K. C. Jones KA8RCJ
620 Meadow Drive
Newark OH 43055

Six for Two

Get range-tested 12-dB gain for under $5! K.C. Jones engineered this 2m delta beam for maximum bang per buck.

Here it is, just what the world needs, another article on two-meter antennas. It has been so long since STS-9 touched down that one would think enough has been said about the construction of two-meter antennas for working the shuttle. Well, I wanted to get my two cents in before I consider the case closed.

I had quite a lot of fun building this antenna and I learned a little in the process. One of the things I learned was that in ham radio it is not necessary to buy when you can build—and the learning experience is great. I will show you the somewhat unusual way I built this antenna while spending very little money.

My need for a two-meter antenna with gain and directivity came about in the same way it did for many others . . . the scheduled launch of STS-9 was drawing nigh. Since money is always tight in our household, my only options were to build an antenna or forget the idea of working the shuttle entirely.

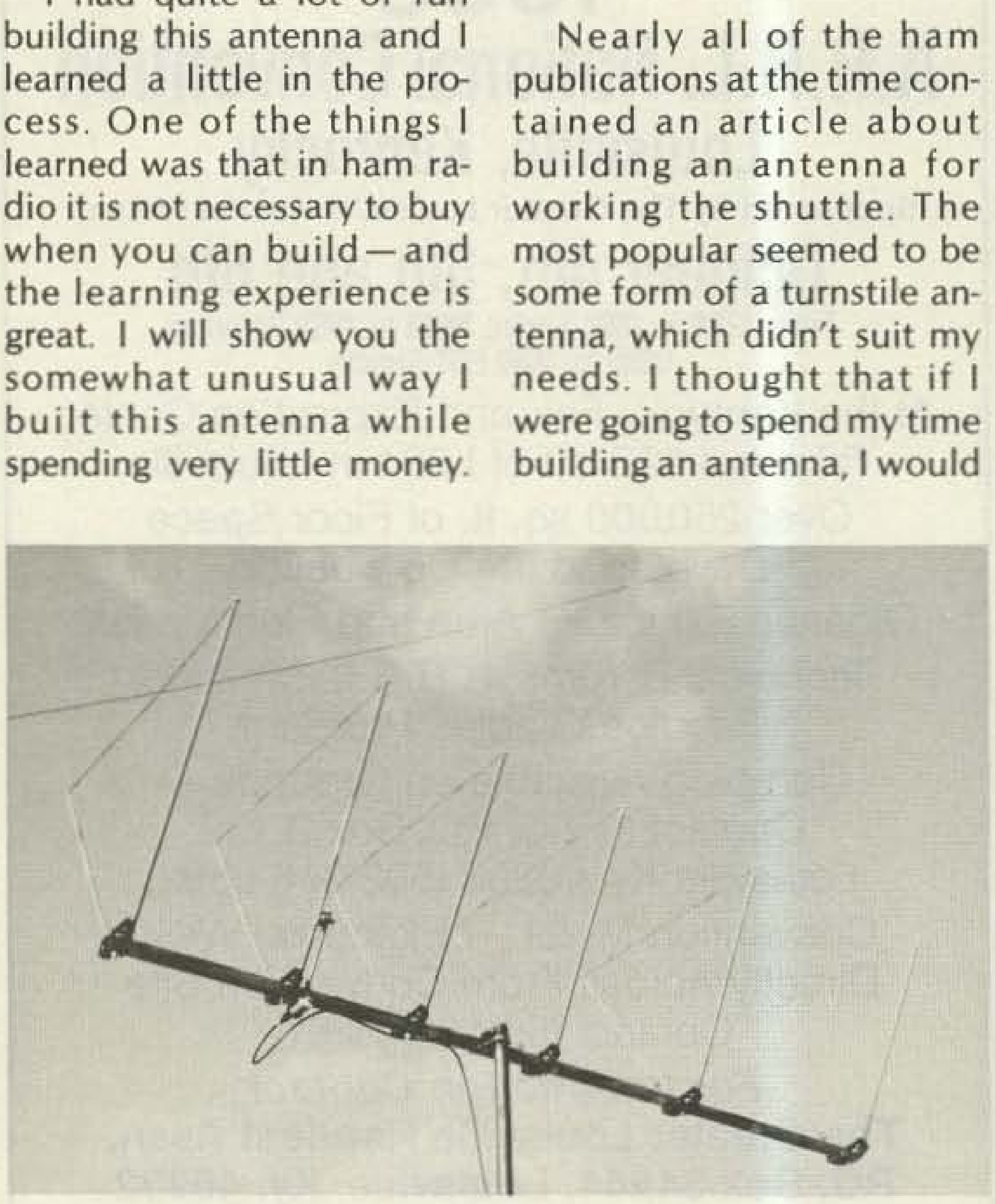
Nearly all of the ham publications at the time contained an article about building an antenna for working the shuttle. The most popular seemed to be some form of a turnstile antenna, which didn't suit my needs. I thought that if I were going to spend my time building an antenna, I would like to be able to use it for some other purpose besides the shuttle.

