jülich transmitting station, the reversible one and multi-band dipole antennas are composed of two similar dipole groups and can be used alternatively as reflector or antenna. The direction of maximum radiation can be exchanged with the plane of the dipole array in mirror image. By means of remote-controlled reversing switches, the direction of maximum radiation can be reversed, enabling a maximum of up to six different beam directions to be used consecutively. With some of the two and three-band antennas, the elevation angle can be electrically slewed so that the antennas are suitable for short and long-distance coverage. The importance of the elevation angle will be further dealt with below. Moreover, with these antennas the direction of maximum radiation can be turned through 180° (reversibility). Other curtain antennas which can only be used




P1
P2
P3

Top left:
Curtain antennas in the erection phase. The cage type half-wave dipoles in front of and behind the screen reflector form the dipole curtain antennas in four bays and stacks

Bottom left:
Diagram showing the feed-in of a curtain antenna and the phase shifters

for long-distance coverage, also permit reversal of the direction of maximum radiation, although no electrical "slewing" of the antenna in the horizontal or vertical direction is possible.

The modern types of curtain antennas are suspended between the masts in pairs and are screened from each other by an aperiodic screen reflector. With these modern curtain antennas, it is possible to supply programmes to target areas in opposite directions at the same time. The reflector is composed of a dense array of horizontal wires located one over the other and set up in the centre between the curtain antennas. To provide more efficient decoupling, antennas of differing frequency ranges have been set up on either side of the reflectors. In addition to the Wertachtal station, the aperiodic screen reflectors are used at Kigali in connection with two and three-band antennas, at Sines with two-band antennas, at Malta with four-band antennas and at Antigua with one and two-band antennas. At the relay stations, as at the other transmitting stations, the basic directions of the antennas including electrical slewing are so defined as to enable all desired coverage areas to be reached. For the various frequency ranges, several antennas are available for each direction. Short wave frequencies in the range of the longer wavelengths enable the nearer and medium distant target areas to be reached, because radiated from the antenna at a high angle of elevation, the short wave signal strikes the earth's surface at a relatively short distance from the transmitter as a reflected ionospheric wave, thus making short wave coverage possible. So target areas situated at shorter distances from the transmitting station are reached by close-range antennas with higher radiation angles. As a rule for target areas in the immediate vicinity of the transmitting station, omnidirectional antennas are used and for those at near and medium distances (1,500 – 3,000 km) directional antennas. The radiation angle is adapted to the distance from the target areas to be covered and is in a reciprocal ratio to the frequency. For long-distance coverage at correspondingly higher frequencies, the optimum radiation angle is about 9° above the horizontal and for close-range coverage higher radiation angles of about 30° are normally used.

Basically, the aim here is to obtain the best reflection conditions of the ionospheric wave radiated to the ionosphere by selecting the most favourable elevation angle of the main radiation lobe. The elevation angle of the curtain antennas is determined by

the construction features of the antennas, that is to say by the height above the ground at which the lowest linear array is suspended as well as by the switching of the antenna elements. The paraphase feeding of the upper and lower antenna elements produces a vertical slewing of the main radiation lobe. For close-range coverage, the Jülich station is equipped with three wide-band omnidirectional cage antennas which, however, on account of the vertical polarization at higher power outputs, have an unfavourable radiation efficiency. At the Kigali, Wertachtal and Malta stations, therefore, horizontally polarized quadrant antennas were erected. The bandwidth comprises two successive broadcast bands. Hence, for the use of the desired short wave range, several two-band antennas had to be provided. This antenna constitutes a full-wave dipole, the halves of which on the horizontal plane enclose an angle of 90° and are suspended from three masts. It possesses good radiation efficiency and has an almost circular horizontal pattern.

For medium distant target areas, curtain antennas with high radiation angles and log-periodic antennas are used as directional antennas. Compared with the long-distance coverage antennas, these have broader main lobes. At the Wertachtal station linear arrays are used. These are constructed of multiple-wire cages and in some cases are arranged under the dipole arrays with the same frequency ranges. HF feeders and HF phase shifters of the dipole arrays can alternatively be switched to the linear arrays so that either the dipole array or the linear array located underneath is operated. The direction of maximum radiation can also be slewed electrically by ± 15° and ± 30°. The log-periodic antennas, or "LP", have a good radiation effeciency and, by virtue of their wider bandwidth, can be used throughout the entire short wave range. The antennas consist of two LP radiators located side by side which are made up of a multitude of dipoles and whose geometrical dimensions increase or decrease periodically in accordance with a fixed and constant ratio. The LP radiators are fed symmetrically but separately and are connected to a phase shifter. By altering the phase position between the two symmetrical feed-in points, an electrical slewing of the main radiation lobe in the horizontal direction by ± 20° can be achieved.

At Jülich and at the Sines relay station, the LP antennas are vertically polarized,

whilst at the Wertachtal station and at the Malta relay station they are horizontally polarized. The LP antennas at Wertachtal are each composed of 2 LP radiators. They are located side by side on a slanting plane. Each radiator has 26 dipoles which are fed in the centre via a feeder. This is composed of two hollow ropes suspended one above the other. Each dipole is formed as a cage by four parallel ropes. Starting from the feed-in point of the radiator, the dipoles have increasing lengths (2.84 m . . . 23.2 m) and are arranged parallel to one another and vertical to the centre guy rope. The shape of the antenna resembles a trapeze, the longest side of which is suspended between masts 45 metres high. The short side of the trapeze with the two feed-in points of the LP radiators is pointing in the direction of maximum radiation and is fixed between three low masts (max. height 5 m).

At the Malta relay station, Deutsche Welle installed its first rotatable LP antenna (frequency range 5.9 – 30 MHz) with a horizontal slewing range from 0 – 360°. This enables the signal to be radiated in any desired azimuth. The antenna consists of the antenna tower and the antenna arm with the central main support and 18 dipoles, in the centre space of which they are connected with the symmetrical feeder. In addition, the main support accomodates a balun transformer for matching the symmetrical feeder to a coaxial feeder.

The elevation angle can be altered by the mechanical tilting motion of the antenna arm from – 35° / + 25°. With every change in the elevation angle, the radiation pattern of the antenna also changes. The antenna is remote-controlled by means of the appropriate control facilities.

Due to the distance between antennas and transmitter building or control centre of the transmitting stations, the slewing and direction reversing facilities as well as the changeover switches between dipole arrays and linear arrays etc. are remote-controlled. On the antenna site so-called substations are located in which instruction translater systems, the motors etc. needed for the control of a maximum of three antenna groups are accomodated.

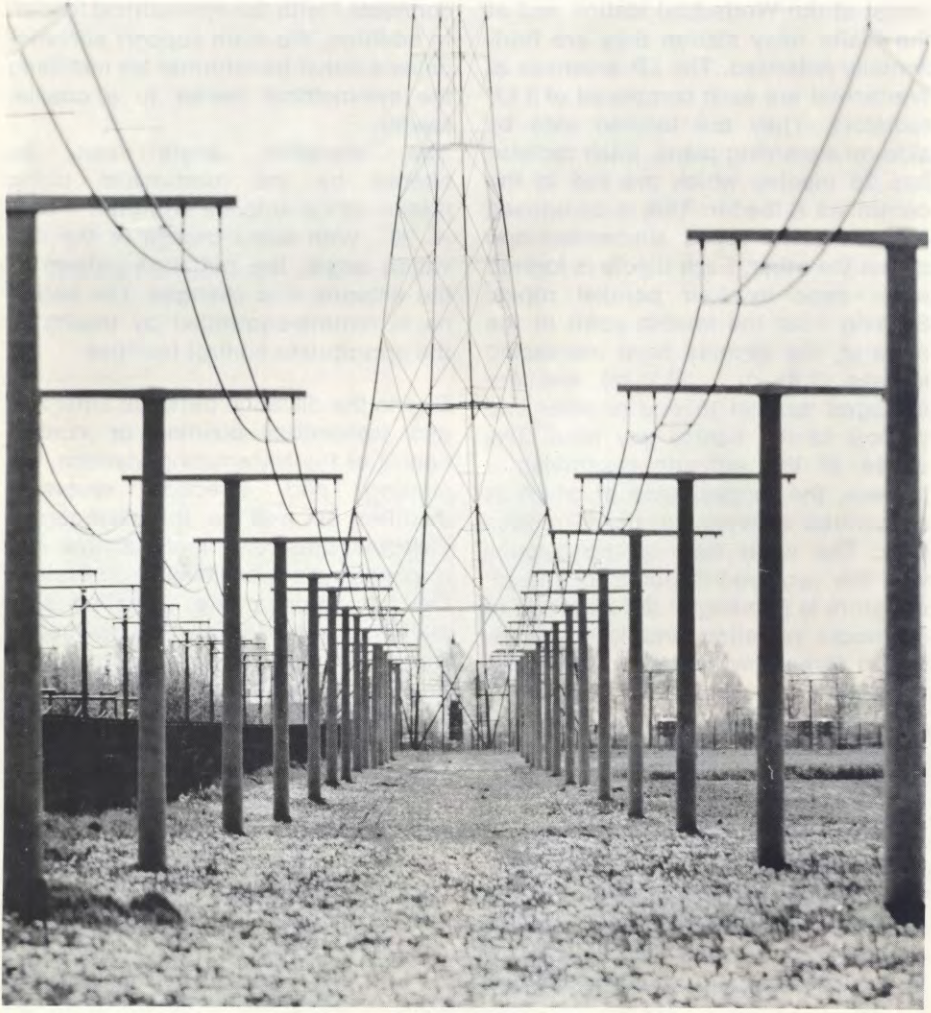
The Transmitting Facilities in Jülich and Wertachtal in Pictures

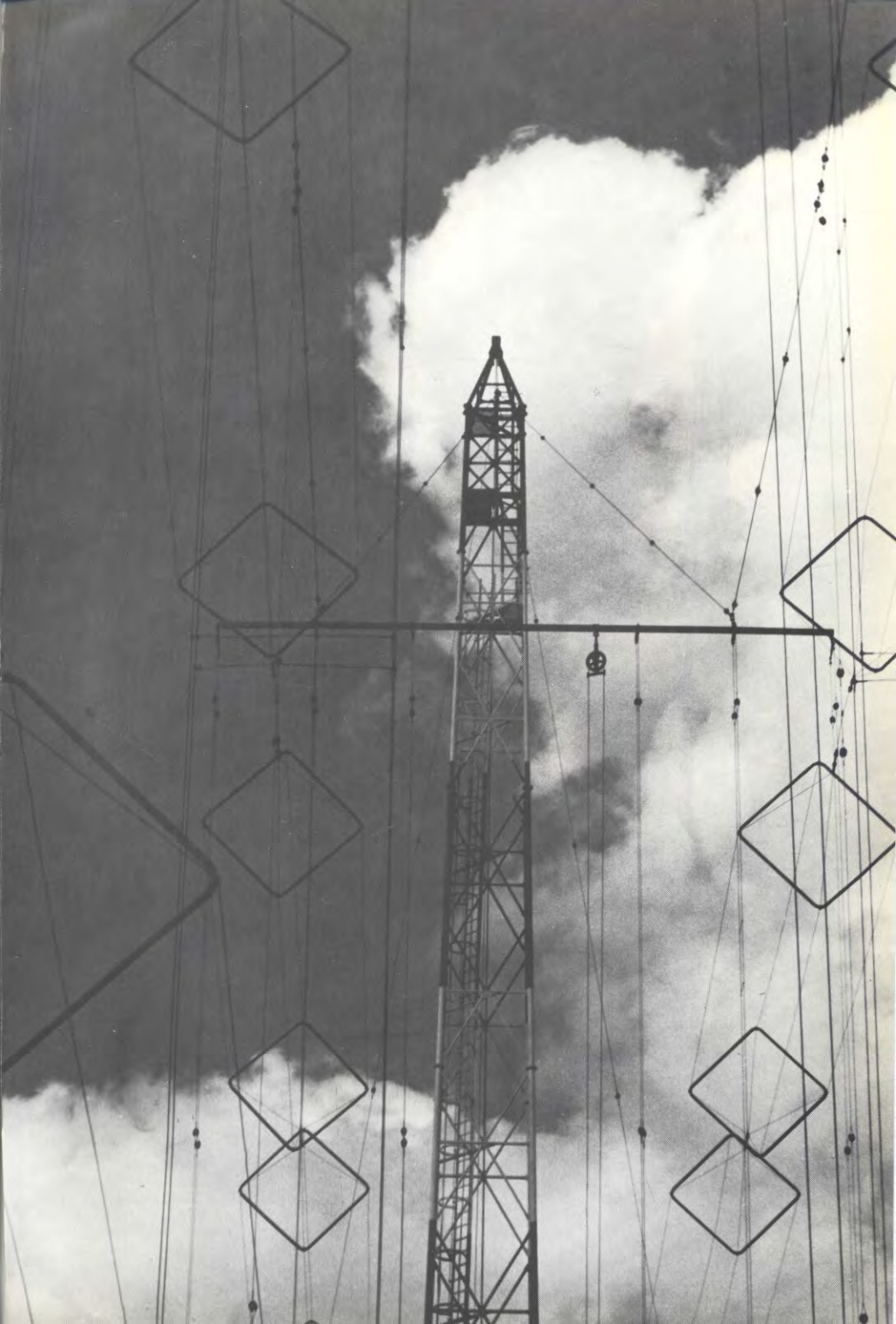
Below:
Jülich transmitting station
feeders to the
"Jülich Curtain Array"

