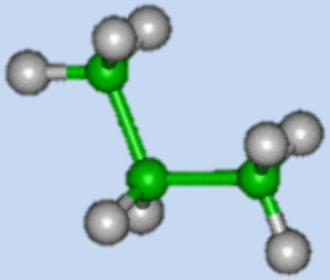
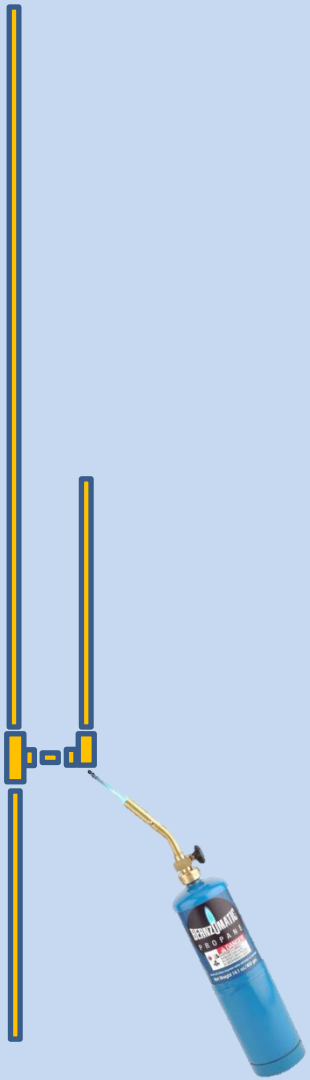
Copper J-Pole

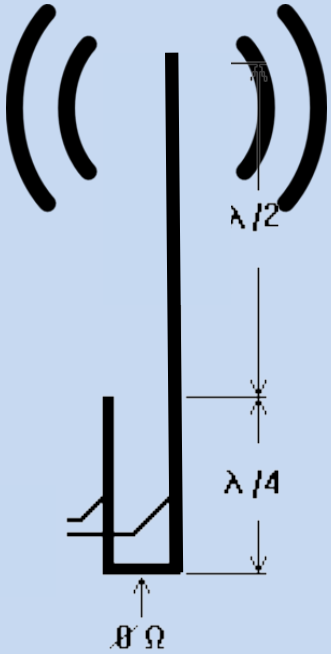
Allen Wolff - KC7O

April 2015



C_3H_8





Copper J-Pole

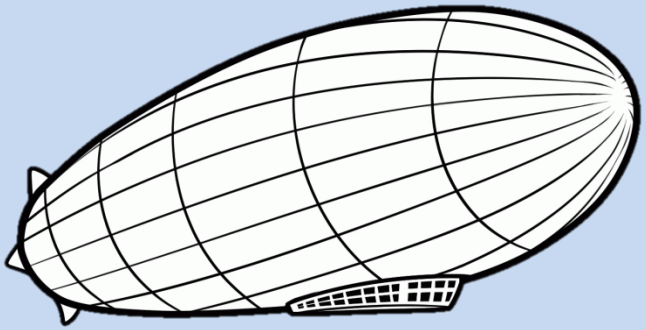
- ***The J-Pole has been around for decades***
- ***There are many articles on the web***
  - ***with different dimensions***
  - ***and different ways to connect the coax***
- ***NOTHING presented here is new, just the objectives for a "Done in One" project***

Copper J-Pole

- ***OBJECTIVES***
  - ***Make a simple design that will work***
  - ***Be reproducible***
  - ***Have a coax fitting***
  - ***~20 year life outdoors if the back of the connector is sealed and the antenna painted***
  - ***Easy to tune the first time***
  - ***1.2:1 maximum at resonance***
  - ***No more than 1.5:1 from 144 - 148 MHz***
  - ***Cost <$23 (heavy duty) without coax***

Home Depot small quantity price - April 2015			
10' - 1/2" copper pipe - Grade L	1	$14.98	$14.98
1/2" Copper Tee	1	$1.19	$1.19
1/2" copper elbow	1	$0.69	$0.69
1/2" copper end cap	2	$0.69	$1.38
3/8" - 7/8" SS hose clamps	2	$0.94	$1.88
			$20.12
Tax		9%	$1.81
SO-239 new - swap meet ($3+ web)	1	$1.00	$1.00
			$22.93

