A quick trip to your local home-improvement store and you'll be ready to tackle these antenna projects, and ask yourself just how much PVC actually is used for plumbing projects.

How To Build Three Omnidirectional Antennas For 440 MHz

BY IVAN T. LORENZEN*, W4JC

Each of the three omnidirectional antennas discussed in this article is made with 300 ohm twin-lead enclosed in protective PVC pipe. All three antennas have wide bandwidth, low SWR, and are easy to make. They can be used for mobile, portable, field day, emergency, or base operations with excellent results. Because of the close proximity to plastic and PVC dielectric the dimensions are significantly shorter than for antennas in open air. The formulas and velocity factors given in texts and handbooks were used as a point from which to start pruning and trimming toward the final dimensions.

The first antenna is a J-pole, a half-wave radiating element end fed by a quarter-wave matching section. As the antenna books say, it gets its gain over a quarter-wave antenna by compressing the directive pattern in the vertical plane, providing an increase in field strength of about 1.7 dB toward the horizon.

The second antenna is a two-element, end-fed collinear. A collinear antenna is inherently broadband, and the books claim 1.9 dB for a two-element collinear over a half-wave dipole. A phasing stub is used between the two radiating elements in order to bring the currents in the two elements in phase.

The third antenna is a four-element collinear fed between the two center elements by means of a quarter-wave matching section. The antenna books give it credit for a 4.3 dB gain over a half-wave dipole.

Using a Radio Shack HTX-404 transceiver, with an RS#19-320 SWR meter mounted directly on it by a BNC/SO-239 adapter, and a 10 ft. length of RG8/M (mini-foam) coax to the antenna, the SWR readings for each of the three antennas were under 1.5:1 from 430 to 450 MHz. All transmitting tests were made outdoors well in the clear, away from extraneous objects.

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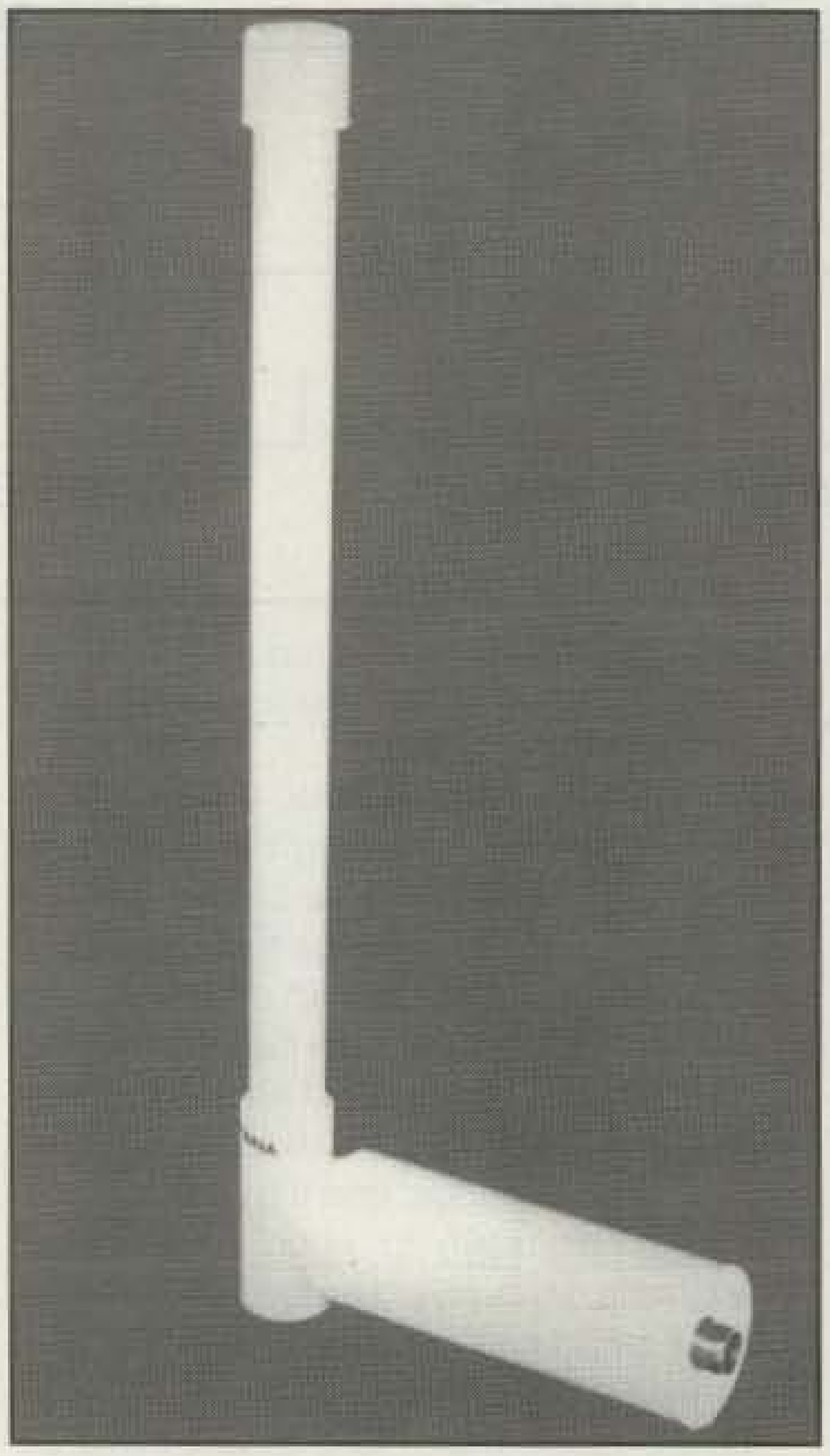

Photo A– The "J" antenna, full-length view.

