Ten for 10

Build a high performance, 10 meter beam for $10.

by Michael Harris KM4UL

I have always enjoyed home-brewing ham radio equipment, and especially antenna projects, because the components are relatively inexpensive and the results are tangible. My wife says that I build and tinker more than I operate. Guilty as charged!

This article is a result of my tinkering, providing a practical example of constructing an X-beam for 10 meters. The antenna uses components commonly available in hardware stores, but it's also very inexpensive even if you have to buy all the materials. I purchased the primary components at my local hardware store for less than ten dollars.

I got into this project because I couldn't establish a schedule with Robin N7NHF in Idaho. His vertical and my delta loop weren't reliably making the trip. After discussing the matter, we decided we needed to improve our antenna situation.

Robin had both an interest and local expertise with quads, so he began his project. I remembered an interesting article, "Designing X-Beams" by Brice Anderson W9PNE in *The ARRL Antenna Compendium, Volume 1*. This article also appears in *The ARRL Handbook*, 67th edition (1990), Chapter 32, "Designing X-beams." The X-beam promised good performance and appeared to be relatively easy to construct. The article discusses design, construction, and tuning in general, but does not focus on a particular design. I picked up the ball from there and the result is an operational X-beam, a regular schedule with Robin, and this article, an explanation of how to duplicate the antenna I built. It contains construction alternatives and hints on prototyping.

Performance

The design article claims gain figures of 6 dBd and a front-to-back ratio of 15–18 dB. What I noticed was an improvement from "headphone copy" to "solid copy" during my schedules with Robin. Good enough for me!

Several hams have mentioned reading "bad things" about X-beams, frequently referring to L.A. Moxon G6XN's *HF Antennas for All Locations*, Chapter 5, "X-Beams and Slopers." These "bad things" relate to getting an acceptable pattern and a characteristically low feedpoint impedance.

The general problem of X-beam patterns was solved in Brice's design by adding the tails. These effectively prevent side lobe radiation and provide a good pattern.

