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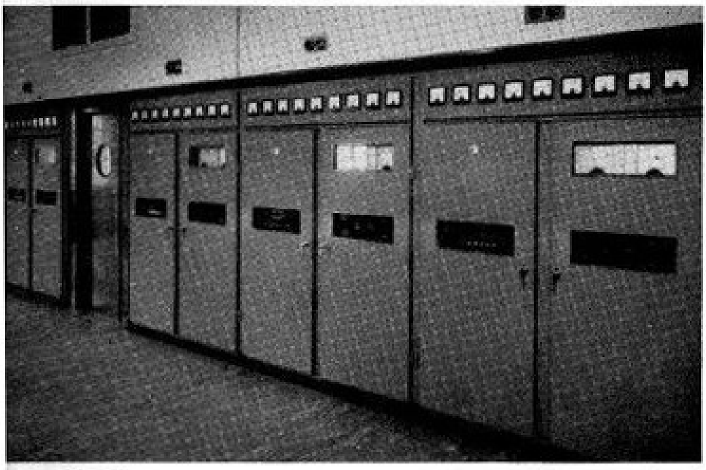
PONTOP PIKE FM BROADCASTING STATION

INTRODUCTION

TODAY, the number of broadcasting stations operating in Europe on the low and medium frequency bands is twice that provided for in the Copenhagen Plan of 1948 which allowed for the maximum number of stations considered possible without causing intolerable mutual interference. The inevitable result is that interference is severe after dark and the effective range of many of the B.B.C stations is seriously curtailed. Moreover, even if the Copenhagen Plan had been strictly observed in all countries, the number of channels allocated to the B.B.C would not have permitted full coverage of the Home Service (with its six regional variants), and the Light and Third Programmes, in addition to the B.B.C programmes for Europe that are also broadcast on medium frequencies.

A general view of the Marconi unattended transmitters at Pontop Pike VHF/FM Station.



The Atlantic City Conference in 1947 recognized these difficulties and allocated 87·5 to 100 Mc/s for broadcasting in the VHF band. Following experiments and test transmissions in this band, which have already been described,[1] the B.B.C has installed and set to work a number of VHF transmitting stations, which are frequency modulated, with a population coverage of 97·1%. Additional stations are under construction and plans are being worked out further to increase the number of listeners who can receive the three sound programmes at a satisfactory standard.

The stations now in operation and the effective radiated power of each of the three programmes is shown in Table 1.

This article describes the general plan and the equipment used at the Pontop Pike station, which is typical of the stations transmitting three programmes each with an effective radiated power of 60 kW.

SERVICE AREA

The Pontop Pike VHF/FM sound services transmitting station is situated about ten miles south west of Newcastle-upon-Tyne on a site 1,000 ft above sea level which it shares with a Band I television station in accordance with B.B.C standard practice. Co-siting of the two services makes for economy in both capital and operating costs. In addition, Town and Country Planning Authorities favour this plan as it minimizes interference with the amenities of the district by reducing the number of masts visible. The buildings are architecturally designed and sited to conform with the surroundings but the site selected for Pontop Pike has also special problems. The area is

TABLE 1

VHF STATIONS IN THE U.K AND N. IRELAND

Stations	*Frequencies (Mc/s)* *Light*	*Third*	*Home*	*Power (e.r.p.) kW (each programme)*
Wrotham	89·1	91·3	93·5	120
Pontop Pike	88·5	90·7	92·9	60
Wenvoe	89·95	96·8	94·3 Welsh 92·125 West	120
Divis	90·1	92·3	94·5	60
Meldrum	88·7	90·9	93·1	60
North Hessary Tor	88·1	90·3	92·5	60
Sutton Coldfield	88·3	90·5	92·7	120
Norwich	89·7	91·9	94·1	120
Blaen-plwyf	88·7	90·9	93·1	60
Holme Moss	89·3	91·5	93·7	120
Rowridge	88·5	90·7	92·9	60
Kirk O'Shotts	89·9	92·1	94·3	120
Sandale	88·1	90·3	92·5 Scottish 94·7 North	120
Llanddona	89·6	91·8	94·0	6
Llangollen	88·9	91·1	93·3	7
Rosemarkie	89·6	91·8	94·0	6
Douglas	88·4	90·6	92·8	3·3
Peterborough	90·1	92·3	94·5	1–21†
Orkney*	89·3*	91·5*	93·7	3·8–25†
Thrumster*	90·1*	92·3*	94·5*	0·1–10†
Dover*	90·0*	92·4*	94·4*	2–10†

* Under construction.