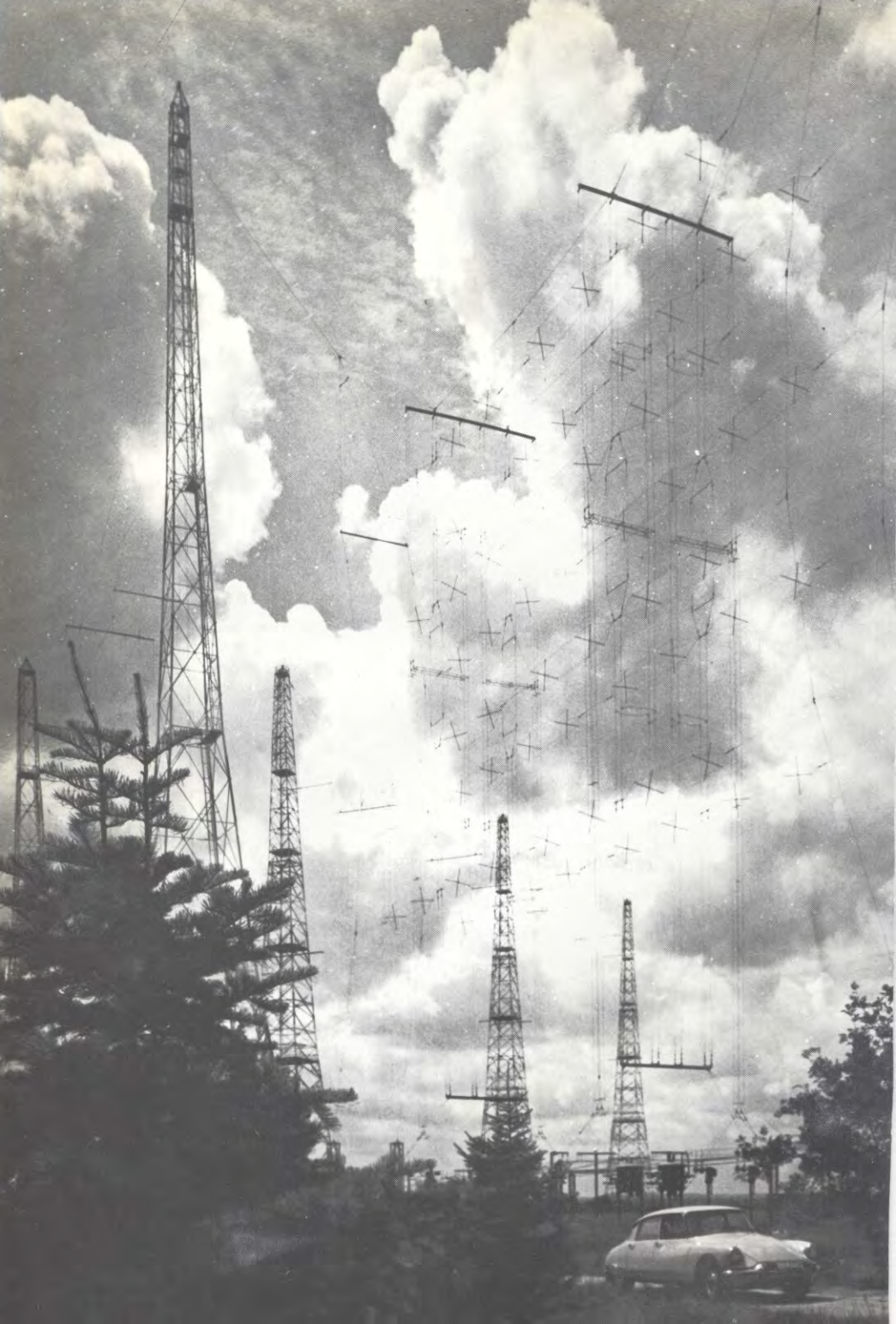
Right:
2-band curtain antenna 15/17 MHz
reversible direction of radiation

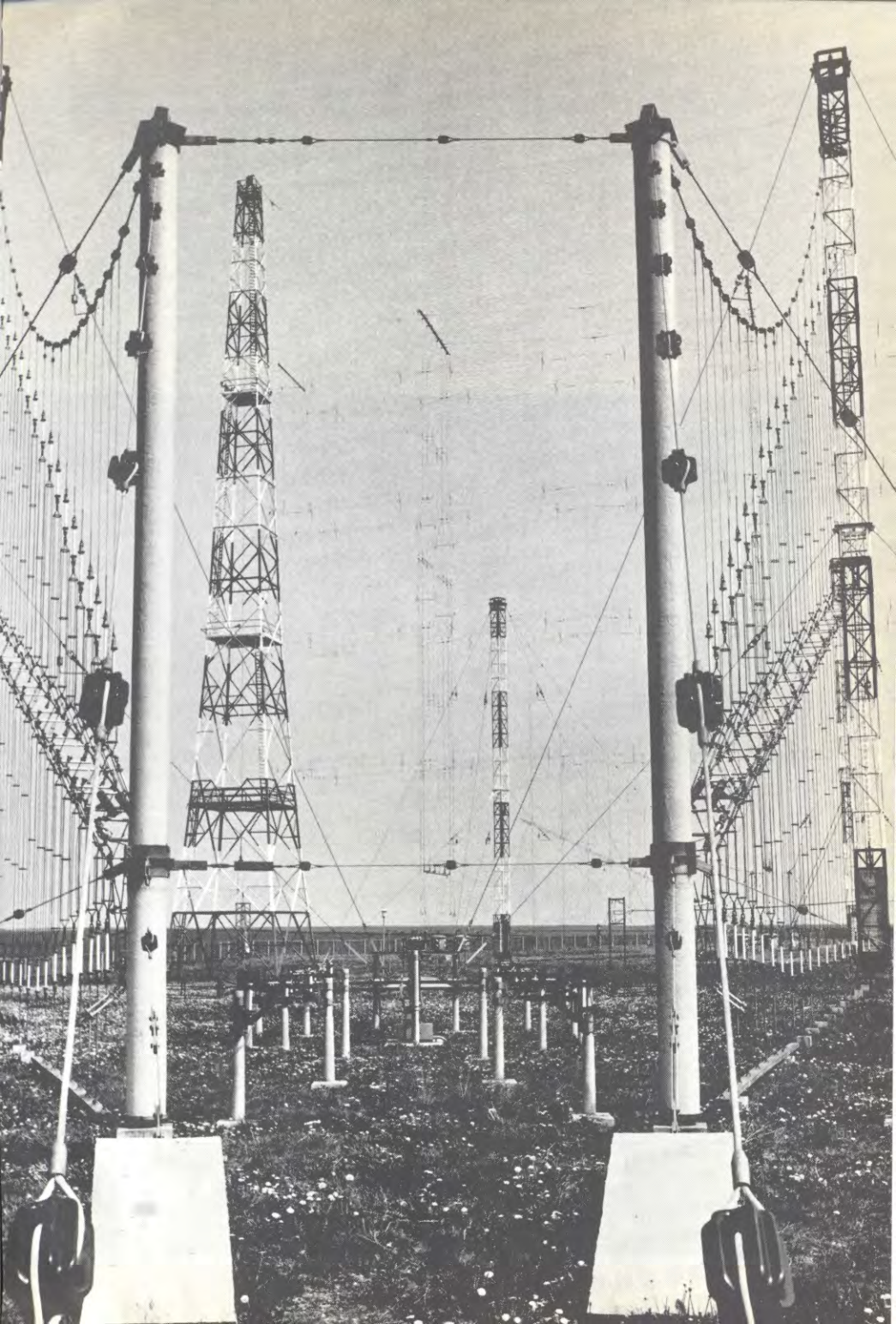
Picture Page 60:
3-band curtain antenna 15/17/21 MHz
reversible direction of radiation
horizontal slewing $\pm$ 10°