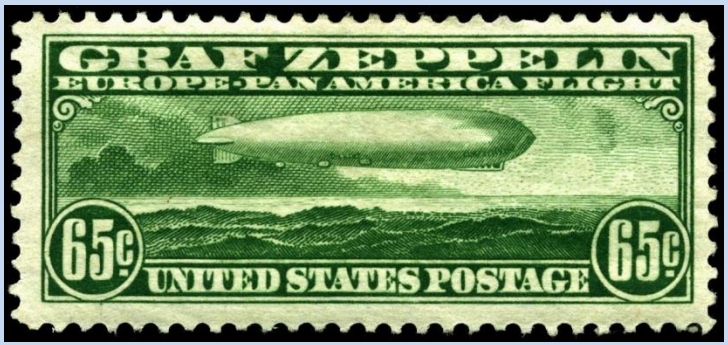
- ***The J-pole antenna, also called the Zepp' antenna (short for Zeppelin), was first invented by the Germans for use in their lighter-than-air balloons***
- ***Trailed behind the airship, it consisted of a single element, one half wavelength long radiator with a quarter wave parallel feed line tuning stub***

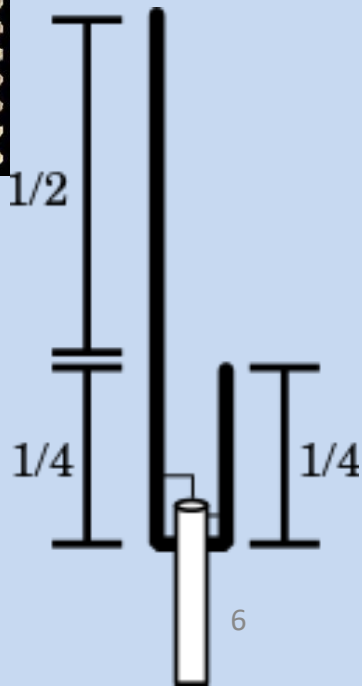


Wikipedia

- ***This was modified into the J-pole configuration by 1943 and became popular with Amateur Radio operators because it is effective and relatively simple to build***

Wikipedia





A million of each were printed in 1930 and are worth $76, $130 & $320 on ebay

M/SGT. TONY LOLACONI

The radio amateur's handbook

THE STANDARD MANUAL OF AMATEUR RADIO COMMUNICATION

1945 EDITION

$1 IN CONTINENTAL U.S.A.

PUBLISHED BY

THE AMERICAN RADIO RELAY LEAGUE

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rated a few feet and running beneath the a- tenna. The counterpoise may be elevated s- feet or so above the ground, so that it will n- interfere with persons walking under it. A lo- resistance connection should be made betwe- the usual ground terminal of the transmitt- and each of the wires in the counterpoise.

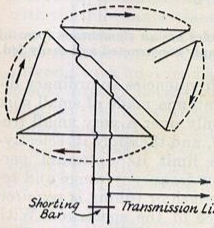

Fig. 1053 — The A- ford loop antenna f- v.h.f. and u.h.f. is ma- up of resonant el- ments fed in phase r- tation, and has hi- radiation efficienc-

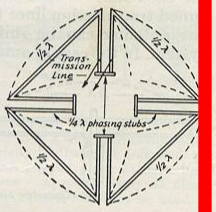

Fig. 1054 — Various feed and phasing arrangements may be used with v.h.f. loops. The shorted ends of the closed quarter-wave matching stubs may be grounded to a metal mast or other support.

Loaded antennas — Methods of securin- maximum usable radiation from a grounded vertical antenna of limited height utilize loading coils and capacity tops. The latter may be in the form of a ring or spider or a top-mounted outrigger. Capacity effect raises the maximum current point nearer the top of the antenna.

Another form of top loading which involves the insertion of an inductance coil near the top, enclosed within a shield can for protection and to increase the top capacity, is particularly suited to mobile installations.

The advantage of top loading in short vertical antennas is that it forces the upper portion of the antenna to carry a more substantial current, making the effective height approach more closely to the actual physical height.

V.h.f. loop antennas — Although the radiation resistance of an ordinary loop transmitting antenna is very low, at the very-high frequencies, the Alford loop shown in Fig. 1053 permits the use of resonant dimensions of the order of ⅛ to ¼ wavelength on each side, resulting in relatively high radiation efficiency as compared with ordinary loop antennas for the lower frequencies.

Various configurations and feed methods are possible, following this general pattern. In the form shown in Fig. 1054, the sides of the loop are half-wave resonant sections linked by half-wave transmission-line matching stubs so arranged that there is a current loop at the center of each side, with the currents in the various sections all in phase rotation. Since the shorted ends of the quarter-wave stubs are at a current node, the system may be directly attached at these points to a grounded metal tower or similar structure.

Center-fed dipoles with low impedance coaxial lines or delta-matched lines may be used, the correct phasing for each line being arranged at the feed-line terminals.

