It's not that hard to build nor is it that big in size. Here's the chance to try out 160 meters from an average city lot and rack up a new country total on top band.

The 160 Meter Top-Loaded Vertical Antenna Revisited

BY LOUIS B. BURKE, JR.*, W7JI

In January 1968 *CQ* magazine published my construction article "Top Loaded 160 Meter Vertical." The antenna system consisted of a base insulated 36 foot telescoping mast top loaded with a coil/whip assembly and minimal ground system. I used this particular antenna for a number of years with good results, realizing that improvements still could be made to the system.

A very good friend, Bill Turney, now WS4Y, was impressed with the performance of the short vertical and asked me if I had any intentions of trying to market the top-loading sections, since the system worked so well and did provide a good antenna system for 160 meters with minimal real-estate requirements. I told Bill that I had no intentions to take on such a project, but if he wanted to do so he had my blessings and I wished him luck with the project.

Bill began manufacturing and selling the top-loading sections under his call at the time of WAØRFF. It's surprising to me how often I run across someone in a QSO who is still using Bill's top-loading section. Speaks rather well for the quality of the project, wouldn't you say?

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Inspiration

In a recent QSO with local amateur Charlie Michaels, W7XC, I began discussing my antenna top-loading system. Not far into our QSO I realized that Charlie wasn't your typical cut-and-dried operator. As it turns out, Charlie is a retired electrical engineer and without a doubt one of the brightest individuals I've had the pleasure of meeting on the amateur bands in quite a number of years.

After several exchanges of information Charlie got out his calculator and began running various formulas calculating the inefficiencies of the coil used in my top-loading section. In the ensuing conversation I discovered that Charlie had written an article in the August 1987 edition of *QEX* magazine entitled "Optimum Wire Size For R.F. Coils." In his article he created a chart devised from algebraically rearranging formulas from works of Terman and Butterworth dealing with the

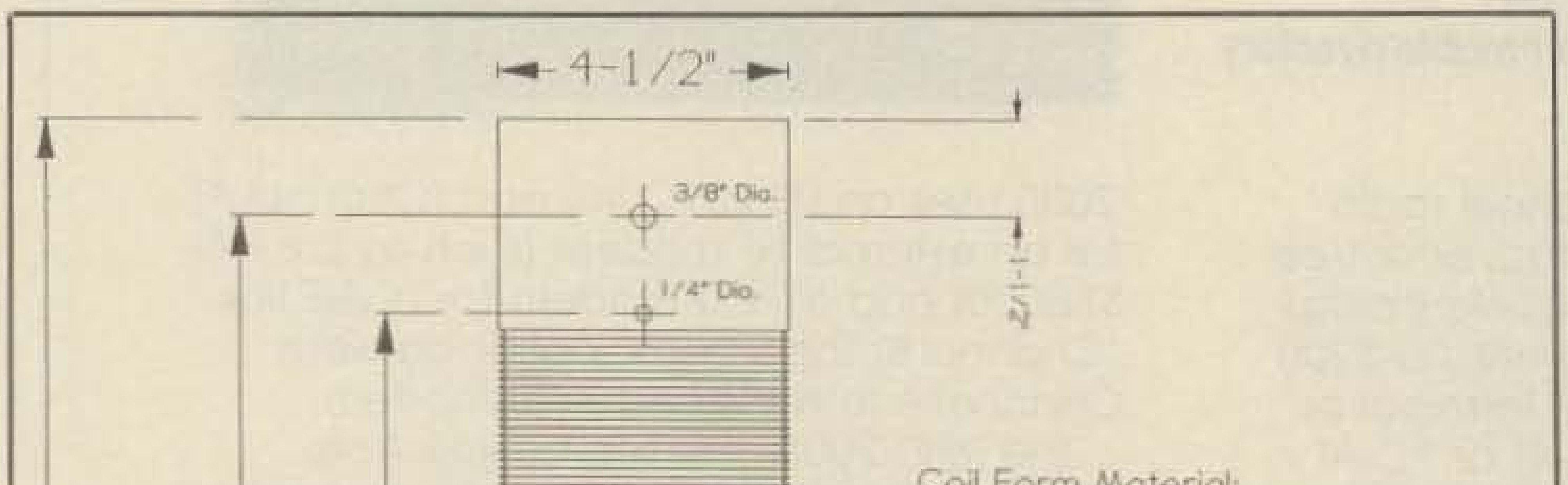

Fig. 1 - Mechanical specifications for the coil. Check the yellow pages of your phone directory for a machine shop in your area.

The completed coil assembly should look like this.

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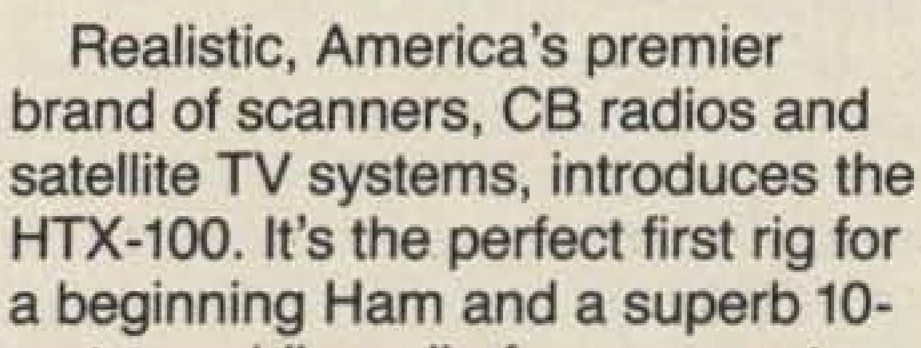

