THE RUGBY RADIO STATION OF THE BRITISH POST OFFICE

AUGUST 1938

THE RUGBY RADIO STATION

GENERAL

The construction of the Rugby Radio Station was originally decided on by the Government of the United Kingdom as a means of providing radio *telegraph* communication of world-wide range throughout the whole of the 24 hours, with a sufficient margin of power to be effective both by day and by night and also during conditions normally unfavourable to radio reception. The importance to a country such as the United Kingdom of being able to communicate immediately and simultaneously with British ships on all seas needs no emphasizing. Rugby was the first high-power station to be constructed for equipment with thermionic valves and it is still one of the most powerful telegraph transmitting stations in the world. The telegraph transmitter was brought into service on January 1, 1926.

SERVICES

News bulletins are broadcast daily to all parts of the Empire and to British ships on the high seas. Radio telegrams received at any Post Office are transmitted to ships in any part of the world. Time signals are also transmitted twice a day direct from the Greenwich Observatory for astronomical and navigational purposes with an accuracy greater than ~~of the order of~~ 1/100th of a second.

The practicability of radio *telephony* over long distances was established shortly after the building of the Rugby Station was commenced, and it was decided to add to the equipment at Rugby a radio telephony transmitter which would give a commercial service to America in conjunction with a similar installation provided in America.

This telephone service was opened on January 7 1927. It was the first international radio telephone service designed for connexion to the ordinary public telephone subscribers' system, and it was also the first long distance radio telephone system brought into daily service in the world. It is still the only multi-channel radio telephone service in existence (*see* below) and it carries an amount of traffic far in excess of that of any other radio telephone service.

Among the unique features of the system is the adoption of what is technically known as "single sideband suppressed carrier transmission." By this means the power used is made six times more effective than the same amount of power would be if radiated from an ordinary telephone station such as is used for broadcasting: in addition the band of wavelengths used in the ether is halved so that interference with other stations is reduced to a minimum.

This successful operation of telephony across the Atlantic was accomplished on a wavelength of 5000 metres and was followed by experiments in the use of short wavelengths which resulted in the opening of an additional channel to America in August 1928, using wavelengths of from 16 to 32 metres.

The use of short wavelengths for radio telephony has enabled the adoption of highly directional means of transmission to be effected by means of combinations of wires in the form of aerial arrays having reflecting systems associated with them, sometimes referred to as "Beam" aerials.

The cost of a short-wave directional system is less than that of the long-wave, mainly due to the fact that very high masts are not necessary. It is unfortunately not so reliable in operation as the long-wave system; but the combination of the two systems has been the means of providing a reliable service to America over the full 24 hours of the day. Three short-wave channels have now been brought into use, making a total of 4 independent channels (1 long-wave and 3 short-wave) now in operation between England and the United States.

Extensions on either side of the Atlantic to the telephone line and cable systems have linked practically the whole of Europe on the one side to the United States, Canada, Mexico,

Bermuda, Jamaica, Miami, Cuba and S. America on the American side by means of the radio channels operated at Rugby.

Unfortunately it is not economically possible to operate long-wave radio telephony to greater distances than from England to America, and the solution of the problem of providing telephonic facilities to the Dominions and other important centres is confined to the use of the short wavelengths.

Rugby is the selected location for the operation of all long distance radio telephony services from this country; and, with the exception of the American service, short waves are being used exclusively.

The Australian service, which is at present available for 10 hours daily, has been in operation since 30 April, 1930. It affords direct connexion between Australia and the United Kingdom and also (by means of switching in London) with practically the whole of the world's telephone users.

A radio telephone service is available between Australia and New Zealand and service is given between the United Kingdom and New Zealand by means of switching in Australia.

Other direct services which have been inaugurated are :—

South America ...	Buenos Aires, 12 December, 1930.
	Rio de Janeiro, 21 May, 1931.
South Africa ...	1 February, 1932.
Extended to Transvaal, 8 August, 1932.	
Egypt	22 June, 1932.
Extended to Palestine, 1 May, 1933.	
Canada	11 July, 1932.
India	1 May, 1933.
Japan	13 March, 1935.
Iceland	1 August, 1935.
Kenya	7 March, 1936.

Rugby is also the transmitting station for the Ship and Shore telephone service, which is available to all ships equipped with suitable radio telephone apparatus.

A criticism sometimes directed against radio telephony is the absence of privacy, should attempts be made to intercept it. Considerable progress has, however, been made in preventing any intelligible reception of the transmissions by unauthorized persons. All channels are equipped with a device at the terminal position in London (where the transmitting and receiving stations are joined to the land-line system) which renders the transmitted speech unintelligible, until it is restored to its normal quality at the distant terminal positions.

DESCRIPTION OF PLANT

The site of the Rugby Radio Station consists of 900 acres situated about 4 miles S.E. of the town of Rugby. Direct main-road access is provided by the Watling Street, which runs past the site, and the nearest railway station is Kilsby and Crick, L.M.S. Railway, about 1½ miles distant.

The station buildings consist of two groups, the Main Station and the New Station.

Electric power is obtained from the system of the Leicestershire and Warwickshire Electric Power Company by means of 3 underground cables, each capable of taking the full load of the station. The cables can be connected to either the Warwick or Hinckley Power Station, so that the risk of failure of power supply is remote. The incoming power supply is three-phase alternating current of 12,000 volts 50 cycles.

