The G4ZU "Bird Cage" Aerial

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A new array giving high gain in limited space. It is similar in some respects to a cubical quad but it has a much improved mechanical structure, higher gain, and facilities for multiband operation without using interlaced elements.

This project started in 1957, the object being to discover some simple structure which would give a power gain of up to 10 *db* in the 20-metre and possibly the 40-metre bands.

A 5-element *wide-spaced* Yagi can provide such a performance, but requires a boom length of at least 57′ on 20-metres and over 110′ on 40-metres. In the hope of achieving a reduction in physical size, tests were conducted with inductively loaded elements, but when an attempt was made to use more than three elements the gain did not increase according to the book. It was found that even the best loading-coils have an effective *rf* resistance of at least 20 ohms. Although the feed impedance of a loaded beam may seem to be around 45 ohms, and although the measured *swr* with a 52 ohm feeder appears satisfactory, the unpleasant truth is really as follows. The 45 ohm impedance at the feed point is made up of two components, the 20 ohm loss resistance in the coils plus the 25 ohm radiation resistance of the beam itself. In other words, only half the transmitter power is radiated. The rest goes to waste in the form of heat. These figures refer to measurements on a typical wide-spaced 3 element array. With closer spacing, and more elements, the position becomes even worse! A 5 element array has a radiation resistance of less than 10 ohms. With 20 ohms loss resistance more than two-thirds of the transmitter power is wasted. There seemed little hope of achieving the power gain desired by such methods. Tests were then made on loop type elements e.g. the Bruce, Bi-square and simple Quad. When used with a second element of similar type, suitably phased, such configurations are capable of quite appreciable power gain. Ten *db* gain would probably be a rather optimistic estimate, but 8½ *db* gain can be realized without much difficulty. There is, however, the disadvantage that the adjustment which provides maximum back-to-front ratio, does not coincide with that for maximum gain. A double loop array also poses numerous mechanical and structural problems. Bamboo rods or wire are all very well for a temporary lash-up, but the appearance could hardly be called professional! The problems to be solved seemed to fall under the following main headings.

1. To devise an entirely new mechanical structure and so position the elements in space as to achieve a sound and clean looking engineering job.
2. To endeavor to arrange that the tuning positions for maximum gain and maximum front-to-back ratio are as far as possible coincident.
3. To find some means for providing additional gain with the object of attaining an overall figure of 10 *db*.
4. To flatten the somewhat sharp tuning and increase the band width by using tubular elements of a reasonable diameter and at the same time to eliminate wood or insulators at high voltage points as these cause serious loss in wet weather.
5. To make provision, if possible, for multiband operation without using interlaced elements.

Keeping all these points in mind, it seemed that the best approach would be to build up an entirely new structure in space starting from first principles, and giving special consideration to item 3—Increased gain. The diagrams show how the array began to take shape. Figure 1 is an ordinary half-wave dipole with a bi-directional pattern. Figure 2 shows a "V" dipole. Such an arrangement, when used with a reflector of similar construction, gives considerable power gain and the front to back ratio greatly exceeds that which can be obtained with a normal two element array.

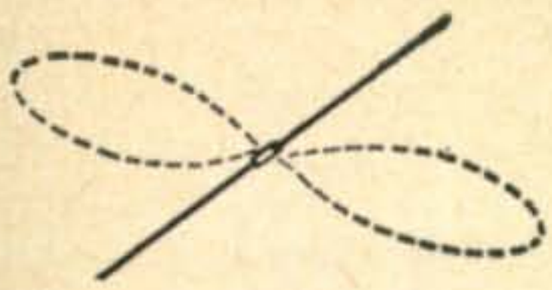


Fig. 1—Half wave dipole with bi-directional pattern.

