W. G. Moneysmith, W4NFR
w4nfr@earthlink.net

A Homecrafted Duplexer for the 70 Centimeter Band

Do you need a duplexer for your 440 MHz repeater? This project may be just what you need

As a newly minted repeater trustee, I was faced with either buying or building a duplexer for the 70 cm band. So I chose the hard way! Not really, it was fun to build, once I got past the "black magic," it was not as difficult as I first thought.

Over the years, I have tuned and retuned many duplexers. Mostly, they were commercial types, so to build one from scratch was a new challenge. In researching this subject, I found information on 2 meter duplexers, but not much on UHF (440 MHz) models.

This unique design uses materials I had in my junkbox and items commonly available at a local hardware store. The BNC connectors are available at hamfests and via the Internet.

Last spring, when I changed out the traps on my Mosley TA-33 triband antenna, little did I know those old traps would get recycled into another Amateur Radio project! I tend to save most usable metal, and in this case the 2 inch diameter aluminum outer sleeves would be the basis for my homecrafted UHF bandpass / band reject duplexer project.

In addition to the aluminum sleeves left over from my Mosley TA-33 traps, I had two pair of 8 × 3 × 2 inch aluminum angle brackets in my junk box. Those angle brackets formed the ends for the duplexer project.

While searching around the shop, I came up with the five BNC "T" connectors and eight BNC Male crimp on connectors for the feed lines. I had to make a trip to the hardware store to purchase a 5 foot long, ½ inch copper pipe and 17 pieces of 12-inch-long "all thread rod," nuts, and lock washers. Everything else was in my junk box.

[Editor's Note: When we reviewed this article for publication acceptance, several Technical Advisors commented against using dissimilar metals in the tuned cavities, and that any *ferromagnetic* metals in the tuned cavities would greatly reduce the unloaded *Q* and increase losses in the duplexer. "Even a

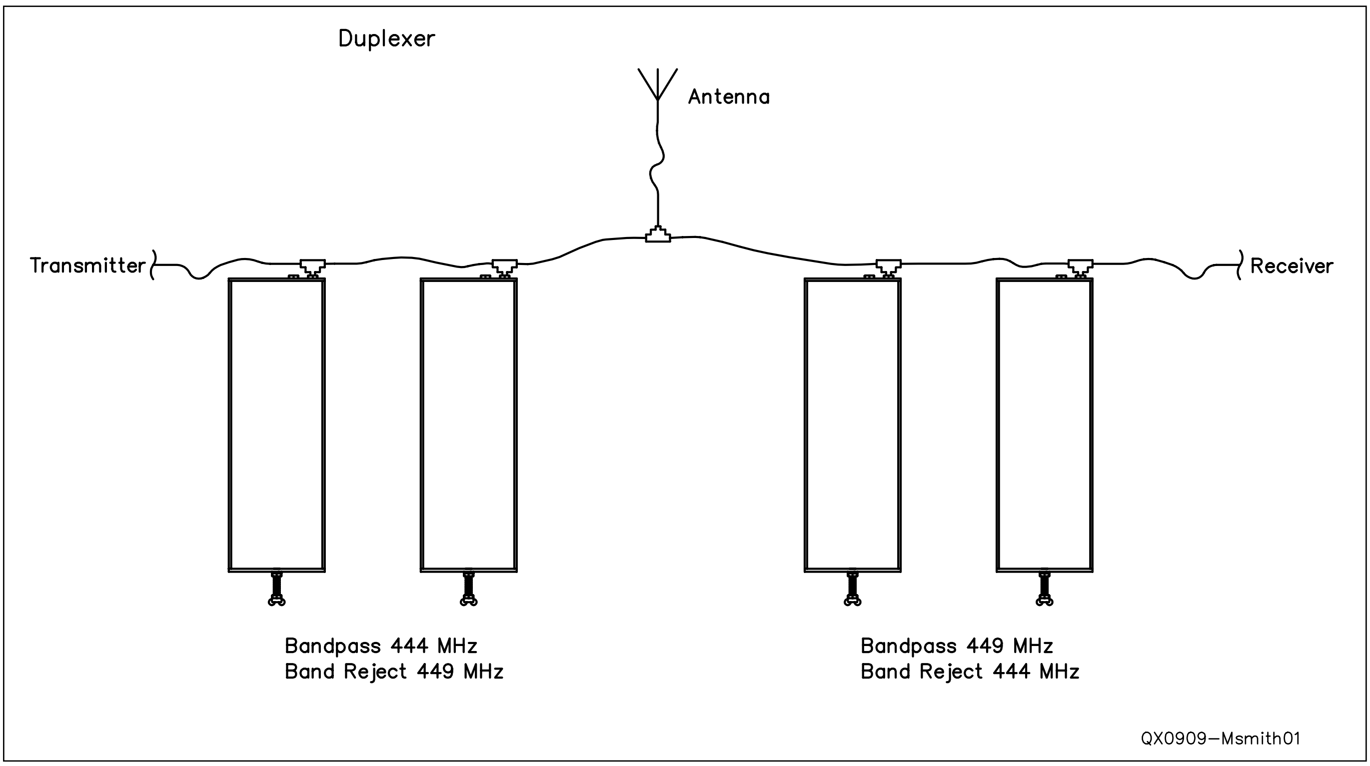

Figure 1 — By using a pair of duplexer "cans" on the transmitter side and another pair on the receiver side, a single antenna can be used with a repeater system.

single steel nut can have a major effect," said one Technical Advisor. Copper pipe could be used for the outer sleeves and brass all thread rod, nuts and lock washers are available from a number of suppliers, including Small Parts (**www.smallparts.com**). The author acknowledged that improved performance may be possible by using all copper or brass components, and suggested that 3 inch copper pipe could be used for the outer sleeves. The length of the sleeves is probably not extremely critical. The spirit of the project was to use available junkbox parts and readily available hardware, however. The project is presented here as it was constructed. Interested builders may want to consider the increased cost of copper pipe and brass hardware for possible performance improvements.]