"J" antenna — This type of antenna, frequently used on the very-high frequencies when vertical polarization is desired, is simply a half-wave radiator fed through a quarter-wave matching section (§ 10-8), the whole being mounted vertically as shown in Fig. 1055. Adjustment and tuning are as described in § 10-8. The bottom of the matching section, being at practically zero r.f. potential, can be grounded for lightning protection.

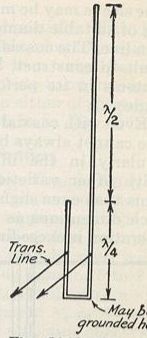

Fig. 1055 — The "J" antenna, usually constructed of hard-drawn metal tubing. The ¾-wave vertical section may be mounted as an extension of a grounded metal mast. The matching stub may be adjusted by a sliding shorting bar.

Coaxial antenna — With the "J" antenna radiation from the matching section and the transmission line tends to combine with the radiation from the antenna in such a way as to raise the angle of radiation. At v.h.f. the lowest possible radiation angle is essential, and the coaxial antenna shown in Fig. 1056 was developed to eliminate feeder radiation. The center conductor of a 70-ohm concentric transmission line is extended one quarter wave beyond the end of the line, to act as the upper half of a half-wave antenna. The lower half is provided by the quarter-wave sleeve, the upper end of which is connected to the outer conductor of the concentric line. The sleeve acts as a shield about the transmission line and very little current is induced on the outside of the line by the antenna field. The line is non-resonant, since its characteristic impedance is the same as the center impedance of the half-wave antenna (§ 10-2).

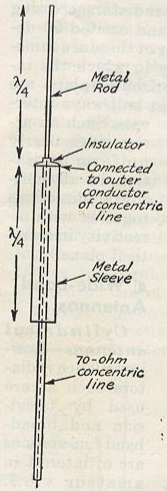

Fig. 1056 — Coaxial antenna. The insulated inner conductor of the 70-ohm concentric line is connected to the quarter-wave metal rod which forms the upper half of the antenna.

node, the system may be directly attached at these points to a grounded metal tower or similar structure.

Center-fed dipoles with low impedance coaxial lines or delta-matched lines may be used, the correct phasing for each line being arranged at the feed-line terminals.

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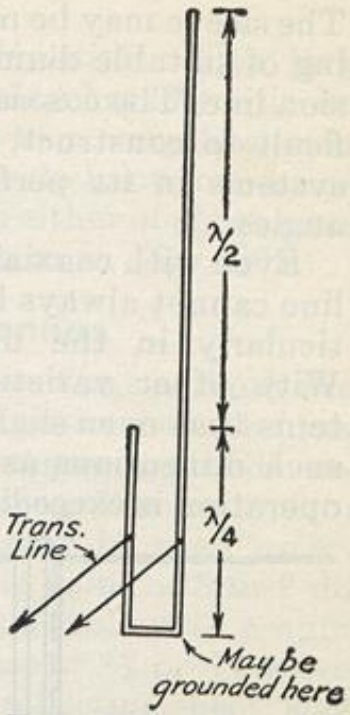


Fig. 1055 — The "J" antenna, usually constructed of hard-drawn metal tubing. The ¾-wave vertical section may be mounted as an extension of a grounded metal mast. The matching stub may be adjusted by a sliding shorting bar.

