BRITISH BROADCASTING CORPORATION

Engineering Information Department

THE BBC ENGINEERING MEASUREMENT AND RECEIVING STATION AT TATSFIELD

MARCH 1961

The BBC Engineering Measurement and Receiving Station at Tatsfield:
A view from the South-East.

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Engineering Information Department,
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1. HISTORY.

The BBC had installed measuring and receiving apparatus in a temporary, hutted location at Keston, Surrey, as early as 1925.

A permanent station near the village of Tatsfield was completed in 1929 at a site carefully chosen for this work. Single-storey buildings of brick and tile, surrounded by several 60-foot (approximately 18 metres) masts, were erected at the new site on the ridge of the North Downs, and situated about 20 miles south of London. The small, initial staff was expanded to meet the requirements of the increasing use of broadcasting, first on medium/long waves, then with the advent of the BBC External Services on short-waves and later with the inauguration of television and f.m. broadcasting services on VHF. More land was acquired at Tatsfield and higher masts, including two of 110-feet (approximately 33 metres), were erected for short-wave aerials.

During the 1939-1945 War period, the station suffered some damage from bombing, mainly during the "Battle of Britain" period and at least partly due to its close proximity to the famous Fighter airfield of Biggin Hill. The two highest masts were destroyed and were replaced by three lattice steel towers 120-feet (approximately 37 metres) high. A fourth tower for VHF Bands I, II and III aerials was built in 1957/58. Rhombic aerials directional towards North America had been installed in 1934 and 1936 on 60 to 80-foot (18 to 24 metres) wooden poles; other short-wave aerials were later suspended between the three lattice towers, and a fifth rhombic aerial directional southward was accommodated in the restricted space left available, using tubular steel and other existing masts.

A separate location fairly remote from the main buildings was chosen to instal the Adcock aerials and underground apparatus-room of the first oscilloscopic ('radio compass') direction finding (d.f.) installation in 1940, which was replaced by more modern equipment of similar but improved type in 1960.

2. THE TATSFIELD SITE.

The station is situated on the Kent-Surrey county border at a point on the chalk hills of the North Downs, in Latitude 51° 17'North and Longitude 00° 00¾' East. It is thus almost exactly on the Greenwich Meridian. The subsoil is chalk with clay intrusions, and the height above sea level is 830 feet (253 metres). The site is served by a lane leading from the "B" Class road between Croydon and Westerham, Kent - a small, country township that is the home of Sir Winston Churchill. The station overlooks the Thames Valley and East London to the northward, and some rolling, farmland country to the southward. It is fairly remote from high-tension electricity power lines, "A" class motor roads and other sources of electrical interference.

The present area of the site is 40 acres (16 hectares approximately).

3. AERIAL ARRAYS.

As noted above, there are four rhombic aerials for short-wave reception from Canada and U.S.A. and one rhombic for reception from the S-S-W direction. There are also short-wave dipole-curtain, folded dipole, inverted-V and Beverage aerials for reception from directions south-eastward, eastward and north-eastward from Tatsfield. With one or two exceptions, these aerials are all connected to the main receiving building through impedance transformers and co-axial, underground cables.