A duplexer provides the means for simultaneous operation of a repeater station having separate transmit and receive frequencies, when using a common antenna. Figure 1 shows a simple block diagram of the station.

I decided to construct a single-loop, series-resonant, notch/bandpass duplexer. This design, shown in Figure 2, uses only one loop and a series capacitor to adjust the notch frequency above or below the passband. A single BNC connector with an external T is used for the feed line connections. Each of the four cavities is tuned with a 1.5 inch diameter circuit board mounted on one end of a threaded rod. Each rod then passes through a threaded hole at the bottom, grounded, end of the cavity and is secured using a lock nut.

The bandpass circuit consists of a 6 inch copper pipe soldered to one end of each cavity and the pass frequency is tuned by adjustment of the circuit board capacitor at the grounded end. The notch frequency is adjusted by a small piston capacitor at the coupling loop, in the series resonant input circuit.

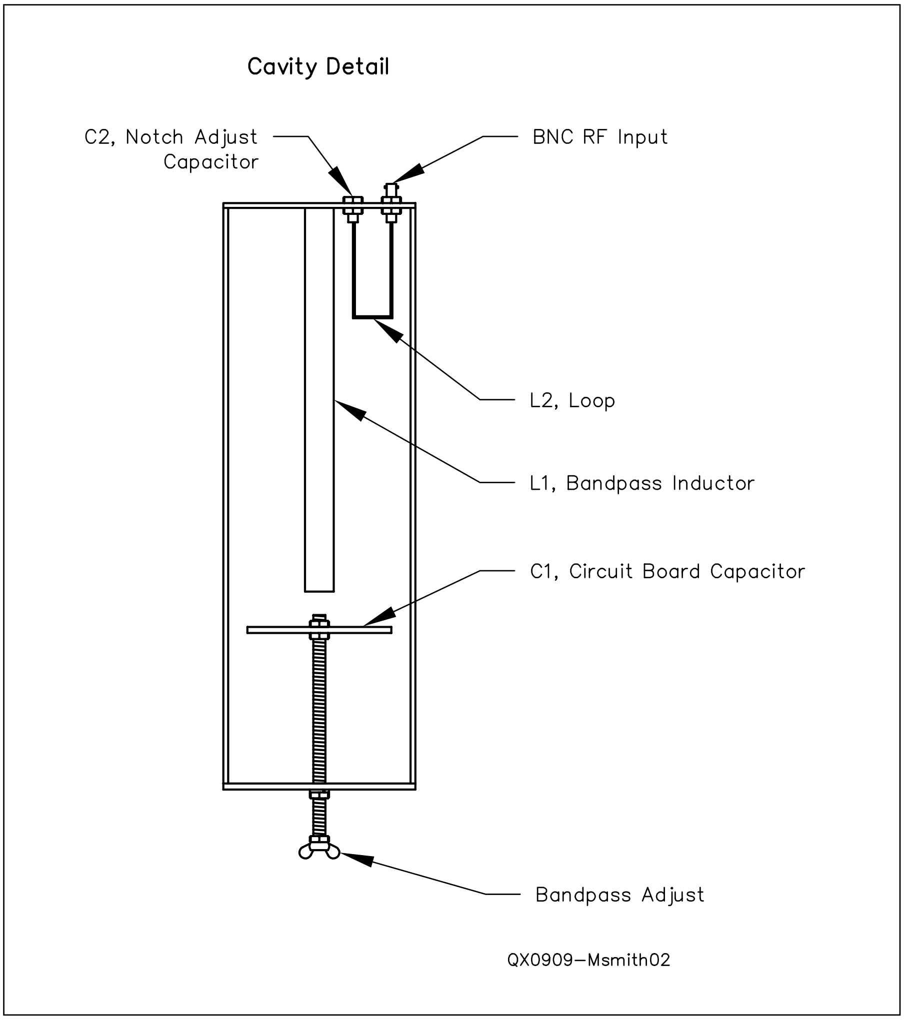

Figure 2 — This drawing shows the internal workings of a duplexer cavity.

Construction

After all the parts are acquired, begin by laying out the four copper-clad circuit board pieces (3 × 3.75 inches) shown in Figure 3. Drill the holes for the female BNC input connector, piston capacitor and "all thread" rods. It is a good idea to use a center punch to mark the hole centers before drilling. Cut out the brass pieces for the four loops, as shown in Figure 4.

A drill press is handy, but a hand drill will work. I used the first circuit board as a pattern for the other three. Once the boards are drilled, lay them on your angle brackets and mark those holes to be drilled, so all the threaded rods will line up for final assembly.