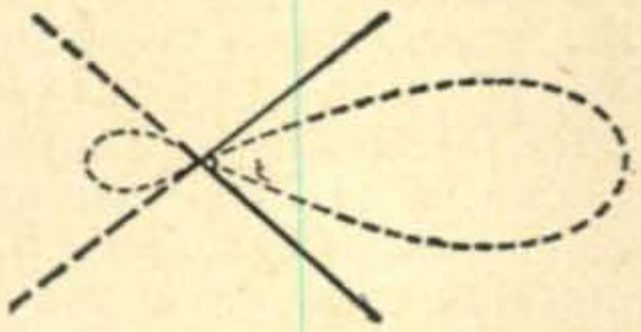


Fig. 2-A V-dipole provides an increase in gain in one direction.

needed. Figure 3 shows two "V" dipoles stacked vertically and fed in phase so as to provide additional power gain. Figure 4 shows the end eighth-wave of each element bent inwards until

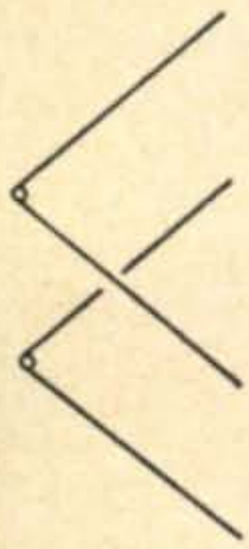


Fig. 3—Stacked V-dipoles fed in phase will provide a power gain.

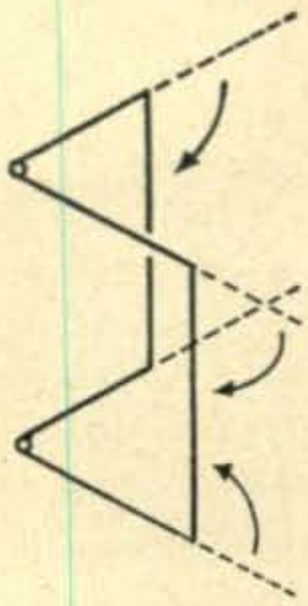


Fig. 4—The end ⅛ wave of each element is bent in.

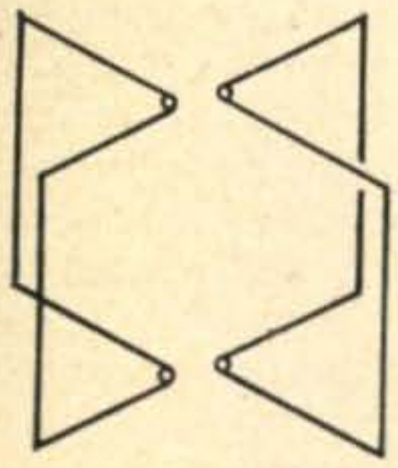


Fig. 5—A reflector is placed in rear of driven element.

they meet. Power can now be fed to the closed loop at a single point either at the top or at the bottom. The next move is to put a similar structure, operating as a reflector, back-to-back with the first (fig. 5).

Construction

Coming now to the actual physical construction Fig. 6 shows one possible approach. Eight radial elements each only one-eighth wavelength long are arranged symmetrically in two stacked bays around a vertical mast. These elements can conveniently be made of ordinary dural tubing. To maintain a correct phase relationship between the two bays, the tips of the elements are joined together with vertical wires approximately one-quarter wavelength long. This incidentally helps to brace the elements against vibration, and ensures a very low wind

