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The DX Partyline Low Noise Wavecatcher

Here's a great noise reduction loop for SWLing.

The old maxim about necessity being the mother of invention is still true. While developing material for my monthly radio show entitled "Tech Talk with Dr. Rick" (which aired last year as a ten-minute segment on HCJB's "DX Partyline"), it became clear to me that not much has been published or devised to mitigate noise problems experienced by shortwave listeners. So I set about to design a very simple and inexpensive antenna that our listeners could build and experiment with. So enthusiastic was the response that we decided to have a "name that antenna contest," and publish a small construction booklet. Here are the details.

Once again a design based upon a square loop has come forth out of HCJB. Nearly everyone is familiar with the cubical quad antenna that was designed by HCJB's own Clarence Moore W9LZX in 1942. The uniform distribution of RF current around brother Moore's loop was the medicine needed to eliminate the problem of burning the ends off of the directional antennas used by HCJB. Many derivatives have come forth from that design, perhaps the most noteworthy within the past 25 years being the "Quagi" antenna[1] developed by Dr. Wayne Overbeck N6NB.

The uniform nature of current distribution of square loops also inspired Brian Beezley K6STI to develop a horizontal loop[2] that exploits this property to minimize, if not eliminate, sources of impulse noise that plague radio reception. For Brian, the need was to drastically reduce noise at 1.8 and 3.5 MHz for the benefit of radio amateurs who enjoy "top band" DXing. What I have done is to optimize this design for use from 3 to 26 MHz for the benefit of the thousands of shortwave DXers out there who suffer from the impact of noise. This noise reduction loop is for you! And hats off to Clarence and Brian for the inspiration!!

The basic design of this type of noise reduction antenna is that of a

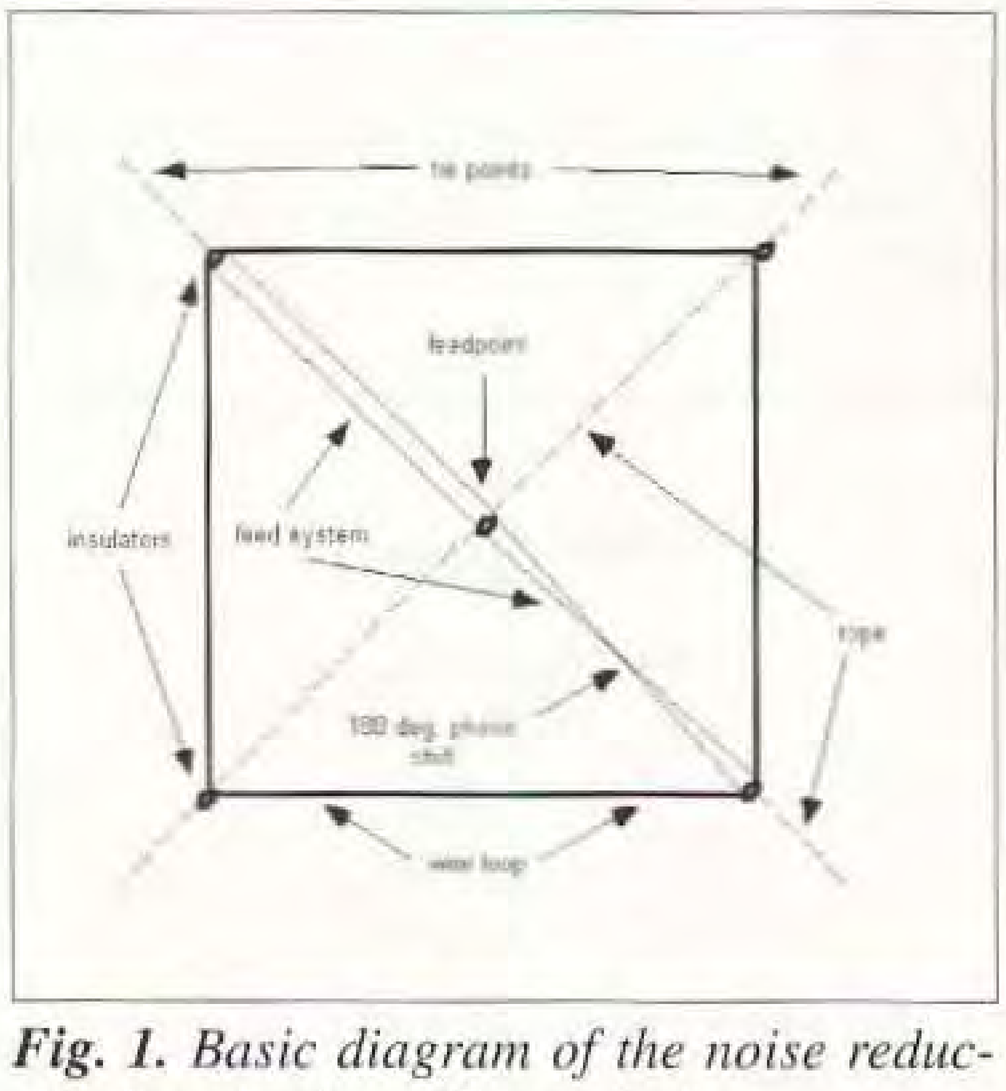

Fig. 1. Basic diagram of the noise reduction loop (attic configuration).

***Photo A.** Here is the low noise loop in the second floor loft of my home QTH.*

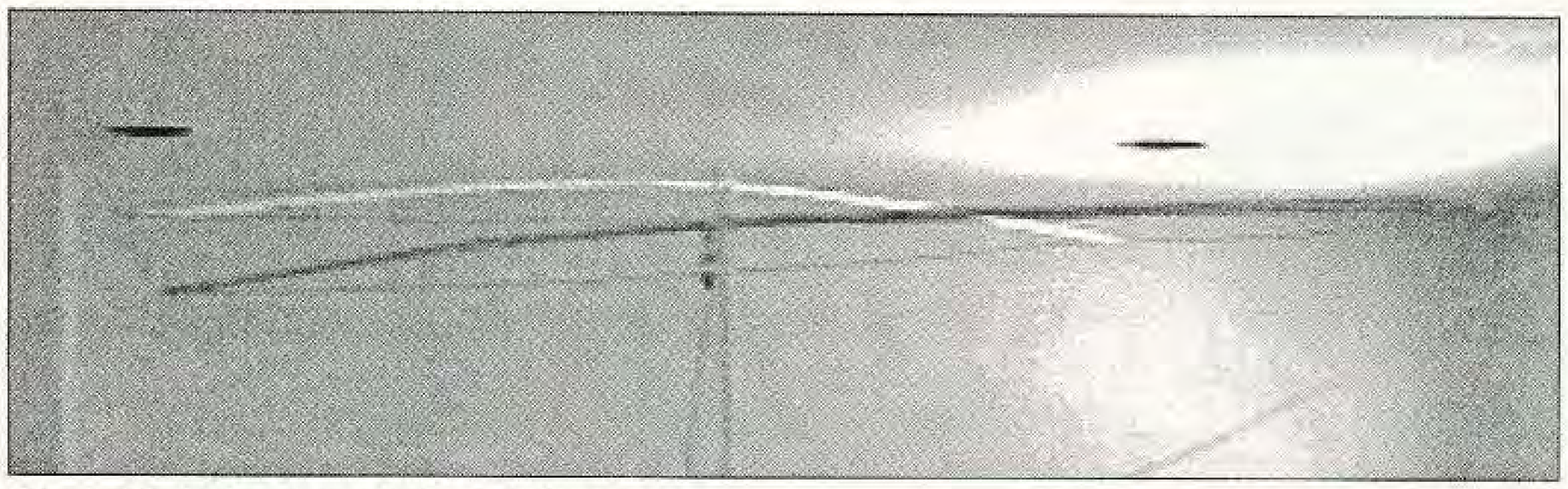

Photo B. Side view of the 5.7-foot loop.

square wire loop configured in a horizontal manner. **Fig. 1** shows the basic layout of the antenna as it is viewed from the top. The loop is formed in two halves, with two of the corners fed through an open hole in a ceramic (or plastic) insulator. The other two corners are fastened at either ends of the same type of insulator, and connected at these points to the feedline, which forms the hypotenuse of the two right triangles that make up the loop.

This type of antenna is extremely lightweight, and may be used quite effectively in the attic of a wood-framed home. **Fig. 1** shows each of the four insulators being tied off to a suitable mechanical fastener such as a ceiling joist. The addition of a rope orthogonal (at a right angle) to the feedline is necessary to keep the loop square when hung properly at all four points.