Remembering an old TV antenna in the attic and finding an old 1970 *ARRL Antenna Book* brought about interesting possibilities. I had visions of some sort of beam antenna built entirely of salvaged parts from the TV antenna. A simple yagi would do the job, or maybe a quad for both vertical and horizontal polarization. But for some reason, the three-element delta-loop configuration in the book caught my eye.

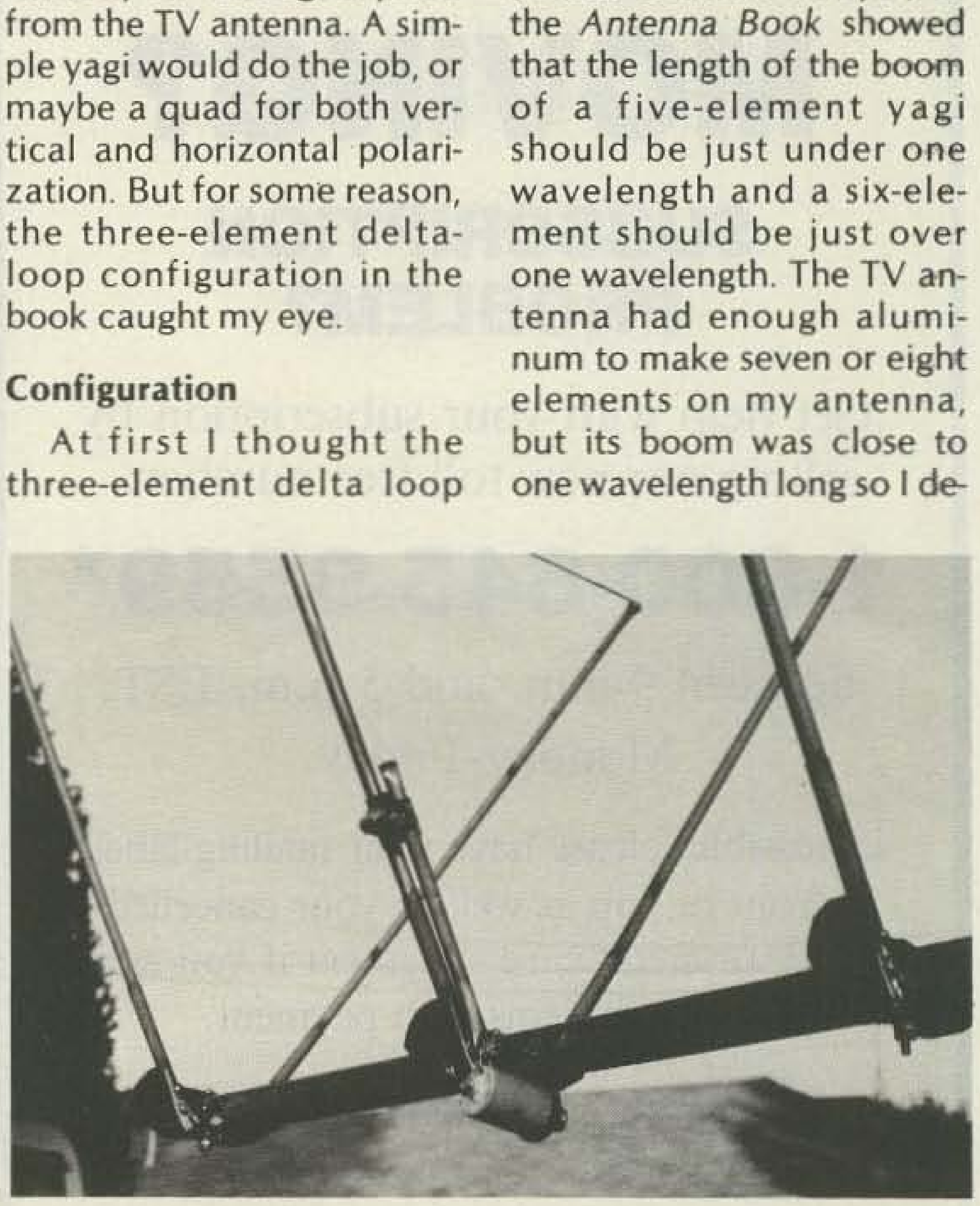
Configuration

At first I thought the three-element delta loop would be the antenna that I would build; however, I soon realized that five or six elements would be possible with the amount of aluminum that could be salvaged from the TV antenna. The first step I took was to come up with a design on paper.

A graph in chapter four ("Multi-Element Arrays") of the *Antenna Book* showed that the length of the boom of a five-element yagi should be just under one wavelength and a six-element should be just over one wavelength. The TV antenna had enough aluminum to make seven or eight elements on my antenna, but its boom was close to one wavelength long so I de-



The six-element delta-loop antenna for 146 MHz.



The gamma match. There is a variable capacitor enclosed in the film can.

cided on building the delta loop with six elements.