† Directional aerial.

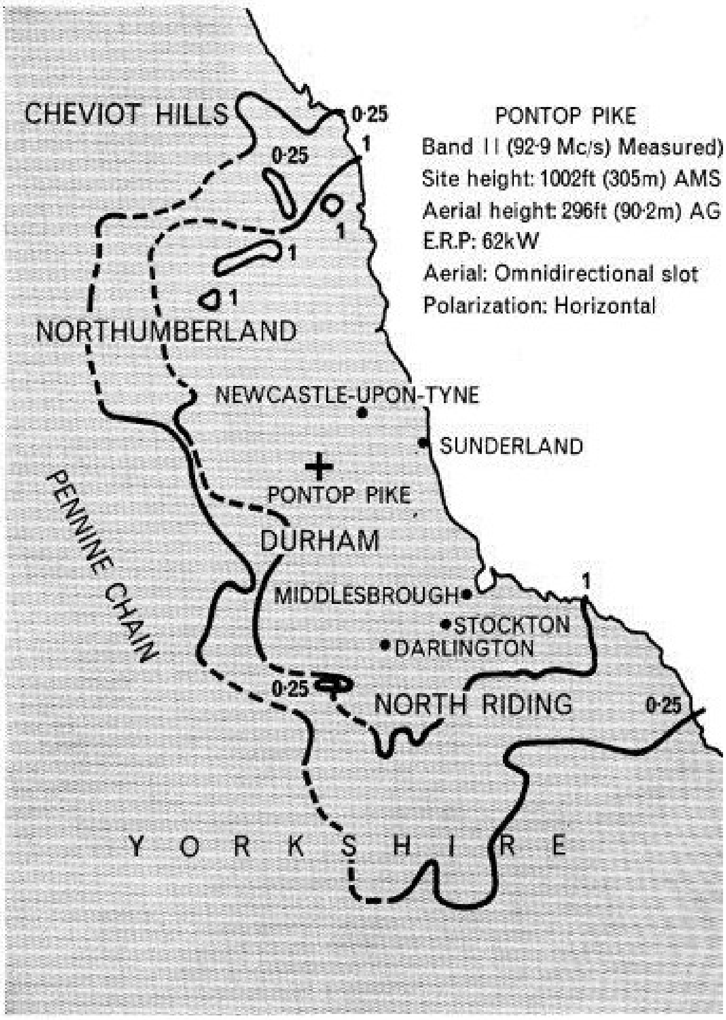


Fig. 1. Field Strength Contour chart of Pontop Pike VHF/FM Station.

subjected to subsidence from disused underground coal mine workings and the planning of the building and of the plant takes this into account. The building is supported on a concrete jointed raft to allow for irregular settlement and the plant is laid out with interconnecting ducts and interconnecting cables with sufficient flexibility to minimize damage. These measures have been successful.

The service area of the VHF station has been surveyed in the field and is shown in Fig. 1. The map shows clearly the effect of screening by land contours on the propagation of VHF. Although the horizontal radiation pattern of the aerial is circular it will be seen that the service is restricted to the west by the Pennine hills and to the north by the Cheviot hills, but the relatively level ground to the south enables this site to serve effectively the populous industrial regions of Middlesbrough, Stockton, Darlington and beyond. In the south it joins up with the service area of the Holme Moss VHF/FM station.