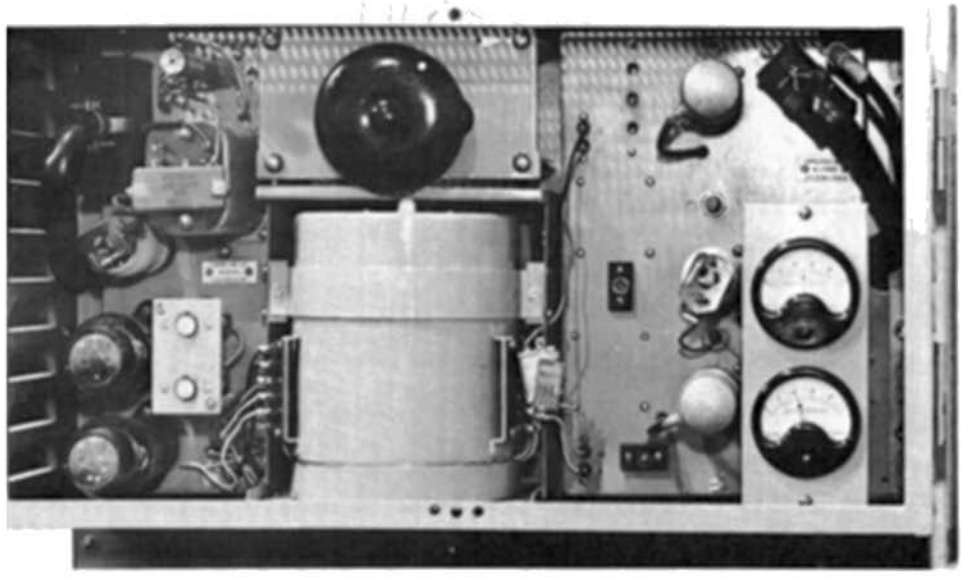
The r.f. co-axial cables from the remote aerials (except those for VHF and UHF), and the aerial feeders to receivers in all parts of the building, terminate on adjacent panels on apparatus bays in the Control and Relaying Room, so that any aerial may be cross-connected to any receiver by means of a short flexible lead. Six wide-band distribution amplifiers, the input and output terminals of which also appear on the same bay, make it possible for any aerial to feed up to eight receivers on the same frequency band without interaction. These amplifiers cover the range 50kc/s to 27Mc/s in nine octave or near-octave frequency-bands, each handled by a separate amplifier unit. The wide-band distribution amplifiers are of low (almost unity) gain, and their insertion between aerial and receiver does not significantly degrade the overall performance of the receiver with respect to the noise, intermodulation or cross-modulation characteristics.

VHF aerial tower:

View of tower looking west. The fixed aerials are for Band II reception while the rotatable aerials at the top cover Bands I and III.

For Band I television reception, fixed horizontal Yagi aerials have been installed on one of the 120-foot towers close to the main building. These aerials are designed to receive the more distant of the BBC's horizontally-polarized television transmissions. The vertically-polarized transmissions are received by means of a vertical dual-rhombic array designed for VHF Band I reception from the northward. Further Band I aerials, as well as aerials for Bands II and III are mounted on the VHF tower built in 1957/58. At the top of this tower are two horizontal Band I Yagi arrays, affixed at right angles to, and on the same shaft as, two Band III Yagi aerials, one horizontally and one vertically polarized, all rotatable by a remotely controlled electric motor, the direction being indicated in the VHF measuring room by means of a 'magslip' indicator. Below these on the tower are mounted Band II arrays each consisting of two vertically stacked four-element Yagi aerials, for reception in each of the eight octantal directions. All the VHF aerials on this tower are connected to the VHF measuring position (F4) by very low loss feeders that are 'filled' with dry nitrogen gas under a slight pressure in order to exclude moisture.

Additional experimental VHF aerials (including a helix) have been installed for receiving earth satellite and other radio signals.



The Essen-National Physical Laboratory designed crystal standard:

The 100kc/s. quartz ring frequency standard. In order to isolate it from mechanical shock, the crystal unit (centre) is mounted on the wall of the temperature-controlled room, independently of the surrounding amplifier and control units.

4. FREQUENCY-MEASURING APPARATUS : FREQUENCY STANDARDS.

Three quartz crystal frequency standards are installed below ground level in a special thermally-controlled Standards Room. One of these standards is an Essen-National Physical Laboratory-designed quartz ring oscillating at 100 kc/s in a circuit designed by the British Post Office Research Laboratories. Another is a BT-cut quartz plate oscillator manufactured by Marconi's W.T. Co. Ltd. oscillating at 5Mc/s. The third crystal, which is retained for standby purposes, is AT-cut oscillating at 1 Mc/s.

A room adjacent to the standards room contains checking and monitoring apparatus with which the frequencies of the standards may be compared with the British National Standard Frequency transmissions from MSF, the similar Standard frequency transmissions from other countries and with U.T.2 time signals from Britain and U.S.A. The Tatsfield standard frequencies may also be compared one with another, and with the sub-standard carrier-frequency of the Droitwich long-wave transmission on 200 kc/s, by means of an oscilloscopic display at a frequency of 20 Mc/s.

The "F1" frequency measuring position:

This recently installed Rohde and Schwarz equipment is used for measurements in the HF band.