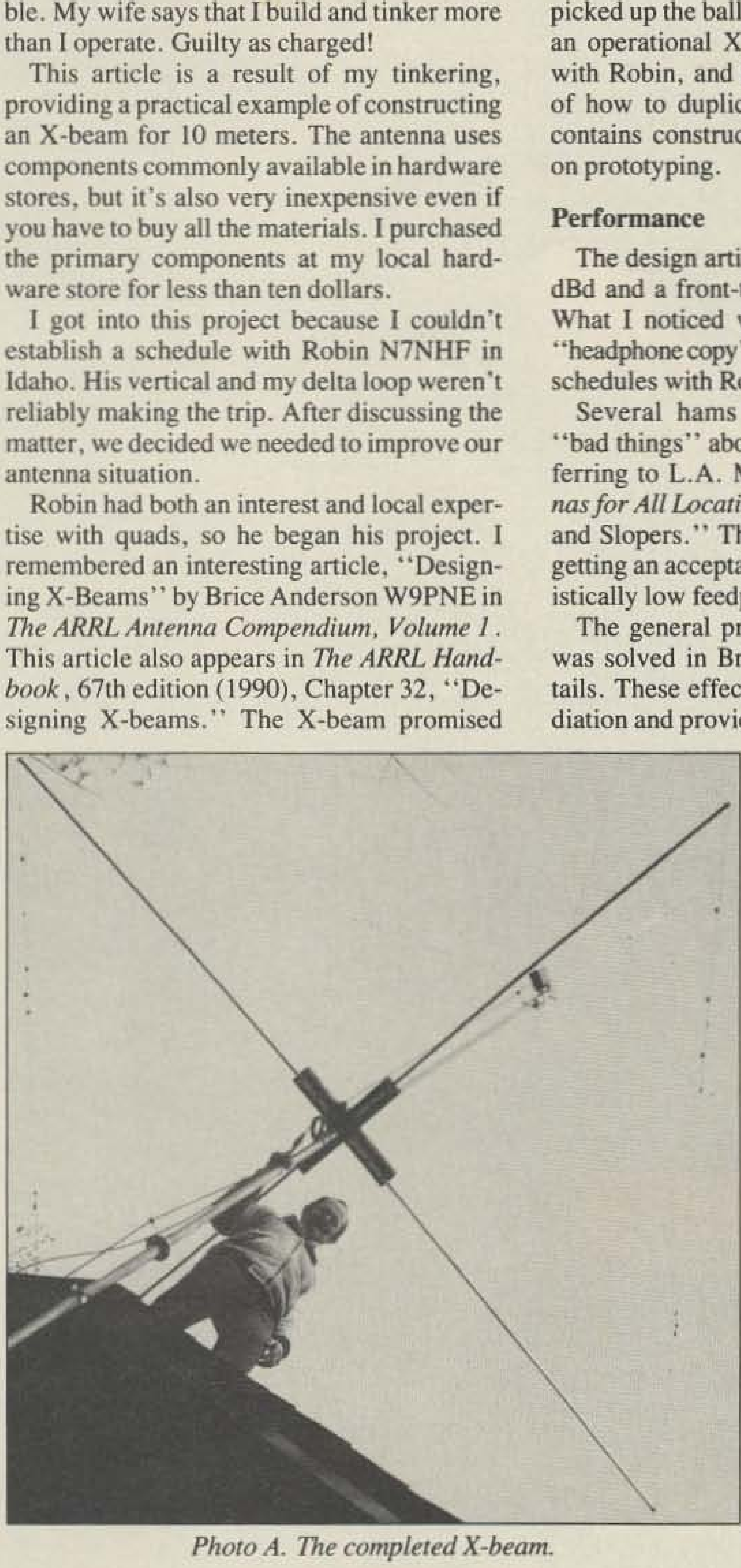

Photo A. The completed X-beam.

The problem of low feedpoint impedances is common to all antennas with close-spaced elements—including yagis. The antenna exhibits a feedpoint impedance of approximately 10 ohms. This is easily matched by techniques commonly used to feed yagi antennas. I used a "Collins balun" as described by George Badger W6TC in "A New Class of Coaxial Line Transformers," *Ham Radio Magazine*, February 1980, Part 1; and Part 2, March 1980. I describe construction of a suitable transformer in this article. I highly recommend this class of coaxial baluns for all antenna work.

I have performed extensive computer modeling of this antenna using MININEC3 (J.C. Logan and J.W. Rockway, *The New MININEC, Version 3: A Mini-Numerical Electromagnetic Code*, NOSC Technical Document 938, National Technical Information Service, 1986). This modeling confirms the gain figures reported by Brice, the effectiveness of the tails, and the feedpoint impedances. The general predictions of the computer modeling have been confirmed by antenna measurements and in-service observations.

Materials

I enjoy reading articles about how somebody built this or that with some exotic material or tool they just happened to have around,

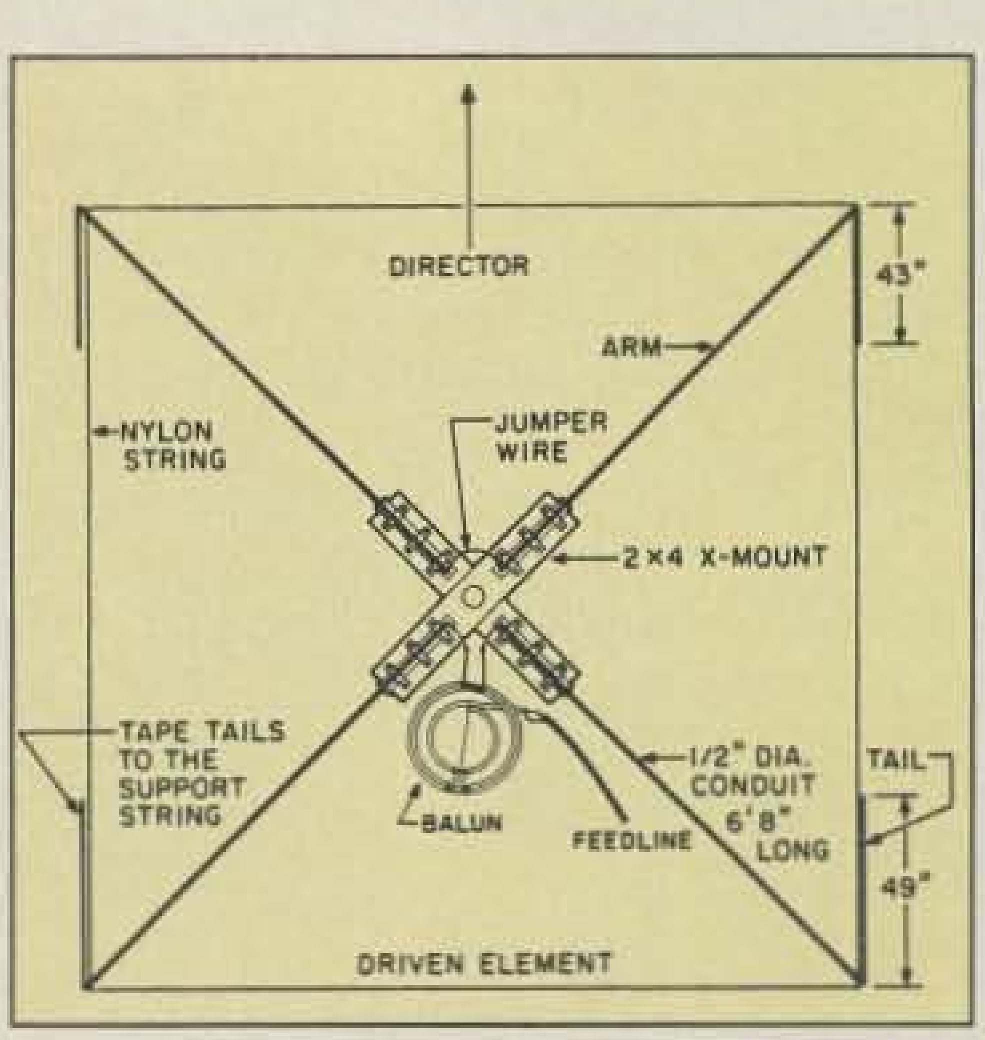

Figure 1. X-beam overview.

