About this Article

This material was included with the downloadable supplemental content accompanying the *ARRL Antenna Book*.

You may print a copy of this material for personal use. Any other use of the information requires permission from the ARRL.

THREE-ELEMENT PORTABLE 6 METER YAGI BY VE7CA

The following material was extracted from earlier editions. Figure and Equation sequence references are those from the 21st edition of *The ARRL Antenna Book*

The idea to build a Yagi antenna resulted when the author traded the family van for a compact car. He needed something that would fit into the trunk of the car. At close to 7-feet long, the quad spreaders were too long. Computer modeling showed that a three-element Yagi on a five-foot boom also could pick up about 1.5 dB gain over the short-boom two-element quad. A five-foot boom fits into the trunk or across the back seat of the car, but something had to be done about the nine-foot elements!

One day VE7CA noticed a box of portable-radio telescoping antenna elements at the radio parts store. They were 54 inches long when fully extended. He next found a 60-inch length of aluminum tubing that fit over the end of the telescoping elements. There are many different sizes of telescoping antenna elements, with different diameters. This is where you will have to use your scrounging skills! **Fig 23** shows how the tubing is used as a center section to join two telescoping elements together. It also serves to extend the total length of each element, since two telescoping elements themselves are not long enough to resonate on six meters. See **Table 3** for dimensions and element spacings. Each center section is slotted at both ends with a hacksaw, and stainless-steel hose clamps are used to secure the telescoping elements.

Fig 24 shows the center sections of the three elements with their mounting brackets. A square boom was used to obtain a flat surface to work with. **Fig 25** shows how the reflector is attached to the end of the boom with two $1^1/_2$-inch 10-32 bolts and wingnuts. **Fig 26A** provides the dimensions and details for the reflector and director element-to-boom brackets, which are formed from $^1/_{16}$-inch plate aluminum. The driven element is split in the center and is insulated from the boom. Fig 26B shows details for the driven-element bracket. **Fig 27** is a photo

Fig 22—Ready for action! VE7CA has set up his quad next to the family van.

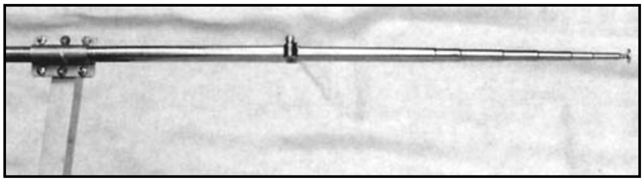

Fig 23—Photo showing a piece of aluminum tubing used as a center section to join the two telescoping tips together.

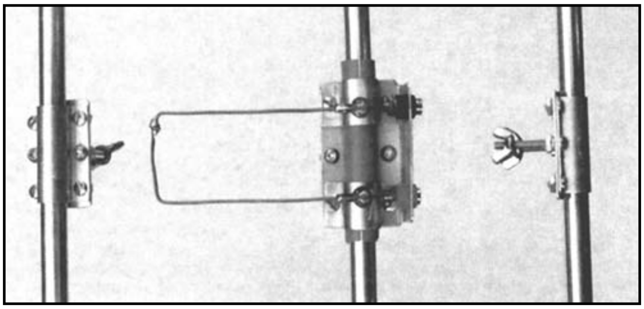

Fig 24—A view of the center sections of the three Yagi elements with their mounting brackets.

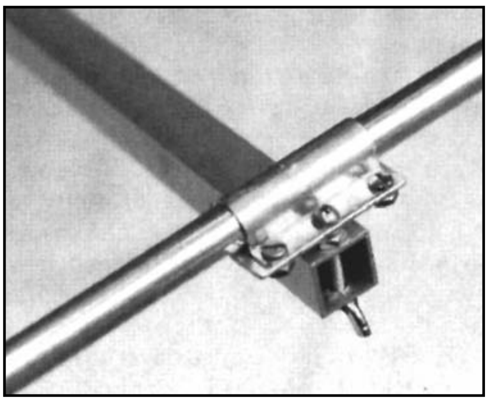

Fig 25—Photo detailing attachment of the reflector to the square-section boom, using two #10 bolts and wingnuts.

