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Above & Beyond

VHF and Above Operation

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VHF to microwave: how to repair old beam antennas

What started out as a winter storm here in San Diego became a severe path of destruction to my amateur-related activities and antenna system. High winds associated with the storm snapped my antenna guy wires and toppled my antenna. That was the start of all the fuss to reconstruct what had been my modest antenna system for VHF.

Evaluating the initial damage was a little hard, as the mast collapse (because of the snapped guy wire) could have been prevented by some simple maintenance. I had apparently left the system in the air for too long, without providing some care and upgrading or replacement of worn parts.

Time had made me complacent in the maintenance of my antenna system. I had not given any attention to a problem which had been waiting to happen for some time. In hindsight, we all should take time to give our systems some attention, to prevent having to replace antennas in a similar fashion.

The main culprit in my failure was the guy wires I had used. Through time they had become weak from stretching and just plain age. A simple bend showed that the material had become less malleable than new material. That should have been a great clue but it went unnoticed. All the signs were observed when the antennas were lying on top of my roof—after the system's key guy wire had broken in the high wind.

At least the roof wasn't damaged when the system came down that stormy evening. Nothing was done at the time, because we determined that no further damage could be done as long as the antennas were resting firmly on top of my roof that Friday evening. Saturday morning would tell the full tale.

I am describing this adventure in reconstruction to show the efforts I went through in an attempt to be cost-effective in making the repairs to the old existing antennas, twisted as they were. First, the careful job of removing the pile of antennas and cable and getting down to business.

On first evaluation, the two-meter and six-meter beam antennas took the worst of the storm's fury. Actually, the six-meter beam boom stopped the entire structure from becoming a tangled mass of scrap aluminum because the long boom end hit the roof and stopped the remaining antennas from becoming an intertwined mess of metal.

All was not well, as the toppling over was done in an 80-or-so mph high wind gust. It just twisted the mast after the guy snapped.

When the antennas came to rest on the end of the six-meter boom there must have been quite a shock to all of their basic structures. The gamma match of the six-meter beam shattered into a number of pieces, as did several elements of the six- and two-meter beam antennas. The RG-58 coax feeding one antenna parted, but the RG-8 (RG-213) coax held together and was at full strain holding the antenna, which was now bent over on the roof. In a way, it became part of the guy system when it went over.

Reconstruction of the system started with cutting the RG-8 coax and getting rid of old cables that were in the way. They had been in the air for many years and showed signs of age on the outer jacket. Most bolts holding the antennas were rusted beyond use and, while some came off with a little oil and elbow grease, quite a few had to be twisted off until they broke. First lesson: Spend the extra cash and use stainless or galvanized hardware on your antenna. They will not rust like common cad-plated nuts and bolts. You will thank me when you have to work on your antenna in a less hostile environment.

Removal of the beam antennas was next, placing what was left of the two- and 3/4-meter yagi antennas on the roof, off of the mast.

The last main structure to be removed was the six-meter beam. The original mast structure was removed and replaced with a new mast for the day when the antennas would go back up. Now the quandary was whether to purchase new antennas or repair the old. Taking stock, I determined that I could purchase new aluminum tubing for the six- and two-meter beam elements and (galvanized) hardware to reattach them for about $12.

The trick to pull off was how to reconstruct the gamma match of both the two- and six-meter feeds. The original gamma match systems were constructed with some sort of plastic and two sections of aluminum tubing forming a capacitor of sorts for the feed. See **Fig. 1.** How to repair this gamma match for these two bands remained to be solved. Would it be better to purchase new antennas or repair the existing? I examined the coax cable and the answer became very clear.

The coax cable was years past due for replacement. I confirmed this by testing the loss of a 50-foot section of RG-213 that had been up for a lot of years. I made a test on a new piece of RG-213 and found that the loss of the old piece was about 1.5 dB greater, compared foot for foot. The old cable had to be replaced. Purchasing new cable would be expensive. I checked the loss tables and found that Belden 9913 might be the best from the cost-to-low-loss standpoint. Expensive, but well worth it.

At two meters, the loss of Belden 9913 was one half the loss of brand new RG-213 (RG-8 quality coax). The 9913 specs at 1.5 dB and the 213 at 3 dB at 150 MHz. At 450 MHz, the Belden 9913 really shines, as its loss is 2.6 dB versus 6 dB for RG-8 types. This is a no-brainer decision—purchase the Belden 9913. Because the 9913 is a hard line type of coax, mating it to a gamma match requires that it be brought out to terminal lugs to bolt to the gamma match sections.