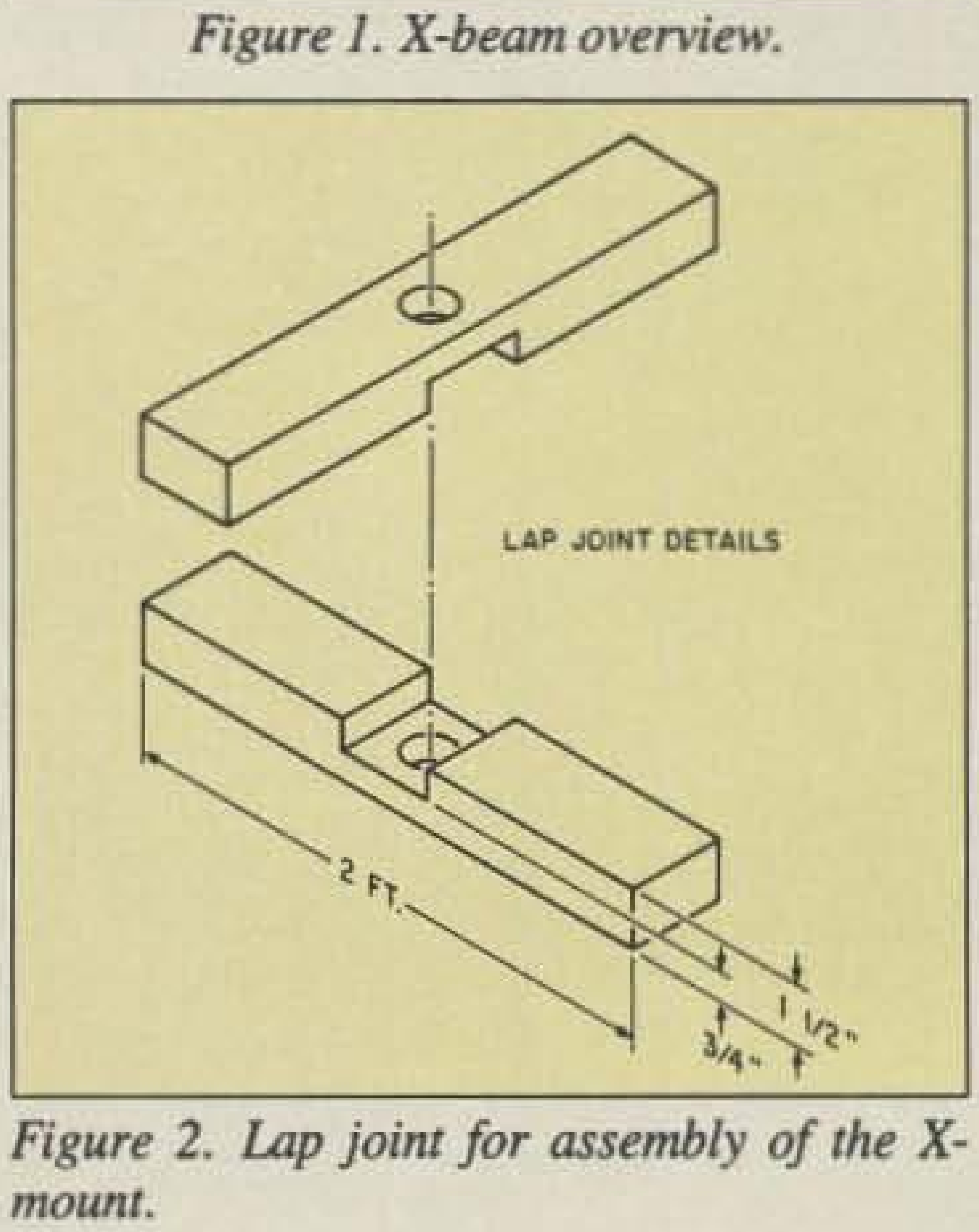

Figure 2. Lap joint for assembly of the X-mount.

but I've never been that fortunate. Fear not—this antenna can be readily constructed using common materials such as wood, steel conduit, and PVC pipe.

I bought the conduit, the PVC pipe, the pipe clamps, and the two-by-fours for less than ten dollars. The miscellaneous hardware alone, if purchased, should cost only a few dollars.

Antenna Components and Construction

The electrical components of the antenna consist of four tubular arms with a wire tail attached to the end of each one. Two arm assemblies are connected and tuned to form a director element; the other two are tuned and form the driven element.