The main aerial system is supported by twelve masts 820 feet high of which eight are arranged in an irregular octagon while the remaining four provide two extensions to the north. These masts support the antenna for the three long-wave services in use, *viz.* the G.B.R. and G.B.V. telegraph channels and the G.B.Y. long-wave transatlantic telephone channel. In addition there are a number of antenna array systems of different types supported on steel towers and used for the short-wave telephone services. The heights of these towers are from 120 to 180 feet and the directions of the

arrays are arranged so that the sharp beam of radiation produced by them is projected in the line of the distant receiving station.

The two telegraph transmitters possess features of special interest. These transmitters are controlled in frequency by ~~means of valve-maintained tuning forks. These forks vibrate at audio frequencies and the particular harmonics of the fork frequencies which equal the frequencies of the waves to be emitted are selected and then amplified in successive stages of the transmitters.~~ From this stage the power is amplified in power amplifiers to the final output of the transmitter.

The long-wave telephone transmitter, G.B.Y., utilises the single sideband system of transmission, while the earlier short-wave telephony transmitters use the normal carrier and double sideband radiation.

The later short-wave equipments use the single sideband double channel system, whereby two independent conversations may be transmitted simultaneously by one transmitter.

The short-wave telephone transmitters in general are arranged to operate on five wavelengths of the order of 16, 24, 32, 40 and 60 metres, and a set of 5 directive antennæ for these wavelengths is provided for each transmitter. A change in wavelength can be carried out in a few minutes.

The frequency of the short-wave transmitters is controlled by means of piezo electric quartz oscillators.

The earlier type of oscillators are maintained at a constant temperature by means of thermostats to maintain a constant frequency of oscillation which is of the order of 2,500 kilocycles per second (120 metres wavelength). Later types of oscillators have a low temperature coefficient and do not necessitate the use of thermostats. Harmonics of this frequency are selected and amplified to control the final output of the transmitter.

A guide to the various items of equipment to be seen in the stations is given in the following list, where the numbers correspond with the numbers given on the accompanying plans.

(1) Control Table G.B.R. Telegraph Transmitter, 18,750 metres (16 kilocycles) 450 K.W. This is one of the most powerful radio telegraph transmitters in the world.

(2) Tuning fork drive units for G.B.R. The tuning fork oscillates at 1777.7 cycles per second and the 9th harmonic is used to energize the transmitter at 16,000 cycles per second.

(3) Intermediate stages for G.B.R. in duplicate, the fork unit drives a 1 K.W. glass valve which in turn drives a 20 K.W. stage of 2 cooled-anode valves.

(4) Final amplifier stages G.B.R., each panel contains 18 cooled-anode valves. Two panels used at a time.

(4A) 250 K.W. demountable valve.

(5) Control table for long-wave single sideband telephone transmitter G.B.Y. 68 Kilocycles (4,400 metres). This is one of the most powerful radio telephone transmitters in the world. Output equivalent to broadcast transmitter of 1,000 K.W.

(6) Low-power modulating equipment in duplicate for G.B.Y., producing single sideband.

(7) Switchboards in duplicate controlling supplies to G.B.Y. modulating equipment.

(8) Intermediate amplifier G.B.Y.—3 cooled-anode valves.

(9) Final amplifier G.B.Y.—15–10 K.W. cooled-anode valves. Not used.

(9A) Final amplifier G.B.Y.—6–100 K.W. cooled-anode valves. 3 used for full output.

(10) Switchboard, controlling high tension direct current plate supply to G.B.R. and G.B.Y. from high tension generators 84 amperes at 7,000 to 18,000 volts.

(11) Low tension switchboard, controlling filament and auxiliary supplies to G.B.R. and G.B.Y.

(12) Valve store room.

(13) High tension testing transformer ; testing up to 75,000 volts.

(14) Valve testing set.

(15) Grid bias and low power plate and filament supplies. (G.B.R.)

(16) Grid bias and low power plate and filament supplies. (G.B.Y.)

(17) Tuning fork control panel. (G.B.V.) Medium power telegraph transmitter 78 Kilocycles (3,840 metres) 40 K.W.

(18) Rectifier and intermediate and final amplifier. (G.B.V.)

(19) High tension switchboard; incoming power supply three-phase 50 cycle 12,000 volts.

(20) Feeder panels 12,000 volts.

(21) High tension three-phase 12,000 volt starting switches for main motor generators.

(22) High tension D.C. motor generator sets for plate supply to G.B.R. and G.B.Y. Each set 500 K.W. at 6,000 to 7,000 volts driven by synchronous motors. All three sets can be connected in series by switches on busbar gallery to give 18,000 volts if required.

(22A) 500 K.W. 12,000 volt D.C. motor generator.

(23) Motor alternator sets for filament current. (G.B.R. and G.B.Y.) Output 200 K.W. three-phase 100 cycles driven by three-phase 50 cycle synchronous motors.

(24) Motor generator and booster sets giving 240 volts D.C. for station control circuits and battery charging.

(25) Low tension 416 volt A.C. 50 cycle three-phase and 240 volt D.C. switchboards.

(26) Grid bias, filament current and low power plate current generators for No. 2 short-wave telephone transmitter.

(27) Ditto for No. 1 short-wave telephone transmitter.

(28) Speech input and testing equipment for No. 2 and No. 1 telephone transmitters.

