Here's an antenna project you build in a weekend and still have time left over to work a few rare ones.

How To Build A Shortened Vertical For 20 And 30 Meters

BY SCOTT M. HOWER*, K7KQ

The completed 20 and 30 meter vertical antenna mounted on the author's roof.

With the decline in sunspot activity, an antenna covering the lower bands was desired to replace a miniature beam used for 10 and 15 meters. A small antenna was required due to local Homeowner Association requirements, but a poor-performance compromise antenna would not be acceptable. It was assumed that 20 meters would still be usable in the upcoming years, and the newly acquired 30 meter band would be an excellent choice for CW DXing. The result of much reading and experimentation was a short trap vertical for 20 and 30 meters with excellent performance; the height of the radiator is less than 10 feet, and the antenna can be built for less than a total of $50.

Most amateurs are under the impression that short antennas yield poor performance. While it is true that as an antenna is made smaller certain tradeoffs are introduced, these tradeoffs do not necessarily mean a reduction in radiating efficiency. Theory tells us this is so, and some excellent articles based on experimentation illustrate that short antennas can be very efficient.[1,2] With a short vertical antenna two items must be treated with importance: ground losses must be minimized and conductor losses must be minimized. The usual good practices of antenna installation apply, of course, such as installing the antenna in the clear. If sufficient care is taken in the design and installation of a short vertical antenna, excellent performance may be expected.

As the height of a vertical antenna is reduced, its radiation resistance is decreased in proportion to the square of its length. If a quarter-wavelength vertical antenna is reduced to one third full size, the radiation resistance is reduced by a factor of approximately nine. Methods such as top loading and linear loading may be used to raise the radiation resistance of the antenna. The efficiency of an antenna can be expressed as

$$\text{Efficiency} = \frac{R_r}{R_r + R_{loss}}$$

where:

R_r = radiation resistance
R_{loss} = loss resistance of conductors, coils, ground losses, etc.

It can be seen that keeping the radiation resistance as high as possible while keeping losses—including ground losses—as low as possible will yield better efficiency.

With a ground-mounted vertical antenna, keeping ground losses to a minimum is the single most important consideration, especially for a shortened antenna with low radiation resistance. An extensive ground system, consisting of 60 or more radials, must be used if the antenna is to be a good performer. By raising the antenna and using an artificial ground plane, ground losses can be minimized. Four resonant radials provide an adequate, low-loss ground-plane system for verticals at base heights of one-half wavelength or more; at base heights below one-half wavelength, more than four radials would be required to provide an adequate ground plane that is of significantly greater conductivity than the lossy earth immediately below the antenna.[3]

The antenna described in this article may be used as either a ground-mounted or elevated radiator. As mentioned earlier, an extensive ground system must be used if the antenna is to be ground mounted. The reader should refer to Sevick's work on ground systems if a truly efficient antenna system is desired. Because of very limited yard area, I chose to go with a roof-mounted artificial ground-plane system using four resonant radials for each band. Either way, the antenna was designed with the highest radiation resistance and lowest conductor losses possible so that efficiency would be maximized.

Theory predicts the radiation resistance of a one-third size vertical antenna to be approximately 3 ohms. By using linear loading—as opposed to base loading—along with a capacitance hat for top loading, a more uniform current distribution is obtained along the length of the antenna, yielding a higher radiation resistance. The use of a capacitance hat will also lower the Q of the antenna, providing a wider bandwidth. Additionally, less helical conductor length is required, resulting in lower resistance losses. The use of large diameter #8 copper wire for the helical conductor further contributes to the wide bandwidth and low resistance losses of this antenna. The result is a measured feedpoint resistance of 40 ohms; radiation resistance is probably about half that value, the difference coming from ground losses, as my installation dictated four radials at a height of only 20 feet. A radiation resistance of 20 ohms is nonetheless an excellent figure for a radiator only one-third full size.

