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A Copper-Pipe Vertical Sleeved Dipole for 2 metres... and 70 cm!

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INTRODUCTION & BACKGROUND

VHF half-wave dipole antennas are generally well known to Radio Amateurs. Further, as we know, a dipole antenna may be used in either the horizontal or vertical plane. In either case, the coaxial feedline at the dipole centre is normally taken off at right angles to the dipole so as to not interfere with or detune the driven element.

This arrangement works well with directive antennas such as a Yagi antenna, where the feedline can exit at 90 degrees supported by the mast. However, when we want to mount a single, non-directional dipole in the vertical plane, a right-angle centre feedline is often impractical. Therefore, modifications to permit end-feeding and mounting the antennas may be made.

This article describes a specific and somewhat subtle construction of what is generally known as a "**Vertical Sleeve Dipole**", sometimes also referred to as a coaxial dipole or even a vertical "bazooka" dipole (see Figure 1).

In this construction, the lower half of the dipole may, for example, consist of a conductive tube or sleeve, thereby allowing the feedline to be routed through it. In common with dipole antennas in general, the vertical sleeve antenna is also omnidirectional, requires no ground plane and has a low angle of radiation.

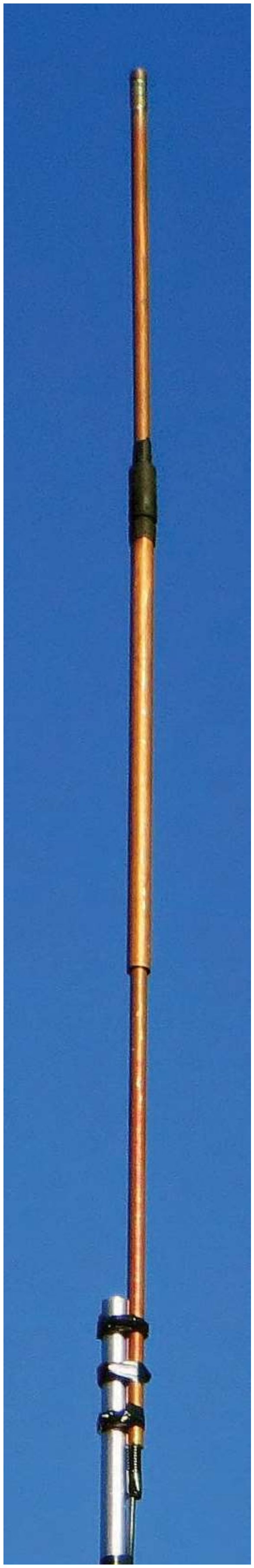


Figure 1: Antenna clamped to a 10-foot mast using three stainless steel adjustable clamps.

The simplest version of the vertical "sleeve" dipole, has one-quarter wavelength of the shield of the coaxial cable folded back over the outside of the coaxial cable insulation. Figure 2 shows a slightly improved iteration, where a conductive sleeve or tube is used in place of the shield braid. This leaves one-quarter wavelength of the inner conductor of the coaxial cable to extend vertically and complete the dipole.

Although this arrangement appears in *The Radio Amateur's Handbook* as far back as 1947, details on the limitations, problems and solutions do not seem to be mentioned. Although useable, this simple iteration has serious practical limitations, mainly due to the strong coupling between the sleeve and the shield of the coaxial feedline.

An excellent description of this effect is found in the March 2015 issue of *QST* magazine: "The Doctor Is In" column "Roll up Your Sleeves and Make a Sleeve Dipole", by Joel Hallas, W1ZR, page 64. In summary, and to emphasize again, the main difficulty in building any sleeve dipole is finding a simple way to defeat the strong coupling between the sleeve and the shield of the coax feedline.

Many articles may be found on websites showing construction variations of the design, and with differing methods of dealing with the sleeve coupling issue and radiation from the feedline.

There are too many to list here so I encourage readers to "Google" some of these alternative designs. A few, which come to mind, are on the websites of KV5R, VE3VDC and N1GY or dozens more, using keywords like "sleeve dipole" or "coaxial dipole".

My idea to document and share this particular design began back in 2014 when I volunteered to refurbish a number of copper-pipe VHF sleeve-dipoles that had been in storage for ARES emergency deployment for a number of years at the local Emergency Measures Organization (EMO) office.

