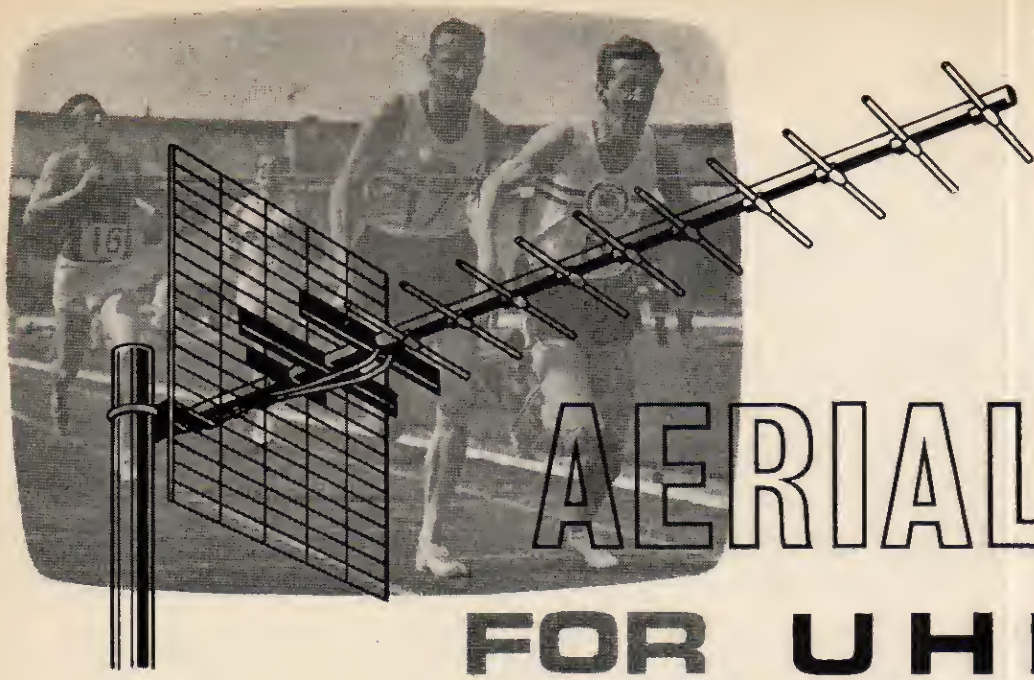


AERIALS FOR UHF

By J. D. Benson

In last month's article we discussed the properties of radio waves when transmitted at different frequencies and in particular some of the conditions which must be observed when attempting to receive u.h.f. transmissions. In this article, practical information is given for the construction of aerials for receiving BBC2 within the service area and for more distant reception.

To join the aerial to the receiver, coaxial cable must be used and for u.h.f. reception low-loss cable is a must. The use of inferior cable can completely negate the effectiveness of the signal induced in the aerial.

The construction of three types of aerial will be considered. One is a loft type for use in areas of strong signal and a further two outdoor arrays to cover medium and long distance will be discussed.

The reception of u.h.f. signals is largely conditioned by the position of the aerial relative to the transmitter, i.e. an aerial at long range but situated on a hilltop may give better results than an aerial within the service area, but which is overshadowed by tall buildings.

In weak signal areas little can be gained by increasing the size of the aerial beyond certain limits, but it is possible to amplify weak u.h.f. signals successfully by the use of transistor pre-amplifiers, mainly because man-made interference is almost non-existent in Bands IV and V. Band I signals are very prone to electrical interference. Therefore, if a weak signal is amplified the interference is also amplified, which generally results in a picture covered in "snow" (patterns of white flecks).

OTHER AREAS

The aerial designs, dealt with in this article are specifically designed for Channel 33 which transmits on the frequencies of 567·25Mc/s for vision and 573·25Mc/s for sound. It was felt that in view of the author's location, i.e. some 60 miles from the transmitter, that maximum results should be aimed at from the one channel in operation instead of designing an aerial to cover the four channels allocated to the area.

Many experimenters and constructors may, however, wish to construct aerials which will cover all channels allocated for their areas, or to design an aerial for the particular transmitter currently working. The following design information will enable constructors to build aerials both loft and outdoor, to meet their own specific requirements. The author does not claim that the information given is based on purely theoretical calculations, but it is based mainly on practical results.