The helical portion of the antenna is used for the 20 meter band only. A trap constructed of coaxial cable is used above the helical portion, and a length of half inch copper pipe is used to add 30 meter operation. Therefore, on 30 meters the antenna is not comprised completely of a helical radiator, thus adding to its performance. The copper pipe has the additional benefit of adding top loading to the 20 meter section due to coupling with the capacitance hat; this further improves the performance of the 20 meter helical antenna.

A coaxial trap was used to electrically separate the 20 and 30 meter sections. Recent research and experimentation with traps constructed from coaxial cable

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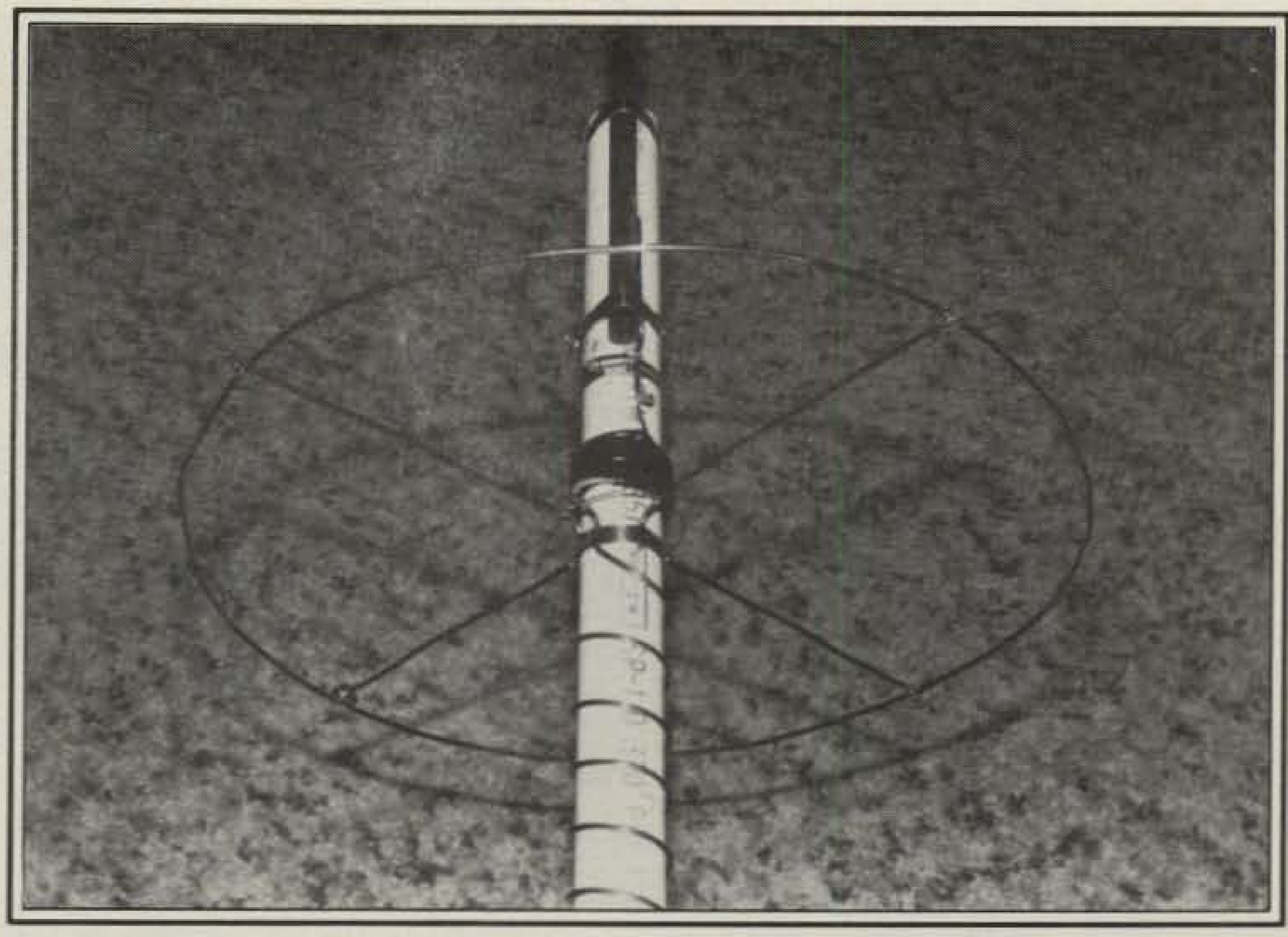