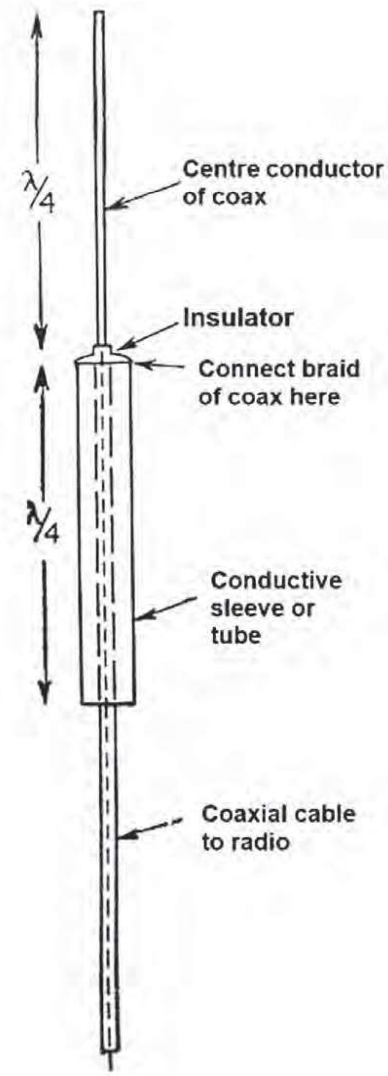


Figure 2: Simple Sleeve Dipole diagram.

My thanks to Ken, VE3RMK, who was a great help in performing the initial tests on the group of antennas. Unfortunately, we could not find anyone with the local Amateur Radio clubs involved who knew of the originators or who had any background on the design.

In any case, after having refurbished and tested nine of them, I became impressed by the features of this antenna:

- Slim profile, ease of storage in a 1.5-inch diameter tube
- Low standing wave ratio (SWR) over the bands

Note:
See last 2 pages
for updated info.

