Build the Featherweight 6-Meter Yagi

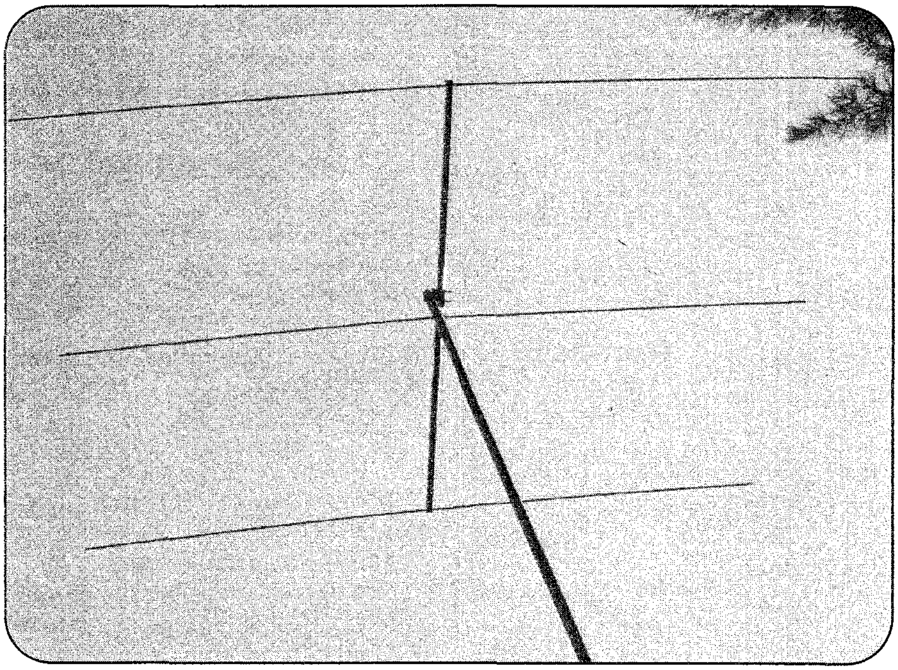
Give your signal extra punch on amateur radio's "magic band" with this compact three-element beam for 6 meters.

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

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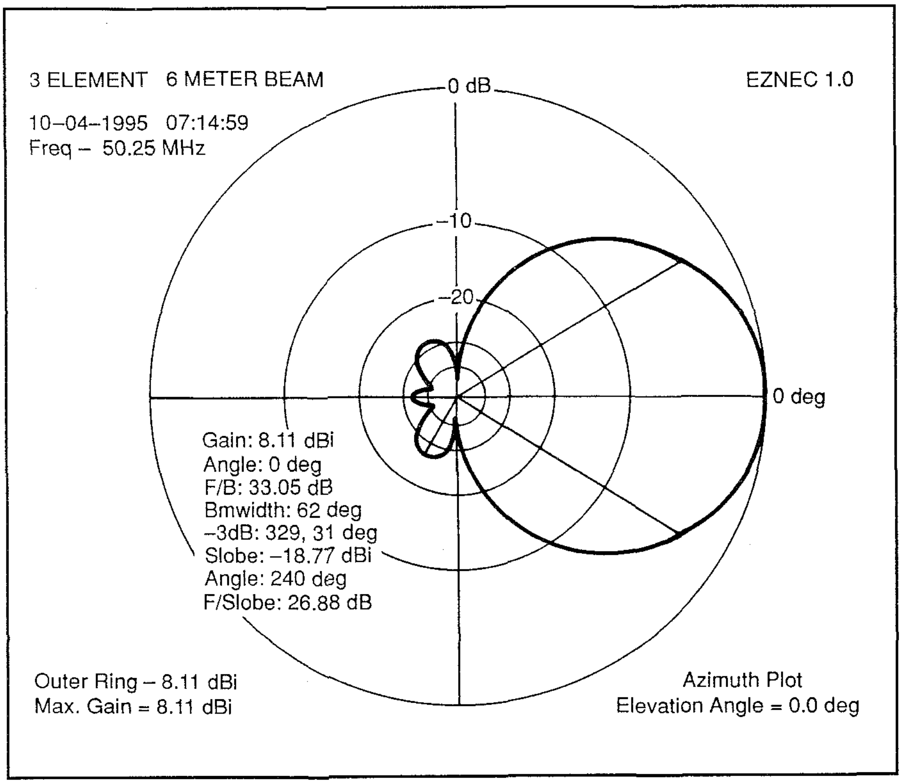


Azimuth Plot. Featherweight antenna modeled on "EZ-NEC"