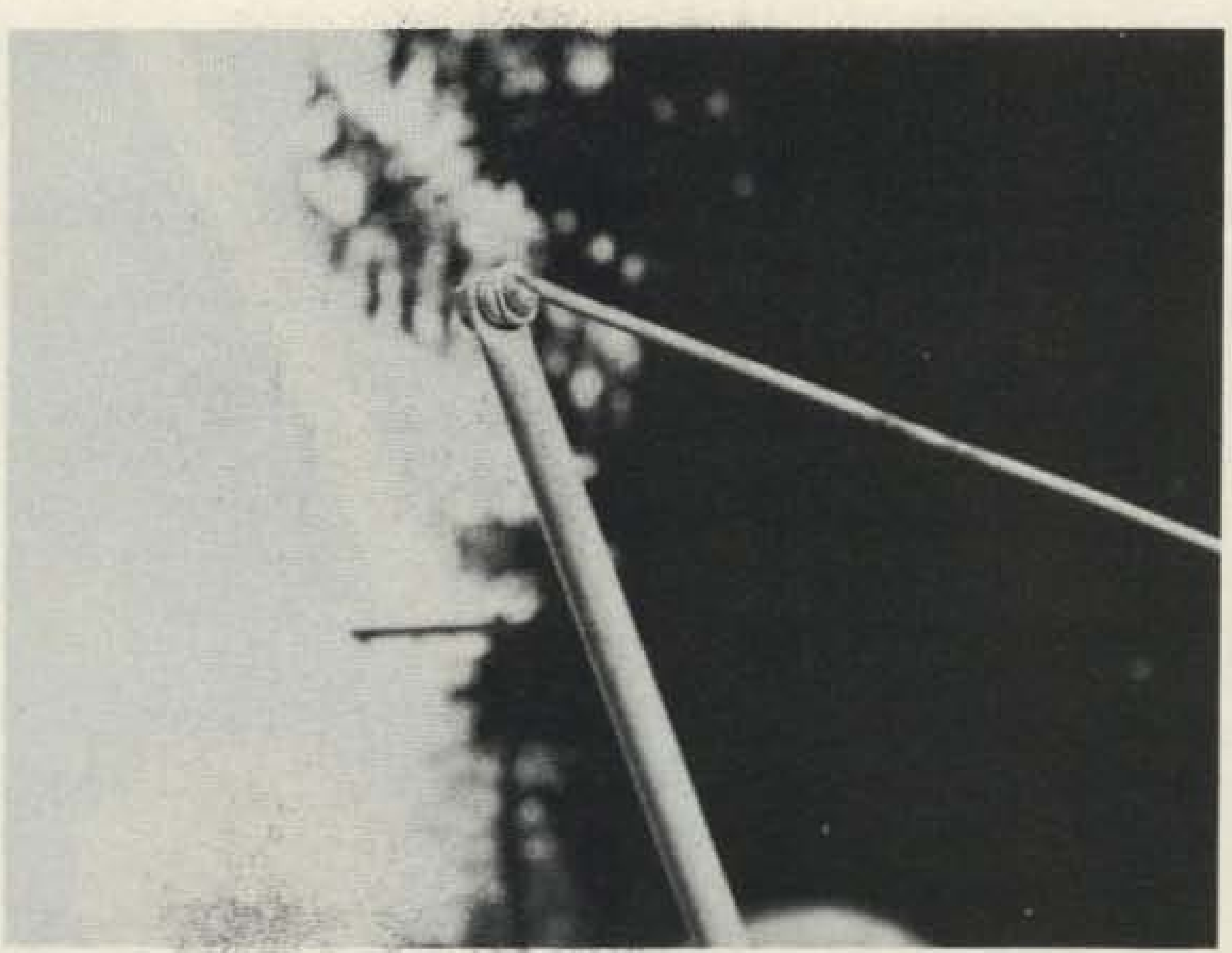
Now that I knew I would use six elements, finding the size of each element was the next bridge to cross. The *Antenna Book* showed the distance around the driven element to be 82 inches. This was arrived at by using the formula, length in feet = 1000/f (where f is the frequency in MHz) found in the chapter dealing with rotatable antennas. I made the reflector five percent larger than the driven element, using the formula, length in feet = 1050/f, and by using the formula, length in feet = 950/f, the first director was made five percent smaller. The sizes of these elements followed closely the sizes of the elements described in the article in the *Antenna Book*.

Now I had three directors to add. I knew the additional directors would decrease in size from the driven element, but not at the same five-percent rate. I made director #2 eight percent smaller than the driven, director #3 ten percent smaller, and director #4 eleven percent smaller than the driven element.

Here is a list of formulas for the length of each element, giving the distance around the loop in feet:

Reflector	—1050/f
Driven	—1000/f
Director 1	—950/f
Director 2	—920/f
Director 3	—900/f
Director 4	—890/f

The angle at the base of the loop should be 65 degrees, according to the article; the other two angles will be equal at 57.5 degrees each.



The ends of each outside element were flattened so that the top piece could be attached with 10 x 24 machine screws.

Now I had six elements. The next question was where to place them on the boom. The reflector and last director were easy, one on one end and one on the other. For the spacing of the other elements, I had to go back to the *ARRL Antenna Book*. In the chapter on "Multi-Element Directive Arrays," I found a table showing optimum element spacing for multi-element yagi arrays. In this table, the formula for the minimum and maximum distances between elements was given. The only thing I had to do was to choose a formula that stayed within the table's guidelines. I also had to remember that the spacings between all the elements had to add up to the length of the boom.