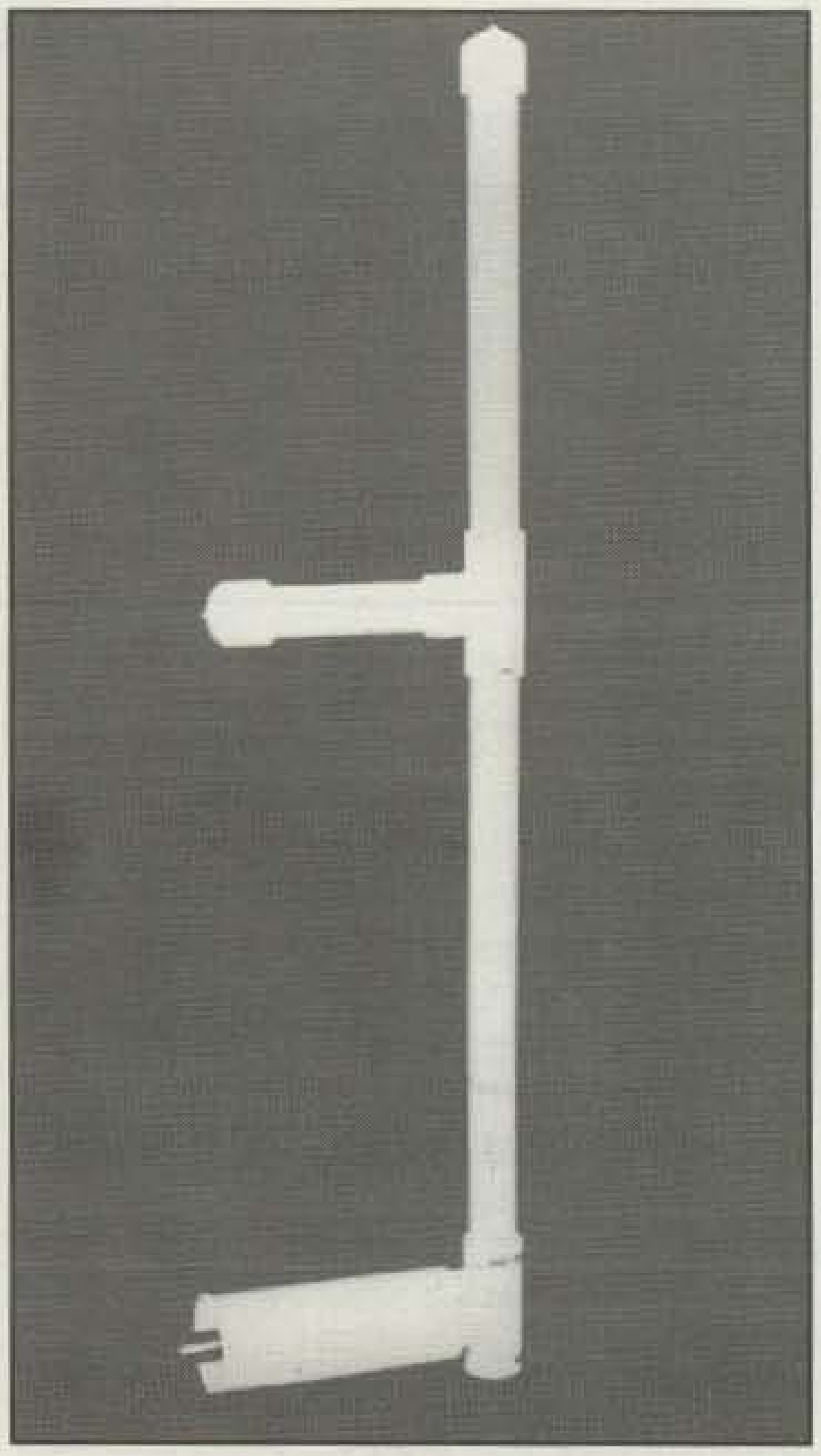

Photo B– Full-length view of the two-element collinear.

As for results, even the single-half-wave "J" connected through a 10 ft. length of RG8/M coax to a 1½ watt handheld transceiver raises repeaters 25 miles away with full quieting and S7 to S9 on the "S" bar graph.

Construction of The "J" Antenna

Dimensions for the "J" antenna are shown in fig. 1. The plastic on the twin-lead can be melted away with a soldering gun or stripped away with a knife. Dimensions are rather critical at this frequency of operation, so press the twin-lead flat and straight when measuring. It will be easier to measure the feed-point connection and the stub length if the closed end of the stub is made flat, as shown, instead of a rounded loop. A rounded loop is made at the top of the antenna for the quarter-inch plastic rod which is inserted into the quarter-inch holes at the top of the PVC pipe to provide support. Cut through one side of the twin lead exactly 5⅜ inch from the bottom of the antenna. This dimension is the most critical of all. Bend the exposed wire over and solder it to the uncut wire.

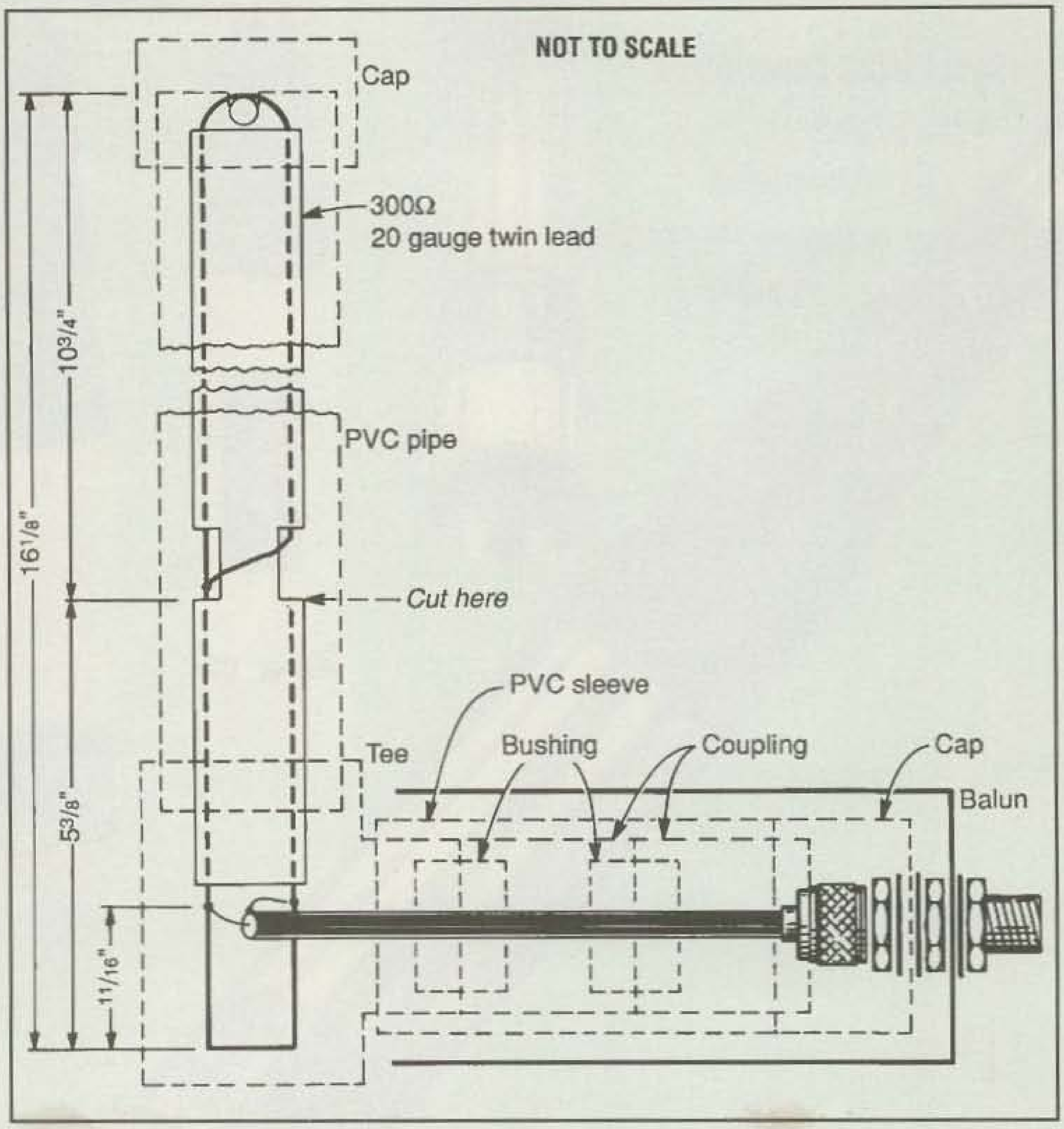

Fig. 1- Dimensions for the 440 MHz "J" antenna.