The mechanical components of the antenna consist of a small X-hub in the center, along with a cord which strings the arms together. The hub supports the radially configured arms, and the cord supports the tails in the same plane as the arms. The electrical components of the coaxial transformer consist of six 50" pieces of 50 ohm coax.

The Hub

I built my hub with two 2' pressure-treated two-by-fours. Join them at the center with a lap joint (see Figure 2). Cut the lap joint with

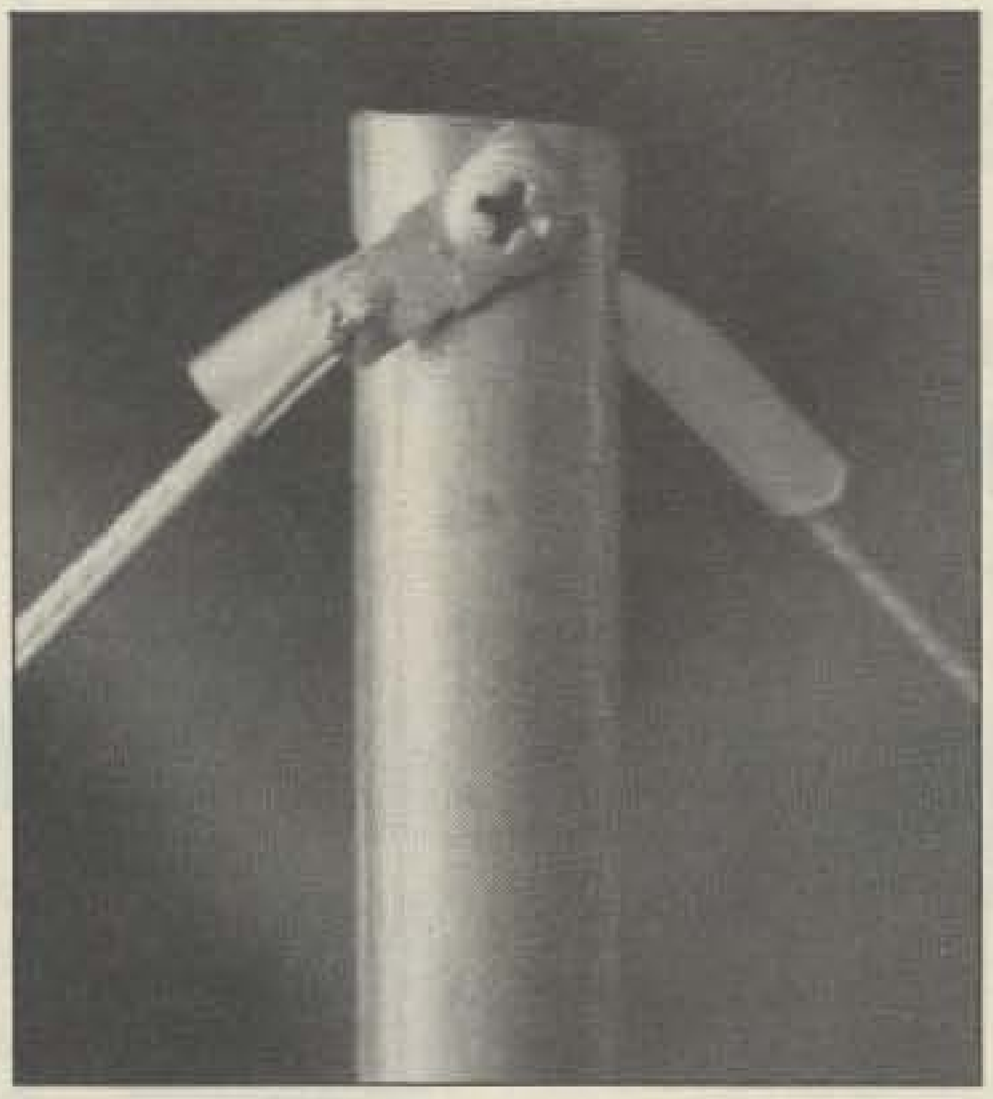

Photo B. Tail attachment and support method. Note the use of silicon tubing to protect the tail support cord.

