A Dish Antenna Anyone Can Build

— no hyperbole, just a parabola

Michael Brown W8DJY
6297 Brown Run Road
Middletown OH 45042

Are you contemplating the challenge of operating on the amateur microwave bands? What about getting in on the excitement of receiving satellite TV signals? These and similiar projects usually require a dish-style antenna. You could buy one or, better yet, you can build one. This article will tell you how.

I wanted to put a signal on the 1296-MHz band. To do the job right, I needed a dish antenna. I took the plunge at a hamfest, buying a surplus military job made of spun aluminum, about 6 feet in diameter. It was one of those good deals you can't pass up.

Now my "good deal" sits in the corner collecting dust, waiting to be sold at the next hamfest. I managed to get a signal on 1296 using a dish two meters in diameter that I built myself. The design is one which uses easily-obtained materials and has a total cost of less than $100. Best of all, it need not be a long, involved project. In fact, you can build a dish like mine in a single weekend.

Photos by Tim Daniel N8RK

Photo A. The finished dish is light enough to be moved easily; the author stores his away each winter.

Some Theory

Before we jump into the details of construction, it would be a good idea to look at the basics of dish design. The dish, resembling an oversized child's snow saucer, is a paraboloid. Its unique geometric properties cause it to collect a beamwidth of energy from a distant source and reflect it to a central point known as the focal point, or focus. Similarly, a signal radiated towards the dish from the focus will be effectively radiated by the antenna.

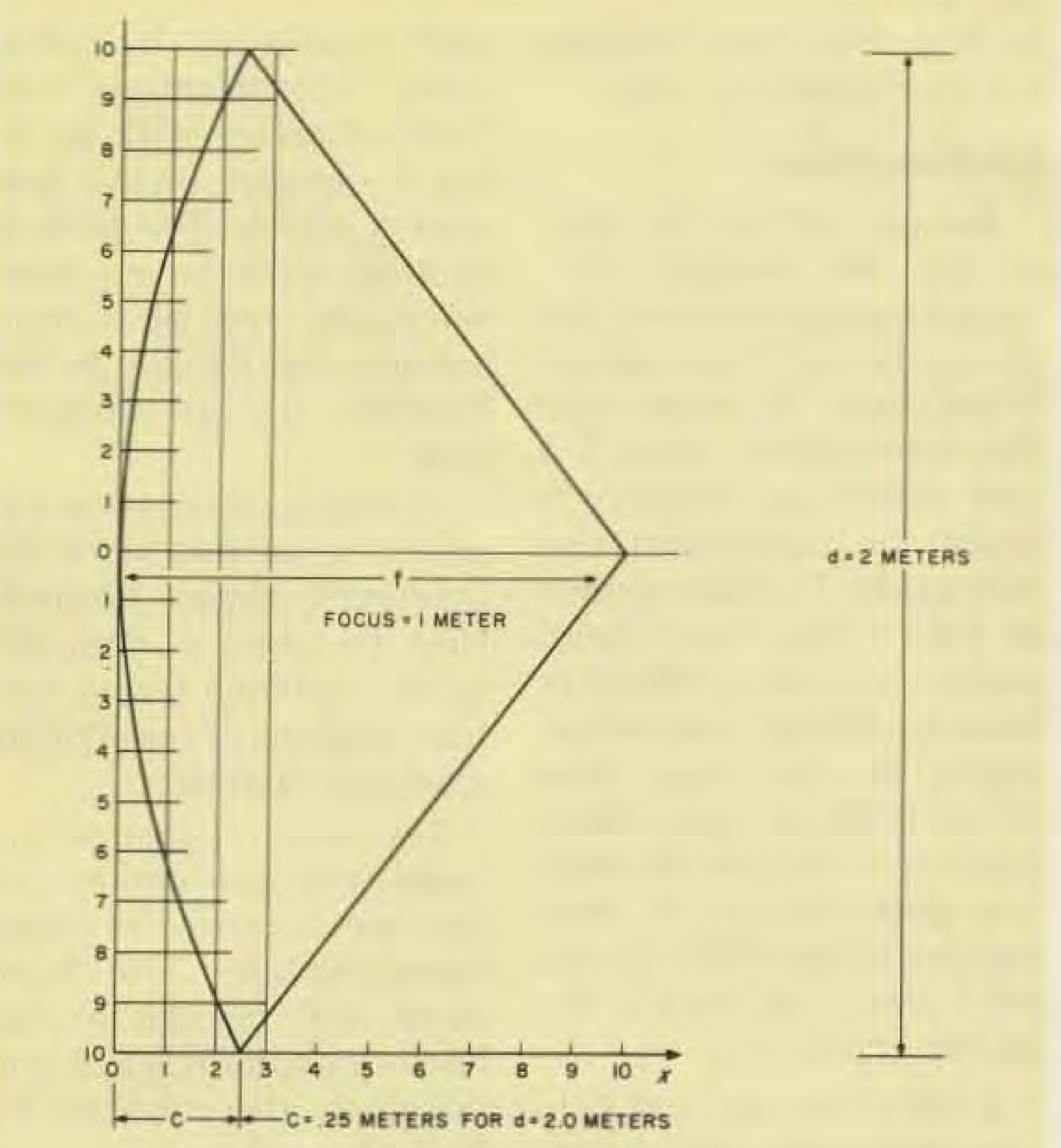
The important dimensions of a paraboloid are shown in Fig. 1. The reason my "good deal" dish turned out to be a piece of junk was that the relationship between the focal point and the diameter was all wrong.

