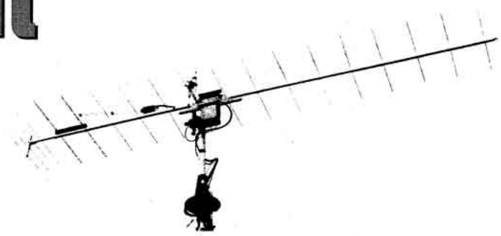
More Out Of Thin Air
(electronic edition)

To Index

'2BCX 16-Element 144MHz Beam



Fred Judd G2BCX

High gain beam antennas of the conventional Yagi type for 144MHz operation are of necessity rather long, the average being 5 to 6 metres to achieve a gain of more than about 14dBd (dB relative to dipole). The alternative way of obtaining high gain would be a pair of beams of smaller dimensions which, suitably phased, should (in theory) provide an increase in gain of 3dB over than of one by itself. Unfortunately, this rarely works out in practice, and the extra gain is usually somewhat less than 3dB.

In fact, the possibility of using a suitably matched and phased pair of 12-element ZL beams (page 72) was considered, since this antenna is physically smaller (3.2m) than a normal Yagi type having the same gain of 13dB.

However, this would have involved double the amount of material required for a single antenna (and thus twice the cost) and a spacing between the pair of at least 0.75λ (almost 2m) in order to achieve anything approaching the extra 3dB gain. Such an array would present a rather large total area to the wind. Neither did the 12-element ZL lend itself to achieving higher gain by simply adding more directors, at least not without extensive modification and increasing the length considerably.

A gain of 3dB over the existing gain of an antenna may not seem worthwhile, but it does in fact mean twice the original radiated power. For example, with an antenna such as the 12-element ZL having a gain of 13dB and radiating all of, say, 10W applied to it, the effective radiated power (e.r.p.) would be almost 200W. Another 3dB would mean an e.r.p. of nearly 400W!

Taking into account all of the foregoing observations, it was decided to investigate the possibilities of a beam antenna that would improve at least 16dBd total gain, be not unduly long, not too expensive to construct, be of reasonably light weight and not present too much area to the wind.

The '2BCX 16-Element Beam

The basis of this antenna is a double driven element and plane reflector system, designed to provide the highest possible initial gain. The driven elements are a pair of folded dipoles, coupled by a short crossed transmissions line so as to obtain current in one element in phase opposition to that in the other, ie. they are driven with 180° phase difference.

Such a system is commonly called an end-fire array (Ref. 1), which with close spacing between the elements (approx λ/8) provides the highest gain possible (nearly 4dB) with any driven linear pair (Ref. 2). The configuration of such an array and its radiation pattern compared with that from a dipole are shown in **Fig. 1**.

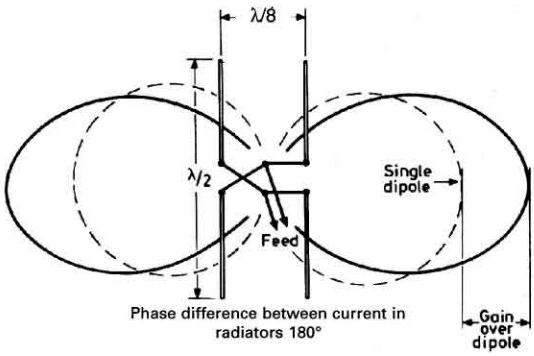


Fig. 1: Function of the two half wave driven radiators with currents 180° out of phase.

We now have a driven element system with a relatively broad bandwidth, by virtue of the folded dipoles, and a large amount of radiation in two directions, which allows the use of a reflector as well as a series of directors. The self impedance of this type of array is, however, only a few ohms and this becomes even less when parasitic elements are in close proximity. Hence the use of a half wave line section to secure a direct match to 50Ω coaxial cable.

Details of the whole antenna are given in **Fig. 2**, which includes all radiator lengths, etc., but not those of the plane reflector elements, the phasing line and the matching line sections. Details for these are included in other diagrams.