LOFT AERIAL

Dealing first with the loft aerial, the reflecting elements are approximately three wavelengths long by one wavelength wide. The "bow tie" overall measurement ($4\frac{3}{4}$in × 2in, Fig. 2b) is half a wavelength calculated on the mean of the vision and sound frequencies for Channel 33.

Half a wavelength $\frac{\lambda}{2} = \frac{300 \times 10^6}{2f}$

If it is required to cover the four channels allocated (i.e. Channels 23, 26, 30, and 33), then the "bow tie" measurement will be based on the mean of the sum of all the four channels vision and sound frequencies. For the London channels this works out at approximately 530Mc/s (see Table 1). The shape of the "bow tie" elements is important as it provides for the correct impedance transfer to the coaxial cable. If the constructor keeps to the proper proportions shown, a very fair match will be obtained.

The distance of the "bow tie" from the apex of the reflectors is also important, with regard to matching; this should be half a wavelength measured from the apex of the "bow tie" triangle.

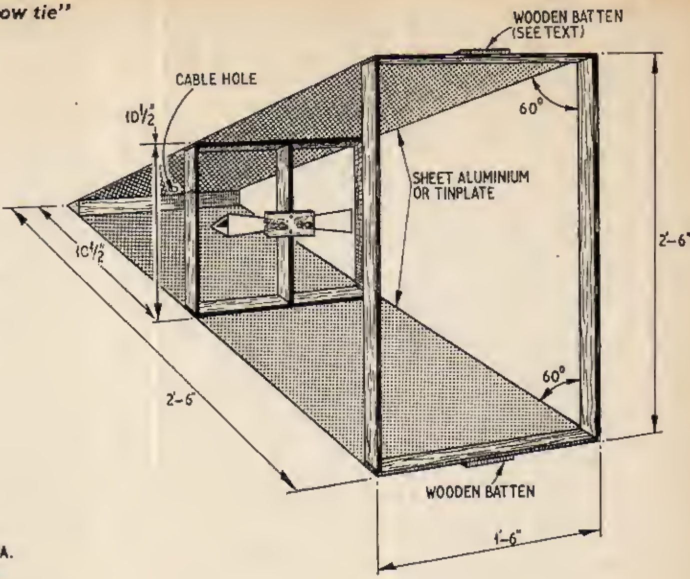


Fig. 1 (right). The complete loft aerial with the "bow tie" inside the 60 degree reflector

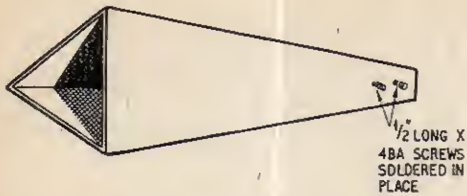


Fig. 2a. Half of the "bow tie" element for the loft aerial. The soldered join is along the back edge or "apex".

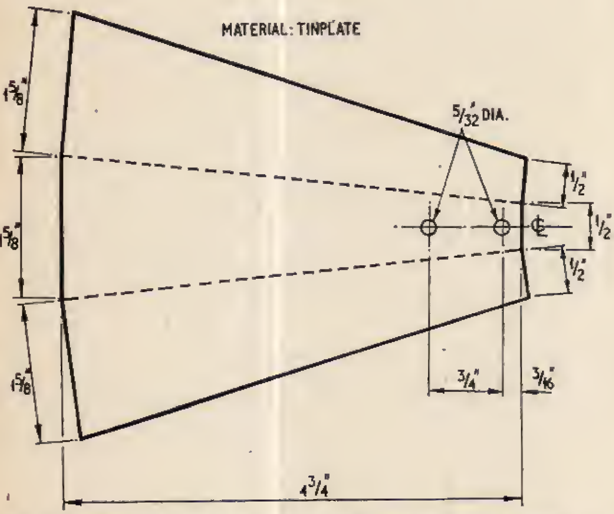


Fig. 2b. Constructional details of the "bow tie". Two are required to be made from sheet tinplate