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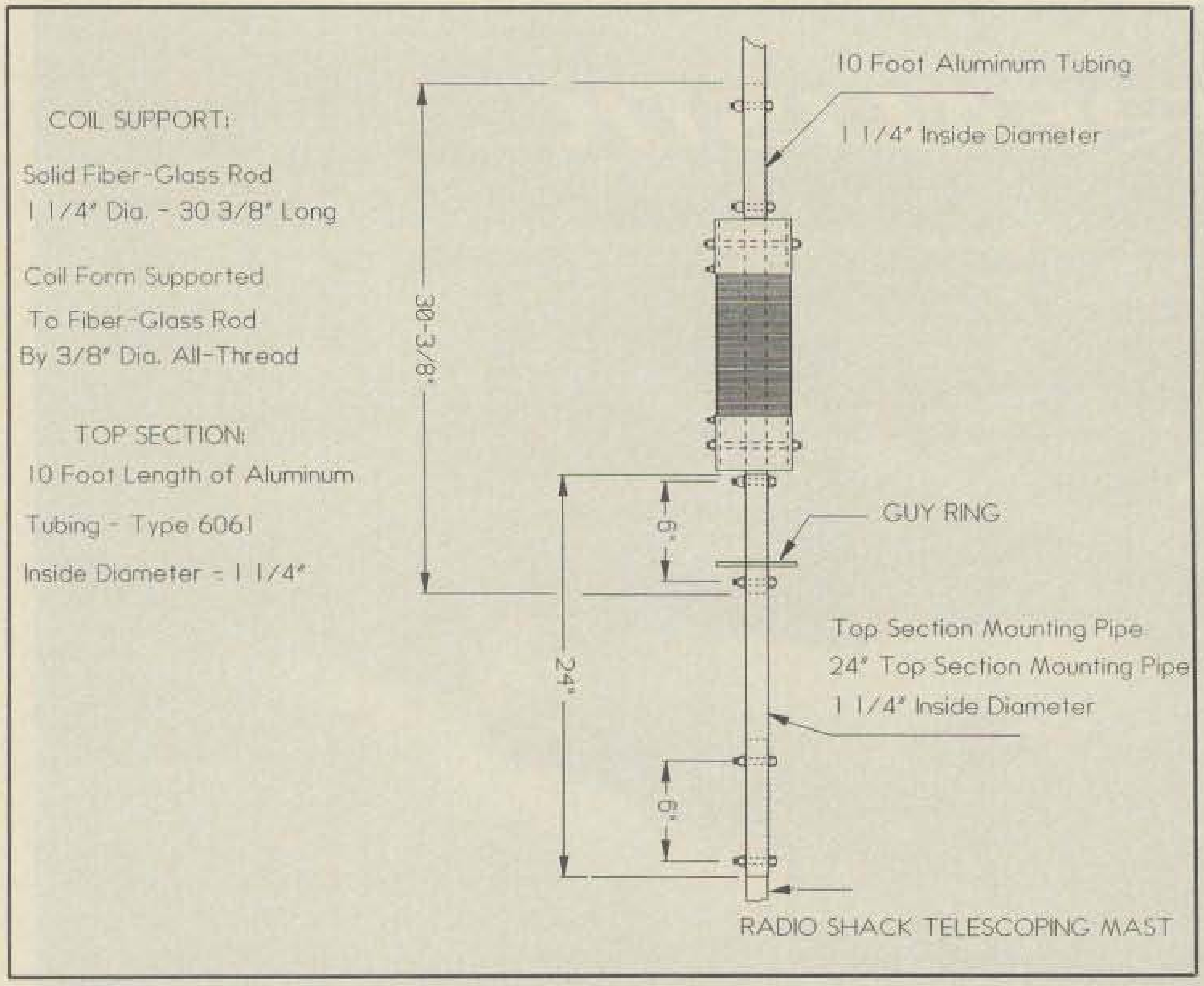


Fig. 2- Support system for the coil assembly.

