

# Notes on Home-Built Antenna Hardware

with permission from **L. B. Cebik, W4RNL**

These notes represent a set of practices that I prefer. The collection is not the only way to do things, but it is one fairly good way among the many acceptable practices. Nevertheless, I recommend that you examine various antenna handbooks for alternatives. We all have different skills and our access to materials may vary. The more techniques that you have at your disposal, the easier it will become to find the ones that fit your circumstances.

**Beam Antenna Hardware** My preferences for beam construction all focus upon one word: quality. Quality construction is a synonym for durability, that is, the ability of the beam antenna to perform for a long period with all of the capabilities it had when you first put it in place. Quality beam construction breaks down into three main materials: stainless steel, aluminum, and polycarbonate.

## Stainless Steel

I prefer to use only one material for all antenna hardware: stainless steel. Not many years ago, we had to use mail order or on-line sources for stainless steel nuts, bolts, and washers. However, these items are now regular stock in many home centers. The reason why I prefer stainless steel is simple. Virtually all beam antennas bring together at least two materials: aluminum and copper.

Dissimilar materials are subject to electrolysis, the corrosion of materials due to a difference in the atomic electrical potential of each material. Copper and aluminum are both conductors, but we cannot durably join the two at a connection point. When some home builders resorted to cheaper aluminum AC wire, they had to find connectors that would prevent electrolysis between the aluminum wire and the brass (mostly copper) screws at the terminals. Only power companies use aluminum wire these days and homes have returned to an all-copper status.

The rate of corrosive effects between dissimilar metals depends on their "nobility." The more distant the metals on the chart (see **Table 1**), the greater the potential between them, even in the most weather-protected conditions. As the table notes, a difference of only +/-0.3 volts between the atomic potential of two metals at a junction indicates the strong possibility of significant corrosion at the junction.

Atomic Potential of Various Metals that Might Come into Contact with Each Other									Potentials in volts				Table 1
Metal	Magnesium	Aluminum	Zinc	Iron	Cadmium	Nickel	Tin	Lead	Copper	Silver	Palladium	Gold	
Magnesium	0.00	-0.71	-1.61	-1.93	-1.97	-2.12	-2.23	-2.24	-2.71	-3.17	-3.36	-3.87	
Aluminum	0.71	0.00	-0.90	-1.22	-1.26	-1.41	-1.52	-1.53	-2.00	-2.46	-2.65	-3.16	
Zinc	1.61	0.90	0.00	-0.32	-0.36	-0.51	-0.62	-0.63	-1.10	-1.56	-1.75	-2.26	
Iron	1.93	1.22	0.32	0.00	-0.04	-0.19	-0.30	-0.31	-0.78	-1.24	-1.43	-1.94	
Cadmium	1.97	1.26	0.36	0.04	0.00	-0.15	-0.26	-0.27	-0.74	-1.20	-1.39	-1.90	
Nickel	2.12	1.41	0.51	0.19	0.15	0.00	-0.11	-0.12	-0.59	-1.05	-1.24	-1.75	
Tin	2.23	1.52	0.62	0.30	0.26	0.11	0.00	-0.01	-0.48	-0.94	-1.13	-1.64	
Lead	2.24	1.53	0.63	0.31	0.27	0.12	0.01	0.00	-0.47	-0.93	-1.12	-1.63	
Copper	2.71	2.00	1.10	0.78	0.74	0.59	0.48	0.47	0.00	-0.46	-0.65	-1.16	
Silver	3.17	2.46	1.56	1.24	1.20	1.05	0.94	0.93	0.46	0.00	-0.19	-0.70	
Palladium	3.36	2.65	1.75	1.43	1.39	1.24	1.13	1.12	0.65	0.19	0.00	-0.51	
Gold	3.87	3.16	2.26	1.94	1.90	1.75	1.64	1.63	1.16	0.70	0.51	0.00	

Notes:

1. Accelerated corrosion can occur between unprotected joints if the algebraic difference in atomic potential is greater than +/-0.3 volts.
2. Metals are considered more noble as they move from Magnesium to Gold.
3. For any two metals in contact, a less noble metal is considered more "anodic" and will give up metal in a contact joint.
4. Adapted from page 18 of *The Grounds for Lightning and EMP Protection*, 2nd Edition, PolyPhaser Corporation.

