What goes around comes around, which in this instance means a good, reliable circular antenna that will help you work DX.

The Full-Wave Loop Sky-Wire Antenna

BY LEW OZIMEK*, N2OZ

During a recent CQ WW DX SSB Contest I hit the optimum in frustration because of my inability to make contacts. I maintain a very modest station and don't expect to overwhelm the air waves, but that performance was the pits! I knew that the bottom of the sunspot cycle had reared its ugly head and that the sunspot monster was voraciously devouring radio signals whenever tantalizing contacts were available, but other stations were making contacts, not me. The final blow came when I heard Malta (9HØDX), a country that has eluded me to date, and I could not make contact. The station's ability to knock off contact after contact in the USA very, very quickly left me completely and utterly frustrated. It was painfully obvious that I must make improvements, especially in my antenna system.

First let me describe my setup. I used a two-wire antenna strung up in the trees fed by open-wire feed lines. The antenna was intended to be a V-Beam, but in fact, it probably was closer to a "Real McCoy Dipole" as described by Lew McCoy, W1ICP, in many of his articles. Each leg was 136 feet long, with one leg reasonably straight and the other bent in several places to fit available trees and space. The second element resembled half of the letter M rather than a dipole or "V" leg. I have no idea what the radiation pattern might have been and doubt whether there are any computer programs available which could generate a model of that antenna. In all fairness, however, I must admit that the antenna, and others similar in design, have given me excellent performance in the past. It was the "now" that had me down.

After my failure to get Malta, I turned off my rig and went out into the woods behind my home and tore down the antenna. Strangely, I found that my "folded" leg was not attached to the high tree I originally had used. It was tied to a small tree five feet off the ground and its effective length was cut in half because it was folded back upon itself. That was enough to destroy whatever limited capability I originally had. (I have not solved the mystery of the change in antenna mounting, but I do have my suspicions.) This experience emphasized the importance of checking your station setup and the performance of each piece of gear, whenever you suspect degradation.

Following my antenna annihilation, if I can call it that, I was left with two pieces of wire, insulators, and feed lines, but not with a usable antenna. Quick action was needed. I turned to the treasure trove of antenna books I have collected over the years (and stored away almost forgotten): *The Antenna Handbook*, published by the ARRL, and two books published by CQ Communications—*Lew McCoy on Antennas*, and *The W6SAI's HF Antenna Handbook*. These constitute a veritable cornucopia of antenna theory, designs, ideas, and concepts with plenty of practical suggestions and guidance. This combination of references offered me many antenna possibilities. I felt like a little boy again with my nose pressed against a candy store show-case studying each piece of candy. Which one of those tantalizing gems should I taste?