In areas containing much motor traffic, experience shows that car ignition interference is likely to reduce seriously the merit of the service at field strengths below 250 μV/m and the trouble will be noticed even at higher field strengths in places where impulsive interference is especially severe or if the amplitude modulation limitation in the receiver is not effective. In rural areas the satisfactory service may extend appreciably beyond the limit of the 250 μV/m contour where conditions are favourable and receiver hiss itself may be the limiting factor.

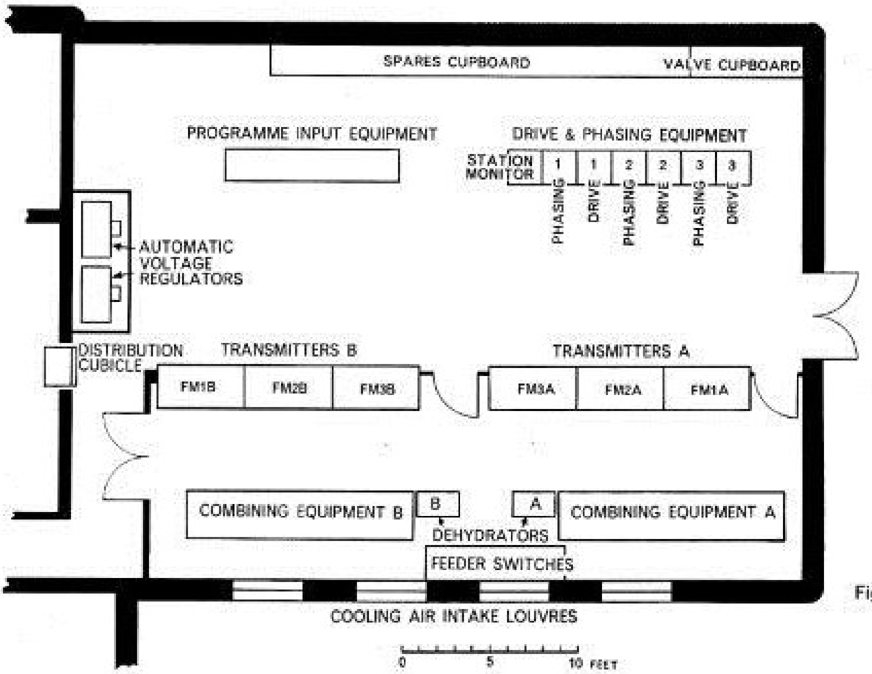


Fig. 2. Plan of Transmission Room.

The population contained within the 250 μV/m contour from Pontop Pike is 2,729,400. This region was amongst the first to be given a VHF/FM service because for many years its medium wave service has shared a frequency with the Northern Ireland Home Service transmitter and both necessarily carried the same programme, thus limiting the number of programme items of local interest which could be carried. The Pontop Pike Home Service transmissions can, of course, carry items of special interest to the North-east of England as well as others taken from the main network. The station also broadcasts the Light and Third Programmes on VHF.

GENERAL TECHNICAL PLANNING

The general planning of the equipment of the stations is centred around two salient principles:

(a) The equipment must operate unattended.

(b) The station must be very reliable in operation.

The equipment is installed in an unattended transmitter hall and is arranged to be completely automatic in operation; it starts and stops transmitting under control of a clock and the technical performance of the equipment is supervised during operation by automatic devices which are centred upon a control and monitoring panel. This panel registers and indicates that the operation of the equipment is normal and in the event of a fault, change over to a standby is effected or alternatively an alarm is arranged to indicate the degree of urgency (e.g., failure of one chain or both main and standby). Outside television service hours, when the site is entirely unattended, the alarm operates in the Newcastle Studios. The automatic operational features are effective and no additional staff has been appointed to supervise the working of the VHF/FM transmitting equipment.

The unattended operation enables the layout to be economical and reduces building costs because it is not necessary to provide the amenities that would be necessary for operational staff. A plan of the FM transmitter hall is shown in Fig. 2.