A fifth insulator is used as the point where the antenna is joined to feedline going to the receiver. Note in the drawing that for the antenna to operate properly, the two ends are fed 180 degrees out of phase by twisting the feeder at one end. The attic antenna works very well when 450-ohm ladder line is used as the feeder.

In order to determine an optimum size for the broad range of frequencies employed by shortwave broadcasters, I built two versions of this antenna, which you can see in **Photos A** and **B**. The first was optimized for higher frequencies of around 12 to 26 MHz, and the second was a compromise that covers the entire range from 3 to 26 MHz. In this case, I used 4-foot- and 5-foot-long solid spreaders instead of just rope. This yielded loops that were approximately 5.7 feet and 7 feet square, respectively. It was my desire to make it possible for this antenna to be hung below a patio, or fastened to a mast outdoors, or even (against the esthetic objections of my wife) to be set it up in the loft of our house. I can't imagine why she would object. I think it is a true work of art.

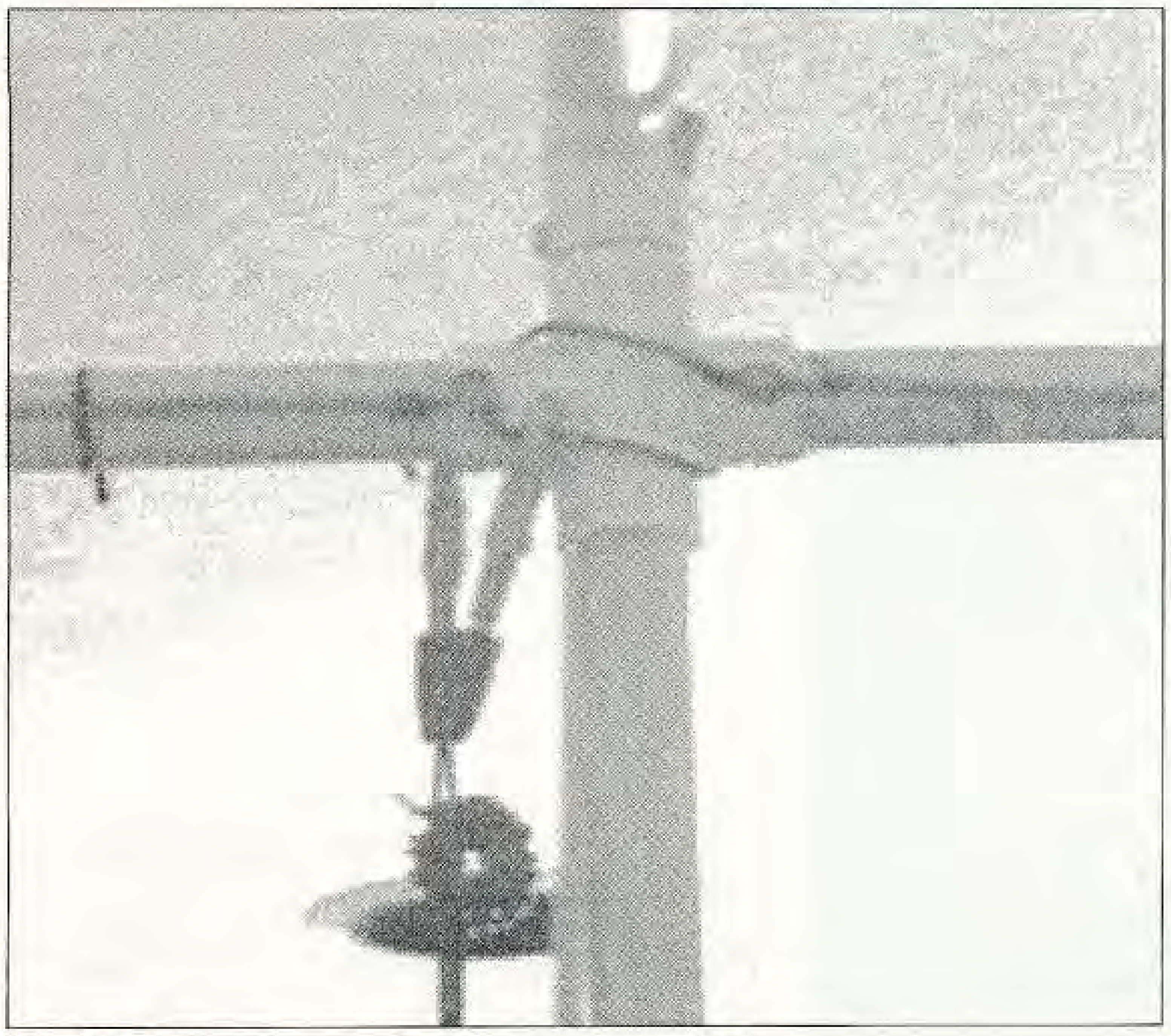

Photo C. Simple wire feed system tie points.

The material I used is half-inch PVC irrigation pipe. It is one of the most inexpensive materials available. You might also want to use wooden dowel rod, bamboo, fiberglass tubing, or some other nonconductive material for your loop. PVC also has an additional advantage, as there are some ready-made fittings that can be purchased off-the-shelf that are handy for joining the spreaders together, and at right angles as well. Take a close look at the photos in **Photos C** and **D**. I used two four-way junctions with a 3-inch piece of 1/2-inch PVC (now invisible) to join them together. I then threaded a small self-tapping screw into each joint to keep them from slipping apart, or twisting away from their 90-degree orientation.

Since some of you might not have ready access to 450-ohm ladderline or

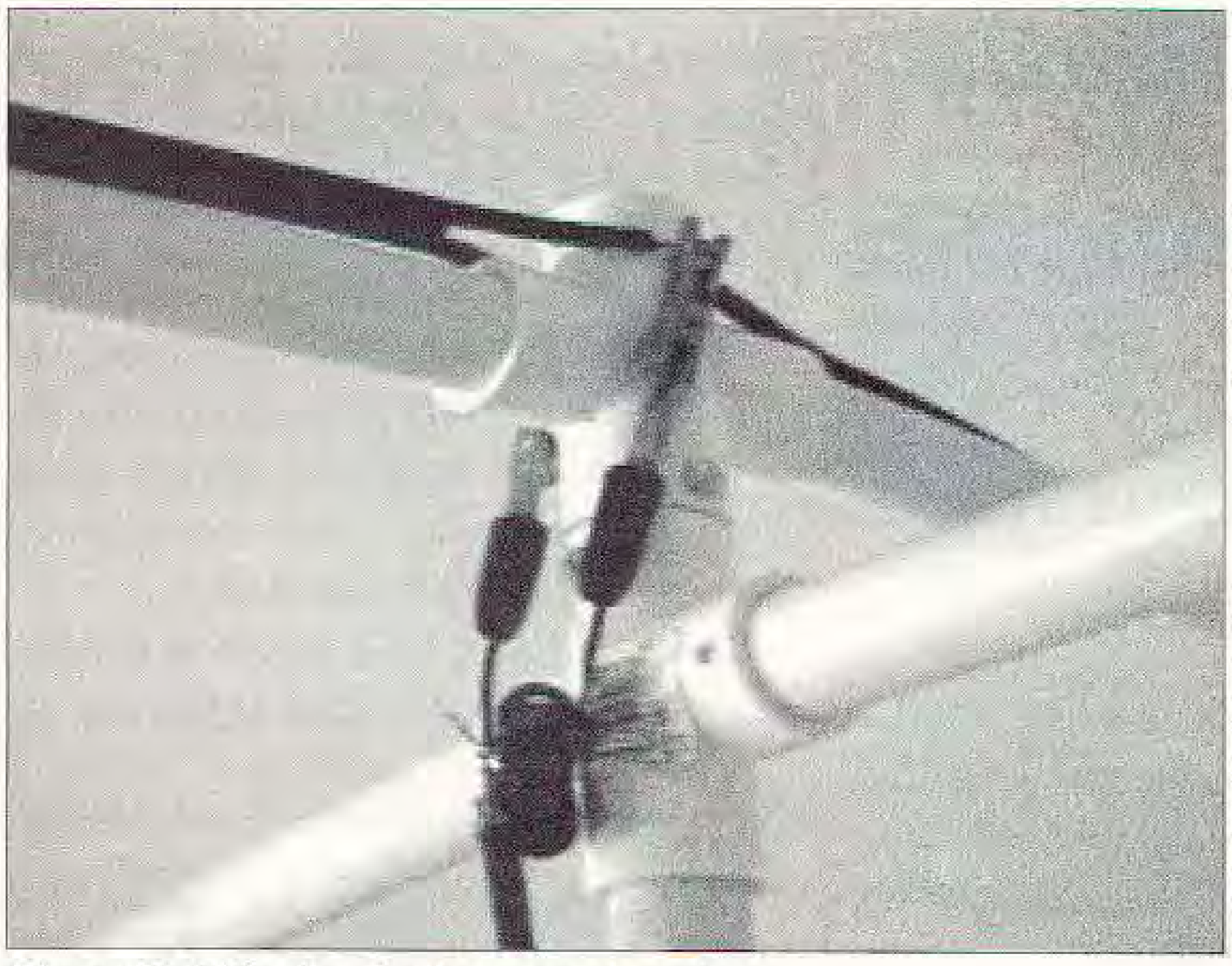

Photo D. 300-ohm feed system tie points.