Known as the f/d ratio, this relationship is very important when it comes time to feed the dish. Experience shows that dishes with f/d ratios of 0.5 and greater can be fed easily with a horn-style array. (My commercial dish's f/d ratio was about 0.25 and was difficult to feed.)

The diameter (d) is important in determining how much gain the antenna will have. Obviously, a dish 6 feet in diameter will collect more signal than a 3-foot dish. Each time you double the diameter, the gain increases by a factor of four (6 dB). The actual gain of a dish depends on its efficiency and the frequency it is used on. Assuming a reasonable efficiency of 50%, a 2-meter dish should have about 25 dB of gain over a dipole source at 1296 MHz. The 3-dB beamwidth will be about 8 degrees. Fig. 2 shows these relationships.

Once you have chosen the desired diameter, you'll know where the focal point should be to achieve an f/d ratio of about 0.5. In the case of a 2-meter dish, f will be at one meter.

The exact curvature needed to obtain a paraboloid with the desired focus and diameter can be found using the equation $y^2 = 4fx$. By calculating a number of points for x and y, you'll have an accurate plot of the shape required. Let's try an example for a dish with the focus at one meter: The x value corresponding to the y point of 0.5 is found by solving the equation $0.5^2 = 4(1)x$. A little algebra yields: $x = 0.5^2/[4(1)]$.



$y^2 = 4fx$

y = 1, x = .25	y = .5, x = .0625
y = .9, x = .2025,	y = .4, x = .04
y = .8, x = .16,	y = .3, x = .0225
y = .7, x = .1225	y = .2, x = .01
y = .6, x = .09	y = .1, x = .0025

Fig. 1. Dish dimensions. Width (c) is found by solving: $f = d^2/16c$.

Punching the calculator keys, we come up with the answer x = 0.625 meters. Fig. 1 also shows that the total width of the dish, c, is found with the equation $f = d^2/16c$.

That's all there is to designing the reflective part of the dish. Now let's look at how to build it. For starters, you should be prepared to work with metric measurements of length. I found that the use of meters and centimeters helps to ensure accurate results. For noncritical measurements, we'll refer to English units.

Once you have a set of x and y values, it is time to fabricate a surface that accurately depicts them. Any irregularities will impair the antenna's gain. At 1296 MHz, deviations of up to 1.5 cm are tolerable. As the frequency increases, this tolerance decreases. Using care, this dish can be built with deviations of less than 0.5 cm.

Making the Ribs

The structural elements that give the dish its strength and special shape are eight wooden ribs. I made mine from scrap 3/4-inch white pine. Each rib was cut from a 40″ × 14″ piece. Any available substitute should work, provided that it is reasonably light and can be cut to the needed shape.

Carefully draw a center line lengthwise, 5.8 cm from one edge of the board, as shown in Fig. 3. Work from this line to lay out a parabola, using the points generated by the $y^2 = 4fx$ equation. The more points you use, the more accurate your paraboloid will be. Carefully draw a line to connect the points on the inner surface. The outer surface should have a shape like the one shown. The lower flat edge will be at the center of the dish, while the upper end will be at the edge, fastened to a ring of aluminum tubing.

After checking the layout, the eight ribs can be rough-cut to about 0.2-cm accuracy using a band or saber saw. Final trimming should be done by sanding. Be sure to keep the flat edge parallel to the center line.