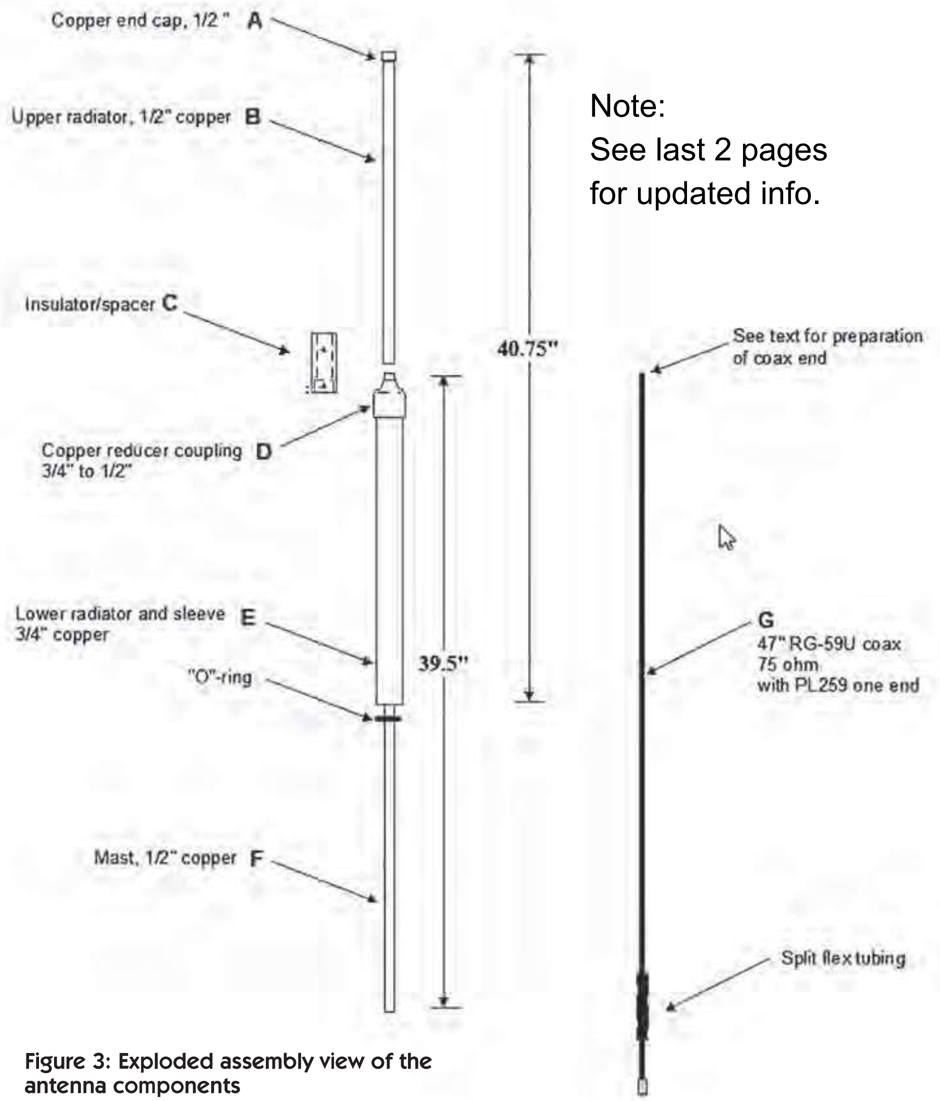


Figure 3: Exploded assembly view of the antenna components

PARTS REQUIRED:

A) 0.5-inch copper pipe end cap; Home Depot 9007-003

B) Upper radiator, 0.5-inch copper pipe, approximately 18 inches; see the text for more information

C) Insulator/spacer, Delrin, etc; see text for alternates

D) Copper reducer coupling, 0.75-inch to 0.5-inch; Home Depot 9000-043

E) Lower radiator and sleeve, 0.75-inch copper pipe, 19.25 inches; see the "Plumbing Parts" sidebar on page 20.

F) Mast, 0.5-inch copper pipe, 39.5-inches

G) 75 ohm RG-59U coax, 47 inches; see the "RG-59U" sidebar

Miscellaneous parts:

- **PL259 male connector**
- **Rosin flux-core wire solder**
- **5/8-inch ID Moen M3957 "O" ring;**
- **2 – 6/32-inch x 3/8-inch L SS machine screws**
- **1 – 1-inch piece of #20 to #24 stranded hook-up wire**
- **6-inch – 3/8-inch ID split flex tubing**
- **Marine Goop or 5-minute epoxy**

- Omnidirectional, with low angle of radiation, characteristic of a dipole
- No ground or ground-plane needed
- No need for additional chokes to suppress line radiation

I felt that the construction, although it appeared to be simple, was actually somewhat unique. A "bonus" I found later, was that this antenna unexpectedly works very well on 70 cm!

Note: Many 2m antennas can also be used on the 70 cm band, which is the approximate third harmonic (i.e.,: 146 x 3 = 438 MHz). As the third harmonic of common 2m designs are below or at the low end of the 70 cm band, 70 cm operation often results in high SWR unless special means are employed to mitigate this.

I observed no feedline or decoupling issues of any kind in the antenna described in this article. The problems I did find during the refurbishment work were mainly mechanical, such as broken coax solder connections and cracked plastic insulators.

I also spent some time researching sleeve dipole origins and eventually turned up the old US patent #2,184,729, by A.B. Bailey, from December 1939 (now long expired of course!). One of the configurations claimed is very similar to the dipoles described herein.

I want to emphasize that I am not the designer of this particular antenna construction described in this article. However, by measuring and studying the nine ARES units – and from lessons learned during the construction of my own unit – I do have a much better understanding of it and at least some of the subtle design features.

My sole contribution to the design described was improving the mechanical weaknesses I had observed in the original insulator and in poor soldering of the coax centre conductor.

Measured SWR Performance:

- On 2 metres, SWR <1.7 from 144 to 149 MHz
- On 70 cm, SWR < 1.6 from 440 to 448 MHz

GENERAL DESCRIPTION

The antenna is made entirely from 0.5-inch and 0.75-inch type M copper pipe, as normally used in ordinary home plumbing (see the "Plumbing Parts" sidebar).

The half-wave dipole is formed by an upper 0.5-inch diameter radiator and a lower 0.75-inch diameter radiator, separated from each other and secured in place by a centre plastic insulator (see Figure 3).

The lower 0.75-inch diameter pipe section also forms the resonant sleeve on its *inner surface*.

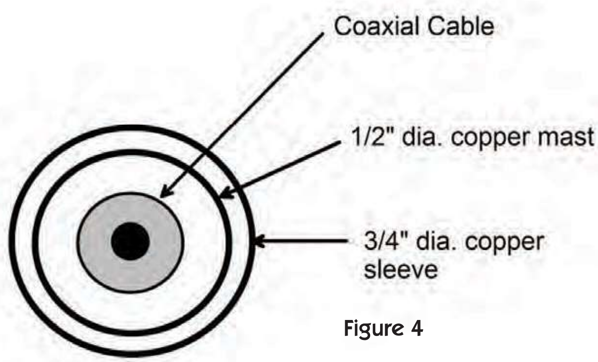


Figure 4

Figure 4 shows the cross-section view of the sleeve/mast/coax cable positioning to help in understanding the construction.