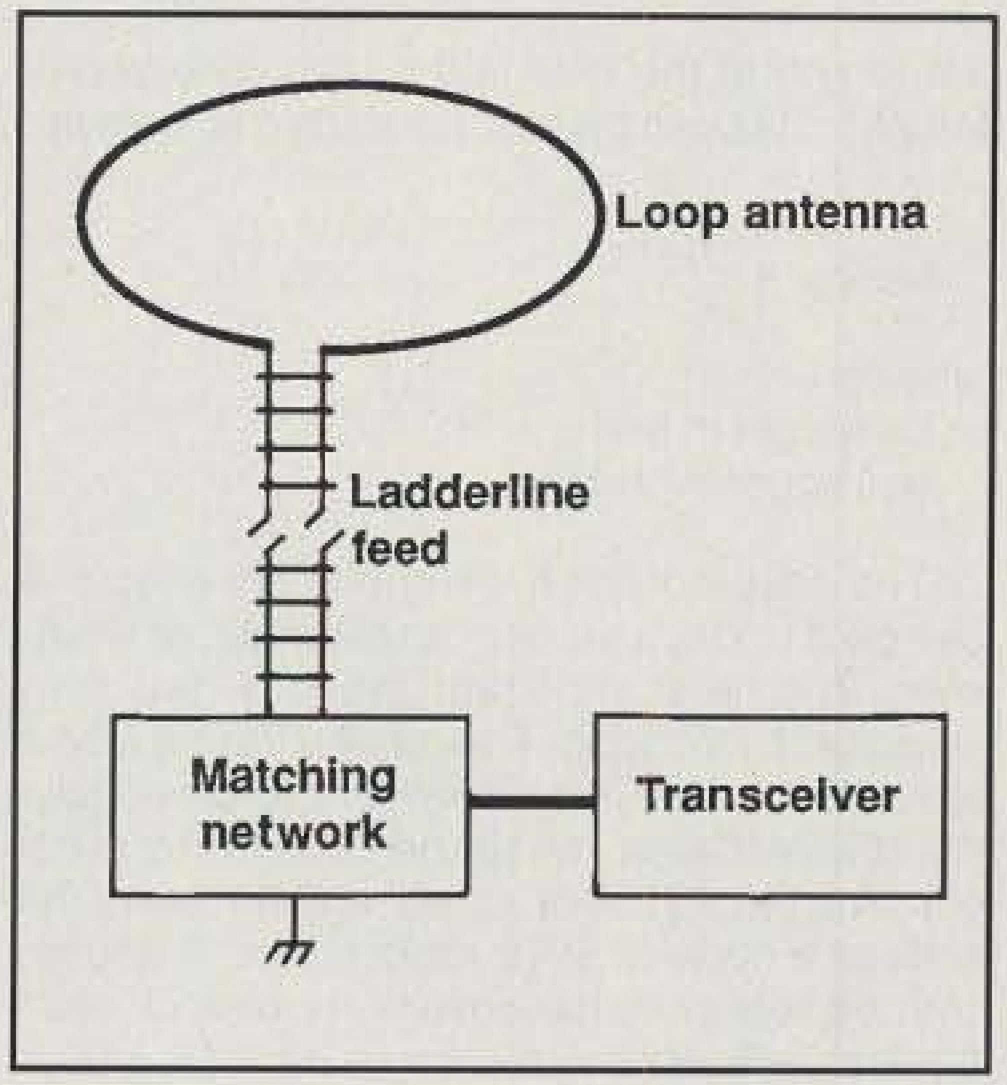

Fig. 1– A Full-wave loop antenna operating as a vertical with top-hat loading.

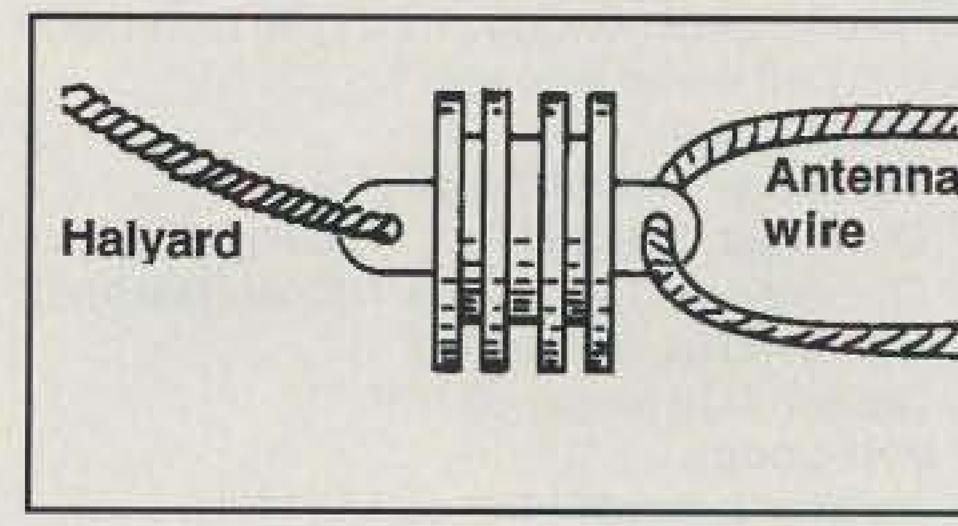

Fig. 2– Free-floating insulator.

