What You've Told Us...

Your responses to our March survey are beginning to paint a picture of *CQ VHF* readers. Some of the results we expected, others were surprises. Here's what we've learned about you so far, based on over 500 responses:

• 96% of our readers are male; 4% are female; 70% of you are married; 30% are single.

• Age figures are a classic "bell curve," with a peak that matches the average age of hams today. Only 2% of our readers in March were under 18, and another 2% were 18–24 years old; 9% of our March readers were 25–34; 29% were 35–44; 31% were 45–54; and 16% were 55–64. Only 8% were 65–74, and 3% were 75 or older.

• Length of time licensed was our first surprise. While 60% of you have been licensed 5 years or less (15% less than a year, 27% 1–2 years, and 19% 2–5 years), a third of you are "old-timers," licensed more than 10 years (13% 11–25 years, *20% over 25 years*). These numbers are consistent with our goal of serving *all* VHF-active hams, including, but certainly not limited to, newer licensees.

• A similar surprise was in the license class statistics. Only 1% of our March readers held Novice licenses; 44% held basic Technician tickets; 21% held Tech-Plus licenses, and only 8% were General Class hams. That didn't surprise us, but this did: 14% of our March readers held Advanced Class licenses and 12% were amateur Extras. Again, while most of our readers (67%) hold "entry-level" licenses, a very significant 26% are dedicated, experienced VHFers with higher class licenses.

• The final surprise was in statistics for band activity. It was *no* suprise that 97% of you are active on 2 meters, or that 55% of you operate 70 centimeters (420–450). But 6 meters was in a surprisingly-strong third-place, with 38% of you active on "the Magic Band." And we were disappointed to see that only 16% of you are on 222 MHz.

• • •

Next month, we'll let you know if additional replies turned up any more surprises, and we'll give you a first look at your replies to our April questions about your education, jobs, and preferred operating modes. Thanks again for your responses.

CQ VHF Ham Radio Above 50 MHz

Reader Survey—June, 1996

We'd like to know more about you...about who you are and where you live, about the kind(s) of work you do, and about your ham radio interests and activities. Why? To help us serve you better.

Each month, we'll ask a few different questions and ask you to indicate your answers by circling certain numbers on the Reader Service Card and returning it to us (we've already paid the postage).

And, as a bit of an incentive, we'll pick one respondent every month and give that person a complimentary one-year subscription (or subscription extension) to CQ VHF. *Over the next few months, we'd like to find out—from your perspective—how* we're *doing:*

A. About this issue of *CQ VHF*:

1. Please indicate whether this issue of *CQ VHF* was addressed to you:

	Circle Reader Service #
Yes	10
No	11

2. If you answered "Yes" above, please indicate whether this was:

A subscription copy	12
A sample copy	13

3. If you are a subscriber, you should have received this issue in early May. Was it on time?

Yes	14
No	15

4. If your answer to Question 1. was "No," please indicate where you got this issue of *CQ VHF*:

At a bookstore/newsstand	16
From a ham radio dealer	17
Directly from CQ (e.g., at a hamfest)	18
From a friend	19
From a club, school, or public library	20

B. Please tell us how we're doing:

5. Please indicate whether—overall—*CQ VHF* (circle all that apply):

Meets the needs of newer hams	21
Meets the needs of experienced hams	22
Meets *your* ham radio needs	23

6. Please indicate whether you would like to see future issues of *CQ VHF* include (circle all that apply):

More high-level technical articles/projects	24
More beginner-level technical articles/projects	25
More operating-related articles	26
More news/opinion-related articles	27
The same mix of articles as in this issue	28

Thank you for your responses. We'll have more questions for you next month.

Build the Featherweight 6-Meter Yagi

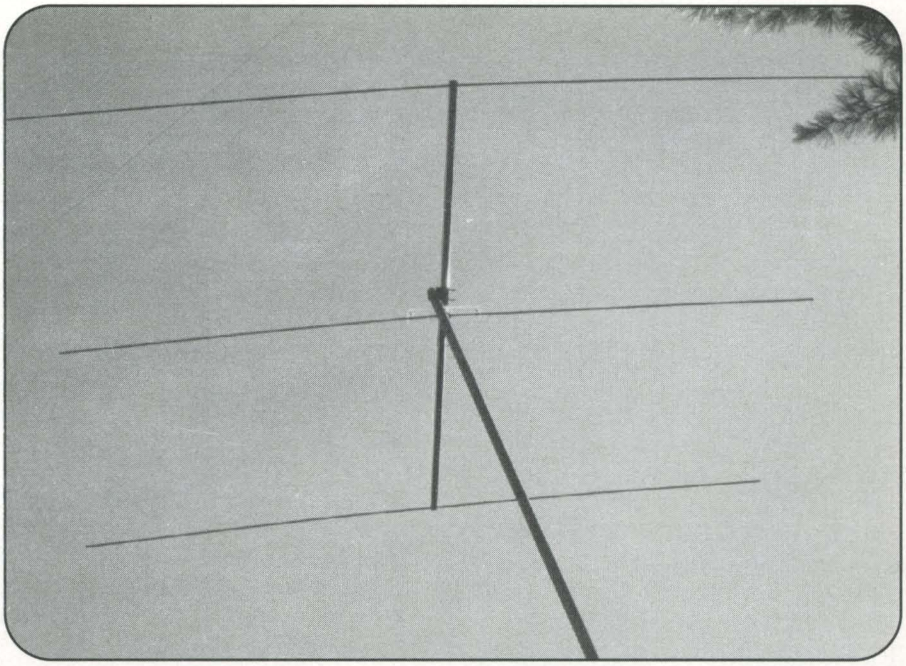
Give your signal extra punch on amateur radio's "magic band" with this compact three-element beam for 6 meters.

By Rick Littlefield, K1BQT*

The *Featherweight* is an ultra-light VHF Yagi that goes where heavier antennas can't. Designed especially for roof-top installations, this compact three-element beam tips the scales at a mere two pounds and uses inexpensive TV hardware to get high above surrounding obstacles.

In addition to being extremely small and light, the *Featherweight* is easy to build using common tools and readily-available hardware. Best of all, it requires no tuning to achieve low-VSWR performance. And, if you're a serious DX hunter, you can add a second *Featherweight* in a stacked array for extra gain and greater capture area.

This particular version is a second-generation rendition of an antenna I originally presented in our sister publication, *Communications Quarterly* ("Tech Notes," Summer, 1995). The dimensions are virtually the same, with minor hardware changes to reduce weight and simplify construction.



The assembled Featherweight 6-meter Yagi at the author's station.