5. FREQUENCY MEASUREMENT.

Three frequency measurement positions in two separate rooms are provided with apparatus designed to ensure that a breakdown of one measuring position does not interrupt measurements in any of the broadcasting bands. Normally, the three positions (designated F-1, F-2 and F-4) are allocated for measurements at medium, high and very high frequencies (MF, HF, and VHF) respectively, but the apparatus is so arranged in conjunction with suitable receivers that a failure of one position can be covered by the others. The types of measuring equipment in the three positions are as follows:-

F-1. Rohde & Schwarz type XUA and XUB (0 - 30Mc/s). Normally used for HF measurements 3 - 30 Mc/s. With harmonic multiplier, can be used for VHF. May also be used to generate precise audio-frequencies, and will operate on MF if required.

F-2. Marconi Instruments Ltd. type TME-2 (1940) (0- 30 Mc/s).

Normally in daily use for LF and MF (Long/Medium waves) measurements but can also be used for HF.

F-4. Schomandl K.G. type ND-5 (0 - 30 Mc/s fundamental frequencies).

With harmonic amplifier 0 - 300 Mc/s and with additional type FD-3 unit 300 - 3000 Mc/s, or higher.

Normally used for VHF and UHF measurement.

All the above apparatus is synchronized with standard frequency supplied from the Standards Room. Positions F-2 and F-4 are installed on adjacent apparatus bays in one room; Position F-1 is in a separate room. HF and MF aerials are provided in each Position. The outputs from VHF and UHF aerials are normally terminated in the F-4 Position.

All BBC transmissions are measured two - three times daily. Interfering signals are also measured as they are observed. Foreign broadcasts in selected bands are measured daily, the stronger signals being measured one or more times each week, but some more distant broadcasts may only be captured at longer intervals of time.

The three Positions are not all staffed together throughout the 24 hours but for most of the time two of them are in operation simultaneously, and less frequently they may all be in use.

The number of daily measurements made varies between 600 and 800, depending upon the season and the demands. The error of measurement never exceeds $1/10^6$ and is in a large proportion not greater than $1/10^7$. In some special measurements, the error is as little as $2/10^9$.

6. FIELD STRENGTH MEASUREMENT.

Two small wood huts separated from the main station buildings are used for this purpose. In one of them, spaced as far as possible from other aerials, there is MF and HF apparatus manufactured by Philips, with an older measuring set of Marconi type TME-18 design that can be used for check and reserve purposes. Each of these sets uses a frame aerial but a vertical aerial may be employed when specified.

The VHF field-strength measurements are made in another small hut with a calibrated Marconi signal-generator and Eddystone receiver.

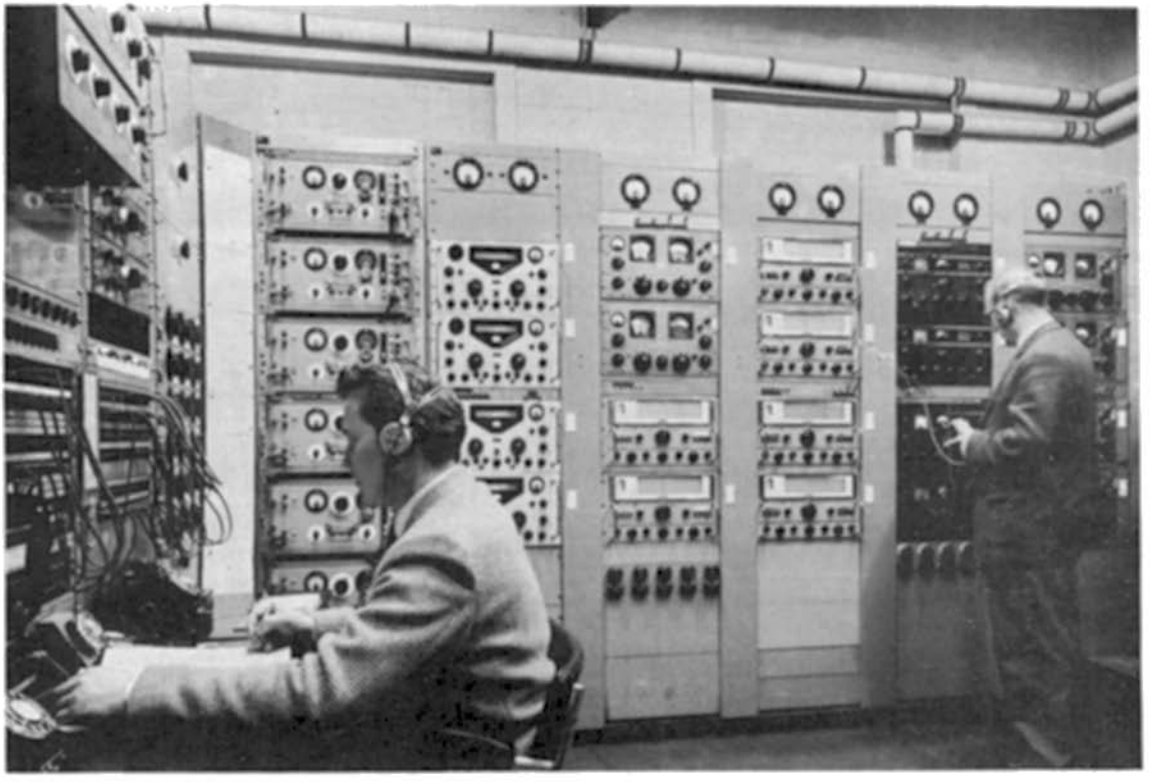
7. RADIO RECEIVING AND RELAYING APPARATUS.