Table 1
Parts List

Quantity	*Description:*
16	"All thread" rods, 12 inches long, no. 8-32.
1	"All thread" rod, 12 inches long, no. 10-24.
4	Aluminum tube, 2 inch diameter, 8 inches long.
32	Nuts, no. 8-32.
16	Nuts, no. 10-24.
20	Split washers, no. 10 size.
4	Screws, ½ inch long, no. 10-24.
4	Lock nuts, no. 10-24.
4	Aluminum angle brackets, 8 x 3 x 2 inches, 1/8 inch thickness.
5	BNC, T connectors.
8	BNC, male, Amphenol RFX, crimp on connectors.
4	C1, circuit board discs, 1.5 inch diameter each, 1/8 center.
4	Circuit boards, single sided copper clad, 3" x 3.75".
4	C2, small piston capacitor, 4-15pf, VOL AP10.
4	L1, copper pipe, 6" long, ½" diameter, cut with tubing cutter.
4	L2, brass or copper flashing for loop construction.
1	RG-142, Mil-C-17, double shielded coaxial cable, 24" long.

Construct four each cables, 6" long. Terminate with BNC male RFX connectors.

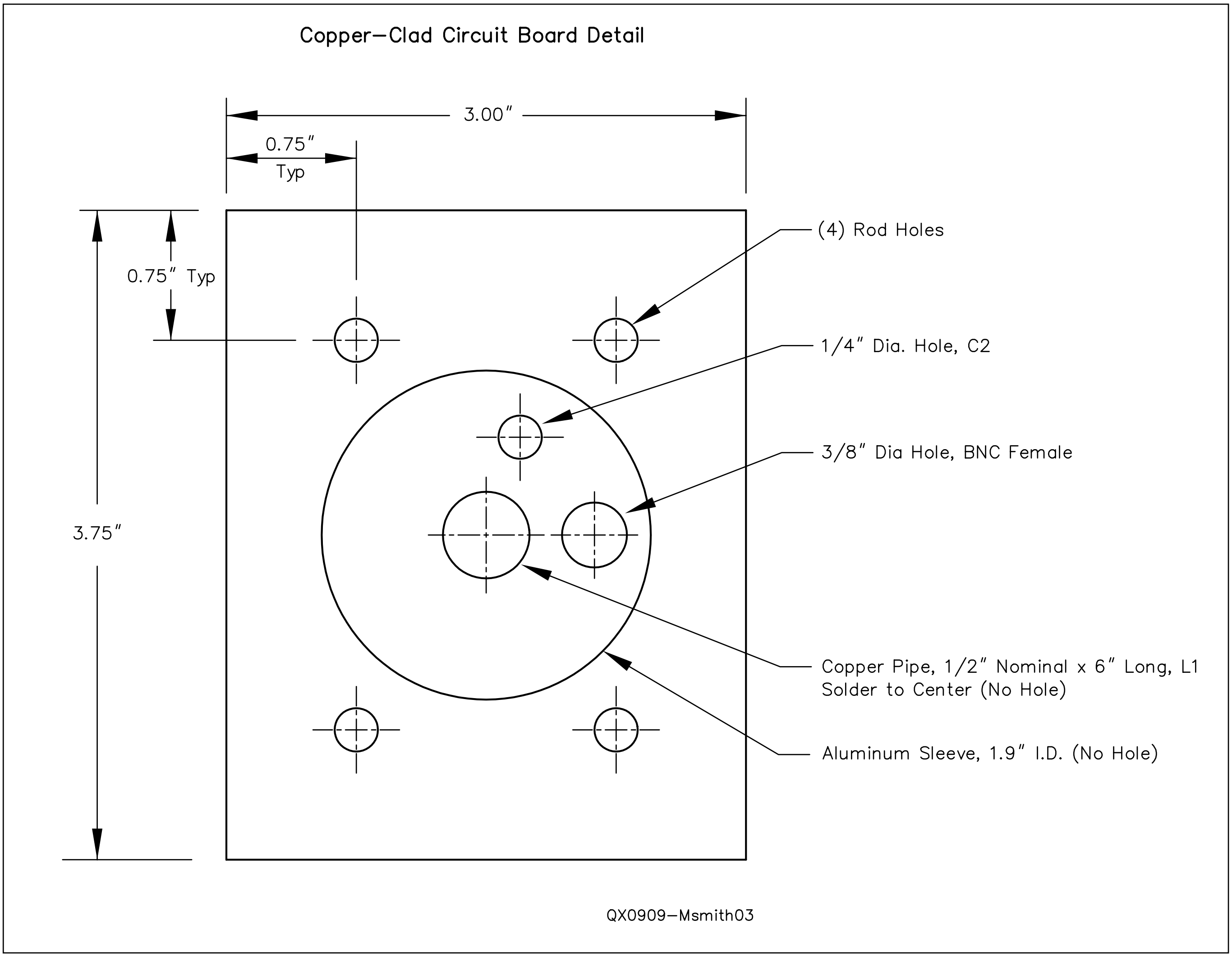

Figure 3 — This illustration shows the construction details for the copper-clad circuit board material used to form the end caps for the duplexer cavities.

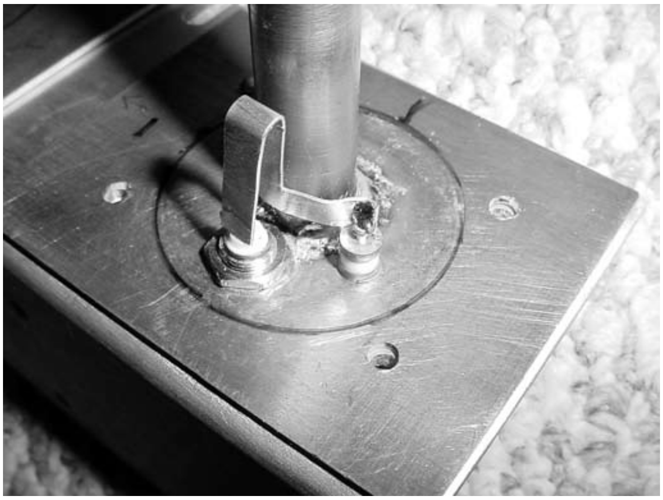

Photo A — This close-up view shows the assembly of one copper-clad circuit board material end plate with the copper pipe for L1 soldered to the circuit board, the BNC connector, copper flashing loop for L2 and the notch-adjust capacitor, C2, installed.

