Director Beams

Improved V.H.F. Antenna Performance with Fewer Elements and No Reflectors

BY FRANK C. JONES,* W6AJF

Nearly all v.h.f. beam antennas use resonant reflectors, to provide good forward gain and reduce signal pick-up and radiation from the rear of the array. However, an investigation of several types of beams conducted in the 220-Mc. band showed that it is possible to dispense with reflectors entirely. Furthermore, by modification of the usual collinear arrangement, a design was evolved that used only half as many directors as one would expect.

The result was a 6-element array with performance equivalent to that of the usual collinear arrangement having four half-wave driven elements, with reflectors. Two of these can be combined into a 12-element beam that is equal to the conventional 16-element design. Of even greater interest, the front-to-back ratio can actually be made better with directors only, without the usual sacrifice in forward gain that is entailed in adjusting for optimum front-to-back ratio.

If a reflector type of beam with four driven elements and four reflectors is adjusted for good front-to-back, over 12 db., the forward gain is reduced at least 1 db.; if it is adjusted for best forward gain, the front-to-back ratio is liable to be considerably less than 10 db. On the other hand, a director-type beam of four driven elements and two directors can be adjusted to provide more than 15 db. front-to-back ratio, without sacrificing more than ½ db. forward gain.

An example is a 12-element 2-meter director beam at W6AJF that has a front-to-back of 17 db. and a forward gain of approximately 13 db. A conventional 16-element collinear array can be adjusted for about this same gain, but the back lobe becomes objectionable, so the usual dimensions provide about 12 db., with a front-to-back ratio of 10 to 12 db.

Something for Nothing?

This better front-to-back and more forward gain with less elements in the array looks like a claim of something for nothing, but such is not the case. There is a price. The director beam must be made with close director•spacing to obtain good rejection off the back without sacrificing forward gain. This means low radiation resistance at the current points, less bandwidth and increased difficulty in matching the beams to standard transmission lines.

The bandwidth limitation is not serious at 144 or 220 Mc., as the director-type array has a bandwidth of about 5 Mc. in these bands, compared to 8 or 12 Mc. for the conventional collinear designs. The bandwidth of the director beam for 50 Mc. would be only about 2 Mc., and perhaps 12 Mc. or so at 420 Mc. These values are too low for full band coverage, so the design would have to be for the parts of these bands which are of primary interest. The bandwidth is ample for the 144- and 220-Mc. bands with design centers at 146 and 222.5 Mc.

A close-spaced director, whether used with one or two driven elements, detunes the driven elements and all elements have to be made a little longer than expected. For example, a director in this design is 39 inches long for the 2-meter band, and 25½ inches long for the 220-Mc. band. Fortunately, the driven elements can be tuned to resonance by a short stub, and the main transmission line tapped across this stub at the proper point for impedance matching. There is, therefore, no critical length for the driven elements in

◆

A 6-element 2-meter array that outperforms the conventional 8-element job. It uses shortened driven elements in pairs, with a single director for each pair. W6AJF's daughter tries it on for size.

◆

---

* 850 Donner Ave., Sonoma, Calif.

such a system. Where two such 3-element bays are used a single stub can be used to resonate the entire system.

In curtain arrays or with Yagis spaced a half wavelength apart, there is a bucking action of directors of one bay upon those of the other. Reflectors spaced a half wave apart aid slightly in the forward gain of a beam, especially in a 4- or 8-element design. Directors, on the other hand, tend to cancel each other's gain when used at half-wave spacings between bays. It was found that ⅝- to ¾-wavelength spacing minimized this effect when two directors were used, but ⅝ wavelength was not sufficient spacing for two bays having four directors each in a broadside beam, in tests at W6AJF. A 2-meter vertically-polarized beam of this type had a very sharp front lobe, with large side lobes and less than expected forward gain. When the two 6-element Yagis that made up this array were cut apart and stacked vertically, a considerable improvement in forward gain resulted, and there was a marked reduction in the side lobes.

One Director for Two Driven Elements

In stacking the 3-element design shown in Fig. 1 the director current maximum points are spaced about a wavelength apart, so there is no appreciable cancellation. A broadside spacing (in vertical arrays) of about ¾ wavelength (60 inches at 2 meters) seems a good compromise value as regards amplitude of side and back lobes.

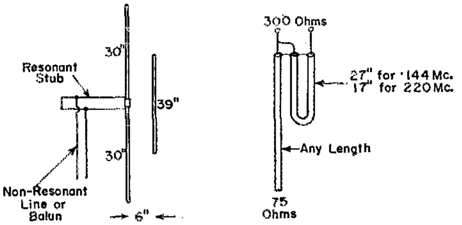


Fig. 1 — A single 3-element 2-meter array having shortened driven elements and one director. Gain of this system is 7 db. A balun for use with coaxial line is shown at the right.