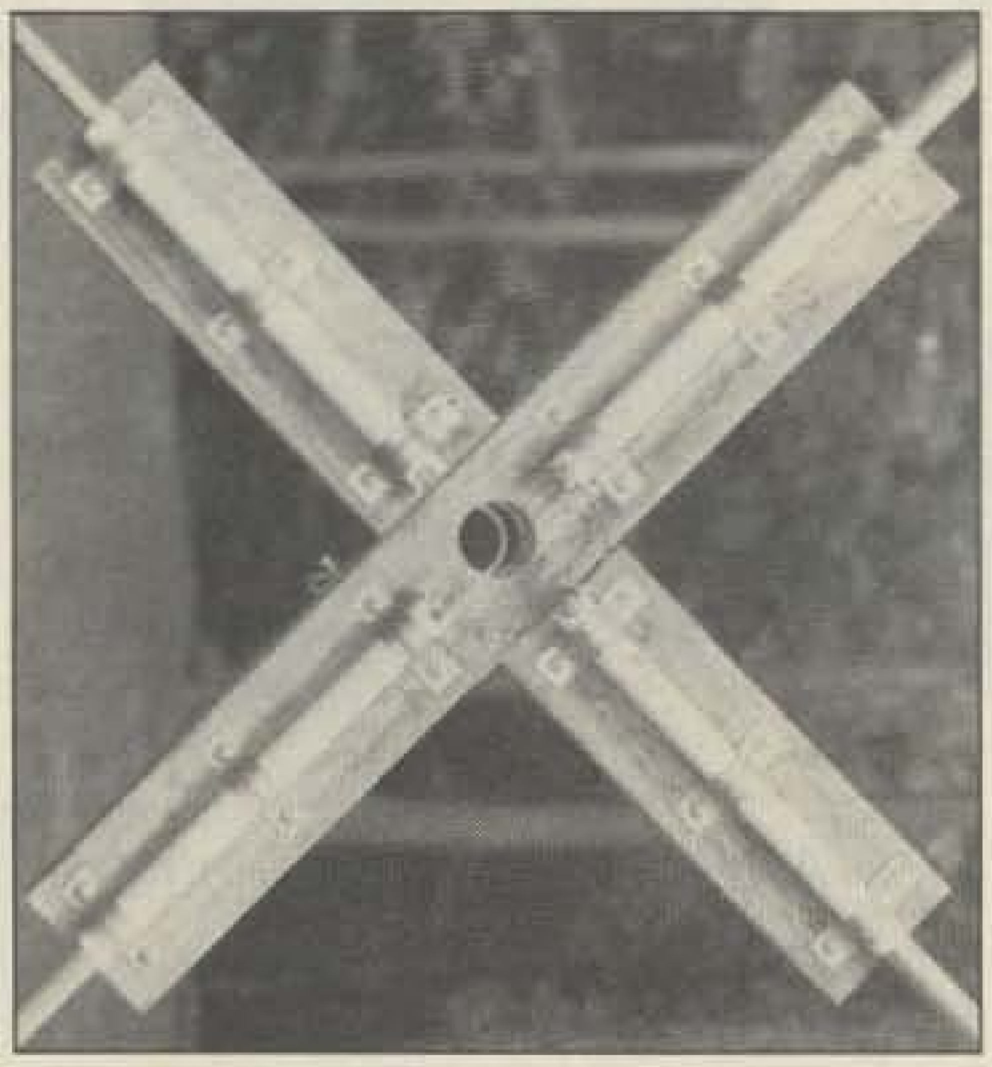

Photo C. The completed hub assembly of the antenna, prior to installation.

a saw and chisel or with a dado blade. Join the pieces with screws and epoxy or waterproof resin glue. Cut a hole in the center to accommodate the mast.

As an alternative, especially for prototyping, substitute a piece of plywood for the two-by-fours. Use exterior plywood and varnish it. I chose the two-by-fours so that the hub wouldn't ice up as much.

The Arms

My local hardware stores don't carry 6061-T6 aluminum, but they stock a nice selection of steel conduit. For this antenna, the steel conduit is an acceptable substitute. The ½" size is close enough to the 200-to-1 length-to-diameter ratio specified in the design article.

Buy four 10' lengths of ½" EMT conduit. Cut each piece to 6'11" with a hacksaw. Clamp the conduit to your workbench and drill a vertical hole at each end to accept the electrical connections.

The Tails

My installed antenna uses #19 AWG stranded hookup wire for the tails, but I've also used #12 AWG home-wire. The wire size will affect the length of the tails required to achieve resonance. The smaller the wire, the longer the tail. I prefer the larger, more solid wire as it remains straight even if the support cord shifts or stretches.

For a center frequency of 28.3 MHz, cut two director element tails, each 43" long, and two driven element tails, each 49" long. These lengths provide about 2" extra for tuning if #19 AWG wire is used. Solder a wire terminal to one end of each wire.

The most important consideration is to always maintain a difference of 6" between the driven and the director tail element lengths. Using two different colored wires for the driven and director element tails can help to reduce confusion later.

The Tail Supports

The tails must be supported in the same plane as the arms. I used 3/32" nylon cord threaded through holes drilled in the end of each arm. I used silicon tubing to provide strain relief for the cord.

Put the tail support holes 90 degrees and ½" in from the hole drilled for the electrical connection. This inset prevents the nut and bolt from touching and rubbing through the tubing.

Drill the tail support holes at one end of each arm using a ¼" drill bit. De-burr the holes with a piece of emery cloth. Cut four 2" pieces of silicone tubing and set them aside. Do not install the tubing until after the arms are insulated and installed. Silicone tubing is sold at aquarium shops as airline tubing, and at hobby shops as fuel tubing. Dacron™ or Kevlar cords are preferable, as they weather well and won't stretch as much as nylon.

