Unique 12 and 17 Meter Dual-Band Beam

Build a high gain beam for these two new WARC bands.

by Robert E. Bloom W6YUY

Have you noticed that there are many monoband beam articles published, but almost none for multi-banders, even for the non-WARC bands? There's the feeling that hamdom has no choice but to buy a multiband beam. I figured, though, that for $500 dollars and up for the commercial products of comparable quality and gain, you could build a multibander for up to a quarter of the price, and learn a lot in the bargain!

This article shows you how to do this. The antenna project here is a unique 12 and 17 meter interspaced dual-band array. This puts you on two great bands. 17 meters has the best of both worlds (so far)—it has propagation characteristics very similar to that most popular DX band, 20 meters, and yet is still only very moderately used. 12 meters is also a very mildly used band, and is open at least as often as 10 meters—which is quite often these days.

Impressive Specs

The forward gain of this beam approaches 8 dBd and has a front-to-back ratio of 25 dB. The single radiator element uses a pair of 12 meter high-"Q" traps and a pair of stacked gamma matching units which accommodate a single 50Ω coaxial cable transmission line. Construction is simple and sturdy.

I suggest this beam for a club project not only because of its fine performance, but also because you save money when you buy aluminum tubing in quantity. A source for the tubing is *Metal & Cable Corporation, 2170 East Aurora Road, POB 117, Twinsburg OH 44087.*