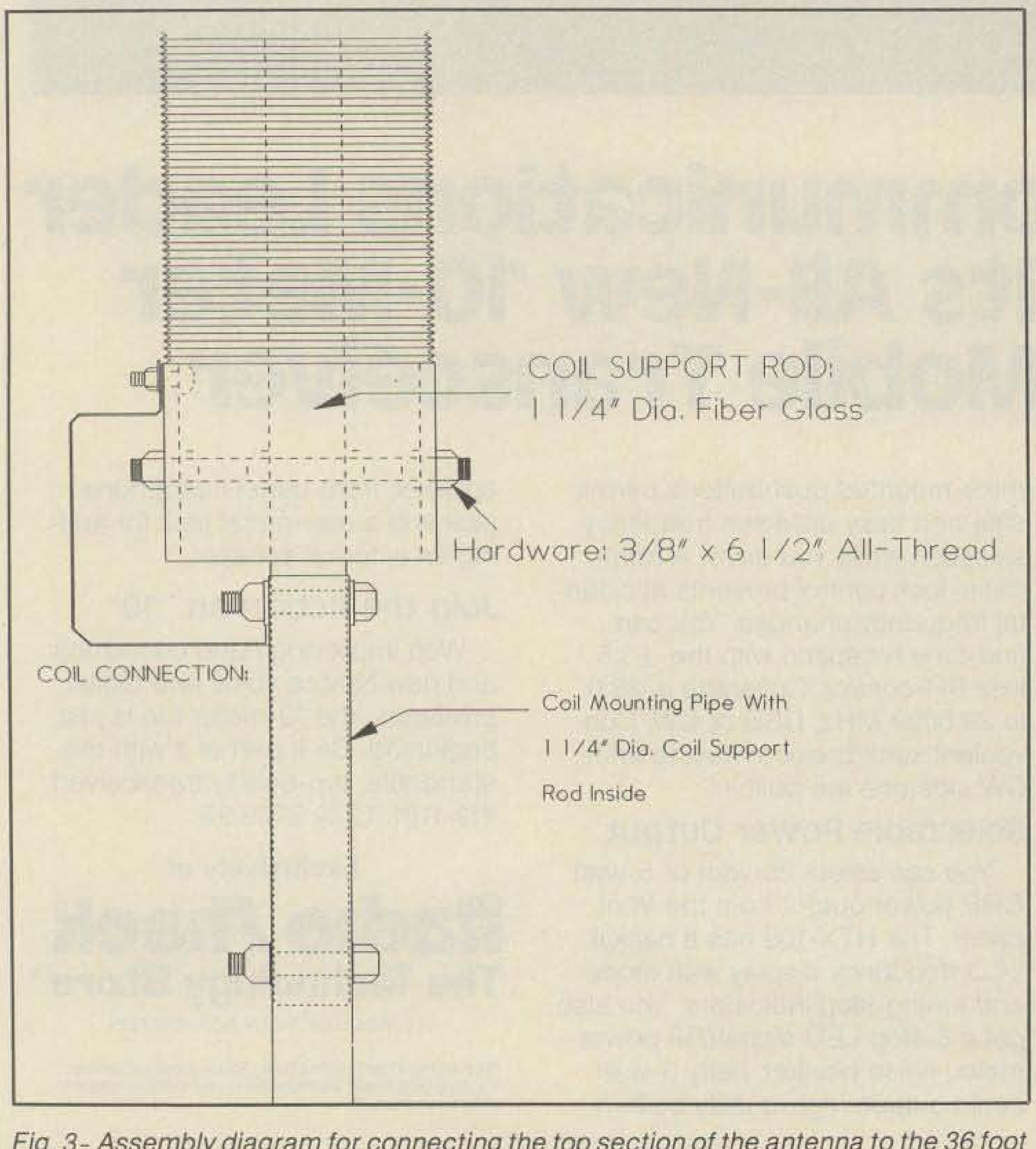


Fig. 3- Assembly diagram for connecting the top section of the antenna to the 36 foot telescoping mast.

optimum wire sizes for a given coil diameter to length ratio and number of turns.

Needless to say, by this time Charlie had certainly piqued my interest. I had always been aware of some of the shortcomings of my system, especially the "Q" of the coil in use. For the first time in 20 years I was actually considering rebuilding the whole system.

Charlie went on to explain his work on choosing the right wire size for a coil of given dimensions and number of turns. Since the coil is the single most important part of my top-loading system, I was very interested in his information. By the time the QSO ended, I had designed a new coil, and Charlie confirmed the proper wire size for the coil dimensions specified. Now the remaining construction details were left up to me.

The Challenge

The design I presented was a coil 4½ inches in diameter and 9 inches in length, wound with 60 turns of number 12 wire, evenly spaced over the 9 inch length of the coil, representing 165 μH of inductance. I began thinking of just how to construct such a coil without compromising the electrical characteristics of the coil.

Before entering into a serious design mode, it was necessary to decide on materials to be used to construct the top-loading section. The design was based on two factors, quality of materials and cost.

Achieving high-quality materials with respect to electrical characteristics and mechanical stability at minimal expense is no simple task. The two most important factors in the design of the coil were the effect of the material used at RF frequencies and the proper spacing of the individual turns. Other factors such as mechanically mounting the coil in such a manner as to minimize the effect of mounting hardware were also considered.

It became obvious to me that some minor compromises would be necessary in order to construct the entire top-loading section with sufficient mechanical strength to self-support on a 40 foot telescoping mast.

Time To Go To Work

I finally decided on using a piece of 4 inch ABS pipe (outside diameter 4½ inches). It is readily available at most hardware or plumbing shops and is very inexpensive. Depending on whose information you read regarding the use of PVC materials at RF frequencies, ABS pipe seems to be a reasonable choice for the money. Next I decided that the only way I could guarantee proper turns spacing was to take the pipe to a machine shop and have the proper number of grooves cut into the material.

I explained to the machinist that I needed 60 grooves, 0.08 inches deep, spaced 0.08 inches apart, over a 9 inch length cut