Keeping the above in mind, here are the formulas I came up with for the element spacing on my six-element delta loop, where L = wavelength in inches.

Reflector/Driven	= .17L
Driven/Director 1	= .15L
Director 1/Director 2	= .17L
Director 2/Director 3	= .22L
Director 3/Director 4	= .28L

Fig. 1. shows the antenna that I was going to build. (The formulas were used as starting points and the actual spacing varied slightly.)

Construction

Now that I had an idea on paper, the next step was to try to build the antenna, but first, I had to disassemble the TV antenna. It was put together almost entirely with rivets, easy to drill out to remove the elements. Everything worthwhile was salvaged. The phasing harness was made of heavy aluminum wire which I carefully straightened out and used later to make the top section of each delta loop. The wire was carefully measured out, for when I finished cutting the pieces that I needed there were only four inches left! One of the plastic insulators which was used on the phasing harness was later fashioned into the spacer for the gamma match.

When I removed the molded-plastic brackets which attached the elements to the boom, I discovered that these same brackets could be reworked to hold the elements in the vertical position rather than horizontal, as on the TV antenna.

Having already figured the dimensions of each of the six loops, I began to cut the elements that were removed from the TV antenna to form the outside elements of each loop on my antenna. The ends of the elements that had been attached to the brackets had been reinforced originally, so I used the same end to attach to the reused bracket on my antenna. The other ends were then flattened so that holes could be drilled in the flat portion to accept screws. After cutting and drilling, the outside elements were cleaned on a buffer to remove the oxidation from all the areas where a connection would be made.

Now each pair of outside elements was mounted to a plastic bracket. Originally done with a rivet, I used 10 x 24 machine screws. At this time each element looked as shown in a), in Fig. 2. Next, I took the heavy aluminum wire which was so carefully cut earlier and

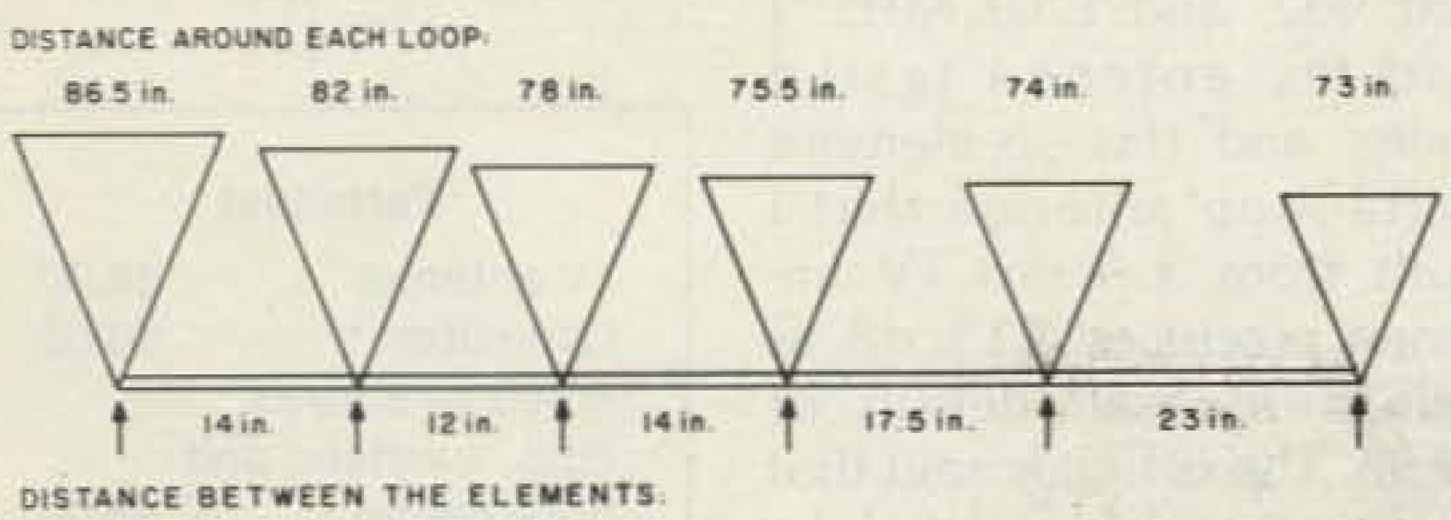


Fig. 1. Here are the dimensions I came up with to build the six-element delta loop.