Picture Page 61:
Vertical polarized log-periodic
antenna at Jülich



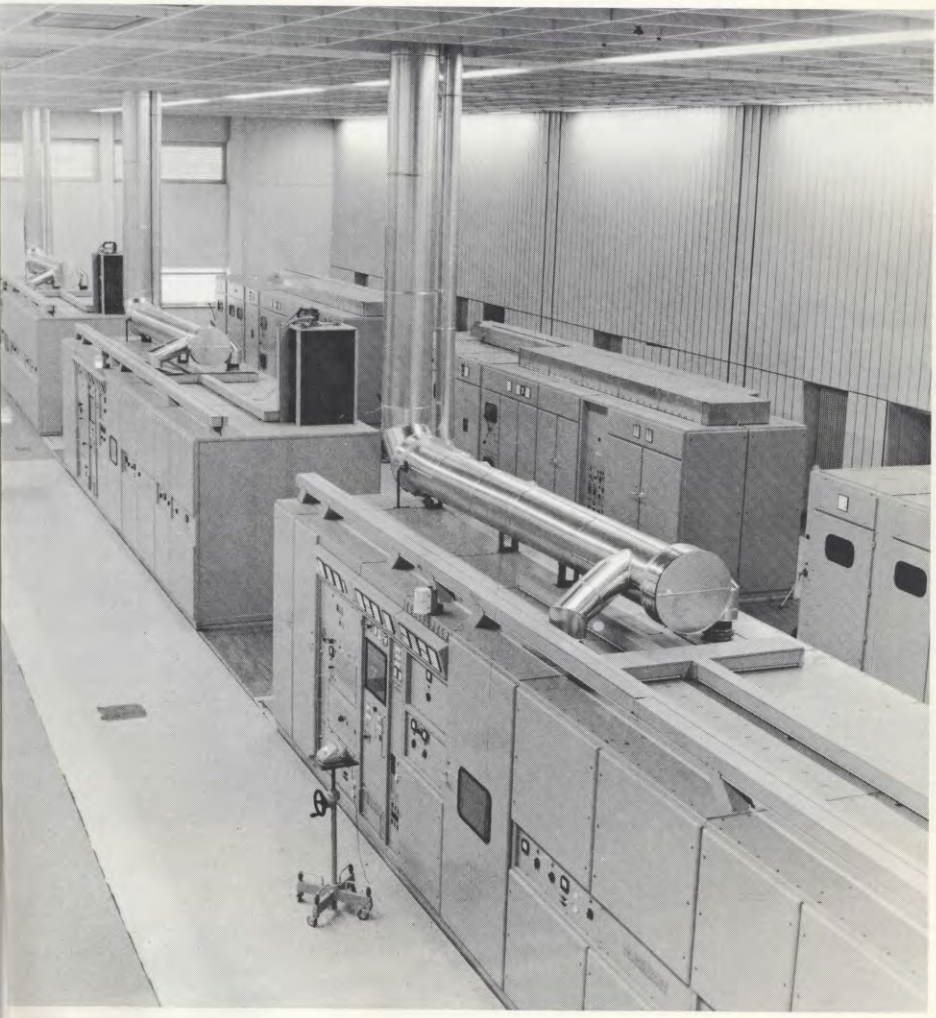




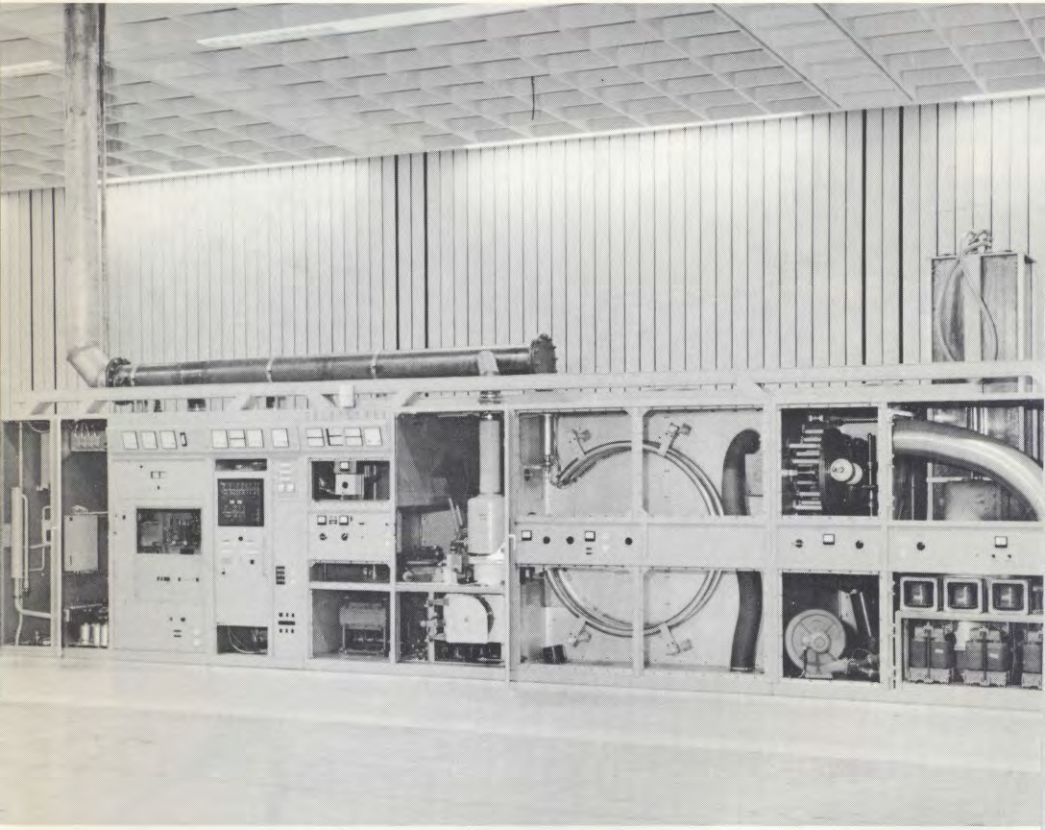


Roof of the transmitter hall at Wertachtal
with heat exchangers and honeycomb coolers

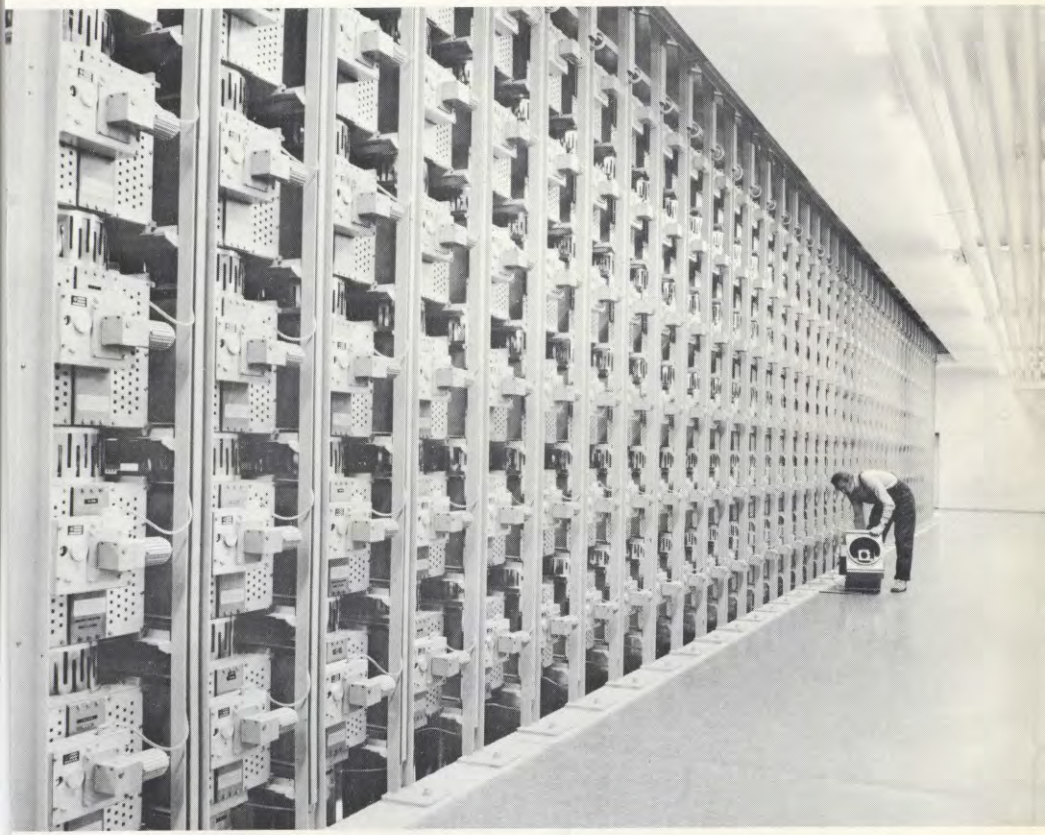
Transmitter hall at Wertachtal
Front row:
Front view of the 500 kW short wave transmitters
Rear row:
Power supplies for the transmitters



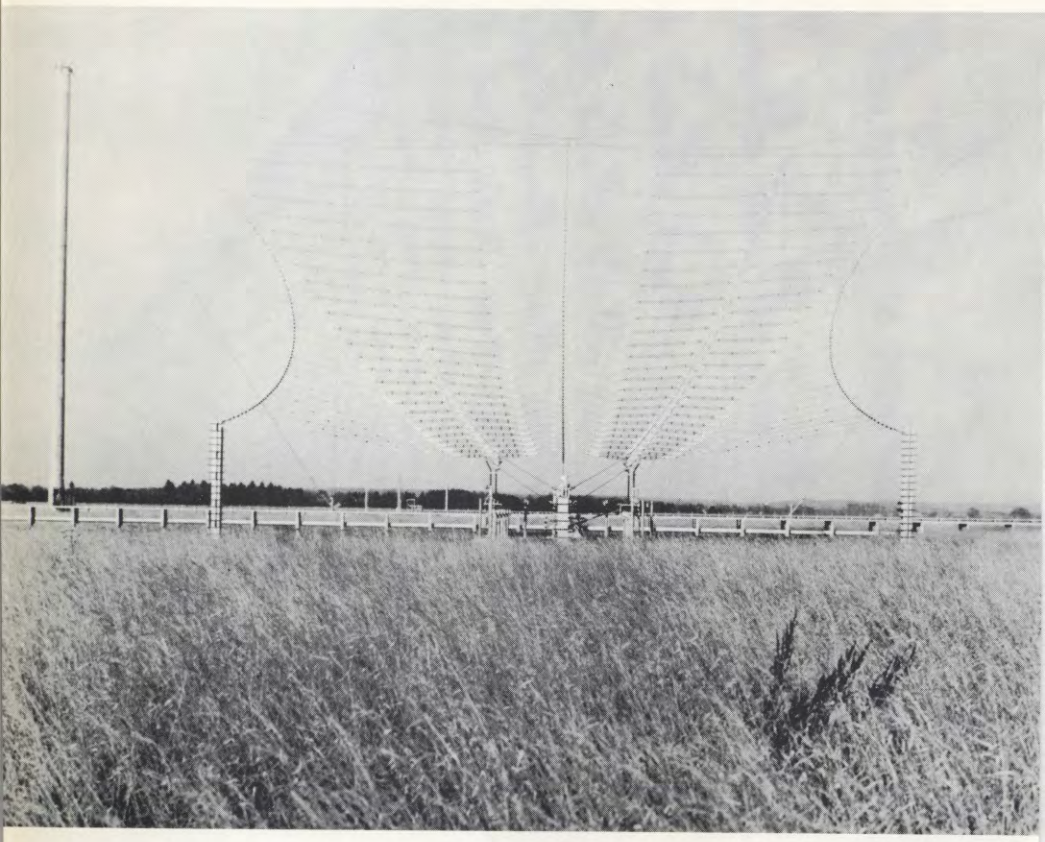
Cabinet style structure of a transmitter with doors and coverplates removed.
The transmitter cabinets contain from left to right:
Evaporation cooling system, modulation amplifier with AF final stage, switchboard and operating console of the transmitter and HF amplifier, valve cabinet with HF final stage, anode tuning circuits, power coupling circuit, low-pass filter



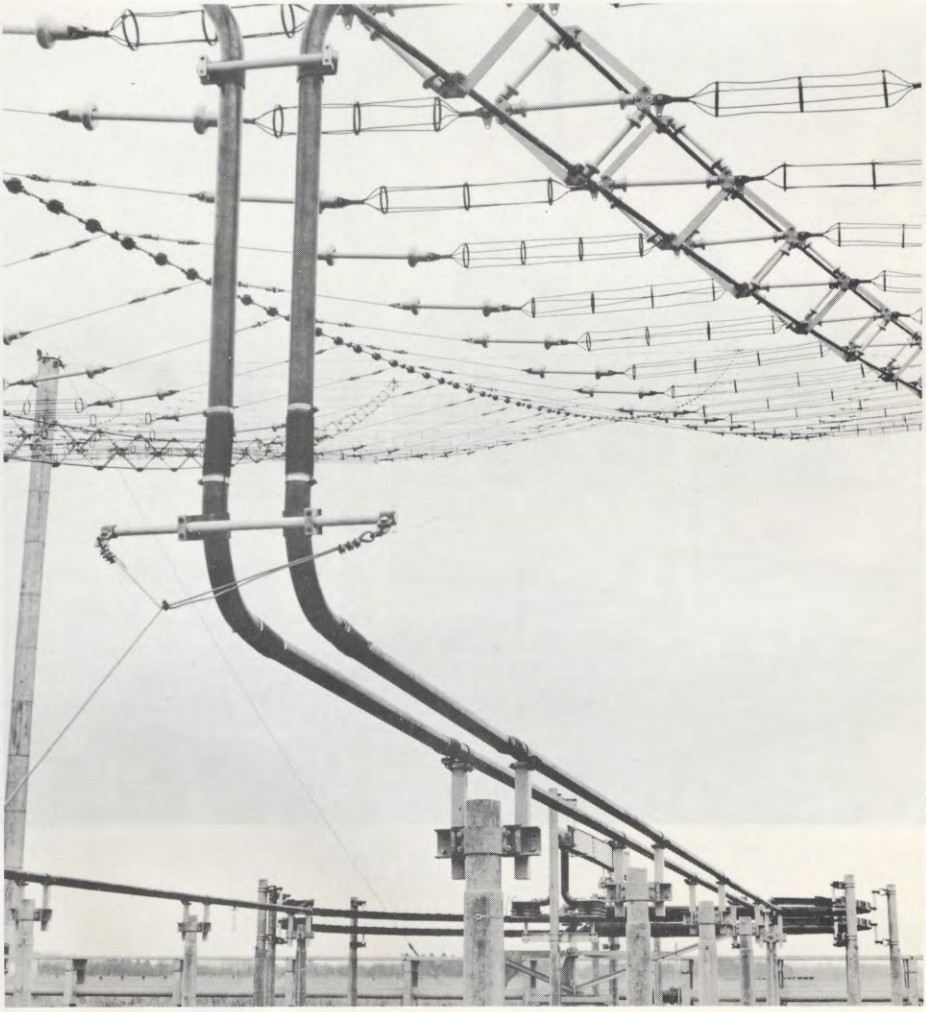
Partial view of the antenna selector switchboard at Wertachtal.
The antenna selector switch system between transmitter output and antenna feeders enables a transmitter to be connected to any desired antenna.
The system is composed of 684 antenna selector switch units