The ribs are all joined at the dish's center by a 3/4-inch-thick plywood mounting plate like the one shown in Fig. 4. Ribs A and B are mounted first, using 1-1/2-inch wood screws. All the other ribs must be shortened to obtain equal inside diameters. Ribs C and D have 3/8″ removed from the inside end. Ribs E, F, G, and H are shortened 3/8″ and mitered with two 45° angles as shown in Fig. 4(a).

Finally, all the remaining ribs are fastened to the mounting plate, first with glue and then with wood screws.

To add strength to the dish's outer edge, I encircled it with 1/2-inch aluminum tubing. Four six-foot lengths were used. To bend the tubing into a circle, one end is plugged, then the tube is filled with sand and carefully bent into shape. This was easier to accomplish than I thought it would be. An undersized piece of tubing is used for coupling between the sec-

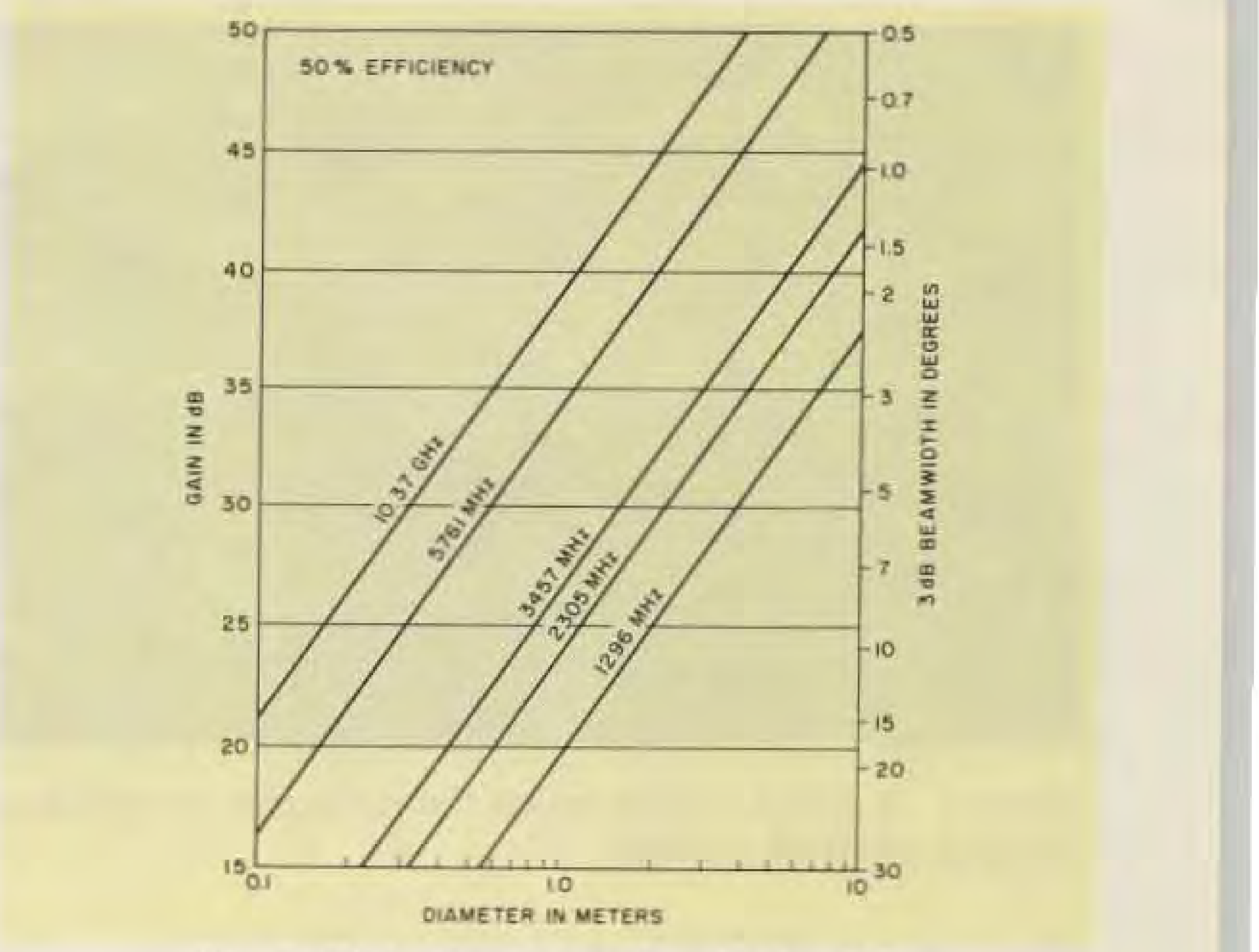


Fig. 2. Dish diameter/gain relationship.