Photo E. Simple feed system.

300-ohm twinlead, I constructed the feeder of the smaller loop out of wire — hence its name: "simple wire" feeder. **Photos C** through **F** show the difference in appearance and construction of the two feeder systems. I used 300-ohm twinlead on the larger loop to see if there was any significant degradation in performance with the simple wire feeder. To my joy, there was not. As for the wire, just about anything will do, just so long as you can solder to it.

I mentioned on one of the *Tech Talk* segments that I built this antenna in less than an hour, so I expect you will have a similar experience, especially considering that I am all thumbs. Your construction time will vary, so here goes.

After joining the two spreader joints together, insert the four spreader elements into the joints. Make sure that the spreaders are mounted at right angles to one another. (A word to the wise: Check this *first,* before sinking the screws.) With the spreaders in place, the hypotenuses of the two loop-halves for each antenna are 8 and 10 feet, respectively.

You may now prepare for the addition of the wire by drilling a small hole just large enough for the wire in the non-fed spreader ends as shown in **Photo G**. Be careful to cut enough wire to allow for each of the two triangles as well as the simple wire feeder, plus a little extra for good measure. (It is much easier to cut off the excess than it is to add more to a short end!) In the case of the smaller loop, this works out to a little less than 20 feet of wire (5.7 + 5.7 + 4 + 4 = 19.4, plus some extra). You may then feed the wire through the hole at the end of the spreader, and keep passing it through until you arrive at the midpoint of the wire.

Next, drill small holes in the "fed end" of the two remaining spreaders, and use tie-wraps to secure the wire to the end on the horizontal sides of the tubing, as shown in **Photo H**. You may then use additional tie-wraps to secure the wire to opposite sides of the spreaders, thus forming a crude "open-wire" feeder for the antenna. You may also use fisherman's twine, string, or other materials to secure the wire to the spreader. However, I don't recommend using a conductive material such as wire, for obvious reasons.

Because I had elected to use the loop wire to also form the simple wire feeder, it is not possible to put a "twist" in one end to accomplish the 180-degree phase shift needed at each end of the feeder. Instead, I did the twist right at the feedpoint of the antenna. After sinking self-tapping screws into the spreader joint, copper wire is used to form the twist as shown in **Photos I** and **J**, with a sort of "under/over" attachment of the wire at opposites sides of the joint. The next step is

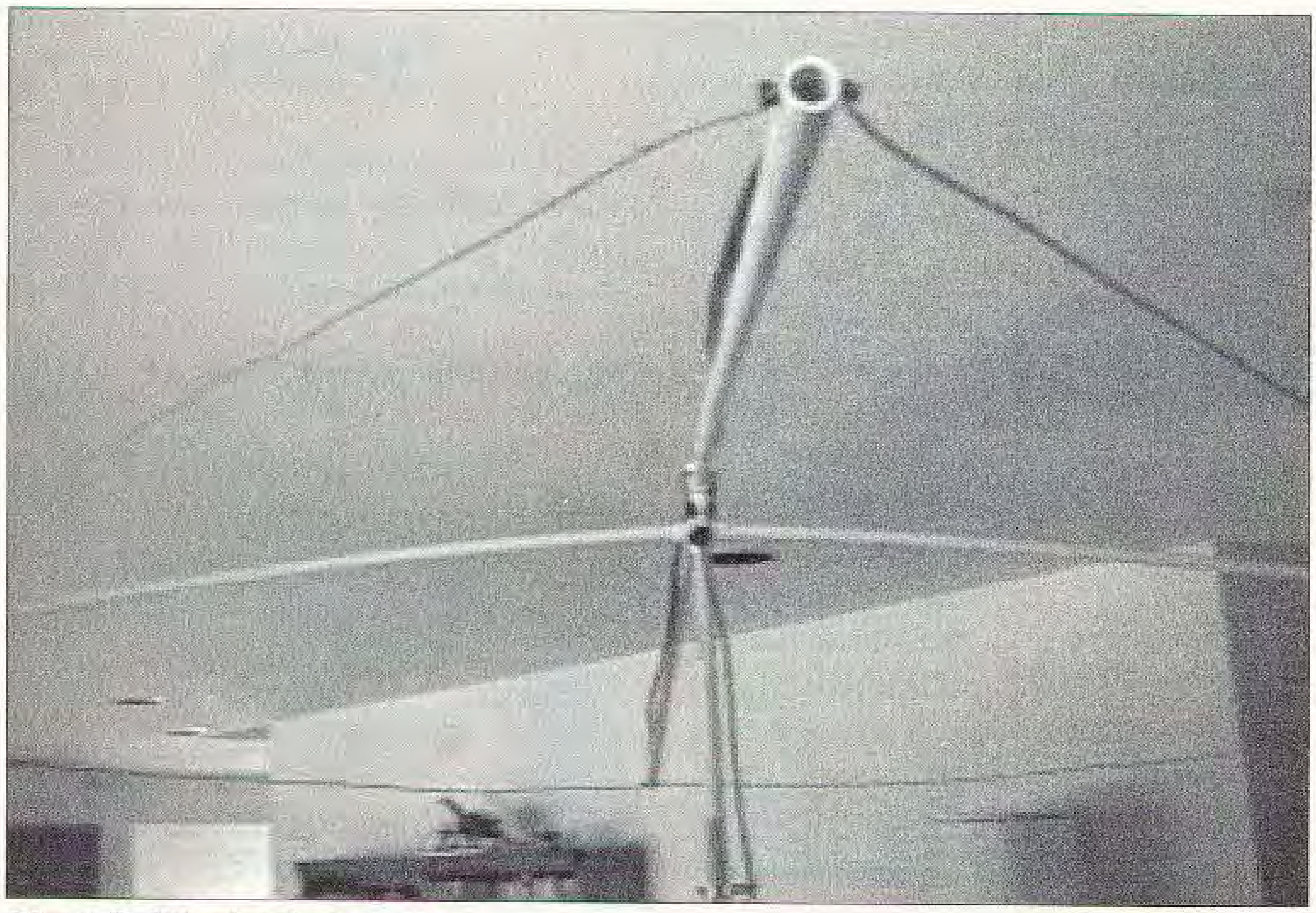

Photo F. 300-ohm feed system.

to cut and solder the loop wire to the pigtails that extend off the screws at opposite ends of the feedpoint you have just fashioned.

As for the larger loop, the decision to construct the feeder out of 300-ohm twinlead caused me to build the antenna slightly differently (you can use either method on either antenna). I used the same through-hole technique on the un-fed spreaders, but on the fed end of the other two spreaders, I sank self-tapping screws in the ends, as shown in **Photo K**. This allows you to use a lot less wire.

Fasten the wire to the screws along with the distant ends of the 300-ohm feeder, and solder them together. **Photos C** through **F** show you how to lay the twinlead along the upper spreader, and fasten it to self-tapping screws that are sunk into the midpoint at opposite sides of the upper center joint. Remember to take care that one feeder has the requisite "twist" in it to form the 180-degree phase shift. Here's a hint for you: If you want to use an ohmmeter to check to see if the phasing is correct, touch the leads of the meter to the opposite poles of the feedpoint. If you measure a short circuit, you did it right! If you measure an open circuit, it's back to work to get it right. I'll let you have some fun figuring that one out yourself.

Feeding the antenna

Hey, the antenna is built already. That was fast! Now comes the important part: hooking the antenna to the receiver. I measured the impedance of the antennas at the various shortwave bands and discovered that they were at or above 150 ohms in most cases. I had intended to use either 75- or 50-ohm coax to feed the antenna so as to maintain good noise isolation going into the shack. In order to get the antenna impedance a bit closer to 50 ohms on my favorite bands, I decided to put a 4:1 balun transformer at the feedpoint of the antenna. I did this to minimize mismatch losses in the coax that would degrade the performance of the antenna.