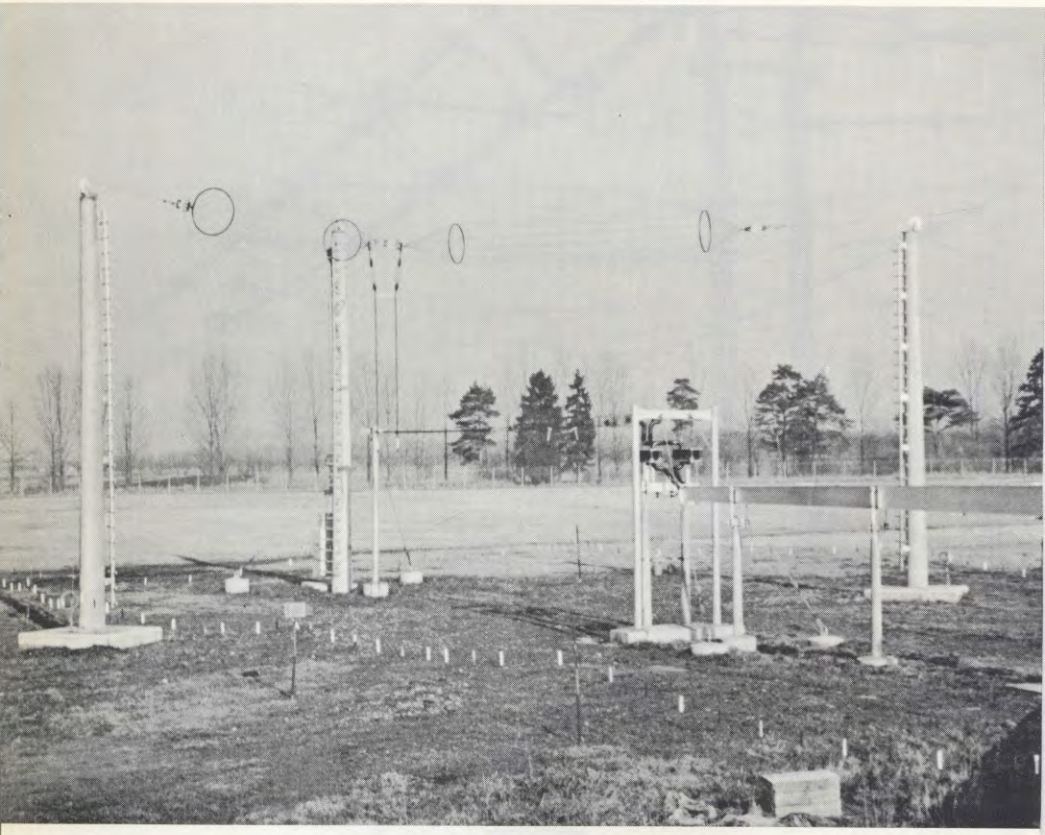
Log-periodic antenna at Wertachtal, consisting of two LP radiators located side by side with 26 dipoles each



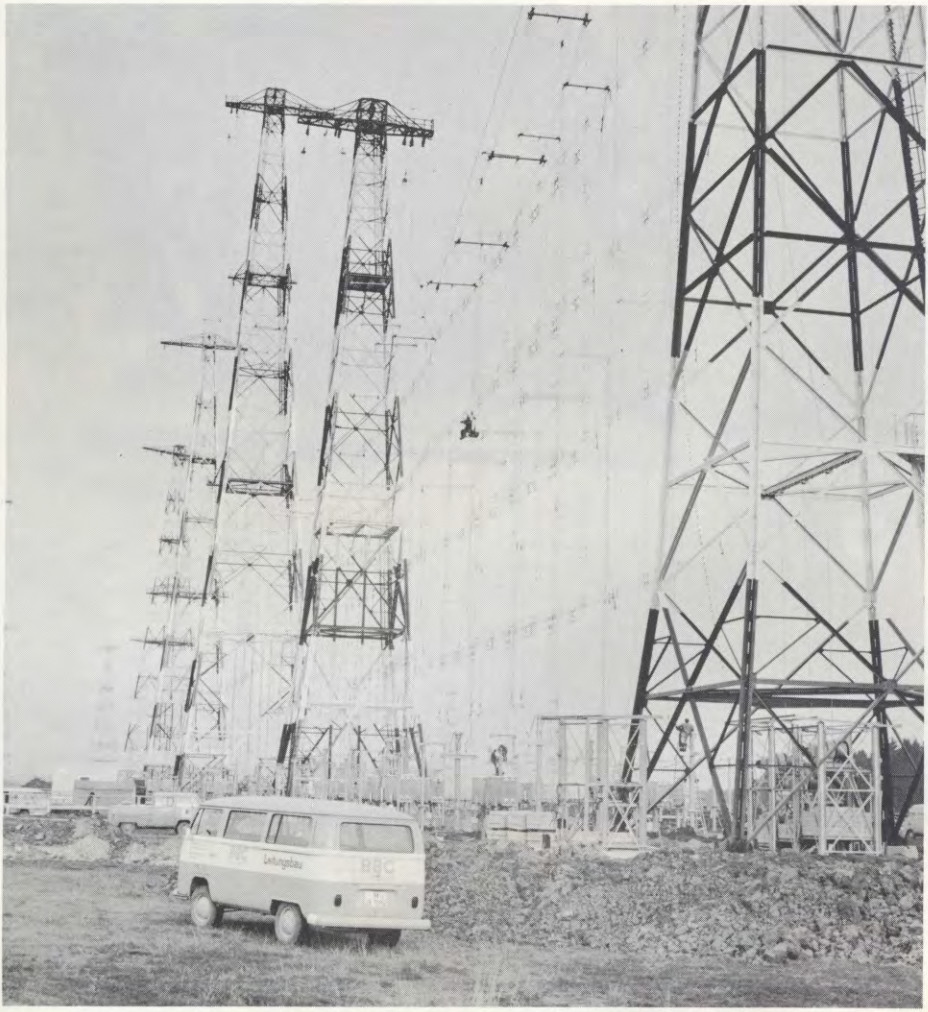
Partial view of an LP antenna; symmetrical feeding of an LP radiator



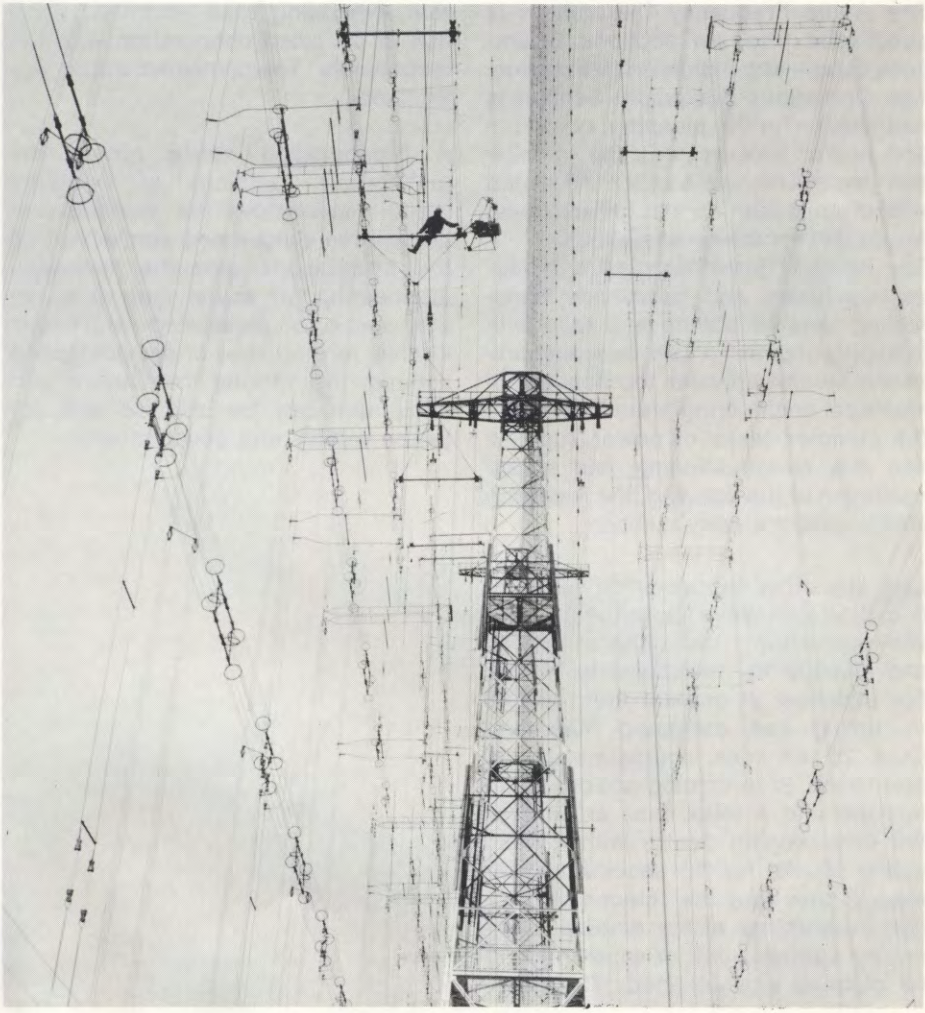
Quadrant antenna at Wertachtal.
In the right foreground the balancing
and transformation line (STL)



Cable connection of a coaxial feeder at Wertachtal



A screen reflector in the middle of the curtain antennas on the left and the right