A view of the completed capacitance hat, coaxial trap, and antenna construction.

has yielded the optimum diameter to be used, which in turn optimizes performance by minimizing cable length, weight, and losses.[4] Traps constructed in this manner are inexpensive, easy to construct, broadband, and quite stable. They can also operate at fairly high levels of power. In my example RG-58/U coaxial cable was used, which should be able to take the full legal limit of power. The smaller RG-174/U type coax may also be used for power levels up to about 500 watts average output. The reader is directed to the article by Sommer for details on winding traps with this type of coax. Whichever type of coax is selected, be sure to obtain true RG-58/U or RG-174/U type cable; capacitance per foot and outer diameter are critical, and substitutes should be avoided. The values for RG-58/U type cable are 28.5 pF per foot with an outer diameter of 0.2 inches. Foam dielectric coax must not be used, as these values are not the same as for polyethylene dielectric.

As mentioned previously, this antenna may be installed at ground level with an extensive radial system, or as an elevated ground-plane antenna. Construction will be the same in both instances. However, tuning of the antenna will be required depending on where the antenna will be located. In either case, start construction of the antenna by cutting the PVC pipe to its desired size. The antenna portion of the PVC pipe takes up about 6 feet, so the pipe should be cut to that length, plus any additional amount required for mounting in your particular installation. Note that the antenna portion may be longer than 6 feet; final tuning will correct for any differences in helical conductor length, and performance will improve. This portion should not be reduced to less than 6 feet, however, as radiation resistance and bandwidth will decrease to smaller values. A size reduction of one third seems to be optimum.

Start by winding 33 feet of #8 solid copper wire on a clean section of 1¼ inch PVC pipe (my piece of PVC pipe was very dirty as purchased—taking a few minutes to wash the pipe with soapy water not only makes working with the pipe easier, but will ensure that any varnish or paint applied to the finished product will adhere properly). Adjust the coil to position it properly on the PVC pipe and make the spacing between turns as equal as possible. Fasten the coil in place with two hose clamps so they are snug; do not tighten down hard yet. Using the top hose clamp and 8 inch lengths of #8 wire, fashion four spokes at the top of the helical coil. With another piece of #8 wire, form a rim around the ends of the spokes.

Smaller wire, such as #20, may be used to lash the rim to the spokes so that they may be held in place for soldering. Using the smaller wire, form a ring around the base of the spokes, about 1 inch out from the PVC pipe, to join the four spokes together with the top of the helical conductor (see photo). Solder all connections, being careful not to use too much heat for too long as the copper wire may melt into the PVC pipe. Tighten to top hose clamp securely (leave the bottom clamp snug for tuning).

The coaxial cable trap is very easy to construct. Take 41 inches of RG-58/U cable and remove about 3 inches of outer jacket from each end, leaving 35 inches of unstripped cable. Pull the inner conductor out of the shield at both ends so that 35½ inches of shielded cable remains intact. The 35½ inch length is critical, as is the type of cable used. As mentioned previously, only true RG-58/U type cable should be used. Wind the length of coax onto the PVC pipe just above the capacitance hat. Use a good quality electrical tape to hold the turns in place. Trim and strip the inner conductor from one end so that it may be joined with the outer braid from the other end of the coil, and solder them together. Now tape the entire trap in place so that the turns are held closely spaced together. Solder the remaining lead at the bottom of the coil to the capacitance hat, and the top lead to a short length of #8 copper wire (see fig. 1). This copper wire should be held in place with a hose clamp and formed to make contact with the bottom portion of the copper pipe.