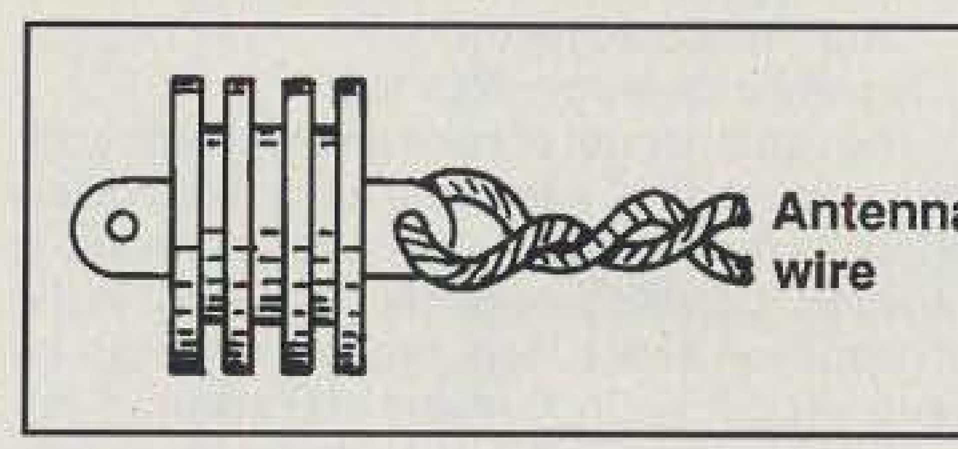

Fig. 3– Antenna twisted around the end of the insulator. If this occurs, free float is destroyed.

Incidentally, I have self-imposed restrictions on antenna installations—namely, no tower, use available trees for supports, wire antennas with multi-band capability if possible, and a preference for open-wire feed line. These do limit my choices, but do not preclude the establishment of an effective antenna system. The resultant antenna(s), based on these guidelines, may not be capable of matching the performance of the "big guns," but should be effective for my method off operating.

Each candidate antenna offered different advantages and called for unique mounting and installation requirements, varying heights, and special real estate or space needs. My first thought was that it would be a cinch to make a choice. After all, I did have a reasonable chunk of land and plenty of trees to use as supports. Many of the trees are over 60 feet tall, which should cover any height requirement.

I first surveyed the area around my house and constructed a diagram of my potential "antenna farm," with approximate dimensions. The plan view showed the location of the house and all trees, shrubbery, etc., which might be involved. Special note was made of the location of all power lines to ensure that I would not violate a basic safety rule: **Do not run wire or feeds over power lines.** Another restriction which limited my choices was not to run lines over the top of my house; just the thought of climbing up on my roof gives me the shakes.

I made a template of some candidate antennas and overlaid them on my plan. After considerable shuffling of templates, I found that I was in trouble. I had too many antenna supports (trees) and not enough free space. The best reasonably clear straight line available ran about 55 feet, and too many antennas needed straight runs which far exceeded that. One design I looked at longingly was the N4PC Multiband Loop[1], but it required a 72 foot phasing line connecting two opposite corners of a rec-

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tangle. I could not find an acceptable clear straight run to satisfy that requirement.

While going through this exercise, I suddenly realized why my recent attempts to install wire antennas were getting more difficult. When I first moved into this house, I was able to install two V-Beams perpendicular to each other without any difficulty. Trying to do the same thing 34 years later just didn't work. I hadn't realized how much my trees had grown in height and how they had filled in with branches. The original open areas and clear paths were long gone. It's hard for me to understand why it took so long for that basic fact to enter my brain.

After more study I decided that the Loop Sky-Wire was the most promising design. What intrigued me was that the design covered a full-wave horizontal loop with excellent multi-band capability. It can be mounted as low as 20 feet above the ground, but is best at a height of 40 feet. In addition, it is more broad-band than a dipole and much more efficient.

The basic dimensions for the 80 meter loop and the 40 meter loop are:

3.5 MHz Loop

Total loop circumference 272 feet
Coverage: 3.5–28 MHz, including 10 MHz
Operates on 1.8 MHz as vertical (see text)
Circle radius 43 feet (or)
Square side length 68 feet

7 MHz Loop

Total loop circumference 142 feet
Coverage: 7–28 MHz, including 10 MHz
Operates on 3.5 MHz as vertical (see text)
Circle radius 23 feet (or)
Square side length 35.5 feet

The actual length of each antenna is not critical; a variation of a few feet will not adversely affect performance. No pruning or tuning is required. Copper wire is normally used in the construction of the loop, but any wire can be used, including Copperweld and covered zip-cord or lamp cord. It can be fed with coaxial cable or open wire, and no baluns or choke coils are needed. For coax feed most users prefer RG-58, RG-59, or RG-62, because RG-8 and RG-11 are too cumbersome. The SWR of this loop generally will not exceed 3 to 1. Of course, my preference was open-wire, and I found that the open-wire feed worked very well with this antenna.