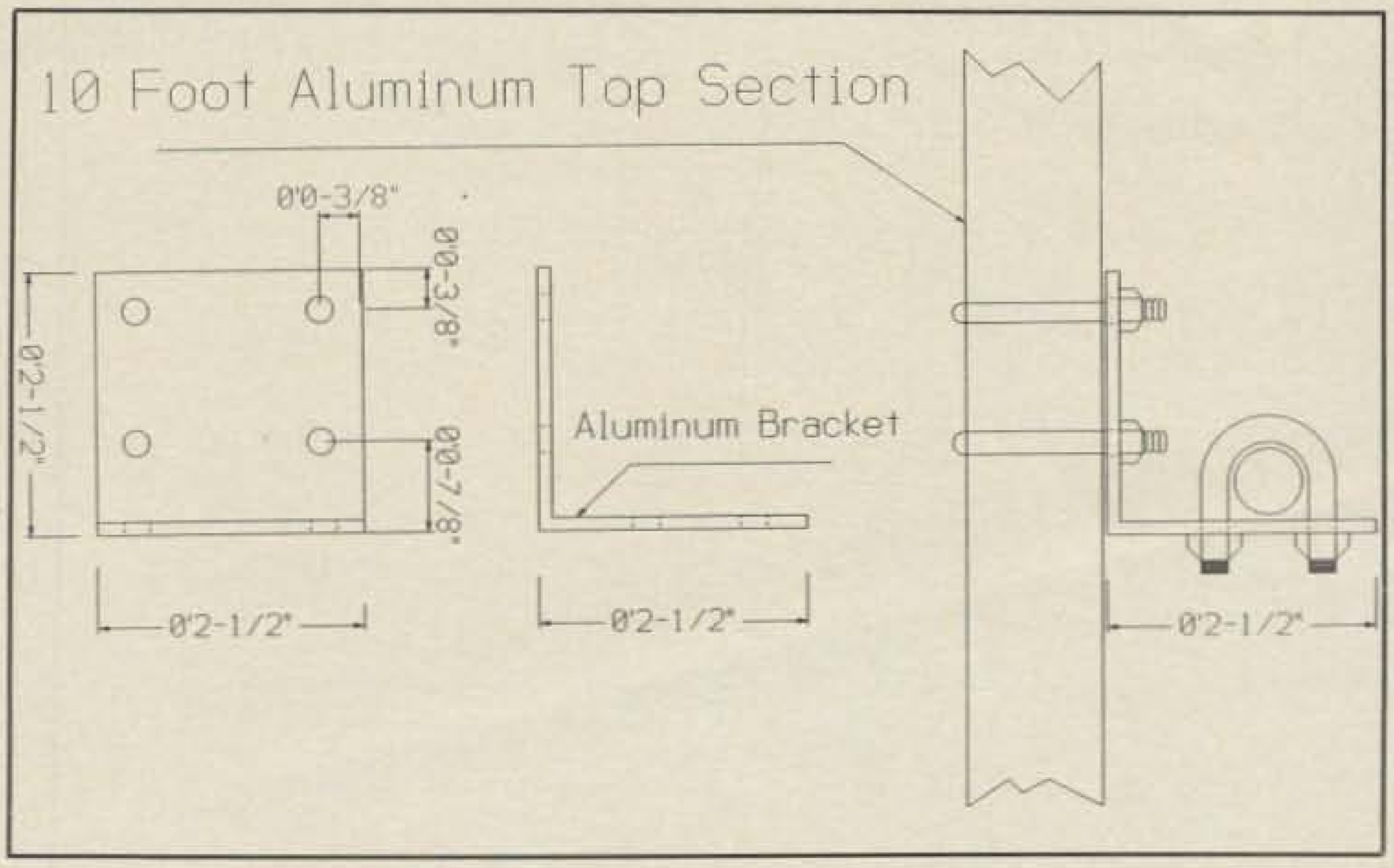


Fig. 4- Mechanical diagram for the support system of the capacity-hat assembly.

into the ABS pipe (see fig. 1). The finished product turned out exceptionally well.

I purchased brass hardware and soldering lugs to use for terminating each end of the coil winding. I also purchased 100 feet of #12 solid copper wire which would be used to wind the coil.

At each end of the coil winding grooves I drilled a ¼ inch diameter hole through one side of the coil form. From the inside of the form I inserted the brass hardware so that the bolt was protruding out of the form. I placed a brass flat washer onto the bolt, followed by a soldering lug, another brass flat washer, a brass lock washer, and the brass nut. This provides a method of terminating each end of the coil winding as well as electrically connecting the coil to the support mast and top section above the coil.

After tightening the hardware, I soldered one end of the #12 wire to the solder lug and stretched the wire across the backyard. I tied the other end of the wire securely to a fence post.

I picked up the coil form and pulled on the wire to remove any slack in the wire. While keeping the wire stretched tightly, I began winding the wire into the grooves. After all 60 turns were wound onto the form, I simply soldered the remaining end of the wire to the solder lug. The finished product is a very professional-looking coil. To waterproof the coil I painted it with several coats of polyurethane.

Due to the weight of the coil I decided that it would be necessary to support it with a material that was both physically strong and a good insulator at radio frequencies. My choice was a 30⅜ inch length of fiberglass rod 1¼ inches in diameter. The coil is supported by centering the 30⅜ inch fiberglass rod through the center of the coil and attaching the coil form to the fiberglass rod with a 6½ inch length of 30⅜ inch diameter all-thread (see fig. 2).

In order to keep the capacitive tuning element at a reasonable physical length, I decided to employ a 10 foot vertical section in conjunction with a horizontal capacity-hat arrangement.

I purchased a 12 foot length of 6061 aluminum tubing with an inside diameter of 1¼ inches and a 12 foot length of ⅝ inch diameter tubing. This material is very light and sturdy and would fit the mechanical requirements. I cut a 2 foot length off the 1¼ inch diameter tubing to use as a method of mechanically attaching the coil to the top of a 36 foot telescoping mast (see fig. 3, top section mounting pipe). One end of the fiberglass rod which supports the coil slips nicely into one end of the 2 foot length of tubing and is secured by two ⅜" × 2¼" bolts completely through the mounting pipe and fiberglass rod. The spacing between these holes is 6 inches. The other end of the "mounting pipe" slips nicely over the end of the top section of a Radio Shack 36 foot telescoping mast and is secured in the same manner (Radio Shack part number 15-5067, see fig. 3).