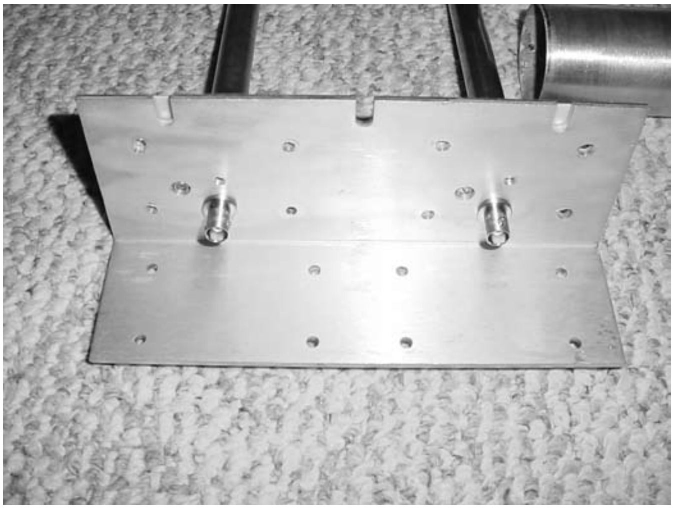

Photo B — A pair of end plate and copper pipe assemblies are attached to one piece of the aluminum angle bracket.

The brackets and rods give the duplexer its mechanical strength.

Clean the copper boards with a rotary brass wire brush on a drill to shine up the surface. Next, cut four 6 inch long pieces of ½ inch copper pipe and clean with a wire brush until shiny bright. Use a tubing cutter to make sure the tubes are cut with perfectly square ends. Be careful not to squeeze the tubing out of round.

Using a propane torch, solder each tube to the center of a piece of the circuit board material. Do not over heat or burn the circuit board material. Make sure each piece of pipe is vertical and perpendicular to its circuit board. Use very little solder, but enough to keep the tube solid to the circuit board.

After the copper pipes have cooled off, mount the small piston capacitors on the circuit boards. Make sure the notch-tuning access holes in the end brackets are drilled 5⁄16 inch diameter, so the circuit board lays flat against the bracket. Next, mount the BNC female input RF connectors, the end brackets and circuit boards.

Make the input brass loops, as shown in Figure 4. Solder the loops to the BNC input and to the notch piston capacitor as shown in Photo A. Make sure the loop is spaced ⅛ inch from the ½ inch copper pipe. Photos B and C show one pair of copper end plates and copper tubing assemblies attached to one of the aluminum angle brackets. Photo D is a side view of this assembly.

The circuit board tuning capacitor shown in Figure 5 is made using a 1.5 inch hole saw to cut out four discs of copper clad circuit board material. Drill a small ⅛ inch diameter hole in the center of each, and mount it on the end of a 3 inch long piece of no. 10-24 "all thread" rod. Tap and thread a small hole in the angle bracket. Thread the capacitor