Design Characteristics

The fundamental frequency of the antenna is the length of the wire in the loop (one wavelength). This can be calculated by the formula:

$$L_{TOTAL} = \frac{1005}{f}$$

where:
L= length in feet
f= frequency in MHz

The shape of the final loop is not critical. It can be a circle, a square, a rectangle, or whatever. The most important aspect is the area enclosed by the loop. *The greater the enclosed area, the better the performance.* Obviously, the greatest area would be covered by a circle. For the 272 foot antenna (80 meter) the area of a circle is 5809 square feet. A square with 68 feet per side covers an area of 4624 square feet, while a rectangle 80 × 56 × 80 × 56 covers 4480 square feet. The area of the circle is approximately 30% larger than the rectangle, a significant difference. Installation of a circular antenna requires an infinite number of support points, which is not practical. Most installations, then, would utilize a four-support rectangle of some sort. With four supports, the objective should be to try to create a square or the closest thing to a square. It is possible to improve performance by adding additional supports. Each such added support creates another side to the figure. Five supports produces a pentagon, six a hexagon, etc. Each additional side increases the enclosed area and improves performance. The closer you get to a circle the better (I can't repeat that enough.).

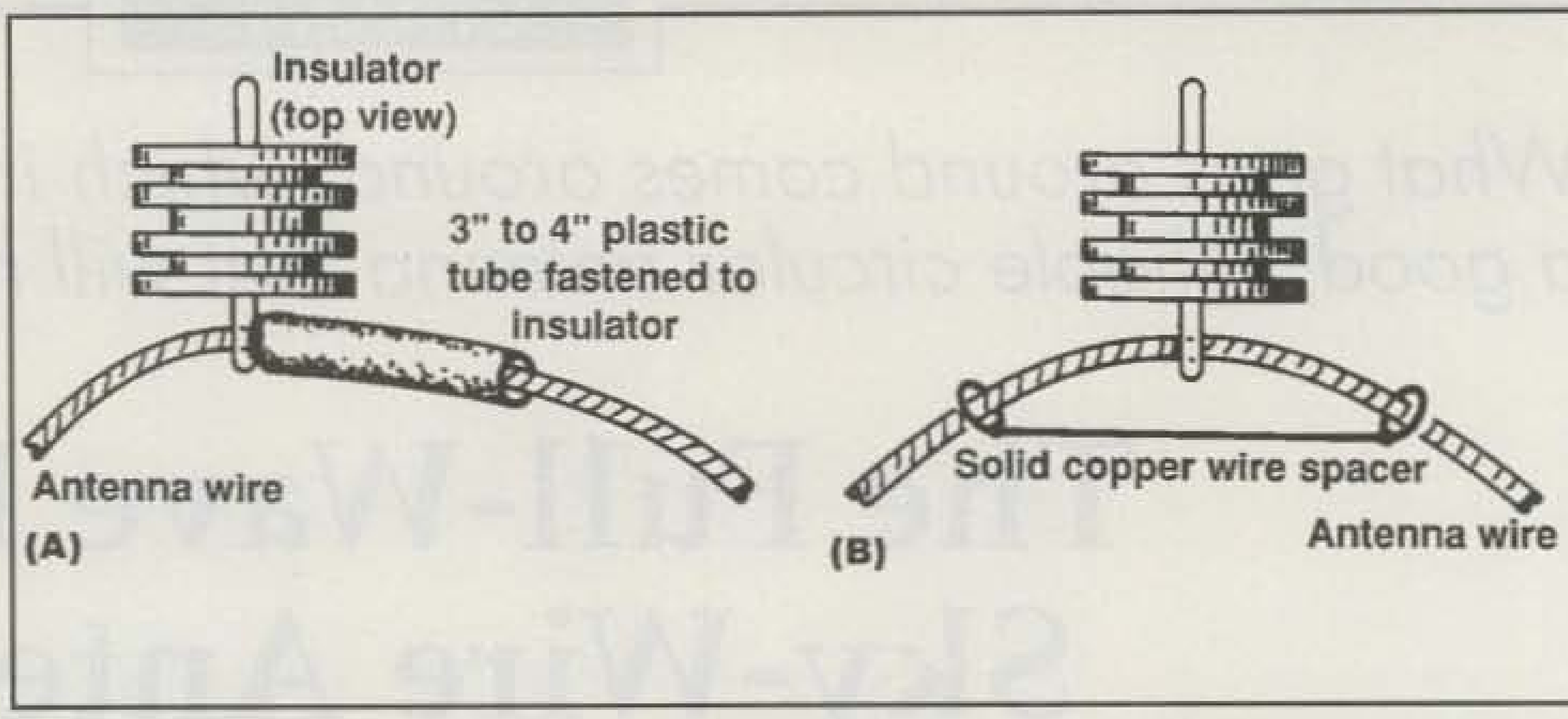

Fig. 4– Two solutions to the twisting problem: (A) Fasten 3 to 4 inch plastic tube (such as PVC) to the insulator. Antenna wire is fed through the tube and insulator. (B) Prepare a heavy wire spacer a shown. Solder the loops and feed the antenna through the loops and insulator. Space between loops is 3 to 4 inches.