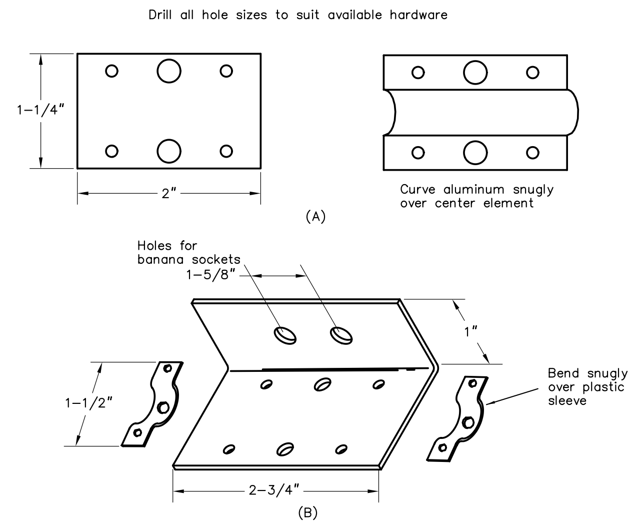

Fig 26—At A, details for the reflector and director element-to-boom brackets, made of 1/16-inch plate aluminum. At B, details for the driven-element bracket. These are screwed to the square boom.

of the driven element with the hairpin matching wire and the banana plugs used to connect the coax to the driven element. You could use a female PL-259 connector if you wish. VE7CA used #14 solid bare copper wire for the hairpin. It is very durable—even after being severely warped in the car trunk, it can be bent back into shape quickly and easily.

The boom is 3/4-inch square aluminum, 65 inches long. The material was found at a local hardware store. To detach the elements, just loosen the wing nuts and remove the elements from the boom. A similar method was used to attach the support mast to the boom.

As with the quad, a choke balun was used, consisting of a coil of 6 turns of coax with an inside diameter of 2 inches. To tune the hairpin match, assemble the Yagi on its mast and extend the elements. Spray switch contact solution on a cloth and wipe any dirt and grease from the elements. Push the elements together and apart a

Table 3

Three-Element Yagi, Element Lengths and Spacing Along the Boom, and Hairpin Dimensions

Element Along Boom	Spacing Section Ele. (inches)	Center Length (inches)	Telescoping (inches)	Total Length (inches)
Reflector	0	22 3/4	51 1/2	125 3/4
Driven	28	9 3/4 *	48 5/8	58 3/16
Director	63 3/8	14 1/2	51 1/4	117
Hairpin	#14 wire	4 long	1 5/8 spacing	

* Driven-element uses 2 sections insulated at center

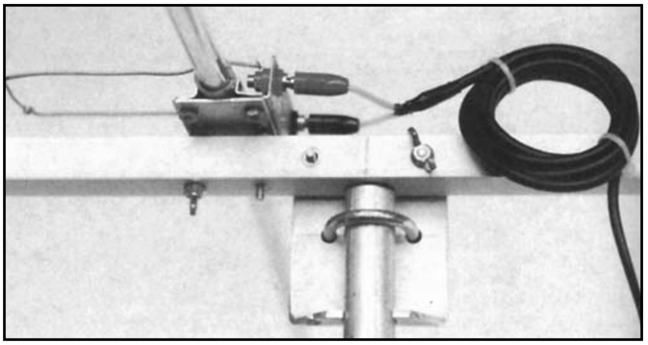

Fig 27—Photo of the driven element, complete with hairpin match and the banana plugs used to connect the coax cable to the driven element.

couple of times so that the contact solution cleans the elements thoroughly. Attach the antenna mast to your vehicle or use whatever method of support you intend to use in the field. Connect an SWR meter and a transmitter to the coax feeding the antenna. VE7CA used two alligator clips soldered together to slide along the two hairpin wires to find the position for the lowest SWR. The dimensions computed by computer were correct! The SWR was below 1.16:1 from 50.05 to 50.2 MHz.

You can take this antenna out of the trunk of the car and assemble it in less than two minutes. One caution: the telescoping elements when fully extended are quite fragile. VE7CA has not broken one as yet, but carrying a spare element just in case would be a good idea.

THREE-ELEMENT PORTABLE 6 METER YAGI BY VE7CA

The following material was extracted from earlier editions. Figure and Equation sequence references are those from the 21st edition of *The ARRL Antenna Book*

When the author attempted to add 17 and 12 meter elements to the existing 20/15/10-meter Yagi model he became exasperated. Adding two more driven elements and reflectors brings many more variables into the equation! It became clear that there was serious interaction between the elements. He could not obtain a workable feed-point impedance on all five bands that could be transformed to 50 Ω using a single hairpin match. There was also serious pattern distortion on 12 meters.