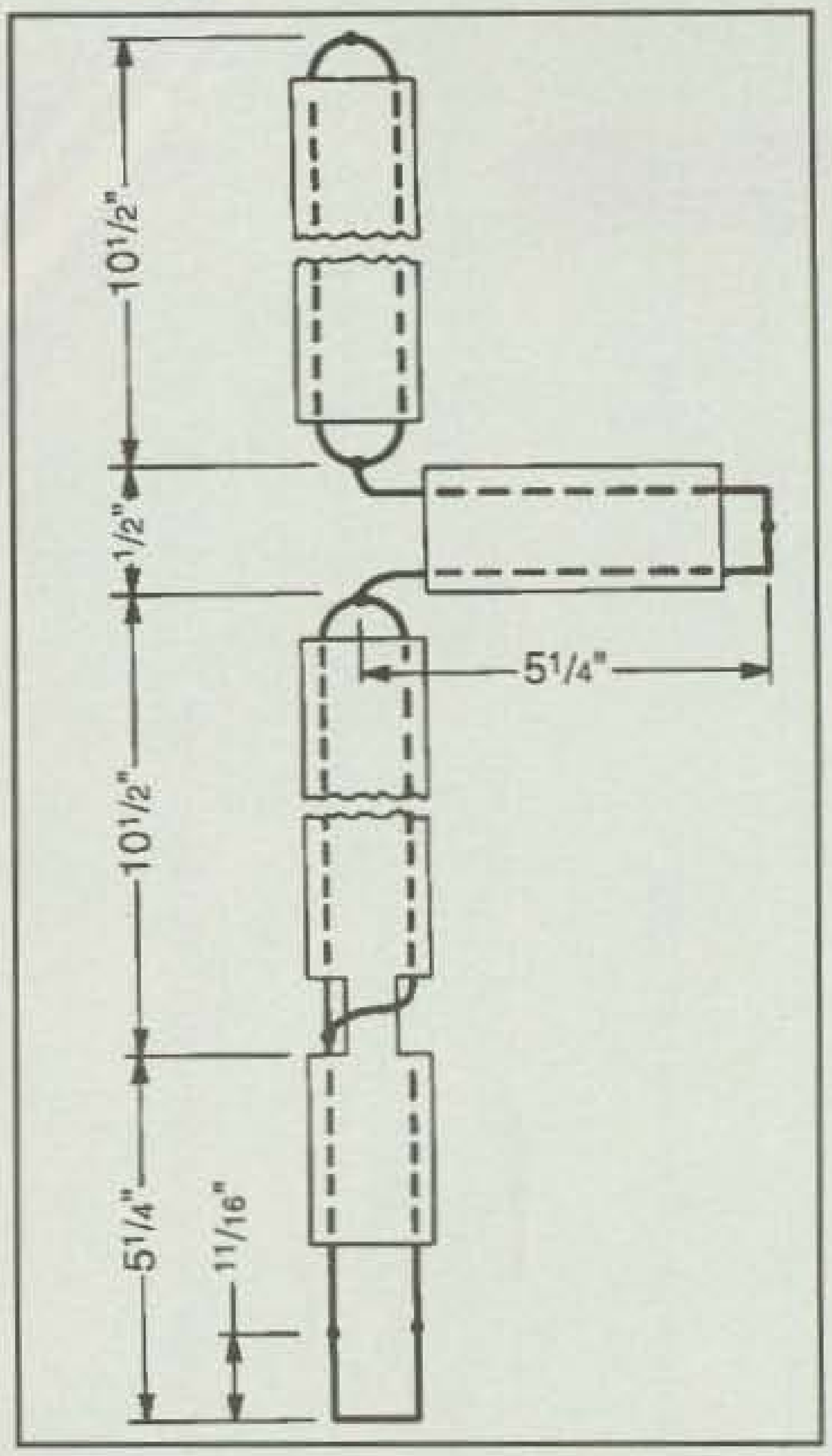

Fig. 2- Basic layout for the two-element collinear.

To minimize antenna currents on the transmission line which can distort the radiation pattern, a linear balun (also known as a bazooka) can be fabricated from an empty, evacuated 7 oz. air-freshener spray can 2 inches in diameter. Drill and file a 5/8 inch hole well centered in the bottom of the can.

The top can be removed by a fine-tooth hacksaw, holding the can against a backstop and sawing around and around. It takes only a few minutes. The cans I have are 5½ inches long after the top is removed. Considering that the balun encloses quite a bit of PVC, as shown in the drawing, it should be close enough to an electrical quarter-wave to provide effective choking against antenna currents flowing onto the outer shield surface of the transmission line. It would be better if the hole in the closed end of the can were soldered directly to the coax braid without using a PL-259 and socket; however, as a compromise to keep things physically rugged, I did it this way. Handbooks show other methods to accomplish this if the antenna is to be used indoors or if weatherproofing is not a problem.

The PVC pipe is 3/4 inch thick-wall type, called Schedule 40. The bushings are cut from pipe and are 1¼ inches long. The tee and couplings are 3/4 inch size. The coax cap is 1 inch size, and the top cap is 3/4 inch. The sleeve, approximately 4⅛ inches long cut from 1¼ inch pipe, adds extra rigidity to the assembly. Your PVC fittings may or may not be the same as mine, since not all PVC is created equal. If you don't already have a 1 inch size PVC pipe cutter, it is worth the cost to get one. Then only the 1¼ pipe sleeve will have to be sawed.

Drill and file or holesaw a 5/8 inch hole in the center of the cap. The easiest way I could find to securely assemble the coax, cap, and SO-239 socket was to use a 1¾ inch bulkhead-type double SO-239 and cut off a short piece from one end of a 10 ft. length of RG8/M coax with PL-259 connectors already attached (Radio Shack #278-979). Screw the PL-259 very tightly onto one end of the bulkhead connector, and then run a nut up against the PL-259, also very tightly, and add an interior-tooth lock washer before inserting the socket into the cap. Add another interior-tooth washer and nut and tighten the assembly with a wrench amd pliers. Just don't strip the threads.

Add the two bushings, two couplings, and the 1¼ inch PVC sleeve as shown in fig. 1. The linear balun can wait until the very last. Cut and dress the open end of the coax so it will reach the center of the tee. Solder the coax to the twin-lead as shown. It will be easier to make a neat braid connection if a No. 18 jumper wire is used to connect the braid to the twin-lead wire. Place the twin-lead across supports and hang the coax so it comes away at a right angle.

To assemble, feed the top of the antenna into the side opening and out through the top of the tee. Slide the tee down onto the twin-lead toward the coax. Bend the bottom of the stub down and back on itself, if necessary, to feed it into the tee. It can be straightened out after it is inside the tee. Push the PVC assembly containing the coax onto the side of the tee, and secure everything together with No. 6×3/8" stainless steel flat-head or oval-head self-tapping screws. A 5/64 inch drill bit is about the right size for pilot holes. Complete the assembly as shown in fig. 1.

Finally, the balun is slipped over the PVC cap and onto the protruding SO-239 socket. Secure it with another interior-tooth lock washer and nut. Apply silicone caulk around the open end of the balun to seal out rain and bugs.

The only source my supply of the 1¾ inch double SO-239 with three lock washers and three nuts is RF Products, 1930-D Murrell Road, Rockledge, FL 32955. The cost is $5.25 postpaid.