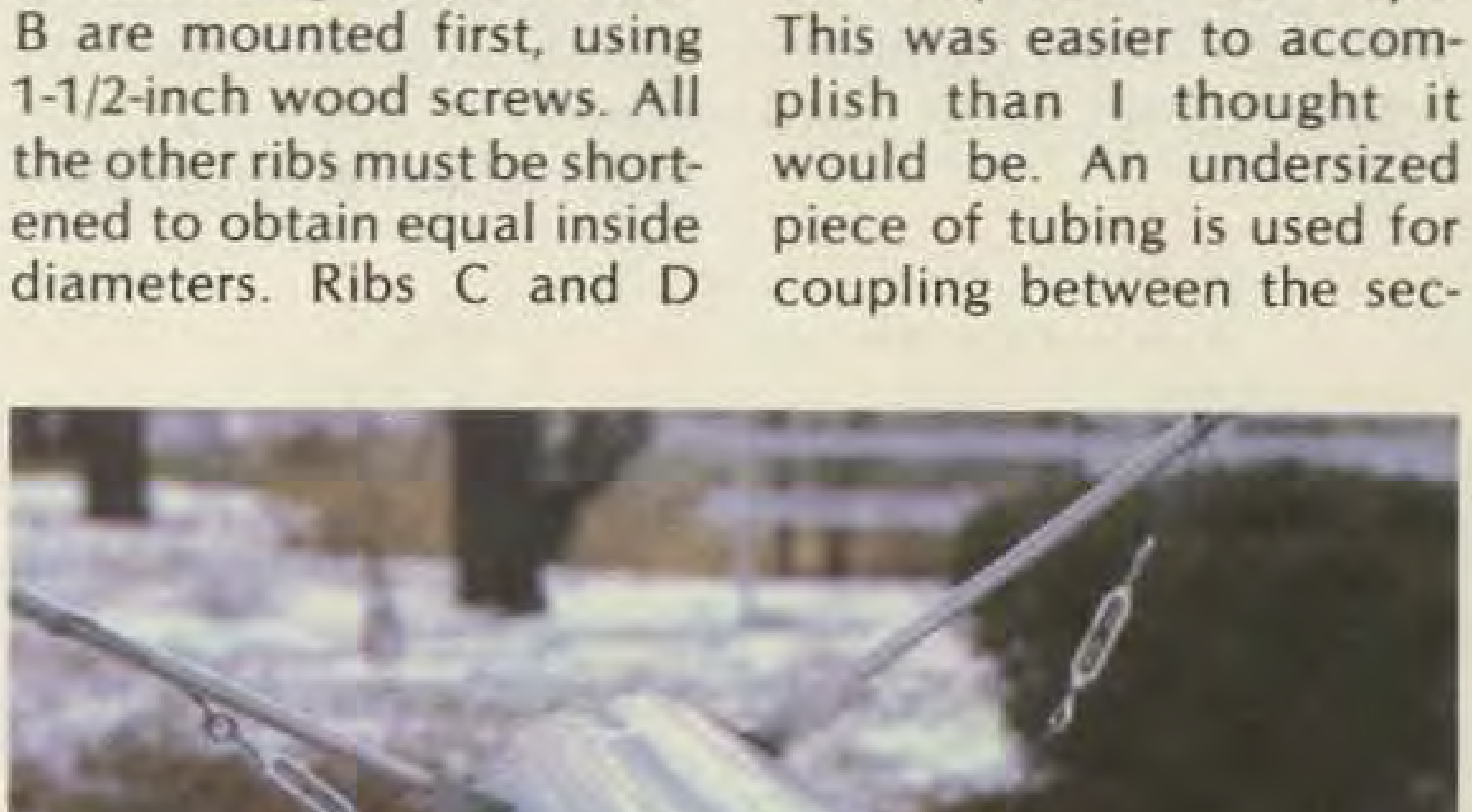


Photo B. A feedhorn can be easily constructed. The pickup is a simple, monopole element.