Specifications

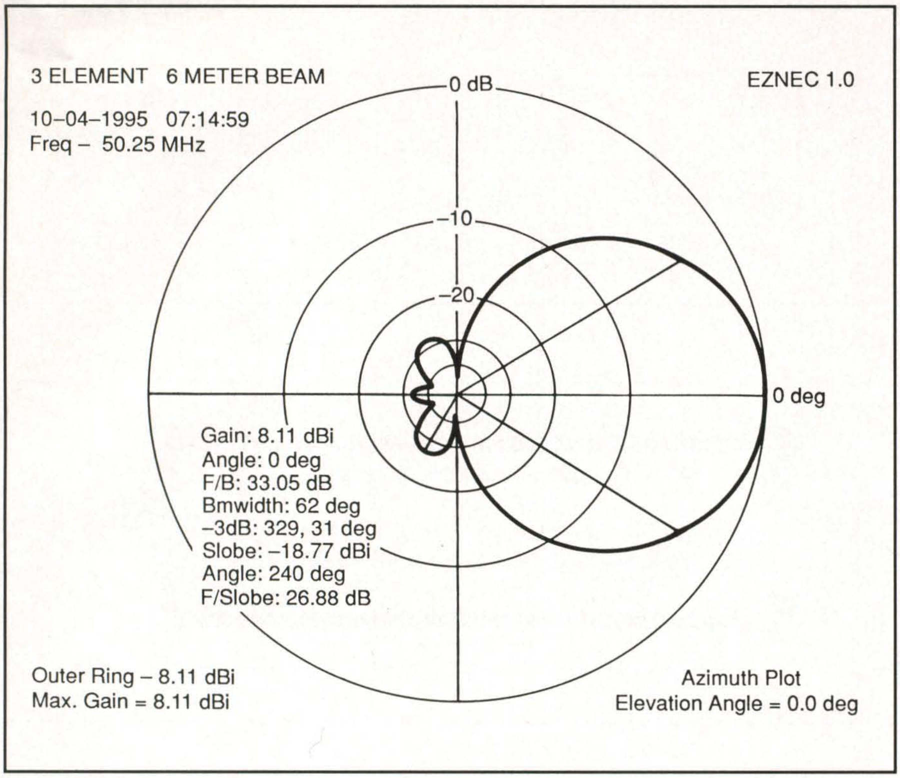
The "Azimuth Plot" shows an "EZ-NEC" analysis of predicted performance for the *Featherweight* antenna (special thanks to Paul Carr, N4PC, for the computer run). The boom is six feet long, with a turning radius of just under six feet. Frequency of resonance (Fr) is typically about 50.250 MHz, or 125 kHz above the SSB calling frequency. The antenna is tuned slightly high because best gain and front-to-back ratio typically occur at Fr *or slightly below.* This places 50.125 MHz on the optimum side of the antenna's performance curve, and also provides compensation for precipitation build-up on rainy days, which tends to lower Fr.

According to EZ-NEC, free-space forward gain is predicted at 8.11 dBi (or 5.97 dBd)†, the –3 dB beamwidth is 62°, and the front-to-back ratio (F/B) is predicted at 33 dB (real-world F/B was measured at –18 dB in a roof-top installation). The use of precise element lengths and *no-tune* hairpin matching eliminate the need for post-construction tuning. The antenna should easily handle 200–300 watts PEP in service. (†*dBi* refers to decibels, or dB, of gain over an *isotropic* antenna in free space, an ideal that exists only as a reference; *dBd* refers to the more realistic measurement of decibels gain over a *dipole* antenna.)

Preparation for Assembly

The "Table of Materials and Hardware" provides a checklist of hardware and materials you'll need prior to assembly. Figure 1 provides an overview of what the completed antenna will look like. Refer to both as you work. Begin preparation by laying out and drilling

**Rick Littlefield, K1BQT, is a regular contributor to* CQ VHF *and* Communications Quarterly.



Azimuth Plot. Featherweight antenna modeled on "EZ-NEC"

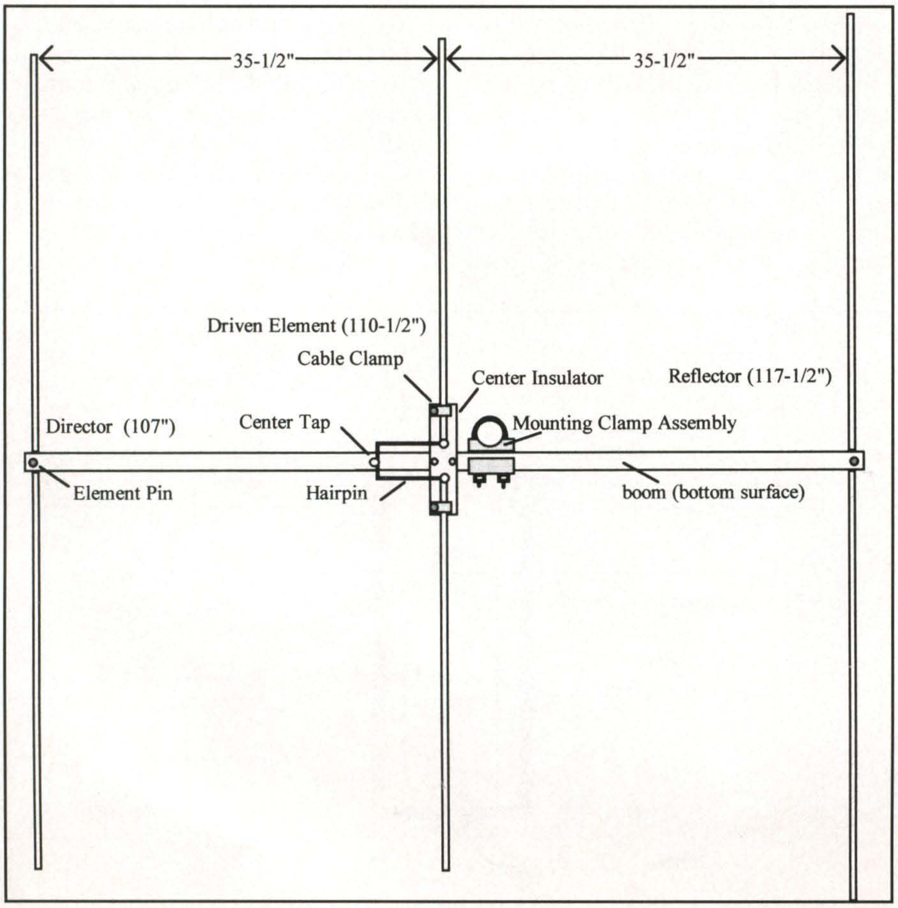


Figure 1. Overall view of the Featherweight 6-meter Yagi.

mounting holes in the boom. Note that the *Featherweight* uses equal element spacing, placing the driven-element insulator at the exact center of the boom. To mark this location, measure three feet from either end. The center insulator will be installed on the *bottom* surface of the boom.

After finding the mid-point, locate and mark hole locations for the mast-mount U-bolt. These will be centered on the *side* surface of the boom at 32 1/2 inches and 34 1/4 inches from one end. Drill two 5/16-inch holes through both walls at these locations (if possible, use a drill press to ensure the drill axis is perpendicular to the boom). The reflector and director mounting holes are positioned 1/2-inch back from each end of the boom. Mark these locations on the *side* surface of the boom, about 3/16-inch up from the bottom. Drill through both walls with a 5/16-inch bit. When drilling, try to make the lower edge of the drill bit contact the inside surface of the boom as it goes through. This will provide a flat channel for seating the element as it passes through the boom.

Now, place a mark on the bottom surface of the boom—directly centered over the element mounting channel—and drill through the bottom wall with a 1/8-inch bit. This hole will be used when pinning the element in place later on.

Next, prepare the Plexiglas® center insulator and spacer, following the detail provided in Figure 2. If you have difficulty finding Plexiglas stock, check your local industrial plastics distributor or automotive glass replacement shop: most will have Plexiglas remnants for a reasonable price. Don't substitute a plastic with unknown insulating properties.