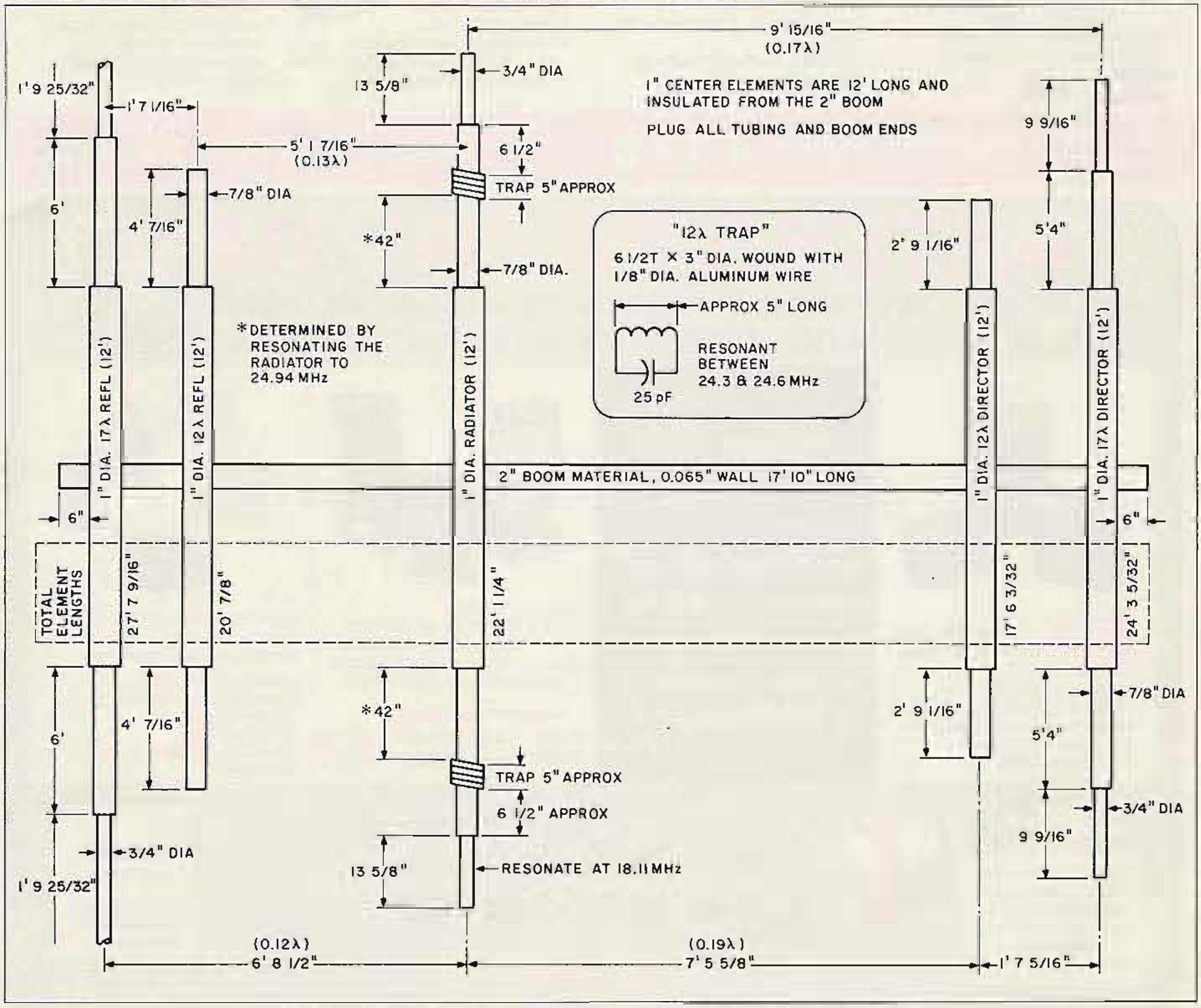

Figure 1. Plan with dimensions for the dual-band 17 and 12 meter beam antenna.