The use of a standard, readily available 0.5-inch to 0.75-inch pipe coupling in the design, allows a 0.5-inch diameter pipe section to be fixed in place as a mounting mast which extends through and below the sleeve. The coaxial cable feed runs up the centre of the mast and is terminated at the junction of the two radiators.

The plastic insulator (see Figure 5) is fixed in place with two 6/32-inch x 3/8-inch L stainless-steel machine screws. For protection from the weather, the insulator may be later sealed with epoxy, or my favourite, “Marine Goop”. A final wrap with self-sealing tape will further help protect from UV aging of the insulator.

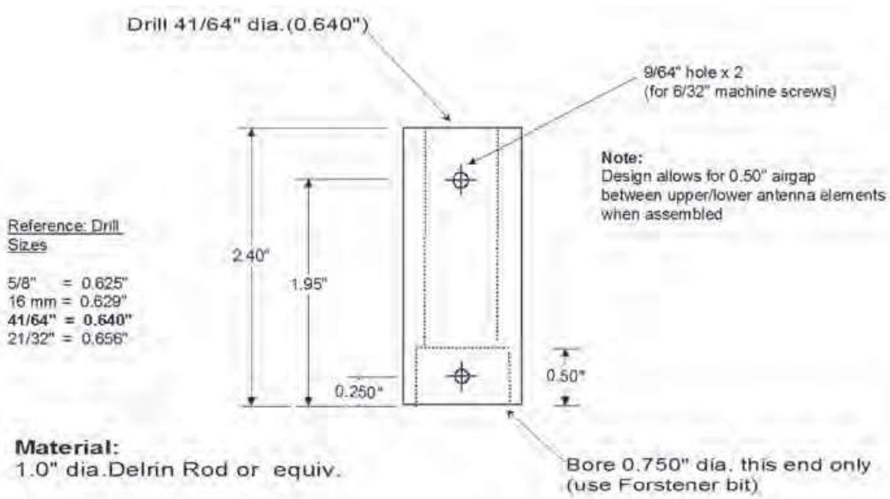


Figure 5: Insulator dimensions

IMPORTANT POINTS IN THE DESIGN

1) Dipole Insulator and Alternates

Figure 5 shows the dimensions of the custom insulator I made, using 1-inch diameter Delrin (generic name: acetyl). Its purpose is to mechanically secure the 2 dipole halves and maintain an insulated stable air gap, while making it possible to solder the RG-59U coax both to the upper and lower dipole sections.

I realize that it may be difficult to duplicate this insulator, unless one has access to a small lathe and the expertise to use it.

Some alternatives which are available from major plumbing stores are shown in Figure 6. The “Push-n-Turn” 0.5-inch solderless coupling – shown on the left in Figure 6 – seems interesting but I found it afterwards and have not used it yet.

Figure 6: Alternative sources of insulators

Sidebar A

Plumbing parts

In Canada and the United States there are at least three common types of copper tubing or pipe used in the plumbing industry. Note that in the “nominal” size of 0.5-inch pipe, the “nominal” OD is actually 5/8-inch.

The most common type used in residential and commercial applications is called “Type M” and it usually has red-coloured printing on it. The main difference is in the inside diameter which, for the most part, will not affect use in this project. Type M has a thinner wall and will be both less expensive and lighter in weight. However, the copper-pipe reducing fitting, used to mount the sleeve, seems to have at least three variations I have seen (see Figure A) so you want to make sure the part you buy fits the rest of the assembly.

Figure A: Copper reducer/coupler variants

In the above photo, the fitting on the left with the X on it (HD #9005-043) requires a 0.75-inch to 0.75-inch copper coupler in order to attach the sleeve. The middle part (HD #9000-043) is the part I used for the project and which accepts the 0.75-inch OD sleeve directly. On the right is another part similar to HD #9000-043, but which has a shorter neck for the 0.5-inch section.

On the right foreground in the photo is a common 0.75-inch to 0.75-inch plastic barbed hose coupling (Poly insert coupling, Home Depot (HD) #UPPC-07).