A high standard of reliability is achieved by planning for simultaneous operation of duplicate equipment. For this purpose the transmitting equipment is separated into two independent chains each containing three 5-kW transmitters. Combining filters enable the three programmes to deliver power to a common feeder as shown diagrammatically in Fig. 3A. The transmitters and the combining filters were designed and supplied by Marconi's Wireless Telegraph Co. Ltd. to a B.B.C specification.

The aerial in turn is separated into two independent halves to accept the two feeders and to maintain complete separation of the two chains. The principle is continued by arranging that the power supply to each of these chains of equipment is obtained from a separate power distribution board which is fed from duplicated mains feeders from two independent sub-stations of the British Electricity Authority's power distribution system. There are, in effect, therefore, two independent transmitting stations on the same site, normally operating simultaneously and in phase, but each capable of independent operation if necessary. Obviously, it is inevitable that a small amount of the equipment must be used in common by the duplicate chains of equipment. This common equipment includes the programme amplifiers and the common radio frequency modulated drive required to excite the duplicate transmitters in synchronism. The common FM drive equipment is duplicated and automatically monitored, and in the event of a fault on the working drive, there is automatic transfer to the stand-by equipment with only a momentary break in transmission. In a similar way, in the event of failure of the power supply arrangements to one half of the station, the common drive equipment changes over automatically to the surviving switchboard and transmission is maintained.

The B.B.C has worked actively, with the ready co-operation of the Industry, in developing systems of unattended and automatic broadcasting stations and detailed descriptions have been published.[2]

TRANSMITTER EQUIPMENT

In common with the other European countries, the B.B.C has adopted pre-emphasis time constant of 50 micro-seconds, and a peak deviation of ± 75 kc/s corresponding with 100% modulation. The transmitter specification to which the Pontop Pike equipment was manufactured included also other operational characteristics. These required a standard of frequency response within ± 1 dB between 30 c/s and 10,000 c/s. The acceptable fall at frequencies beyond this range was also prescribed. The proportion of permissible amplitude modulation must not exceed 7%, assuming the aerial load reflection coefficient is not greater than 5%. At Pontop Pike, Marconi transmitters, type BD 301, were adopted giving a radio frequency power output of 5 kW approximately. The transmitting equipment is laid out as shown in Fig. 2 and comprises three pairs of transmitters; the three pairs are allocated to carry the Home, Light and Third Programmes respectively.

Each programme is taken from line through amplifiers containing a programme level limiter and is fed to a FM drive unit which is of particular interest.[3] Briefly described, the modulator drive unit comprises a crystal with centre frequency near 4 Mc/s which is deviated by a balanced modulator. With an input audio frequency level of + 12 dB, referred to 1 mW in 600 ohms, the 4 Mc/s master oscillator crystal is deviated ± 4·17 kc/s. Frequency multiplication follows, raising the final frequency delivered to the transmitter proper to the required frequency in the range 88–100 Mc/s with a frequency deviation of ± 75 kc/s. The method is robust and satisfactory in performance. In the B.B.C's arrangement of plant at Pontop Pike, the FM drives are mounted in pairs and very careful screening is required to ensure absence of cross-talk between drives. The spare is kept energized for immediate automatic selection in the event of a fault on the working drive, and levels as low as − 70 dBs of cross-talk may be audible on the low noise level FM transmitting system.

The power delivered to the transmitter is approximately 5 W at carrier frequency and with the required deviation. This input is used to drive two transmitters simultaneously and in phase through phasing amplifiers. Each transmitter amplifies the drive up to 5 kW and delivers its output to a separate feeder and independent half aerial. The phase of the RF power output into the feeders is monitored and a phase comparator automatically corrects any phase error which may appear in comparing the RF output from each