Once you've cut and drilled the Plexiglas pieces as shown, you can use the spacer as a drilling template to mark the insulator mounting hole locations at the center of the boom. Use a 7/64-inch bit to drill two pilot holes for the #12 sheet-metal mounting screws.

The hairpin matching inductor is easily fashioned from #8 soft-drawn solid-aluminum ground wire (Radio Shack #15-035). The exact dimensions are shown in Figure 3. When forming the hairpin, make sure both sides are straight, symmetrical, and conform to the pattern. This will be installed later.

The elements are cut from 5/16-inch thin-wall aluminum antenna tubing. This normally comes in 12-foot lengths, and may be purchased from aluminum products supply houses, such as Metal and Cable Corporation in Twinsburg, Ohio (also, check your area Yellow Pages for a local aluminum tubing distributor).

Cut the director exactly 107 inches in length and cut the reflector to 117 1/2 inches. Drill a 1/8-inch hole at the exact center of each element (at 53 1/2 inches for the director and 58 3/4 inches for the reflector). These holes will be used later for pinning the element to the boom.

The driven element is made from two tubing sections cut to 54 3/4 inches each. To prepare these for mounting, crimp the last 1/2-inch of one end flat in a vise, then drill a 3/16-inch hole centered about 1/4-inch from the end.

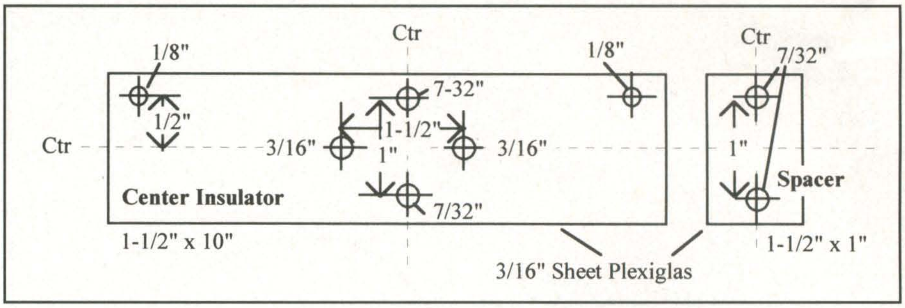


Figure 2. Center block and spacer detail.

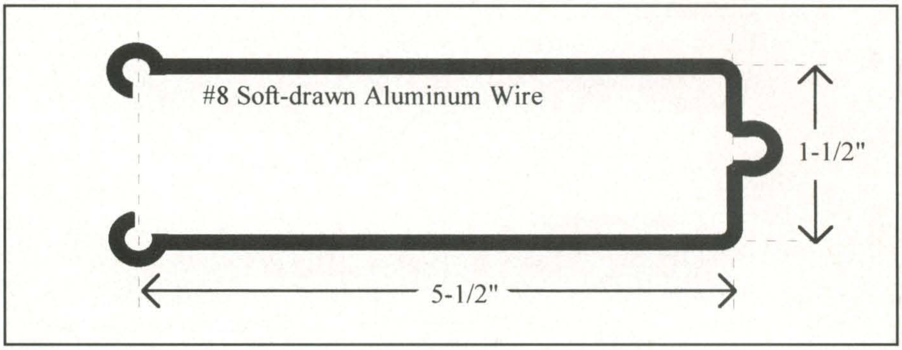


Figure 3. Hairpin matching inductor detail.

Assembly

Use Figure 1 as a guide during assembly. Place the Plexiglas center insulator and spacer in position, sandwiching the spacer between the insulator and the boom. Secure both with two #12 x 3/4-inch sheet-metal mounting screws, using a square to confirm that the center insulator is seated exactly 90° to the boom.

Next, use two #8-32 x 1-inch machine screws to mount the hairpin and driven element sections. Refer to Figure 4 for mounting details. Make sure the hairpin center-tap points toward the *front* of the antenna (away from the U-bolt holes). Once the driven element sections are bolted in place, secure each to the insulator with 5/16-inch nylon cable clamps. If 5/16-inch clamps are not available, use 3/8-inch clamps and build up the driven element with a few turns of electrical tape to provide a snug fit. Confirm that each side of the driven element sits 90° to the boom. If either element is off, loosen its cable clamp and reposition.

To ground the hairpin center tap to the boom, drill a 1/8-inch pilot hole on-center, inserting the drill bit through the hairpin tap. Secure the tap in place using a #8 sheet-metal screw and a 1/4-inch x 5/16-inch diameter spacer, as shown in Figure 5. The director and reflector are mounted as shown in Figure 6. Slide each element into place so that the 1/8-inch hole

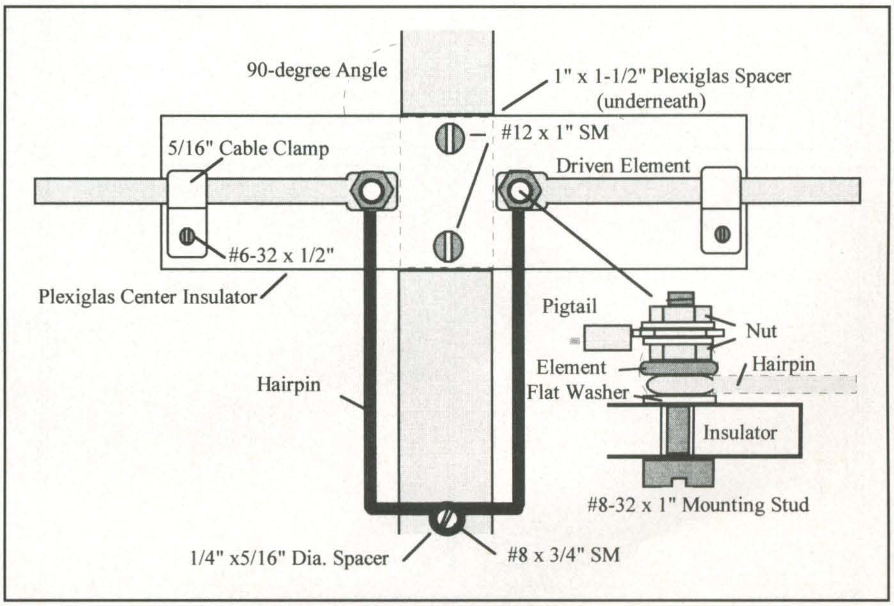


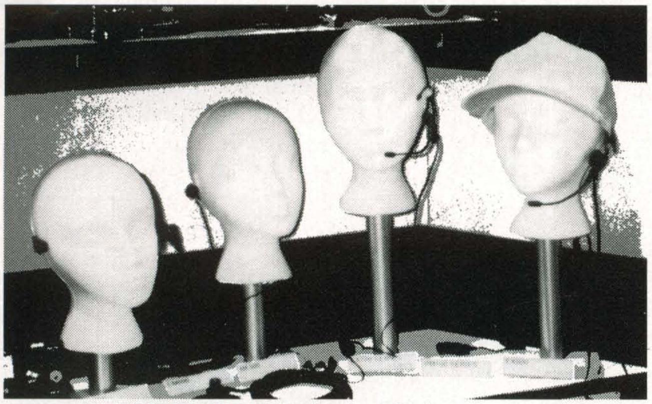
Figure 4. Center block assembly detail.

Snapshots?