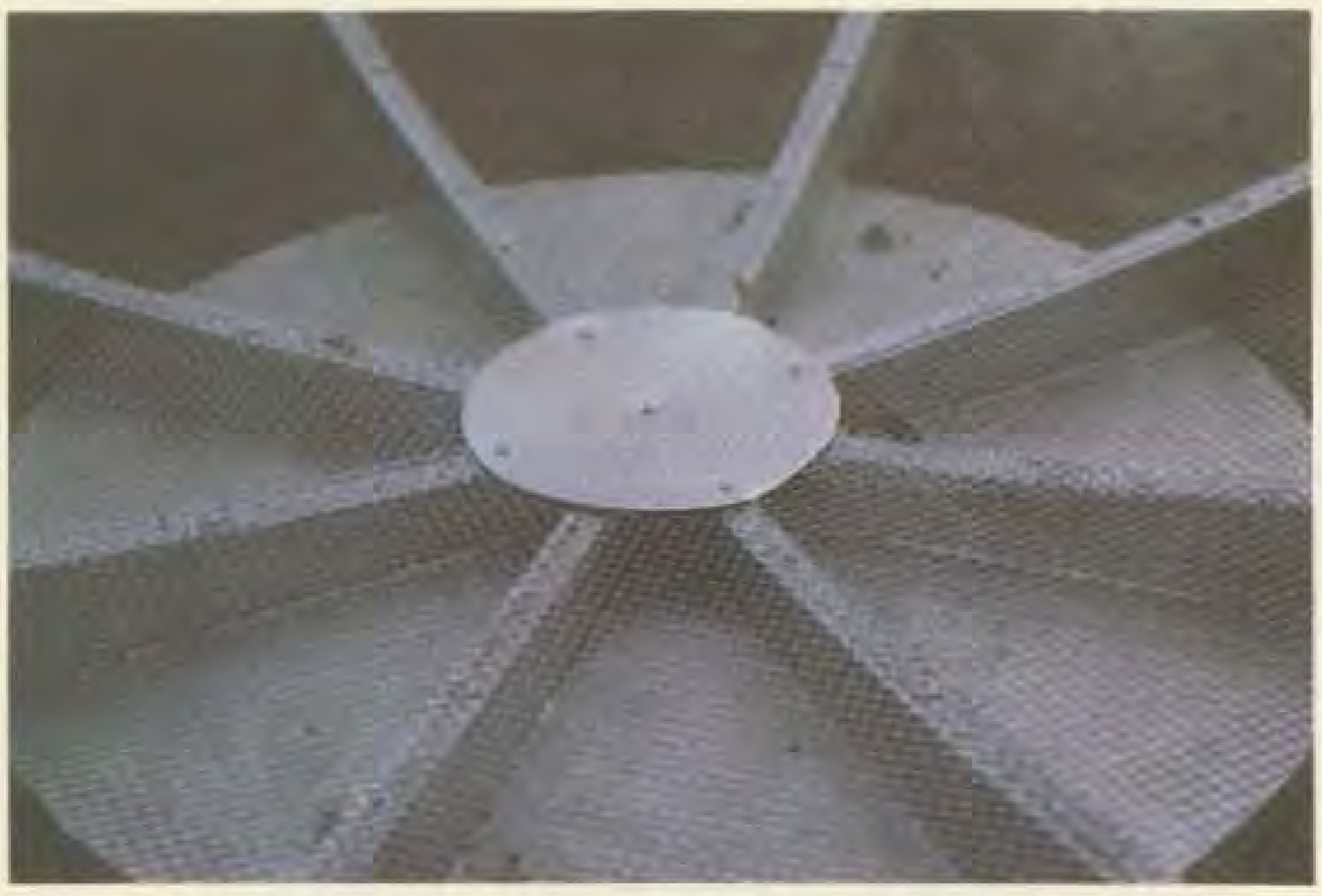


Photo C. A circular plate holds the reflective screening in place at the dish's center.

tions. The shaped lengths are fastened to the dish perimeter with 5-cent conduit clamps as shown in Fig. 4(b). Since the ribs give the dish its shape, getting the outside circle perfect is not necessary.

Covering the Frame

The next step is to cover your frame with a reflective surface. I used 1/4-inch hardware cloth because it was cheap and available. To make the job easier, I cut the cloth into eight slightly oversized triangles. Staple a triangle between two adjoining ribs and then trim the excess outer edge to size. Next, tie-wrap the perimeter to the aluminum tubing using nylon cord with cable-wrapping technique. Be sure to wear gloves when working with the hardware cloth.

Once all the screen is in place, eight flathead screws are used to hold it on each rib. (The staples are no longer needed and can be removed.) Since eight layers of hardware cloth overlap at the center, they must be trimmed and then securely fastened beneath a seven-inch diameter disc.

At this stage, all the essential parts of the reflector are complete. Since my dish is going to be mounted in an exposed location, I decided to strengthen it by adding bracing between the ribs about midway from the center. A framework was fastened to the center plate so that the whole antenna can be bolted to a mast.