To complete the top section above the coil it was necessary to construct a form

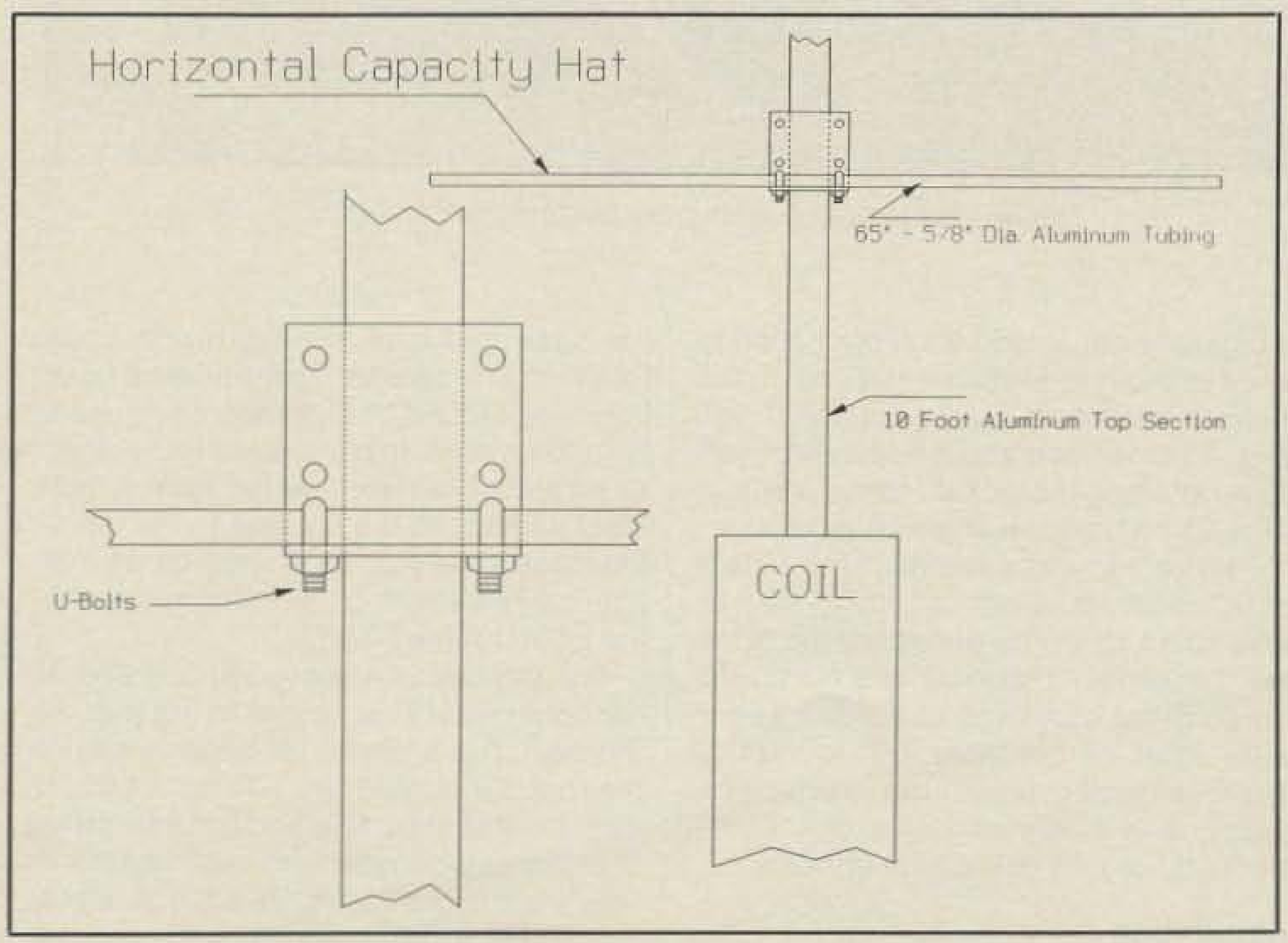
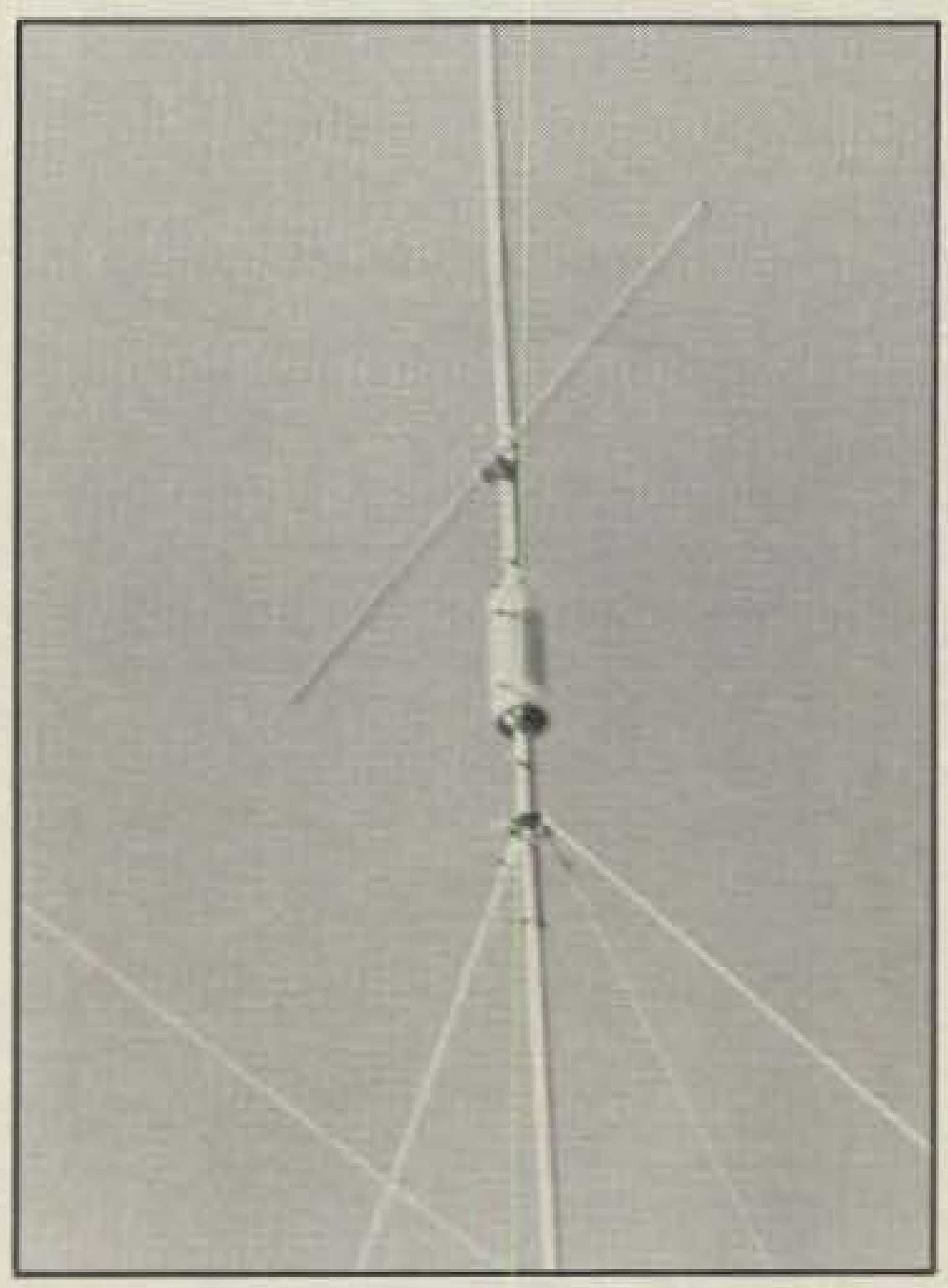


Fig. 5- The horizontal capacity-hat diagram.



A view of the top section of the 160 meter vertical showing the coil and the capacity-hat assembly.