(29) No. 2 short-wave telephone transmitter (16.38, 24.69, 33.26 and 43.45 metres). This transmitter and all other short-wave transmitters are controlled in frequency by a quartz piezo electric oscillator working on about 100 metres wave, the output of which is multiplied in frequency and

amplified in eight stages. Used on the Japan and S. America services.

(30) Final amplifier No. 2—2 triode demountable valves.

(31) Rectifier for H.T. supply No. 2 hot cathode mercury vapour.

(32) Rectifier for H.T. supply, No. 1 transmitter—hard thermionic valves.

(33) Crystal and low power stages No. 1 transmitter (16.11, 24.41, and 30.15 metres) used on Indian service.

(34) Intermediate amplifier stages. (No. 1.)

(35) Final amplifier stage No. 1—4 water-cooled valves.

(36) High tension 12,000 volt three-phase incoming supply; short-wave building.

(37) Low tension 416 volt three-phase distributing switchboard.

(38) Motor generator sets furnishing grid bias, filament current, and low power plate supplies for short-wave telephone transmitters.

(39) Speech input and testing equipment for short-wave telephone transmitters.

(40) Rectifier for H.T. supply No. 4 transmitter—used on Australian service. Mercury arc.

(41) Crystal control stages. (No. 4.)

(42) Intermediate amplifier stages. (No. 4.)

(43) Final amplifier. (No. 4)—4 water-cooled valves.

(44) Rectifier for H.T. supply to short-wave telephone transmitter No. 3 used on U.S.A. circuit.—Hard thermionic valves.

(45) No. 3 transmitter—final stage 4 water-cooled valves.

(46) Rectifier for No. 7.

(47) Transmitter No. 7—final stage 2 water-cooled valves. Used on Ship and Shore telephony service.

(48) Space allocated to new long-wave high power single sideband telephone transmitter similar to G.B.Y. for transatlantic service.

(49) Speech input and testing equipment for No. 9.

(50) No. 5 transmitter working to Cape Town (same as (40) and (45)).

(51) No. 6 transmitter working to Montreal. Similar to No. 4 (41) to (43).

(52) No. 8 rebuilt experimental transmitter now installed for commercial service. Working to Kenya and Egypt.

(53) Sideband equipment for 2nd long-wave U.S.A. telephone.

(54) Rectifier for No. 5 (50). Mercury arc.

(55) Rectifier for No. 6 (51). Hot cathode mercury vapour.

(56) Rectifier for No. 8 (52). Hard thermionic valves.

(57) Auxiliary supply for sideband equipment (53).

(58) Rectifier for H.T. supply No. 10 transmitter working to U.S.A. H.C. mercury vapour.

(59) Low power modulator equipment No. 10.

(60) Intermediate amp stages No. 10.

(61) Final amp No. 10. 2 tetrode demountable valves.

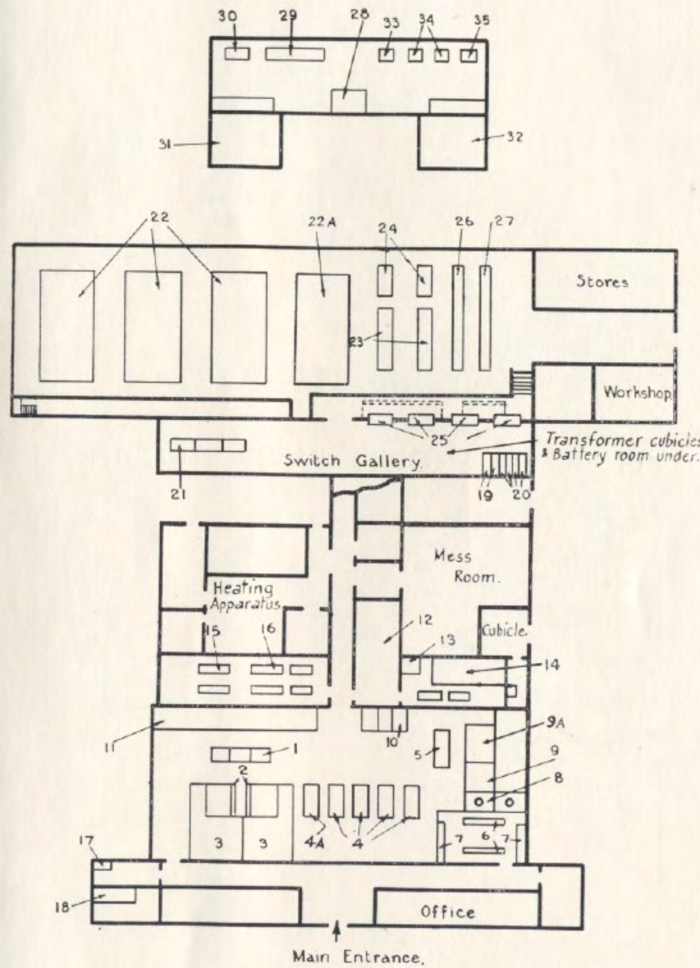
(62) Rectifier for H.T. supply No. 9 transmitter working to U.S.A. Mercury arc.

(63) Intermediate amp stages No. 9.

(64) Final amp No. 9. 2 tetrode demountable valves.