You Be the "Photographer"

Do you know an interesting short story about a well-known person in the history of ham radio, radio communications, or electronics generally? About the origin of some of the terms we use every day? A significant event in ham history? Or a person who made a significant contribution to the radio art but is not well recognized? Why not tell us about it in 150 words or less, include any documentation you have as proof of your story, and mail it to CQ VHF, 76 N. Broadway, Hicksville, NY 11801, via fax to (516) 681-2926 or via e-mail to <CQVHF@aol.com>? "True facts" only, please. If we can't verify it, we won't print it. If we do print it, we'll give you a free one-year subscription (or extension) to *CQ VHF*.

HEADSETS



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ME-300 - Lapel/Shirt Clip
EX-700 - Ear Clip
EX-800 - Hat Clip

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		PS-400X	RS-300	PS-50T/50TM	PS-220
Input Voltage		AC 230 V or 117 V AC on ODR, ±5%			
Output Voltage		~15 V DC variable		9 ~ 15 VDC	1 ~ 15 VDC
Output Current	Max. *(1)	40 A	30 A	5.2A	20A
	Rating	32 A	24 A	4.2 A	16 A
	Rating *(2)	24 A	15 A		
Voltage Fluctuation		Less than 1% (with rated output)		Less than 2% (with rated output)	
Ripple Voltage		Less than 3 mV (with rated output)			
Protection Circuit		when 42 A	when 32 A	when 5.2A	when 22 A
Dimensions (W × H × D mm)		216 × 110 × 280	172 × 150 × 240	135 x 87 x 200 (m/m)	156 × 145 × 260
Net Weight		8.5 kg	8.9 kg	2.5 kg	7 kg
Power Consumption		690 W max.	600 W max.	120 W max.	500 W max

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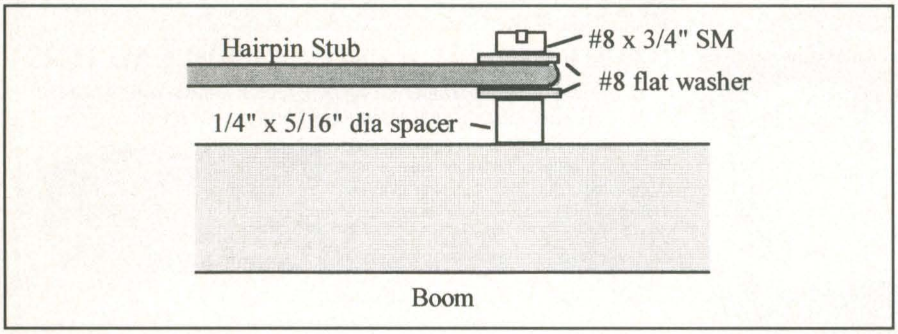


Figure 5. Hairpin center-tap grounding detail.

in the middle of the element lines up with the 1/8-inch hole in the bottom surface of the boom. Pin the element in position with #6 hardware. Tighten firmly to prevent movement, but avoid crushing the aluminum tubing.

This completes assembly of the basic antenna. Make sure all elements are perpendicular to the boom. Also, confirm that the elements are in line and that spacing between element tips is approximately 35 1/2 inches. If necessary, bend the elements slightly to correct any misalignment. To prevent wind vibration in the elements, use a pair of pliers to crimp each element tip closed (TV-antenna style).

Balun and Feedline Installation

A lightweight antenna deserves a lightweight feedline! RG-8X (or mini-8) foam coax provides an ideal feed for the *Featherweight* antenna. This cable is readily available, easy to install, and will perform well for rooftop runs of up to 60 or 70 feet at 50 MHz. For longer runs, use an ultra-low loss cable, such as Belden 9913, to reach the antenna site, then use RG-8X up the TV mast and around the rotor.

The antenna's driven element is balanced and requires a 1:1 balun at the feedpoint. The easiest (if not the most technically correct) way to meet this requirement is to install ferrite sleeves over the feedline at the antenna feedpoint. This creates a "current balun" that will choke RF radiation off the outside of the coax braid and prevent pattern distortion.

Figure 7 shows how to prepare the feedline balun for installation. First, slip three FB43-5621 coax sleeves over the antenna-end of the RG-8X coax line. Then, strip back the plastic outer insulation 1 inch and prepare pigtails as shown. Install a spade lug on each pigtail (crimp-type lugs should be both crimped *and* soldered to ensure a good electrical connection). Pigtail length should not exceed 1 inch including the lug, since longer leads may lower the antenna's Fr. Position the three FB43-5621 ferrite sleeves to within 1/4-inch of the end of the outer covering and wrap three to four turns of electrical tape around the coax—behind the third sleeve—to form a stop.

Finally, apply two to three thin coats of "Seal-All" (or similar waterproofing sealant) to the braid area of the pigtail to retard water migration into the cable. When the sealant is fully dry, connect each coax pig-tail to a driven element mounting stud using #8 nuts (stainless steel wing nuts may also be used).

When mounting the *Featherweight*, note that the center insulator is positioned on the *bottom* side of the boom. If possible, use a TV-antenna mounting kit that includes boom reinforcement plates for a 1-inch square boom (1-inch x 1-inch is the standard boom size for TV antennas). This will protect the boom from being crushed or distorted by the mounting hardware. If a reinforcement plate is not available, consider making one—or at least using fender washers—to spread out the force applied by the U-bolt mounting nuts. Coax should exit the driven element at a 90° angle to the center insulator and run down the mast. Secure feedline tightly to the mast with electrical tape—just below the balun—to provide stress relief and prevent feedline breakage at the pigtails.

An Option for Rovers

If you want to use your *Featherweight* for mountaintopping or "roving" in a contest, this optional method for mounting the director and reflector will enable you to remove elements quickly and pack the antenna for easy transportation.

First, fabricate two 6-inch element sleeves from 3/8-inch diameter thin-wall aluminum tubing, as shown in Figure 8. To prepare the element sleeves, slot each end at 90° with a bandsaw, making four slots of about 3/4 of an inch long each. Then, drill a 1/8-inch pinning hole at the exact center of each tube. If your antenna is already assembled, remove the director and reflector from the boom and ream the 5/16-inch element mounting holes out to 3/8-inch to accommodate the larger-diameter element sleeves. Cut the reflector and director elements in half at their exact center. To re-install the elements, insert each half into the appropriate sleeve and clamp in place using small stainless-steel hose clamps (available at most hardware stores).

To collapse the driven element sections for transport, either unbolt and remove them or unscrew the cable-clamps and swing each element back parallel with the boom. With a little practice, assembly and disassembly takes only a minute. This modification has little or no effect on antenna Fr or performance.

Antenna Mounting Tips

The *Featherweight* provides about the same mast-loading as a small "economy-sized" TV antenna. Because of this, you can mount it significantly higher than a comparable commercially-built 6-meter Yagi. Standard TV-antenna mounting

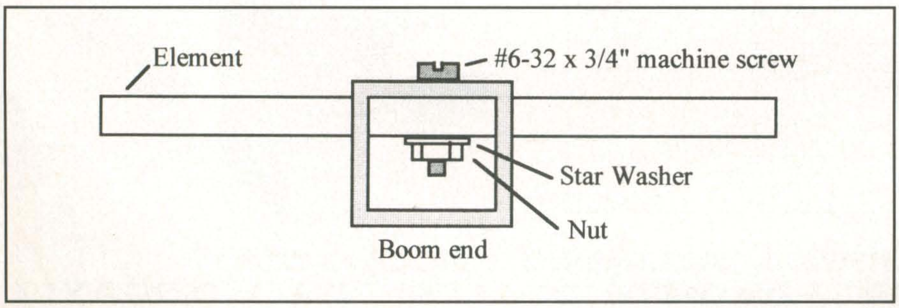


Figure 6. Element mounting detail.

hardware and virtually any light-duty rotor will do the job.