Operation of the 3.5 MHz loop on 1.8 MHz and the 7 MHz loop on 3.5 MHz is accomplished by keeping the feed as vertical as possible from the shack to the antenna. Both feed lines of the open-wire line (or center conductor and shield of Coax) are connected together and fed to the transmitter through a matching network against a good ground (see fig. 1). The result is a vertical antenna with top-hat loading. In actuality, all bands can be covered in the vertical mode, but the best performance will occur when operating as a horizontal loop.

Construction

I prepared a length of white line (white for visibility) equal to the planned length of the antenna—272 feet. Using the site plan as a guide, I laid out the line on the ground in the approximate shape of the loop. This identified each potential point of support—one for each turn. I ended up with six acceptable support points, which when connected formed an approximate hexagon. It is a very irregular hexagon with some sides as long as 70 feet and some as short as 30 feet. I did not concern myself with the final configuration. I only tried to enclose the largest area and still feed the antenna reasonably close to my shack.

At each of the selected feed points, I installed a halyard to support the antenna corners. I know most amateurs use a sling-shot to launch halyards over tree limbs. This technique has two problems for me: (1) sling-shots are not legally sold in New York; and (2) every time I tried to use one, I could not get the lead weight high enough into the air. As a result I turned to my trusty surf fishing rod with 1 ounce or 2 ounce lead weights and mono-filament line. After a little practice, I found that I could place the line over an acceptable limb, not always on the first try. At least four of my lines are higher that 55 feet, and two are about 45 feet. That fishing rod can really flip a lead sinker a long distance, and the mono-filament easily hauled up the Dacron rope I used for halyards.

For my installation I used 14-gauge Flex-Weave™ 168-strand copper wire distributed by Radioware (see ads in *CQ*). This wire is also available in 12-gauge. It is very flexible and easy to use (it can even be tied into knots).

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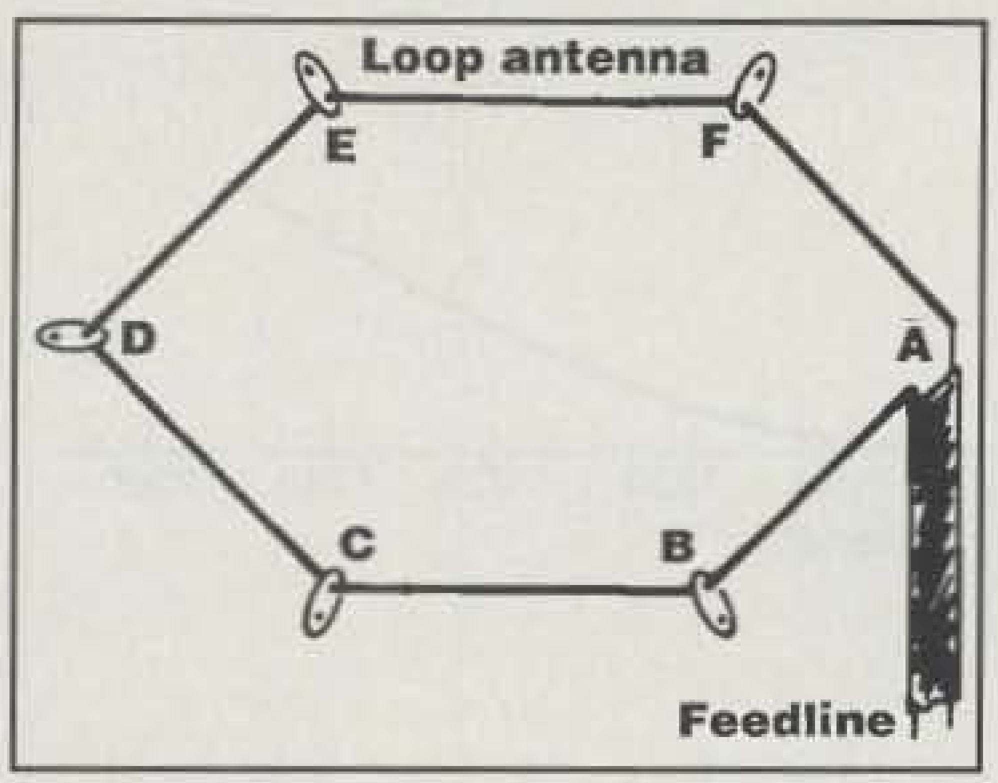