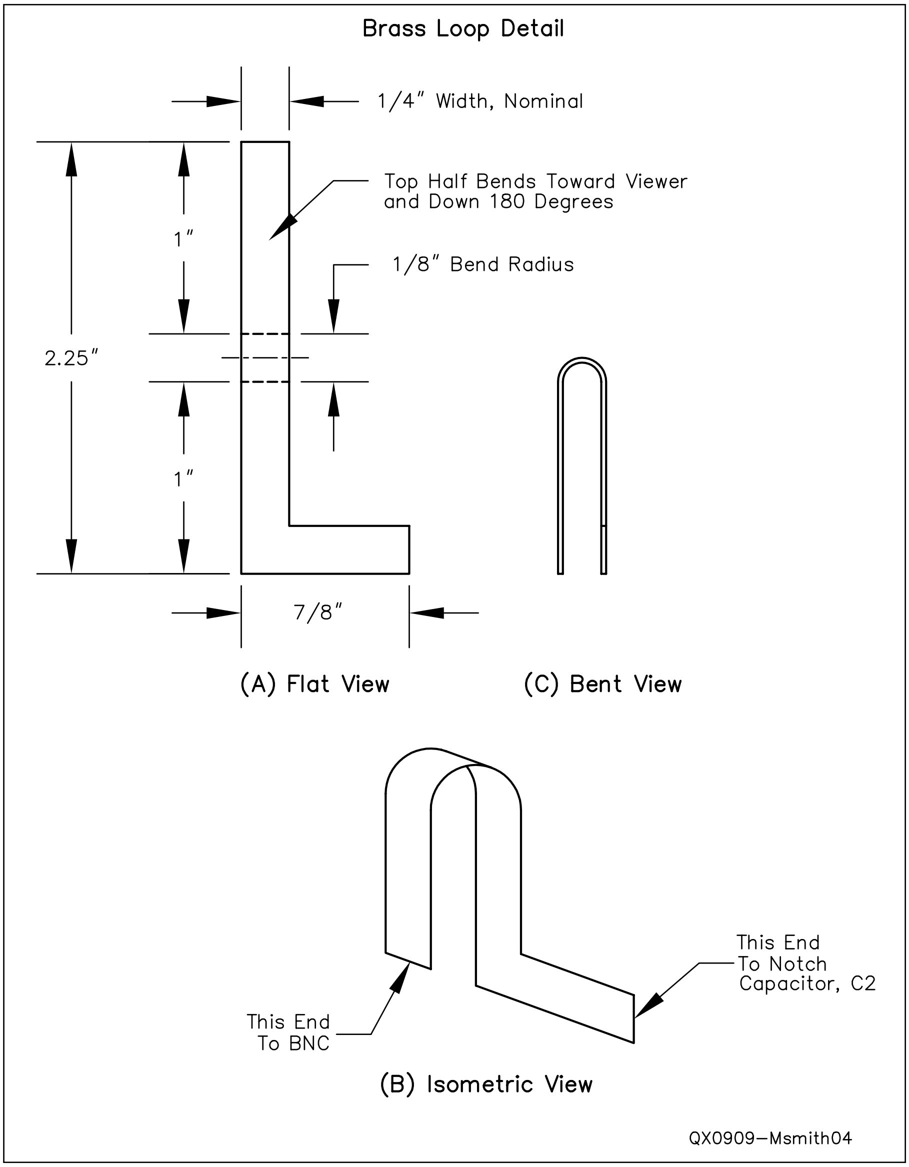

Figure 4 — Use brass or copper flashing to form loop L2 for each cavity.

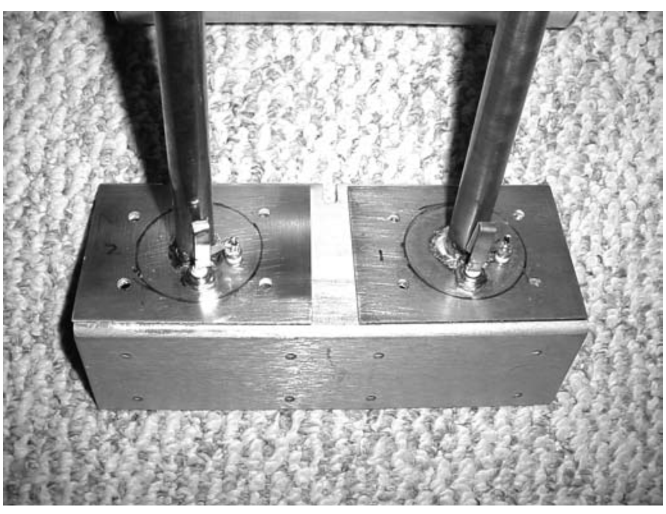

Photo C — This photo shows a completed end assembly for one pair of the duplexer cavities.

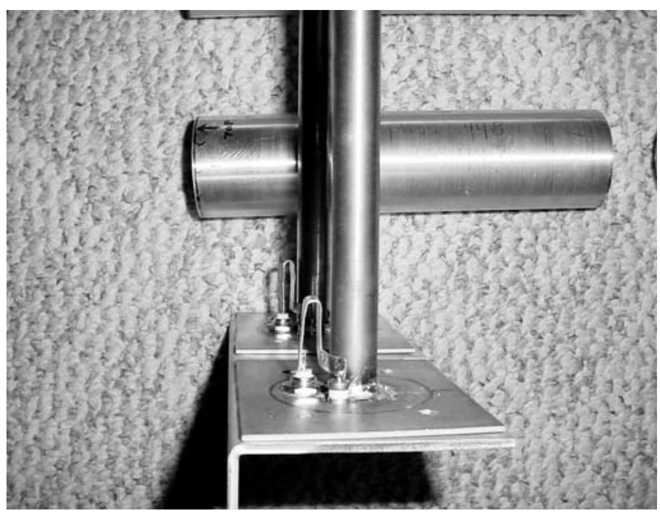

Photo D — Here is a side view of the completed end assembly.

rod into this hole and lock it in place with a no. 10-24 nut and no. 10 lock washer.

The 2 inch diameter aluminum tubes were originally 12 inches long, and they are cut to a length of 8 inches for this project. Make sure to cut squarely to ensure a nice tight fit against the brackets and circuit boards.

Mechanical Assembly

You are now ready to assemble the duplexer. Put two of the 8 inch aluminum sleeves over a pair of the ½ inch copper pipes, between end brackets. Secure the brackets with no. 8-32 "all thread" rods, using a no. 8-32 nut and lock washer on one end and a no. 8-32 nut on the other end. When completed, cut off the excess rod with a hacksaw. Center up the aluminum sleeves and tighten the nuts evenly until all are solid.