Approximately 70 radio receivers have been installed to provide reception facilities throughout the LF, MF, HF, VHF, and UHF bands in the frequency range from 15 kc/s to 500 Mc/s. Above this frequency, temporary facilities exist for reception up to 700 Mc/s which may soon be replaced by more sophisticated apparatus.

The types of receivers in use are:-

Communication Receivers :	Racal type RA-17. British G.E.C. type BRT-400 Eddystone types 770-R and 770-U Marconi CR-200 and CR-100 Hammarlund SP-600 R.C.A. type AR-88D and AR-88L.
Single sideband Receiver:	Mullard GFR-552
Exalted carrier Triple Diversity Apparatus :	Press Wireless Inc.
Television Receivers (U.K. Standards) :	Murphy Radio V-176C and V-250A. Ekco T-231F.
Television Receiver (European and French Standards) :	Philips type 21-TK-280A.
Television Receiver (USA Standards) :	R.C.A. Victor.
Domestic F/M Receivers :	Various
Transistorized Portable Receivers for tracing sources of electrical noise etc. :	Perdio types AM/FM 95 and Multiband 91.

A number of these receivers are installed throughout the building at monitoring and measuring positions. The remainder, including Racal, G.E.C., Hammarlund and R.C.A. types as well as the Press Wireless exalted carrier equipment, are concentrated in the Control and Relaying Room, and are used, normally in double or triple diversity, for broadcast relay reception. Also in this room are the aerial distribution bays and audio-frequency line equipment.



The Control and Relaying Room, showing the bays of diversity receivers: *On the left is the audio-frequency line equipment.*

The combined, diversity, a.f. outputs from the relaying receivers are connected through filters, bass and treble response correction networks and fader controls to any one of six line-amplifiers and thence to any of the six equalized programme circuits to the Bush House and Broadcasting House control rooms of the BBC in London. Each of the six relaying "chains" can thus be used to feed to London separate programmes received by Tatsfield, and each "chain" has three inputs from different, selected receiver systems which, if the necessary number of transmissions of the required programme can be simultaneously received, may be selected by the fader units on a basis of first, second and third choice at the line-amplifier chain inputs. Thus, a failure of a particular transmission on a chosen frequency that is being relayed may quickly be corrected, by fading out the faulty signal and fading in an alternative transmission carrying the required programme.

A new design of this audio-frequency selector and amplifier apparatus, replacing similar apparatus of war-time design, has been planned for installation in 1961.

Equipment bays in the Operational Supervisory Room (S.M.E.s' Room):
On the right is the teleprinter receiver.

8. OPERATIONAL SUPERVISORY ROOM (S.M.E.s' Room).

This duty-position checks and confirms all abnormalities in BBC transmissions reported by monitoring staff, investigates all the more difficult cases of interference and generally correlates all the operational work of the station, reporting every observation of interest in its log-book to Engineer-in-Charge and taking action by telephone to have errors in BBC transmissions remedied immediately. The duty engineer has full responsibility, particularly in the evening and overnight periods, and when the higher staff are off duty.