Even building a WARC-only triband Yagi for 30/17/12 meters turned out to be a real challenge. VE7CA had difficulty finding a combination that would allow him to use a single matching system to transform the feed-point impedance of the combined driven elements to 50 Ω. He couldn't create a 30/17/12 triband Yagi using the same design principles as his 20/15/10-meter version. The main problem occurred on 12 meters. Not only was the feed-point impedance unmanageable, but the radiation pattern had four lobes, not the single lobe you'd like from a Yagi.

He decided to try the *Modified Coaxial-Sleeve* method, more aptly termed by K9AY the *Coupled-Resonator (C-R)* in his article in *The ARRL Antenna Compendium, Vol 5*. The K9AY method uses a single driven element, with other elements placed in very close proximity (but not physically connected) to the driven element. By starting with the dimensions suggested by K9AY for a triband 30/17/12-meter dipole, VE7CA was able to develop a 2-element Yagi with acceptable feed-point impedances on all three bands using a single hairpin match. Notice that this WARC design uses a 2 × 2-inch wooden boom length that is 230 cm (7.5 feet) long. Of course, the antenna can't fit into a typical ski boot anymore, so VE7CA had to put it on a roof rack for transportation.

The space between the tightly coupled driven elements is only 3.7 cm (1.5 inches), so you need to use more PVC pipe spreaders than in the 20/15/10 design to make sure the driven-element wires stay as close as possible to the desired spacing without physically touching each other. The driven elements lie in the horizontal plane and the hairpin match and feed line hang down vertically from the center of the 30-meter driven element.

The spacing between the 30-meter driven elements and the other two conductors and the size of the wire all played a part in developing this antenna for a single feed line with the common hairpin match. Do not change the wire size from the recommended #14 for the driven elements unless you are willing to spend a considerable amount of time with a *NEC*-based modeling program retweaking the antenna. This is not the case with the 20/15/10 tri-band Yagi, where any convenient sized wire is acceptable.

Using #14 gauge wire allows all the Yagi antennas in this article to be used at the maximum power levels allowed in North America. The only limiting factor is the power handling capability of the feed line. However, even RG-58 should work for the relatively short length from the feed point down to ground level, where you can change to RG-8 or some other higher-power, lower-loss coaxial cable if you wish. **Fig 30** is a detailed drawing of the 30/17/12-meter driven element. The other dimensions for the 30/17/12-meter triband Yagi are shown in **Table 5**.

Assembly

When you are ready to assemble your wire Yagi, start by attaching the longest reflector element and the driven element assembly to the wood end booms. Do this with the wires and the booms on the ground. Next attach the V slings to both of the booms and with ropes attached to the V slings pull the array up off the ground between two supports (perhaps two trees). A height of 1.5 meters (5 feet) above the ground makes it easy to work on the antenna while you add the other reflector elements and adjust the V slings. Pull them tight so that the array is fairly flat. It won't stay horizontal, because the driven elements are heavier than a single reflector element. So you will need to support the 2 × 2-inch spreaders so they are horizontal. Lean the booms on something at a convenient height, such as the rungs of two step ladders. Now add the two other reflector elements, but don't pull them as tight as the longest reflector. Next attach the feed line.

Table 5
Dimensions for 30/17/12-Meter Tribander

Frequency MHz	*Spacing DE to Refl cm (feet)*	*Driven Element Length cm (feet)*	*Reflector Length cm (feet)*	*Hairpin Length cm (inches)*
10.12	230 (7.5)	713 (23.4) Half	1476 (48.4)	24.5 (9.5)
18.11	165 (5.4)	808 (26.5)	822 (27.0)	
24.91	120 (3.9)	570 (18.7)	606 (19.9)	

Spacing between hairpin wires is 10 cm (4 inches). Note that dimensions for 17 and 12-meter driven elements are full lengths, since they are not broken with insulator in the middle, unlike all driven elements for 20/15/10-meter triband design in Table 4.