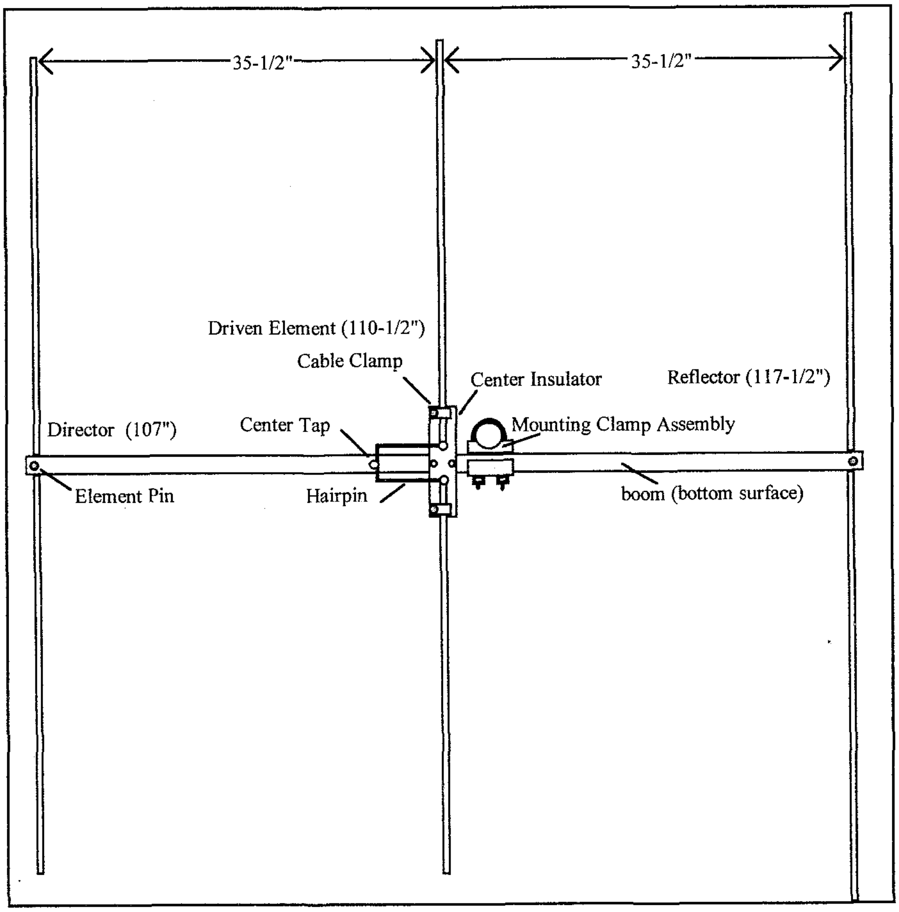


Figure 1. Overall view of the Featherweight 6-meter Yagi.

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.

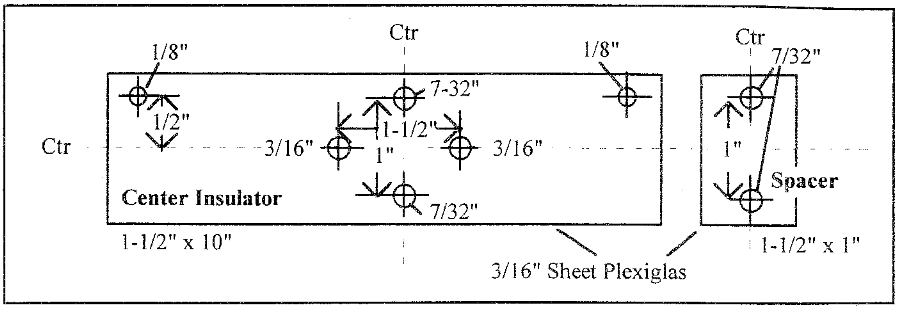


Figure 2. Center block and spacer detail.

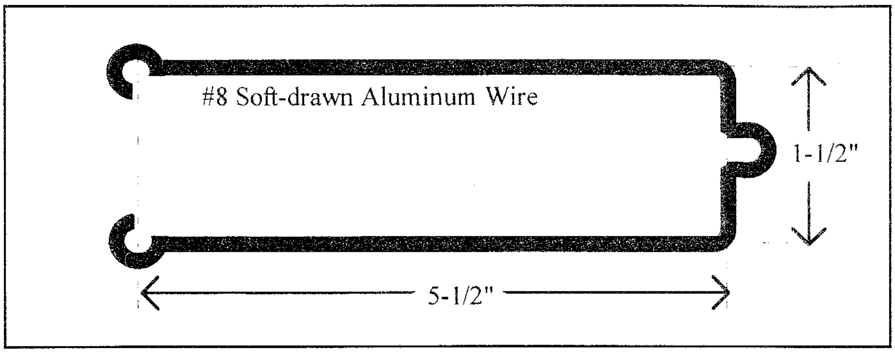


Figure 3. Hairpin matching inductor detail.

