# Stacking UHF Antennas

## *Get gain with less pain.*

by Ronald Baker WB4HFN

Venturing into amateur television or "ATV" for the first time presented me with new and exciting challenges. Not only was I operating at unfamiliar frequencies; I also had to deal with the greater bandwidth needed for video transmission. The most important consideration for me was the antenna system.

Towers and large obtrusive antennas are not allowed in my subdivision. Next to a good antenna system, overall height is the most important factor. For my application, height was not a problem since I live on a hilltop several hundred feet above average terrain. My problem was to design a good antenna system that would be physically small and still provide adequate gain.

### Design

In talking with other hams operating ATV, the general recommendation was: "The higher the better, using the biggest antenna you can rotate." Antenna-wise, most of the operators were using antennas with gains of 13.5 dB to 18 dB. Researching various antennas, I found that for the required gain the boom length is 10 to 20 feet. That length would be too obtrusive for my neighborhood. To solve this problem, I set out to design and build an antenna system that would give me a minimum of 14 dB gain with an overall boom length of under five feet.

Not knowing a lot about VHF/UHF antenna design, I first looked at various antenna manufacturers and discovered that Cushcraft makes a beam that covers the 430 to 440 MHz band, with 11.5 dB gain, and a boom length of four feet. It seemed to fit my requirements, except for the gain.

I erected a system using this antenna and found that it performed well, but the lack of gain was very noticeable. The antenna match right out of the box was almost perfect. I measured very low standing wave or reflected power with a Bird model 43 wattmeter at 432 MHz. At this point, the only thing I needed was more gain. One way to quickly get an additional 3 dB would be to stack two antennas together. Since the antennas are vertically polarized, stacking would eliminate the need for a Fiberglas mast. Normally, a metal mast going through a vertically mounted beam tends to distort the radiation pattern and can affect the overall gain, especially at VHF/UHF frequencies.

There are many different types of UHF beams on the market today, but most are not suited for ATV operations. Most commercially available antennas are designed for the FM portion of the band between 440 and 450 MHz. This type of antenna works well at the designed frequencies, but performance in the 420 to 430 MHz region is compromised because the element length is too short for a proper match. Operating ATV, you will quickly learn that every dB of gain or loss affects picture quality. The Cushcraft model 432-11 antenna is still a slight compromise because it's designed to operate in the 430 to 440 MHz range. This is the SSB portion of the band and is shared with the upper half of the ATV band. This segment of the band is usually where you will find ATV repeater input frequencies, which will present a good match to your ATV transmitter.

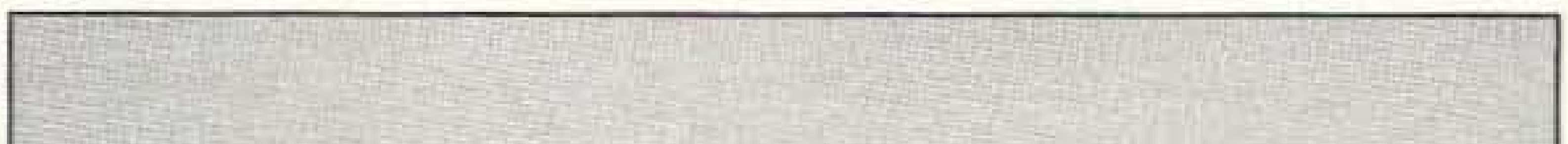

*Photo A. The stacked UHF antennas.*

Signal loss in the 420 to 430 segment was noticeably greater. This segment is usually reserved for the ATV repeater transmitters, which have the signal advantage over an individual station. Also, receive signal loss can be further minimized by using a good RF preamp, preferably mast-mounted. Most ATV operators will tell you that using a good RF preamp is essential, no matter what type of antenna design you use.