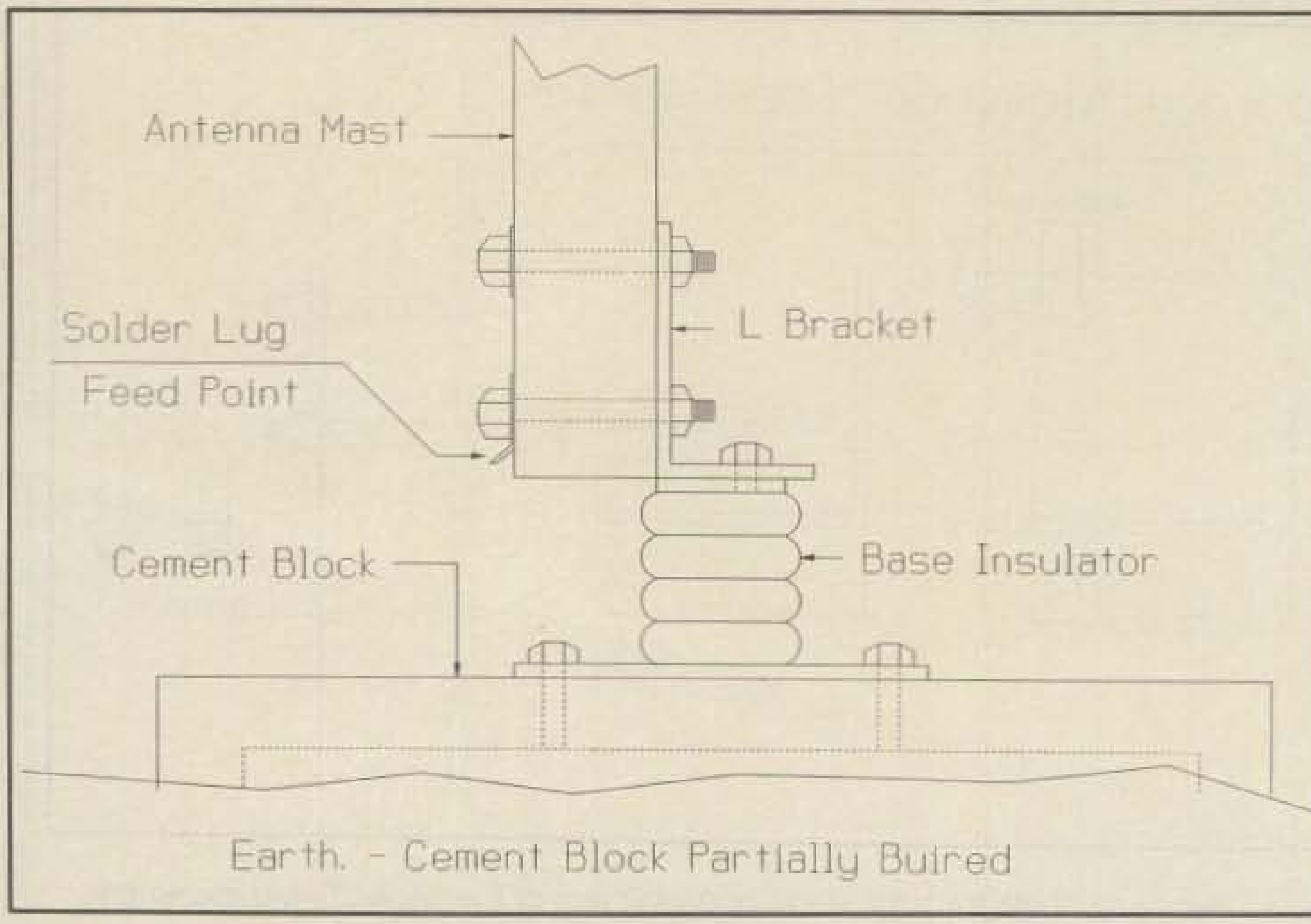
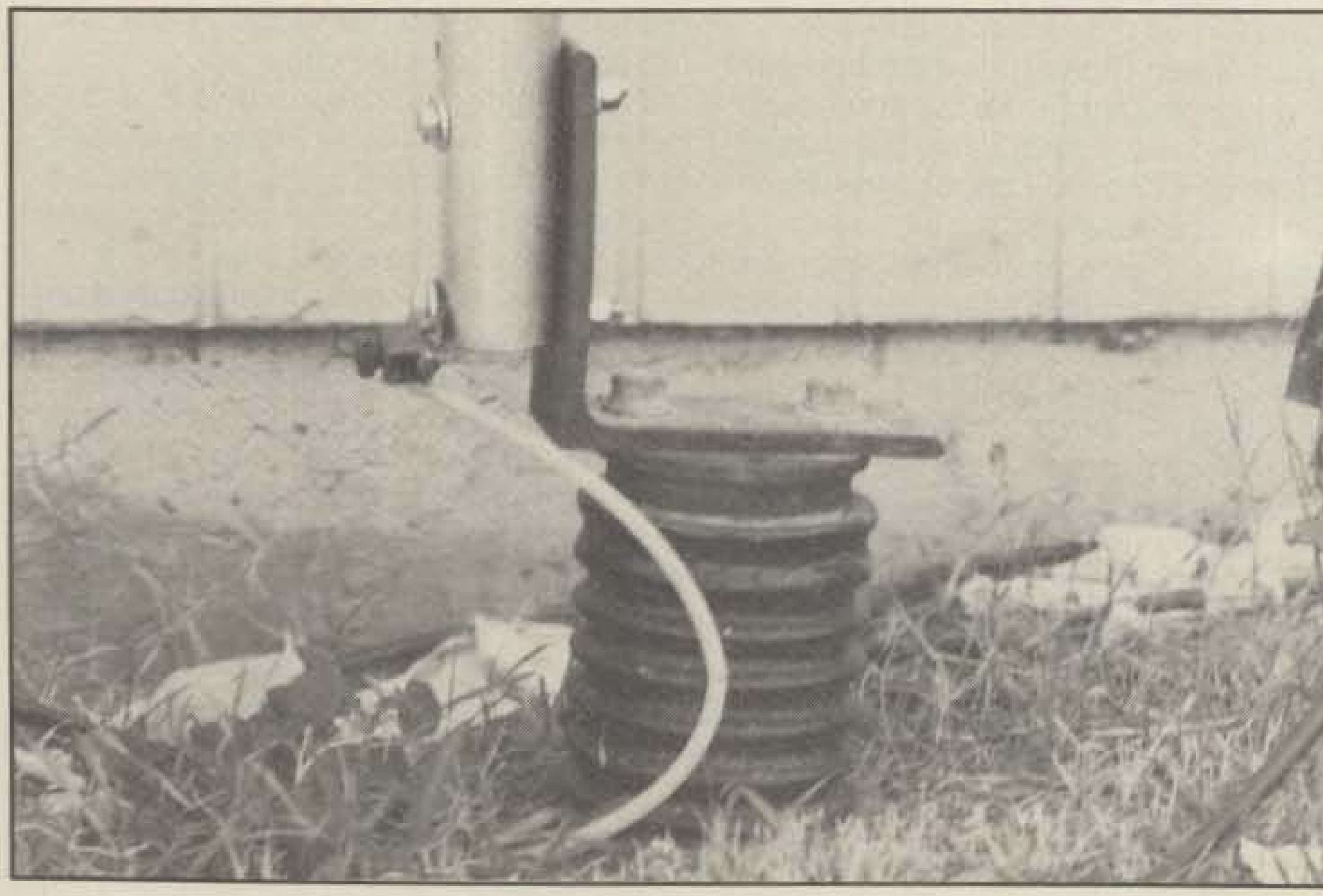


Fig. 6 - The base insulator assembly for the vertical antenna.