The copper pipe is a 34 inch long section of ½ inch pipe obtainable at most hardware stores. For my antenna an end cap was also purchased and soldered in place on the top end to keep out rain and moisture. Lightly sanding the pipe with fine sandpaper before mounting is a good idea so that paint or varnish applied later will adhere properly. Mount the copper pipe to the PVC pipe with two hose clamps, the bottom clamp also holding the #8 copper wire coming up from the trap firmly in place (see fig. 2). Do not solder the wire to the pipe yet, as some fine-tuning may be desired.

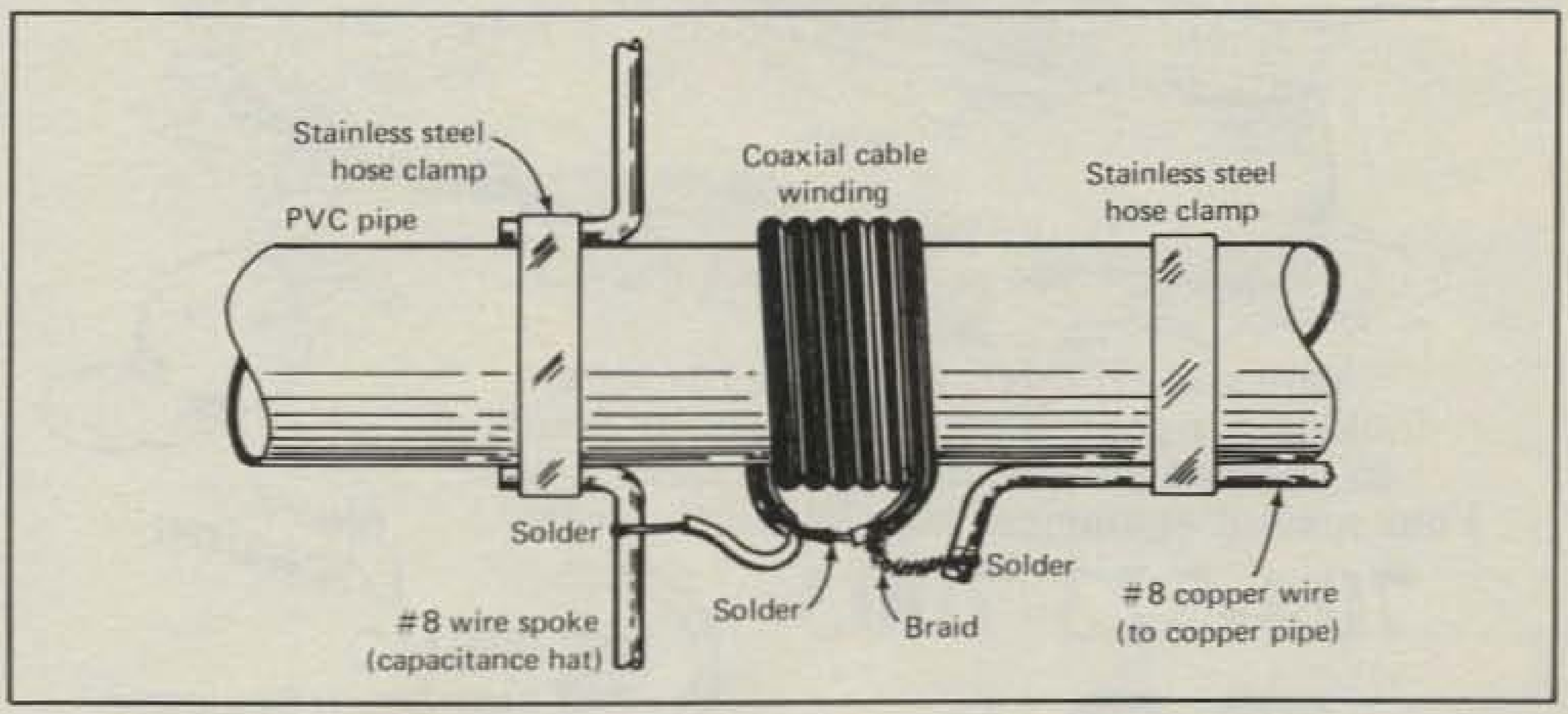


Fig. 1– Details of the coaxial cable trap and connections to the capacitance hat and copper pipe.