Coaxial antenna — With the "J" antenna

1938 FCC grants 2 ½ meters 112–116 Mc moved to 144-148 Mc in 1945

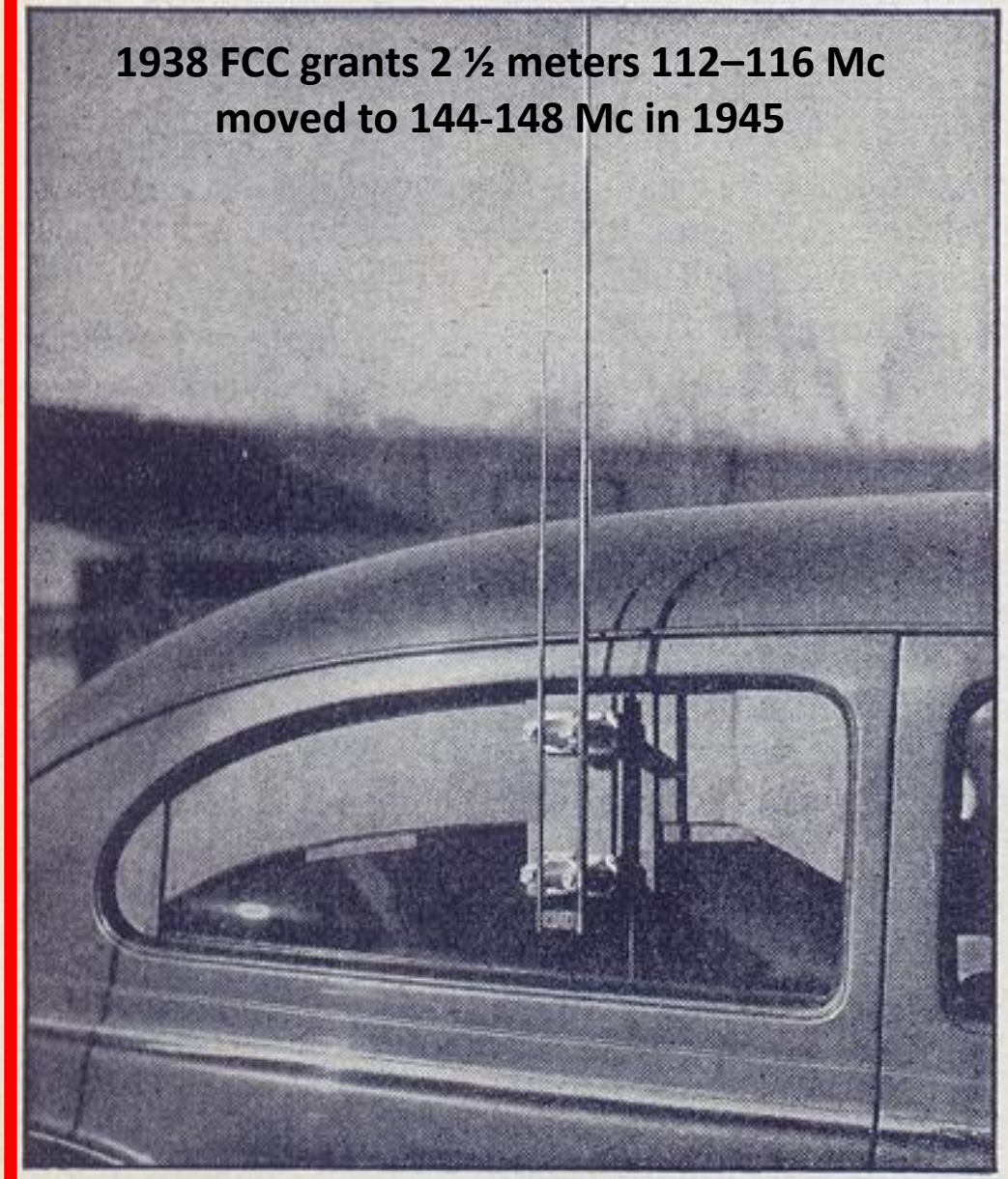
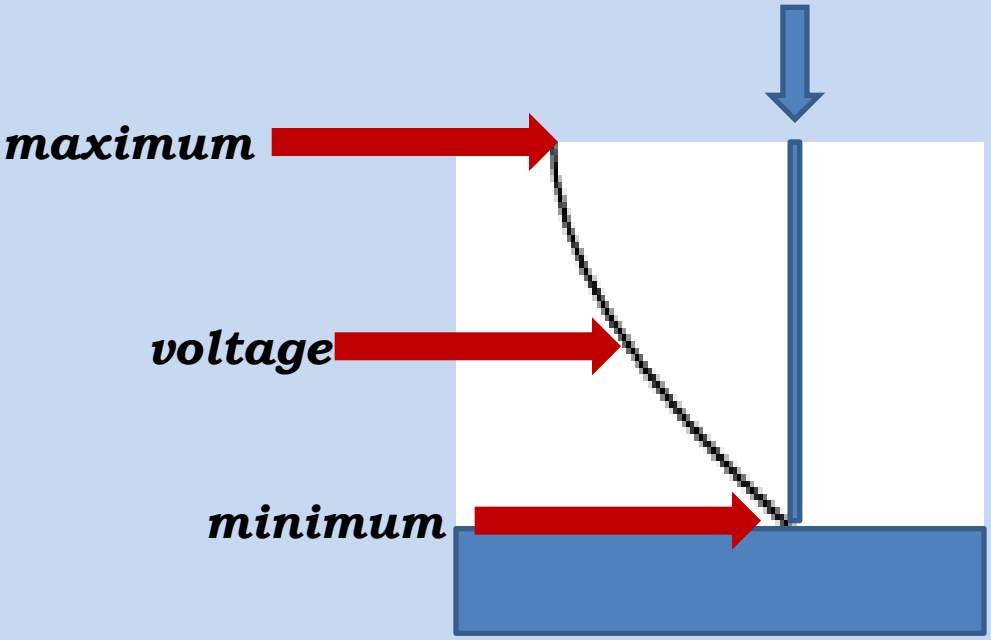


Fig. 1754 — A J-type antenna for 112-Mc. mobile operation can be mounted easily in the window of a car, allowing the radiator proper to be placed above the roof of the vehicle. The dimensions are given in Fig. 1755.