Tuning

I tune each cavity separately in the beginning, using a 5 W 440 MHz handheld transceiver and a dummy load with built-in wattmeter. A BNC T connector is secured to the BNC female on the cavity. Install a shielded RF cable from the transceiver to the T and place another RF cable from the T to the dummy load/wattmeter. Set

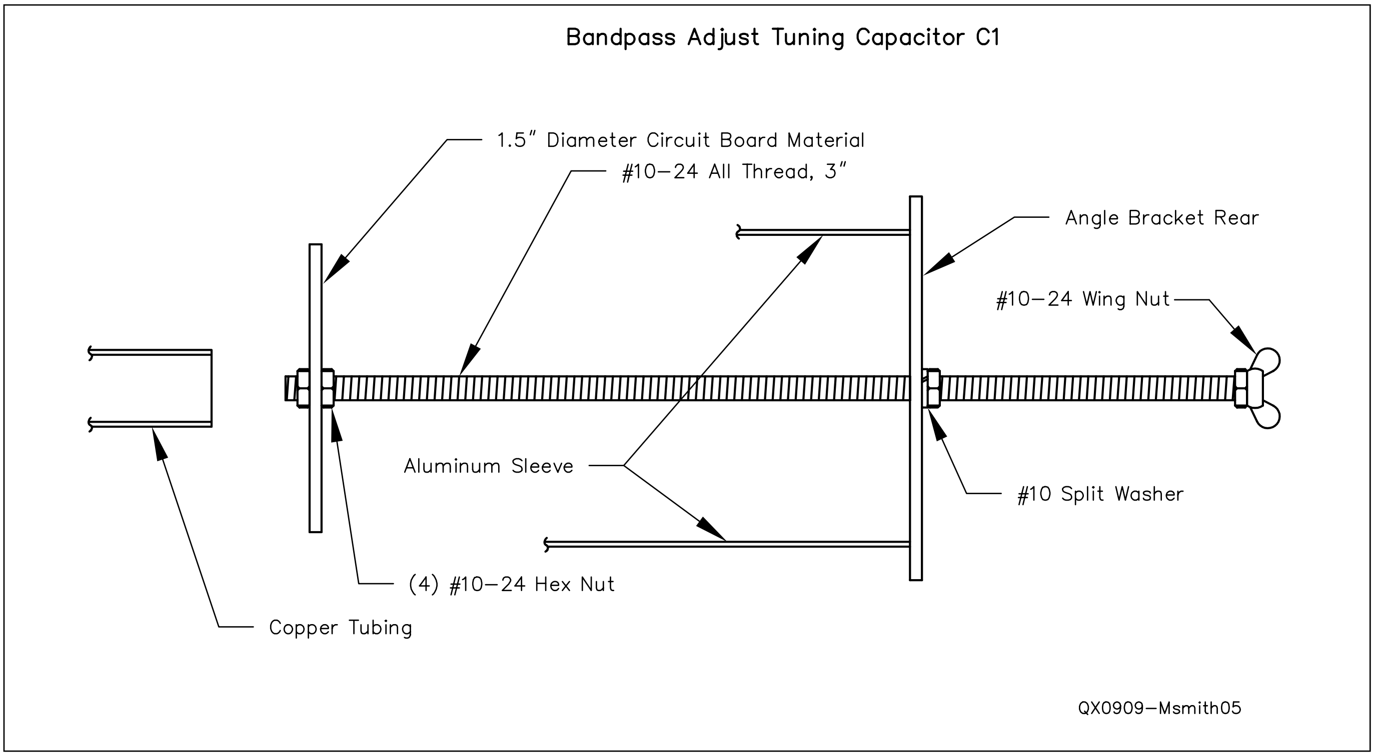

Figure 5 — Here are the construction details for the bandpass tuning capacitors used in each cavity.

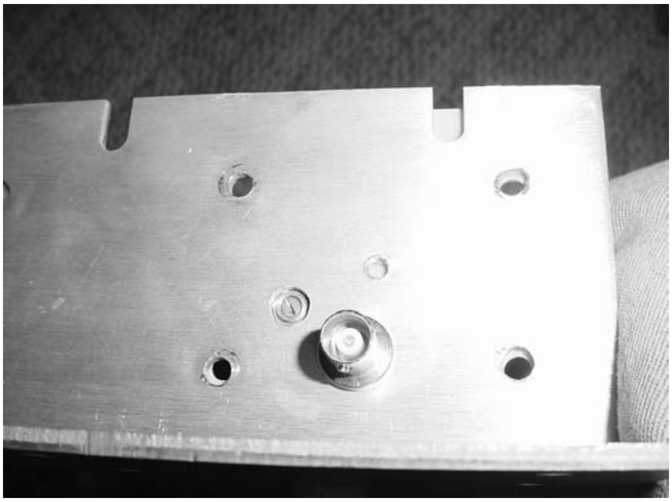

Photo E — This close-up view shows the RF input BNC connector and the notch adjust capacitor through holes in the angle bracket. The holes for the all thread rods are also visible.

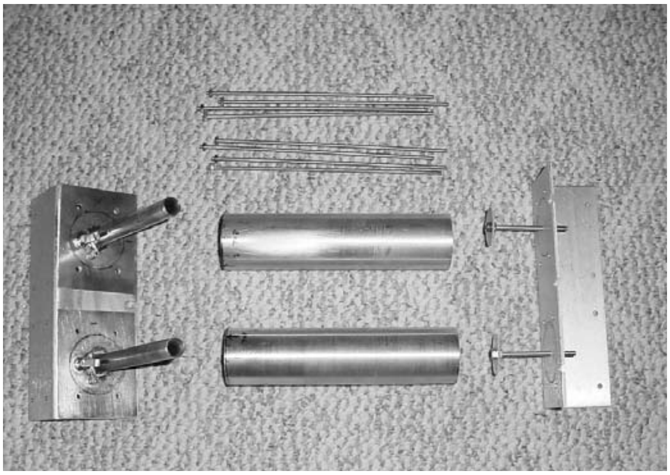

Photo F — The copper pipe assembly, aluminum tube "cans" and all thread rods are laid out ready for assembly. The bandpass adjustment capacitors have been installed in holes in the second aluminum angle bracket.