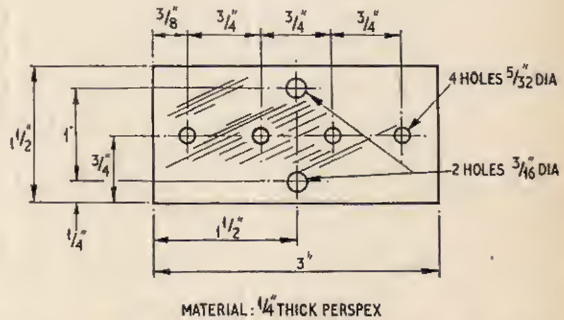


Fig. 2c. Perspex insulator for joining the two halves of the "bow tie" leaving a small air gap between them

The loft type aerial shown in Fig. 1 is of simple construction and has been designed to give best results on Channel 33. The measurements must be adhered to. Wood sizes have been left to the constructor, but the angle of 60 degrees should be accurate, as this contributes largely to the matching of the dipole to cable.

The "bow-tie" dipole elements (Fig. 2) can be made from tinplate and, before bending into shape (Fig. 2a), the 4 B.A. fixing bolts should be soldered in position to prevent turning when mounting on the perspex insulator shown in Fig. 2c. The aerial can be supported by cords attached to the wooden batten which runs along the middle of the reflector surfaces. The "mouth" of the aerial should be directed towards the transmitter and the aerial should be positioned as far away as possible from all metal fixtures (for example, pipes and tanks), which may be in the roof loft.

The gain from this type of aerial is high; it has been successfully used at distances of up to 20 miles from the transmitter. Positioning of the aerial is best carried out by two persons, one moving the aerial in the loft and the other at the receiver to note when best results are obtained.

OUTDOOR YAGI

The construction of the Yagi array calls for careful calculations and measurements. The dipole is half a wavelength overall and is calculated by using the following formula:

Length $= \frac{300 \times 10^6}{2 \times 530 \times 10^6}$ metres, which resolves to approximately 28·5 centimetres, which in British units is 11·5 inches. The figure 530 is arrived at by taking the mean of the sum of the vision and sound frequencies of all four channels. In using this formula a correction factor relating to the diameter of the dipole elements should be included, but in practice no ill effects could be observed by its omission. The parasitic element in the centre of the folded dipole is made approximately 15 per cent shorter than the dipole, i.e. approx. 9·5 inches.

The spacing of the Yagi elements from the folded dipole has been based on 0·25 wavelength which gives high gain and good matching. The reflector, which is generally designed at 10 per cent longer than the dipole, is in this case 40 per cent longer to improve the front to back ratio. The vertical overall measurements of the reflector is half a wavelength plus 10 per cent.

Table 1: ALLOCATION OF U.H.F. CHANNELS FOR BBC2

Station	Channels	Frequencies (Mc/s) Vision	Sound	Mean channel frequency (Mc/s)	Mean Station frequency (Mc/s)	in operation
Crystal Palace, London	33	567·25	573·25	570·25	530·25	now
	23	487·25	493·25	490·25		
	26	511·25	517·25	514·25		
	30	543·25	549·25	546·25		
*Sutton Coldfield, Warwickshire	40	623·25	629·25	626·25	664·25	now
	43	647·25	653·25	650·25		
	46	671·25	677·25	674·25		
	50	703·25	709·25	706·25		
Wenvoe, South Wales	44	655·25	661·25	658·25	672·25	12 Sept. 1965
	41	631·25	637·25	634·25		
	47	679·25	685·25	682·25		
	51	711·25	717·25	714·25		
Winter Hill, Lancashire	62	799·25	805·25	802·25	788·25	17 Oct. 1965
	55	743·25	749·25	746·25		
	59	775·25	781·25	778·25		
	65	823·25	829·25	826·25		
Emley Moor, Yorkshire	51	711·25	717·25	714·25	672·25	17 Oct. 1965
	41	631·25	637·25	634·25		
	44	655·25	661·25	658·25		
	47	679·25	685·25	682·25		
Rowridge, I.O.W.	24	495·25	501·25	498·25	540·25	14 Nov. 1965
	21	471·25	477·25	474·25		
	31	551·25	557·25	554·25		
	41	631·25	637·25	634·25		
Black Hill, Lanarkshire	46	671·25	677·25	674·25	664·25	12 Dec. 1965
	40	623·25	629·25	626·25		
	43	647·25	653·25	650·25		
	50	703·25	709·25	706·25		

All of the above stations are horizontally polarised.
The first named channel for each station is, or will be, used initially. The other three channels in each case are for possible future services.
* Sutton Coldfield is, at present, in operation temporarily on low power and becomes permanent on full power 4 October 1965.