The #12 solid conductor of the 9913 cable was a slight problem because it has a spiral-wrapped internal construction that provides low loss but also allows water to enter at the coax end if not properly sealed. I solved this problem by crimping on my bolt connectors and then sealing the end of the open coax inner section with a small dab of RTV. I then overwrapped the center section and braid with good quality electrical tape, making many twists, figure-eights, and crossed-over tape sections to add additional protection from the weather.

Someone suggested the I apply a layer of varnish or plastic spray to cover the tape. On the advice of Kerry N6IZW, we tried some plastic sprinkler pipe glue and overcoated the tape with the plastic cement. This seemed to be best, as it really made what seemed to me to be a bond with the electrical tape and the jacket of the 9913 coax cable. This looked to me to be the best method of sealing the Belden 9913. Additionally, when I mounted the cable on the gamma match I positioned the cable on top and ran the crimp-on connections on down, forming a sort of drip loop preventing moisture from easily entering the coax cable. See **Fig. 2.**

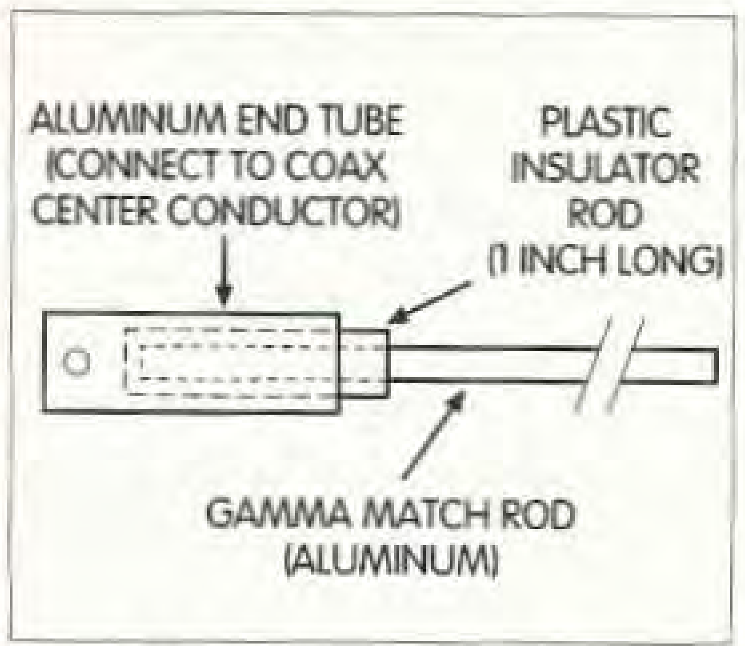

Fig. 1. Basic yagi gamma matching design typical of most commercial designs using plastic matching capacitor.

Now that my main expenditure was going for new Belden 9913 coax to replace my old lossy cable, the idea of a couple of new $150 beam antennas for two and six meters would be scrapped and the old antennas repaired. With $12 allocated for replacement element parts, the problem now remaining was how to repair the gamma matching scheme on the existing beam antennas.

Looking through various antenna handbooks and other literature, I found a simple rule stating that the gamma capacitor should be about 170 pF at 14 MHz and then scaled proportionally for other frequencies. Some simple math meant that at double the frequency, the capacitor value would be halved (28 MHz = 85 pF, 56 MHz = 42 pF, making a two-meter capacitor somewhere in the 10 pF range).

I reconstructed my six-meter gamma match by soldering a 37 pF glass piston capacitor onto short sections of brass tubing that fit over the piston capacitor and would fit over the old aluminum gamma match adjustment arm. The end by the connection to the insulator and center of the coax attachment was flattened and drilled to accept a #8 stainless bolt. The other end of the capacitor brass extension tube was slipped over the gamma arm and drilled to be secured with a 4-40 stainless bolt and nut. This attached the brass and aluminum rod firmly together, making a good electrical connection. With max capacitance at 37 pF, the brass sleeves were then overtaped and coated with plastic cement. See **Fig. 3.**