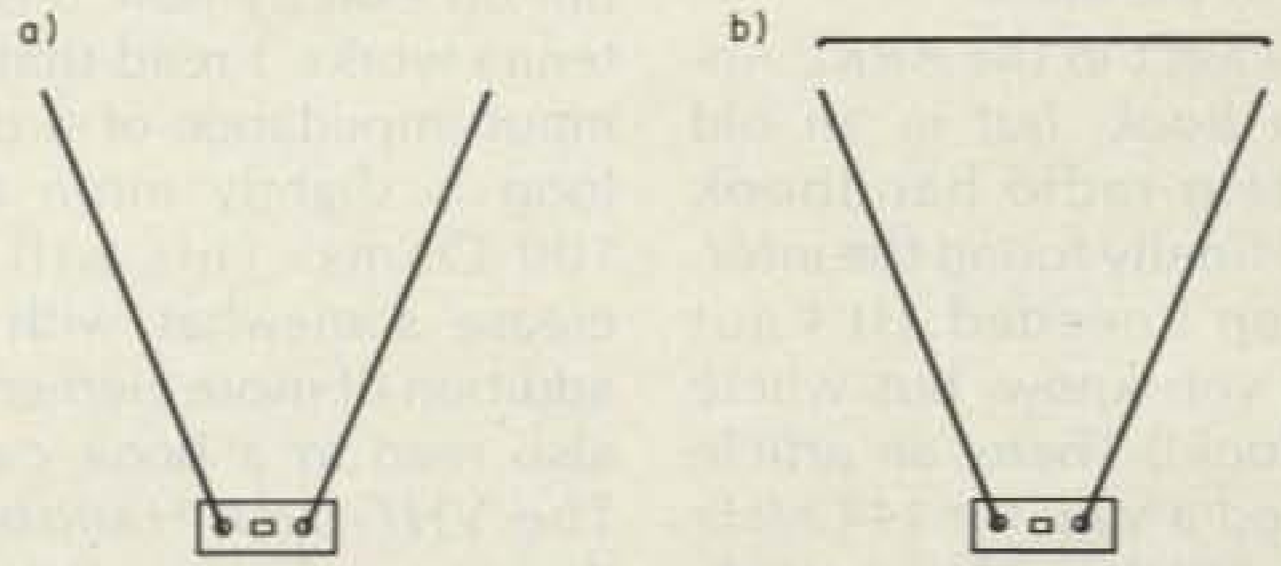


Fig. 2. With eyes formed in the ends of the horizontal pieces, they are attached to the ends of the outside elements, which were flattened and drilled earlier.