Fig. 5– The final configuration of the loop antenna in the approximate shape of a hexagon. Support insulators are located at points B, C, D, E, and F. A special center support insulator is at point A.

Despite the manufacturer's claim that it will not kink, I did find that it will kink if handled carelessly. These kinks were easy to straighten, however, and a little care soon eliminated that problem. I threaded sufficient wire through insulators and kept each of the insulators free to float on the wire (see fig. 2) to allow the antenna to be pulled taut once it was elevated. Note that wire and feeds were not yet soldered together. Weaving the antenna under and between trees would have been impossible if the ends of the loop were connected. It would have been great to have a helicopter available which could drop an assembled antenna into place from above, or if I had an open area large enough to lay out a pre-assembled antenna and still have supports available on its perimeter. Maybe some lucky reader will have such a space. The installation then would be a snap.

I started at the approximate center of the loop and attached the center insulator to the halyard. It was only partially elevated pending completion of the loop. Incidentally, I found one problem with the Flex-Weave™ at this point. The wire I used twisted around the end of the insulator, destroying the free-float capability. After a little thought, I found an effective way to deal with the problem (figs. 3 and 4 show the problem and present two solutions). I then moved alternately from side to side around the perimeter of the loop, fastening insulators to the halyards as appropriate and partially hauling the antenna into the air. I left full slack at points D and E of fig. 5, the two support points opposite the feed point. I then soldered the ladder line to the antenna wires. The ladder line is supported by a commercial center insulator specifically designed to secure ladder line to wire antennas. A number of excellent products for this purpose are available in the commercial marketplace, or one can be home brewed using plastic material.[2,3]

Hauling the antenna into place was the final step. I found it necessary to move from point to point, back and forth, raising each element separately as much as possible. I did find that branches interfered with the easy elevation of the antenna at some points despite my preplanning. This forced me to place guide lines (Dacron rope) over some of the sides of the hexagon so that the wire could be pulled clear of branches as the antenna was being raised. It is a good idea to install such guide lines while the antenna is on the ground; they can be removed when the installation is complete or retained for possible future adjustment of the antenna. Once the antenna was up, I added a counter-weight to three of the halyards to compensate for any movement in the trees which might place a strain on the antenna itself.

The feed line is supported at several points to prevent unnecessary movement. Excessive whipping of the feed (such as that caused by wind) can cause weakening and ultimately result in breakage. I found that electric fence stand-offs provide excellent support for ladder line (these stand-offs are also available from Rdioware).

Getting feed line from the antenna to the shack has proven troublesome to many amateurs. Years ago I replaced a window pane near my rig with a 1/4 inch thick sheet of plastic. Two feed-through insulators mounted through the plastic pane provide a means of easily connecting the inside and outside feed lines together. I have used this method for years without ever having a problem.

Performance Check

I connected the feed lines to the transceiver via my antenna tuner and checked my ability to load the antenna. I easily achieved an SWR of 1.0 on all bands. Logging the tuner settings permitted movement back and forth between bands quickly. I next checked the SWR broadband characteristics for each of the bands. The resulting data is plotted in fig. 6. This data was taken by selecting a point approximately in the center of a band and adjusting the tuner for a SWR of 1.0. Readings were then taken at frequencies above and below the starting point, to the ends of that band. Each band was separately tuned for optimum performance, but once the initial setting was made, no additional changes were made.