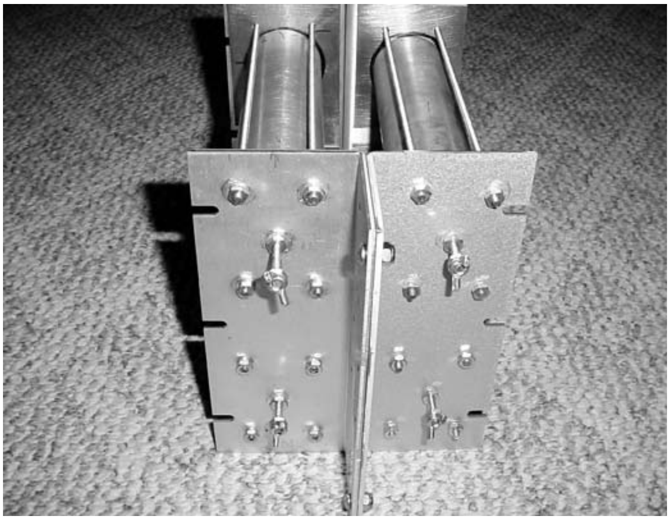

Photo G — This end view of the completed pair of cavities shows the bandpass tuning adjustment all thread rods through the angle brackets.

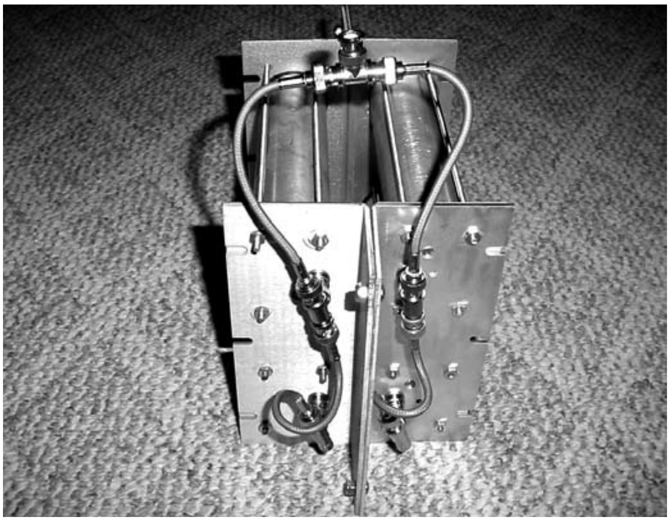

Photo H — Here is the completed duplexer assembly, including the interconnecting coaxial cables.

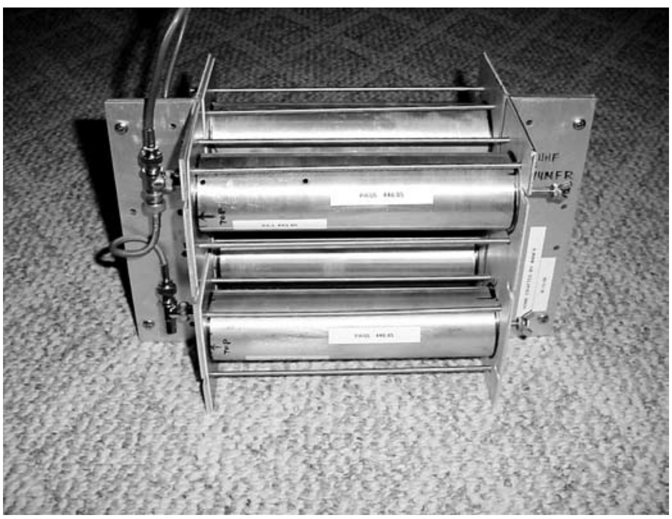

Photo I — This side view of the completed duplexer assembly shows all four duplexer cavities.

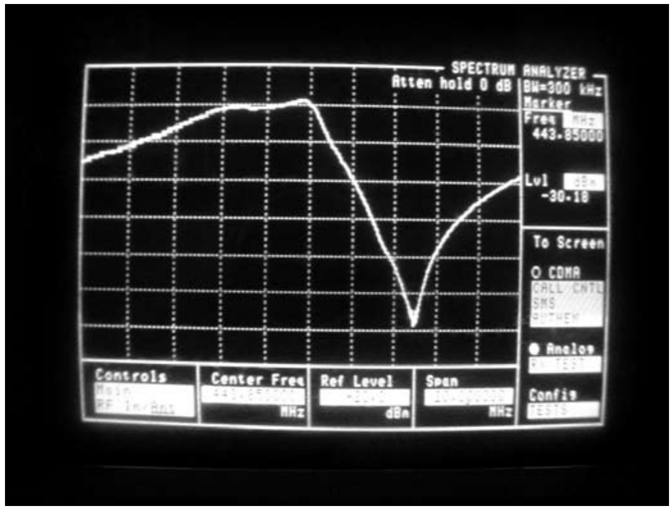

Photo J — This spectrum analyzer sweep shows the transmit frequency passband, centered at 443.85 MHz. Note that the received signal at 448.85 MHz is greatly reduced. The sweep was done using the two cavities on the transmitter side of the duplexer.