The completed base assembly as described in fig. 6.

of capacity-hat to add additional capacitance in order to resonate the coil on the desired operating frequency of 1.855 MHz. This was accomplished by fabricating a right-angle bracket from a piece of ⅛" × 2½" aluminum angle (see fig. 4).

The bracket was secured to the 10 foot vertical aluminum tubing with 1½ inch U-bolts about 15 inches above the top of the coil. I originally mounted two horizontal capacity-hat elements at 90 degrees to each other on the mast, but found that this arrangement presented too much capacity, and I removed one of the elements during my initial tune-up tests.

Installation

The antenna mast must be insulated at the base and kept free from physically touching any objects. To fabricate a base insulator, I found an old power-line insulator and bolted it to a cement block. I then fabricated a large L-bracket from ⅜ inch steel and bolted the bracket to the top of the base insulator as a method of mechanically attaching the antenna base to the insulator (see fig. 6).

My antenna is mounted at one end of my home and is very close to the wall. At the point the antenna passes the eve of the roof, I mounted two 10 inch stand-off insulators side by side and bolted a strap of aluminum between the two insulators. This aluminum strap is drilled to accept a 2 inch U-bolt. The antenna mast is bolted to the aluminum strap with a 2 inch U-bolt

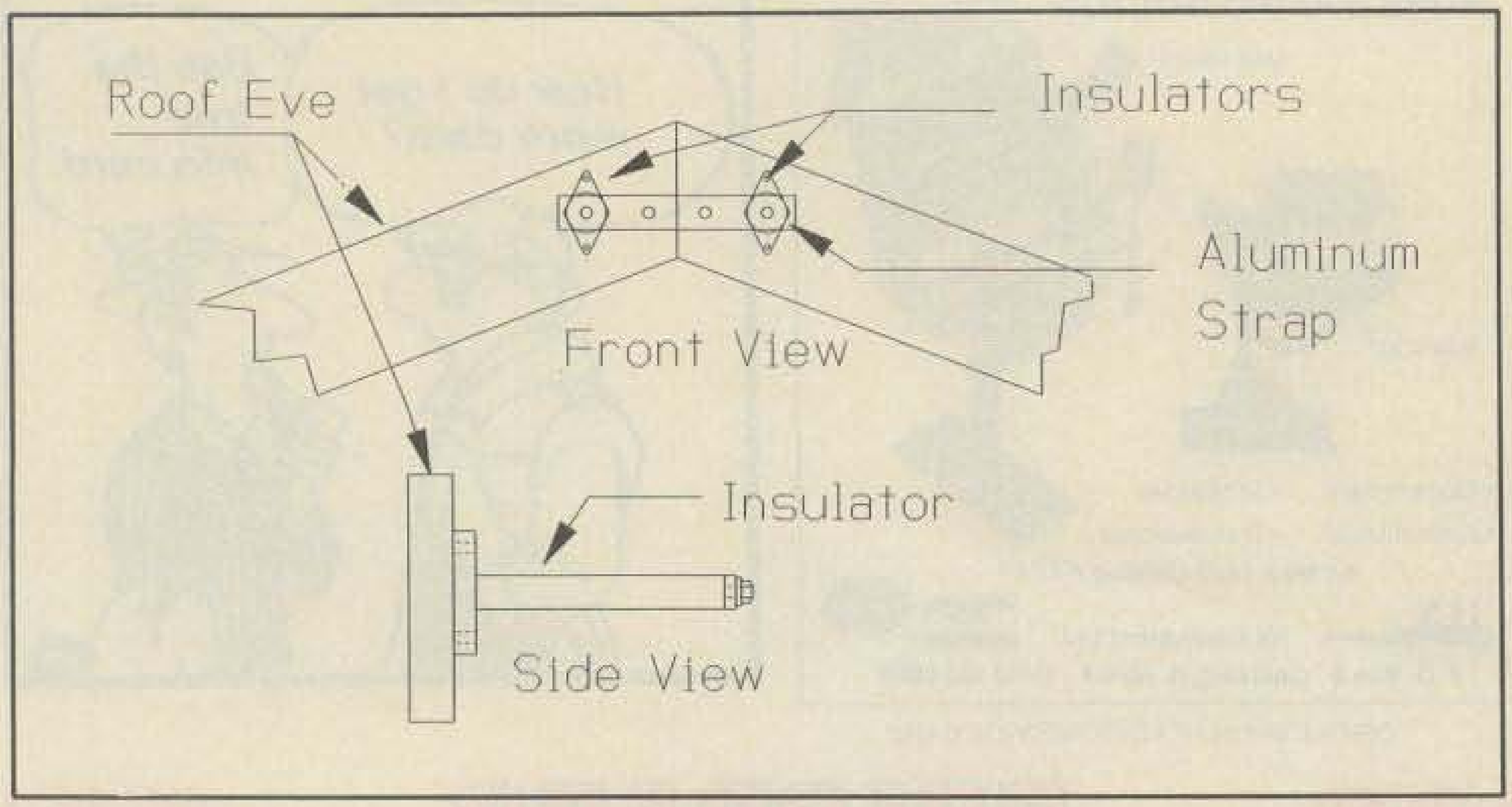


Fig. 7- Method of supporting the antenna from the eve of the house.

A simple, neat installation via long stand-off insulators.