Insulating the Arms

The arms should be insulated from the hub for consistent performance. I used ½" type SDR PVC pipe (not schedule 40). It provides

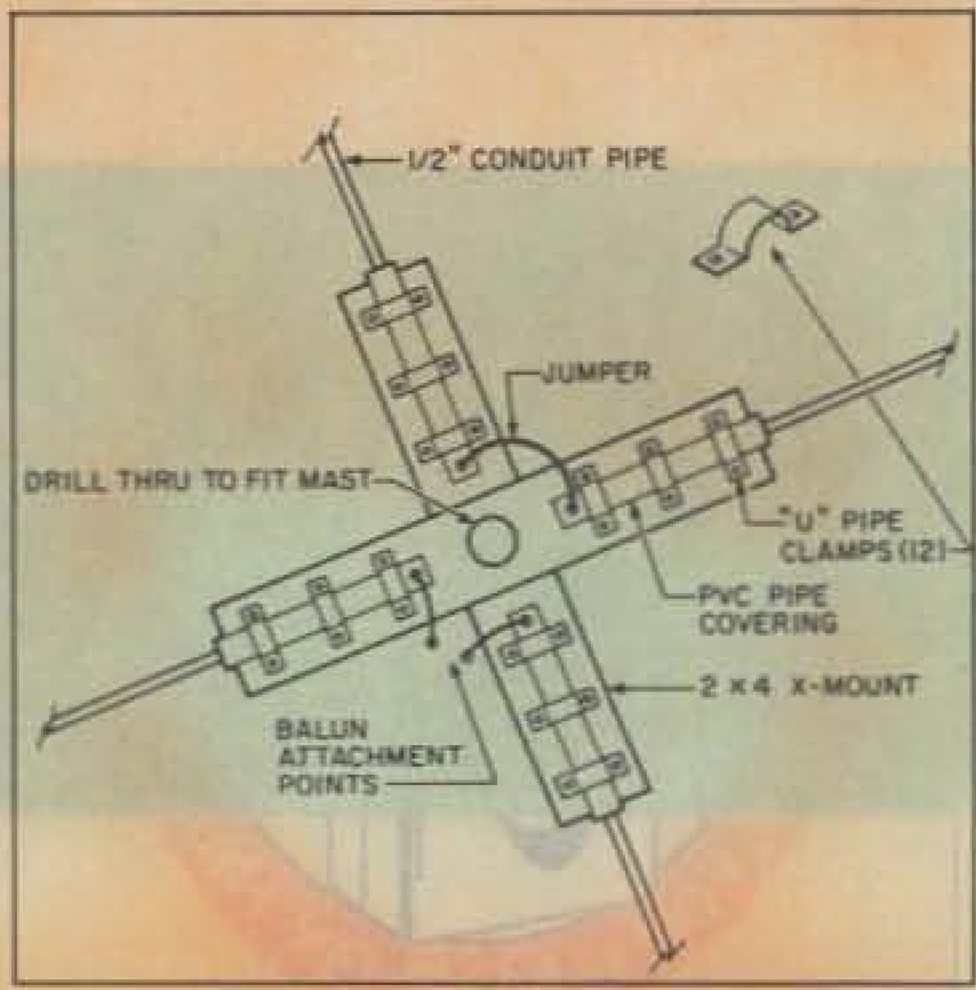

Figure 3. X-mount construction details.