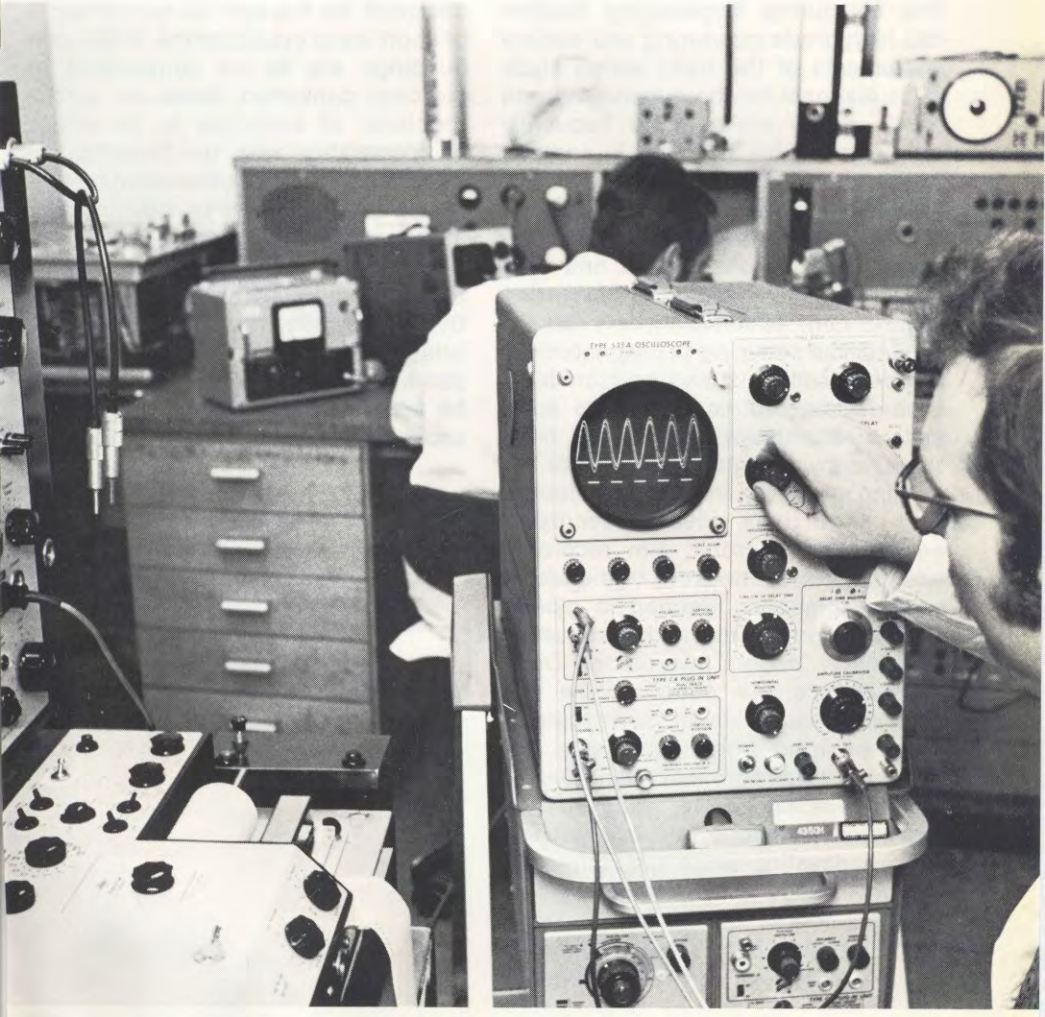
Audio Frequency Engineering

The Audio Frequency Department is subdivided into the sections Operations Equipment, Supply and Measuring. The Operations Equipment Section is responsible for the planning, construction and/or procurement, the installation and maintenance of the video and sound equipment for the broadcasting house and for the relay stations.
The efficient functioning of a broadcasting house and its outside transmitting centres stands and falls with its supply of power and its telecommunication facilities. Under the heading of electrical engineering, therefore, come the complex tasks of power supplies and the air-conditioning and sound insulation of the building, the receiving station and the relay stations.

Like any other broadcasting corporation, Deutsche Welle has extensive telecommunication installations inside and outside its broadcasting house. For instance, at present there are 60 in-coming and out-going telephone lines, 25 talk-lines, approximately 700 extensions, 27 in-coming and out-going teletype and 4 telex lines as well as the time-keeping centre with 2 main quartz clocks for 10 second and 20 minute lines and the telecommunication installations at the outside transmitting centres – all of which have to be planned and serviced. To ensure that everything runs smoothly, there has to be close cooperation with the responsible Telecommunications Authorities.

A broadcasting house having the multifarious functions of Deutsche Welle necessitates the execution of continuous checks and controls of all the installations of audio frequency engineering for sound and vision by the section's measuring engineers. Thanks to a number of special testing set-ups, the various instruments and equipment can be checked and adjusted rapidly and economically.

Measurements engineering laboratory



The Measuring Engineering Section has high-grade measuring and control instruments of the most varied kinds at its disposal for the supervision and repair of the entire audio frequency equipment in the building. In addition to the recording machines in the studios and the receiving plants, all the portable recorders used by the reporters have to be serviced and their proper use supervised. The Measuring Engineering Section is not only responsible for the servicing of the production and broadcasting studio equipment but such specialized equipment as automatic transmission continuity, high-speed copying machines, 14-track recording machines, the dubbing studios, main control room, video tape recording equipment, electronic film recording equipment etc. The work of the Measuring Engineering Section is closely linked to that of the audio frequency laboratory. Modern studios and Deutsche Welle's own patents show that in some cases pioneer developments have emerged from this sector. For instance, it was here that the automatic studio was conceived, which in the meantime has gone into operation at the broadcasting house and at the relay stations. Digital circuits store and control the course of the transmission. Among other things, the AF laboratory has to carry out new developments designed for the special requirements of short wave broadcasting. When new buildings are to be constructed or old ones converted, there are various problems of acoustics to be solved in cooperation with the Building Department. In addition, the constant flow of new developments by industry have to be studied and tested to decide whether they are suitable for use in the audio frequency equipment of Deutsche Welle, whilst existing measuring procedures have to be improved. A great deal of this work has to be preceded by basic physical tests and experiments.

Studio Operations and Engineering

The Studio Operations and Engineering Department, which is responsible for the entire field of technical production and broadcasting on sound radio and the Television Transcription Service, is divided into the sub-departments Central Planning, Sound, Vision and Telecommunications.

As Deutsche Welle at present broadcasts in 34 languages, particularly heavy demands are made on the Studio Operations and Engineering Department, the staff of which is naturally the largest within the entire scope of engineering departments. These demands require great adaptability in cooperating with the foreign personnel who come from all the countries of the world.

The **Central Planning** Department arranges for the proper employment of personnel and engineering facilities in all sections and works in close cooperation with the different programme departments. Its duties also include the assignment of the various production groups, the OB vans as well as the keeping of the necessary statistical records.

The **Sound Engineering** Department is responsible for the entire sound radio production. It is divided into four production groups covering the different activities in this field. These include the entire broadcasting procedure and tape copying. By processing used tapes, a saving in costs is effected as the tapes can be used again. A great deal of the work in this department is taken up with the extensive preparations required for re-recording and closed- circuit transmission and with the coordination of the relay stations. And finally this department ensures that there is a smooth supply of the necessary materials to all studios.

The **Vision Engineering Department** deals with the video processing sector, film dubbing and film processing. Video processing includes all activities in the field of electronic and film recording and processing. The dubbing section is concerned with sound processing ranging from the relatively simple recording of film commentaries to the more difficult lip-synching TV work. And lastly, film work here includes examining films, negative cutting, development and film treatment (cleaning, waxing, matting and polishing).

Attached to the **Telecommunications Department** are the telephone exchange, telex exchange and the agency teleprinter room. It is under these headings that the extensive communications facilities – internal and external – of a large broadcasting corporation are operated on a 24 hour service.

Studios

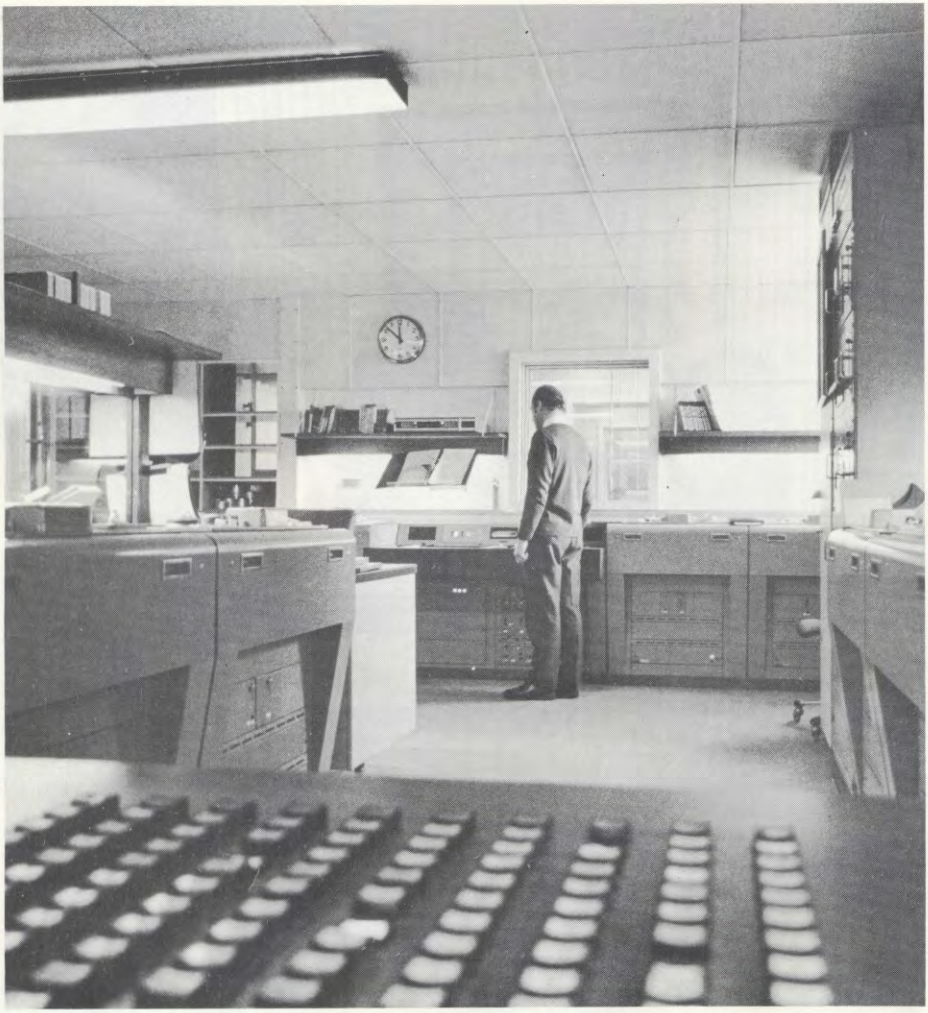
In 1968, the first automatic transmission control centre went into operation at Deutsche Welle. With it three transmitting studios can be centrally controlled by one technician. By the automatic operation of three programmes simultaneously, considerable savings in personnel are achieved. At the same time, the whole course of transmission is smoother and more secure against breakdown. By this automatic operation, a greater subdivision of the programme is possible, thus saving additional production times. By 1973, the automatic system had already completed more than 200,000 working hours which speaks for its quality. A second automatic installation of this kind was put into operation in 1976 so that it will then be possible for all transmissions to be operated automatically.

In 1975, Deutsche Welle had 8 broadcasting studios, 21 production studios and 4 recording channels. The tape machines in the production studios have been so adapted as to enable the control pulses needed for the operation of the automatic studio to be dispensed with. Apart from the studios in Cologne, DW has a modern studio with two control rooms in Bonn. This studio is also used for live transmissions. The Studio Operations and Engineering Department is also responsible for the broadcasting equipment at the Federal Press and Information Office in Bonn. The DW "Studio Bonn" at the Press House is the main centre for all broadcasting corporations in the Federal Republic.

The relay stations at Rwanda in Africa, Sines in Portugal and in Malta are also equipped with automatic studios. Here they are used primarily for programmes coming from the relay receivers or for taped programme contributions.