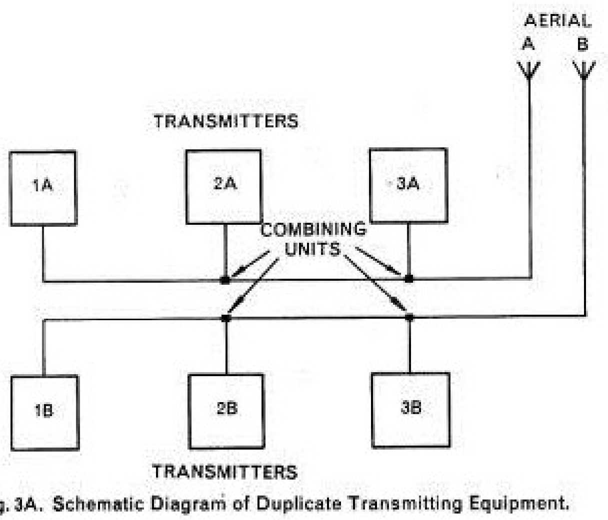


Fig. 3A. Schematic Diagram of Duplicate Transmitting Equipment.

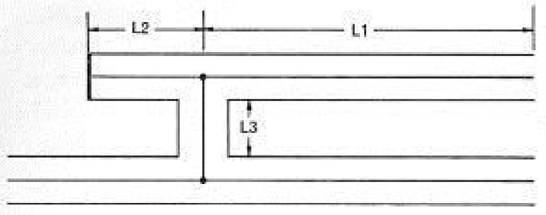


Fig. 3B. Basic circuit of Notch Filter.

transmitter. Experience shows that the differential phase error is very small after the first few minutes and when the transmitters have reached operational temperature. At certain stations commissioned later, automatic phase control has been omitted as being unnecessary.

The transmitters are equipped adequately with metering to permit quick observation on the performance of the equipment. Centre frequency and deviation meters are built in, but for thorough checks on performance and for fault finding the station is equipped with test equipment giving accurate performance indications. This equipment is built into a test bay and connects by cable to sampling points in the chain of transmitting equipment.

As the transmitters are unattended, only the demands of the plant need be taken into account in the heating and ventilation system. The six transmitters together take in cooling air at the rate of 4,800 cubic ft per minute from the transmitter hall. The air intake by transmitters is filtered and by discharging the heated air into the room, the waste heat is used for room temperature control. Thermostats are provided which divert the cooling air outside the building when temperature rises excessively. On the other hand, when the transmitters are not in use, automatically controlled louvres in the building hall are closed to conserve heat and to prevent ingress of damp cold air. This is of value in reducing corrosion due to salt laden air or when the atmosphere is polluted by industrial smoke and fumes.

The reliable performance of the Pontop Pike equipment, which has been repeated at other VHF stations, justifies the planning with duplicate operating chains of equipment. The total loss of programme due to equipment and valve faults on VHF stations is 0·006% of the programme time. There are inevitably longer periods when only half the equipment has been radiating due to a fault affecting only a single chain (e.g. by the eventual failure of transmitting valves).

COMBINING AND NOTCHING FILTERS

The combining filters referred to in the previous paragraph and shown in Fig. 4 are a coaxial embodiment of the Maxwell Bridge. The function of the combining unit is to isolate from each other the output terminals of the three transmitters which comprise one associated group feeding a common half aerial. If the main coaxial feeder is accurately terminated, the bridge circuit of the combining filter is balanced and there is no coupling between the transmitters. In practice, however, the balance cannot be perfect at all three frequencies and the isolation given is approximately 30 dB. This is sufficient separation to ensure that cross modulation of the carrier frequencies in the final stage anodes of the transmitters have negligible practical importance.

The degree of isolation achieved by the combining filters determines the level of spurious frequency radiation caused by intermodulation of the three carriers at the transmitter final stage anodes. A level of