In most locations, the antenna may be mounted up to 10 feet above the rotor without over-stressing the bearings (if possible, use aluminum mast above the rotor). To avoid property damage and personal injury, plan your installation carefully in advance and arrange to have at least one extra pair of hands available during the raising. If you plan to mount the antenna on an existing tower, allow at least 5 feet of vertical spacing from VHF Yagis, and more from larger HF Yagis (the more, the better).

Although the *Featherweight* may seem somewhat delicate and flexible by communication-antenna standards, it is surprisingly resilient. My own stacked array has survived a number of New Hampshire ice storms and still remains aloft. If standard TV antennas can survive in your climate, the *Featherweight* should certainly survive as well.

Getting Stacked

For improved weak-signal performance, you may stack two *Featherweights* with 5/8-wave spacing (see photo). Overall gain should increase to between 8 and 9 dBd, and the *apparent gain* on some signals may be higher due to the larger capture area provided by using two antennas.

To keep my stacked array light and easy to manage, I used a single length of 12-foot x 1 1/4-inch thin-wall aluminum as a stacking mast. This configuration was still easy to support using TV hardware and a small TV-type rotor.

If you decide to stack, you'll need a stacking harness to match impedances and distribute in-phase power to both antennas. To make a harness, use RG-59 75-ohm coax (solid or foam). Start by cutting one *electrical-wavelength* of cable, using a grid-dip meter or VSWR analyzer to determine the exact electrical length. Then install the specified FB43-5621 ferrite baluns and pigtails at each end, as detailed in Figure 7 (RG-59 is the same diameter as Mini-8, and the preparation procedure is the same).

Next, measure exactly one quarter way down the length of the harness, and cut the cable in two. Install PL259s on these ends and splice back together using a coaxial "T" adapter. This becomes the array's 50-ohm feedpoint.

Finally, connect the phasing harness to the antennas (see Figure 9). When you do

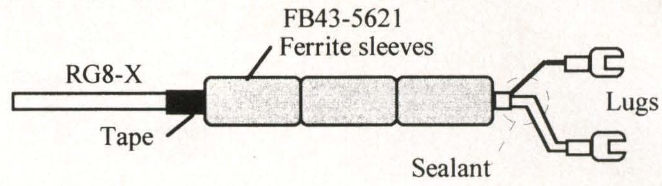


Figure 7. Balun and feedline pigtail detail.

this, *be sure to transpose the pigtail connections on the second antenna*: if this is not done, the two Yagis will be fed out-of-phase and the signals will cancel each other instead of adding together for improved gain.

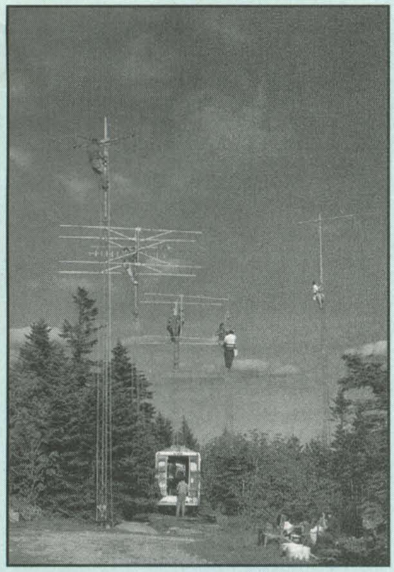
Mount the first antenna as close as possible to the top of the rotor, and mount the second at the very top of the 12-foot stacking mast (if you use thin-wall mast, it may be helpful to install a short length of wooden dowel in the top and bottom to prevent U-bolts from crushing the tubing wall). This arrangement will provide about 11 feet, 6 inches of spacing, which approximates 5/8-wavelength at 50 MHz. Electrically, this spacing provides a good compromise between optimum gain and a clean pattern that's free of side-lobes.

On-air Performance

If you cut the elements exactly to length and formed the hairpin accurate-

Table of Materials and Hardware

ITEM	QTY
Aluminum	
117 1/2" x 5/16" dia. thin-wall tubing (reflector element)	1
107" x 5/16" dia. thin-wall tubing (director element)	1
54 3/4" x 5/16" dia. thin-wall tubing (driven element)	2
72" x 1" x 1" square .047" thin-wall aluminum boom	1
Hairpin matching stub (from #8 solid ground wire) 1 1/2" x 5 1/2"	1
1/4" x 5/16" aluminum spacer (made from element scrap)	1
Stainless Steel Hardware	
#12 x 3/4" pan-head sheet metal screws	2
#8-32 x 1" pan-head machine screws	2
#8 flat washers	8
#8-32 hex nuts	6
#8 x 3/4" sheet metal screw	1
#6-32 x 3/4" pan-head machine screws	2
#6-32 x 1/2" pan-head machine screws	2
#6 star lock washers	4
#6-32 nuts	4
Other Materials	
1 1/2" x 10" x 3/8" Plexiglas driven element insulator	1
1 1/2" x 1" x 3/8" Plexiglas insulator spacer	1
5/16" (or 3/8") plastic cable clamp	2
FB43-5621 ferrite balun sleeve	3
#8 spade lugs (crimp or solder type)	2
Antenna mounting U-bolt kit with nuts, lock washers, and mast clamp	1
Reinforcement plate for 1" x 1" square tubing	1
Tube, Seal-All™ or other waterproof sealant	1
Rover Option	
6" x 3/8" thin-wall aluminum tubing sections	2
Small stainless-steel hose clamps	4



On the Cover

It's setup time at W2SZ/1. "The Mt. Greylock Expeditionary Force"—the championship VHF contest team from the Rensselaer Polytechnic Institute (RPI) Radio Club, in Troy, New York, sets up for the June VHF contest on the 3,491-foot summit of Mt. Greylock, located in western Massachusetts (FN32jp).

Barely visible on the far left of our photo is the microwave truck, better known as "The White Elephant." It houses stations for 903, 1,296, 2,304, 3,456 and 5,760 MHz, plus 10 and 24 GHz. The first tower on the left holds some FM antennas, plus a shared dish antenna for 2,304, 3,456, and 5,760 MHz (the dish hadn't yet been installed when this photo was taken).

The second tower from the left holds the 432-MHz SSB/CW array, a group of four 28-element Yagis in an H-frame arrangement at 40 feet. The truck in the center, known affectionately as "Wilfrid," is home to the 144-, 222-, and 432-MHz stations. Tower #3, behind Wilfrid, is the FM tower, holding two 13-element beams for 2 meters and two 16-element Yagis on 222 MHz.

To Wilfrid's right is tower #4, which holds four 16-element Yagis for 222-MHz SSB/CW. And on the far right is the 2-meter SSB/ CW tower. When all the antennas are installed, it will hold four 16-element Yagis in a vertical stack at 15, 30, 45, and 60 feet.

Not visible in this photo are the 6-meter station (in its own truck), the "repair shop" (in another truck), the 6-meter tower and antennas (four six-element beams in a vertical stack, and the towers and dishes for 903/1,296 MHz and 10/24 GHz.