When it came to stacking UHF antennas, I thought it a simple matter to mount two antennas, hook up a phasing harness, and attach the feedline, WELL . . . ALMOST! Mounting the antenna was a simple task. Using a "T" configuration mast I mounted the antennas on each end with 26 inches separation, as specified by the manufacturer. The actual separation between antennas varies with the type of antenna and boom length. Figure 1 shows the overall construction.

The antenna phasing harness presented an interesting challenge. I had two options for a harness: Purchase one or construct my own. Spending $50 for a ready-made harness consisting of four coax connectors, one "T" connector, and a few feet of RG-59, was totally out of the question. Not knowing much about phase harness construction, I hit the books for information. I was surprised to find little information available, and what I did find was vague, with no clear-cut answers. I even contacted the antenna manufacturer where I received a few suggestions, but again nothing definite.

With all the discussion and reading, I was able to determine the length of the cable. The cable from the "T" connector to the an-

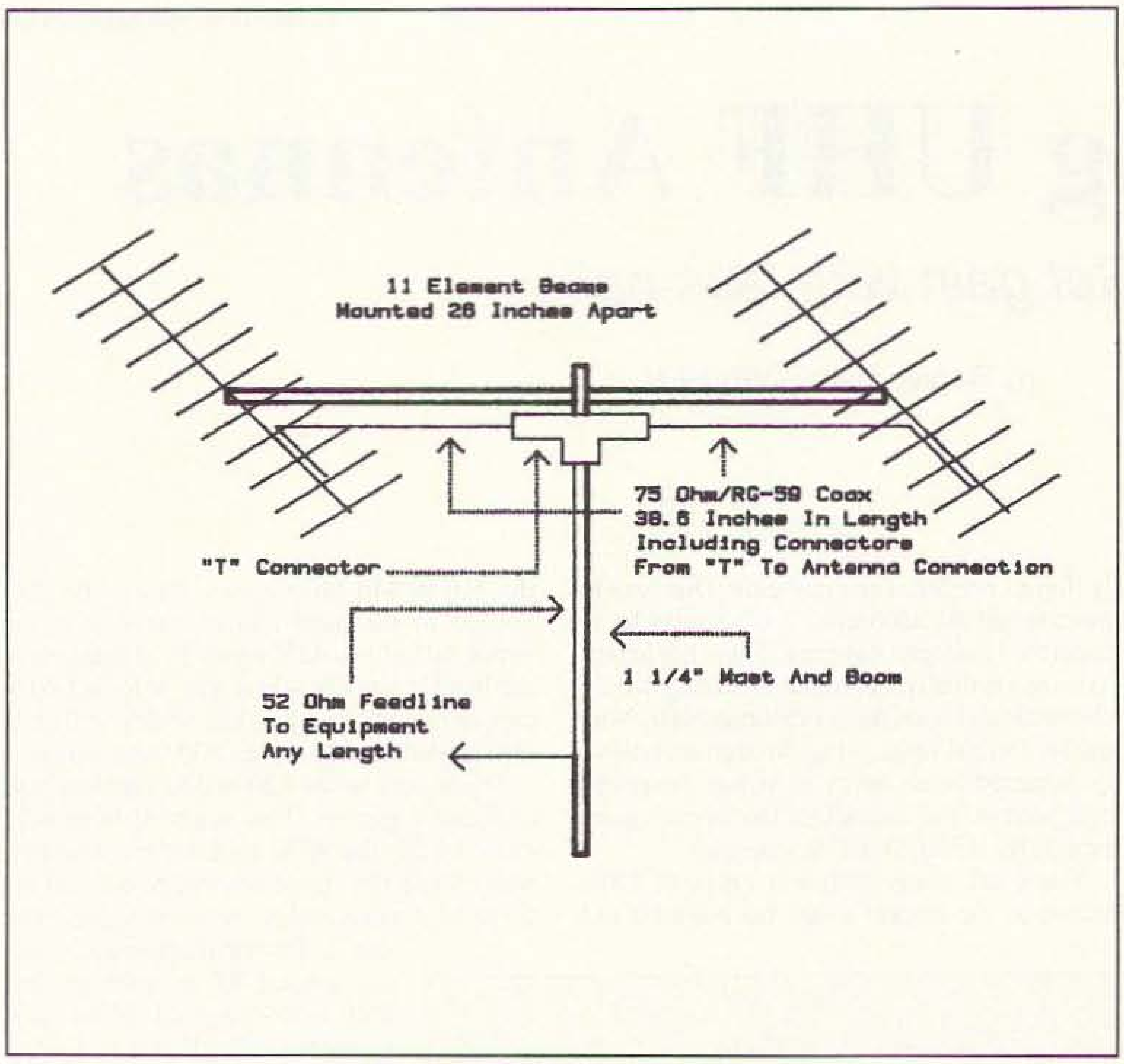


*Figure 1. Final assembly detail.*

tenna must be an odd multiple of a quarter wavelength, minus the length equal to the propagational delay of the cable. Propagational delay is a comparison expressed as the percentage of the time it takes for signal to travel through coax to the time it takes to travel the same distance through free space.

The cable length, including connectors, must be the same on both sides of the "T" connector. The feedline to the "T" connector from your equipment can be any length.

For example, let's use the frequency 432 MHz and RG-59 75 ohm cable.

Our formula is: CL = MQW x PPD

CL = the length of the coax cable in inches, including connectors from the "T" connector to the antenna.

MQW = the odd multiple of a quarter wavelength in inches, at the operating frequency.

PPD = the coax propagational delay, which for RG-59 is 85%. In the formula this number is expressed as a decimal number.

First, determine the quarter wavelength of the operating frequency using the formula:

Quarter wavelength in inches = 2808/frequency in MHz

In our example: Quarter wavelength = 2808/432

Quarter wavelength = 6.50 inches