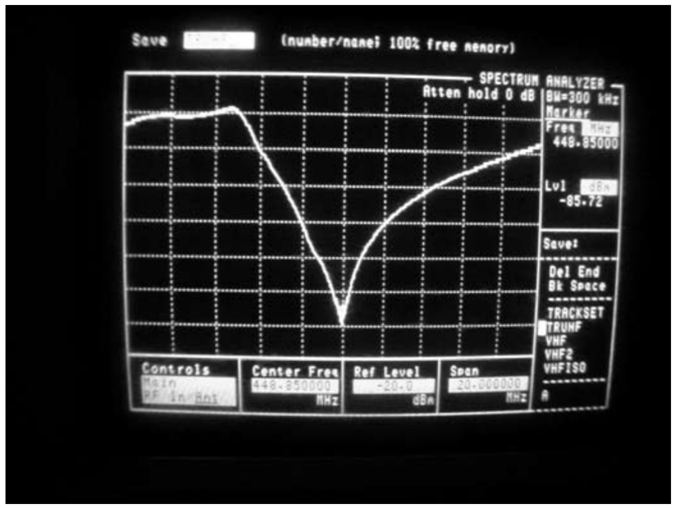

Photo K — This spectrum analyzer sweep shows the receive frequency notch, centered at 448.85 MHz, also using the two cavities on the transmitter side of the duplexer.

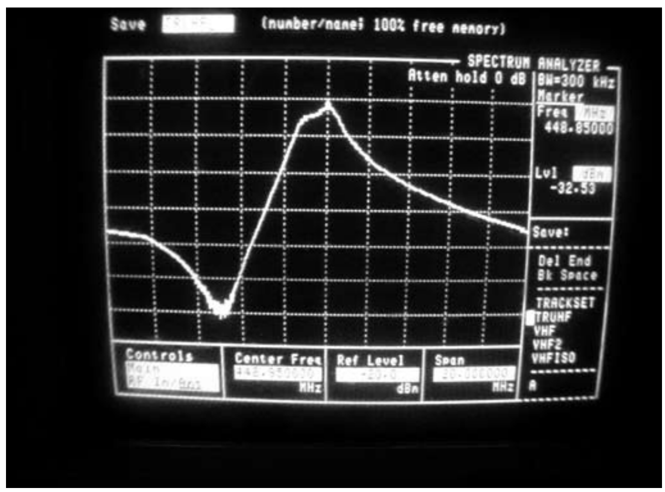

Photo L — The spectrum analyzer sweep of the receive frequency passband, centered at 448.85 MHz, using the two cavities on the receiver side of the duplexer.

the radio transmit frequency to the bandpass frequency (448.85 MHz in this case) and key the transmitter. Adjust the circuit board tuning capacitor rod on the end of the mounting bracket for maximum throughput as indicated on the wattmeter.

Next, change the handheld transceiver frequency to the notch frequency (443.85 MHz), key the handheld and tune the notch capacitor for a minimum reading on the wattmeter. Repeat this for the second cavity and set the assembly aside for now. Tune the other set of cavities in a similar manner, but reverse the passband and notch frequencies.

After all of the cavities have been roughed in, install T connectors on all cavities. Install quarter wavelength (6 inch) feed lines using RG-142 double shielded coaxial cable and BNC male connectors.

Both sides of the duplexer can now be mounted back to back using no. 10-24, ½ inch long screws and lock nuts. The cables from both sides can now be connected to the antenna BNC T connector. Recheck your passband and reject adjustments. Terminate the unused ports with a 50 Ω load. Touch up your bandpass and notch adjustments and this completes the project.

Test Results

I used a spectrum analyzer to record the results of frequency sweeps of the duplexer cavities. Photo J shows the transmit frequency passband sweep, while Photo K shows the receive frequency notch sweep. These photos are for the two cavities on the transmit frequency side of the duplexer.

Photo L shows the receive frequency passband sweep, while Photo M shows the transmit frequency notch sweep. These photos are for the two cavities on the receive frequency side of the duplexer.

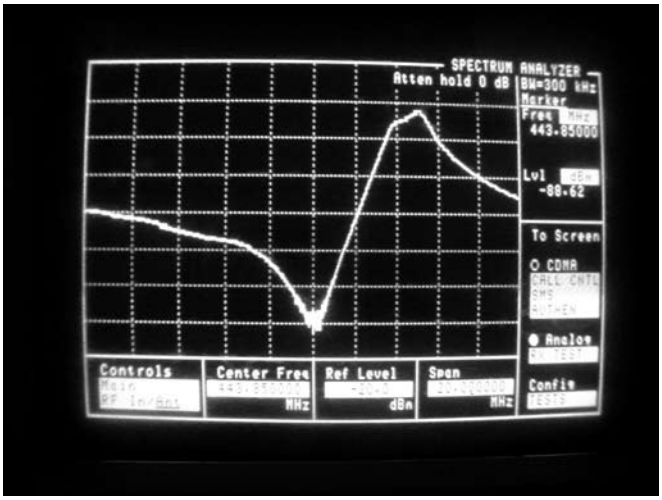

Photo M — This is the spectrum analyzer sweep of the transmit frequency notch, centered at 443.85 MHz, using the two cavities on the receiver side of the duplexer.

W.G. Moneysmith, W4NFR, has been enjoying ham radio as an Extra class licensee since 1961. Bill enjoys all facets of radio, especially AM, CW, PSK-31, RTTY, Packet, DSSTV, QRP and chasing DX. He is an avid electronics and ham radio enthusiast, with a particular interest in antennas. He has written many technical articles and is a retired Electronics Engineer. Current activities include RV camping/traveling, gardening, wood carving, gold panning and metal detecting with my wife, Lydia.

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