The three speaker's studios
in the automatic transmission
control centre

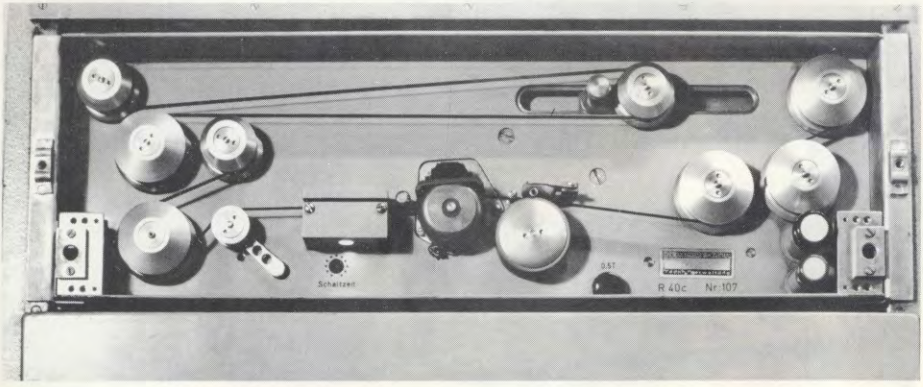
Automatic transmission control centre at the broadcasting house in Cologne



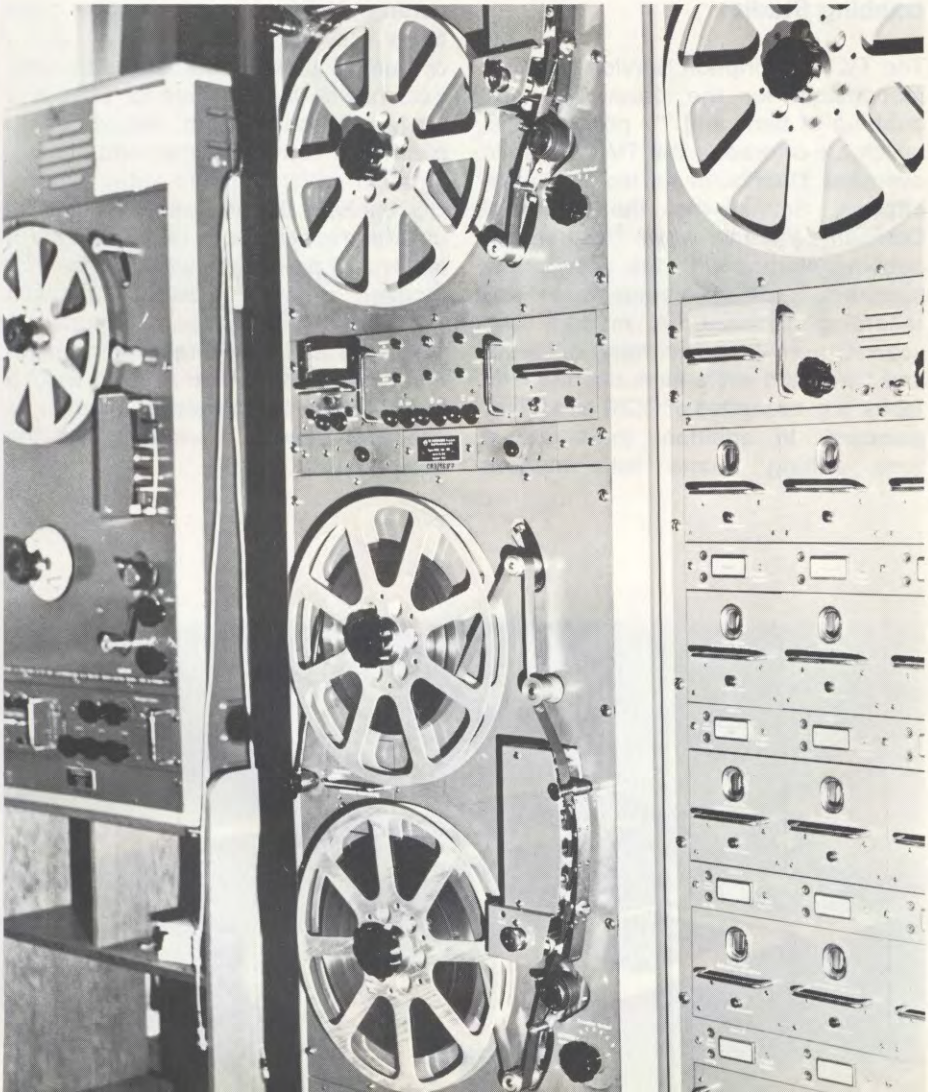
Recording studio for pre-production
Foreground: Recording channel with control panel and recording machines
Background: Window with speaker's studios beyond

Top:
Control room studio 85

Bottom:
Infinite loops recorder for identification signal



14-track magnetic sound recorder



Dubbing Studios

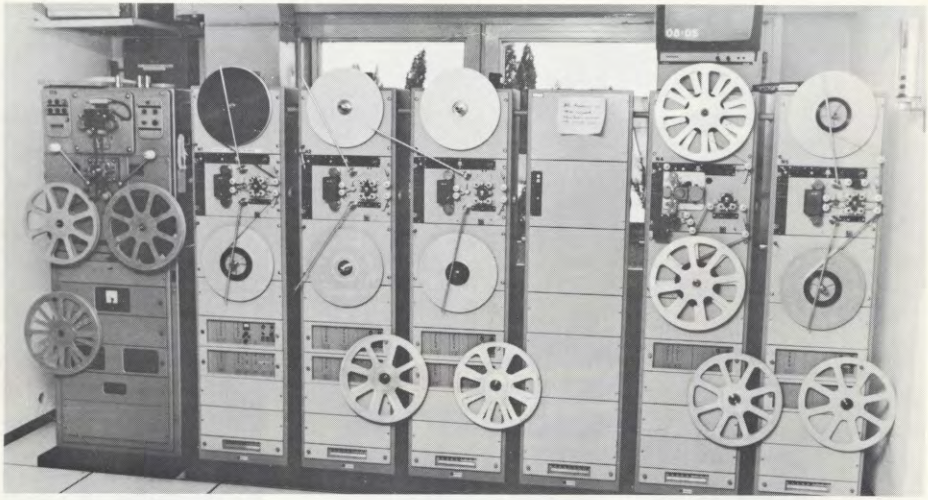
The TV Transcription Service of DW is responsible for the production and dubbing of films and TV programmes, which are offered to the TV stations in overseas. Distributor for the TV Transcription Service is the TransTel Company. For this work, DW has two dubbing studios with the appropriate scanners, control equipment and recording facilities. A modern film scanner permits re-recording of colour and black and white films on magnetic tapes, e.g. cassettes of CCIR and NTSC standard. In addition, there are 9 films editing rooms with modern cutting tables, one 4-copy test table (simultaneous check of 4 copies), 3 video recorders with playback having the facilities for black and white and colour film recording. An electronic cutting device used in combination with magnetic video recording enables the programmed cutting of video recordings to take place much faster and practically without loss. For location shooting, camera vans with two 16 mm film cameras, various accessories and sound recording equipment are used. A cleaning and waxing facility and a filmprocessor including a chemical deposit room complete the equipment.

Left:
Electronic cutting unit for the video tape recording (VTR) system

Below:
VTR-system

Top:
Equipment for the sound dubbing of films

Below:
Colour film recording equipment



OB van

Part of control panel
in OB van

OB Van

To supplement the stationary studio facilities, DW has an OB (outside broadcast) van and a recording van. The necessary technical equipment of these vehicles has been provided in accordance with Deutsche Welle's own plans. The large OB van has a 6-channel mixing console with all the necessary control facilities. In addition to two studio machines, the equipment here includes tape recorders for commentators and reporters, wireless microphones and directional microphones, a television set with TV camera and radio telephone.

By means of the car's transmitter and an extendable antenna, radio transmissions to the broadcasting house are possible. The recording van is designed entirely for battery operation. It has a transistor mixing console with 4 channels and a built-in tape recording machine with reporter's equipment. Other equipment consists of a wireless microphone, connections for one incoming and one out-going telephone line and for two microphones, a radio telephone for connections via the land mobile telephone service and two walkie-talkies for talkback purposes.

Tape Copying Plant

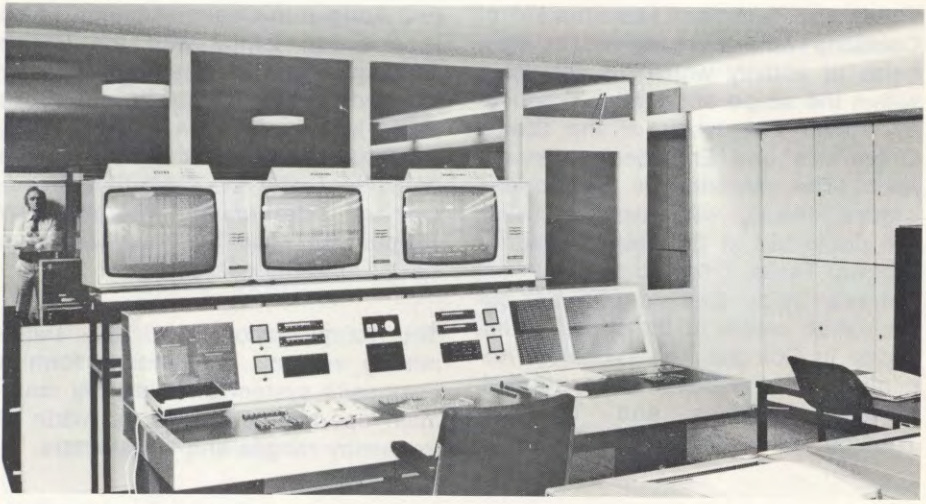
Deutsche Welle not only broadcasts radio programmes but also produces programmes for hundreds of broadcasting companies in other countries. It is therefore necessary to have facilities for the rapid copying of large numbers of tapes. For this purpose Deutsche Welle uses a small mono-copying unit and a larger one for stereo, a master recorder controlling 5 or 10 slave machines. Recordings can be copied at four and eight times the speed of the original recording without any difference in quality being detectable between the original and the copy.

Main Control Room

In every broadcasting house, the central control room is the nerve centre of all technical operations. Here, the lines from all the production and transmission studios and recording channels come together. There are also direct programme and telephone lines to the central control room from the Deutsche Welle studio in Bonn and from Berlin. This means that studio recordings from these places can be treated as if they had come from a studio in the same building. Connections inside the broadcasting house and with other broadcasting houses are established by means of a modern process computer. The ARD has established its own computer-controlled closed-circuit transmission system to which the Deutsche Welle main control room is also connected. The through connection of lines from the receiving station to the monitor service is also effected at the main control room. All broadcast programmes which pass from the studios via the central control room to the transmitter are recorded on a 14-track magnetic tape recording machine like that used in air-traffic control. These recordings are kept for approximately three months during the course of which they are available so that the contents of the programmes broadcast can be checked. The finding of a certain part of the programme that may be required for checking, is facilitated by the fact that the telephone time announcement are continuously registered on the first track. The tape machines with the infinite tape loops on which the DW identification signal is recorded, are also located in the central control room. The identification signal can be switched through to any studio and faded into the programme. In order to enable full use to be made of information received on television, TV programmes can be switched through to monitor sets in various studios. From his TV monitor in the studio, the editor — especially of a foreign language programme — can introduce a report on current events as he sees them on the screen, without having to translate from German. The tape recorders for DW programme monitoring and the supervision of the transmitters at Jülich and Wertachtal are also computer-controlled.

Top:
Main control room

Bottom:
Central closed-circuit recording room



Department For General Tasks

Within the Technical Management of Deutsche Welle, there are various other fields of activity which do not come within the scope of the High Frequency, Audio Frequency or the Studio Operations and Engineering Department. The departments or working groups dealing with these activities are combined in the Department for General Tasks. It has to deal with the overseas relay stations and the coordination centre at the broadcasting house in Cologne, the Technical Administration, the Building Department, General Activities and Technical Training.

The Relay Stations

The short wave bands are today so crowded that coverage of the more remotely situated countries of the world using transmitters located in Germany alone is either of only poor quality or is not possible at all. Only relay stations situated closer to the target areas can supply such powerful signals as to ensure better coverage.

Deutsche Welle is, therefore, building up a network of relay stations. Such stations already in operation are at Kigali (Rwanda/Africa), Sines (Portugal), Malta in the Mediterranean and Antigua in Central America which is operated jointly with the British Broadcasting Corporation. Another location desired for a Deutsche Welle relay station is Asia. Furthermore, Deutsche Welle has an exchange agreement with the Canadian Broadcasting Corporation whereby DW programmes can be broadcast from Sackville in Canada.

The relay stations and the transmitting stations in Germany form a composite system enabling the maximum operational use to be made of frequency ranges and transmitters.