The idea of using a single director with two driven elements, as shown in Fig. 1, was developed by Ralph Bykerk, W6YSD. Tests on 220 Mc. proved that actually more gain could be obtained with one director than with two, when using two half-wave driven elements, because of the close end-to-end spacing of directors when two are used. Gain measurements at 145 and 221 Mc. showed 7 db. gain with this simple 3-element beam, and front-to-back ratios as high as 30 db. Six-element beams of the type shown in Fig. 2 gave maximum values of 11 db. forward gain, with an average of 10 db. over the whole 144- and 220-Mc. bands.

The two driven elements were originally cut to 38 inches (for 2 meters) but a reduction of the radiating portions to 30 inches did not reduce the forward gain because the two current points were moved down behind the director. Apparently, the gain of this arrangement compensated for the reduction in field strength, from the driven elements alone, when their current maximum points are brought to less than a half wave apart.

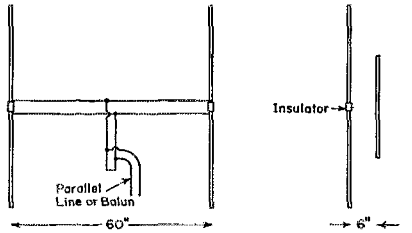


Fig. 2 — Two 3-element arrays for 144 Mc. may be connected about ¾ wavelength apart to make a 6-element beam having a gain of 10 db. or better.

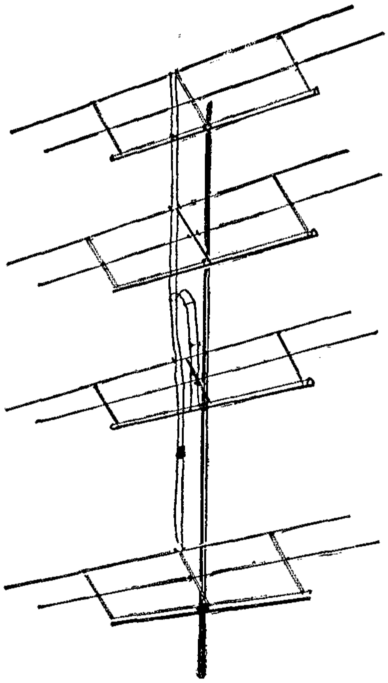
The shorter driven elements require a longer tuning stub for the whole beam.

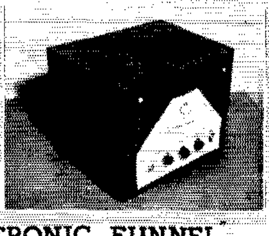
One 6-element array, shown in the photograph, uses 300-ohm Twin-Lead for all portions of the feed system. The driven elements are half-inch aluminum tubing 31 inches long, mounted on ³⁄₁₆-inch canvas bakelite insulators. The latter have short aluminum sleeves over them where they pierce the 1-inch mounting booms, leaving an insulation gap of about ½ inch on each side to the two driven elements. The main boom is 1-inch aluminum tubing 5 feet long, so the distance between the elements is 58 inches. The short booms on which the directors are mounted are 7 inches long, to allow a spacing from the driven elements of 6 inches. The directors, being mounted at their electrical centers, are not insulated.

The phasing line of 300-ohm Twin-Lead is not transposed. For this particular antenna the tuning stub was 32 inches long, with the 300-ohm feeder tapped up 3 inches from the shorted end. For test purposes, a balun was used at the feed point to step this impedance down to 75 ohms for connection to 75-ohm coaxial transmission line to the transmitter. Extreme care must be taken to maintain exactly equal line impedances and power input to the lines when comparing a beam with a standard dipole antenna for relative forward gain figures. These conditions are most readily met when coaxial line is used.

Another 2-meter 6-element beam was made with open-wire feeders. In this case the directors were 39 inches long, of ¼-inch diameter, mounted 6 inches in front of the driven elements, as before. The latter were 30 inches long, of the same material. End insulators were of fiber bakelite tubing, ½-inch o.d. and ¼-inch i.d., to take the driven elements. This particular model had 54-inch spacing broadside, instead of the preferred value of about 60 inches. The tuning stub of open-wire line turned out to be 43 inches long, with the main transmission line tapped at 6 inches from the shorted end. The length of the stub should be adjusted for resonance at the band

(*Continued on page 128*)





Director Beams

(*Continued from page 24*)

center, and the position of the taps for the transmission line should be made carefully for minimum standing-wave ratio. Both adjustments can be carried out experimentally by means of a power-indicating standing-wave meter. A suitable balun is shown in Fig. 1.