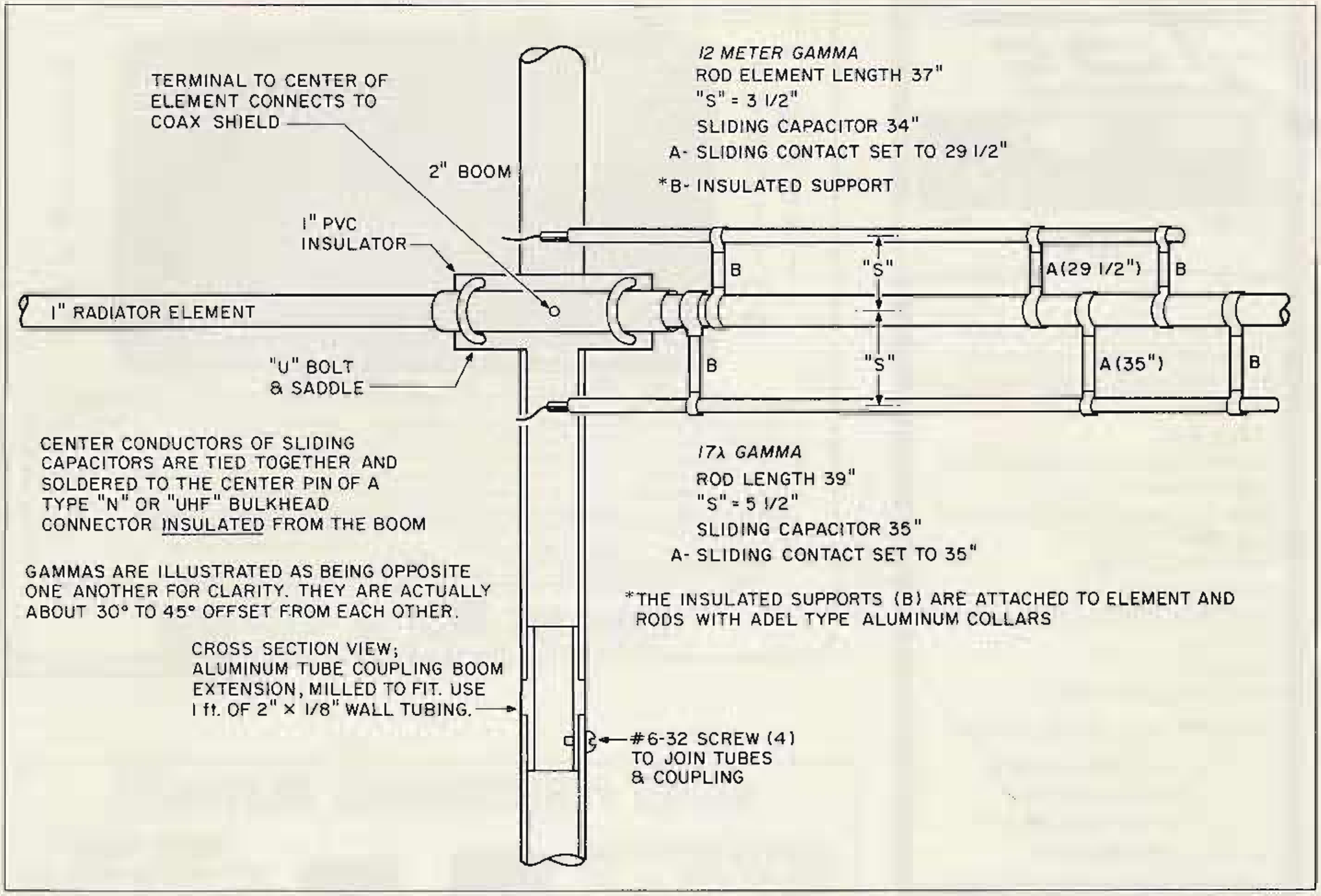

Figure 2. Stacked gamma matching devices.

This unit has a boom length of 17 feet plus, and is actually equivalent to a new commercial product with a boom length of 19 feet. You may wonder how it's possible for an array to perform as well as one with a longer boom length. The element spacing is similar to that of the 19 footer, but the trick here is that I use only a single radiator for the two bands; the 19-footer uses two, one for each band. The second radiator has to be separated from the other element, which demands more boom space without adding an iota of gain.

Parallel Gamma Matches

Feeding a beam with multiple gamma matches is not new, but little has been written on the subject. I found mention of them only in *The New Beam Antenna Handbook*, by William Orr W6SAI and Stuart Cowan W2LX. This book is one of the best ham antenna publications available.

If you follow my dimensions on both the beam and trap construction, and make the initial SWR adjustments to the radiator, forward gain will be within 0.5 dB of optimum. Any changes, such as increasing the diameter of element tubing, will change the taper factor and require lengthening of these elements.

About Gain Figures

According to feasibility charts for a 3-element array, obtained from the *New Beam Antenna Handbook* mentioned above, the maximum forward gain possible at a given frequency and optimum boom spacing (0.45λ) is 7.8 dBd. An ad for a particular antenna manufacturer, however, states that their beam with the same configuration has 8.5 dBd gain! Since it has been shown in the past, however, that gains stated in ads are usually not rigorously verified (which in fact led several magazine to refuse to run ads for antennas with gain figures), don't hope for more than 8 dBd out of this configuration. Still, that's a hefty figure!

Front-to-back ratio is the most difficult of the two main characteristics of a beam to pin a value on. With the presence of earth ground, the ratio depends on the angle of the signal arriving at the rear of the array. It will vary widely between a low and high angle signal. Nonetheless, feasibility studies show that a typical F-to-B for this configuration is 25 dB.

Effects of Traps

The physical length of the trap coil and its inductance determine both the length of the inside element (that part of the radiator element in front of the trap) and the length of the lower frequency element beyond the trap. Essentially, the hat capacity of the trap shortens the inner length, and the coil inductance shortens the lower frequency stub dimension.

Figure 1 provides all of the element dimensions. All element material other than the boom has a wall thickness of 0.058″. This is the only size that will allow telescoping of elements and clearance of several thousandths of an inch. The boom wall thickness is 0.065″.