Table 2: BBC2 FILL-IN STATIONS FOR THE LONDON REGION

Due to hills obstructing the path of u.h.f. signals to aerials in valley areas, the following fill-in stations are to be brought into service in the near future in the London Region.

Station	Channel	Frequencies (Mc/s) Vision	Sound	Mean channel frequency (Mc/s)	Polarisation
Hertford	64	815·25	821·25	818·25	All these stations will be vertically polarised
Tunbridge Wells	44	655·25	661·25	658·25	
Reigate	63	807·25	813·25	810·25	
Guildford	46	671·25	677·25	674·25	

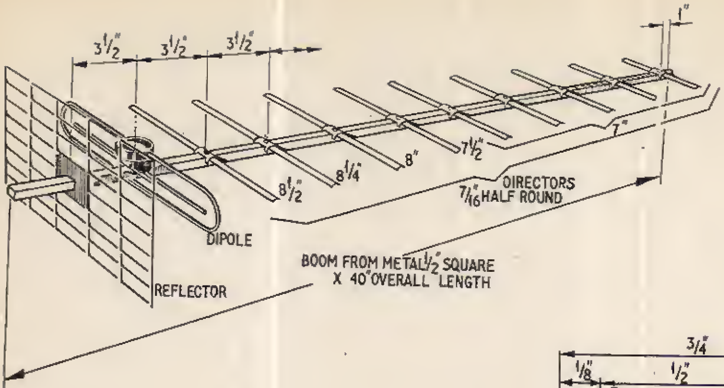


Fig. 3a (left). The outdoor Yagi array for Channel 33 ready for erection. Note the lengths of the directors. The last five directors at the end of the boom are all 7 inches long

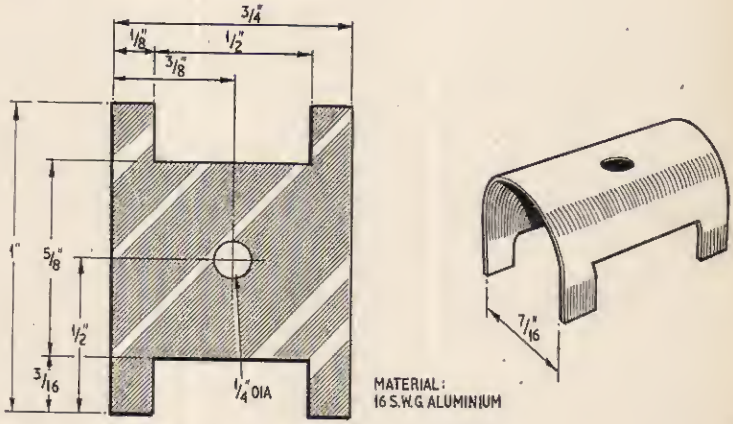


Fig. 3b (right). Constructional details of one of the clamps for fixing a director to the boom

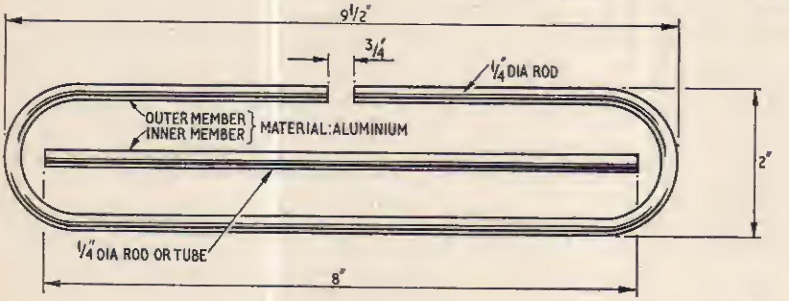


Fig. 4a. (left) The folded dipole. and central parasitic element for reception on Channel 33