Next, determine the length of coax needed between the "T" connector and the antenna. For my project I needed a minimum of 35 inches of cable to make the connection from the "T" connector to the antenna. I chose to use the seventh multiple, which gave me an overall length of 45.50 inches. Next, we multiply this number by the coax propagational delay of 85 percent, as shown below.

CL = MQW x PPD

CL = 45.50 inches x 0.85

CL = 38.67 inches

As shown in our formula, the proper coax length for the phasing harness is 38.67 inches from the "T" connector to the antenna. This measurement is tip-to-tip, with connectors as shown in Figure 2.

### Tuning

Tuning the antenna system is a simple task. You must use a power meter or SWR bridge designed for UHF, such as the Bird Model 43. The meters designed for HF and even 2 meters are usually not accurate at UHF frequencies.

After the antenna system has been assembled and mounted on the "T" shape boom, tune both antennas individually for minimum reflected power or SWR. In this step the coax from your equipment is connected directly to the antenna. The phasing harness is NOT connected.

After both antennas are properly tuned individually, connect the phasing harness to the antennas as shown in Figure 1. If everything is tuned properly and the harness is cut correctly, the SWR should still be good, but slightly higher than the reading you had with each antenna individually. At this point, all further adjustments to fine-tune the antenna array can be made by adjusting only one antenna. It doesn't make a difference which one you use to make the adjustments—the important thing is to adjust only one antenna. I tried various methods of adjustment and found that this method works the best.

Overall antenna performance in the upper portion of the band was very good, considering the antenna's size. The manufacturer antenna gain specification for this design was 16.8 dB. Even though I feel this may not be a realistic figure, there was a definite improvement over a single antenna of the same type. In comparing this design with the larger ATV antennas, it performed very close to the antennas in the 10 to 14-foot range that give between 14.2 to 14.8 dB gain.

If you need a good antenna system on ATV and have space limitations, this design works well. At UHF frequencies, height above average terrain is extremely important. Even the best antenna system performs poorly if you're looking into trees, hills or nearby structures.