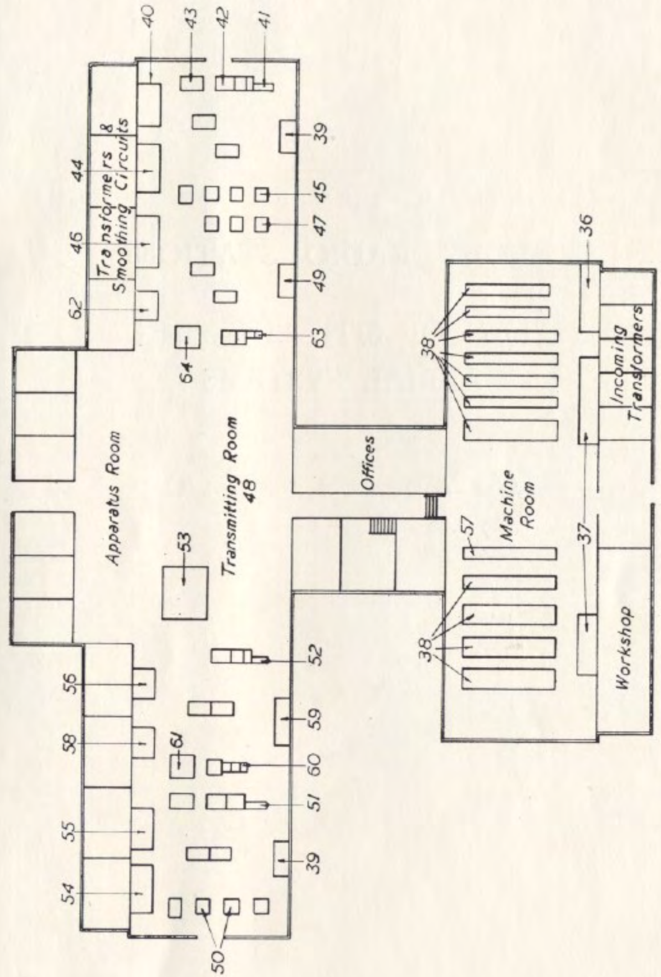
RUGBY RADIO STATION

PLAN OF MAIN BUILDINGS



RUGBY RADIO STATION

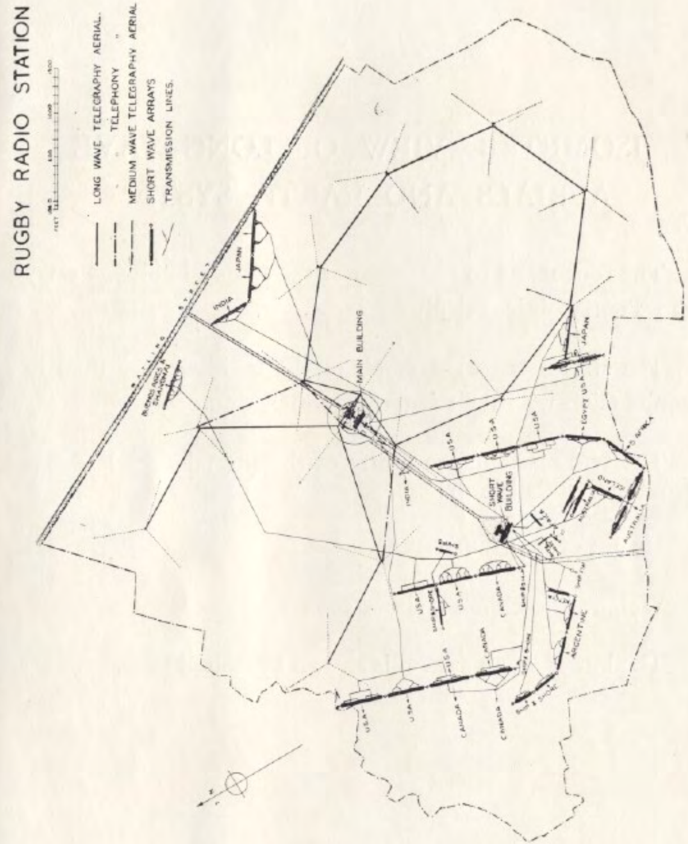
PLAN OF SHORT WAVE BUILDING



RUGBY RADIO STATION

PLAN OF SITE SHOWING
AERIAL SYSTEMS

(AREA OF SITE, 900 acres)



ISOMETRIC VIEW OF LONG-WAVE AERIALS AND EARTH SYSTEM

The four masts to the north of the station buildings carry the Transatlantic Telephony aerial.