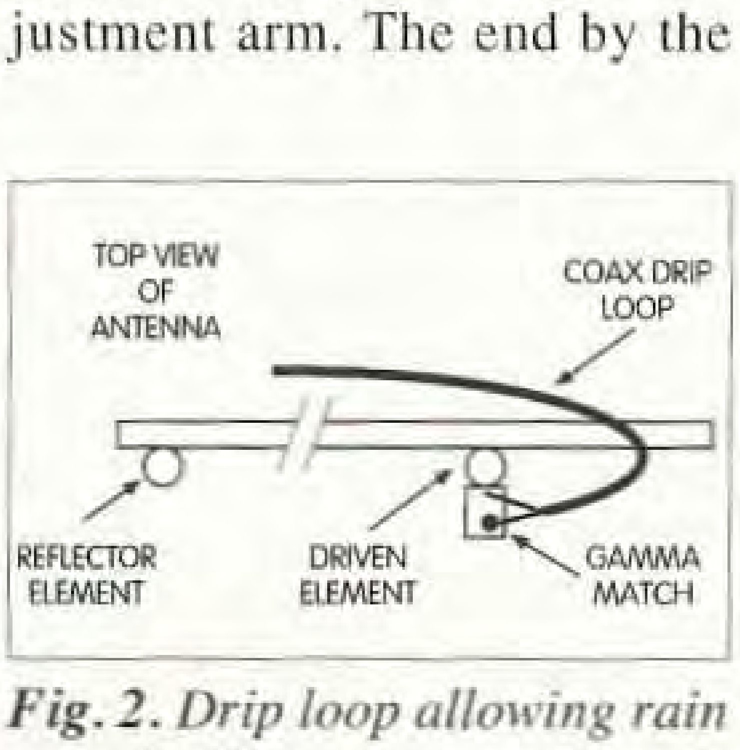

Fig. 2. Drip loop allowing rain to roll off the coax end termination by having the open end sealed and pointing down so it will not collect moisture.

This worked amazingly well, but it soon became evident that the construction was not sturdy enough for the application. The glass piston capacitor and associated rebuilt gamma arm worked very well and was easy to adjust to resonance on the six-meter beam. However, this arrangement was not as good as I thought because I cracked three glass piston capacitors before I gave up on the idea.

In actuality everything worked well, but the glass piston capacitor I used was not sturdy enough. Looking through my junk box, I found several doorknob-type high voltage ceramic capacitors in the 25 and 100 pF range. These are the ones that have for the center connection a brass 6-32 screw mounting shaft.

I tried to insert the capacitors into the brass tubing I used with the earlier piston capacitors, and had to file off the edges. Then I soldered the capacitor onto the brass tubing sections and confirmed that while the value of capacitance was a little low, this worked quite well. The hammer test with a screwdriver proved the assembly to be quite rugged (see **Fig. 4**).

Because the assembly used a gamma capacitor of 25 pF, the gamma matching arm had to be set at maximum to bring the section into resonance at 50 MHz for a great SWR of 1:1 or quite near it. As the test was made on the ground, there were, I am sure, stray effects showing up—but it worked well.

Just as with the glass piston capacitor, 37 to 40 pF would be the ideal capacitance desired for the ceramic high voltage capacitor as well. Junk boxes being what they are, I don't believe you or I will find a 40 pF capacitor. I had to settle on a 50 pF one and use it on the final gamma matching arm I constructed for the six-meter beam. The total cost of reconstruction for the gamma match was 50 cents and about five hours of elbow grease.

Oh, I forgot: There was that pint of gas to travel to K6DS's QTH to pick up the 50 pF ceramic capacitor that I used. I put the 50 pF unit on the antenna, confirmed a greater adjustment range over frequency, and then left it on for a final match when the antenna is up on the mast in the air.

For all these tests, I have attributed the ease with which I was able to make them to my MFJ-259 antenna analyzer SWR meter. Makes the evaluation and adjustment of antennas in the 2 to 150 MHz range quite easy.

Well, as you suspect, all the coax cables are cut to length and crimp connected in place, overwrapped, and sealed with connectors on the appropriate ends. What else remains to be done? In my case, it's mostly metalwork, making gusset plates to mount the boom to the two-inch mast section.

Here comes the hard part. I had to settle for less than I'd planned, as I could not find galvanized two-inch muffler U-bolts with back plates to fasten securely to the mast. I had to compromise with (untested) standard muffler clamps. These arrived as black steel and I am not sure how they will stand up to the weather.