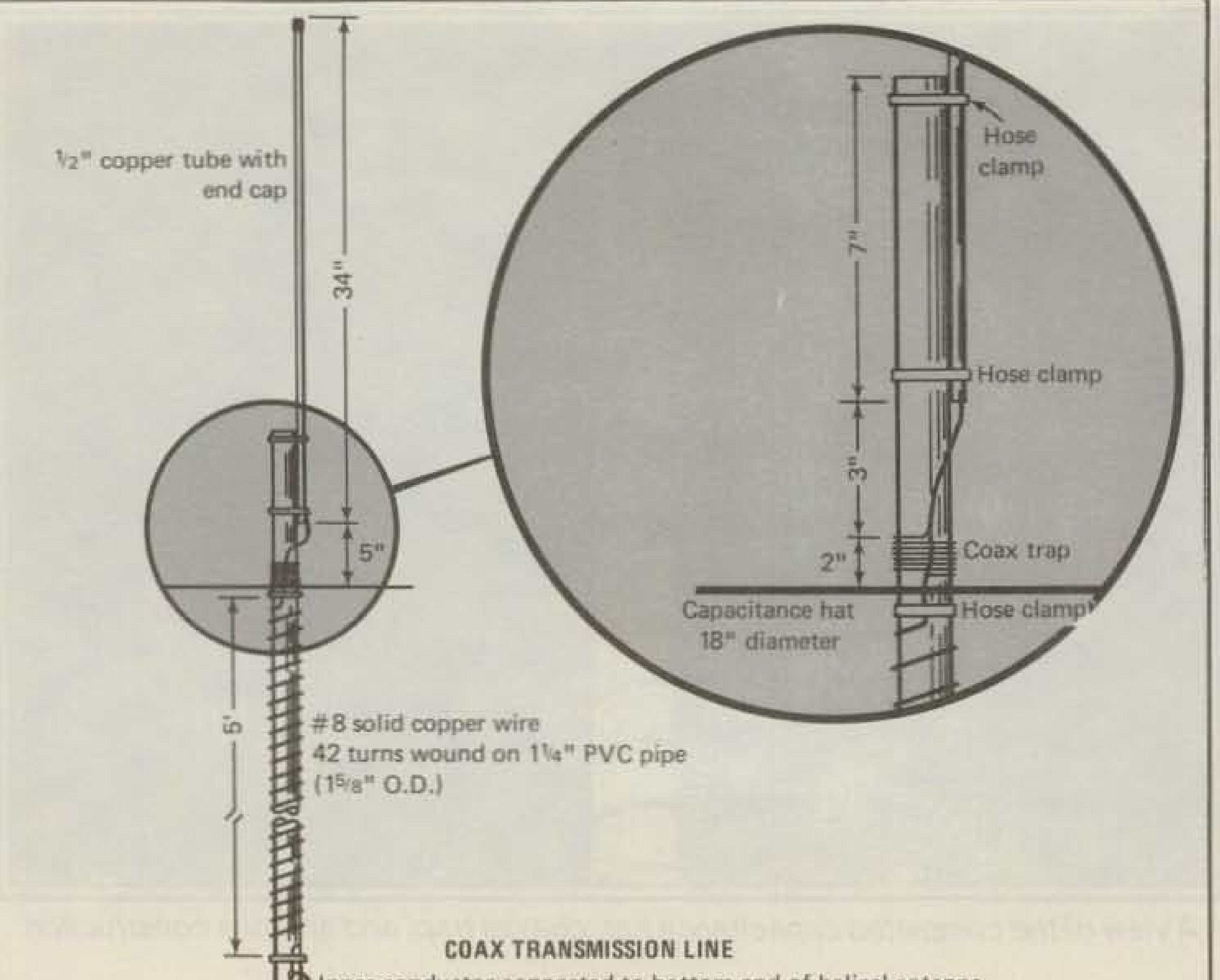