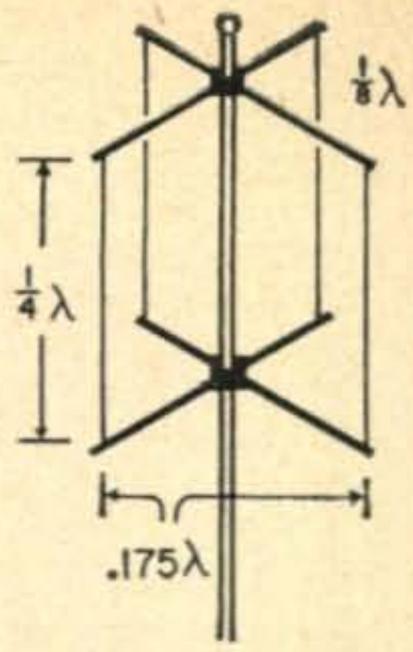
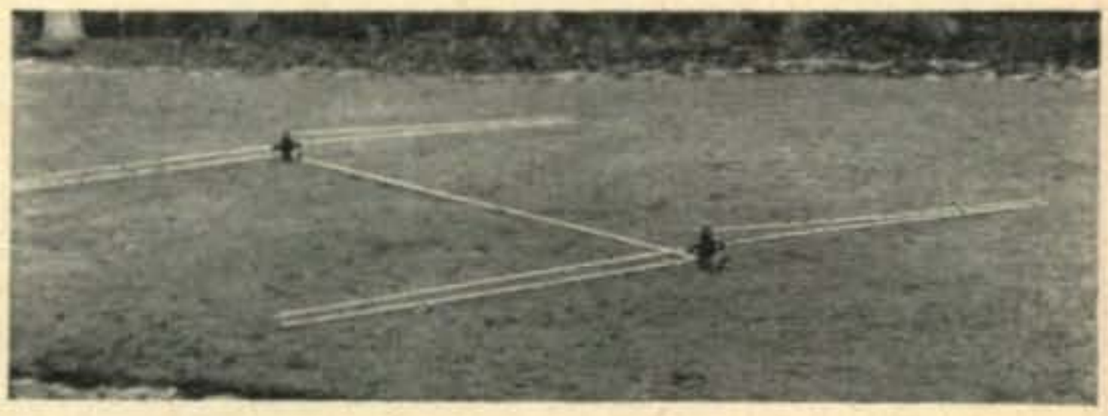


Fig. 6—A possible method of construction.

resistance. It will be immediately apparent that such an arrangement is much more attractive from a structural point of view than the normal cubical quad. Fig. 7, A & B. Due to the "V" dipole effect the power gain is also 1-1½



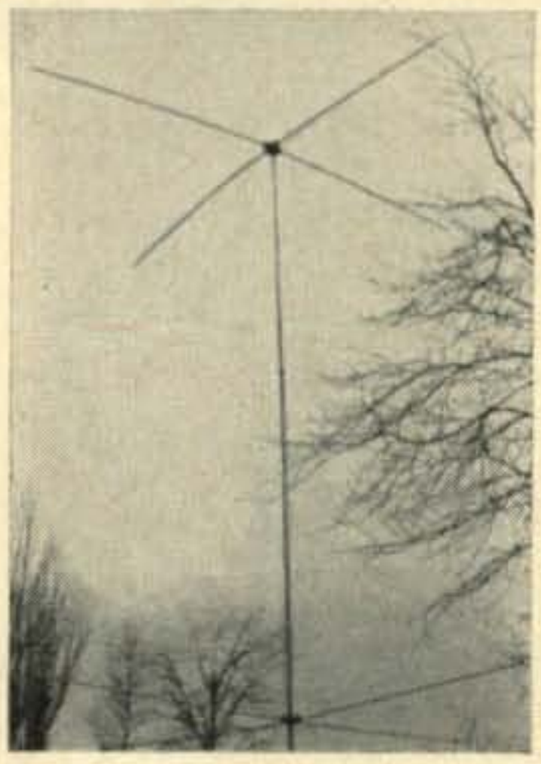


Fig. 7A—(Above) Before erection.

Fig. 7B—(Left) After erection, with radial arms disposed at right angles.

db better. Further, it was found that, quite by chance, the side lobes with this type of arrangement are practically non-existent and the adjustment for maximum gain coincides very closely with the adjustment for maximum front-to-back ratio. It will be seen that the spread of the array and the spacing between the vertical wires is approximately .175 of a wavelength so that it can rotate in a circle of 8′ radius. With such a spacing the feed impedance comes out to quite a convenient figure of 40/50 ohms depending upon tuning and height above ground. The general performance was so promising that in February 1958 a Patent Application was filed under serial 4083/58. A number of additional developments were then completed, to give more flexible methods of feed and to provide multi-band operation, and these improvements were incorporated in a further Patent Application filed in January 1959 under serial 187. Some of these modifications are shown in figs. 8, 9 and 10. Fig. 10 in particular should prove attractive to those with limited

space as it is effective not only on 20 metres but also on 40 metres, with a turning circle radius of 8'! The stub which in the drawing is shown flapping in the breeze would of course in actual use be passed down inside the tubular mast.