Anatomy of a Workable Multi-Metal Connection

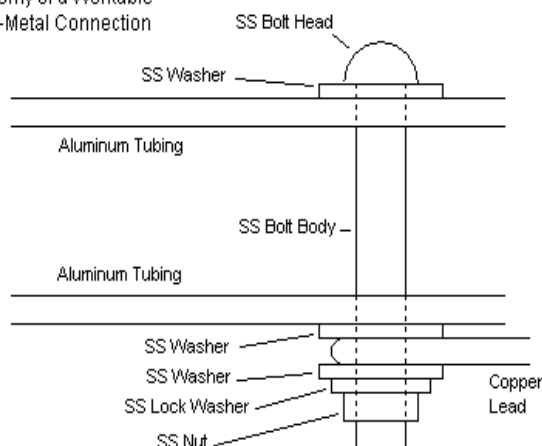


Fig. 1

Note how far apart that aluminum and copper fall on the table.

Stainless steel is generally inert to electrolysis. Hence, it makes the best simple buffer between different metals that might show significant corrosive effects. **Fig. 1** shows a sample connection at possibly the feedpoint of a beam's driven element. Note that the system uses not only a stainless nut and bolt, but also stainless washers. Hence, the copper wire is isolated physically but not electrically from the aluminum tube.

Two washers deserve special mention. I place a washer under the bolt head to spread the force that the head exerts on the softer aluminum tube. Excess tightening will not result in the bolt head widening the hole in the tubing. In most cases, I add a fiberglass rod within the tube to strengthen the assembly. If I butt-join tubes, I add an inner tube for the same reason.

The other notable washer occurs next to the nut. I use a stainless lock washer to ensure that the assembly does not come apart after a season of flexing in the weather.

### Aluminum

The subject of aluminum bothers many a newer antenna builder because of its cost if we buy it new from reputable sources. Due to cost, many builders resort to wire beams, while others build only antennas for which they can find used TV antenna elements. At one time, home centers carried a large and varied stock of aluminum tubing, but in recent years, the centers have shifted their stocking philosophies from "do-it-yourself-in-your-own way" to "do-it-as-pre-packaged." Some antenna builders have shifted to the use of L-stock and square stock.

First, round tubing is the best material available for HF antenna elements, since it tends to slip the wind best. Flat surfaces tend to increase wind resistance. Second, I do not recommend even home-center tubing for antennas designed to withstand many seasons of rough weather. The tubing available in home centers is of dubious lineage, and its strength data is often wholly unavailable. Most of all, I do NOT recommend the use of aluminum conduit for antenna elements. Conduit is a form of softer pipe. It not only weighs more than tubing, it also bends permanently under loads.

The best material for U.S. antenna builders is 6063-T832 aluminum tubing, available from various outlets. The tubing is strong, and the most common wall thickness for the home antenna builder is 0.058". It is also available in outer diameter increments of 1/8" (0.125"). If we used a wall thickness of 0.0625"-- that is, 1/2 the increment between tubing sizes -- we would ideally have a perfect

Aluminum Tubing  
Types and Overlap

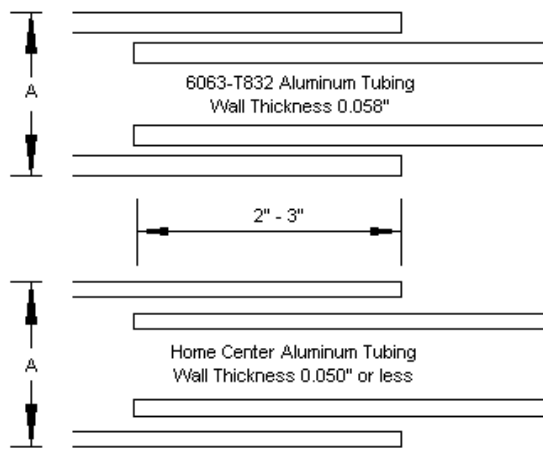


Fig. 2

fit from one size to the next. However, this approach fails to recognize that even computer-controlled industrial processes have allowances. Hence, the 0.058" wall thickness allows the closest practical size for nesting one tube inside the next larger size, as suggested in Fig. 2.

The lower portion of the figure suggests the use of home-center tubing, which usually has a wall thickness of 0.050" or less. Note the larger spacing between the nested segments. The larger spacing yields more wiggle room, which calls for special measures to ensure a tight mechanical bond between element sections. The upper portion of the sketch with the standard 6063-T832 tubing would allow the use of a simple pair of sheet metal screws to bond the sections--stainless steel sheet metal screws, of course.