The total length of the antenna is 4.26m and it has a measured gain of 16dBd. Three prototypes were constructed and tested, and the final version as described here has been in use for almost a year at a height of about 8m above ground and 21m a.s.l.

Distances of 160km and over have been worked consistently on 144MHz f.m. regardless of conditions, and large numbers of continental stations (in France, Belgium, Holland and Germany) have been worked direct with average signal reports of well over S9 during only medium 'lift' conditions.

Construction

All details for construction as for the prototype shown in the photo are included in the various diagrams. It is important to maintain good insulation at the driven element and phasing line junctions, and along the matching line and its feed point and also to ensure that water cannot enter the phasing line and coaxial cable connection boxes.

The main boom is of 1in (25.4mm) square section aluminium tube and this is usually sold in standard lengths of 4m. The plane reflector is therefore mounted on a short length of 0.75in (19mm) square section tube that will fit into the end of the main boom as in **Figs. 3** and **4**.

Construction of the two driven dipoles and assembly with the phasing line box is shown in **Fig. 3**. This box can be made from plastics electrical trunking, blocked at each end with Perspex or plywood, about 10mm thick.

To Index

To Index

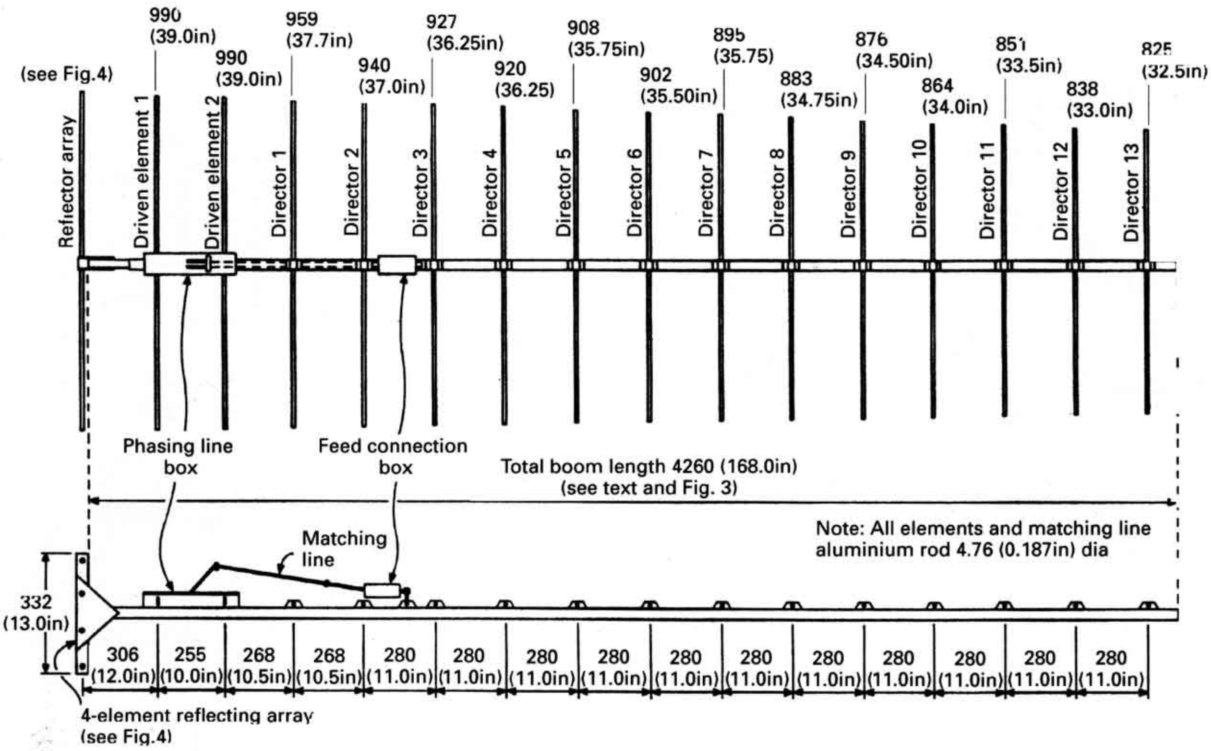


Fig. 2: General details - boom length and director lengths and spacing, etc. See also Figs. 4 and 5 for assembly of reflector and matching line.