To avoid erroneous reports from more junior staff, it is essential for a Monitoring station to cross-check its observations before passing them to the authority concerned. In order that this may be done quickly and efficiently, the Senior Maintenance Engineers' room is provided with its own apparatus, including receivers for all frequency-bands, some directional aerial facilities, simplified frequency-checking apparatus, telegraphy and teletype recorders, a calibrated oscilloscope for waveform and modulation depth measurement, band-scanning and ionospheric-absorption records etc. All lines to London and the listening

outputs from each of the other duty positions and measuring rooms are duplicated at the S.M.E.s position and he has immediate control of magnetic tape recorders, one of which has twin tracks, with timing pulses automatically recorded on the second track.

Ionospheric (F and Sporadic-E layer) reports are issued two-hourly from this position from observations of the HRF (Operational MUF) of the Atlantic and Eastern-Eurasian paths, and the S.M.E. controls the condition-indicator lamps indicating the state of the ionosphere throughout the station. D-layer absorption is also recorded on daily charts to indicate S.I.D.s.

There are also television receivers for British, for European C.C.I.R. and French, and for U.S.A. television standards in this position.

9. MONITORING CUBICLES.

Five small rooms are concerned with monitoring BBC programmes, and also certain British Commonwealth and other broadcasts by request. Four of them have very precisely-calibrated radio receivers, aerial selector switching, and dialling facilities to obtain any BBC programme direct by telephone line from London for comparison purposes. Their staff is responsible for checking BBC shortwave transmissions for correctness of programme (as scheduled), for interference and jamming. The receiver, switching and transistor line-amplifier are installed on a metal desk in these cubicles.

One of the five monitoring cubicles:
To the left of the receiver are the programme selector dial and small loudspeaker, and the aerial switch.

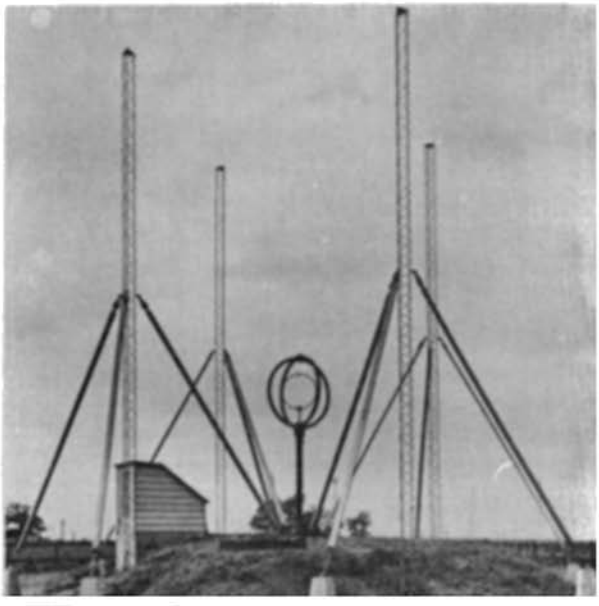
The fifth monitoring room has apparatus-bay mounted receivers with different equipment, and is used for medium-wave and general-purpose listening, recording the beat-frequencies between synchronized transmissions, and other work.

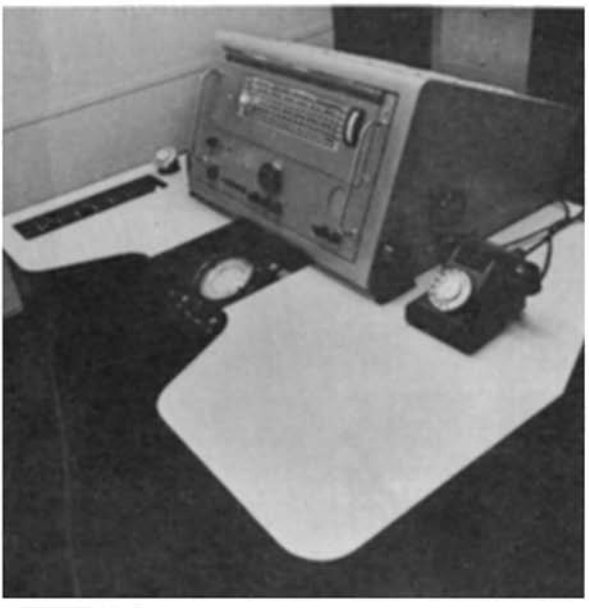
Every cubicle (as indeed each duty position and Office) has dialling telephone facilities for intercommunication.