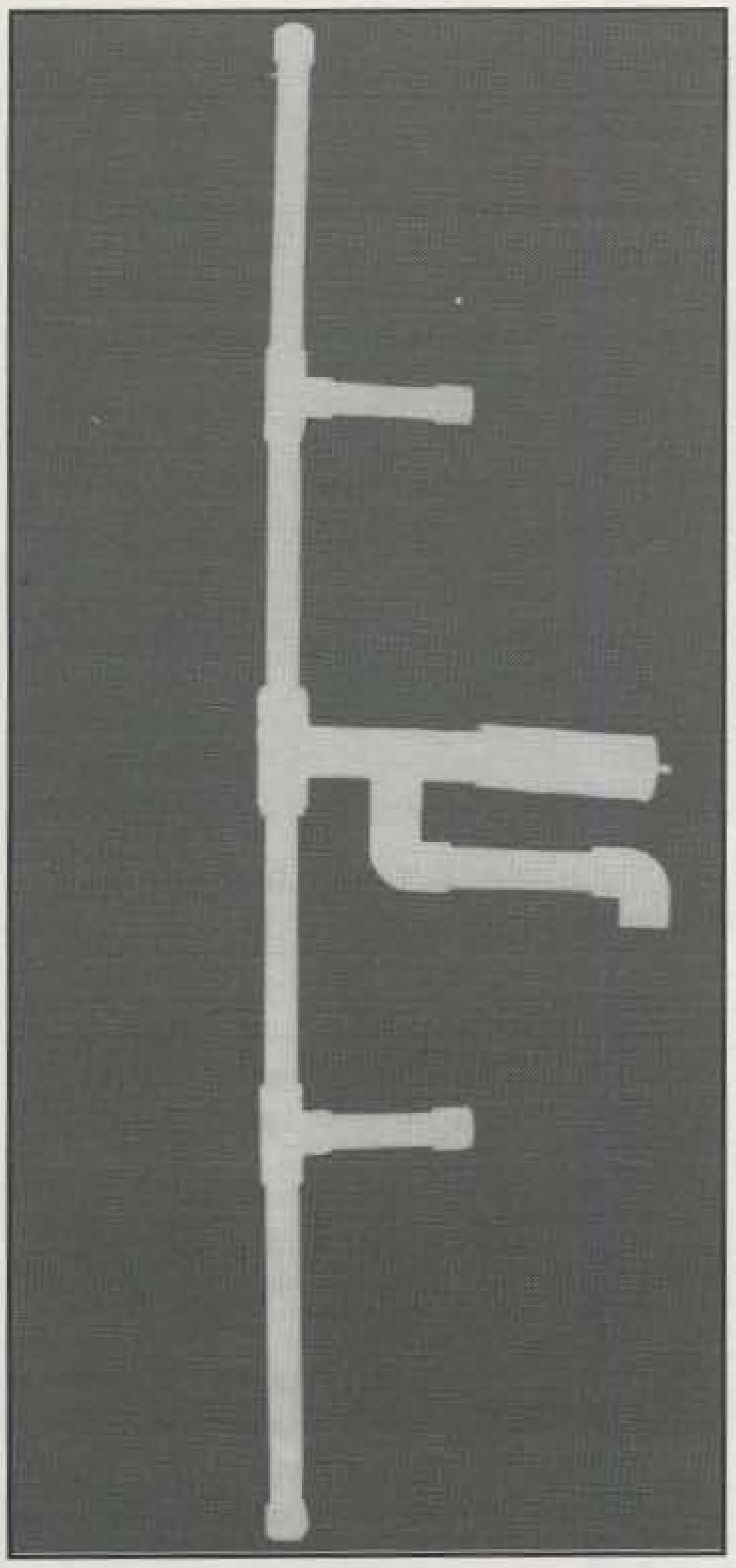

Photo C– Full-length view of the four-element collinear with its mounting arm.

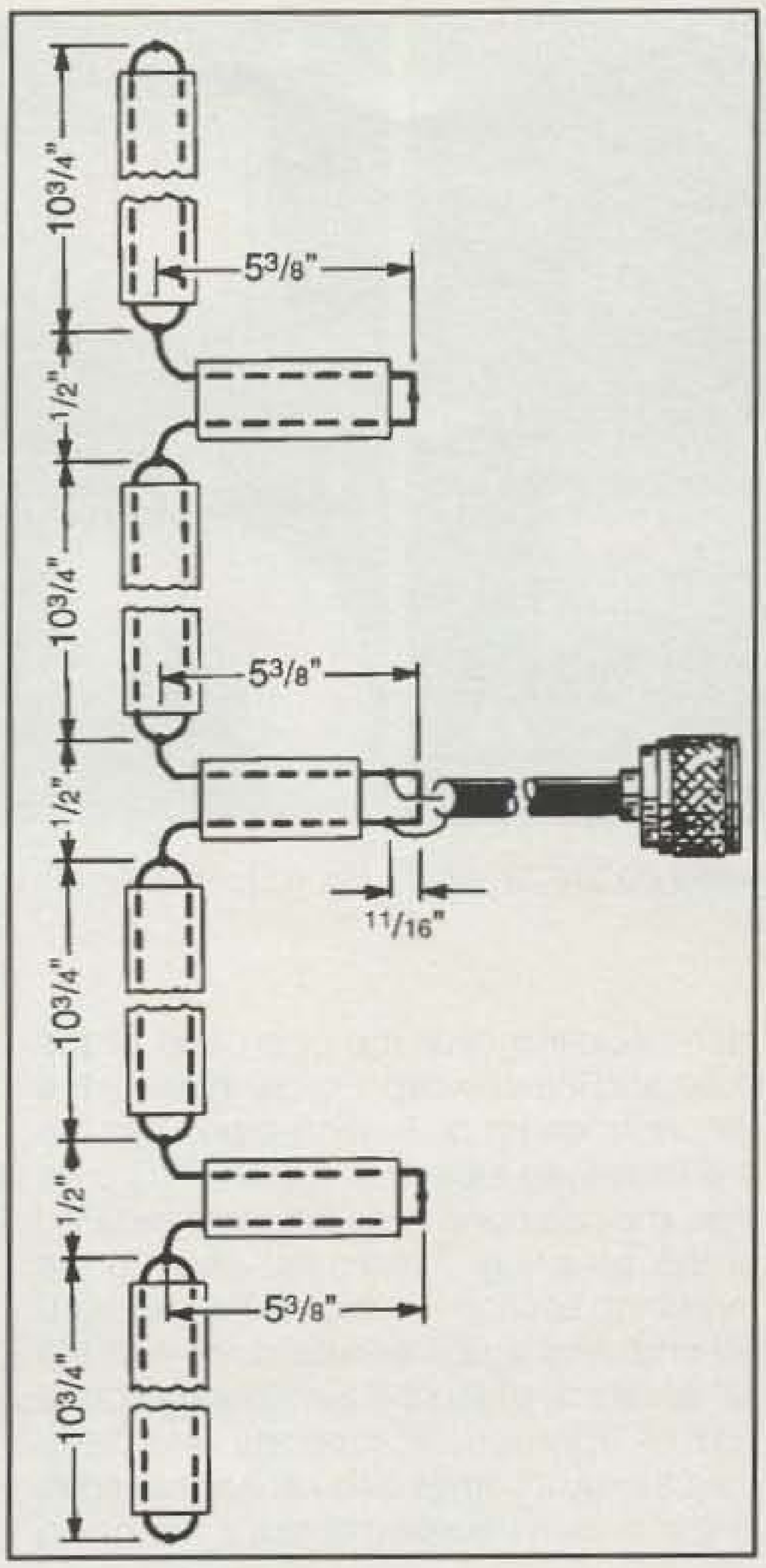

Fig. 3– Basic layout for the four-element collinear.