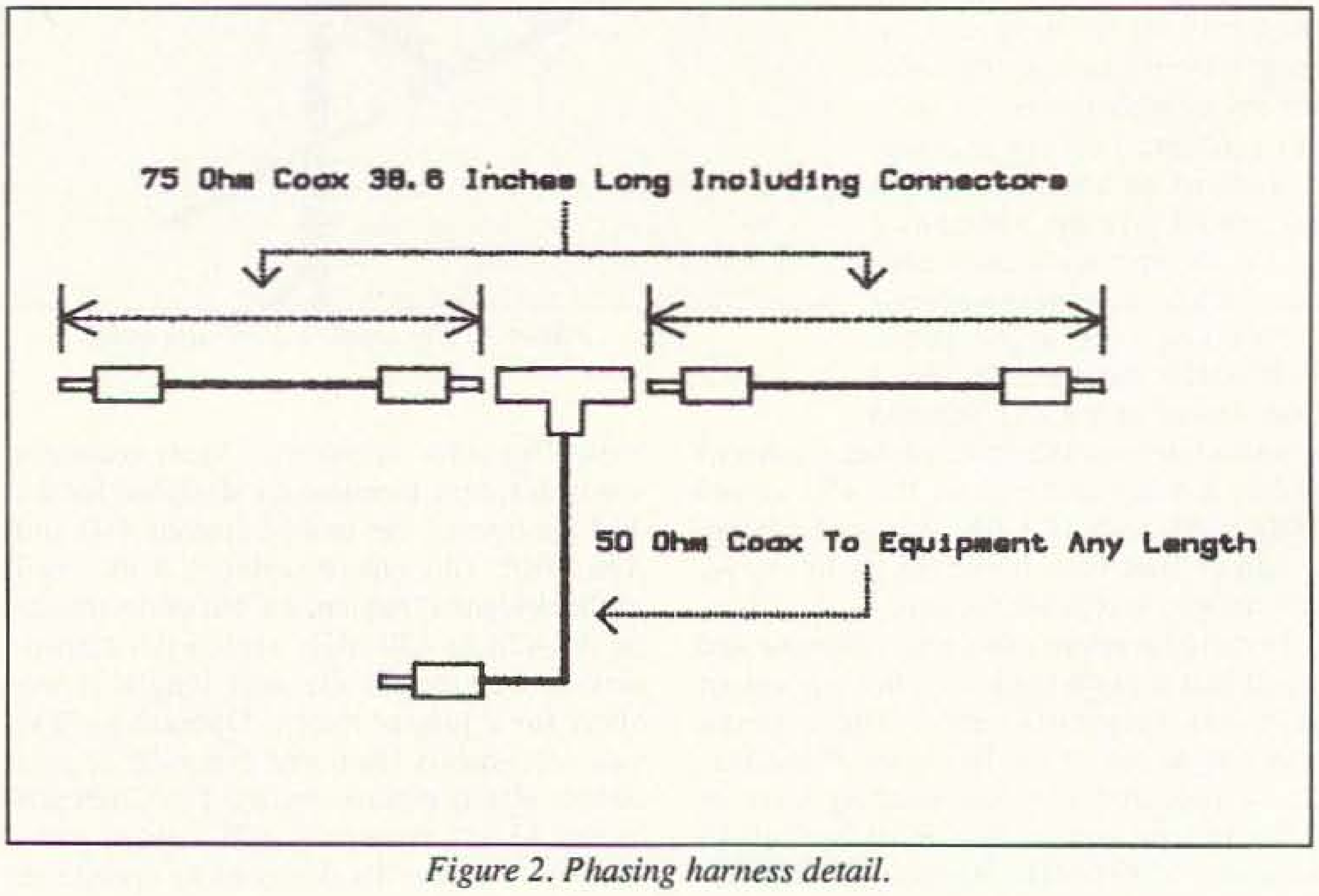


*Figure 2. Phasing harness detail.*