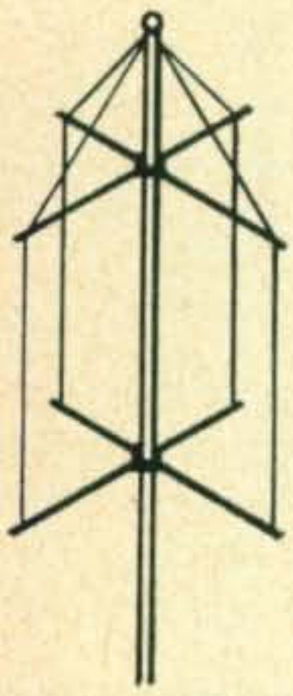


Fig. 8—Vertical wires extended to brace the radial elements.

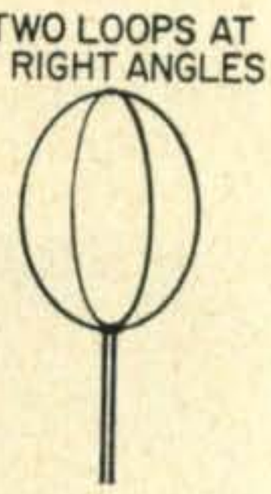


Fig. 9—Two loops at right is another form of birdcage.

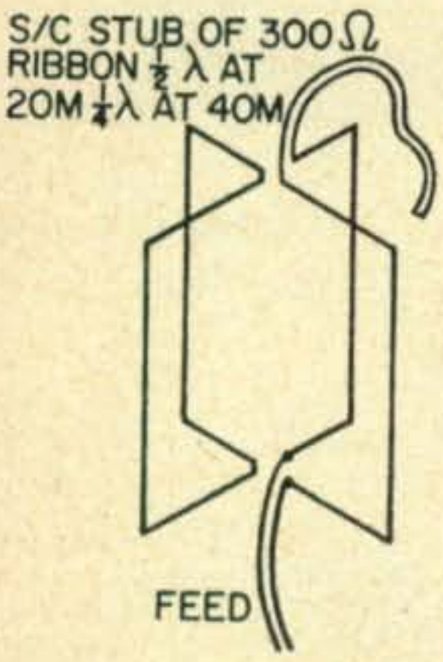


Fig. 10—This construction is ideal for 10 and 20. The stub may be inserted in the mast.

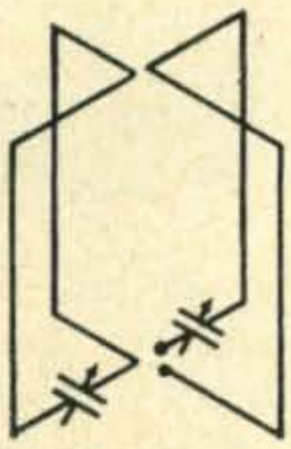


Fig. 11—This single band job uses a condenser to tune the reflector for maximum gain. The condenser in the radiator is tuned for minimum swr.

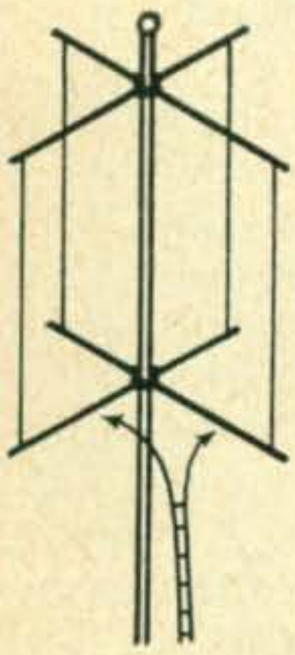


Fig. 12—Tapping points along the radiators permits selection of impedance from 50 to 600 ohms.