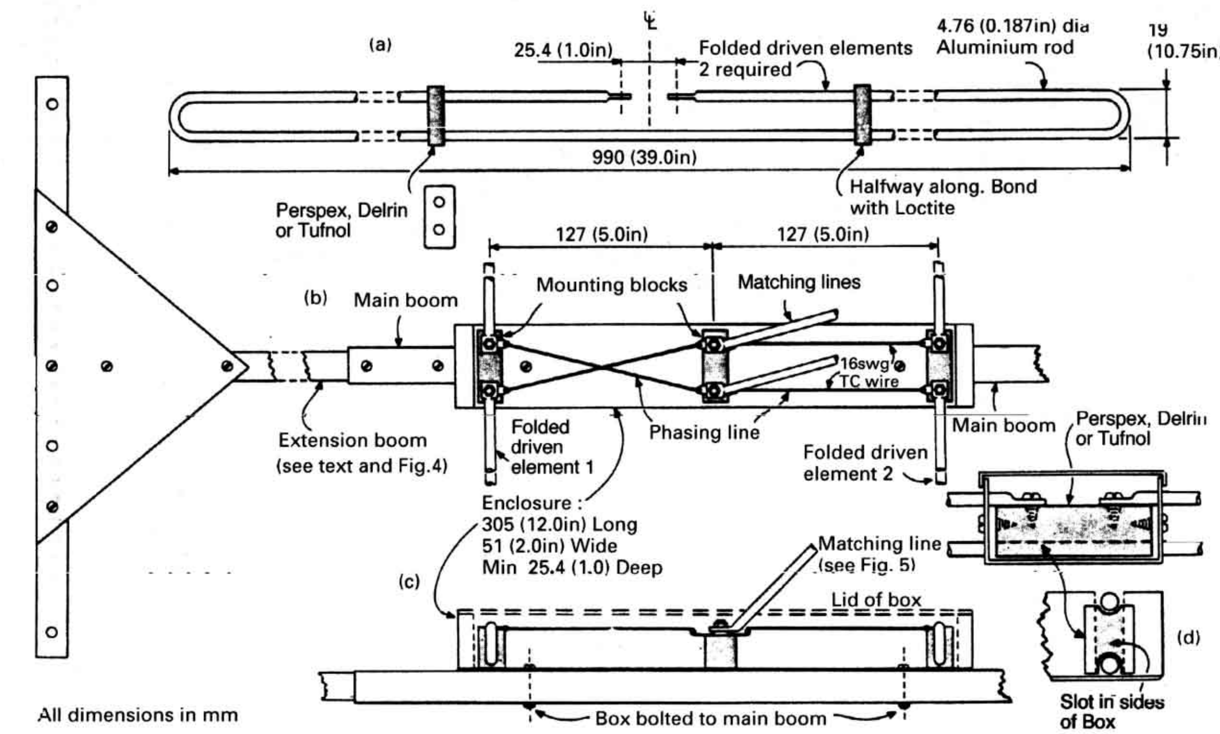


Fig. 3: (a) The half-wave folded dipoles (two required). (b) Phasing line and dipole connections - top view. (c) Side view - box bolted directly to boom. (d) Suggested method of securing dipoles within box.