For field day, emergency, or other portable use just slip a PVC pipe mast over a stake tapped into the ground 12 inches or so. A stake can easily be made by flattening one end of a 4 ft. length of metal thin-wall conduit.

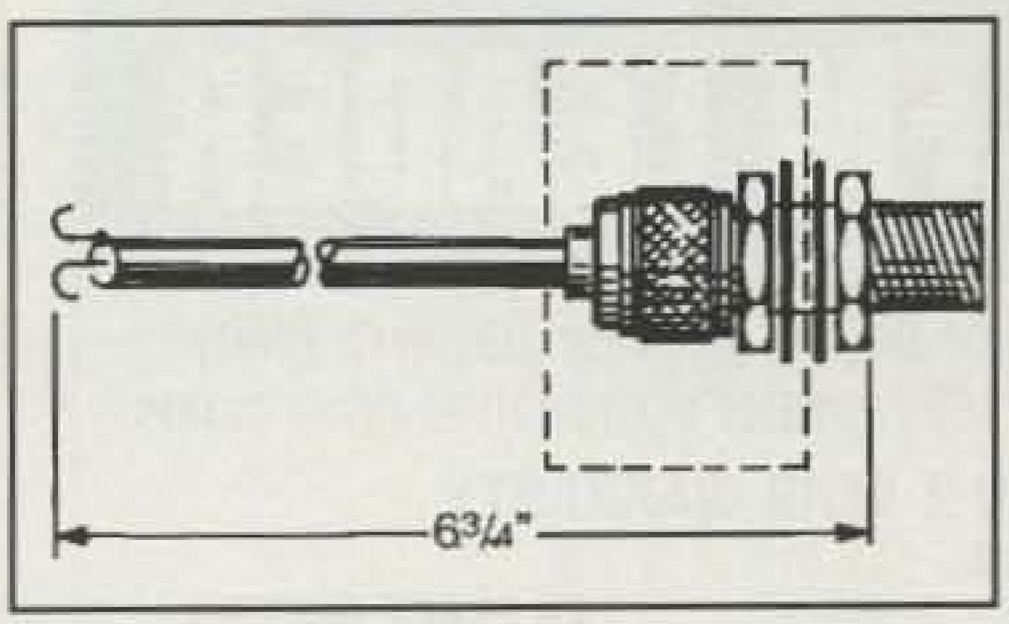

Fig. 4– Construction details of the bulkhead connector, 1 inch cap, and coax for the four-element collinear.

Construction of The End-Fed Two-Element Collinear

The two-element collinear uses a "J" at the bottom with an additional half-wave radiating element and a phasing stub on top of it. Construction is similar to the "J" with the addition of appropriate PVC housings for the stub and added radiator. The extra PVC pieces needed are: one tee, one cap, 3/4 inch PVC pipe about 4 5/8 inches long, and 3/4 inch PVC pipe about 10 inches long. The basic layout is shown in fig. 2.

It will be noted that both of the radiating elements and the quarter-wave matching section have been shortened slightly. When the same dimensions as those in the "J" were used, the SWR was a little over 1.6:1 at 450 MHz. The dimensions shown in fig. 2 brought the SWR down to 1.2:1. The coax/balun assembly for the two-element collinear is the same as for the "J." Refer to fig. 1.

Construction of The Four-Element Collinear

The physical assembly of this antenna is similar to that of the "J" and the two-element collinear (see fig. 5). Start with the vertical twin-lead portion and the two phasing stubs as shown in fig. 3. Also make up the matching section, but set it aside until later. Next, make the coax, cap, and bulkhead connector assembly shown

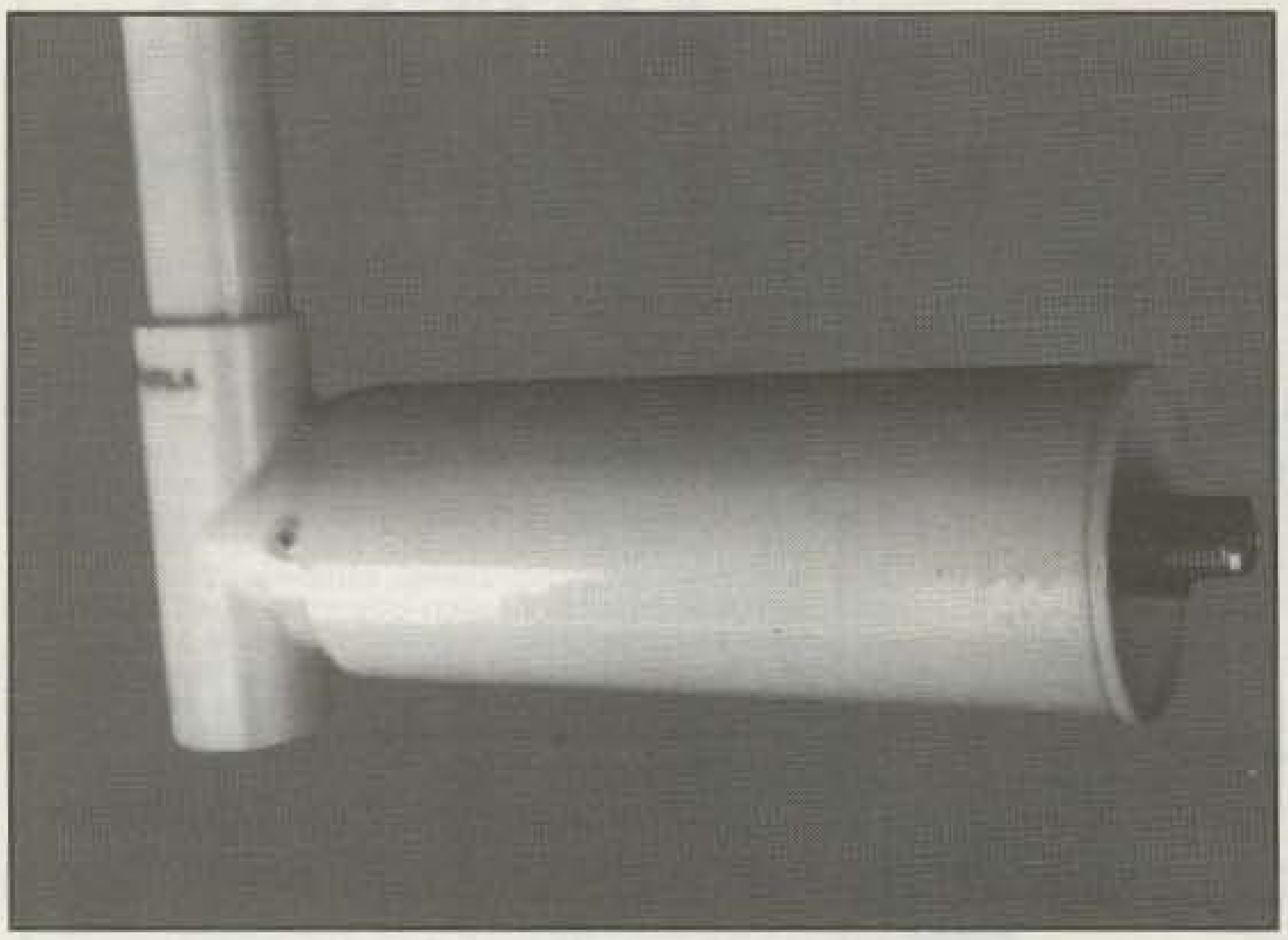

Photo D- Close-up view of the balun as installed on the "J" and the two-element antennas.