Single Band Operation

For those who are only interested in single band operation fig. 11 shows another interesting arrangement. The height of the array is increased to just over one-quarter wave-length so as to be resonant outside the low end of the band. The series condenser on the reflector loop then permits precise adjustment for maximum gain at any point *in* the band. The series condenser on the radiator feed provides adjustment for the lowest possible standing-wave ratio in the feeder. Another approach would be as per fig. 12. Tapping points on the radiator rods after the style of a T-match would permit selection of an impedance to suit anything from co-ax to a 300 ohm or 600 ohm open wire line.

Credit must go to the little girl next door for christening the array. When tests were first being made on a scale model at 145 *mc* she asked if the thing on the pole was a "Bird-Cage?" The label seems to have stuck and all things considered it is perhaps not inappropriate.

For the benefit of those who would like to give the Birdcage a try, dimensions are given in the appendix which should enable anyone to construct the single-band version without difficulty. The dimensions are for 20-metres but can of course be re-scaled for other bands.

Technical Appendix And Constructional Details

For 20m. Horizontal elements: all ⅛ wave long. 8ft—8ft 8 ins
Vertical wires. all ¼ wave long. 17ft approx.

Precise length of vertical wires can be adjusted for resonance and lowest SWR at the desired frequency, or the series condenser method of fig. 11 can be used.

The reflector should be tuned for max F/B ratio. The easiest way of doing this is terminate the lower end of the reflector loop in an open wire stub and slide a shorting bar along the stub for minimum radiation off the back. This setting will be very close to the adjustment for maximum gain.

The eight radial rods can be supported by blocks of insulating material or ordinary harwood dipped in wax. The *rf* potential is low and no leakage problems will be encountered.

Total distance round radiator loop is approximately one wavelength or $2 \times \frac{495}{f}$

Reflector loop is 5% longer due to extra wire in the stub.

It is an advantage when using coax cable to feed the radiator loop at the *top* taking the feeder up *inside* the quarter wave vertical mast. This gives perfect Balun Action thus avoiding loss or pattern distortion due to feeder radiation, and is much more satisfactory than so called gamma matches which are critical in adjustment and likely to introduce power losses.

Radiation is entirely horizontally polarized. There is a phase reversal at the centre of each vertical wire with zero current flowing. The vertical wires fulfill the same function as the

[*Continued on page 117*]

been interested in the instrumentation which amateurs could make themselves, so as to better understand the principles and processes involved in radio.

Reinartz retired January 30 from his post at Eimac. He and his wife, who now reside in Burlingame, plan to retire to Aptos, where they'll continue to be active on the air—and Reinartz can get in plenty of fishing.

Mrs. Gertrude Reinartz, daughter of a South Coventry farmer, only recently gave up letting her husband be the only radio amateur in the family—after 43 years of marriage. She's now K6MJH. ■

CONVERTER [*from page 43*]

used equally well in this position, such as the 7F8, 6J6, 12AX7 or 12AT7). Recent articles in a number of magazines have shown dual-triode oscillators of this sort, but so far as is known they have not been used in broad-band converters.

The final result of this rather simple modification is a mobile converter that performs exceedingly well, being nearly as stable as a crystal-controlled converter. There is no longer any evidence of mixer pulling, thus making alignment a breeze by comparison. Changes in the B-plus voltage have almost no effect on the oscillator frequency. It may not be crystal-controlled, but it's mighty hard to tell the difference now. ■

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vertical wires in a Zerba or Lazy H and are used solely to provide correct phasing between the upper and lower bays.

The X construction brings the current loops in close proximity giving power transfer to the parasitic element more efficiently than with a Quad or 2 element yagi. The performance closely approaches that of an all driven array.

The main advantages over a cubical quad are as follows:

1) No horizontal boom to distort the pattern or absorb energy.
2) No insulators at high voltage points to introduce loss.
3) Tubing is used in place of wire for the parts of the array carrying maximum current. i.e. Less resistive loss.
4) Perfect balun action due to the quarter wave vertical mast. No matching to adjust—no line radiation.
5) The X type elements have higher Q than a quad loop. The gain is therefore improved. (See W6SAI antenna handbook)
6) The X elements give better F/B ratio.
7) The mechanical advantages are self evident.
8) Extremely low angle of radiation when used at normal heights. ■