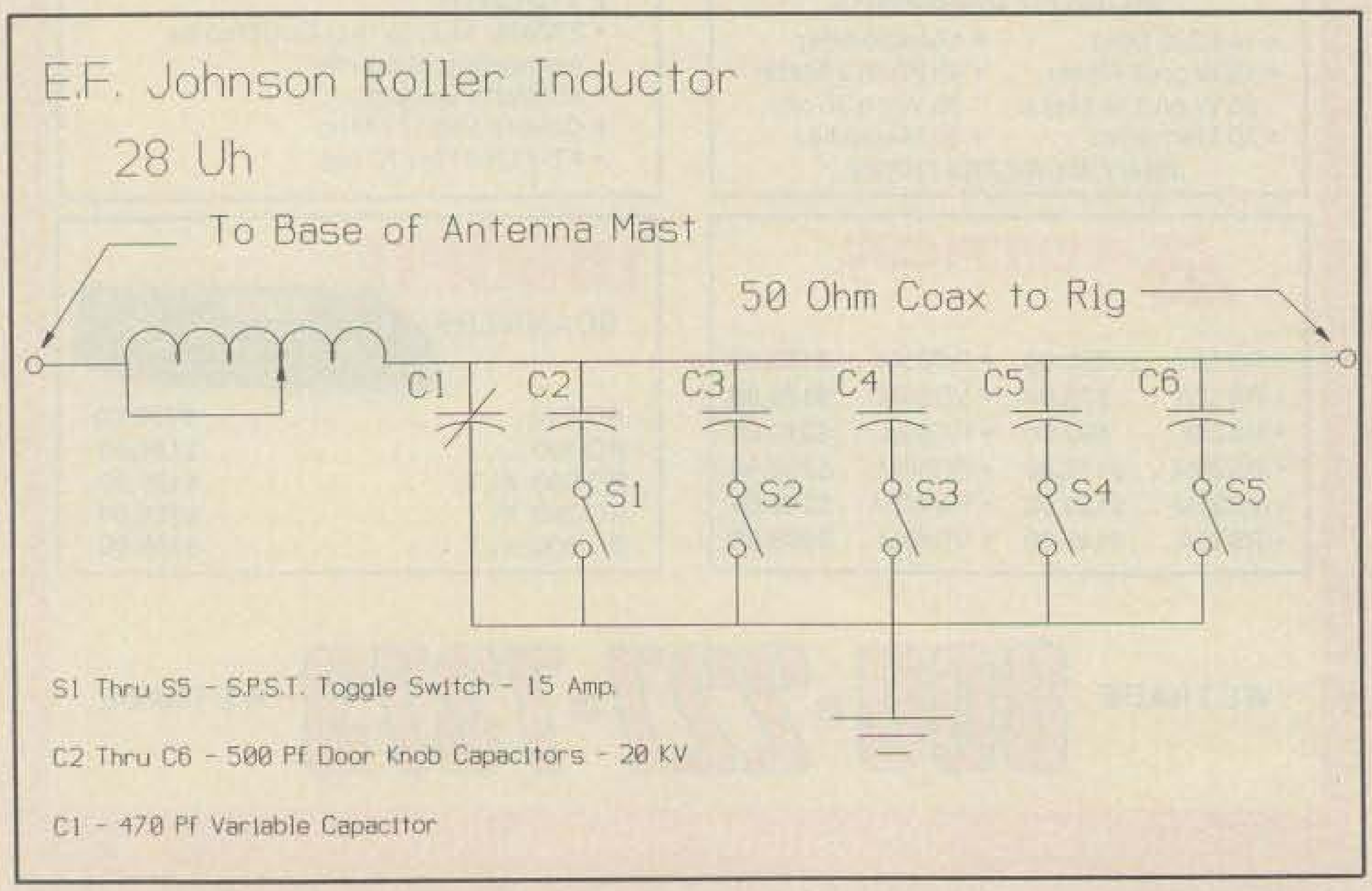


Fig. 8- Details of the author's L-network used in tuning the 160 meter vertical antenna.

at the eve of the roof as an additional means of stabilizing the mast (see fig. 7).

The mast is then guyed with nylon rope at approximately 10 feet above the roof and at the guy ring located just beneath the coil. At both guy points I employ four-way guying utilizing eye-bolts screwed into the roof as anchor points.

Tuning The Antenna

I used a Delta OIB-1 Operating Impedance Bridge to measure the resistive and reactive components of the antenna. My initial measurements indicated that the antenna was inductive. Therefore, I removed one of the horizontal capacity elements and remeasured the base impedance.

My second measurement revealed that the antenna was resonant at 1.834 MHz. Since I wanted to operate with the antenna resonant at 1.855 MHz, I lowered the telescoping mast to a point that allowed me to reach the horizontal capacity-hat element. Using a small tubing cutter I removed 3 inches from each end of the element. Raising the telescoping mast back to the 40 foot level, I again measured the base impedance and found it to be resonant at 1.853 MHz. I decided to accept 1.853 MHz as the resonant operating frequency.

The final base impedance measurement was 40 ohms resistive, plus or minus J0. At this point I installed my L-network in series with the feedpoint of the antenna and adjusted for an input impedance of 50 ohms, plus or minus J0 (see fig. 8 for details on the L-network).

To verify that my measurements were correct, I inserted a Bird wattmeter, model 43 in series with the input feedline and checked the reflected power. The reflected power was zero.

On-the-air tests seem to indicate that the new top-loaded vertical is working very well. The system does provide a limited bandwidth of approximately 20 kHz before requiring retuning of the L-network.

I would certainly recommend this antenna to anyone interested in operating on 160, even if you have enough room to construct a full-size horizontal dipole. You will find that the short vertical will almost always perform much better than a full-size horizontal dipole.

In the interest of safety, I would like to point out that a 36 foot vertical antenna could be an excellent lightning rod. I would strongly suggest a method of grounding the base of the antenna to a good, solid earth ground during long periods of non-use, especially prior to an incoming storm.

As with almost all vertical antenna systems, a good radial ground system is required for maximum performance.

I welcome any comments or suggestions on the design or construction techniques employed in this construction project. CQ