The overseas relay stations, as their name implies, operate on a purely relay basis, that is to say they rebroadcast programmes transmitted from the broadcasting house in Cologne. For the transfer of these programmes, three different procedures are employed:

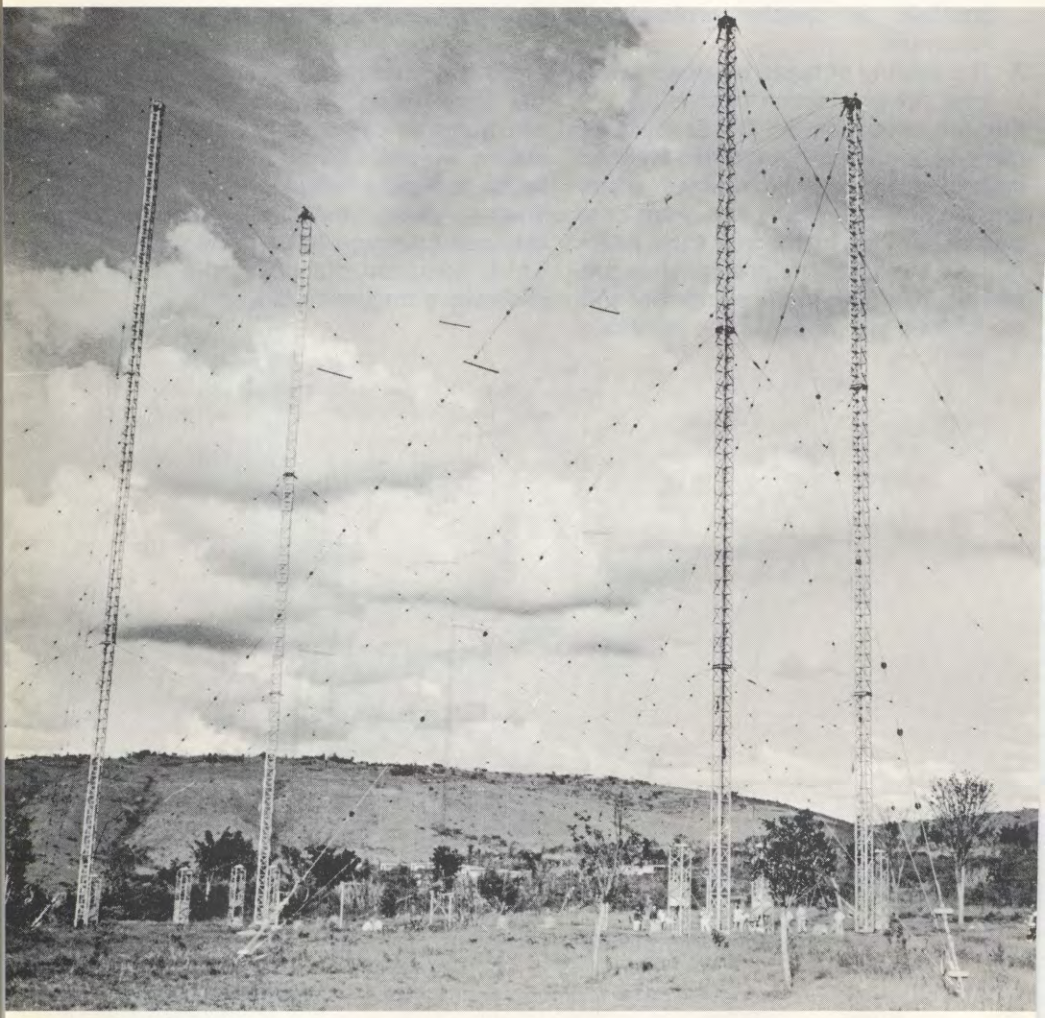
1. In-feed via the regular broadcasts from Germany which at the same time can be received by listeners in adjacent areas using ordinary radio receivers.

2. Special transmissions by the SSB process, reception of which is only

possible by special professional receivers.

3. The mailing of tapes wherever long-term pre-production is possible.

For the reception of the broadcasts (procedures 1 and 2), receiving stations have been or will be erected which are sufficiently far away from the transmitters as to be free from interference by them. The programmes are picked up by high-grade equipment and the signals are processed to eliminate as far as possible all interference and disturbances resp. They are then relayed via cable or via radio link to the transmitting stations. Here modern antenna systems have been installed in accordance with the very latest technical developments which enable close, medium and long-distance coverage to be provided and which comprise practically the entire short wave frequency range.

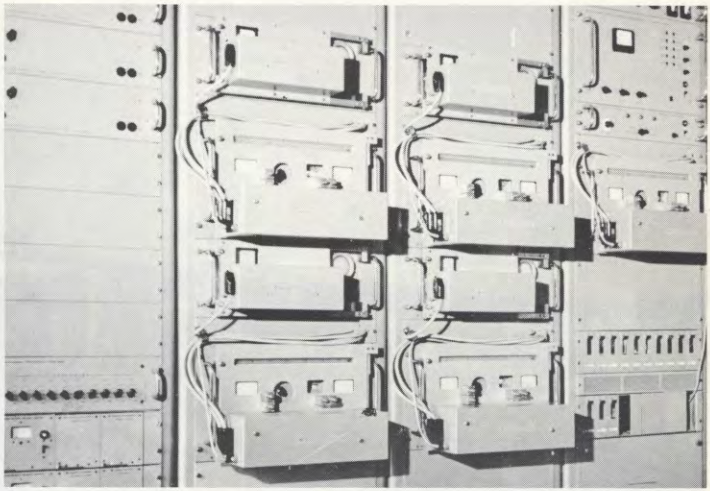


The Deutsche Welle Transmitting Facilities at the Relay Stations in Pictures

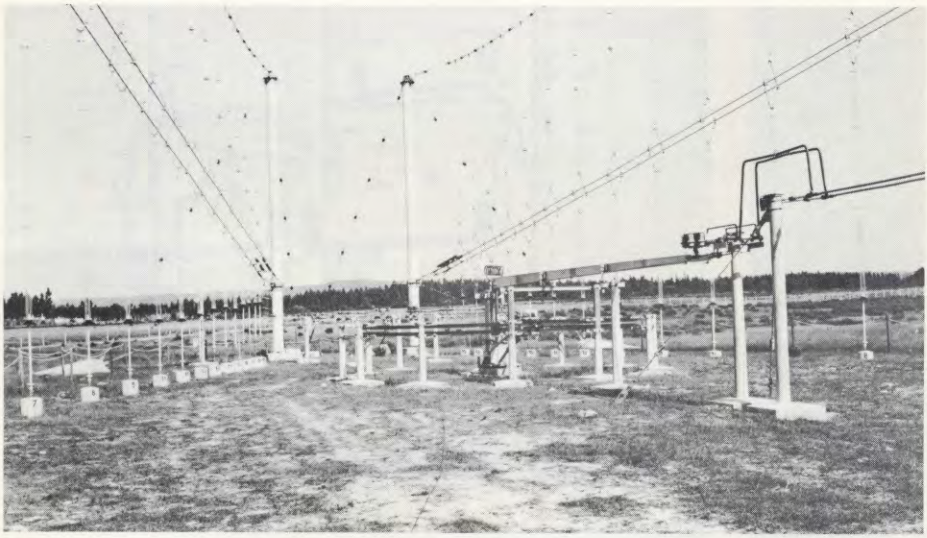
Left:
Curtain antennas with screen reflector at Kigali

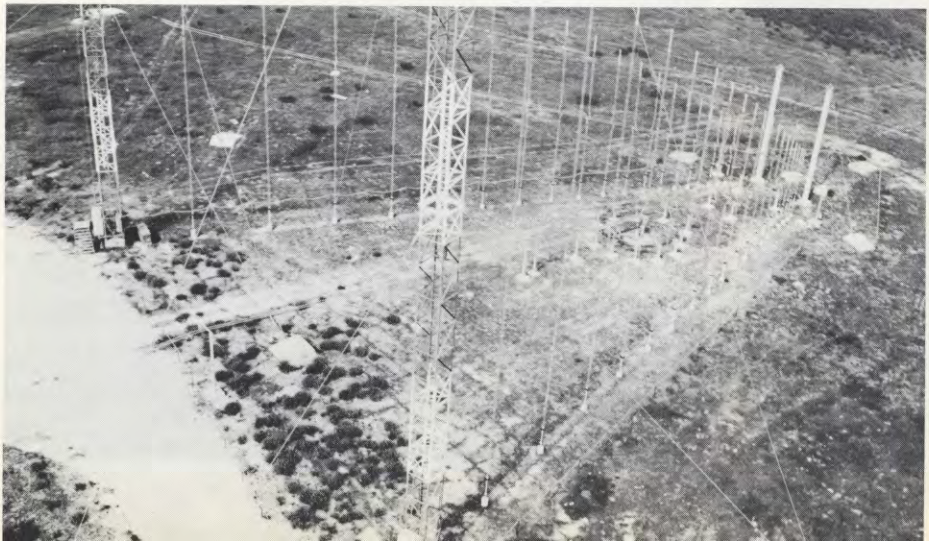
Top right:
Remote-controlled receivers at Gazogi

Bottom right:
Automatic transmission studio receiver operation and teleprinter in the building on Mount Kinyinya



Top and bottom:
Vertical polarized log-periodic antenna for 6 – 26 MHz at Sines; the antenna is designed for a carrier power of 250 kW with hundred per cent modulation