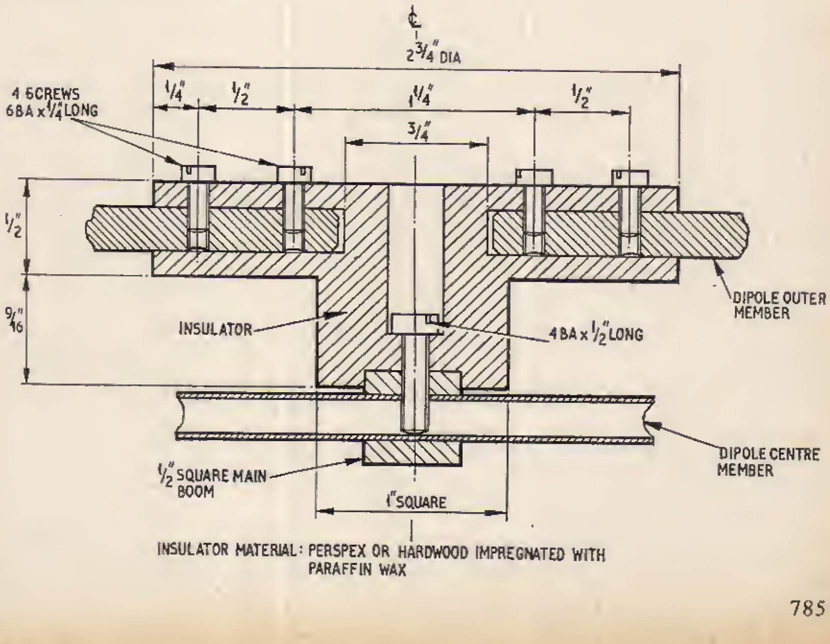


Fig. 4b. Method of mounting the dipole and central parasitic element. The centre member is a tight fit in a hole through the boom. The boom is then drilled and tapped to take the 4 B.A. screw which holds the insulator rigidly in position on top of the boom. The insulators can be made from round or square material as shown, but it must be strong and weather-proof. Connections to the dipole ends can be made by soldering lugs under the 6 B.A. screw heads on the uppermost surface

A*

The director elements are spaced 0·25 wavelength from the folded dipole and from each other. The director nearest the dipole is 10 per cent shorter than the dipole and 10 per cent longer than the next one in front. This can be continued for all the directors. In the aerial design given the last five directors were made the same length; no deterioration could be detected.

The design of u.h.f. aerials is a difficult problem and one that even manufacturers differ on. The problems which confront the aerial designer are many and whilst no claim is made that the design figures given are optimum, a very serviceable aerial can be constructed if they are carefully adhered to.

As an outdoor aerial is subjected to wind and rain the construction must be rugged but light in weight and rust resistant. The design is the result of a great deal of experimental work and gives excellent gain under adverse conditions. Used at 50 miles range with a single stage transistor pre-amplifier, excellent results can be obtained. The construction is straight-forward and well within the average experimenter's resources.

Since light weight is essential, aluminium has been used throughout with the exception of the securing clamps which are of steel, plated to prevent rust. Well painted brass or sheet iron clamps would do equally well.

Most of the metal sections used can be obtained from ironmongers or "do-it-yourself" shops, but in case of difficulty all necessary parts cut to size and drilled, can be obtained from Messrs. George Morton (Aerials) Ltd., Shuttleworth Road, Goldington, Bedford, who state that parts or complete sets of parts can be supplied for constructing these outdoor aerials —but not the loft array.

The main boom of the aerial is made of $\frac{1}{2}$in square section aluminium tube. The nine directors are $\frac{7}{16}$in half round section aluminium; each one is held in position by a 4 B.A. screw and clip which is fitted to each director to prevent it twisting out of alignment. Note the differing lengths of these directors in Fig. 3a and clip in Fig. 3b.

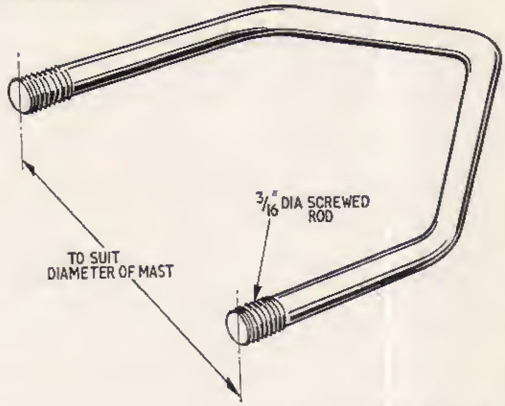


Fig. 5a. This 'U'-shaped cleat is fixed to the upper holes in the bracket (see below) to hold this bracket firmly to a vertical pole