The sketch also specifies an overlap of 2" to 3" at the junction. There are special cases in which it is wise to double tubing. For example, the centermost part of a 20-meter beam element might use about 3' of 1.25" stock. The next exposed length might be only 24" or so, but the 1.25" tubing would go all the way to the element center, giving the middle of the element extra strength to bear higher wind loads. Where we do not need doubling strength, 2" to 3" of overlap is sufficient to provide a strong connection without adding unnecessary weight to the element.

Some antenna makers prefer to use thinner-wall tubing to create equally strong but lighter and more flexible element assemblies. Other makers use swaging techniques to decrease the element diameter by either 1.5 or 2 steps, relative to our standard 1/8" increments. In most cases, the home builder does not have access to the necessary equipment to handle such techniques, and the lighter tubing in the requisite aluminum type may not be readily accessible. Hence, the use of the tubing that we have noted is almost the *de facto* American standard. In contrast, European antenna makers tend to prefer heavier tubing (in metric increments, of course). Their antennas tend to bear larger ice and snow loads, but may require a larger rotator to turn effectively.

### Polycarbonate

Since I use antenna modeling software to design antennas that I build, I always plan on insulating and isolating the elements from the supporting boom. NEC and MININEC calculate only axial currents along an element and hence cannot show the effects of the boom, were we to make a direct connection. All beam designs that appear at this site either use non-conductive booms or use plates to insulate and isolate the elements from the boom.

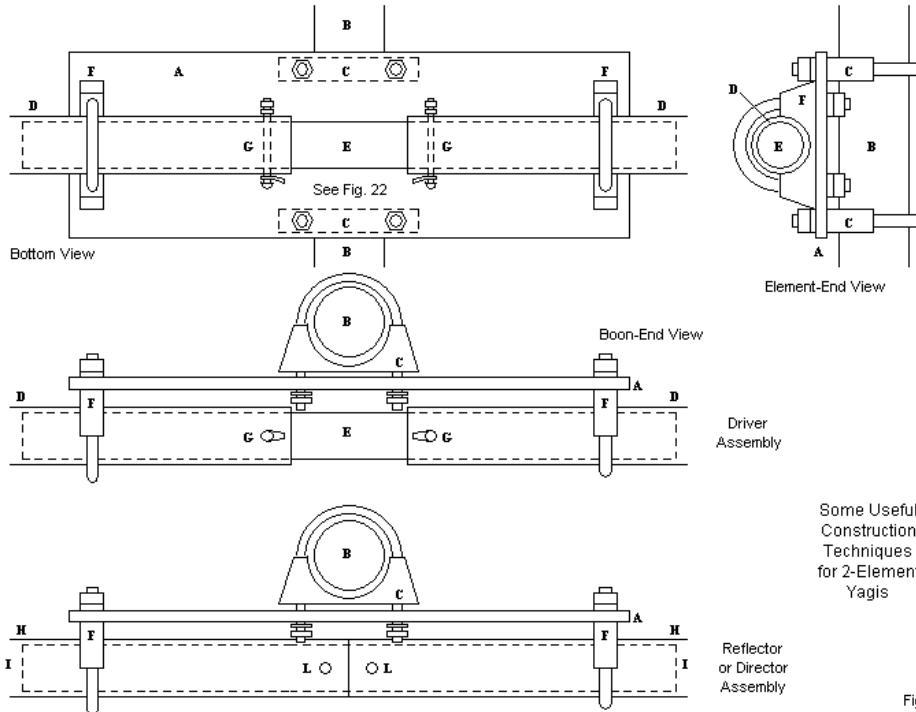
Table 2. Key to elements in the constructions sketches (See Fig. 3 and Fig. 4)

A	Polycarbonate element-to-boom mounting plate
B	Boom
C	Boom stainless-steel U-bolts and saddles
D	Driven element tube
E	Driven element gap insulating rod or tube
F	Element stainless-steel U-bolts and saddles
G	Stainless-steel nuts/bolts/washers/soldering lugs
H	Reflector or director element tubes
I	Inner linking conductive tube
J	L-stock coax connector mounting plate
K	Through-chassis coax connector
L	Stainless-steel sheet-metal screws

At HF, the best plate material in my experience is polycarbonate. Lexan is a GE trademark and trade name for the material. Do not confuse the material with acrylic materials that ball up under a saw blade. As well, polycarbonate differs from Plexiglas, another trademarked material. All of these materials are related chemically, but we can obtain "true" polycarbonate from on-line sources in convenient size sheets that we can then saw and drill with woodworking tools. Simply be certain that the polycarbonate is UV protected.