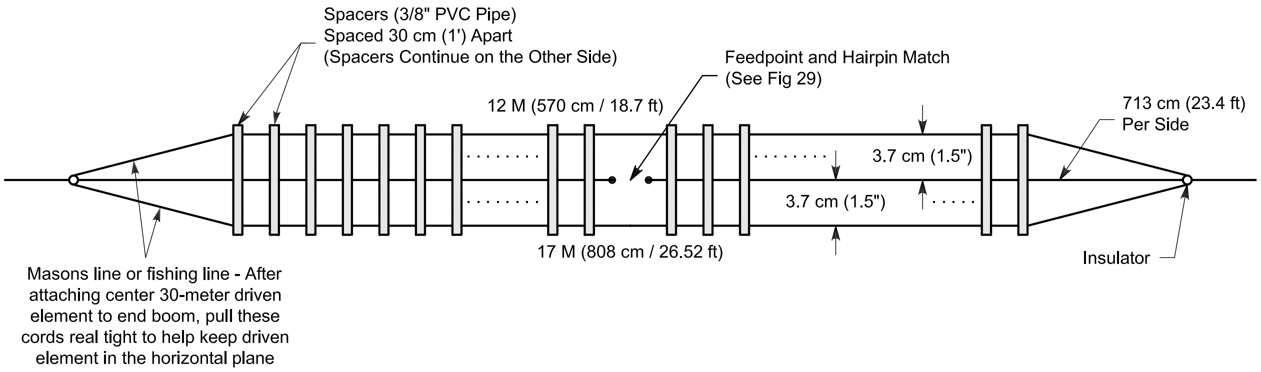

Fig 30—Layout of 30-meter driven element with coupled resonators for 17 and 12 meters.

V Slings

Since the author wanted to be able to raise the 30/17/12-meter triband antenna by himself, he again used only one rope on either end of the array. One end goes over a tree limb and the other end is tied to a stake in the ground or some other nearby support, perhaps a tree trunk. Using only one attachment rope on either end makes it very easy to change beam direction by walking the antenna around the antenna support tree or tower. To accomplish this he used two V slings, one on each end attached to the 2 × 2-inch spreaders.

The secret to keeping the antenna level in the horizontal plane is that the V slings are not equilateral in shape. The combined weight of driven elements, balun and feed line is heavier than the reflectors. If the length of the sides of the V are equal, the array will rotate downwards. The driven elements will end up facing the ground, with the reflectors facing up. Adjust the V slings so that the antenna will stay level in the horizontal plane by shortening the length of the side of the V attached to the driven elements. It is quite easy to adjust in the field, and once you have it adjusted it stays balanced.

Once you raise the antenna to its operating position and in the horizontal plane, you can change direction 180° by pulling on the feed line. As you pull, the whole array will slowly turn over. Stop it from turning by holding onto the feed line once the array has swung over to face the opposite direction.

SWR Adjustment

Since you may situate your antenna in an entirely different position than VE7CA did, you may need to fine tune your antenna. Begin with the dimensions in Table 5 as a starting point. Make a temporary shorting bar using two alligator clips joined by a piece of wire and attach them at the recommended position. Next raise the antenna to the desired final position. Using an antenna analyzer (or transmitter and SWR meter) plot the SWR over all three bands. Start with the lowest band, 30 meters and adjust the shorting bar up or down to find the lowest SWR point in the portion of the band you plan to operate in. (This procedure also works if you wish to adjust the 20/15/10-meter tribander. Start with the lowest frequency.)

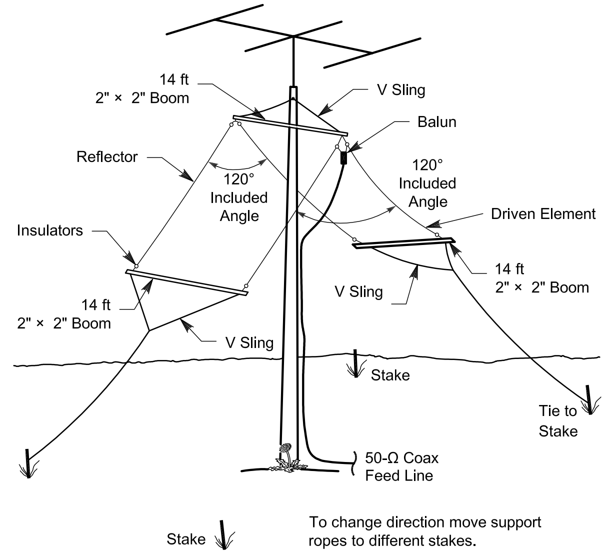

Fig 31—Layout for inverted-V 40-meter portable wire Yagi suspended from tower.

You shouldn't have to move the shorting bar very far from the suggested length. Now that you have determined the right shorting-bar position, adjust the other two driven element lengths for the lowest SWR in the portion of those bands in which you plan to operate. You may have to compromise with the position of the shorting bar to find a satisfactory range where the SWR is acceptable on all three bands. After satisfying himself with the position of the shorting bar, VE7CA replaced the alligator clips simply by folding one side of the parallel hair-pin wire lengths over to the other side and soldering it in the position where the alligator clips had been attached. The author does not recommend changing the reflector element lengths unless you are familiar with antenna modeling programs and are willing to model different spacing or element lengths.