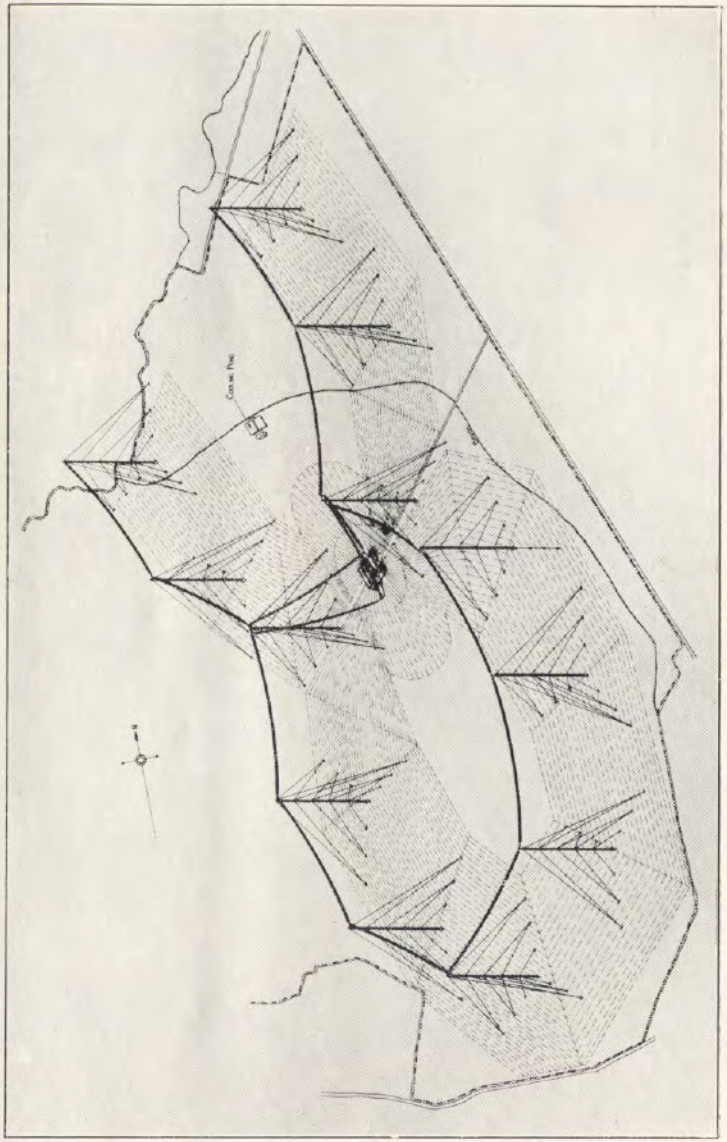
The six masts to the south of the buildings are used in conjunction with the telegraphic installation.

The two masts in the centre of the site take the leads-up from both installations.

Height of masts, 820 feet.

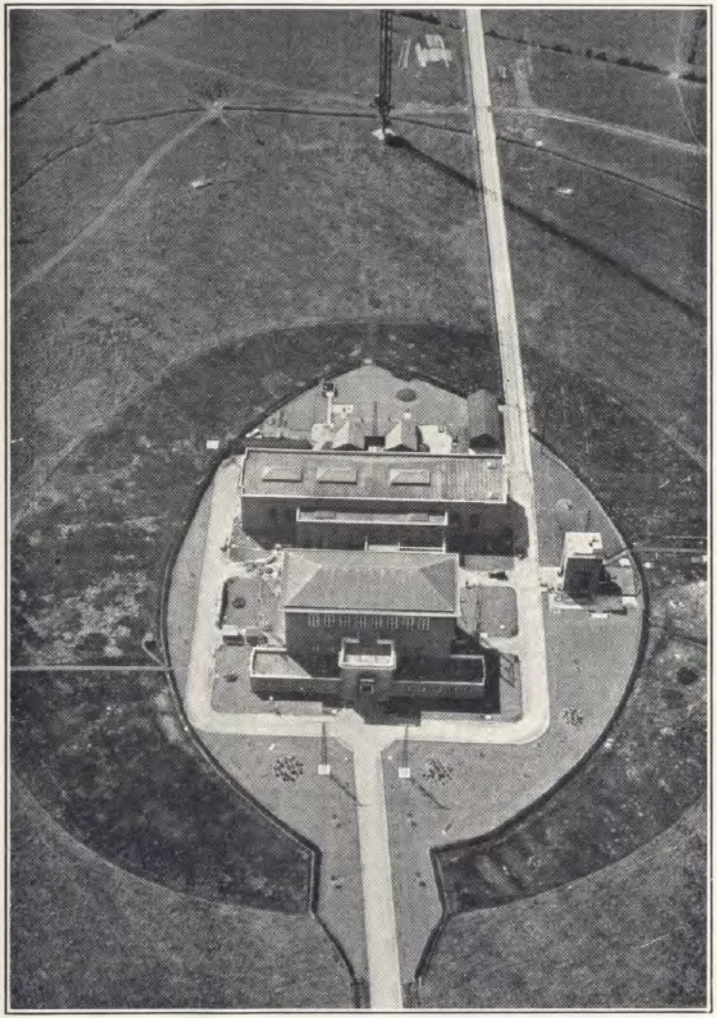
Weight of each mast, about 200 tons.

The buried earth system is shown by dotted lines.