Fig. 2 and **Table 1** show how the feedpoint impedance of the antenna varies from 3 to 26 MHz. These measurements were taken with a 4:1 balun (terminated with a 50-ohm load on its primary side) across the feedpoint of the loop. I chose to use a 4:1 balun as I had intended to use 50-ohm coax to feed the antenna, and wanted to keep the end points of the impedance excursions down to a manageable level.

I had originally built the balun when I constructed the smaller loop. Its impedances are a little higher. The impedance of the smaller loop does not drop off at the higher frequencies as much as the larger loop. As it turns out, the larger loop resonates at around 33 MHz, while the smaller loop resonates at around 45 MHz. However, the larger loop has some directional characteristics at the higher frequencies that can come in handy, depending upon your setup. Its larger aperture has a beneficial effect at the lower frequencies as well. I also got a nice peak right

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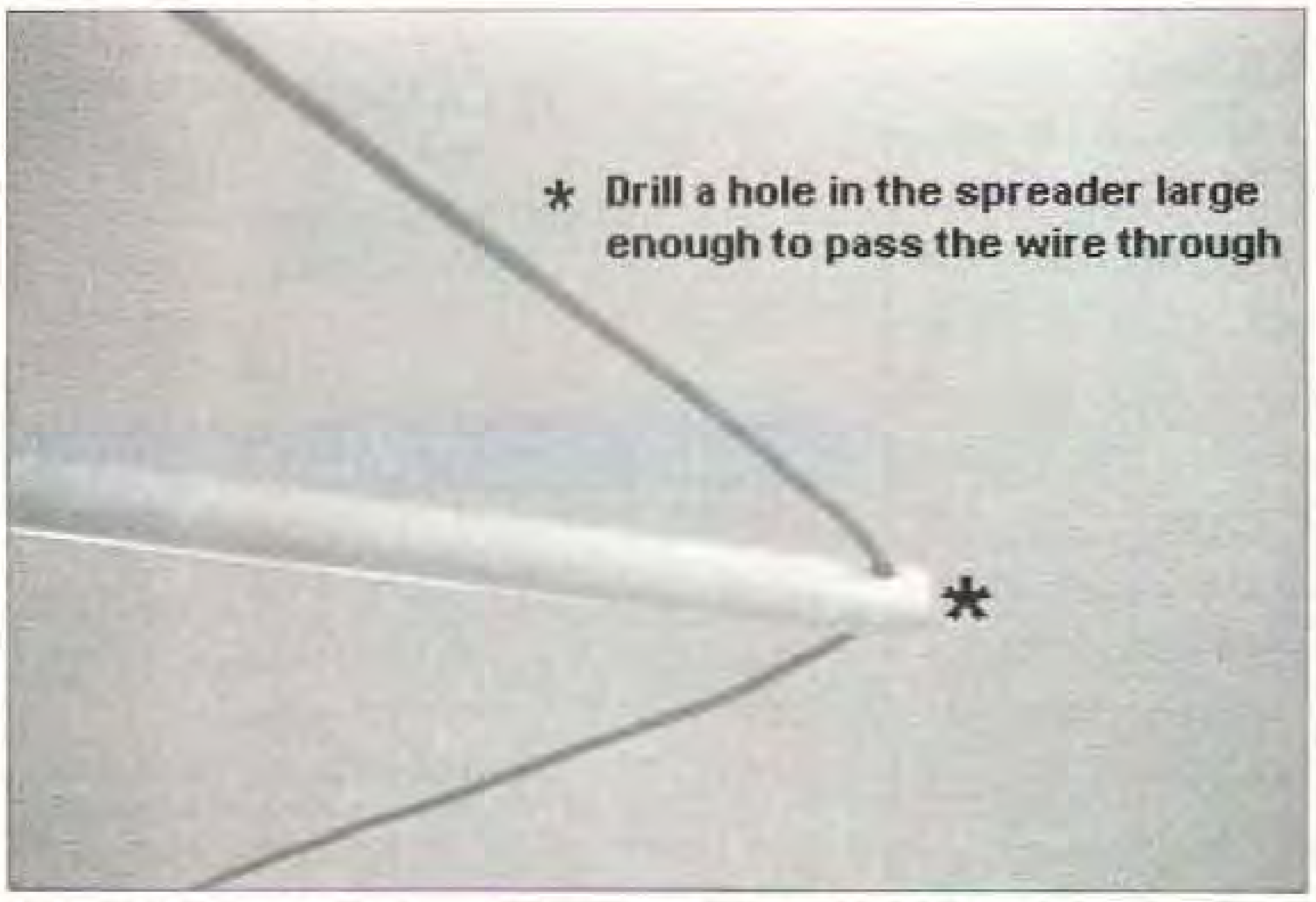

Photo G. *Construction of the non-fed corner of the loop.*

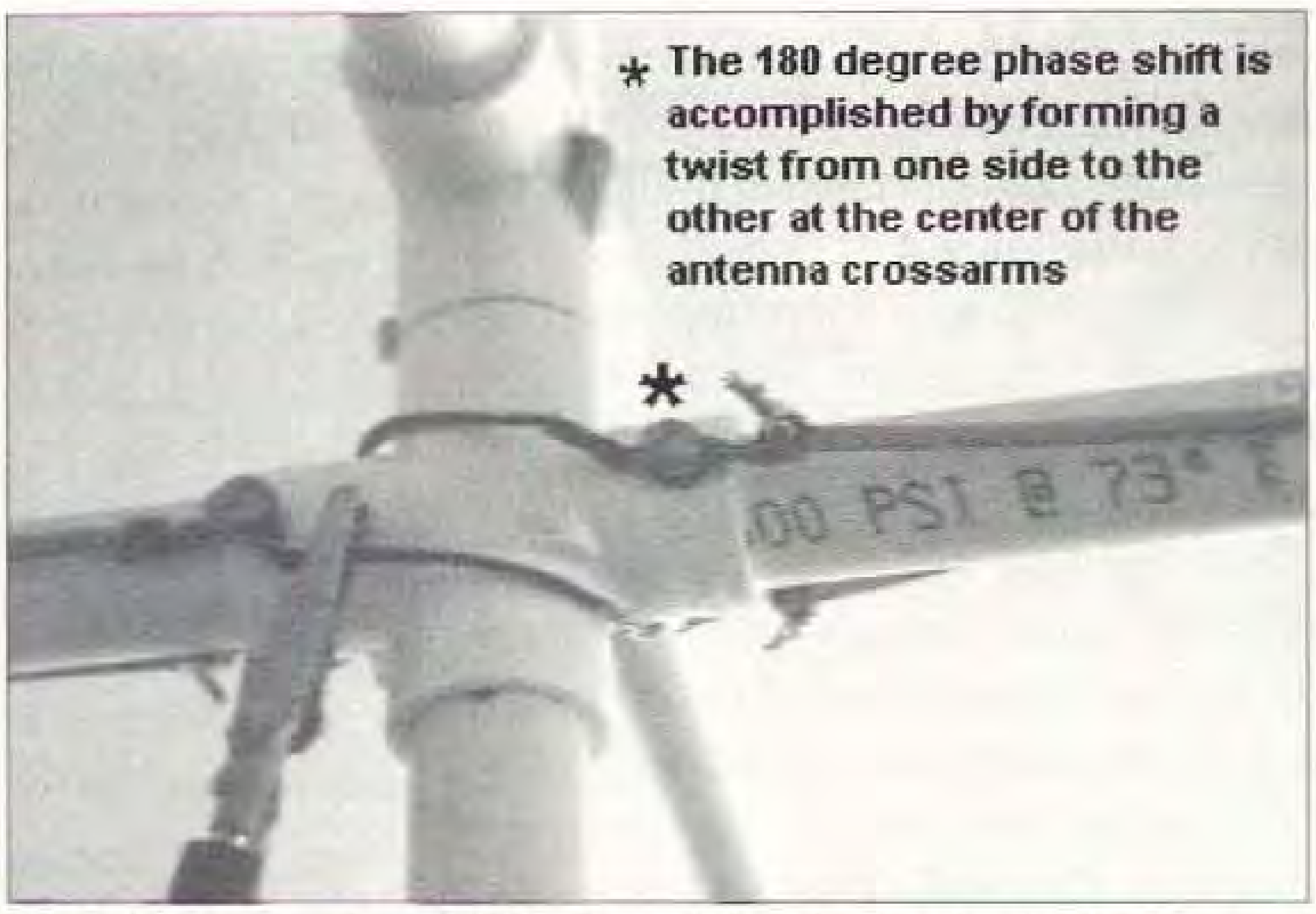

Photo I. *Construction of 180° phase shift in the simple wire feed system.*

around 9745 and 12015 kHz, which transforms down to about 60 and 50 ohms, respectively. This is an acceptable untuned mismatch on my two favorite DX frequencies!