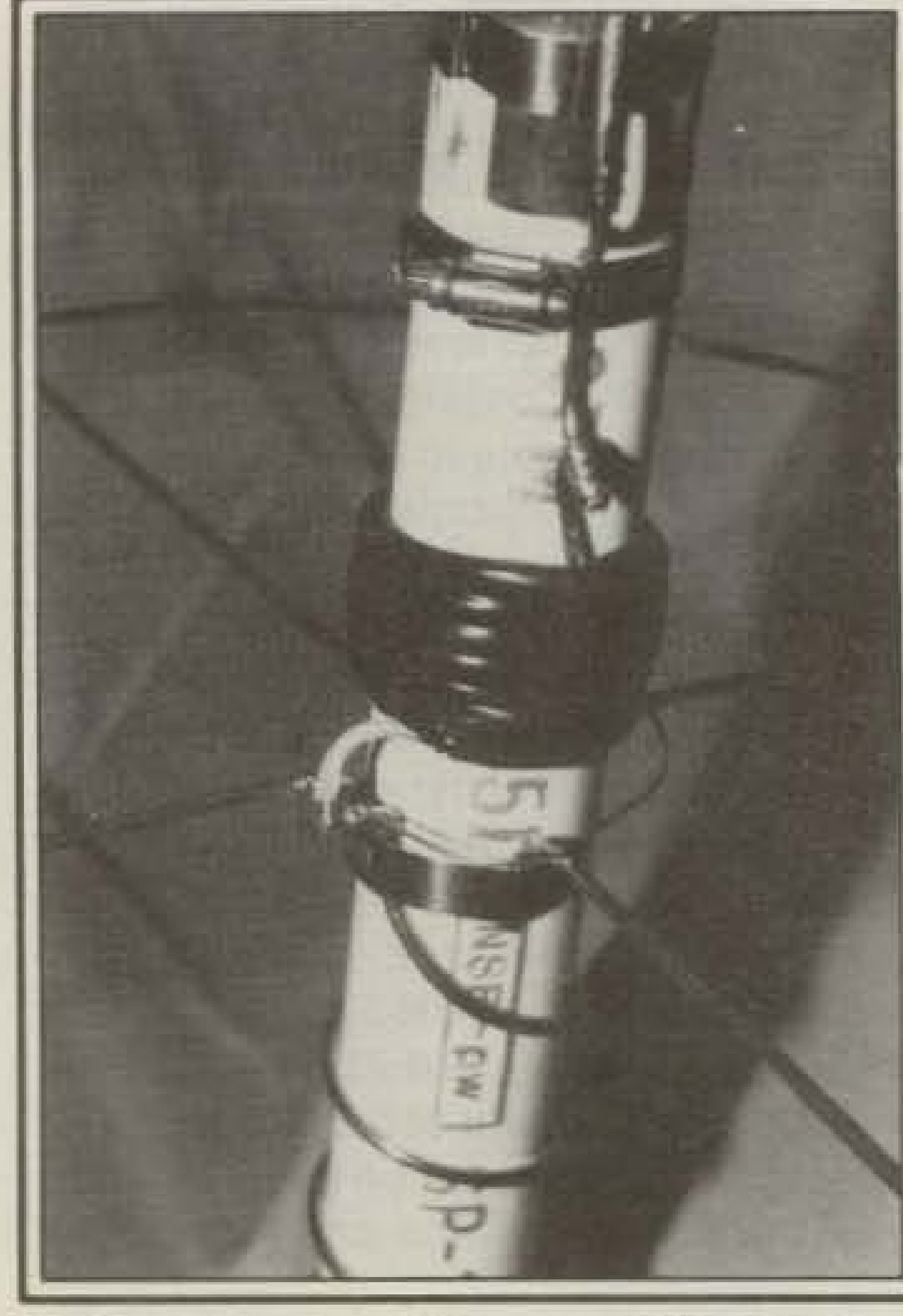