I manufactured my mounting plates from four muffler clamps to secure the beam antennas to the two-inch main mast. It resulted in a very sturdy mounting arrangement, and was constructed out of scrap aluminum old panel sections that came out of the old junk box. I picked up the muffler clamps at a muffler repair shop. They came with the round-to-flat

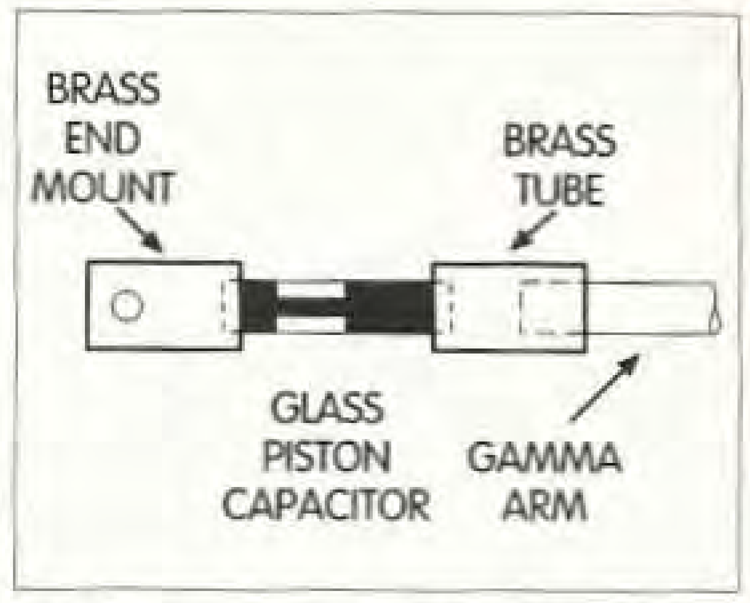

Fig. 3. The first attempt at constructing the gamma match section with a glass piston capacitor soldered to small sections of brass tubing for connections to the mounting insulator and gamma aluminum rod.

adapter clamp plate so necessary for securing the round tube of the boom and mast sections tightly.

The muffler-type clamps are probably available from some hardware source, but I was unable to locate them and settled for the muffler shop clamps. The cost was minimal for the clamps: one dollar for the two-inch ones, and less for smaller clamps. Quite reasonable. I lubed mine with a little grease and slipped an SMA coax protector cover over the bolt ends to protect them from rusting. Can't have everything, but you can prepare for the future.

I hope you have gotten some ideas on antenna reconstruction from my sad tale of the destruction that occurred on that Friday evening when things went "bump in the night." 73, Chuck WB6IGP.

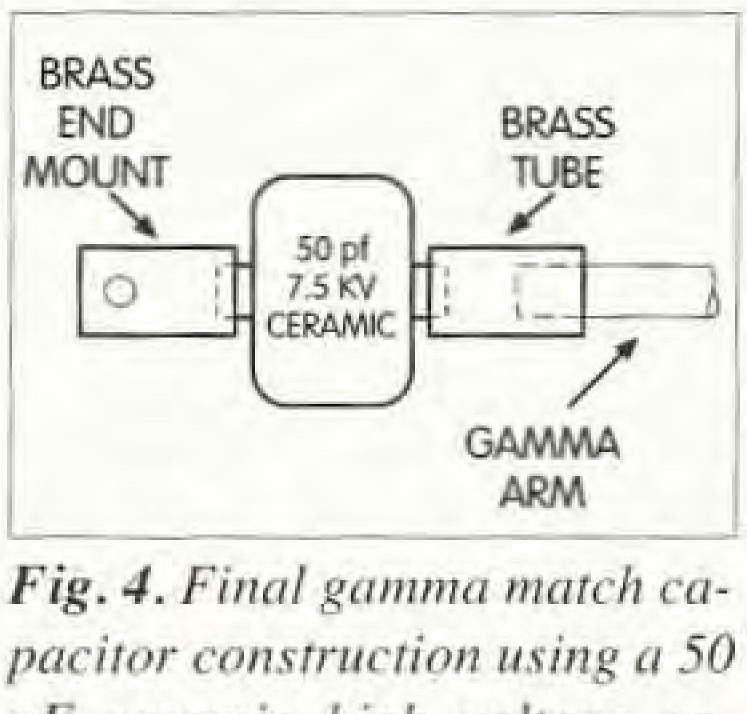

Fig. 4. Final gamma match capacitor construction using a 50 pF ceramic high voltage capacitor attached to brass tubing. Near end swaged for nut and bolt attachment and the other end inserted into the original aluminum gamma match arm. Attached with a 4-40 bolt through both brass and aluminum rod.