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

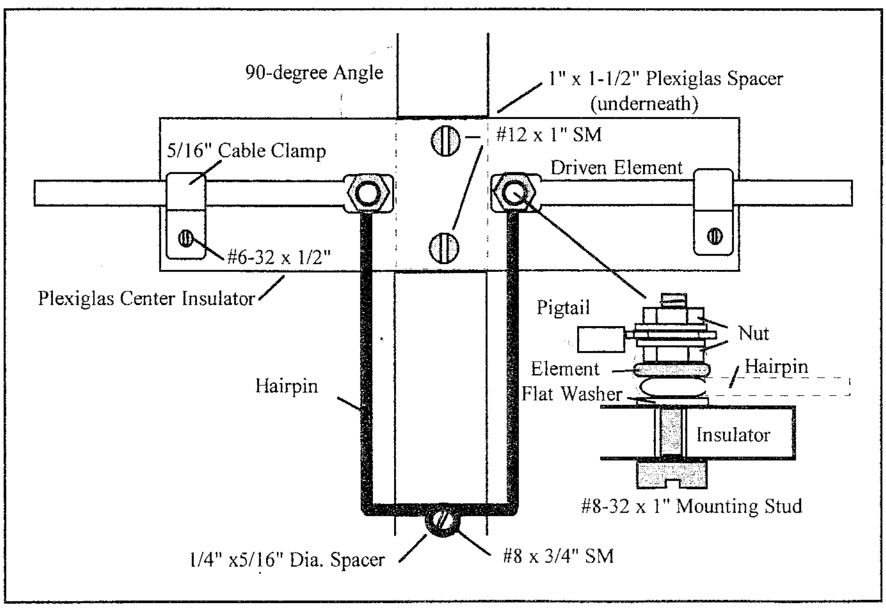


Figure 4. Center block assembly detail.

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.*

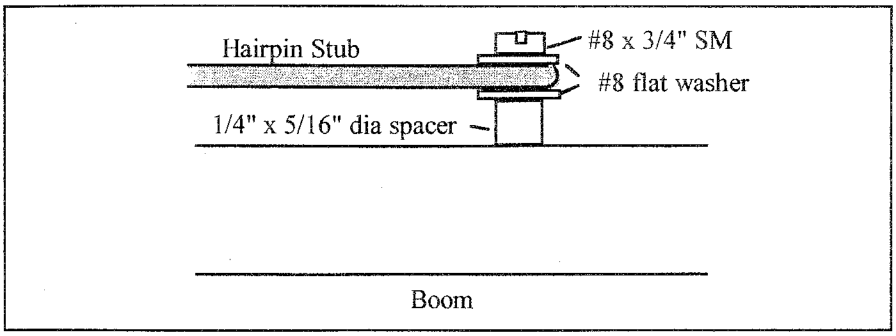


Figure 5. Hairpin center-tap grounding detail.

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).

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.

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.

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

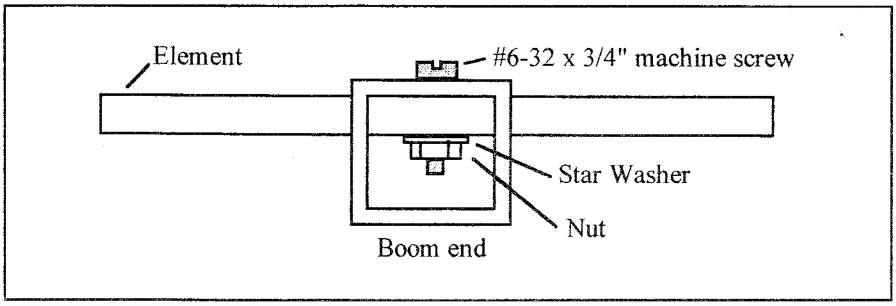


Figure 6. Element mounting detail.

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.

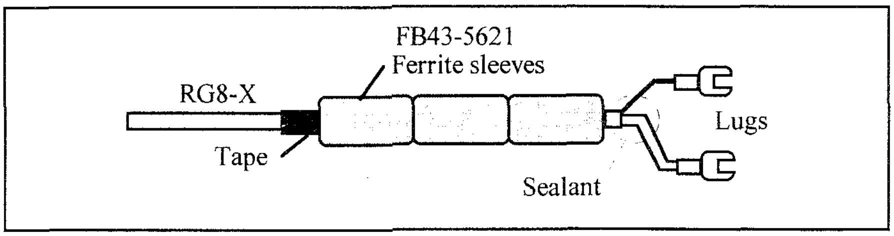


Figure 7. Balun and feedline pigtail detail.