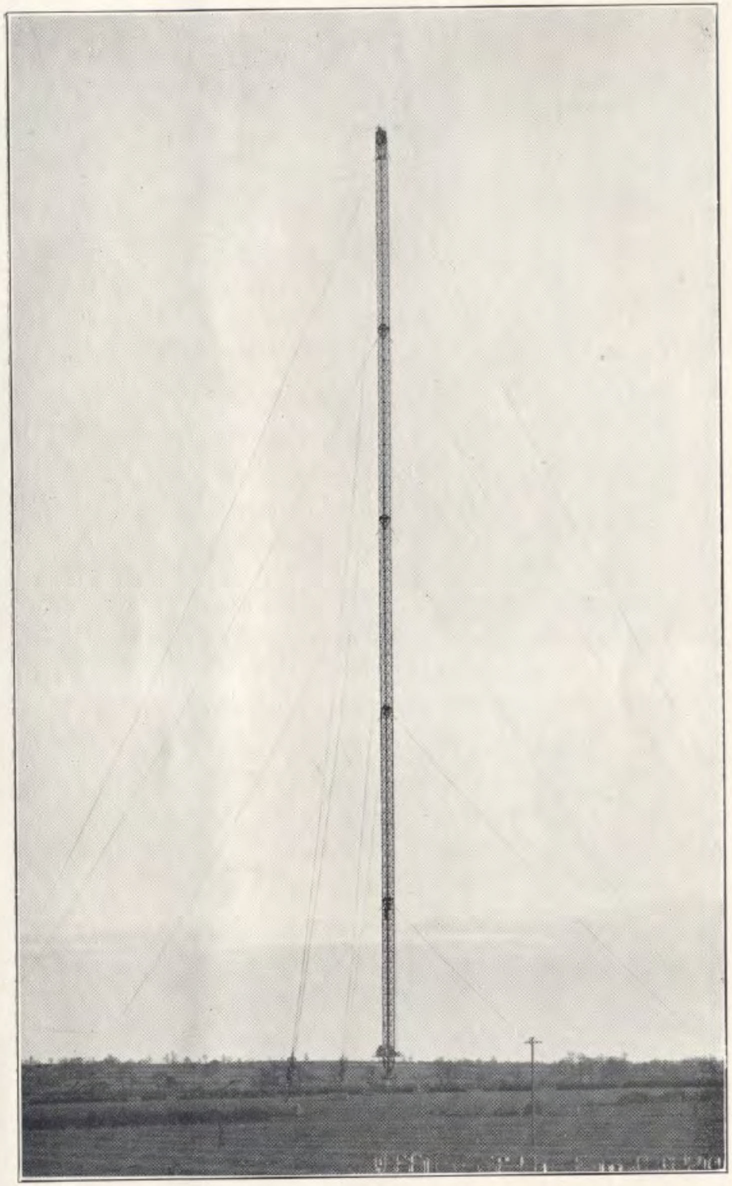
GENERAL VIEW OF STATION MAIN BUILDINGS FROM ONE OF THE MASTS

The main transmitter building is in the foreground. The long building contains the main motor generators and switchgear. Behind this is the annex containing two short-wave transmitters. In the background is the base of one of the 820 ft. masts and the road to the short-wave telephony building. The earth system leaves the building by overhead wires and enters the earth in the annular space round the building.



THE RUGBY MASTS

The Rugby masts, twelve in number, are placed 440 yards apart. They are 820 feet in height and are triangular in shape, the three vertical posts of each mast being spaced 10 feet apart. The system of bracing adopted between the vertical members is that known as K bracing. The base of each mast terminates in a tripod, the lower portion of which forms a socket. The mast is thus capable of free movement about its lower extremity. The masts are insulated by means of porcelain and Swedish granite insulators. Each mast is supported by 15 wire stay ropes, arranged in five groups of three stays. The masts are constructed to withstand wind pressure of 140 m.p.h. and a horizontal pull of 10 tons at the top. Maintenance work and inspection are facilitated by the provision of an electric lift on each mast capable of carrying three persons.



POWER PLANT

The photograph gives a general view of the Machine Room.

The main motor-generators are shown in the background. They supply the extra high tension direct current for the anode supply to the long-wave telegraph and telephone transmitters G.B.R. and G.B.Y. Three sets are provided each having an output of 500 kilowatts at 6,000 volts. The sets are capable of being used singly or in series, and their purpose is to provide high tension direct current for the valves. The power available from these machines is thus 1,500 kilowatts at 18,000 volts. In addition a fourth set is provided having an output of 500 kilowatts at 12,000 volts.

In the foreground are two smaller sets each of 200 kilowatts for heating valve filaments and two motor-generator and booster sets for low tension supply, used for various purposes throughout the building.