This year's ARRL VHF QSO Party is on June 8 and 9. And you don't need a megastation at 3,500 feet to have fun! (Thanks to Doug Sharp, WB2KMY, for the W2SZ station information.) (Cover photo by Larry Mulvehill, WB2ZPI.)

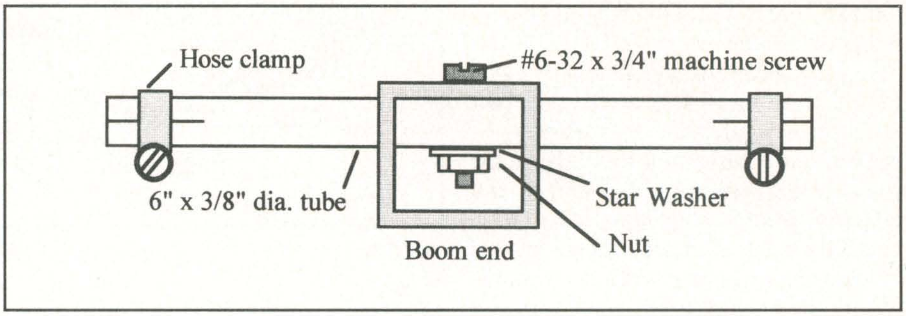


Figure 8. "Rover Option" element mounting detail.

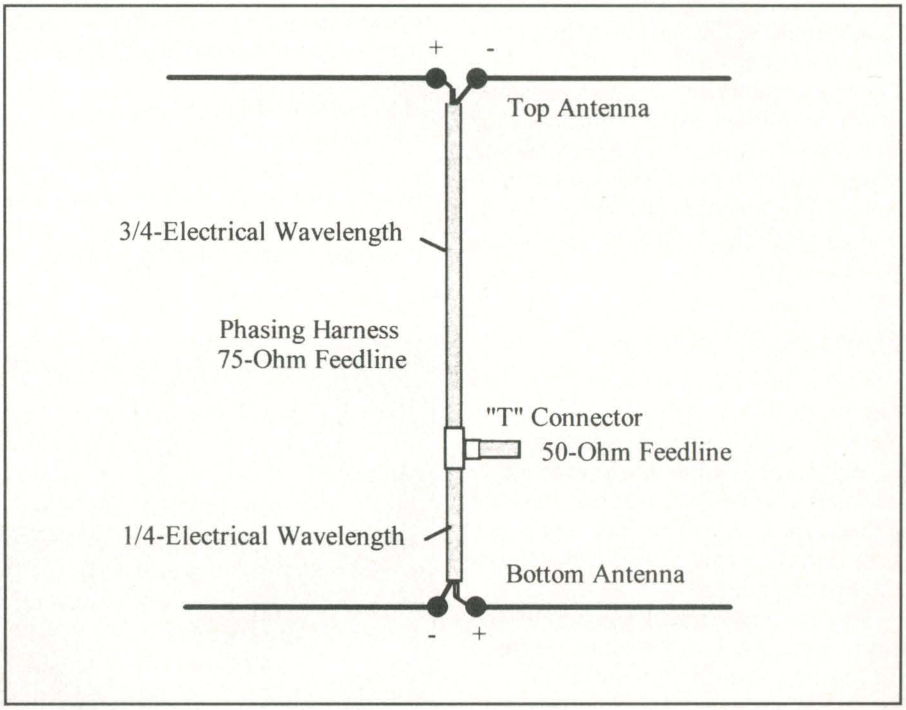


Figure 9. Phasing harness for stacking two Featherweight Yagis.

ly, your antenna should require no additional adjustment for low-VSWR operation in the SSB portion of the 6-meter band. If it resonates slightly low, simply nibble a small amount of aluminum off the tips of the driven element to bring it on frequency (no more than 1/16-inch per side at a time; it doesn't take much). To date, I've built six of these antennas for various purposes, and all resonated within +/- 150 kHz of the design frequency. The design appears to be extremely repeatable!

Small but Powerful

The *Featherweight* may be small in size, but it appears to perform like a fully-grown contender on the air.

I live on a small lake in southern New Hampshire with tall trees and granite hills in almost every direction—a poor VHF location at best! Despite this handicap, I logged over 150 grids and 20 countries via Sporadic-E last summer using a pair of these antennas supported by a simple chimney mount. Even during the off-season when the band seems relatively dead, I routinely work stations from New Jersey to Nova Scotia. Not bad for a station in a hole!

Six meters can be a *very* interesting band—and you don't need high sunspots, a huge tower, or a giant antenna to have fun. Many new HF rigs now cover 6 meters, so why not put up a simple Yagi like the *Featherweight* and explore your radio's full potential? ■

Building Stripline Power Dividers Using Waveguide

Stacked antenna arrays improve performance on any band. But you have to split the power between the antennas. And that poses special problems at higher frequencies. (Note: This is a project for experienced builders.)

By Ron Whitsel, WA3AXV*

One of the ways to improve the overall performance of any radio station is to put up bigger antennas. Antenna improvements affect both the transmitted and received signals and thus increase your operating range. Once you reach a certain point, the only practical way to get "bigger" antennas is to put up multiple antennas phased in such a way so that the total gain of the array increases (hopefully). For VHF and above, this usually requires the ubiquitous *power divider.*

Over the years I have built power dividers using coaxial cable or round copper tubing to achieve the necessary matching of the various antennas in an array. Recently, I've been using *waveguide* to construct two- and four-way power dividers. *(Waveguide is a hollow, rectangular metal tube normally used as feedline at microwave frequencies.—ed.)* The waveguide has the advantage of being rectangular, which greatly facilitates the attachment of coaxial cable connectors. It is also made of copper, unlike power dividers made of square or rectangular aluminum tubing, so the whole assembly can be soldered for long-lasting, waterproof, electrical connections.

How Power Dividers Work

A few words are in order on how power dividers work. Once you understand the simple theory of operation of a power divider (combiner also), then you may come up with another way of building 1/4-wave (1/4 λ) transmission line transformers that better suit your needs or available materials list. The basic objective is to build transmission lines with the proper characteristic impedance to match two different RF impedances. The shape or size of the transmission line doesn't matter as long as it is the right impedance.

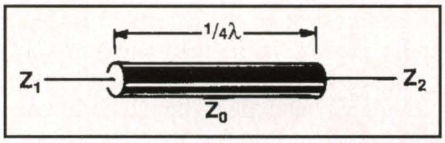


Figure 1. A quarter-wave transmission-line transformer. See text for details.

The two most common configurations are intended to combine either two or four antennas, each with a nominal impedance of 50 ohms. If you were to merely connect two antennas together with *equal* lengths of 50-ohm cable, the resulting impedance at the joined ends would be 25 ohms. This really isn't too bad, but we can do better. If we could somehow "transform" the 50 ohms at the end of each cable to 100 ohms, then when we joined the new ends together we would be back to 50 ohms. (The impedances combine like resistors in parallel). Such an impedance transforming device (pictured in Figure 1) is an electrical 1/4 λ piece of transmission line (cut to the frequency of interest and compensated for the velocity factor of the transmission line) having a characteristic impedance (Z_0) determined by the equation:

$Z_0 = \sqrt{Z1 * Z2}$ Where Z1 = Input Impedance, Z2 = Output Impedance

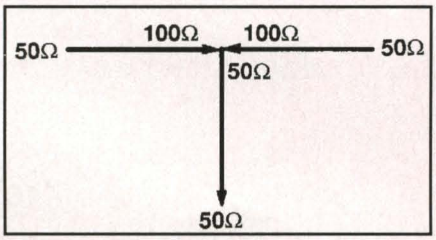


Figure 2. Impedance matching in a two-way power divider.