The plate size will vary with the amateur band, which generally determines element size and weight. 1/4" thick material generally satisfies most upper HF requirements. Although polycarbonate is satisfactory well into the lower UHF range, many VHF and UHF beam builders prefer Delrin and other later materials for insulating plates and shapes.

To use polycarbonate plates effectively requires that we design an assembly that makes best use of their strengths. The assembly requires a variety of parts. **Table 2** provides a key to the parts that appear in the sketches in **Fig. 3** and **Fig. 4**. The plate itself is oblong, extending 6 to 12 inches along the element axis and perhaps 4 to 6 inches along the boom axis. The larger numbers, of course, apply to bands like 20 and 17, while the smaller dimensions are for 12 and 10 meters. As suggested by **Fig. 3**, the use of a longer dimension along the element axis places the element U-bolts at a larger distance to allow for assembly work at the element center.



Stainless steel U-bolts attach the element to one side of the plate, while similar U-bolts clamp the plate to the boom on the other side. I prefer the type of U-bolt that comes with a cast saddle over other types. The absence of any saddle tends to allow element slippage over time. Muffler-clamp type saddles contact the element in two lines, which can more easily deform the element tube than the solid cast saddle. In most cases, the boom U-bolts will be larger than the element U-bolts, since booms may range from about 1.25" for lighter beams to perhaps 2" for longer ones. Boom materials can be either 6063-T832 or 6061-T6. For anything

Fig. 3

heavier than a 2-element beam, it is useful to use thicker tube walls, perhaps 0.125". For smaller beams, you can nest 1.125" tubing with 0.058" walls inside 1.25" tubing with the same wall thickness. If you need a longer boom than the stock available, you may stagger the junctions of the inner and outer tubes to achieve a stronger boom with a uniform diameter.

For parasitic elements, you may use a single center element section or you may link two sections with an inner strengthening tube. Even where you do not need doubling, the inner tube should extend at least to the edges of the polycarbonate plate so that the U-bolts go around a double thickness of tubing to help avoid crushing. The driver element replaces the linking tube with a non-conductive rod or tube, such as fiberglass. The rod helps align the element and provides for the required driven element gap. Note that the gap in any antenna is a part of the total element length. It is NOT an addition to the length. The gap size is not critical, since the leads from either side of the gap to the feedline connector make up any missing length. Essentially, the final gap size is the spacing between the conductors in the feedline.

All hardware (except for U-bolt cast saddles) is stainless steel. **Fig. 4** shows an exception to this rule. The support for the coax connector consists of a short length of 1" by 1/16" thick L-stock. The length is just enough to serve as a U-bolt keeper bar. At the center, a 5/8" hole allows you to mount a through-chassis coax UHF connector. Leads to the element are short and direct. Use a "liquid" (plastic) electrical tape product to seal the coax connector rear end--and the coax junction once you install the feedline. The general ideas in these sketches permit any number of variations. Besides studying alternative techniques that appear in articles and handbooks, you may also examine various commercially made beams that you encounter. Very often, manufacturers place their assembly manuals on line for the benefit of prospective buyers and those who obtain beams second hand. These manuals are excellent sources of ideas ready for your local adaptation.

Whichever system of mounting that you use, be certain that the assembly has the quality necessary for durable service. Most beams operate at the tops of expensive towers with equally expensive rotators to direct them. The antenna itself should not be a weak link in this otherwise sturdy system.

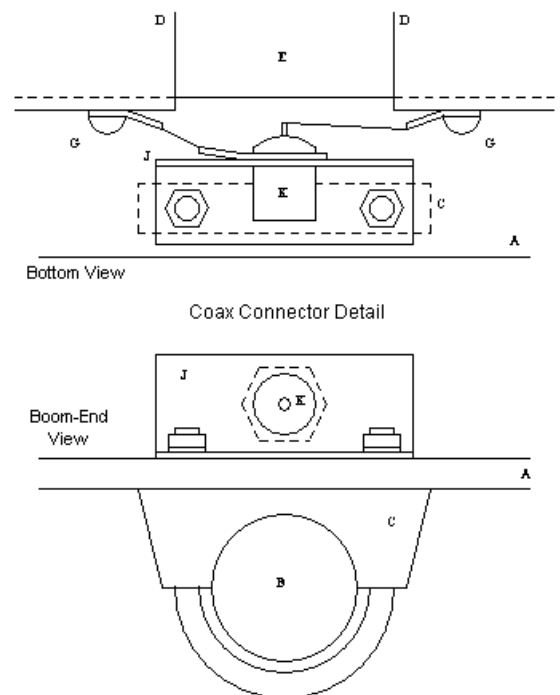


Fig. 4