40-Meter Wire Yagis

After his November 2001 *QST* article, VE7CA received several requests for a 40-meter wire Yagi. One ham mentioned that he wanted to be able to pull up a 40-meter Yagi between two towers and to be able to flip it over to change direction. Another wanted a 40-meter Yagi he could pull up on a single tower for the winter DX contests and then put it away during the summer. So VE7CA ran four different 40-meter scenarios in his computer models:

1. A horizontal 2-element wire Yagi at 65 feet.
2. A sloping 2-element wire Yagi, with one end at 65 feet and sloping downward 30° from vertical.
3. A sloping 2-element wire Yagi, with one end at 65 feet and sloping downward 65° from vertical.
4. An inverted-V 2-element wire Yagi with the apex at 65 feet and an included angle between the wires of 120°.

Fig 31 shows the layout for an inverted-V system and **Table 6** lists the element and hairpin lengths. Elevation patterns for the 40 meter antennas are compared in **Fig 32**, with a reference antenna of a single flattop dipole at 65 feet. As they say, a picture is worth a thousand words. If your interest is DX, it is very clear that horizontal and high is a very good rule of thumb for most antennas.

Yes, a 1/4 wave vertical over salt water or 120 1/4-wave radials over good ground will produce very low radiation angles, but such systems are not exactly portable and we don't all live near the ocean. Mind you, if you can manage to locate antenna Number 3 (the most vertically oriented wire Yagi) next to the ocean, you would be very happy.

The point here is that if you have two towers and you're not fortunate enough to be located on a saltwater marsh, you should pull the 40-meter array up as high and as horizontal as you can. If you have only one tower and don't need to change direction often, then try the inverted-V configuration. You can still change the direction by walking each end around the tower.

However, even the sloping 40-meter Yagi with one end at 65 feet up a tower (or tree) and the other end attached with a long rope as far as possible from the tower will still put out a very respectable signal. It is directional, and you can walk it around the tower to change direction or you can flip the antenna over and change direction 180° very quickly.

Table 6
40-Meter Wire Yagi Configurations

Configuration	*Driven Element cm (feet)*	*Reflector cm (feet)*	*Hairpin Length cm (feet)*
1. Horizontal	1978 (64.90)	2098 (68.83)	Approx 50 cm
2. –30° Sloper	1978 (64.90)	2113 (69.32)	(22 inches)
3. –65° Sloper	1978 (64.90)	2101 (68.93)	
4. Inverted V	2040 (66.93)	2126 (69.75)	

Spacing between driven element and reflector is 427 cm (14 feet). Spacing between parallel hairpin wires is 10 cm (4 inches). The lengths shown above are the total wire length for each element.

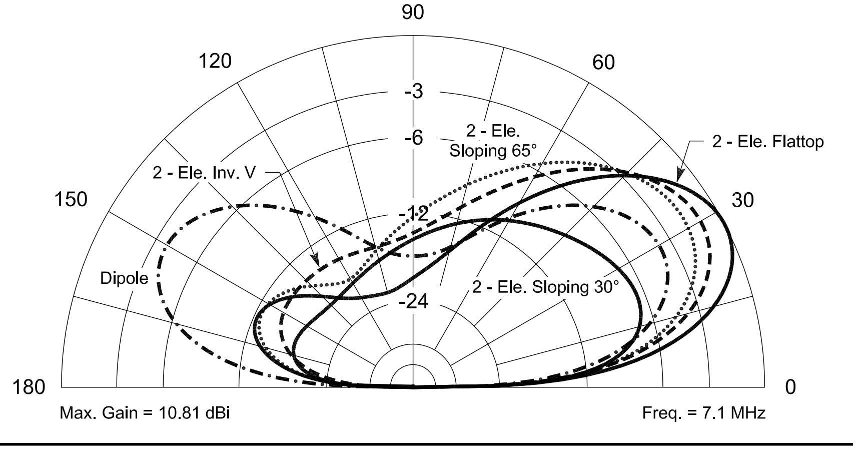

Fig 32—Comparisons of elevation patterns for five 40-meter antennas: a 2-element flattop Yagi at 65 feet; a 2-element inverted-V Yagi at 65 feet; a 2-element Yagi sloped 65° from the vertical plane; a 2-element Yagi sloped 30° from the vertical plane; and a horizontal dipole at 65 feet.