Feedhorn Ideas

Because of the f/d rati of 0.5, the obvious fee choice becomes a horn. The theory behind horn design is not trivial. To make matters worse, there often is a vast difference between a design on paper and one that works. The horn shown in Fig. 5 has been field-proven on the 1296-MHz band by K9KFR and others. Horns of this type have about 8 dB of gain. Other types of feeds can be used; one good source of information is the RSGB book, *VHF-UHF Manual*, by Jessop and Evans.

Unless you can find a tin can that meets the dimensions shown in Fig. 5, you will need to make one. Using light-weight aluminum stock, I made a cylinder from a 18" × 28.25" piece. Next, a cap is fashioned to fit into one end. Small vee-shaped tabs are bent 90° and riveted to the cylinder wall. The result is a tube with an inside length of 16" and a diameter of 9".

The location of the tuned element is critical. A type-N connector should be mounted 2" from the rear wall. A 1/4-wave driven element (1.8" of 1/4-inch copper tubing or 1/8" welding rod) is adjusted by filing. Using approximately one Watt of power with an in-line wattmeter, file for best vswr. *Caution: The horn is emitting microwaves; keep hands and eyes away from the opening.* Be sure to use hardline for all connections.

It should come as no surprise that at this point the antenna is almost finished. Now the horn is mounted on the antenna frame with four sections of telescoping aluminum tubing.

The exact distance between the dish center and the horn must be found experimentally. The focal point will *not* be at the horn's outside edge, it will be inside the cylinder. To find the exact focus, the dish should be aimed at a signal source and the horn moved up and down until the received signal is at a maximum. If your 1296 receiving gear includes a low-noise amplifier, then one excellent signal source is "sun noise." Aim the dish at the sun, and your receiver should give a noticeable output.

The antenna's polarity is determined by the position of the driven element. Rotating the horn 90° changes the antenna from vertical to horizontal or vice versa. When the driven

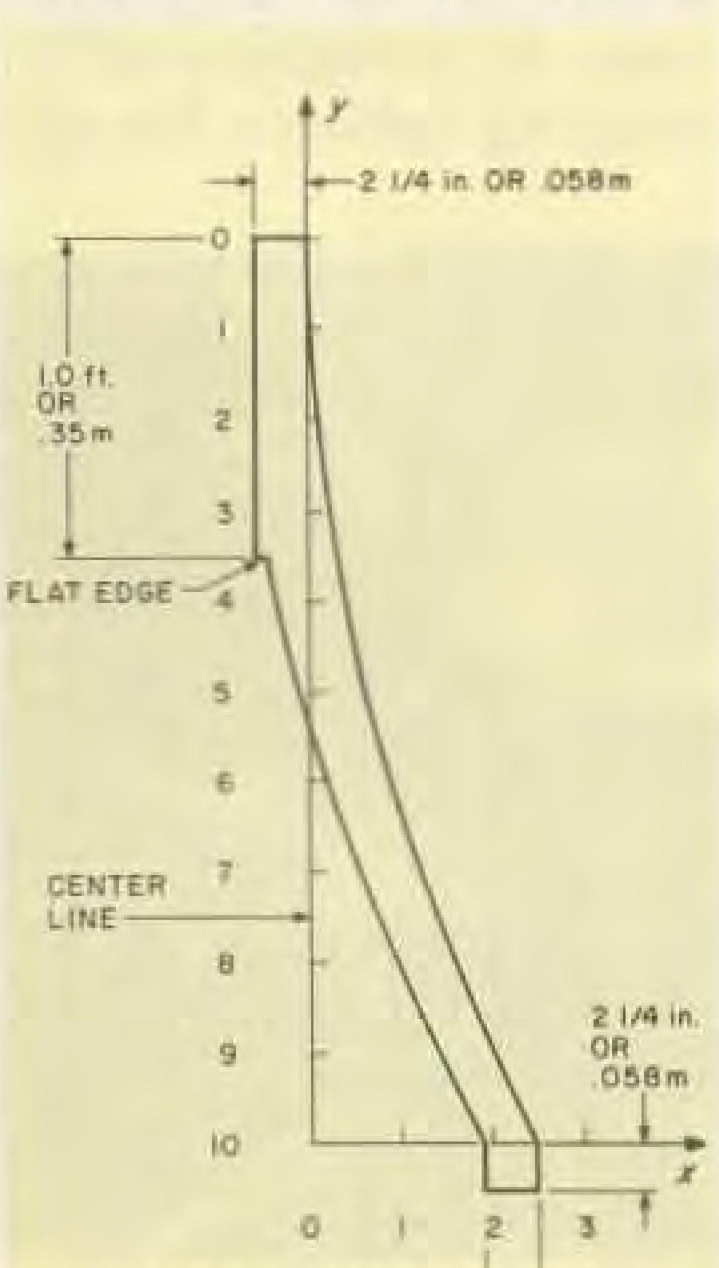


Fig. 3. Rib detail.