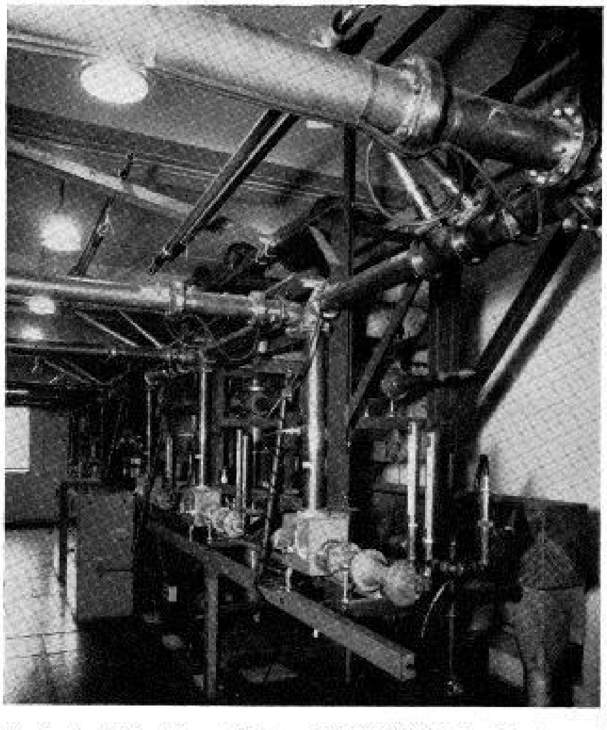


Fig. 4. Combining filters at Pontop Pike VHF/FM Station. Experimental Notch Filters used in initial tests may be seen supported above the main assembly.

about − 60 dB of spurious radiation can be achieved by the use of combining filters alone but the B.B.C practice is to increase this further by the use of additional rejection filters; a final level of spurious radiation below − 80 dB is achieved.

These basic filters are illustrated in Fig. 3B, the lengths L1, L2 and L3 being chosen so that the filter passes and stops the required frequencies and, also, so that a satisfactory compromise between the power dissipated at the pass frequency and the insertion loss at the stop frequency is obtained. By the adoption of standard intervals of 2·2 Mc/s in the frequencies allocated to the individual transmitting stations, the standardization of combining filters and notch filters is aided.

The low level of spurious frequency radiation effected by these means is sufficient to ensure that interference by radiation of out-of-band signals with communication services operating in adjacent bands is unlikely. Experience shows that cross-modulation occurring in the receiver circuits themselves when operating very near the station is likely to create more difficulty than the radiation from the transmitters of out-of-band frequencies at the very low levels achieved.

MAST AND AERIAL

The modification of the service area by ground level contours is referred to in an earlier paragraph and this is closely related to the height of the aerial. In planning the technical equipment of a transmitting station, an early decision is required on the effective height and gain. At Pontop Pike the problem is complicated by the need for accommodation on the mast for the Band I television aerials and other projected services; another factor is the use of one aerial to radiate all three VHF services simultaneously and the design ensures that the impedance is flat enough over all three carrier frequencies.

The three carrier frequencies for Pontop Pike shown in Table 1 extend over 4·4 Mc/s. In addition to the radiation factors, the three frequencies must give loads to terminate the aerial feeder satisfactorily to enable the combining filters to be effective and to ensure that amplitude modulation is not introduced. The aerial has eight tiers each of four vertical slots and after allowing for feeder and other losses, the effective power gain is six times. This aerial gives the required horizontal polarization and the cylindrical form of the aerial has advantages mechanically. The cylinder, constructed of aluminium alloy, can enclose the steel lattice mast, and wind tunnel tests show that the combination has no greater wind resistance than the steel lattice mast alone. This results from the reduced air turbulence.

The general view of the aerial is shown in Fig. 5. It is mounted 300 ft above ground with space above for the television aerials. To facilitate construction and electrical adjustments each slot element is formed in an aluminium sheet quadrant, seen in Fig. 6. The backing screen of aluminium mesh gives mechanical rigidity for handling during transport and erection and eventually provides the electrical screen covering the mast steel work. It also ensures that personnel within the cylinder during transmission are not subjected to dangerous levels of RF fields. The quadrant incorporates local feeder terminations and these can have preliminary electrical adjustments made upon