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.

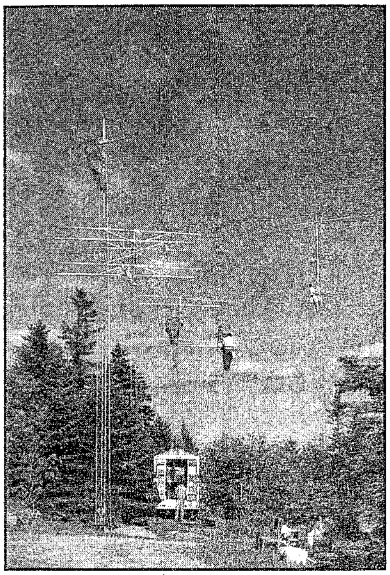
Finally, connect the phasing harness to the antennas (see Figure 9). When you do this, *be sure to transpose the pigtail connections on the second antenna*: if this is not done, the two Yagis will be fed out-of-phase and the signals will cancel each other instead of adding together for improved gain.

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.

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.)

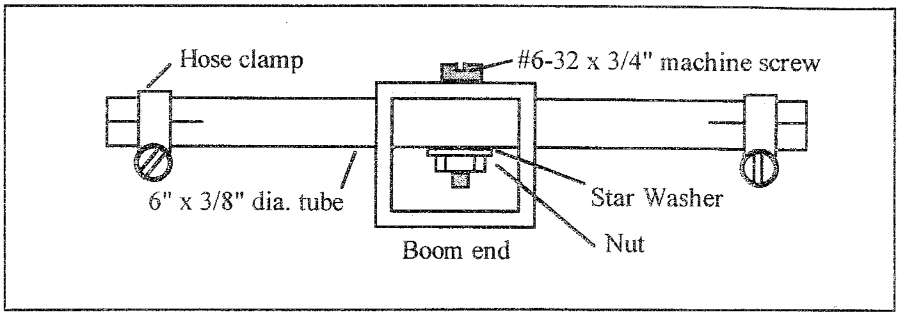


Figure 8. "Rover Option" element mounting detail.

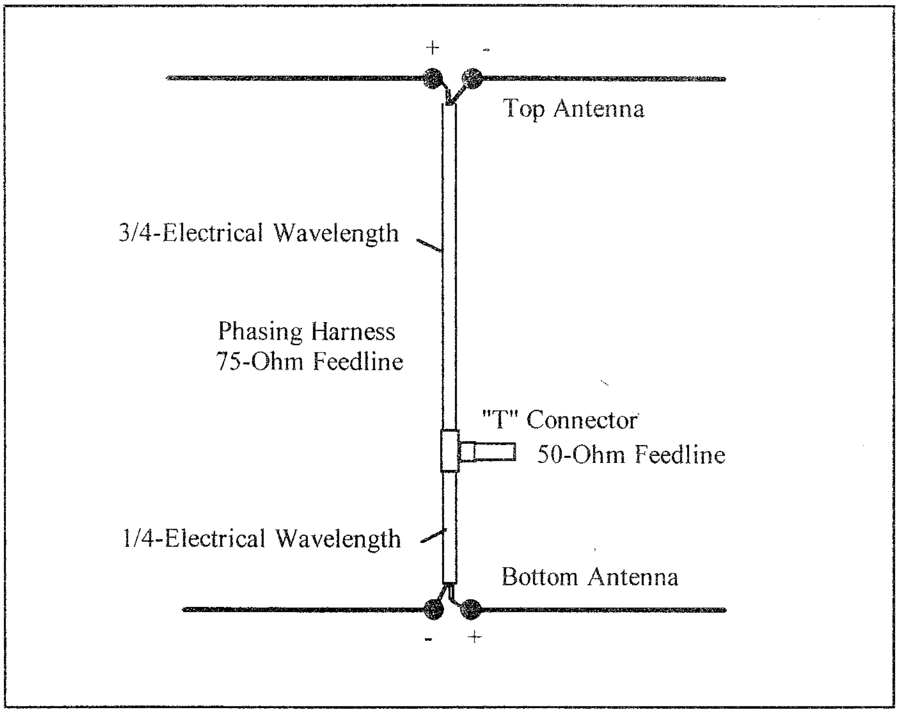


Figure 9. Phasing harness for stacking two Featherweight Yagis.

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!

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?