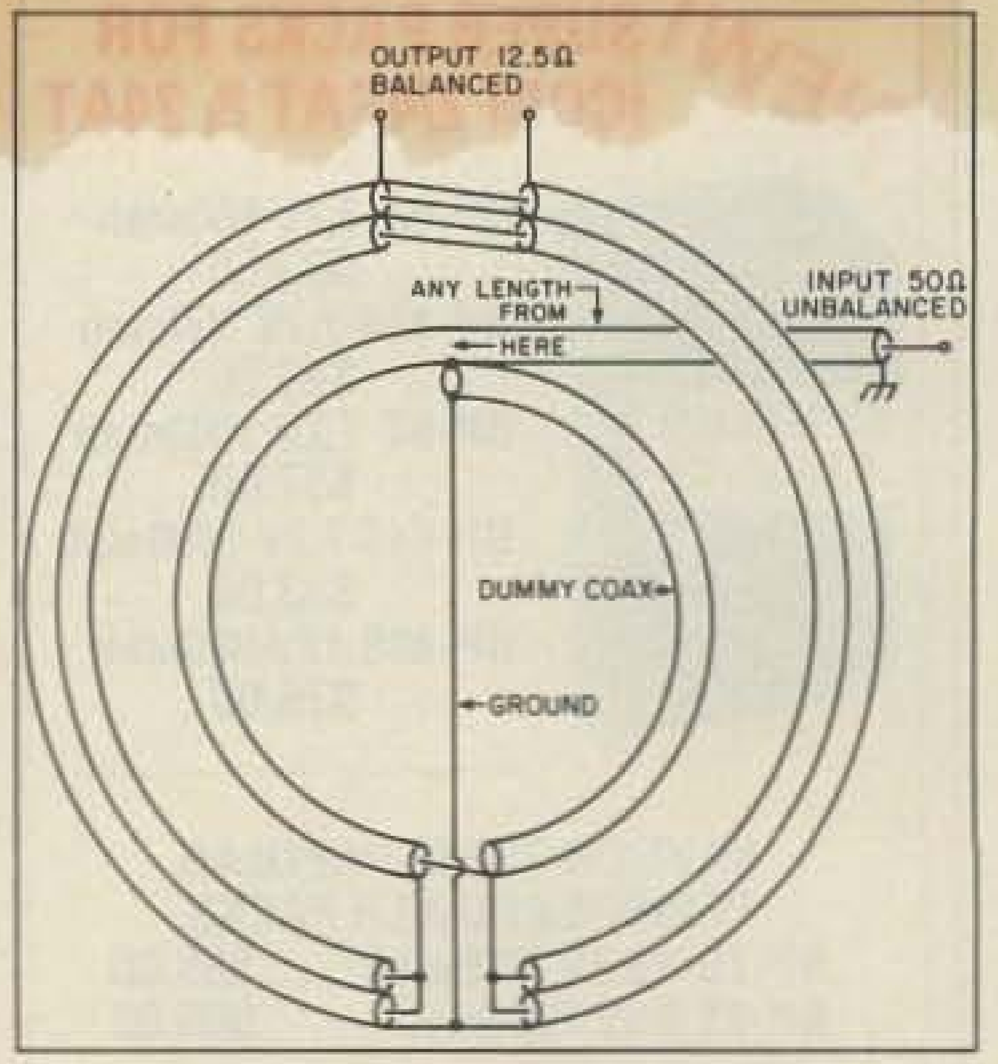

Figure 4. Collins balun.

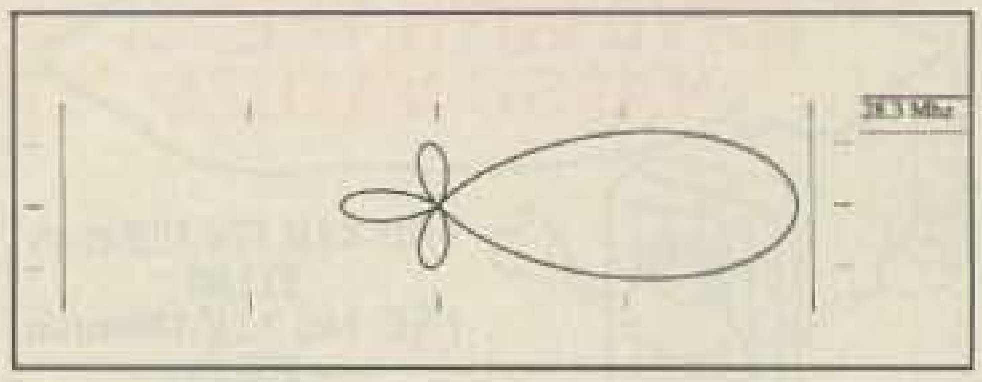

Figure 5. X-beam pattern.

a good, albeit tight, fit around ½" EMT conduit.

Cut four 11" lengths. The fit is very tight, so use warm soapy water as a lubricant. Start a length of PVC over the inside end of the arm. Install it fully by repeatedly driving it against a concrete floor. Repeat this procedure for the remaining arms. Substantial force can be used without damaging the PVC. Sanding the conduit may help, but be careful not to sand through the zinc coating.

Open up the electrical connection holes you drilled by cutting away some of the PVC. I used a ⅜" spade wood bit in my drill to shave it away. You can use a knife, but the PVC is difficult to cut.

Building the Coaxial Balun

This Collins coaxial balun consists of two stages. The first stage matches 50 ohms unbalanced to 50 ohms balanced; the second matches 50 ohms balanced to 12.5 ohms balanced. Use a compact low-loss coaxial cable such as RG-8X—this balun is bulky.

Build each stage separately, then solder them together in series. To prevent confusion later, mark the ends of the lengths of coax before you begin winding them. Keep the interconnections short. Use the coaxial braid at the 12.5 ohm output to connect directly to the antenna feedpoints.

Figure 4 shows the interconnections and layout as if the balun wasn't coiled. In practice, the lengths are wound into a coil with a diameter of six or seven inches. This diameter isn't extremely critical; it depends on the coaxial cable you use. The ground wire should be short, but its length isn't critical, either. The dummy length of coax in the input stage can be replaced with a wire, provided it is the same length (50"), and is wound in the same manner.

Use electrical tape to hold the windings together—sparingly during construction, and with a vengeance prior to installation. Waterproof the balun by using a polyurethane spray or a silicone rubber compound.