Eighty and 40 meters show a peak in tuning and will require minor adjustment while moving up and down in frequency, but the span between SWR readings of 2.0 is quite acceptable. As the frequency increases, the coverage is flatter and flatter. On 10 meters the data show very flat response even if the curve is a little "snaky." Notice how flat 17 and 15 meters plotted. Remember this data was taken with a ladder-line as the feed. Different numbers will result if coax is used.

I decided that actual on-the-air results would provide real-world performance of this antenna. All of the simulations and computer predictions would be meaningless if they could not be supported by actual data. I was concerned, however, about getting meaningful DX test data in view of the low (nonexistent?) sunspot level. After thinking about it for a while, I concluded that poor propagation conditions would actually provide a very effective test of the antenna. To make it tougher, I decided to concentrate in the 20 meter phone band (a very competitive arena) with a touch, if possible, in one other band. In addition, all testing would be done using an ICOM IC-735 barefoot. Under these conditions the following DX contacts were made over a relatively short period of time (no contests): PZ1DR Suriname, DL1JGP Germany, LZ5VJ Bulgaria, 7X2LS Algeria, GIØKOW No. Ireland (5×9 +20), XE3VD Mexico, IK2DIA Italy, LA3PU Norway, CT1GQ Portugal, OD5MM Lebanon, HB9ADD Switzerland, ET3BT Ethiopia, V51GB Namibia, OA4QV Peru, S54ZZ Slovenia, 9H1RB Malta,

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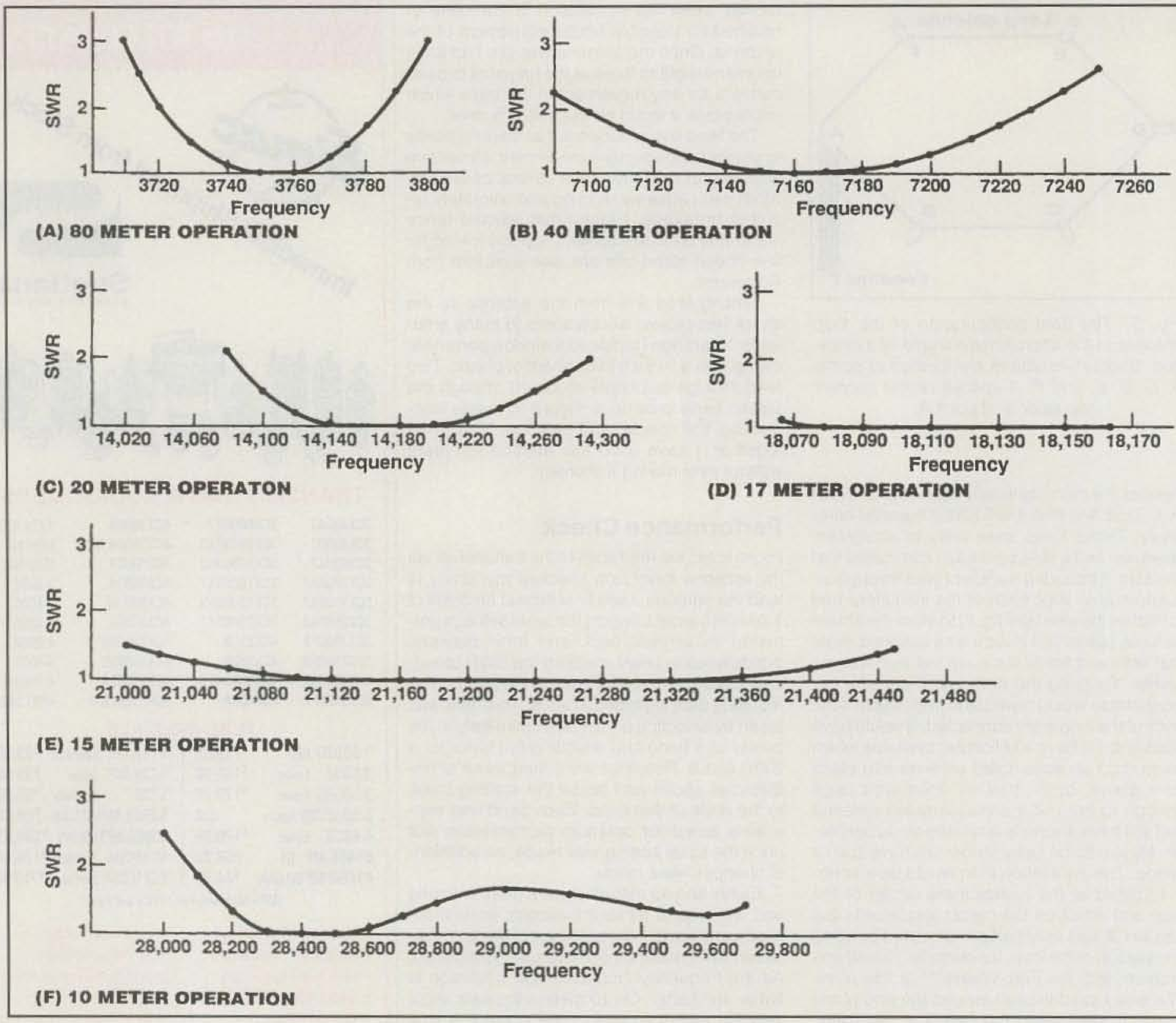