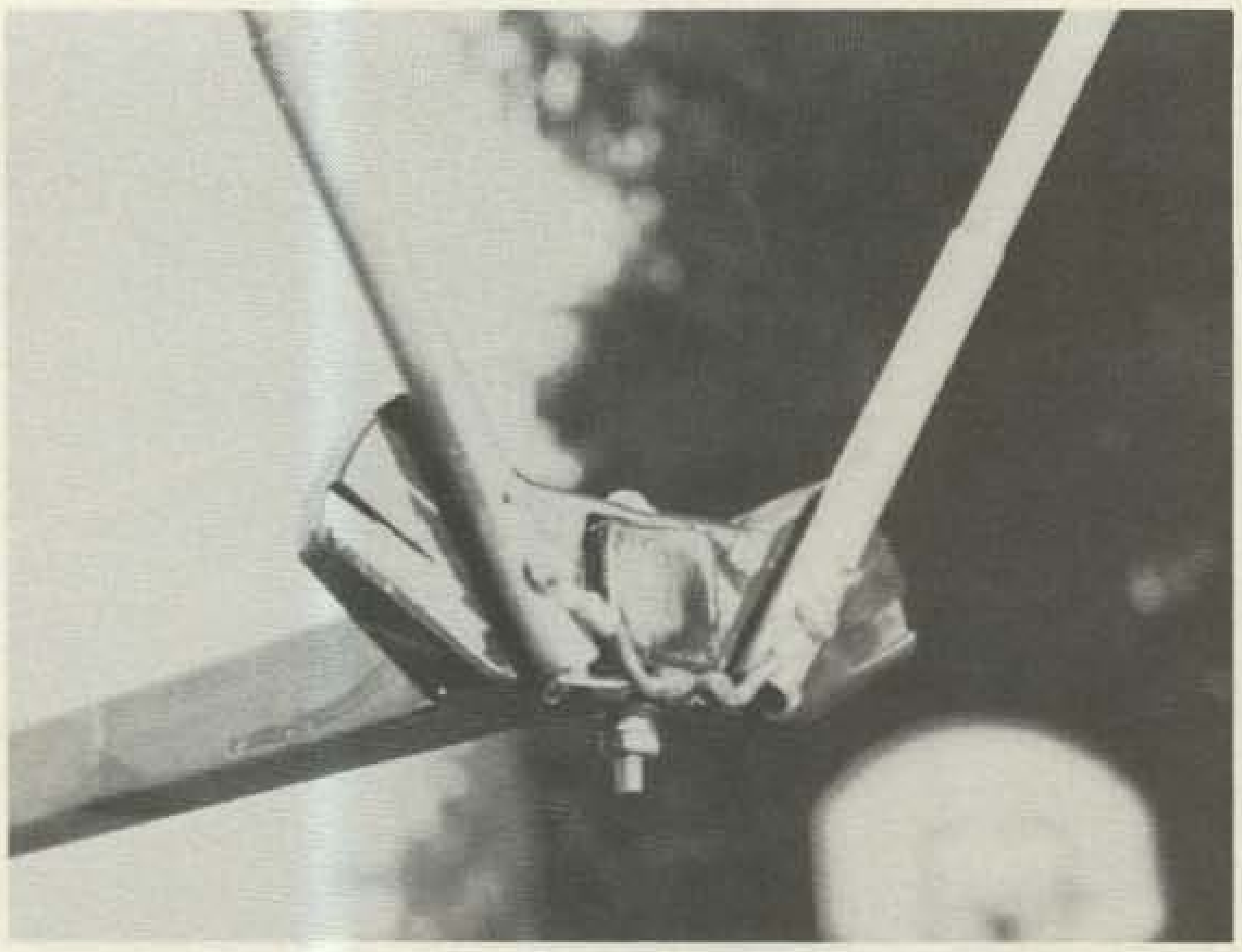
formed small eyes in the ends of each wire. Then each piece of wire was attached as the top horizontal piece of the element it was cut for. This also was done with 10 × 24 machine screws—see b) in Fig. 2.

Now that I had six complete elements, I drilled the boom at the points mentioned earlier. The boom and each plastic bracket were drilled so as to accept a 10×24 screw. Next, I slid each element onto the boom to its proper location.

Since each outside element was mounted to plastic, each loop was open at the bottom. Also, each element was insulated from the boom. To close each loop, I used #14 primary wire. At this time I also made each element common to the boom with the same wire. This was done simply because the article in the *Antenna Book* showed that the elements of the delta loop were all common to the boom. (At some later time I plan to make each element insulated from the boom to see what, if any, changes occur.)