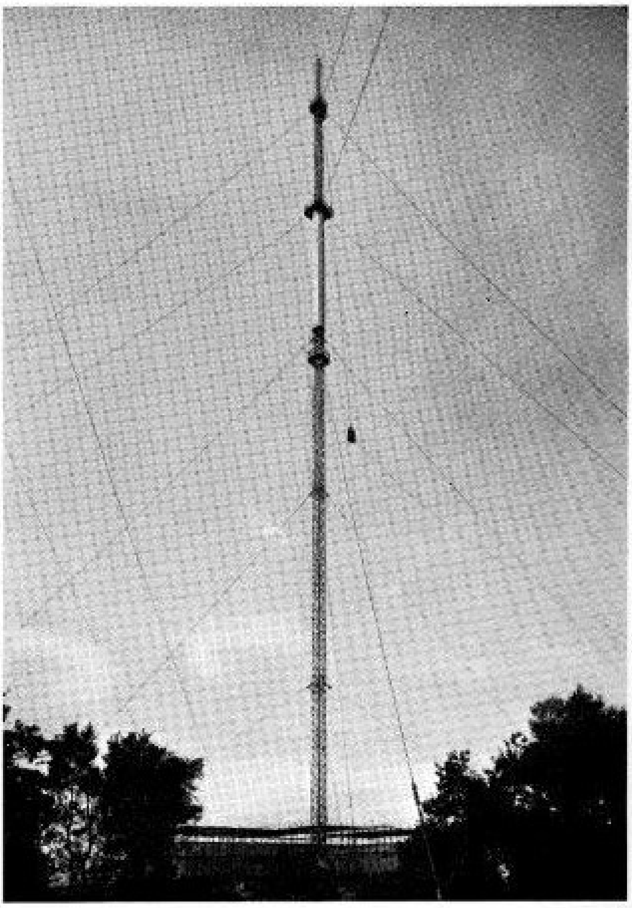


Fig. 5. A general view of the 500-ft aerial mast showing the 90-ft cylinder with 8 tiers of 4 shots forming the VHF sound broadcasting aerial.

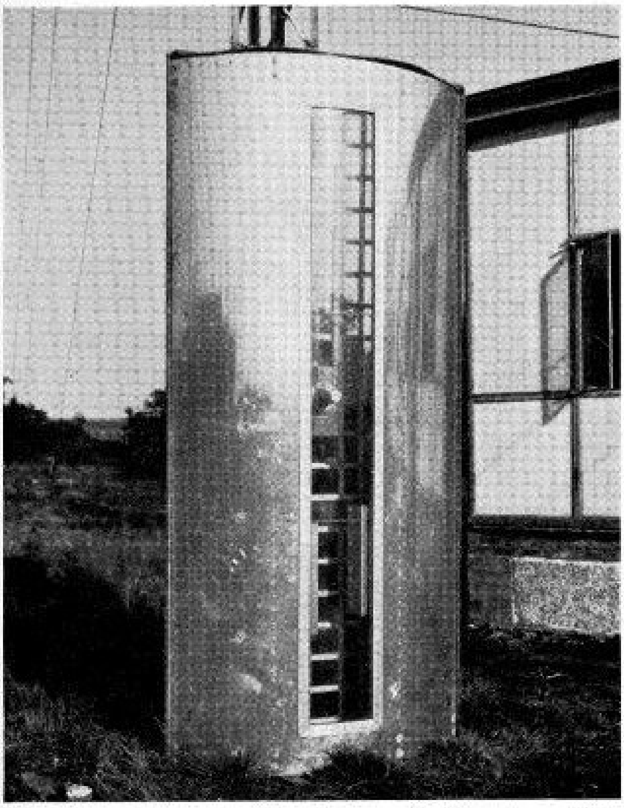


Fig. 6. A view of the outside of one of the quadrants forming part of the VHF sound broadcasting aerial.

them before they are hoisted into position. Further facilities are provided for the adjustment of feeder matching, bandwidth, and electrical slot length.

The aerial comprises two sections each of four tiers of slots. Each section is fed by a separate main RF feeder which sub-divides to the required branch feeders within the cylinder itself. At this station the main feeders are $3\frac{1}{4}$ in. diameter outer copper tube concentric feeders of 51·5 ohms characteristic impedance.

ACKNOWLEDGEMENTS

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