The center section of each parasitic element is a 12′ length of 1″ outer diameter (O.D.) tubing. A ⅞″ O.D. material telescopes therein, and where necessary for an additional taper, use a ¾″ O.D. material. The best aluminum tubing is 6061-T-6 (61S-T6) and comes in 12-foot lengths. You can also use Type 6063 T-8, sometimes used by manufacturers, though it is softer, and bends and fatigues more easily. The unreinforced 27′ plus 17 meter reflector bows a bit on the beam; you can insert a 10½′ section of ⅞″ material inside the 1″ center segment to double the wall thickness.

When determining the length of telescoping elements, be sure to allow 5″ to 8″ for the telescoping segment that holds the element in place. Cross-slot the ends of all element sections away from the boom, where telescoping will be required. To do this, use a hack saw to cut slots of 1¼″ to 1½″ and deburr with a fine tooth file. Slotting allows a good quality aircraft type hose clamp to bind the material securely.

I suggest coating all telescoping segments with an oxidation inhibitor, such as No Ox™, Ox-guard™, Cual-aid™, or Penetrox™. These trade names are available through electrical supply houses. Without this, you won't be able to slide the telescoped sections after a few months. If your climate is antenna-hostile, with rain, sleet, snow, and especially high salt content in the air, seal the door knob capacitor ends with plumber's white silicone sealant and position them beneath the element when you erect the antenna.

Gamma Matching Units

Figure 2 shows the gamma match dimensions. These are made of ½″ O.D. tubing. A means for tuning out the inductive reactance of the gamma element must be provided. Salvage the dielectric and center conductor portion from sections of ½″ coaxial cable: RG-8, RG-9, RG-11, RG-13, or equivalent. When telescoped into the ½″ gamma element, this becomes a variable capacitor. The telescoping fit is rather loose, but tuning is broad enough for a stable value. Rule of thumb normally calls for approximately 7 pF per wavelength, but in this case 5 pF per λ works better. Use the length as shown in Figure 2 and follow all dimensions.

The center conductors of both sliding capacitors are tied together and connected to the center pin type "N" or UHF bulkhead connector. The connector is mounted close to the gamma feedpoint. The shell or shield side of the bulkhead connector is insulated from the boom. I used a 1/16″ thick piece of Teflon™ for insulation and held the bulkhead assembly to the boom with a large hose clamp.

How do stacked gammas interact with one another? I found that with only one gamma in the circuit at a time, the tuned positions did not exactly coincide, as they did when both were in the circuit. I attribute this to a shift in the impedance point on the radiator due to loading by the additional gamma. But once the proper point has been established, the two units do not see each other due to their high "Q" at their respective frequencies. Electrically, only one is effectively in the circuit at a time.

Insulating Elements from the Boom

All five elements are insulated from the boom to prevent any reaction from boom resonance, if present, and to preserve a good front-to-back ratio. 10″ or 11″ sections of 1″ schedule 40 PVC pipe slides over the 1″ center elements. There are two ways to secure the PVC's rather loose fit. You can seal the PVC with a layer of plumber's white silicone sealant or by drilling a ¼″ hole in the center of the PVC; then drilling and tapping an 8/32 hole at the 6′ point of the element sections, lining up the holes of the PVC and the element. I prefer the latter method because the ¼″ hole in the PVC not only simplifies alignment, but recesses the head of the screw. After securing the element with U-bolt and saddles, tighten the nuts to compress the PVC to the tubing.

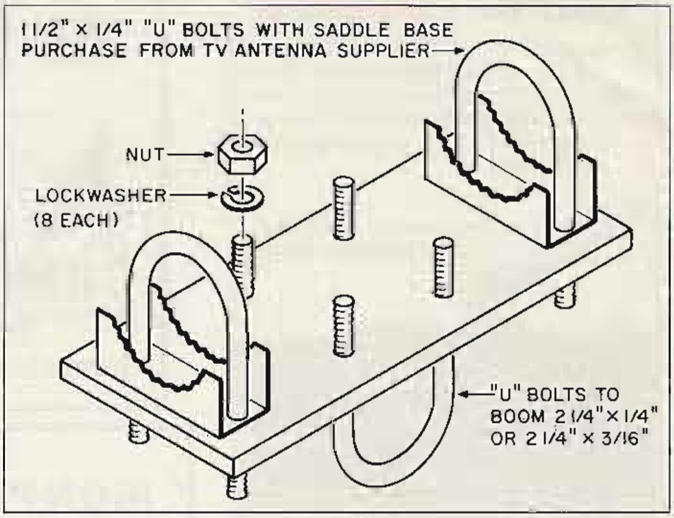

Figure 3. Parasitic and radiator element mounting plate.