Now that each element was mounted to its proper position on the boom, I had to figure a way to feed the antenna. The article showed that one way was with twinlead. This would not be acceptable for me as I had no way of matching it. The article also showed the antenna being fed through a gamma match made of RG-8 coax. I tried this, but it proved to be difficult to work with. After fumbling around with some other ideas, I decided to go back to the book.

It wasn't in the *ARRL Antenna Book*, but in an old amateur-radio handbook that I finally found the information I needed. (It's not what you know, but where you look!) There, an article showed a yagi for 144 MHz being fed through a variable capacitor (50 pF) and a gamma rod five inches long. I found a capacitor in the junk box that I thought was around 0 to 30 pF, and the gamma rod was made from a piece of aluminum element from the TV antenna.



A view of the bracket. Note the #14 wire strap that closes the loop and makes the element common to the boom.

The capacitor should have sufficient plate spacing to handle some power. The five-inch gamma rod didn't tune quite the way I thought it should, so a seven-inch gamma rod was tried and seemed to give the proper match. I used a plastic insulator from the phasing harness on the TV antenna as a standoff for the gamma match and a hose clamp as a shorting strap. The variable capacitor was sealed in a plastic 35mm film can.

At this time I sealed all connections with spray-on clear lacquer. This included spraying the film can to make it air tight.

Theory

I am not an engineer, so I won't try to go into any detail on exactly how this antenna works. I read that the input impedance of a delta loop is slightly more than 100 Ohms. This will decrease somewhat with the addition of more elements. I also read in a book called *The VHF-UHF Handbook* that a good rule of thumb for finding the size of the variable capacitor on a gamma match is to allow 15 pF per meter of wavelength. This followed closely with what I used on my antenna.

The size of the driven element doesn't need to be exact because, like a quad, the delta loop seems to be broadbanded. All of my calculations were based on an antenna for 146 MHz, and the antenna was built and tuned to 146 MHz. A 30-Watt rig was used, and a wattmeter that read in reflected power, not swr. At either end of the band there was only a very slight amount of power being reflected, with the wattmeter showing a full 30-Watt output. Using a field-strength meter, there seemed to be a very narrow pattern off the front of the antenna and a small lobe off the back. I have not yet tried to draw a pattern of the antenna.

An antenna range was set up at the '84 Dayton Hamfest on Sunday of that event, by a group testing forward gain of home-brew and commercial antennas for 144, 220, 432, and 1269 MHz. I had my antenna tested there, and this six-element delta-loop antenna that I built from a scrap TV antenna produced 12.1 dB of gain with a gain density of 10.98. The officials said that the range produced slightly-higher-than-actual results for short-boom yagis. At any rate, I was very pleased with how well the antenna performed, and I also won a prize for the home-brew 144-MHz category.

Conclusion

This antenna is not original in design; the delta loop has been around for a long while. The formulas I used for element size and spacing can be found in books that could be in any ham's library. The point I wanted to make was that I took an old TV antenna that was destined for the trash can, did some research, worked out a few design problems, and built an antenna that performs as well as one costing ten times as much or more. I learned some things about antennas and about problems associated with VHF that don't occur at HF.

There are plenty of unused TV antennas in the air today with the ever-growing use of cable services. As a matter of fact, just about a month ago I took down a TV antenna for a friend, and the only fee was that I got to keep the antenna and the 30-foot mast pipe. I plan to make a seven-element yagi out of this antenna. With just a little looking around, one old TV antenna can be found to turn into a nice beam antenna for the VHF or UHF bands.

By the way, the "ham-in-space aficionados" have probably already checked out my call, but for the rest of you who might be reading this, no, my call was not one of those heard by Owen Garriott in the spacecraft, *Columbia*. I was, however, able to copy him on two separate passes across the Midwest!

Not too bad! ■

Parts List

TV antenna	$0.00
Capacitor	$0.00
Machine screws, nuts, washers, and hose clamp	$5.00
Total	$5.00