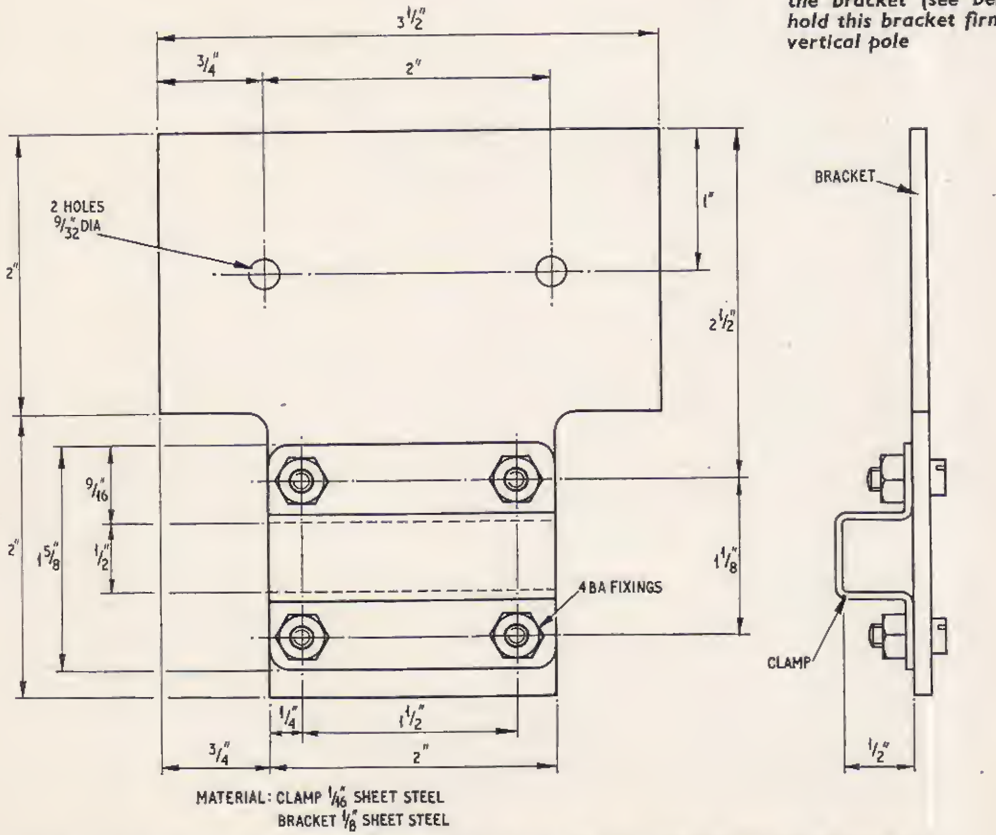


Fig. 5b. Details of the clamping plate and bracket. All parts should be well protected by painting with a primer, undercoat and gloss finish before assembly

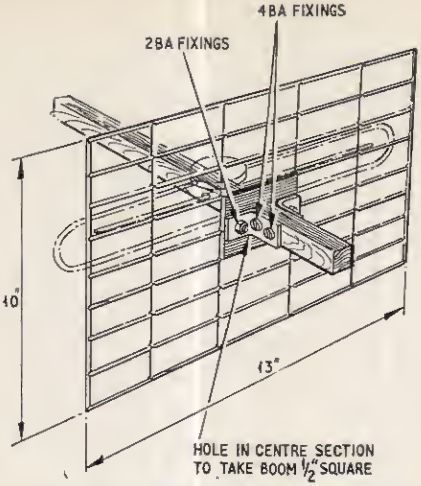
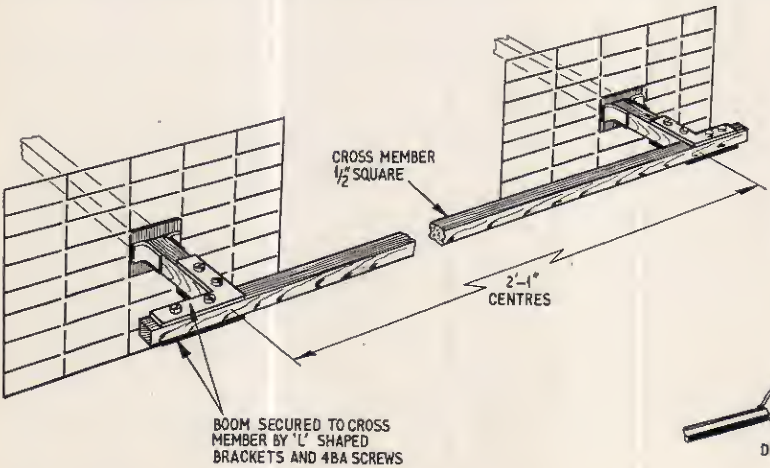