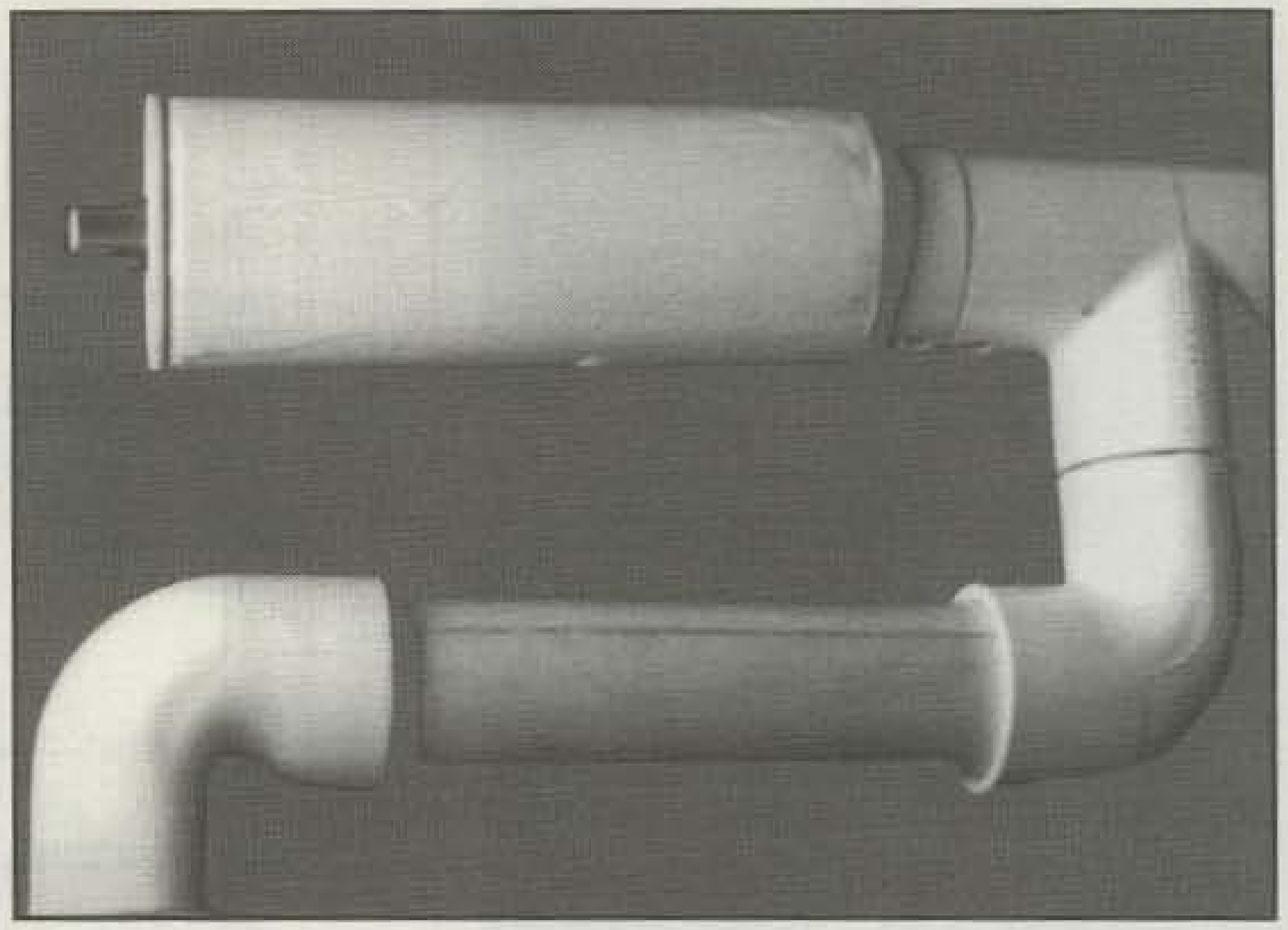

Photo E– Close-up view of the balun and mounting arm on the four-element collinear.

in fig. 4. I didn't have any low-loss coax readily available, and considering the low loss in this short length of coax, I used a piece of RG8/Minifoam with a PL-259 plug already attached. Don't forget the interior-tooth lock washers on both sides of the cap, and be sure the nuts are tight. Note that the overall length dimension is to the outside surface of the nut securing the connector to the cap. This is where the inside surface of the balun rests.

Next, in the following order slip a ¾ inch coupling over the open end of the coax and into the cap. Follow this with the 3½ inch length of ¾ inch pipe. Slip the 4½ inch long sleeve of 1 inch PVC pipe over the coax and onto the exposed end of the coupling. Solder the coax to the matching section 11/16 inch from the shorted end, and again as was done with the "J" antenna, place the twin-lead across a pair of appropriate supports and hang the coax so it comes away at a right angle. Slip a ¾ inch coupling onto the matching