To Index

To Index

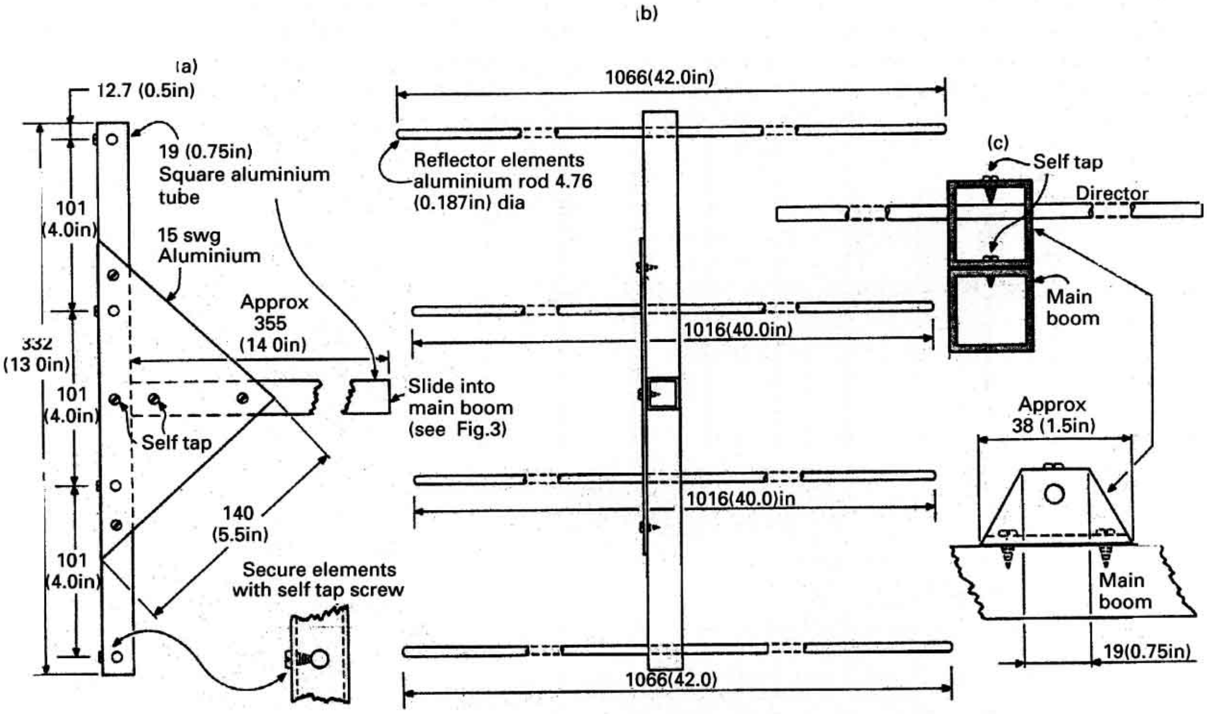


Fig. 4: (a) Side view - assembly of plane reflector. (b) Reflector details. (c) Method of securing directors to main boom.