Here's how to make a simple 4:1 balun that will help to minimize impedance mismatches from 3 to 26 MHz. There are various ways of constructing a 4:1 balun, but I chose to build one similar to what is described on page 25-16 of the 1991 edition of the *ARRL Antenna Book.* **Fig. 3** shows the drawings from that page. The construction of the balun is very simple. Start with an Amidon T-68 series powdered iron core with an inside diameter of 0.6 inches. Next, take some 24-gauge plastic-coated wire and wind 10 turns on the core as shown in **Photo L**, then solder the ends as shown, leaving a pigtail at each end that could be connected to the feedpoint on the loop as well as the coax (see **Photo M**).

Since I was doing a lot of experimenting, I decided to put some clip leads on the ends of the high impedance side of the balun so that I could quickly connect and disconnect from the antenna in order to make measurements, and the like. I strongly recommend that you solder the pigtails directly to the feedpoint on the loop when you have finished your own experimenting.

Tuning the antenna

In Brian Beezley's article, and in a subsequent work by Ed Andress W6KUT[3], it is suggested that to achieve peak performance, the loop be tuned in such a way that it becomes resonant on the band (and in the case of very high Q, the exact frequency) on which it will be used. This is entirely true. However, in the vast majority of SWL applications, and especially in the case where cost and complexity are to be avoided, this is not practical. This would require a matching network for each of the shortwave bands all the way from 3 to 26 MHz. To those who are not constrained by cost and complexity I highly recommend this approach. Ed and Brian's articles provide excellent insight into how this can be accomplished.

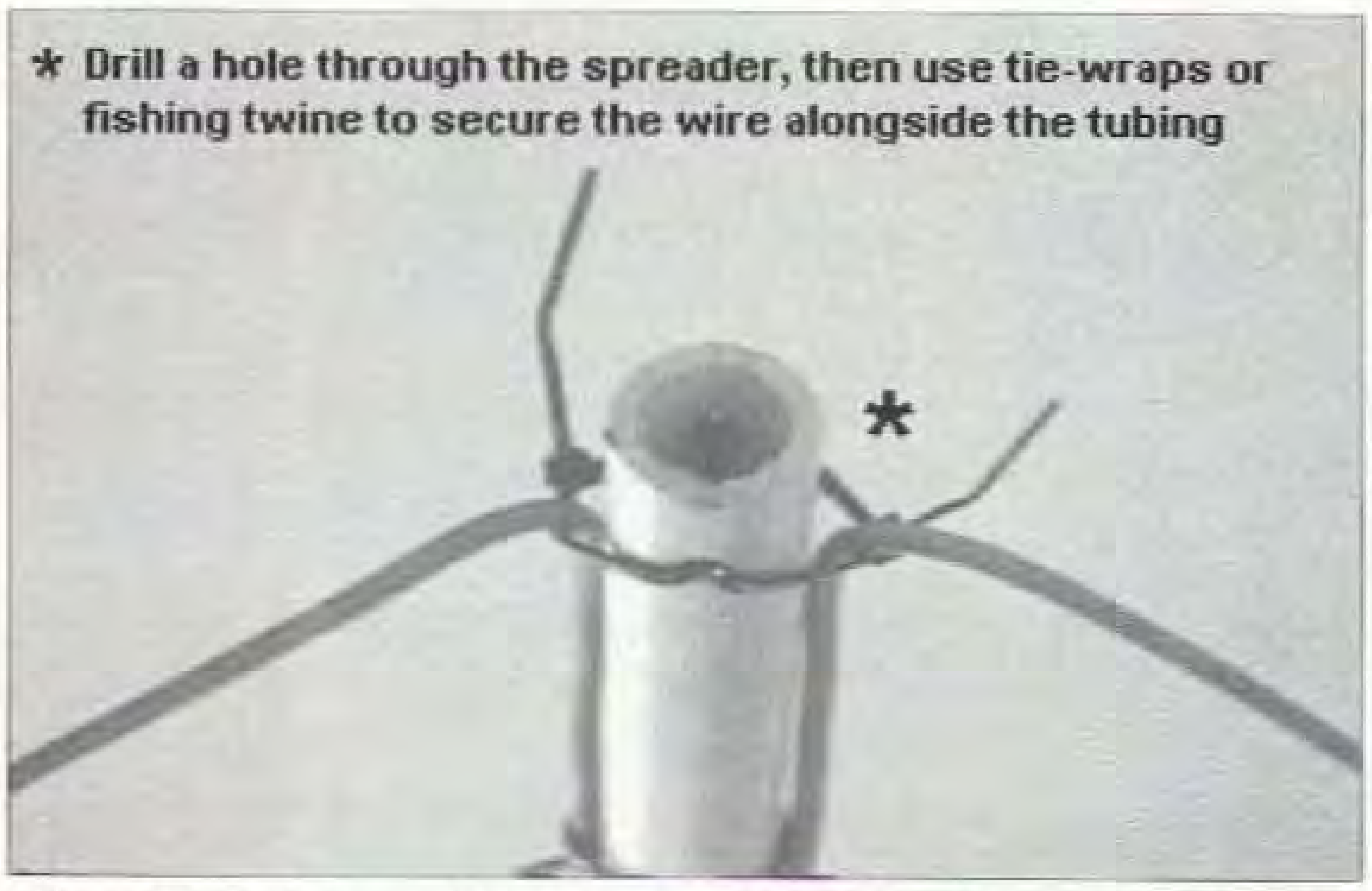

Photo H. *End view of the transition from loop to simple wire feed system.*

Fortunately, acceptable performance may be obtained by tuning the antenna remotely. This can be accomplished in either of two ways. The first way is with a simple antenna tuner. I tested this method with a couple of small tuners I had lying around. In technical terms, this method provides a conjugate match for the antenna and receiver by tuning (matching) the impedance discontinuity present at the receiver's end of the coax coming from the loop. In simple terms, it makes the antenna and receiver happy because they both see a 1:1 match of their characteristic impedance when looking into the coax.

However, this approach has a couple of disadvantages (but not terribly bad ones in a receive-only system). First, the antenna is nonresonant, so its efficiency is not optimum compared to the resonant case. Also, one of the fundamental characteristics of transmission lines is that they not only function as a waveguide for received signals, but also are complex impedance transformers. Consequently, in a remotely tuned system, the untuned impedances can vary greatly from the antenna to the receiver. Thus a higher loss component can be expected. Ah, but we can fix that with a preamp. More on that later as well.

The other approach, one suggested by the MFJ Corporation[4], is to series-resonate the whole circuit at the receiver's end with a simple LC network. The MFJ-956 does a reasonable

Photo J. Bottom view of phase shift construction.

job at this. It is a simple circuit that has a 350 pF variable capacitor in series with several switched inductor values to select the band and tuning range that you desire. And it's inexpensive, too, costing less than $50 U.S., if my memory serves me correctly ($49.95, to be exact — ed.).

If you don't have one available to you, and can build one yourself, all you need to do is put a 350 pF variable capacitor in series with a toroidal inductor (the same size and material used on the balun) that has 30 or 40 turns of #30 enameled magnet wire on it. You can experimentally choose several "taps" on the inductor, and select them with a wafer switch to tune the desired band along with the variable capacitor (see **Fig. 4**).