Putting it Together

Prepare the hub. (Refer to Figure 1 and Photos B and C for detailed views.) Start by marking a centerline on each two-by-four. Next, place the pipe clamps. I used three pipe clamps per arm: one at each end, and one in the middle. Be sure to use the proper type of clamps—½" electrical clamps for clamping conduit directly, and ½" plumbing clamps for clamping the insulated arms. Locate the inner edge of each innermost clamp 1¾" from the center to provide clearance for the mast. Drill pilot holes for the clamp screws. Install the clamps loosely.

Install the arms by slipping each arm, in turn, under the clamps, then snugging the clamps. Allow the inner end of each arm to extend ½" beyond the edge of the inside clamp. This provides access to the end of the arm for electrical connections. Clamping the hub to a workbench or your deck reduces the number of hands required for this procedure. Rotate each arm to properly align the electrical and tail support holes, then tighten the clamps securely.

Next, attach each tail loosely to the arm. If possible, use stainless hardware. Be sure to install the director element and driven element tails properly. This step is best performed before you install the tail support tubing.

To support the tails, install a 2" piece of silicone tubing through the hole at the end of each arm. Thread the tail support cord through each arm in turn. Pull the cord tightly, as it will sag when the tails are attached. Line the tails up along the cord and secure them at several points with electrical tape. Tighten the tail-to-arm connections securely.

To wrap it up, connect the director element arms. I used a short piece of #12 AWG copper wire. Coax braid will also work well.

Feeding the Antenna

The feedpoint impedance of this antenna is 10 ohms at resonance. With proper matching to 50 ohm coaxial lines, this antenna provides a 2:1 VSWR bandwidth of about 600 kHz on 10 meters.

For my prototype antenna I used a coaxial "choke" balun consisting of 10 turns of coaxial cable wound into a 6" diameter loop. I matched the transceiver to the line using a transmatch.

For my installed antenna I used the two-stage Collins balun described in this article. This balun provides a 12.5 ohm balanced to 50 ohm unbalanced transformation. A 2:1 VSWR bandwidth of 600 kHz is exhibited without the use of a transmatch.

I strongly suggest the use of a balun, and I heartily recommend the Collins class of baluns, but the coil-of-coax type will work in a pinch.

Tune-Up

Install the beam on your test tower. I used an 8' wooden ladder for my test tower. It's high enough off the ground, yet access to the tails is convenient.

Tune-up is accomplished by trimming the tails. Be sure to keep the director element tails and the driven element tails the same lengths, respectively. Also, be sure to maintain a difference in length of 6" between the director element tails and the driven element tails.

Use a dip meter, noise bridge, or SWR meter to test for resonance. I borrowed a dip meter for the tune-up procedure. If you use a dip meter, be sure you are familiar with its limitations. During my tests, I found that the antenna was resonant at a frequency 5% higher than that indicated by the dip meter.

Proceed by trimming the tails ½" at a time, testing for resonance until the correct resonance is achieved. Note that the antenna is fairly sensitive to nearby objects, such as your body.

Perform the final tune-up with the antenna installed. I ended up with director element tail lengths of 41", and driven element tail lengths of 47", for a resonance at 28.3 MHz.

Prototyping

This is a very easy antenna to prototype. The difference between my prototype and the installed antenna was about $3, plus an hour of labor.

I prototyped mine by directly clamping the conduit to a scrap piece of wood. I attached the wire tails with ground wire clips, supported the tails by taping them to a cord drawn around the perimeter, and made the connections at the hub by clamping the wires under the pipe clamps. I completed my "installation" by clamping it to an 8' wooden ladder in my living room.

Installation

I installed the beam at the base of the top section of my 36' push-up mast, inverting the beam and attaching it to the underside of the guy ring. I had to do this to prevent mechanical interference between the hub and the clamp for the top mast section. I did not have to worry about interfering with guy wires, as my mast is not guyed. The mast's sheltered location, light antenna load, and mechanical attachment to the house, precluded the need for guy wires.

To prevent rotation about the mast, I fashioned two L-shaped pieces of plumber's metal strapping and screwed them to the guy ring. I secured the assembly to the mast with a hose clamp. This is adequate for me, as I don't have a rotor, and I am using the antenna for fixed direction schedule work. As an alternative, especially if you are using a rotator, use a heavy-duty L-bracket with pipe clamps that fit your mast.

Complete the installation by securing the balun to the mast. I wound electrical tape through each stage of the balun, and around the feedline below the balun.

I'm confident that you'll find this to be a compact, high performance beam which is easy to build and won't lighten your pocket book. Enjoy it! Be sure to remember that "59" means "armchair copy" and "20 over 9" means "You woke up the kids." You'll be hearing this new jargon often! 73

Contact Michael Harris KM4UL at 5917 Crabapple Rd., Durham NC 27712.

Parts List

4	10' lengths of ½" EMT conduit
1	10' length of ½" SDR PVC pipe
12	½" plumbing pipe clamps
1	8" length of silicon tubing
4	4' lengths of wire scraps
2	24" lengths of pressure-treated two-by-four
6	50" lengths of coax (RG-8X preferable)
	Misc. Hardware as required