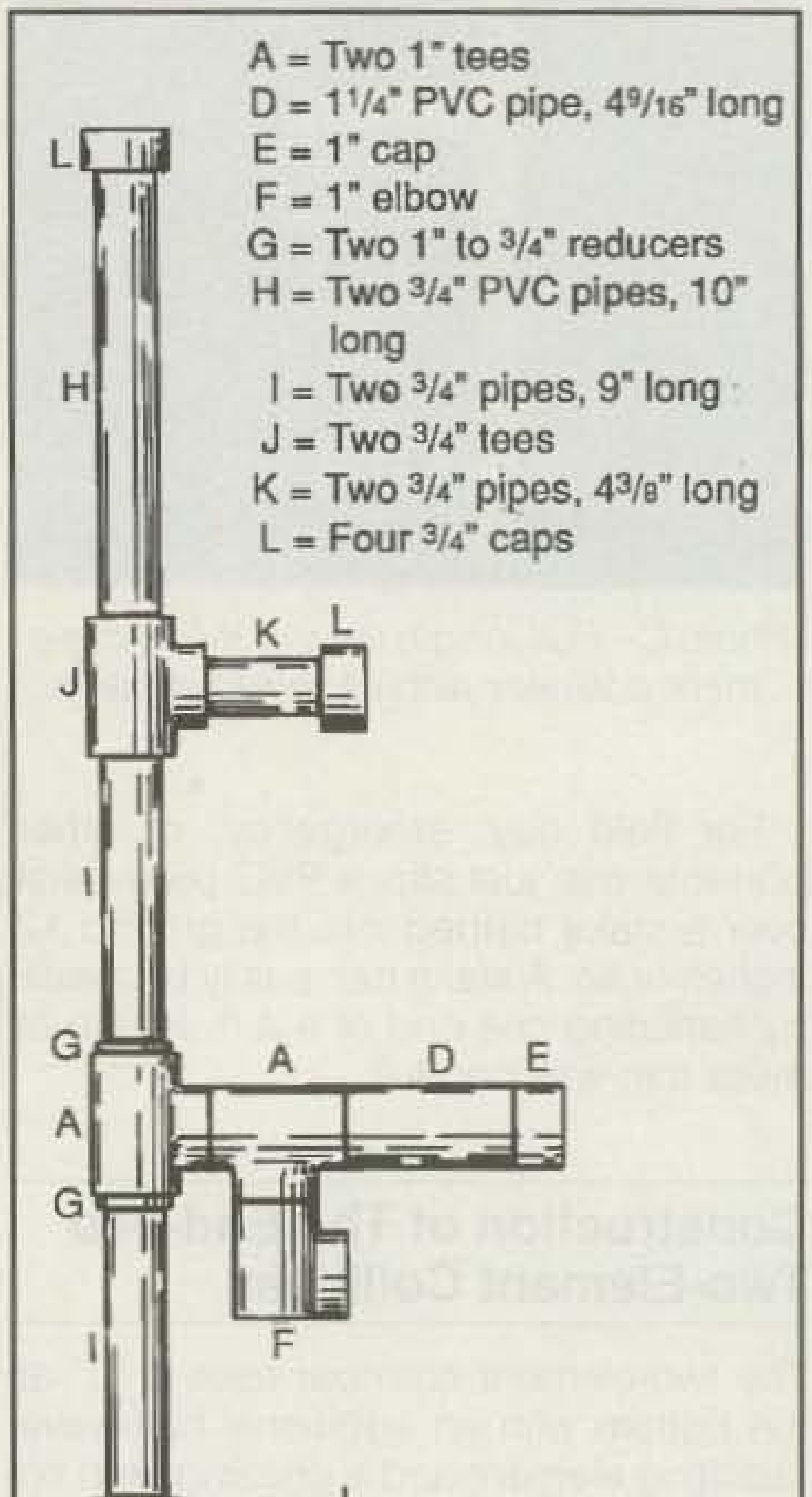

Fig. 5– PVC parts list and layout for the four-element collinear enclosure. See fig. 6 for details on parts A through G.

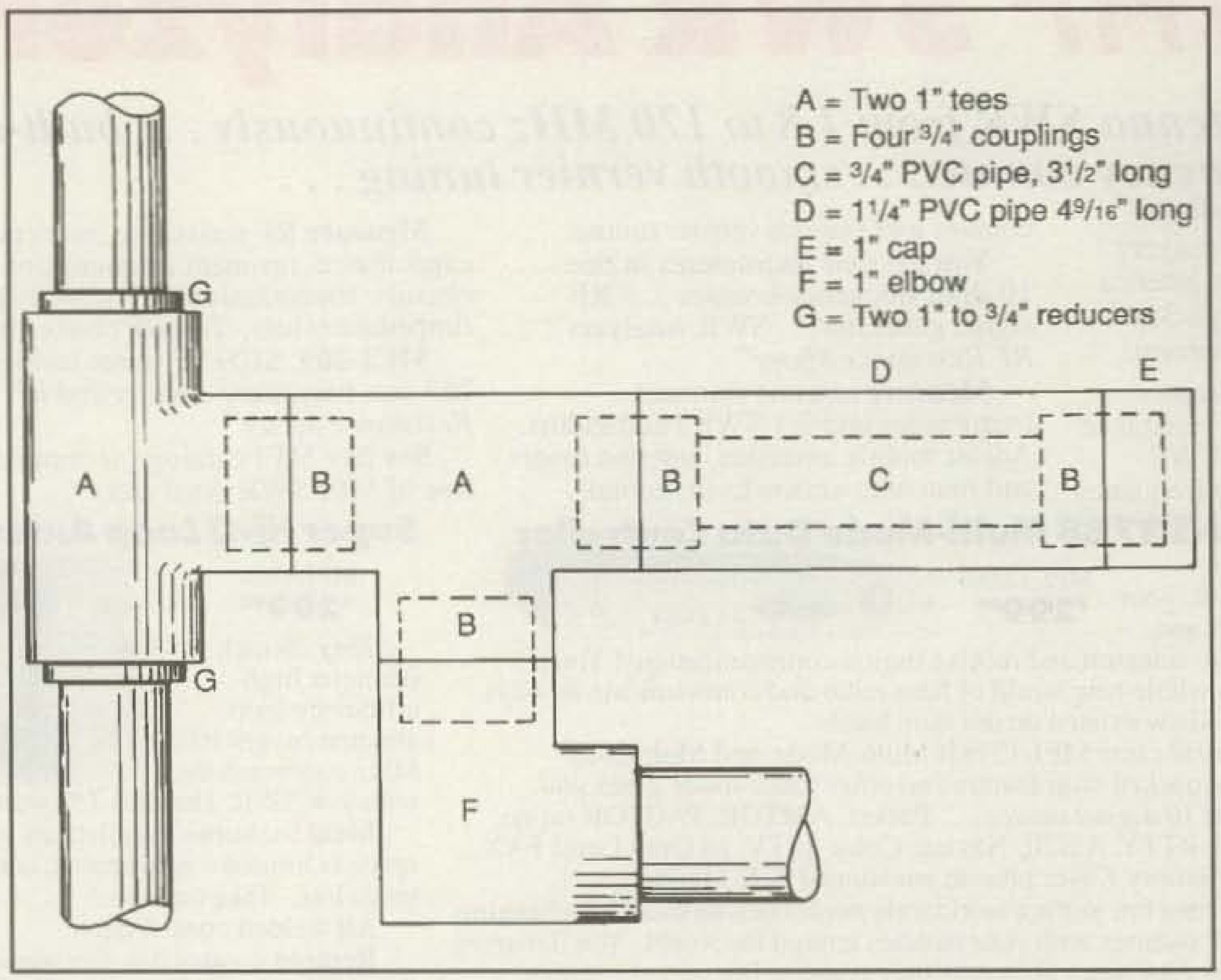

Fig. 6– Details of the PVC assembly for the balun and matching section enclosure for the four-element enclosure. The elbow fits into the 1 inch mounting arm.