This method also works quite well, but is rather sensitive to the impedance of the device it is feeding. It likes to

QRG	Antenna Z	
MHz	Magnitude	Angle
3.0	72.0	71.0
6.0	148.0	48.0
7.4	180.0	38.0
9.7	257.0	46.0
12.0	188.0	25.0
13.6	172.00	32.0
15.0	150.0	37.0
17.7	122.0	43.0
21.5	92.0	54.0
26.4	52.0	65.0

Table 1. Plotted points ***on Fig. 2.***

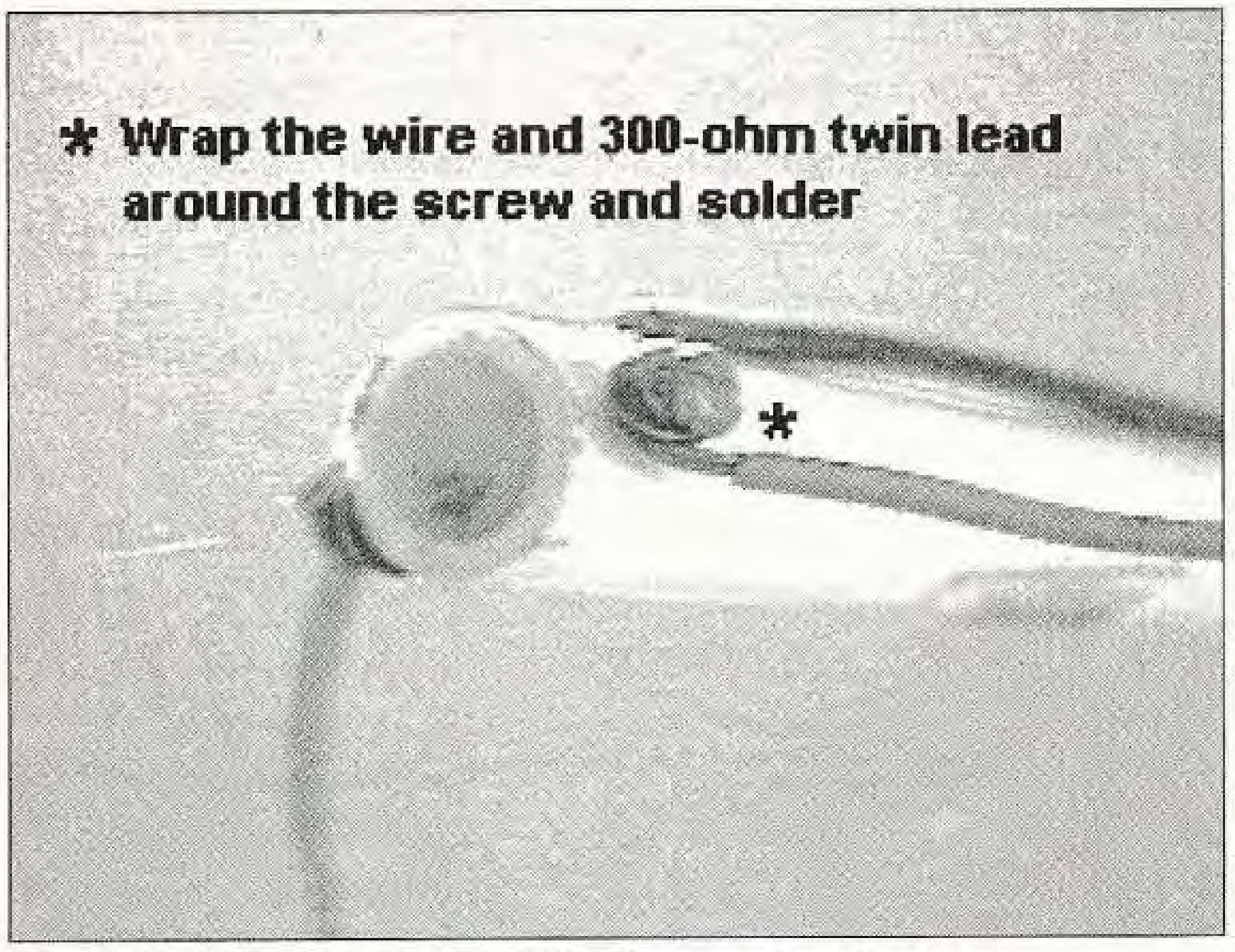

Photo K. Formation of the 300-ohm twinlead feeder.

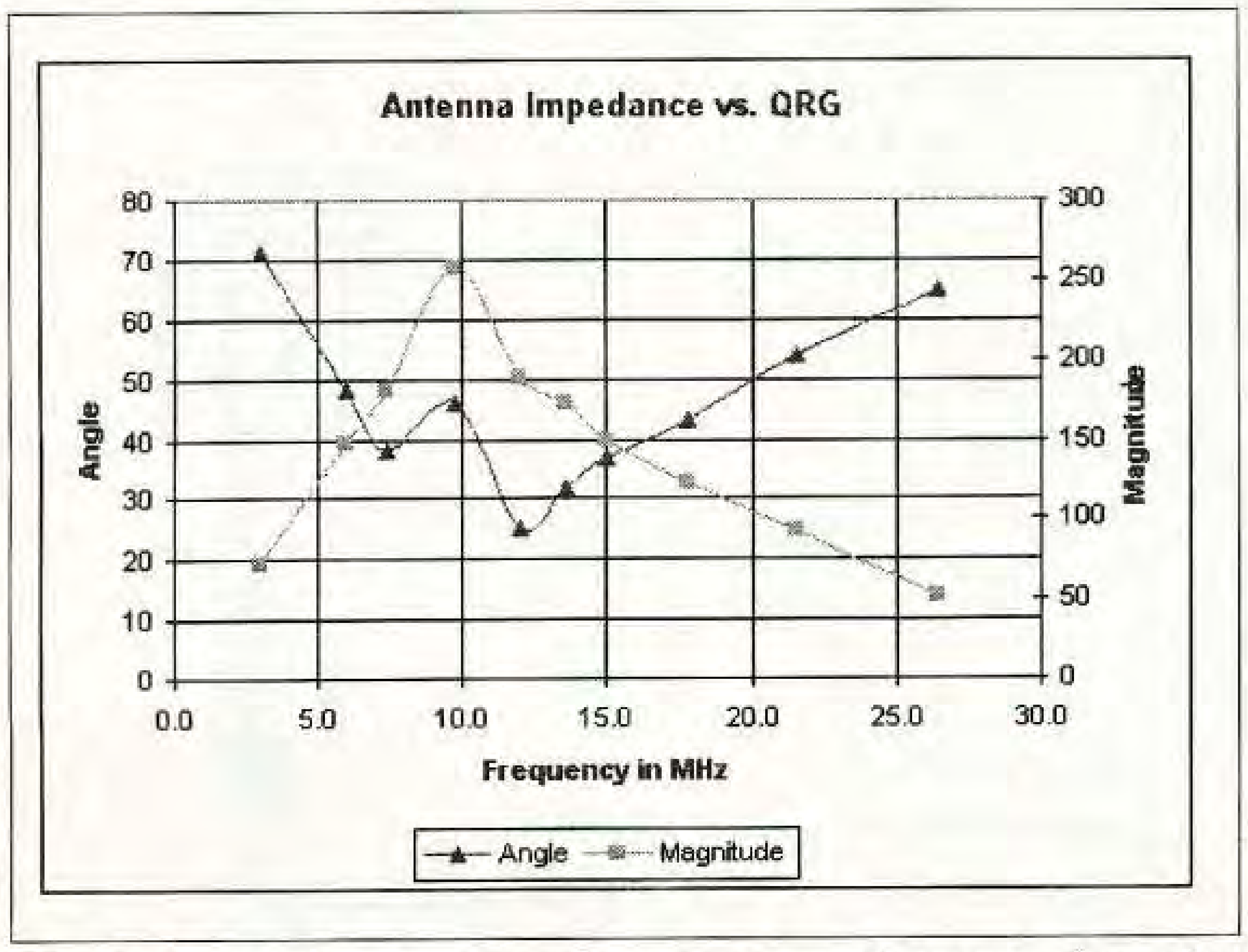

Fig. 2. Larger loop antenna impedance vs. frequency (see also Table 1).