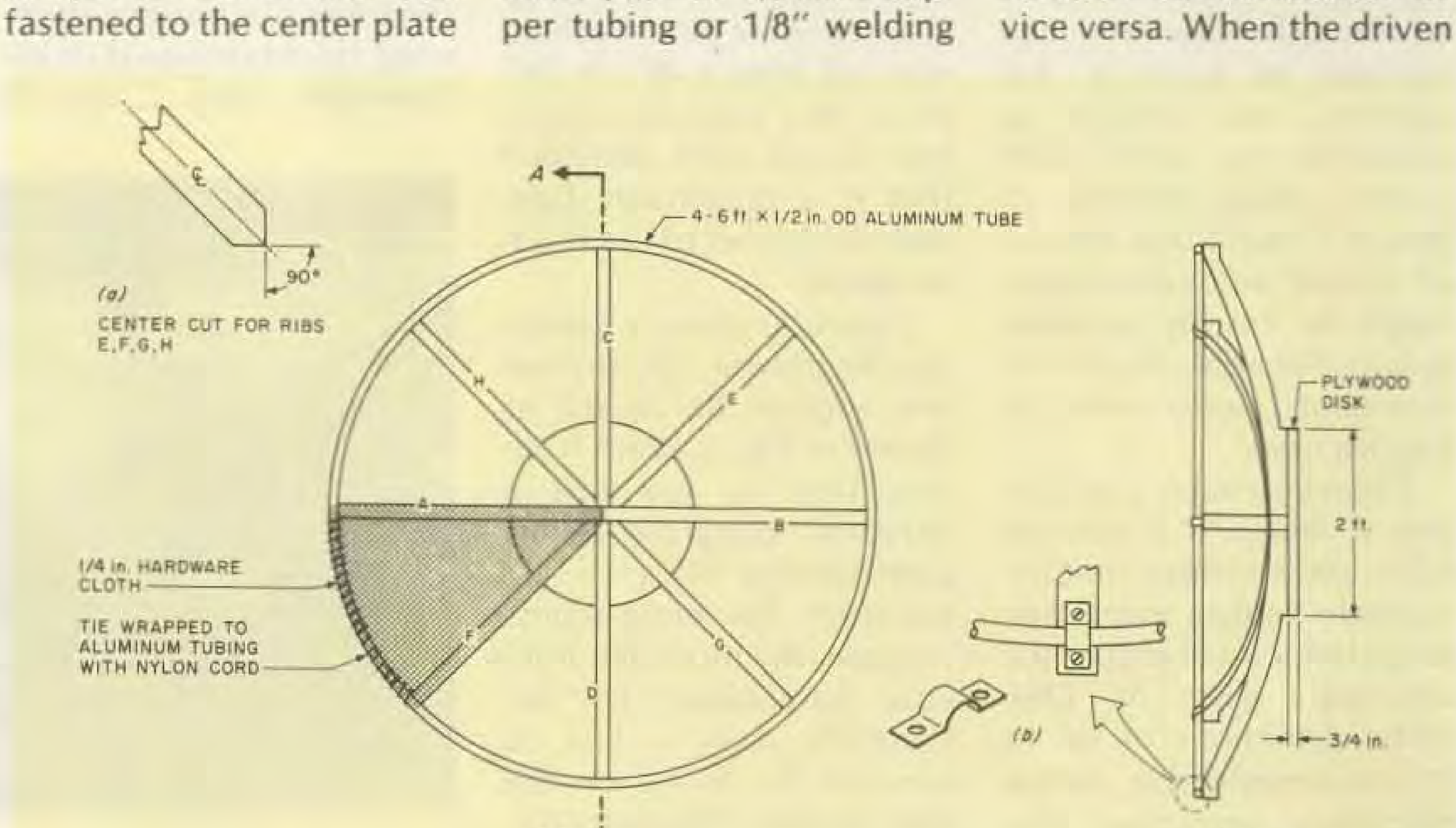


Fig. 4. Assembly of the ribs.