In the above example, we want to take the 50 ohms at the end of the cable and "step it up" to 100 ohms. The formula predicts that if the 1/4 λ transmission line impedance is $\sqrt{50 * 100}$ or 70.7 ohms, then we will achieve the desired results (see Figure 2). This "transformer" effect also works with any odd number of quarterwaves (i.e. 3/4 λ, 5/4 λ 7/4 λ, etc.). Aha! So this is why we used to use RG-11 (75-ohm coax) to match two antennas in the good old days. The trick was to get the RG-11 the right length (odd number of electrical quarter waves). In this case, the whole piece of RG-11 was the transformer. If we are using a power divider, then the only requirement is that all of the 50-ohm "phasing" lines have to be the same length, any length, but all the same. Much easier!

Connecting Four Antennas

In the case of four antennas, if we connect two of the antenna feeds together with equal lengths of 50-ohm cable, then

**This article originally appeared in the November, 1995, issue of* Cheesebits, *the newsletter of the Mt. Airy VHF Radio Club (the Packrats). Reprinted with permission.*

	WR-90		WR-=75		WR-62	
	t=.031"	t=.062"	t=.031"	t=.062"	t=.031"	t=.062"
50 Ohm	w= .490"	w= .420"	w= .450"	w= .380"	w= .360"	w= .290"
70 Ohm	w= .290"	w= .240"	w= .270"	w= .220"	w= .210"	w= .160"

Table 1. Center Conductor Width

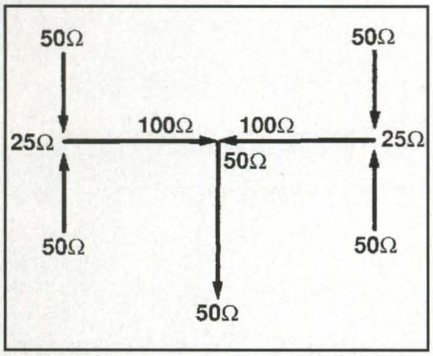


Figure 3. Impedance matching in a four-way power divider.

the impedance at this point is 25 ohms. The transformer has to then step up this 25-ohm load to 100 ohms. Thus when we connect the transformed 100 ohms from the other two antennas, the resulting impedance at the center will be back to 50 ohms (see Figure 3). The transformers required must have a characteristic impedance of 50 ohms ($Z_0 = \sqrt{25 * 100} = 50$ ohms). Once again this could all be done with coaxial cables of the proper length, but it is much easier to do it with a power divider.

Power Dividers Made from Waveguide

What is described here is just one way of building power dividers. There are other configurations, such as having two or four antennas connected to one end of a power divider and using a single 1/4 λ transformer to step up to 50 ohms. The theory is the same for all cases, just different numbers. I think you will find the construction of the actual device is easier in the configurations described here.

Figure 4 is an end view of a stripline (waveguide) transmission line. In typical stripline applications, the sides are not present. When used as a power divider, the presence of the sides of the waveguide does not affect the results because of the distance from the center conductor. Eagleware RF design software was used to calculate the width of the center conductor (w) that is required to achieve the 70- and 50-ohm characteristic impedances needed for the two- and four-way power dividers. Calculations are provided for .031" and .062" thick (t) material. Use brass shim stock or hobby brass for the center conductors. The thicker material may be necessary only if you contemplate using this technique on the "DC" bands, 220 MHz and below. For 432 and above, use the 1/32" (.031") stock. I used WR-90 waveguide (.90" x .40" inside) for all of my power dividers. The smaller dimension is designated as "b" in Figure 4. Dimensions are also provided for WR-75 (.750" x .375") and WR-62 (.622" x .311") guide, if that's what you have around (see Table 1). The smaller size guides, in fact, would be desirable for 2,304 and 3,456 MHz where SMA connectors should be used.

Table 1 gives the dimensions for the center conductor width (w), depending upon the type of waveguide used and whether a two- or four-way divider is being constructed. Keep in mind that the characteristic impedance is dependent only on the physical dimensions of the guide and the center conductor. The frequency of operation is determined by the *length* of the center conductor.

The length of the center conductor is a 1/2 λ, since these power dividers are actually two 1/4 λ transmission line sections in parallel. Table 2 gives the center conductor length (air dielectric) for the bands where stacked antennas are likely to be used. For the 2,304 and 3,456 MHz bands, I recommend building power dividers for 1/3 the frequency. Remember these transformers work on all odd multiples of a quarter-wavelength, so a power divider built for 432 MHz will work just fine on 1,296 MHz. Likewise, 768 MHz for 2,304 MHz and 1,152 MHz for 3,456 MHz. The dimensions for the higher frequencies get quite small and building becomes difficult. The larger size of the lower frequency versions makes them much easier to build. Note: These devices tend to be rather low Q, so don't worry about small dimensional errors.

The length of the actual piece of waveguide used is not critical. It can be any length that allows for easy mounting of the RF connectors. The ends can be open or closed. Since weather is probably a concern, you should seal the ends. One of the easiest ways is fit a small piece of wood in the opening and seal it with RTV or some other waterproof sealant. If you feel ambitious, you can fit a cap made from copper or brass and solder it in place. Remember there is no need for this end cap to be conductive.

Construction

The two- and four-way power dividers are constructed in the same manner. The outside connectors are located 1/2 λ apart for the frequency desired (see Figures 5 and 6). Drill holes that will provide clearance (≈0.625") for the small "lip" on "N" jacks (drill through both sides of the waveguide for the four-way) or drill smaller holes (≈0.25") if SMA jacks are utilized. Locate the center between the outside connectors and drill through both

	50 MHz	144 MHz	222 MHz	432 MHz	903 MHz	1296 MHz*	2304 MHz (768 MHz)	3456 MHz (1152 MHz)
1/2 λ	118"	40.9"	26.6"	13.66"	6.53"	4.55"	2.56" (7.68")	1.71" (5.13")
1/4 λ	59"	20.5"	13.3"	6.83"	3.26"	2.27"	1.28" (3.84")	0.85" (2.56")

*Table 2. Center Conductor Length. *Dimensions for 432 MHz also work at 1,296.*

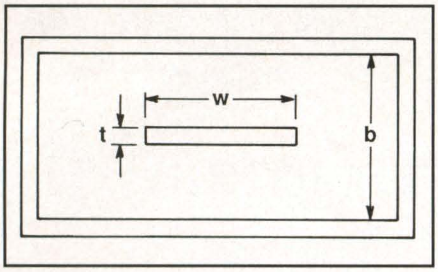


Figure 4. End view of waveguide with center conductor.

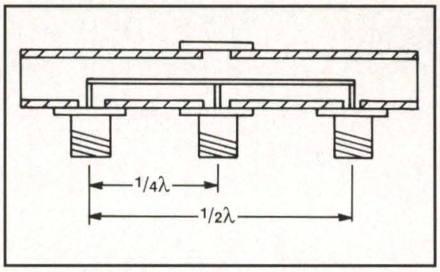


Figure 5. Side view, cross-section of two-way power divider.