10. DIRECTION FINDING.

A modern, cathode ray, radio-compass direction finder with Adcock and crossed-loop aerials is available at a separate site, distant about 200 yards (approx. 180 metres) from the main statinn. It is staffed when required but not continuously. The apparatus, manufactured by The Plessey Co. Ltd. (type BW-58) is of 1960 design and has replaced an earlier instrument installed in 1940. It has proved its utility in helping to trace the origin of interference and in identifying unknown transmissions. The frequency range is from 150 kc/s to 27 Mc/s. If the received signal is sufficiently stable the directional error does not normally exceed 1-2 degrees after correction for "site error."

Goniomenters, rotatable VHF aerials and radial aerials at the main station enable the approximate directions of signals in higher frequency bands to be estimated fairly closely.





Cathode-ray direction-finding installation:

Left: *Direction-finding loops for long-wave measurements and the Adcock aerials for medium- and short-wave measurements.*

Right: *The operating position.*

11. BAND SCANNING.

Equipment of modified British Post Office design is provided for this work. It is quickly usable in the MF and HF bands and can be adapted for LF or VHF scanning. In the VHF band, the band scanned is more limited in any one condition of adjustment.

12. SPECTRUM ANALYSIS.

Apparatus for this purpose is usable at LF, MF and HF and can quickly be adapted for VHF although its display bandwidth is at present unsuitable for the wide sidebands of television or frequency modulation. Cameras can be fitted over the oscilloscope to photograph the display.

13. TEST APPARATUS AND MAINTENANCE LABORATORIES.

Test apparatus provided includes a portable HF bridge for measuring the impedance of cables, aerial transformers and other circuits. Comprehensive equipment for the standardized testing of radio receivers has been installed in two laboratories, one set of apparatus normally dealing with Tatsfield receivers (which are tested and re-aligned at approximately monthly intervals). The other more elaborate apparatus is used for full performance testing of various designs of domestic and commercial radio receivers that are of particular interest to the BBC. On these, Test Reports with tabular and graphical results and with the method of testing clearly defined, are issued for BBC information, copies being sent to the manufacturers of the receivers tested. From these reports, information is also contributed to C.C.I.R. and British Standards Institution. The Procedure used in Receiver Testing is regularly revised and published.

14. STATION POWER SUPPLY AND HEATING etc.

Three-phase Electricity supply at e.h.t. (11 KV) is taken from the South-Eastern Electricity Board and is transformed to 230 volts and maintained at this potential by voltage regulators. An automatic self-starting diesel-alternator set supplies current after an interval of only 8 seconds if the normal electricity supply fails but the load has to be restricted to supplying essential radio apparatus and lighting.

The normal load of the station is in the region of 50 KVA., and the maximum connected load is 75 KVA.

The station is heated by an oil-fired boiler and hot water radiators which are partly pump-assisted. Sufficient oil for several weeks use is stored and, in emergency, the diesel-alternator would also have sufficient oil-supply for a similar period.

15. ADMINISTRATION OFFICES.

The Engineer-in-Charge (E.i.C.), the Assistant E.i.C., and another senior assistant, together with clerical staff, have offices in a separate small building adjacent to the main building.

16. STAFF AMENITIES.

The operational duty staff work shifts and the station is open for service 24 hours a day. The number of shift staff on duty varies from a minimum of 8 (from 2300 hours through the night) to 12. There is an additional day-maintenance group of 6 engineers/technicians and a daytime manual staff (including aerial rigger, experimental mechanic and cleaners) of 5 men.

There is a small restaurant and a Catering Staff of two.

A separate Clubhouse building provides recreational amenities.

Reference:

Griffiths H.V. "The BBC Measuring and Technical Receiving Station at Tatsfield".
BBC Quarterly, Vol. IX, No. 1, Spring 1954.