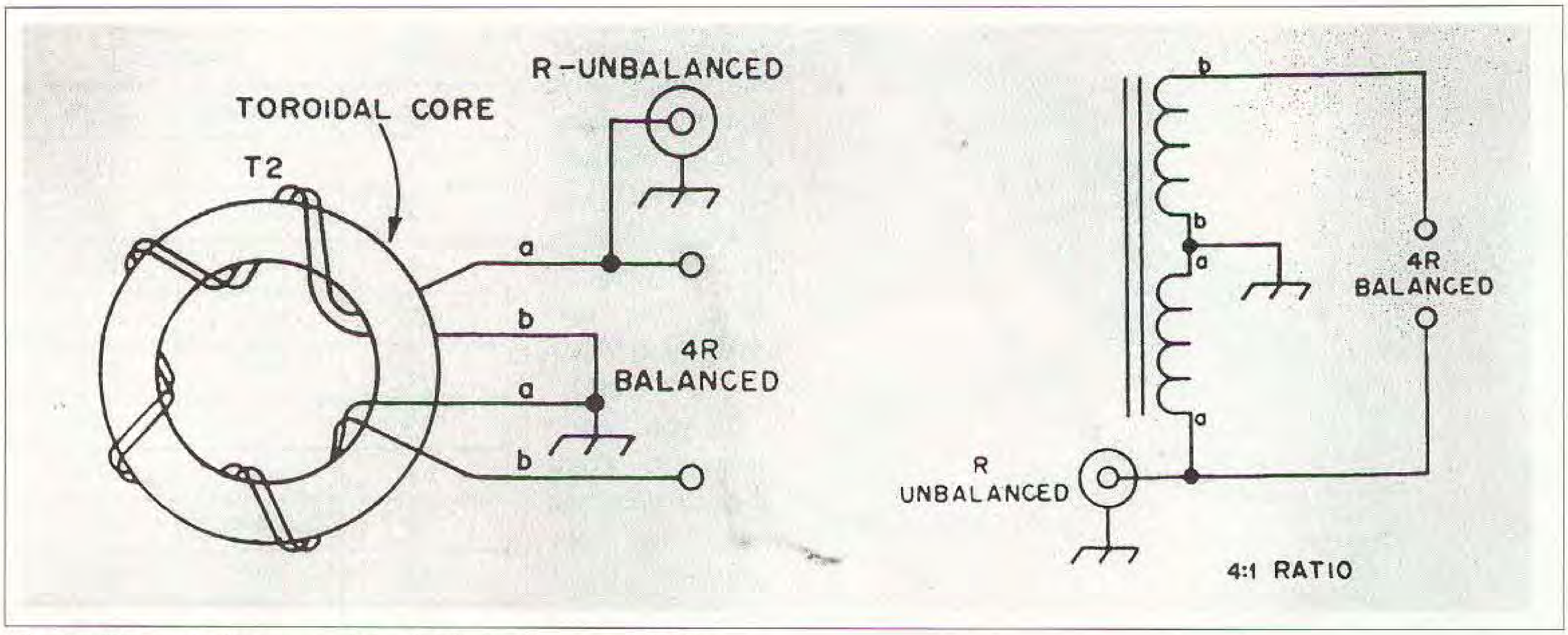

Fig. 3. Schematic diagrams of the 4:1 balun (courtesy ARRL).

see a high impedance of 50 ohms or greater, and that's where a small preamplifier comes in handy. This method also has the benefit of functioning as a rudimentary filter for reducing or eliminating interference and desensitization that comes from nearby AM and FM broadcast stations. If you find that you cannot find a "peak" on one of the desired SW bands, try using a slightly longer or shorter coax jumper to, or from, the filter. Recall that in **Fig. 2**, the impedance of the larger loop is rather low at the upper and lower frequencies. The 4:1 balun makes those impedances even lower. A tuner will usually fix that problem, but if you only have a series-resonant circuit like this one, an additional coax jumper can often transform that impedance to a much more manageable point on the Smith Chart.

Photo L. *Winding and construction of the 4:1 balun.*

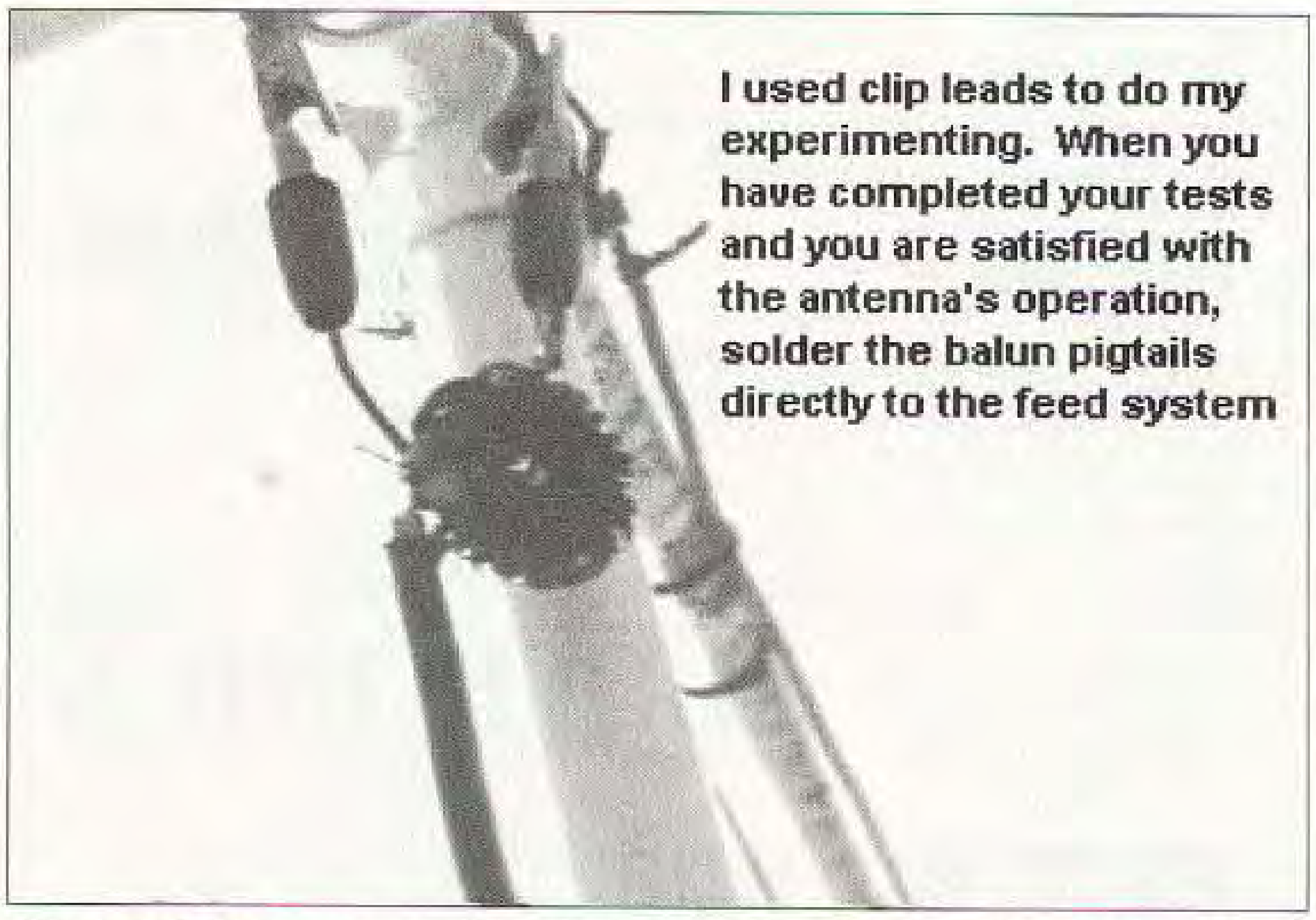

Photo M. *Placement of the balun on the simple wire feed system.*

The preamplifier

The advantage of using coaxial transmission line in this system is that it provides a reasonably good shield against noise that might be induced into the feed system. The disadvantage is that losses can be much greater in a nonresonant system like this one. Ladderline has much less loss, but you have to be much more careful to avoid induced interference.

Fortunately, a great deal of those losses can be compensated for with an effective preamplifier. There are many good designs that provide between 15 and 35 dB of gain. The amount of gain