Fig. 2– Construction details for the shortened two-band vertical antenna.



A close-up view of the coaxial cable trap showing the connections to the capacitance hat and the 30 meter section.

To tune the antenna, it must first be mounted in its final configuration, whether that be ground or roof mounted. Start by tuning the 20 meter portion using a noise bridge or SWR bridge. If a noise bridge is used, it would be wise to feed the antenna with a length of coax cut to an electrical half wavelength at 14 MHz. By doing so, the readings obtained with the noise bridge will be indicative of the impedance at the antenna's feed point; otherwise, a Smith chart must be used to obtain the antenna impedance. Whichever device is used to tune the antenna, turns will no doubt need to be removed from the bottom of the helical portion until resonance is reached. Starting with 33 feet of helical conductor, I had to remove roughly 10 feet of wire before resonance was found. Although this is tedious work, it was nonetheless nice to know that less wire was needed than normally predicted for a short helical antenna of this type, indicating the effectiveness of top loading. When turns are removed from the bottom of the coil, it is necessary to pull the windings down so that the bottom end of the coil remains at the same spot. Resonance will be indicated by either minimum SWR or a reading of zero reactance on the noise bridge.

Once the 20 meter section has been tuned, slide the copper pipe up or down as necessary to tune the 30 meter section. As mentioned previously, some coupling does take place between the top and bottom sections so that some interaction will occur; however, the effect is slight. It is best to use an SWR bridge to tune this section, as the feedline will not be an electrical half wavelength at 10 MHz. The readings will be in the ballpark once tuning of the 20 meter section has been completed.

After both 20 and 30 meter sections are tuned properly, solder the #8 wire to the bottom of the copper pipe and ensure that all hose clamps are tight (some clamps may need tightening after soldering, as the copper wire may have melted slightly into the PVC. When all connections are tight and sound, give the helical coil, capacitance hat, and the copper pipe two coats of spar varnish or suitable paint. Once the varnish or paint has dried, weatherproof the trap and all connections with a silicone rubber sealant. Do not forget to plug the bottom of the copper pipe with the sealant to keep out moisture. I used a white interior/exterior epoxy paint and white sealant for an excellent protective finish and unobtrusive appearance.

The antenna was tuned for the middle of the 20 and 30 meter bands. Four 17 foot radials and four 24 foot radials were run out from the base of the antenna along the rooftop of my house. A feedpoint impedance of 40 ± j0 ohms was measured at 14.200 and 10.125 MHz; SWR measured less than 2:0:1 across the entire 20 meter band, bottoming out at about 1:2:1 at reasonance for both 20 and 30 meters.

It was hoped that the high feedpoint resistance measured and wide bandwidth were an indication that my attempts to build an efficient short antenna were successful. I am happy to report that results on the bands proved this to be so. Signal reports have been good to excellent on both bands, and i have enjoyed many solid contacts despite poor conditions and various bouts with QRM on 20 meters. The antenna as described is self-supporting, having survived several windstorms with no guys required. Little detuning has been observed despite rain, snow, or a coating of ice. With careful attention to a ground system, this antenna will be an excellent performer in a small package.

List of Materials

10 feet 1 ¼ inch PVC pipe (O.D. approx. 1.7 inches).

50 feet #8 solid copper wire (available at electrical supply store).

34 inch copper pipe, ½ inch type.

1 end cap for above.

4 feet RG-58/U type coax (Radio Shack 276-1326 or equiv.).

5 stainless steel hose clamps, 1½ to 2½ inch.

Misc.: antenna mounting hardware, radial wire, electrical tape, spar varnish or paint, silicone sealant.

Footnotes

[1] J. Sevick, "The Ground-Image Vertical Antenna," *QST*, July 1971.

[2] R. Gorski, "Efficient Short Radiators," *QST*, April 1977.

[3] K.T. Thurber, Jr., "Antennas," *CQ*, February 1985, and D. Newcomb, "Notes on Ground Radial Systems."

[4] R. Sommer, "Optimizing Coaxial Cable Traps," *QST*, December 1984.