Fig. 6. Constructional details of the reflector fixed to the ½in square aluminium boom

The folded dipole is made from a piece of ¼in solid aluminium (this facilitates bending) and the centre element is of the same material (see Fig. 4a). It will be noted that an extra element is positioned in the centre of the dipole. This extra element is of the highest importance and is responsible for matching the dipole to the feeder cable.

The folded dipole calls for special attention. A special insulator (Fig. 4b) and connection has been used which protects the cable joints from the weather. The use of this special insulator is advised but readers may be able to improve on it and devise an alternative. One method of mounting the dipole and central element



is shown in detail. A block of perspex or hard wood impregnated with paraffin wax can be used. If this method of construction is used the terminal screws should be varnished or painted to prevent corrosion.

The reflector, behind the dipole, is of cast aluminium or it can be fabricated from stout galvanised wire as in Fig. 6. An alternative would be to cut the grid from hardboard and cover with foil.

Throughout the construction, spring washers should be used to prevent the elements becoming loose through vibration in the wind.

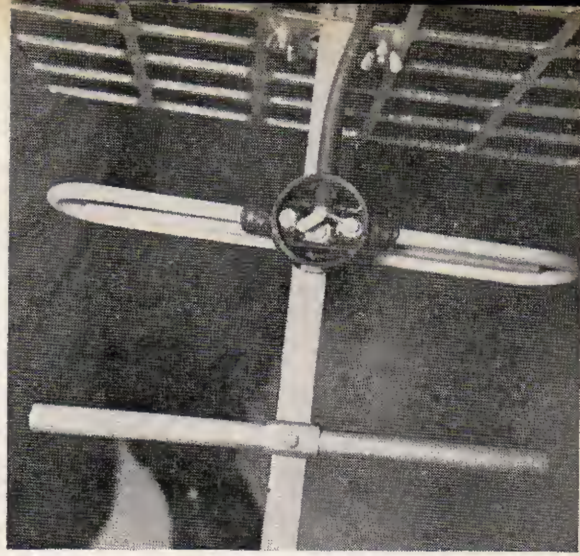


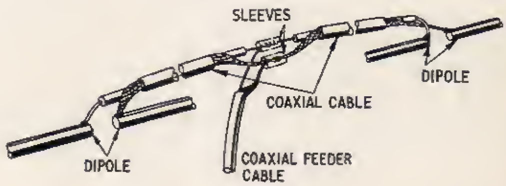
Fig. 7. Close-up view of the dipole showing the coaxial cable connections inside a moulded plastics insulator

ERECTION

The completed aerial should be erected in the highest position possible, consistent with the position of surrounding buildings, and accurately aligned on the transmitter with the help of a friend who can report on results from the receiver below. (Note the coaxial cable connections in Figs. 7 and 8b). U.H.F. aerials must be kept in strict alignment with the transmitter for constant results.

Fig. 8a (left). Details of a twin Yagi arrangement, showing the method of erecting the two arrays on a ½in square aluminium cross boom

Fig. 8b (below). The connections of the coaxial feeder cable to the two dipoles so that they are arranged "core, screen, core, screen"



Wooden poles should *not* be used for supporting the aerial, as they have been known to twist by as much as 15 degrees due to wet weather conditions.

For distance up to 20 miles, one array is sufficient, provided the site is not overshadowed by tall buildings. Under such conditions two arrays in tandem may be necessary (see Fig. 8 above). For long distance reception two arrays in tandem with a transistor pre-amplifier, preferably mounted at the mast head, will give reliable results. ★