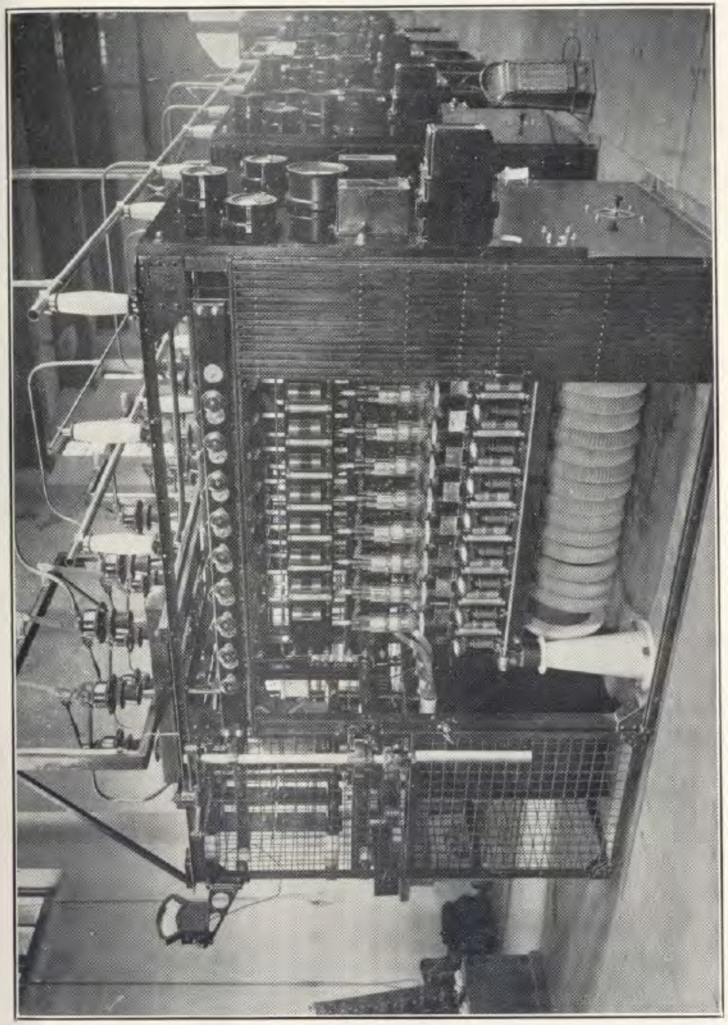
TELEGRAPH TRANSMITTER. VALVE PANELS

Commencing with the tuning fork with its output of the order of the millionth part of a watt, six stages of amplification are required before current is delivered to the aerial circuit. The first high-power stage, which amplifies to 2 kilowatts, uses an air-cooled valve. Two water-cooled valves, each having an output of 10 kilowatts, are used for the penultimate stage.

The photograph shows one of the main valve panels, of which five are installed for the final stage of amplification. Four of the panels are identical and each panel carries 18 water-cooled 10-kilowatt valves, 2 panels being used to give a maximum output of 350 kilowatts to the aerial, leaving three panels spare. The insulated busbars above the panels provide a means of readily connecting and disconnecting panels when it is necessary to throw a panel out of use or to bring a spare panel into use, during maintenance or valve-changing operations.

A fifth panel contains a 250 kilowatt demountable valve used in parallel with one normal panel.

The operation of the transmitter is controlled entirely from the Control Table in front of the valve panels. Apparatus is also fitted on this table for checking the signals emitted from the aerial and for observing the signals arriving from the Central Telegraph Office in London, from which Office the transmitter is worked by the method known as "land line control."