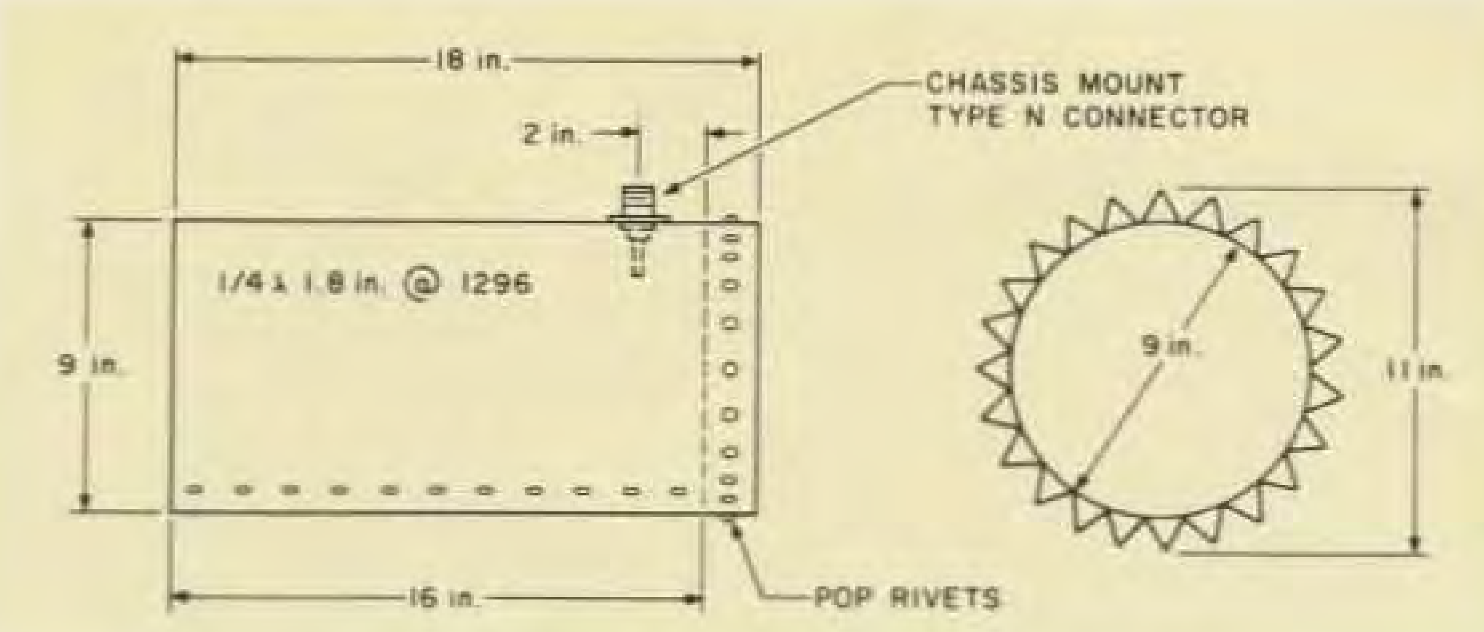


Fig. 5. Feedhorn design.

Photo D. Building a 1296-MHz dish need not be difficult, but it will require some home-brewing.

element is horizontal relative to the Earth, the antenna is horizontally polarized and is set for 1296-MHz tropo operation. Once the focus and polarity are set, bolt everything into place and start enjoying your new antenna.

Life on 1296

You might be interested in the rest of my 1296-MHz station. For receiving, I use a preamplifier made with an MRF901 transistor, followed by a Microwave Module that converts the signal to 28 MHz where an amateur transceiver is used. On transmit, a home-brew varactor tripler provides 3/4-Watt output on 1296 when driven with a ten-Watt, 432-MHz signal. This may not seem like much power, but I make the most of it by using hardline between the dish and the shack. Thanks to my dish antenna, the 1296 effort has been a success. The first two contacts were with K9KFR and WA8JHW, each more than 100 miles away.

This article is being written in the winter, and the dish has been stored away, safe from ice and other hazards. When warm weather returns, you can be sure that W8DJY will be back on 1296. In the meantime, plans are being made for a much bigger dish and a more powerful transmitter.

As you can see, building a dish need not be difficult. This project was the result of a lot of help and ideas from fellow VHF-UHF enthusiasts, including WB8EEX, whose garage proved invaluable, W8ULC, who handled the fancy footwork on the tower, and K9KFR, who patiently helped get a feed that worked.

About the only thing that can't be changed is the basic parabolic shape. Make the most of the materials that are available in your area; be brave; experiment! If you have questions, please include an SASE. See you on 1296! ■