The other two parts shown are called 0.5-inch PVC risers, HD #94351 and #94352. Note that in order to use any of the three plastic parts mentioned, it will be necessary to carefully drill out the centre using a 41/64-inch diameter drill bit. A 5/8-inch diameter drill will likely be too snug to use.

2) Sleeve/Choke

The lower 0.75-inch pipe section forms the lower half of the dipole radiator with its outside “skin”, while the inner surface forms the resonant choke section. Because of the construction using the copper reducer coupling, the inner and outer surfaces have slightly different lengths. This results in the dipole being slightly off-centre-fed. The design approach is to first select the sleeve length for choke resonance at your chosen centre frequency. I used 19.25-inch for 146.500 MHz. The length of the top section of the dipole is then adjusted for best SWR.

3) Assembling the Sleeve Section

Due to the construction of the copper reducer/coupling, the effective length of the sleeve cavity is very close to the cut length of the sleeve (see Figure 7), showing a cut away section of that part.

Figure 7: Cut-away view of the copper reducer/coupling showing positioning of the sleeve and coaxial cable

First, clean the mating surfaces of the mast section, the reducer/coupling and the 0.75-inch diameter sleeve with steel wool or fine sandpaper in preparation for soldering. Then insert the 39.5-inch mast section into the copper reducer/coupling through the neck and letting it extend to 0.5-inch max.

Note: you will have to use a round file to remove the formed copper stop ring that is inside the neck of the copper reducer/coupling.

Insert the cleaned end of the 0.75-inch sleeve into the lower part of the copper reducer/coupling. Slip the 5/8-inch ID “O” ring over the mast and up into the sleeve section about 0.5 inches. This will help keep the mast section centred when soldering and will also keep “critters” from nesting there later on. Using a propane torch, heat the copper reducer/coupler and run a solder bead around the two mating surfaces. Not much is needed.

4) RG-59U

Why use 75 ohm RG-59U and not, for example, 50 ohm RG-58U, RG-8X or RG-213 coaxial cable for the feeder? The simple answer is that you will get a better match and lower SWR by using 75 ohm coax for the feed cable from the dipole ahead of your regular 50 ohm coax run to the rig.

Note: you can look up centre-fed dipole characteristics in any of the Amateur Radio Handbooks or Antenna books.

I observed that the length of the 75 ohm RG-59U cable used in all the ARES samples was 47 inches, which puts any resonances outside the band. I am not sure if this was deliberate by the original designers, or just convenience.

5) Installing the insulator and the RG-59U coax feeder

Some pre-planning is required here. The insulator should be prepared with the two screw clearance holes drilled and so it slides easily but snugly on the 0.5-inch pipe sections. It helps to make a simple assembly jig out of wood scraps to help hold and line up the upper and lower sections. The insulator should first be positioned over the 0.5-inch gap and then the screw holes in the copper sections can be drilled and tapped. Slide the insulator up and out of the way.

Slide the 6-inch length of split flex tubing – used as a “grommet” at the end of the mast – over the end of the RG-59U coax. Then prepare the bare end of the RG-59U coax as shown in Figure 8 with the braid well tinned and formed as shown. Then solder a 1-inch piece of #20 insulated wire to the centre conductor of the coax and insulate with a small piece of heat shrink tubing.

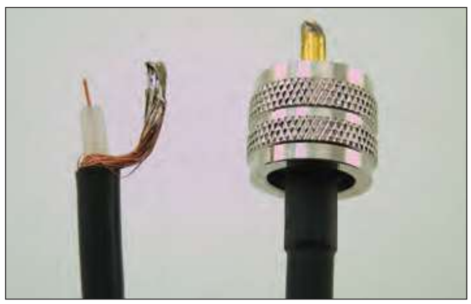


Figure 8: Preparation of the RG-59U coaxial feeder cable

Feed the RG-59U coax up the inside of the 0.5-inch mast and sweat-solder the braid securely to the inside lip of the mast (see Figure 9).

Figure 9: Preparation of the centre conductor of the RG-59U using #20 wire pig-tail

Next form the small piece of #20 wire into an “S” shape and solder its end to the inside lip of the top radiator so as to provide a bit of strain relief (see Figure 10).