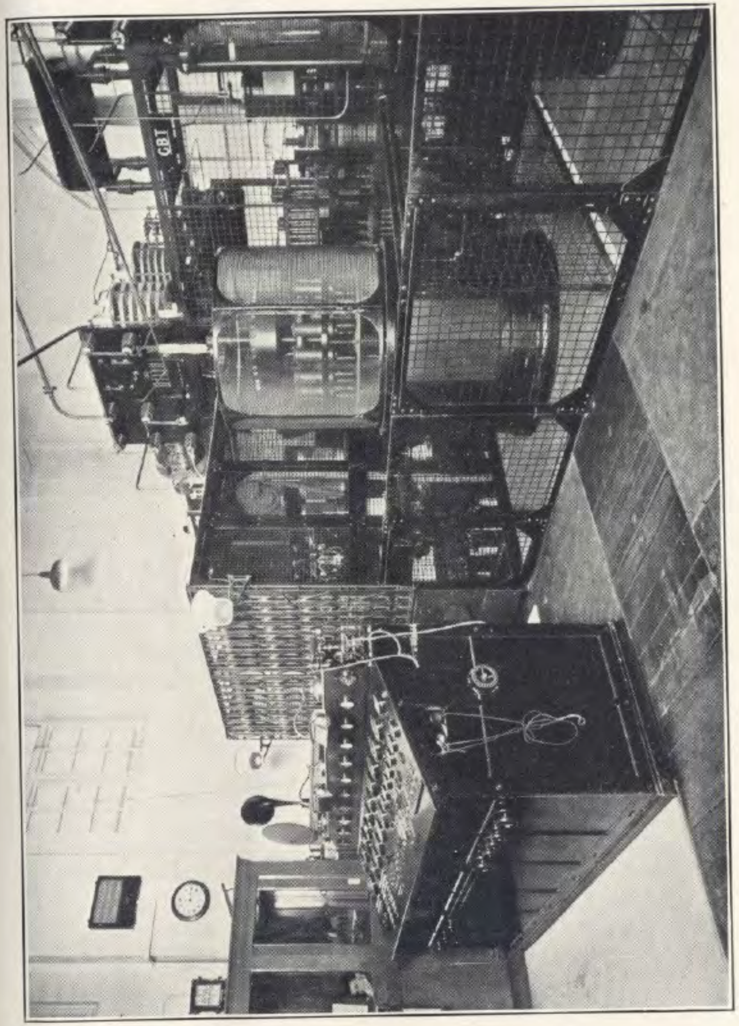


TRANSATLANTIC LONG-WAVE TELEPHONY EQUIPMENT

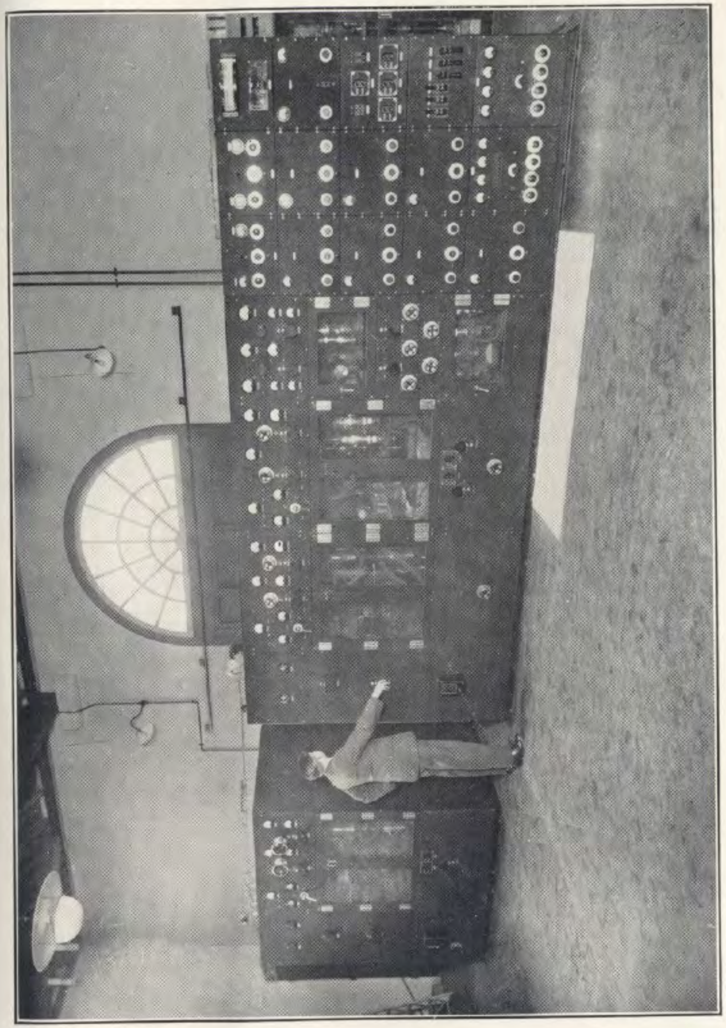
The Transatlantic Long Wave Telephony Equipment is situated at one end of the valve room in the main building. The view shows the control table on the left-hand side and the power units comprising the main amplifier. One of these units is fitted with fifteen 10 kilowatt water-cooled valves, and can be used in conjunction with one panel of eighteen 10 kilowatt water-cooled valves of the telegraph transmitter to provide full output.

A second and later amplifier consisting of six 100-kilowatt water-cooled valves is normally used—three of the six valves being sufficient to provide full output.

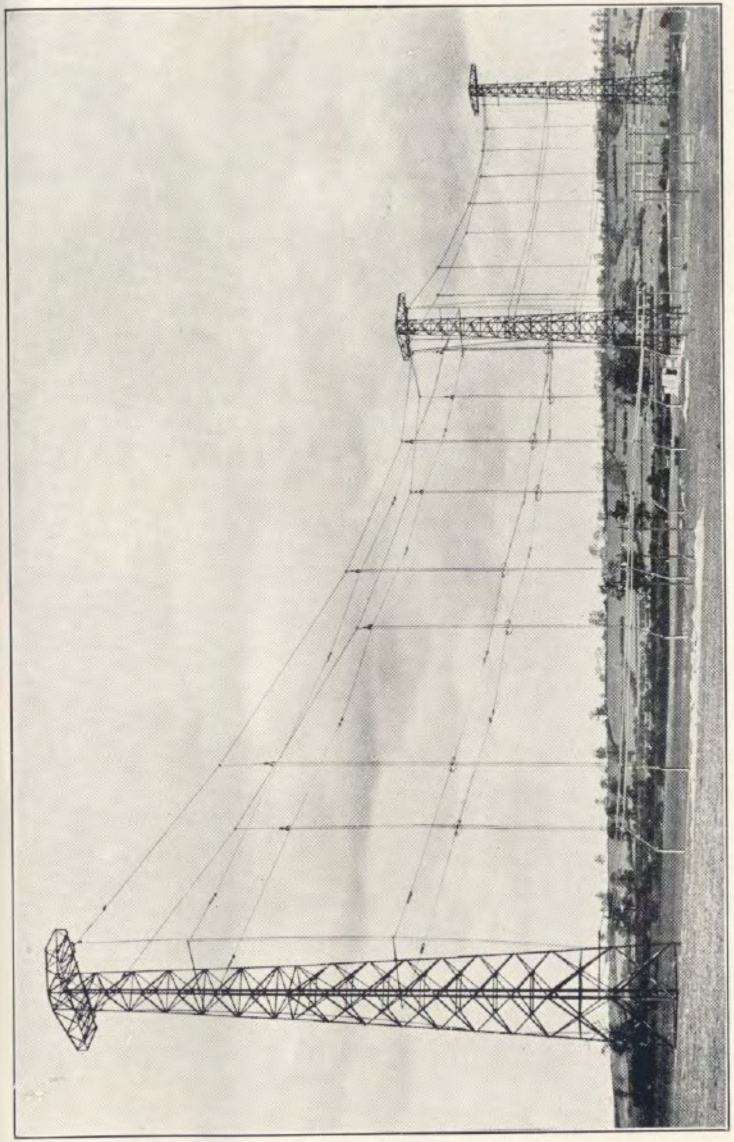
All instruments are fitted on the control table, so that the operator has the transmitter completely under his supervision from this point.



SHORT-WAVE TELEPHONY
TRANSMITTER USED ON
THE AUSTRALIAN SERVICE



A TYPICAL SHORT-WAVE
TRANSMITTING ARRAY
AT RUGBY



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