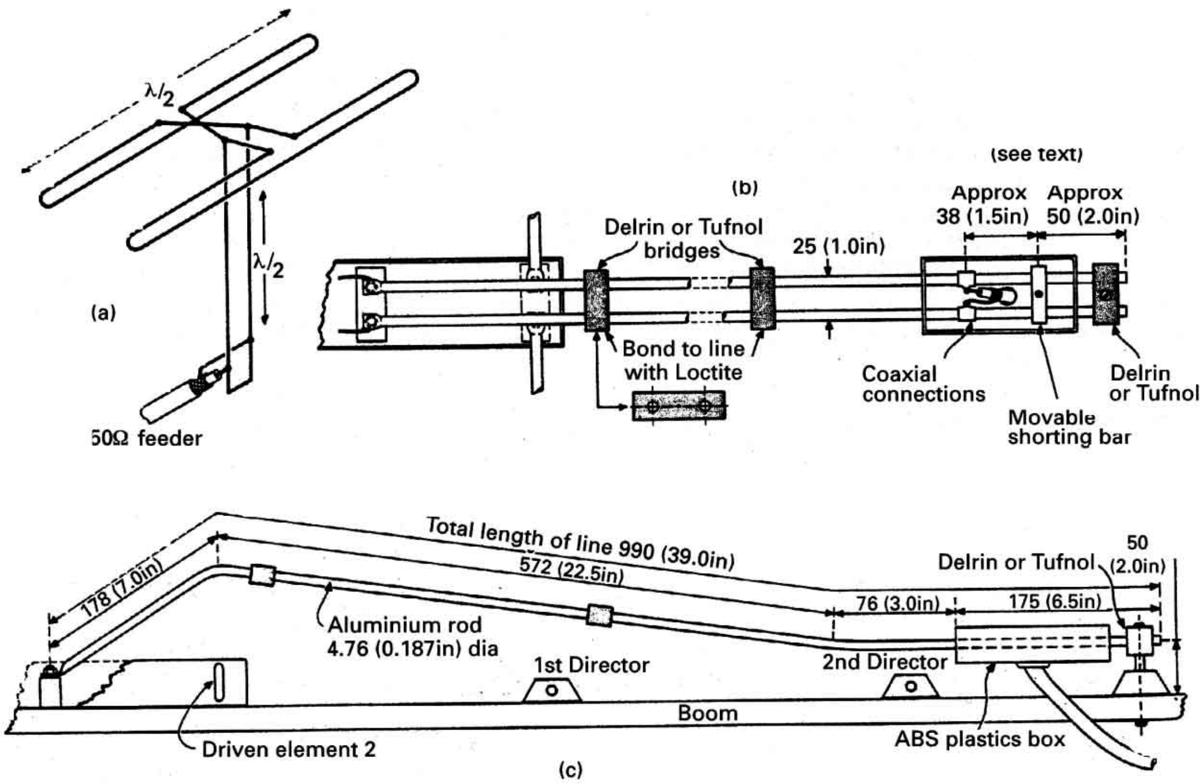


Fig. 5: (a) Method of half wave line match to primary radiators. (b) Top view of matching line assembly. (c) Side view.

To Index

To Index

may be Delrin, Tufnol, Perspex or p.t.f.e. Note how the matching line is connected to the centre of the phasing line, so to make entry holes for this in the lid of the box.

The two driven elements can be 'U' formed at each end by means of a round piece of metal or wood clamped in a vice. Heat the point where the 'U' bend is to be made but bend slowly and gradually and don't overheat the aluminium.

A trial on a scrap length is recommended. Remember, however, to put the element spacers on before the bends are made and thread these to the appropriate points before the connecting flats are hammered out and drilled.

Construction and assembly of the plane reflector is shown in **Fig. 4**. It consists of four elements to form the required plane area and lengths of these are set to take velocity factor into account.

Note also the method of securing the self-tapping screws (zinc plated) through the vertical boom, which is attached to the horizontal boom section by the triangular aluminium plate. Lengths and spacings for the 13 directors are given in **Fig. 2** and these are mounted on the main boom by supports cut from 1in (25.4mm) square section tubes as in **Fig. 4(c)**.

The final part of construction is the half wave matching line and coaxial line feed box as in **Fig. 5**, in which (a) shows the theoretical arrangement, (b) a view of the line form above and (c) from the side. The photo, **Fig. 6**, shows a close view of this assembly.

Make the holes for the line just large enough for the coaxial feed box to move backward or forward to facilitate the setting of the shorting bar and the points of connection for the cable. When these have been established, the box can be secured to the lines by Araldite.

Adjustment And Performance

Setting the feed point and shorting bar positions are the only adjustments necessary, but must be carried out with the full length of coaxial cable to be used, preferably low-loss cable such as UR67. Set the antenna up at least 2m above ground and in a clear space.

This will most likely be in the garden, and if the transmitter can be taken out near the antenna it will be much easier to watch the power or v.s.w.r. meter whilst adjustments are being made. Set the shorting bar and coaxial feed points has shown in **Fig. 5(b)**.

Adjust both one way or the other to obtain lowest v.s.w.r. or maximum power into the antenna at mid-band, ie. 145MHz. It should be possible to get the v.s.w.r. down to 1.1 to 1.2 at mid-band, and this should rise only slightly at each end of the band.