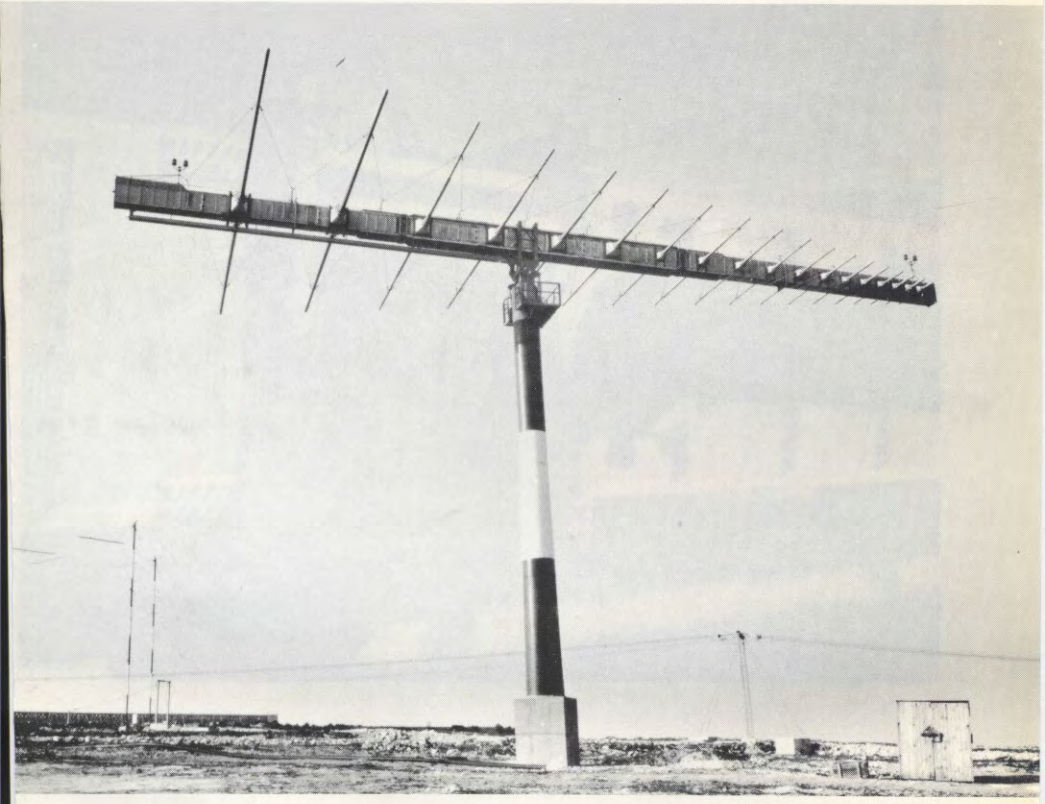


Top:
Transmitter building and 4-band curtain antennas at the Malta relay station

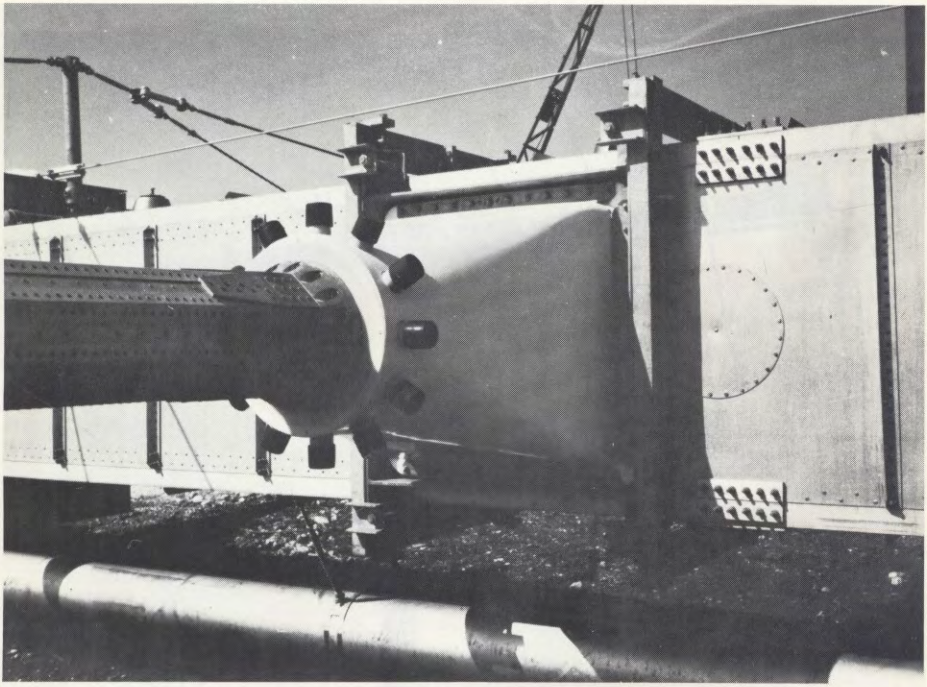
Bottom:
Transmitter hall

Nigret receiving station;
automatic transmission studio
with receiving installations
and speaker's studio at the Malta
relay station

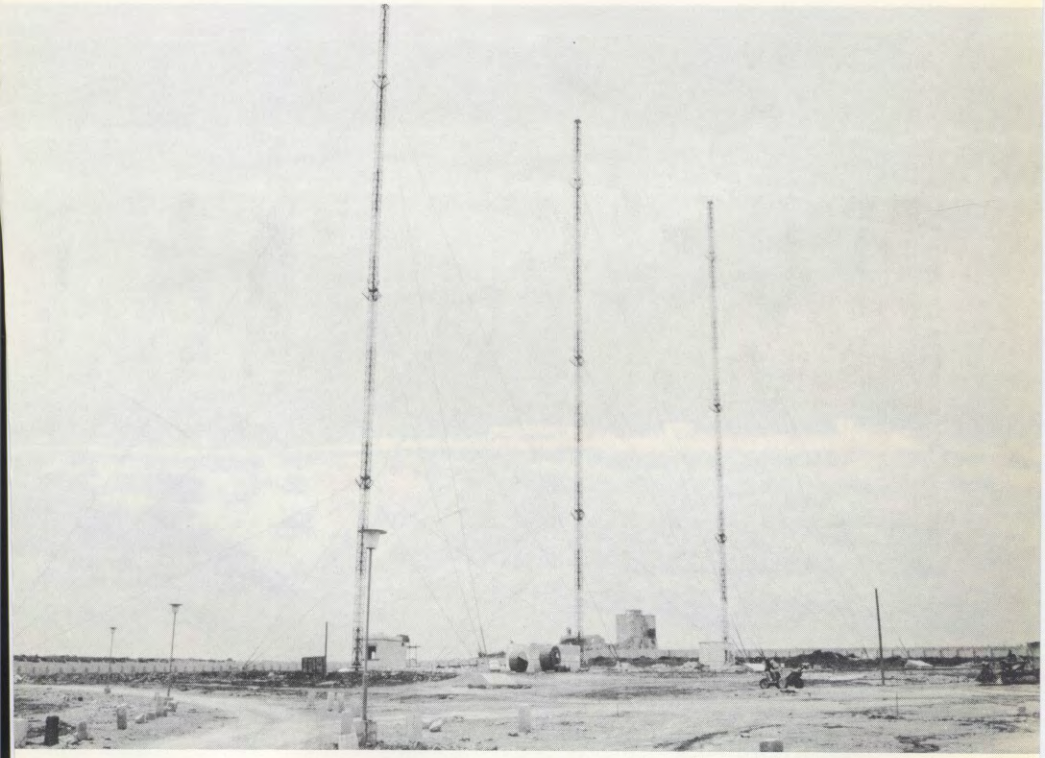
Rotatable LP antenna at the Malta relay station; Height: 23.15 m
Length of main support: 40.2 m
Span of the largest dipole: 26.1 m
Max. diameter of the mast: 1.6 m
Weight of the antenna: 16.4 tons



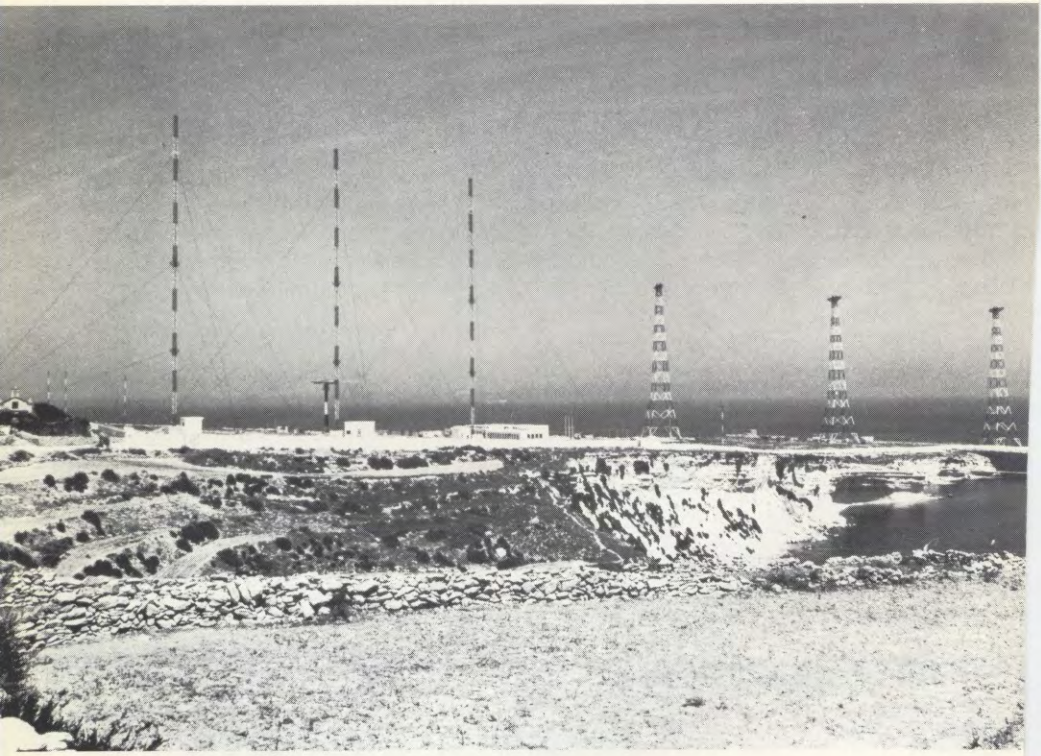
Assembly of the antenna boom of the rotatable LP antenna at the Malta relay station



Medium wave three-mast antenna system at the Malta relay station



Cyclops (Malta) transmitting station
left: medium wave antenna system
right: 4-band short wave curtain antennas



Relay Coordination

Among the principal functions of the Department for General Tasks are the organization and coordination of the varied engineering and personnel requirements of the relay stations. This necessitates close cooperation with other DW departments as well as with those of the engineering, administration and programme production. Understandably, this work is rendered more difficult by the great distance between the relay stations and the broadcasting house in Cologne. Often the possibility of good and rapid communication is essential. And so there is a permanent radio teletype link with the relay stations at Kigali and Malta.

General Functions

General functions include participation in the work of the CCIR (Consultative Committee International Radio) and similar organizations. It is within this framework that studies and research projects have to be carried out which then serve as constributions to the work of the international organizations. Furthermore, publications dealing with the technical aspects of Deutsche Welle work have to be read, classified and then passed on to the appropriate personnel. This department also coordinates the technical publications of Deutsche Welle and files applications for patents and copyrights on technical developments. Work on the assessment, coordination, preparation and execution of suggestions for improvements also comes within the scope of this department. Recommendations for the business management are made by an impartial committee.

Technical Administration

This department is responsible for the purchase and disposal of thousands of apparatuses, plants, materials and spares every year and for supplies to all branch offices of Deutsche Welle at home and abroad. This calls for extremely close cooperation with customs authorities, forwarding agents and airline companies. Another function of this department is the care of the technical library which forms an important basis for the work of the various departments.

Building Department

The Building Department is responsible for the planning and construction of all new buildings. The buildings

required by a broadcasting corporation, with their costly technical installations at home and abroad, involve work that differs considerably from that of conventional building departments both as regards execution and subsequent maintenance. For instance, the planning of buildings in other countries with the materials and methods available there, requires an entirely different approach from that needed for the engineering buildings at the underground measuring and monitoring station at Bockhacken for instance. The Building Department could not handle the building of the big new broadcasting house in Cologne with its own personnel alone. So in such cases it acts as the liaison with the building companies concerned. It also coordinates all the activities of this project group inside and outside Deutsche Welle.

Technical Training

This sector includes the training and further education of technical and management personnel from the developing countries.

The individual advanced training of qualified radio engineers from Africa which started in 1963, developed in 1967 into the holding of regular training courses. And in 1970, the "Centre of Training for Qualified Radio Personnel from the Developing Countries" was founded in cooperation with the Federal Ministry for Economic Cooperation. Since then regular 14-month courses have been held on studio and measuring techniques for personnel from the English and French-speaking developing countries.

The training programme is drawn up in accordance with the development standards of the country concerned, and training courses in other specialized subjects – given suitable equipment – are possible. The theoretical and practical lessons are given by 6 instructors with overseas experience and a knowledge of foreign languages. For these training courses, classrooms are available together with laboratories and teaching studios equipped with all the customary broadcasting installations. These are augmented by modern teaching aids such as film, slide and overhead projectors, electronic trainers and video recorders.

Up to 1973, more than 100 technicians from 30 countries in Africa, Asia and the Middle East had successfully com-

pleted the training and continuation courses run by the Technical Training Department.

The progressive development of new technologies means that also in the field of broadcasting there has to be continuous adaptation in order to keep abreast of new developments. The Technical Training Department organizes and coordinates internal further training measures for all technical personnel. In addition to experts from science and industry, increasing numbers of Deutsche Welle's own staff are being engaged to give technical lectures and to conduct training courses.

Summary

By short wave broadcasting, Deutsche Welle is using one of the most modern forms of communication.

In order to meet its commitments as the external service of the Federal Republic of Germany, Deutsche Welle has to supply listeners all over the world with regular programmes and to ensure good reception quality despite fluctuating propagation conditions.

The maximum efficiency of our work is determined primarily by the number of transmitters used, the decentralized location of those transmitters (i.e. relay stations) and by their power output. The extent and structure of the technical operating systems required for short wave broadcasting are largely influenced by the transmission medium itself; here the work of the engineering is composed of the production and transmission of the programmes. The extensive use of automation in the field of transmission technology has proved of decisive importance. In this context, special mention must be made of automatic transmission control and then also of the computer-controlled operations centre at the broadcasting house and the partly automatic operation of the transmitting stations.

Automation, which points the way to the future, permits maximum use to be made of the technical facilities of short wave broadcasting whilst providing considerably increased operational safety. It also means that the existing installations can easily be extended and enlarged and ensures considerable savings in costs and personnel.

DEUTSCHE WELLE ENGINEERING