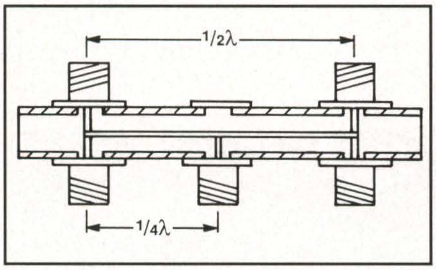


Figure 6. Side view, cross-section of four-way power divider.

sides of the waveguide. The hole opposite the antenna connector will allow you to solder the center pin of the connector to the center conductor inside the waveguide. This hole has to be covered with a small piece of copper or brass after the power divider is assembled.

CAUTION: Use Eye Protection!

After all of the holes are drilled, it's time to break out the heavy heat. This is not a job for any kind of wimpy soldering iron: a propane torch is required. I have had the best luck with plumber's solder (no acid core and use "real" lead-tin) and paste solder flux. Shine up all the copper or brass parts with emery paper and lightly coat with flux the areas to be soldered. Put a small amount of flux on the base of the connectors and place in position. Do all three connectors on one side at once. Heat the waveguide until the solder starts to flow under the connector. If the solder doesn't flow freely, then either there is not enough heat or the parts are "dirty" or oxidized.

WARNING: ALL PARTS ARE VERY HOT AT THIS POINT!

Mounting SMA Connectors

SMA connectors can also be mounted this way, but be careful, as the gold conductive surface is an extremely thin "flash" coat that is easily damaged. Once the gold is gone, you will not be able to solder the connector. An alternative method for the SMAs is to heat the body of the power divider (leave the connectors off) with the torch and, when very hot, use a soldering iron and 60/40 solder to solder the connectors, just like you were soldering to a PC board. Still use the acid flux to prevent the heated copper from oxidizing while it is being heated.

Once the connectors are soldered on one side, it's time to install the center conductor. A hole drilled in the center of the brass strip (tight fit on center pin) will facilitate soldering the center pin of the center connector. You may have to trim a little off the ends of the connector pins so that the center conductor is positioned in the center of the small dimension of the waveguide. Position the center conductor inside the waveguide and centered on the three connector pins. Solder the center pin first through the access hole and then the end pins through the open ends of the waveguide. Once this is done, it's time to turn the power divider over and solder the connectors on the other side (if you're building the four-way version) and to cover the access hole for both the two- and four-way. Use the same procedure as above.

Clean off the excess flux as best you can. Commercial flux remover in a spray can seems to work on either the acid or rosin flux residue. Be careful and use eye protection for all phases of construction and clean up. If you clean off the flux while there is still a little residual heat in the waveguide, it will go a lot easier. So clean up before it cools completely.

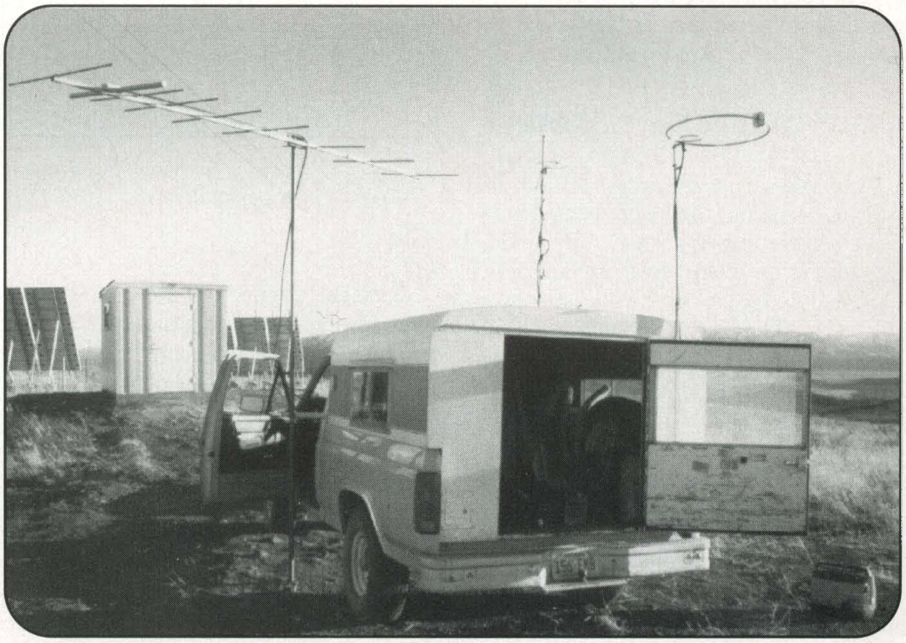
Finish up the power divider by covering the ends as discussed above. A coat of paint is optional. Attach equal lengths of 50-ohm cable to all antennas, then connect your radio and call CQ. ■

If It's June, It's Contest Time... and More!

The biggest VHF contest of the year is this month...and it's also the peak month for Sporadic-E, so be sure you're on the air!

Finally. After all the months of planning and preparation, contest time is *here*! We've reviewed strategy, visited the operating site in spring to check on access and new commercial users, and operated the Memorial Day weekend as a dry run, trying to break the station early. And we've announced our intentions to any and all who would listen, via Internet reflectors, newsgroups, postcards to area clubs/newsletters, and by checking into local FM/SSB nets pleading our cause several weeks beforehand.

Is this much pre-contest effort really worth it? Most definitely! Remember the "Five Ps"...*Prior Planning Prevents Poor Performance*! Be sure to check all information sources one last time before heading out. Many folks never know exactly where they will be operating until moments before the contest weekend. Last year, Ron, WZ1V, and I compiled a list of planned operations and posted it on the VHF reflector and the N.E.W.S. (North East Weak Signal) Group World Wide Web page. Check it out before you leave.



NC7K's rover station in a recent photo. The loop antennas cut down range somewhat, but minimize set-up and tear-down time.

Calling Channel Controversy

Monopolization of the calling channels continues to be a major headache during contests. Many operators have expressed their frustration and have even called for banning the use of calling frequencies during contests. My suggestion is simple: We don't need more rules regarding the calling channels, we need to be smarter in using them.

During the 1996 January VHF Sweepstakes, I operated as a rover throughout most of California (*see "Confessions of a Single-Op Rover," elsewhere in this issue.—ed.*). I opted to use only mobile antennas, which allowed for rapid grid-to-grid movement but reduced my ability to quickly QSO stations beyond 400 miles as compared to stopping and setting up a Yagi. This meant I needed to be loud while mobile and needed to move fast. Loud was not a problem using a pair of KB6KQ miniloops and a 400-watt amplifier borrowed from KA6CHJ. But to hear, I had to be creative and devise a winning strategy. I would call CQ on 144.200 during quiet moments, announcing my primary operating frequency of 144.210, and then QSY, *not even listening for replies on the calling channel*. This worked extremely well, giving me semi-private use of the frequency and the ability to hear better because of reduced QRM. I was also able to hear well as there was only me (and the people I worked) on the frequency.

MegaRover Recognition

Recognizing the efforts of all the hard-working rovers who, in each June contest, brave the elements, traffic, sleep deprivation, and equipment problems, I'm sponsoring a new award, the *MegaRover Plaque*. Scoring is simple: total number of unique stations worked multiplied by the number of grids visited during the June VHF contest. A station may be

By Tim Marek, NC7K