Before the antenna is finally hoisted to the mast, make sure that the phasing line and coaxial connection boxes are sealed everywhere against the ingress of water, eg. around the entry of the driven elements and matching line, etc. Suitable sealants are Scotchkote, Araldite or Evostik.

Give the phasing line and its bridge spacers one or two coats of polyurethane varnish. This is important for the prevention of r.f. leakage that could occur with rain or frost.

Finally, the radiation pattern of the antenna which is shown in **Fig. 7**. was obtained under ideal conditions and is the true pattern with a main lobe beam width of 30° at 3dB down. The radiation pattern in the vertical mode is almost identical except that the main lobe is a degree or so wider at 3dB down.

To Index

The second pattern, **Fig. 8**, was taken from signal arriving from a fairly long distance and with the antenna operating in a normal environment, ie. at the top of its mast at the writer's QTH. As will be seen, there is no distortion of the main lobe, and the minimal differences in the small side and rear lobes are due to random reflection likely to occur in normal condition.

Finally, it may be worth mentioning that the overall performance of this antenna in terms of gain and radiation pattern is virtually identical with that of a well-known commercial 16-element beam with a total length of 6m.

References: *Antennas*, Kraus McGraw-Hill.
Antenna Arrays with closely spaced elements. Proxc. IRE. Feb 1940.

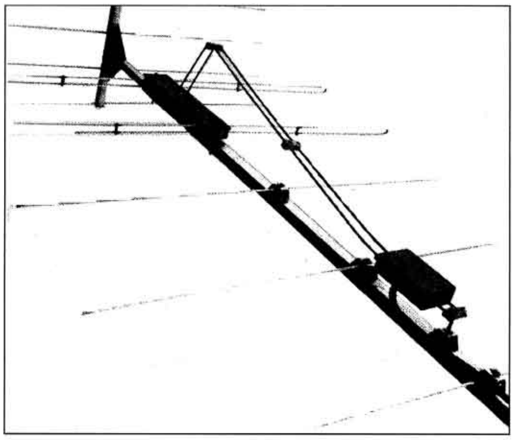


Fig. 6: Photo of phasing line box, matching line and coaxial connecting box.

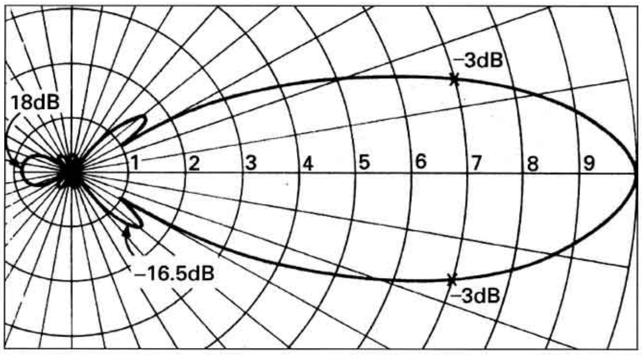


Fig. 7: Radiation pattern in horizontal mode under ideal test conditions.

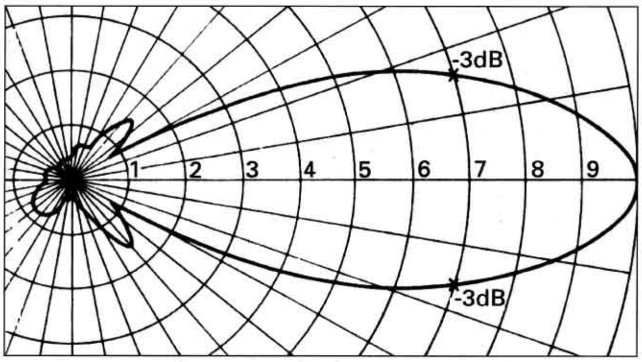


Fig. 8: Radiation pattern in horizontal mode with antenna in normal environment (see text).