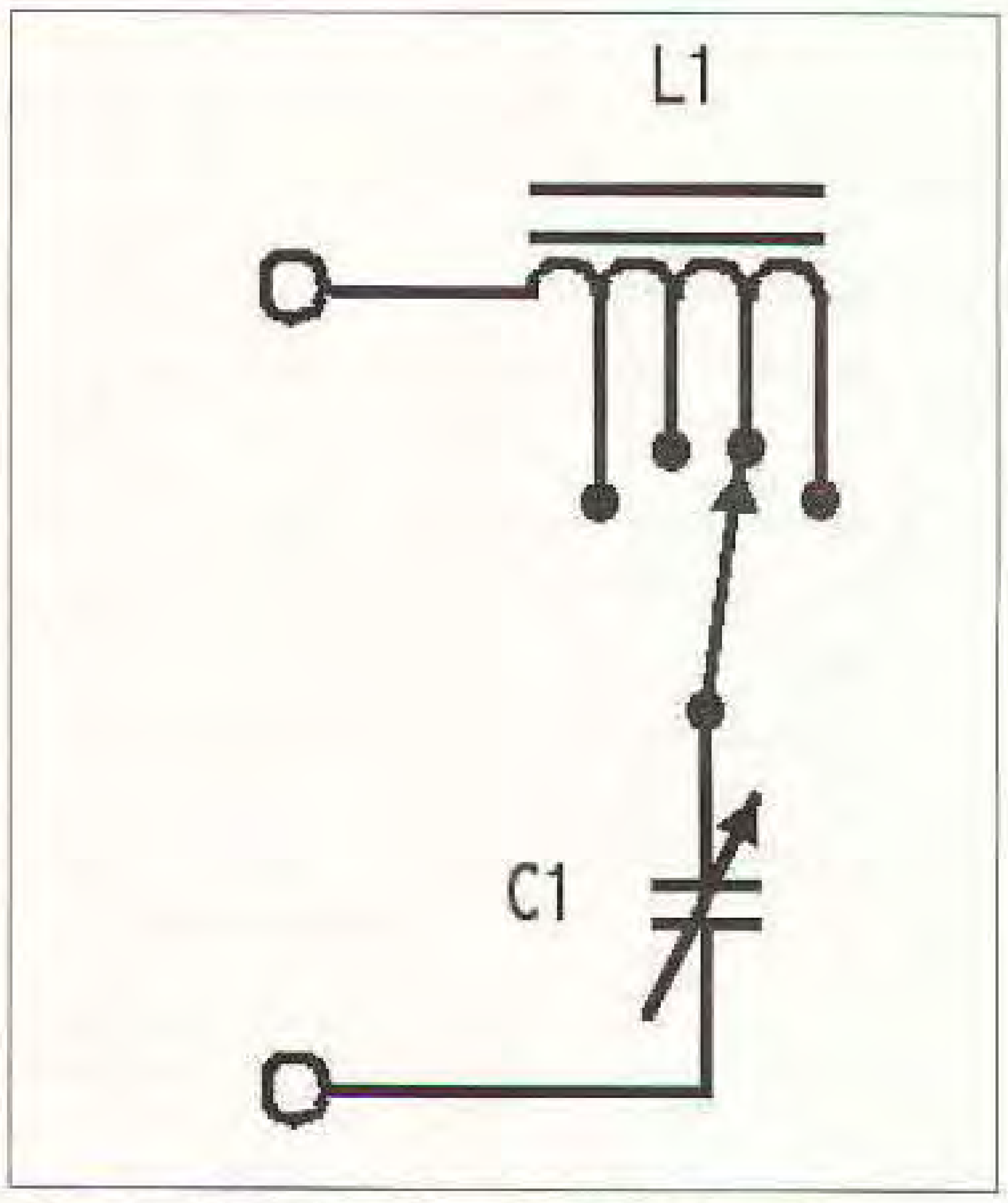

Fig. 4. *Multiband series LC circuit.*

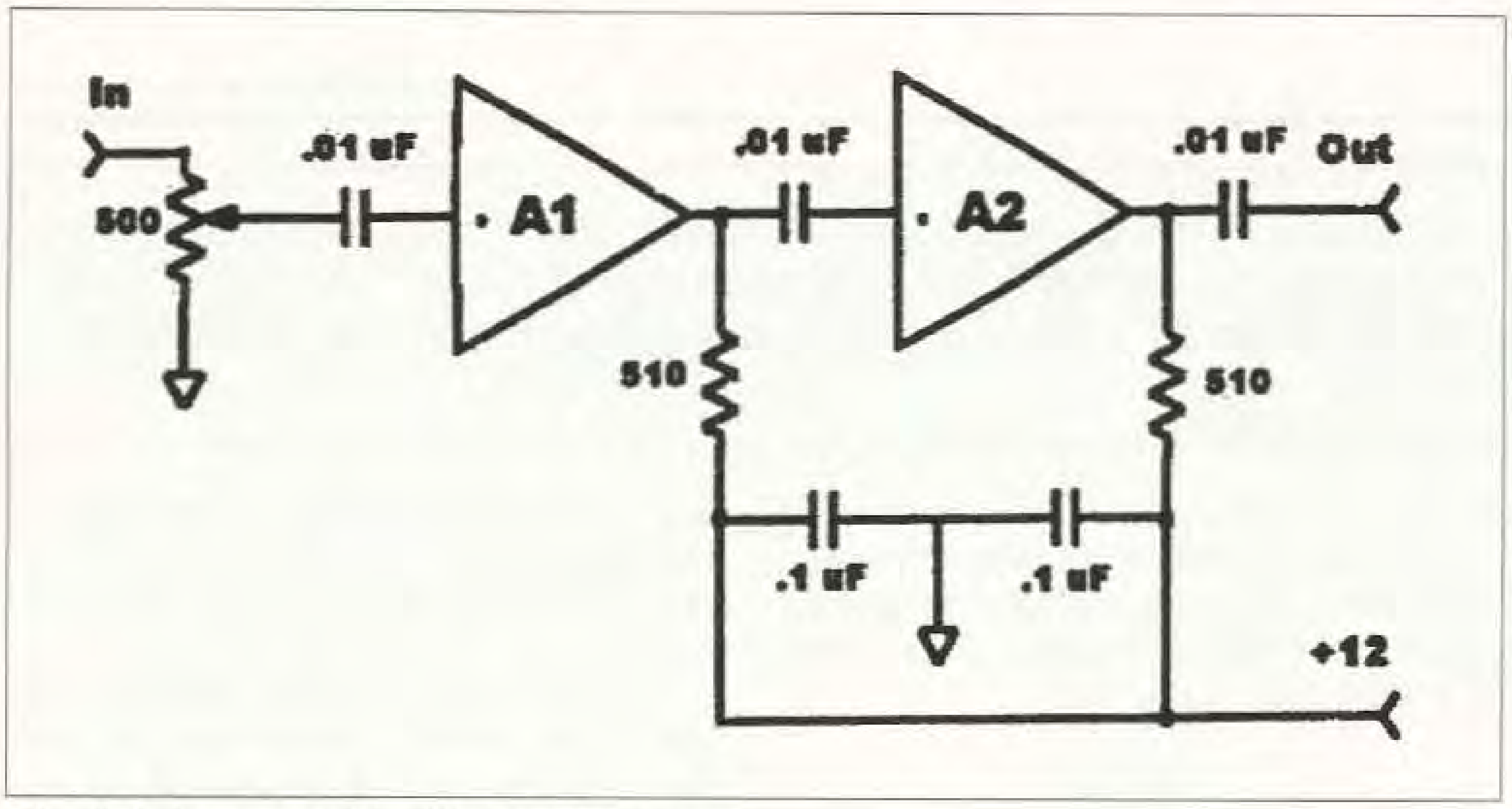

Fig. 5. Schematic of the 30 dB gain preamp.

required depends greatly on the configuration of your listening station. I had wonderful results with a little broadband U-310 amplifier (that's a field effect transistor, or FET) that I built. It gave me about 15 dB gain, which was all I needed as my receiver has a hot front end.

My friend, Dr. John Petrich W7HQJ, came up with an outstanding little preamplifier that is not only easy to build, but also provides upwards of 35 dB of gain — and that can come in handy with receivers that have a stingy front end. When I used it in conjunction with the series LC tuner and the loop indoors, I was logging stations from every corner of the globe. It didn't perform as well as my 86-foot-long centerfed wire at 110 feet, but I didn't expect it to, either.

The basic building block of this amplifier is the MAR6 MMIC made by Mini Circuit Labs[5]. It is designed to operate within a 50-ohm system, which makes building this preamp a breeze. It should be noted that if only modest gain of 15 dB is desired, only one amplifier is used. This will eliminate the need for one each of the 0.1, 0.01 capacitors, and the 510-ohm resistor.

Because the MMICs are 50 ohms in and out, there's no need for fancy impedance transformation networks and the like on the circuit board. You can simply cut squares on the foil side of a PC board, and solder the handful of components in place. I'll leave that piece up to your imagination.

This leads me to some final comments I'd like to make. As I said before, the job of reducing noise while covering such a broad range of frequencies, while providing a very simple, inexpensive solution, is a pretty tall order. The hours and hours I spent with this antenna have convinced me that it goes a long way to satisfy those goals. But I also hope that you will just have some fun building it and playing with it. It is my sincere desire that you, and others, will come up with numerous ways of improving on its design and construction. I hope, too, that there will be some perfectionists out there who will come up with a version of this antenna that is truly elegant.

Just use your imagination, and have some fun. It's cheap! Oh, and if you think of anything that I overlooked and should be included in future extrapolations of this little antenna, please let me know, will you?

Notes

1. Overbeck, W. "The VHF Quagi." *QST.* April 1977, pp. 11–14.

2. Beezley, B. "A Receiving Antenna That Rejects Local Noise." *QST.* September 1995, pp. 33–36.

3. Andress, E. "A K6STI Low-Noise Receiving Antenna for 80 and 160 Meters." *QST.* Sep. 1995, pp. 37–41.

4. P.O. Box 494, Mississippi State MS 39762, USA; [http://www.mfjenter- prises. com].

5. P.O. Box 7128, Branson MO 65615, USA; (800) 654-7949.