Figure 10: Positioning of upper radiator and soldering to RG-59U pigtail

Sidebar B

RG-59 Coax Cable Today

RG-59/U (75 ohm) coaxial cable, has been around a long time. Cable sold today as RG-59/U is no longer rigidly controlled, and may no longer meet the original military specs. An example is the RG-59 commonly packed with cable TV boxes or satellite receivers. They are electrically much the same, but some are constructed differently and have little braid and instead rely on an aluminum foil wrap over the dielectric.

I looked at these as well as at RG-6/U used in satellite and cable TV for this project, but decided instead to use the original RG-59/U that has the heavy copper braid and a solid centre conductor (Belden #8241). This is easily soldered to the inside of the copper pipe elements and makes a strong physical connection that is not easily achievable with the other coaxial cable variants.

I acknowledge that some Amateurs, such as Phil Salas, AD5X, claim to have successfully soldered RG-6U with the aluminum braid and wrap, but for this project I think it is simpler just to use the Belden #8241.

Phil’s article can be found online at: http://www.ad5x.com/images/Articles/Connectorizing%20RG6.pdf

Figure 11: Installation of insulator

Now move the insulator down into position and secure with the two 6/32-inch machine screws into the pre-tapped holes in the copper pipes (see Figure 11).

Notes:

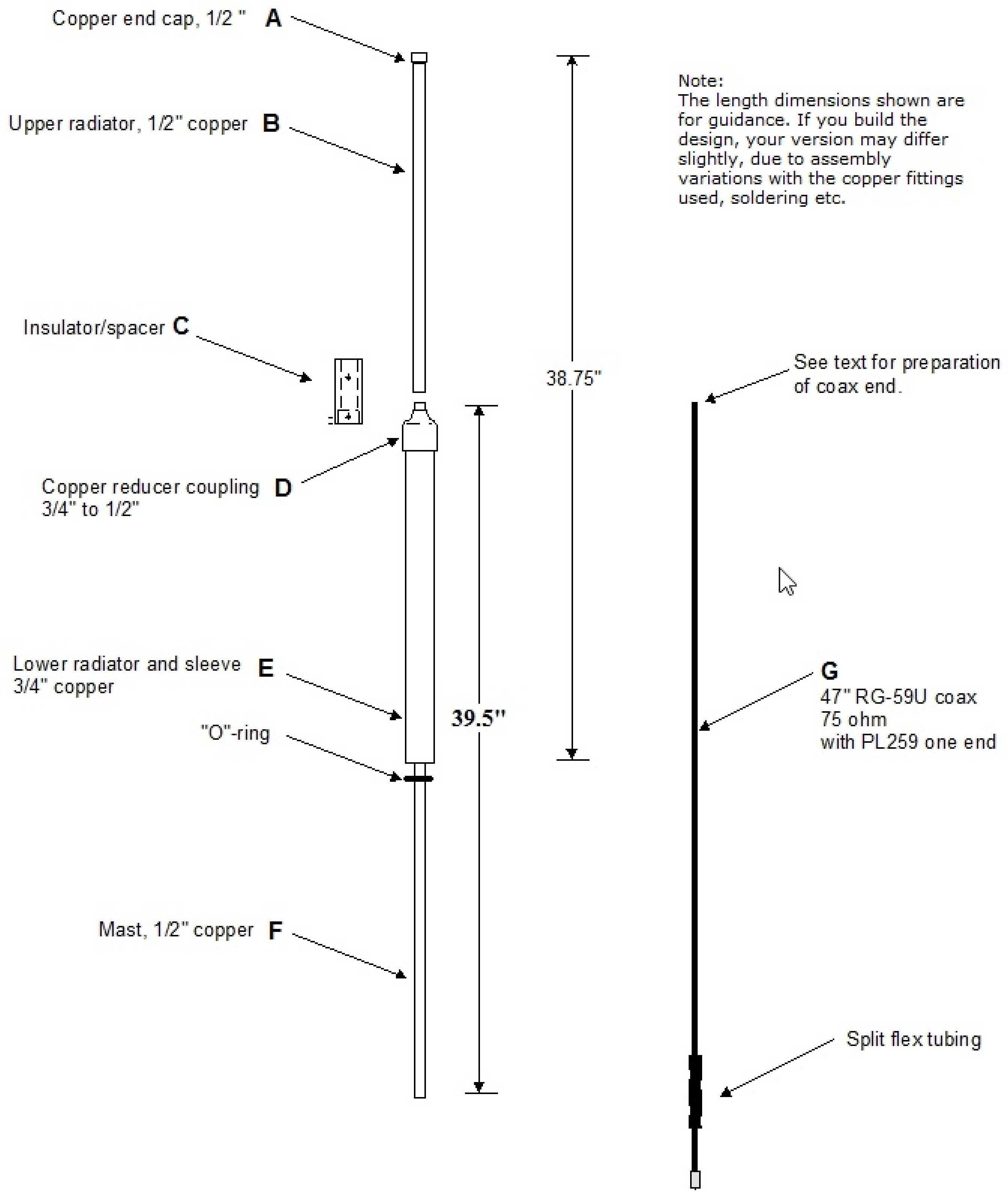
1) Do not glue or wrap the insulator in place until you have finished all testing and adjusting!