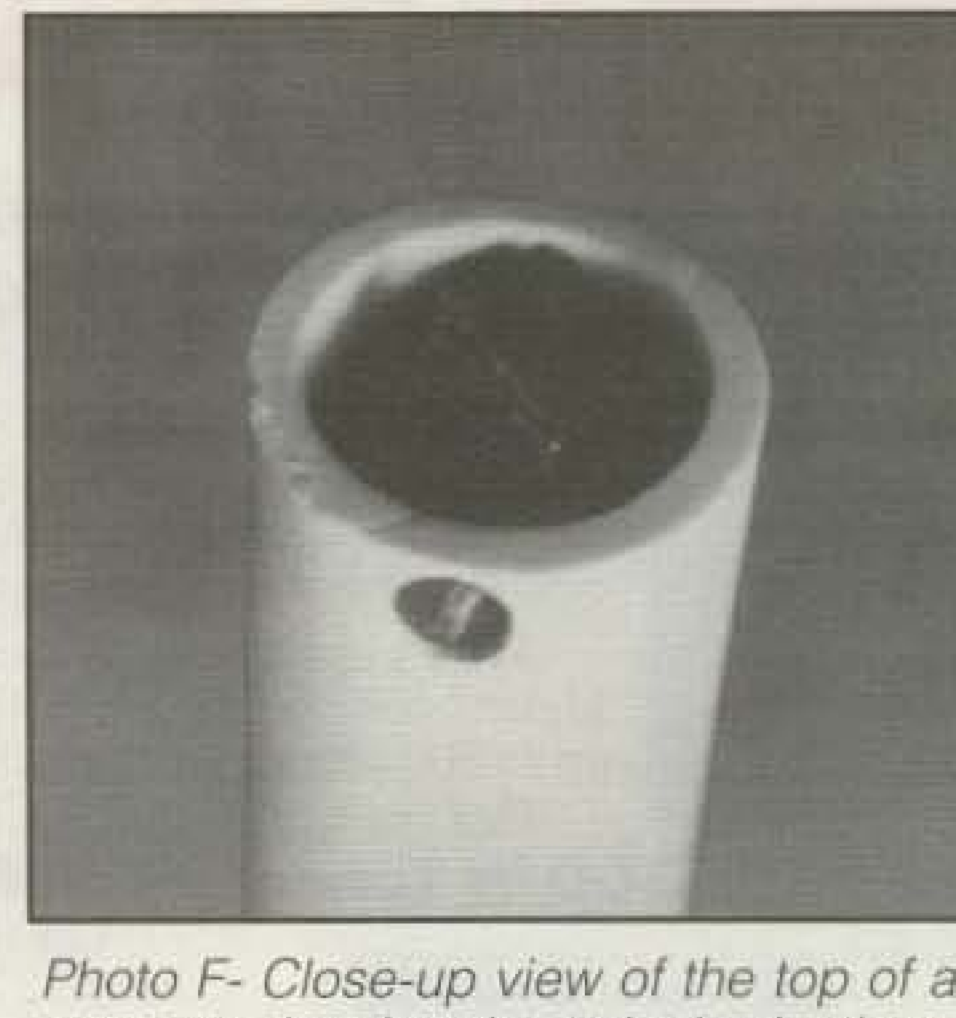

Photo F- Close-up view of the top of an antenna showing the 1/4 inch plastic rod supporting the twin-lead.

section and onto the 3 1/2 inch pipe inside the outer sleeve. As you insert the coax/matching section connection into the PVC, bend the stub toward the coax only enough to get it inside, so that the coax will not lay against the stub. Feed a 1 inch tee onto the matching section and push it against the sleeve as shown in fig. 6. Slip a 3/4 inch coupling over the matching section and into the tee. The open end of the matching section will protrude from the coupling about an inch. The 1 inch elbow and its bushing can wait until last, along with the balun.

Next solder the matching section to the radiating elements as shown in fig. 3. Carefully feed both ends of the radiating section into the side opening of a 1 inch tee, bringing one end out through the top and the other end out through the bottom. Gently work the tee toward the matching section, laying the stubs against the radiating elements as the tee passes over them. Push the tee onto the coupling protruding from the mounting-arm tee. Straighten the twin-lead that is now inside the tee to eliminate any twists. Slip a 1 inch to 3/4 inch reducer over each end of the radiating elements and work them down into the center tee. Install the stub tees as described above and complete the assembly. Again, straighten the twin-lead inside the tees.

No. 6x3/8" stainless steel self-tapping screws can be used to secure the various PVC pieces together. I used oval-head screws on the balun assembly, counter-sinking the pilot holes. Pan-head screws were used in the other places.

As happened with the two-element collinear, the SWR rises at the high end of the band. Since the SWR is under 1.5:1 at 450 MHz, I left it as is. It appears likely that shortening the element and stub lengths to the same dimensions as those for the two-element antenna, or adjusting the feed-point tap, would bring the SWR down lower, but the practical improvement obviously would be slight. ■

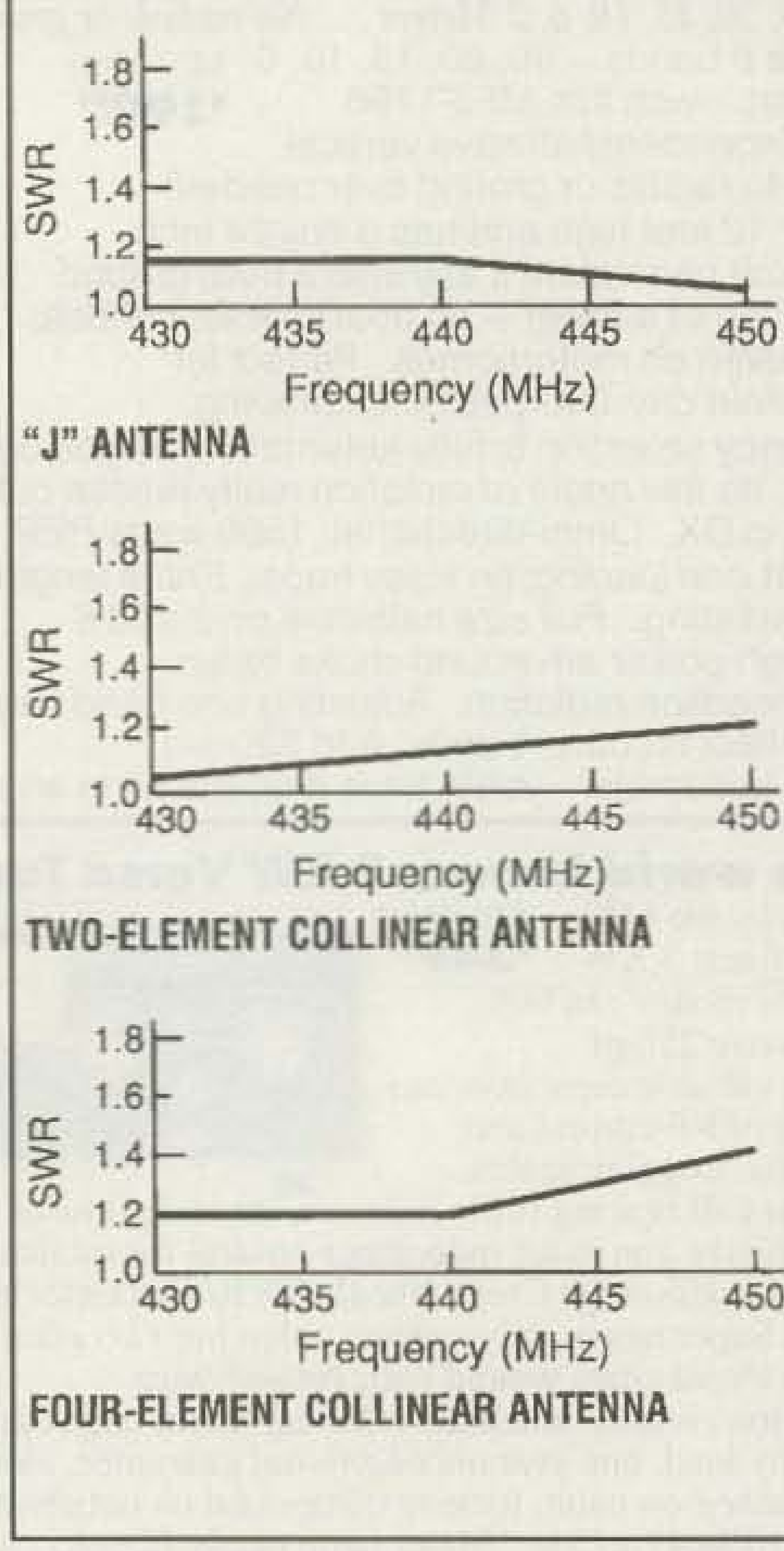

Fig. 7– SWR charts for the three 440 MHz antennas.