Fig. 6– Eighty meter full-wave loop antenna band-width in terms of SWR in the feed line.

YW1A Venezuela, Z32XX Macedonia, ZA1AJ Albania, EA1UX Spain, A61AN United Arab Emirates, 9A3KQ Croatia, JW5NM Svalbard, PA3GIO Netherlands, OM9AJP Czechoslovakia, G5RR England, UR4MZL Ukraine, SP9AYB Poland, EW3EE Belarus, 9Y4LF Trinidad, YU1AVA Yugoslavia, J37LF Grenada (17m), EA8BYR Canary Islands (17m), 6Y5DA Jamaica, GU3EJL Guernsey, VO1TX Newfoundland, OE6EEG Austria, TU2DP Ivory Coast, GW3XCR Wales, HK5LEX Colombia (17m), 4N4L Bosnia/Herzegovina, TJ1RA Cameroon (17m), SM3JLA Sweden, LY2BTA Lithuania, ZD7CTO St. Helena, J73HW Dominica, WL7MA Alaska, HG1P Hungary, KP4DLM Puerto Rico, YO4GAB Romania, KG4MN Guantanamo Bay, OHØ/SMØIHR Aland Island, OX3KV Greenland, 9K2KO Kuwait, ON4AEK Belgium, 8R1AK Guyana, C53HG Gambia, CYØAA Sable Island, HR1JPT Honduras, A71DX Qatar, PY4AH Brazil, GMØLYM Scotland, YN1XC Nicaragua, KG4MN/KP2 Virgin Islands, CO8LY Cuba, 5N7YZC Nigeria (17m), P43DJ Aruba.

Countries were repeated, but only the first contact made was listed. Note that I got Malta, the elusive country that started me on this exercise. These contacts alone are two thirds of the way to DXCC! Overall it was a very satisfactory and pleasing performance; the distances covered were excellent, and the radiation patterns good. I rate this antenna as a "keeper." It is inexpensive, relatively easy to install, and effective. With it in place, I am now looking forward to an improvement in the sunspot cycle, which happily will be here soon.

Post Script

I relied on the SWR readings provided by my Heath Antenna Tuner model SA 2060A to tune the antenna system. It seemed appropriate to determine how effectively the tuner matched the system (the lowest SWR reading doesn't necessarily provide the best transfer of power to the antenna). I inserted an Omega System Inc. Extended Range Antenna Noise Bridge (Model TE7-02) between the receiver and the tuner. The noise bridge was set at 50 ohms and the antenna tuner was adjusted for the best noise null in the receiver. On 20 and 17 meters the noise null setting was essentially the same as the lowest SWR setting of the tuner. On 15 and 10 meters a slight adjustment was needed to make the readings match. This gave me a sense of confidence in the ability of the antenna tuner to adequately adjust the system and to provide meaningful data. The slight adjustment on the highest bands was not severe enough to invalidate the data.

A special word of caution is necessary. This antenna, because of its height and effectiveness, can be an attractive target for lightning. Provide proper protection at all times, including grounding the antenna when it is not in use. I never leave my antenna connected to the rig if there is any danger of lightning or if I will be away for any period of time. ■

References

1. Paul D. Carr, N4PC, "The Full-Wave 80 Meter Loop Antenna—Revisited," *CQ*, August 1990.

2. Doug DeMaw, W1FB, "The Joys and Sorrows of Ladder Line," *CQ*, April 1993.

3. Steve Ford, WB8IMY, "The Lure of the Ladder Line," *QST*, December 1993.