2) Ignore the unused third hole in the insulator (my error!)

SOURCES FOR SIMILAR DESIGNS

Isopole Antennas: www.isopole.com

Kreco Antennas: www.krecoantennas.com

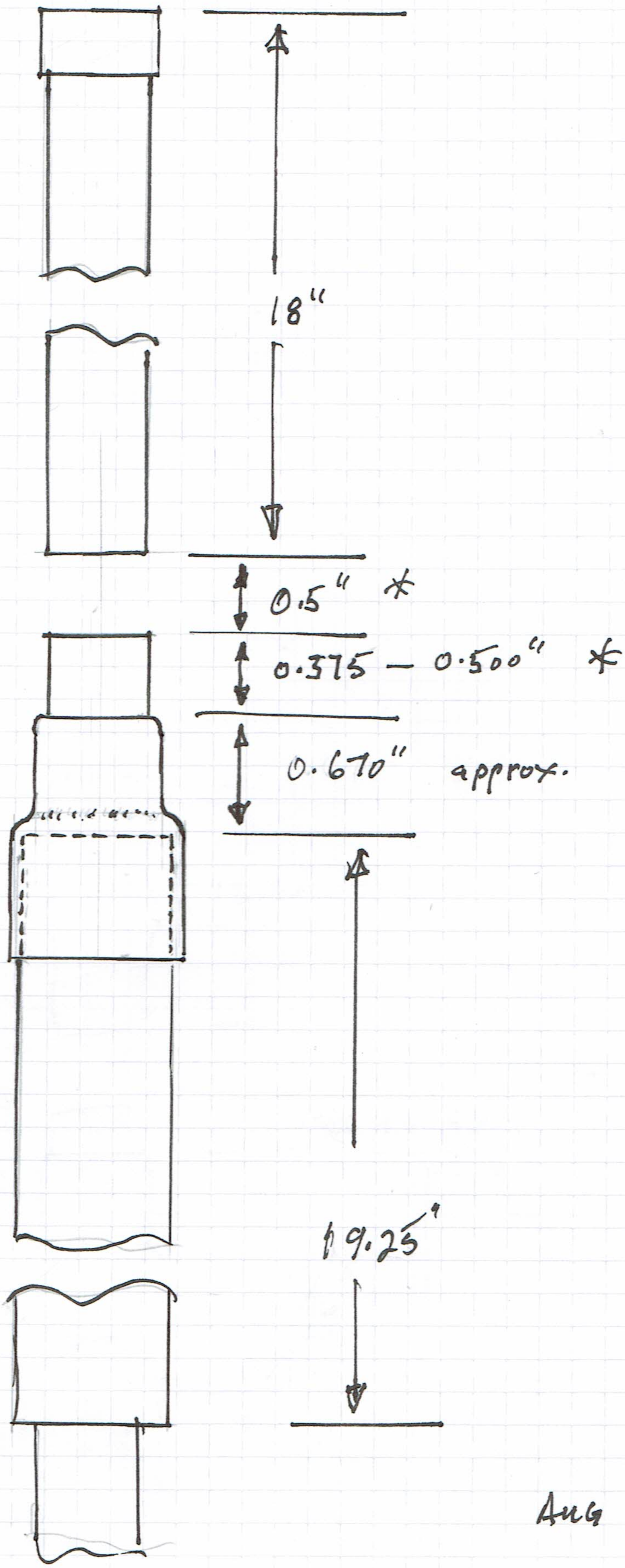


Copper Vertical Sleeved dipole - 2 meters
sleeve-dipole.dsf

Aug.11,2016
38.75" was 40.75"

NOTE:

VARIABLES WHICH MAY AFFECT DIPOLE LENGTH ARE MARKED *



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