One of the 12-element beams, Fig. 3, has No. 12 wire on 2-inch spreaders (for high power) for the phasing lines. Each line was made the same length, and tapped at the exact center, so that each pair of driven elements would be in phase. The whole system was then resonated with a single shorted stub approximately 40 inches long. The balun taps were about 5¼ inches up from the short in this case. The positions for the short and the taps were found by using a temporary stub about four feet long, sliding the shorting bar and the taps until maximum forward power and minimum reflected power were indicated on the s.w.r. meter.

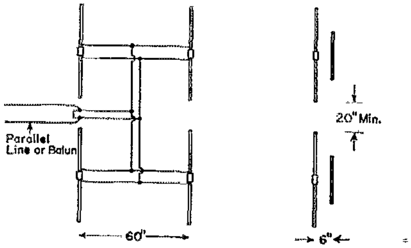


Fig. 3 — **A 12-element array having a gain of 13 db. The entire system may be fed through a single tuning stub as shown.**

A 6-element array for 222 Mc. has driven elements 20 inches long, with directors 25½ inches long of ¼-inch thin-walled brass tubing. End insulators of ¼-inch o.d. fiber bakelite mount in a 1⅛-inch square wooden boom 3½ feet long. The directors are 4 inches in front of the driven elements. The phasing line of TV ladder line is 40 inches, with a 26½-inch tuning stub at the center. When 300-ohm tubular-type line is employed it is tapped 2½ inches up from the short. Metal construction would have been satisfactory, but in view of the small size, wood was used.

The simple 6-element array of Fig. 2 offers good possibilities for portable operation. A gain of 10 db. or more over a car antenna of the same height (more if a few feet of mast is added) can mean a tremendous improvement on long-distance contacts. Either the 6- or the 12-element beam is light in weight and of low wind resistance and can be handled readily by one man. The horizontal directivity pattern is the same with both beams (when vertical polarization is used) but the gain of the 12-element array is increased by 3 db. because of the lowered vertical angle of radiation.

(*Continued on page 130*)

Applying the Principle to Long Yagi Arrays

A conventional 6-element Yagi with one reflector and four directors gave a measured gain of 9 db. over the reference dipole. A special Yagi with two shortened driven elements and four directors (no reflector) gave 10-db. gain at 145 Mc. Apparently, this design can be used on Yagi antennas to give better performance, and preliminary calculations indicate that a single long Yagi can be tuned up to operate over one megacycle of the 2-meter band with a forward gain of 17 db. This would involve a boom length of some 24 feet, however. Experimentally, it may be possible to better this figure for a very narrow bandwidth. This offers interesting possibilities for long-distance 2-meter c.w. communication, say, between 144.0 and 144.2 Mc., with selective receivers and a few hundred watts of transmitter output.

"Tiny Tim"

(*Continued from page 27*)

be operated from a car using an 8-foot whip, properly loaded, worked against the car body as ground. I'm even thinking of trying it as aircraft mobile!

With this self-contained ham station you built yourself, you're ready for any emergency with a reliable, low-power c.w. station on 40 and 80 — and you can have plenty of fun with it from your home station, out in a boat, at the beach, climbing a mountain, or whatever.

I wish to acknowledge the helpful suggestions of the late Walter Bradley, W1FWH, of ARRL, and the assistance of my 11-year-old son, WN1BRS, in assembling the rig and manning the home station during tests.

I.F. Amplifier

(*Continued from page 34*)

The over-all bandwidth of the amplifier can be calculated from

$$\Delta f \cong k_c f_0 \sqrt{2} \sqrt[4]{\left[\frac{1}{m^2}\right]^{\frac{1}{n}} - 1}$$

$$\text{where } m = \frac{\text{voltage at } \frac{\Delta f}{2} \text{ cycles off resonance}}{\text{voltage at resonance}},$$

n = number of identical stages.

For the bandwidth at 3 db. ($n = 3$),

$m = 0.707$,

$\Delta f = 112$ cycles.

The response curve of the complete amplifier is given in Fig. 6. The bandwidth is 220 cycles at 20 db. down and 1000 cycles at 100 db. down.

B.F.O.

In the unit constructed by the author, the b.f.o. inductor, L_7, has a Q of about 25. The coil

(*Continued on page 132*)