Making the Trap Coils

Trap coils have disadvantages: they complicate determination of the length of the parasitic elements; increase gain loss due to the reduced element length; and add to construction problems. They're often a necessary evil, however, when designing a multiband beam.

I made the two 12 meter radiator traps with ⅛″ aluminum wire. You can find this wire in well-stocked hardware stores or electrical supply houses. Buy the insulated type if possible.

My coils have a green transparent plastic insulation which stripped off the ends quite easily. The cost for 50′ was under $6, and it'd be even less from an electrical supplier. You will need about six feet per coil. The coil requires 6½ turns of 3″ diameter. Allow 2″ to 2½″ at the end of each coil so that it can be mounted centrally and have about ¾″ in contact with the element.

Aircraft hose clamps hold the coil in place. Use the shaft of a ½″ drill or other tool to initially space the coil turns. A 25 pF 5000 volt doorknob high-Q transmitting capacitor (or a pair of 50 pF in series) shunt and mount inside the coil. The capacitors are connected to lugs that contact the elements. The traps are made resonant between 24.3 and 24.6 MHz. The object is to present a very high reactance to the lower frequency element stub beyond the trap.

Parts List

Item	Tubing	Price/Ft.	Subtotal
1.	12′, 1/2″ O.D. x 0.058″ Wall	0.73	$ 8.96
2.	12′, 3/4 O.D. x 0.058 Wall	1.02	12.24
3.	60′, 7/8 O.D. x 0.058 Wall	1.10	66.00
4.	60′, 1″ O.D. x 0.058 Wall	1.16	69.60
5.	24′, 2″ O.D. x 0.065 Wall "Boom"	2.79	66.96
6.	1 sheet 27½″ x 10″ x ⅛″ 3½ lbs.	2.50/lb.	8.75
7.	50′, ⅛″ aluminum wire	5.75	
8.	14 ea. 2¼″ x 5″ x 5/16″ U-Bolts	0.65 ea.	9.10
9.	10 ea. 1¼″ x 3″ x ¼″ U-Bolts/Saddles	0.65 ea.	6.50
10.	1 ea. 8 oz. Tube, Oxguard/Oxidization/Inhibitor	4.79	4.79
Total			$258.65

The above total is near the *maximum* figure you would pay if you bought all the materials in single units. With salvaging and quantity orders, expect that figure to drop by as much as one half.

Note that in item 5, I used less than 18′. Item 7 required only 11′. This list doesn't include end caps, Adel collar clips, plumber's sealant, or sales tax. Also, about 1′ of 2″ x 0.225 wall aluminum tube must be milled to couple two pieces of boom material.

The insulating material for the traps is made of two 4¾″ lengths of ¾″ O.D. schedule 40 PVC pipe. Chuck about 2″ of the material into a bench vise and cut two 9″ lengths of ¾″ element tubing. These will become the outer conductors of the traps.

The inside diameter of the ¾″ PVC is too small to accommodate the ¾″ aluminum tubing. Prepare the inside by either reaming or filing a small amount to help start insertion of the aluminum tube. Carefully heat the PVC end with a small propane torch. Keep moving the flame to prevent scorching the PVC. The material will soon become soft and pliable. Force about 2″ of the 9″ length of tubing into one end of the PVC, keeping the alignment straight.

To gain confidence, experiment a little with a sample piece. After completing the procedure for the short ends, do the other end of the coil. This time the length of ¾″ tubing is 4¼ feet. This will become the 12 meter section that telescopes into the 1″ diameter center section element.

When you're finished, clean up any burnt spots with a file or sandpaper. Drill a 6/32 tapped hole near the ends of the PVC about ½″ to ¾″. Drill clean through both the PVC and aluminum tubing to the opposite side. Tap the hole on both sides and use 1¼″ long 6/32 screws. Slide a soldering lug, a 5/16″ flat washer, onto the screw and screw it into the tapped hole and out the end. Secure using a flat washer, star washer, and nut. Repeat on the opposite end of the PVC.

CAUTION: Be sure to allow a proper distance between the lugs to accept the 25 pF capacitor. These screws and lugs become the connection for the capacitor to the 12 meter and 17 meter element sections as well as shunting the coil. Repeat the procedure for the second trap.

Perform the final grid dipping when the coils are in place on the antenna assembly. Dip for a frequency between 24.3 or 24.6

MHz. If the frequency is too low, the coil will need stretching (wider spacing between turns). You can adjust the coil length by repositioning the coil hose clamps. If the frequency is too high, you may have to squeeze the turns closer together.

Element to Boom Brackets

Figure 3 shows the bracket for holding the radiator and parasitic elements to the boom. This is made from ⅛″ thick aluminum plate. The narrow dimension is 3¼″ (if you use material 3/16″ thick, you can reduce this to 3″) and length is 9″ to 10″. The U-bolt should be ¼″ to 5/16″ in diameter, and have a saddle for seating the elements.

The U-bolts to the boom should also have saddles. These may be more difficult to find, but I would start looking for them at auto muffler shops. Check also in electrical and plumbing supply houses. You can use U-bolts without saddles on the boom, but they shift out of alignment after a time. If you can't find U-bolts with saddles, then drill, after aligning them, an 8/32″ or 10/32″ tapped hole through the element plate and boom and secure them with a short screw.

When assembly is completed, find a relatively clear area and mount the antenna between two wooden ladders. This is easier if your boom length extends 6″ beyond the elements at either end. To block the assembly up, place short lengths of 2″ x 4″s on edge under the element support plate. With the boom 5′ above ground, you have easy access for the initial tuning.

> ***"The forward gain of this beam approaches 8 dBd and has a front-to-back ratio of 25 dB."***

Initial Tuning and Settings

Prepare a 3–5 foot length of small diameter 50Ω cable (RG-58 or equivalent). Put a coax connector on one end to mate with the one on the array, and make a 3″ loop at the other end (center conductor to shield) to couple with the coil of a grid dip test instrument. Disconnect the sliding connectors of the gammas. Coupling between the gamma element and the radiator should be sufficient for measuring the radiator resonance.

Starting with 12 meters, look for a dip near 24.9 MHz. There may be a number of dips over a wide frequency range, but concentrate on those of concern. When you locate one near the frequency, verify it by touching the coil or the radiator element ahead of the coil. The frequency dip will shift or disappear. By adjusting the length of the 12 meter telescoping section (that portion of the element ahead of the trap), you should be able to set the resonant frequency to 24.94 MHz. Touching the stub element beyond the trap should not disturb the dip, indicating that the trap is performing properly. Mark the point of insertion of the 12 meter element with pencil or paper tape. If you have not located a dip by now, you may have to connect the sliding contact of the gamma. But, using this system, I had no problem locating any of the dips. Adjust both left and right sections of the dipole to the same dimensions.

Now, locate the 17 meter radiator resonance. Once you find it, adjust the 17 meter stub for a frequency of 18.11 MHz. The stub will be very sensitive as to position.

Loading and Adjusting the Beam

The unit is now ready for an RF energy test. You will need a Bird Model 43 or equivalent, and a 1 or 5 watt Bird slug element (the directional coupler element). Connect both gamma sliding contacts to the approximate dimensional positions.

Before continuing, remember that you are in the RF field of the radiated energy. Low power (below ten watts) is fine, but be careful to not pump much more RF than that into the beam while working near it, especially while standing in the beam path. Only you are responsible for taking the necessary precautions here!

Begin by applying 1 or 5 watts, depending on the full scale rating of the wattmeter element at a frequency of 24.94 MHz. Reverse the direction of the Bird slug element. The meter now indicates the magnitude of the reflected energy. Move yourself out of the field of the radiator, and observe the meter indication. Adjust the 12 meter gamma sliding contact to reduce the reflected power indication, thus reducing the SWR.

You may achieve further reduction by making a small adjustment in the length of the 12 meter element section. Adjust both sides of the element equally. With this minimized to a small percentage of the scale, change frequency to 18.11 MHz and re-establish the power setting. Adjust the gamma slide contact on the 17 meter gamma for minimum reflected indication. Further adjustment is made by positioning the 17 meter stub element beyond the trap. The end section adjustment is very sensitive to length and the proximity of your body. Adjust for minimum indication. Halve the perceived change length needed for each element, since the other end of the element must also be adjusted by the same amount, to maintain dipole length symmetry. For example, should you find a change of ½″ is required, then change it by ¼″ on the first element end, and then go to the other end of the dipole and set the length by the same amount (to total ½″) so that the stub lengths are equal. Keep repeating these adjustments until you achieve unity or minimum SWR.

Be sure to adjust for 12 meters first, since these adjustments affect the 17 meter element/gamma match tunings. When completed, reposition the array. Set the reflector end on the ground and prop the director end up in the air 45 to 70 degrees and in the clear. For this, I suggest using a 6-foot length of 2″ x 4″. Notch out one end so that it will cradle the 2″ boom material at a point behind the 12 meter director. Using C-clamps, attach the 2″ x 4″ to the side of a six-foot ladder. Position the ladder so that it supports the boom with the antenna facing upwards and away from any nearby obstacles, like trees or buildings.

Once again, check for minimum reflection indication. And touch up on gamma slide contact position and element lengths. Start with 12 meters and conclude with 17 meters. At this point, expect little change.

Further tuning depends on the type of your tower and its location. It's best to final-tune the antenna at operational height, though this is impossible most of the time.

If the tower is crank-up or tilt, so much the better. First lower it to minimum height. If there is a sturdy nearby structure, stand on it to insert the sliding elements, having marked the position of and removed these elements before mounting the boom to the mast. When the sliders are out, there is only 6 feet of element on each side of the boom. Still, erection is a two-person job.

Insert the telescoping elements after the antenna is in place on the tower. I was able to position my antenna at 15 or so feet, and make finite element adjustments at that height. Very little adjustment was necessary. At worse, if no further adjustment is physically possible, the most you'd lose in gain would be ½–¾ dB. With my array at full height (45 feet), I have unity SWR on 17 meters and and a maximum of 1.3:1 on 12 meters. My 940S automatic antenna tuner allows me to obtain a perfect conjugate match of the entire system on both bands. A conjugate match keeps all the system currents in phase. With frequencies in the HF spectrum and ½″ variety transmission line, there will essentially be no loss, and any reflected energy on the line will eventually be radiated.

Performance

With 100 watts into the transmission line, my signals on either band are consistently among the stronger on the band. Minutes after erecting the dual band beam, I got on the air, and immediately worked IK6BAK in Cesena, Italy, on 12 m, and ZL1PD, in Auckland, New Zealand, on 17 meters. Both answered immediately on my initial abbreviated call during a pile-up, and gave me a resounding 5-9+ report. From my QTH, you just can't get much further away than Auckland! And that was just the beginning of many long and rewarding DX QSOs on these two new WARC bands with the dual-bander.

I hope you have as much fun as I did building and using this beam! Let me hear from you. An SASE is sure to get a reply.

Robert E. Bloom W6YUY has worked in many phases of radiocommunications engineering, including broadcasting, antenna design, and tower structure design. He has had his ticket since the early thirties. Bob can be reached at 8622 Rubio Ave., Sepulveda CA 91343.