If it's shorted, how does it work???

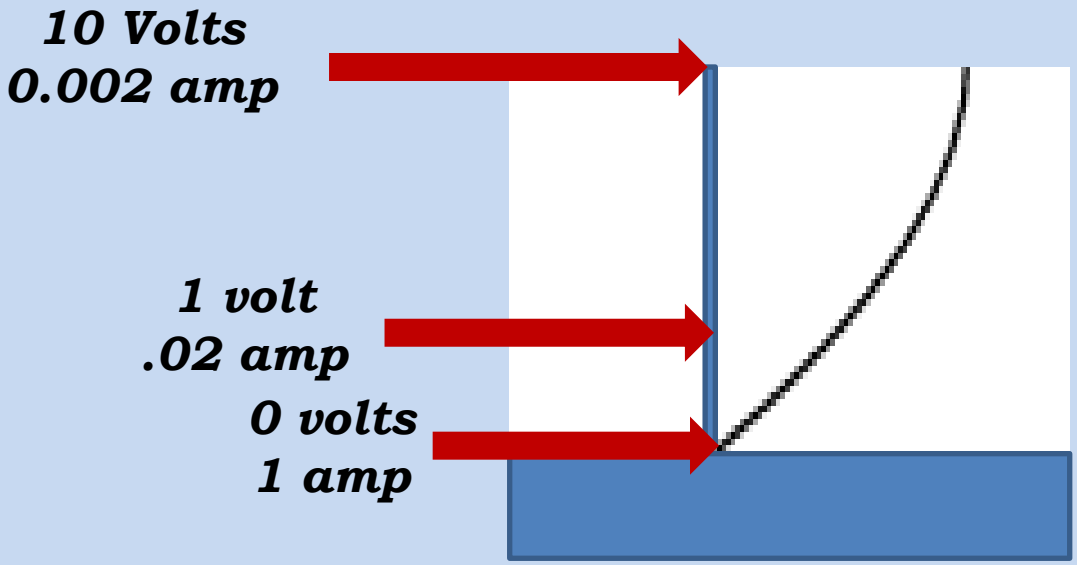
¼ λ Vertical



RF Voltage and Current

Remember the formula
E=IR
Voltage = Current times Resistance

So R=E/I
Using hypothetical numbers

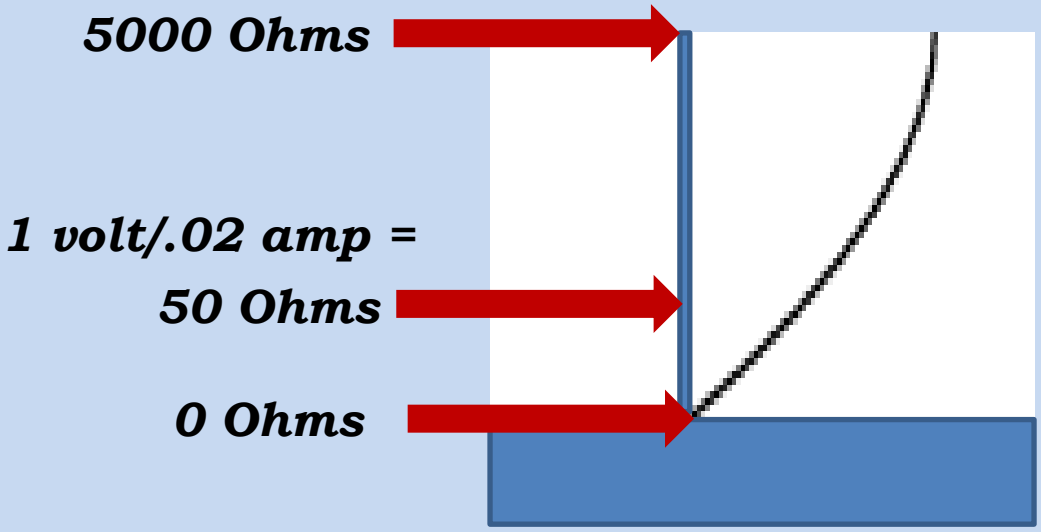


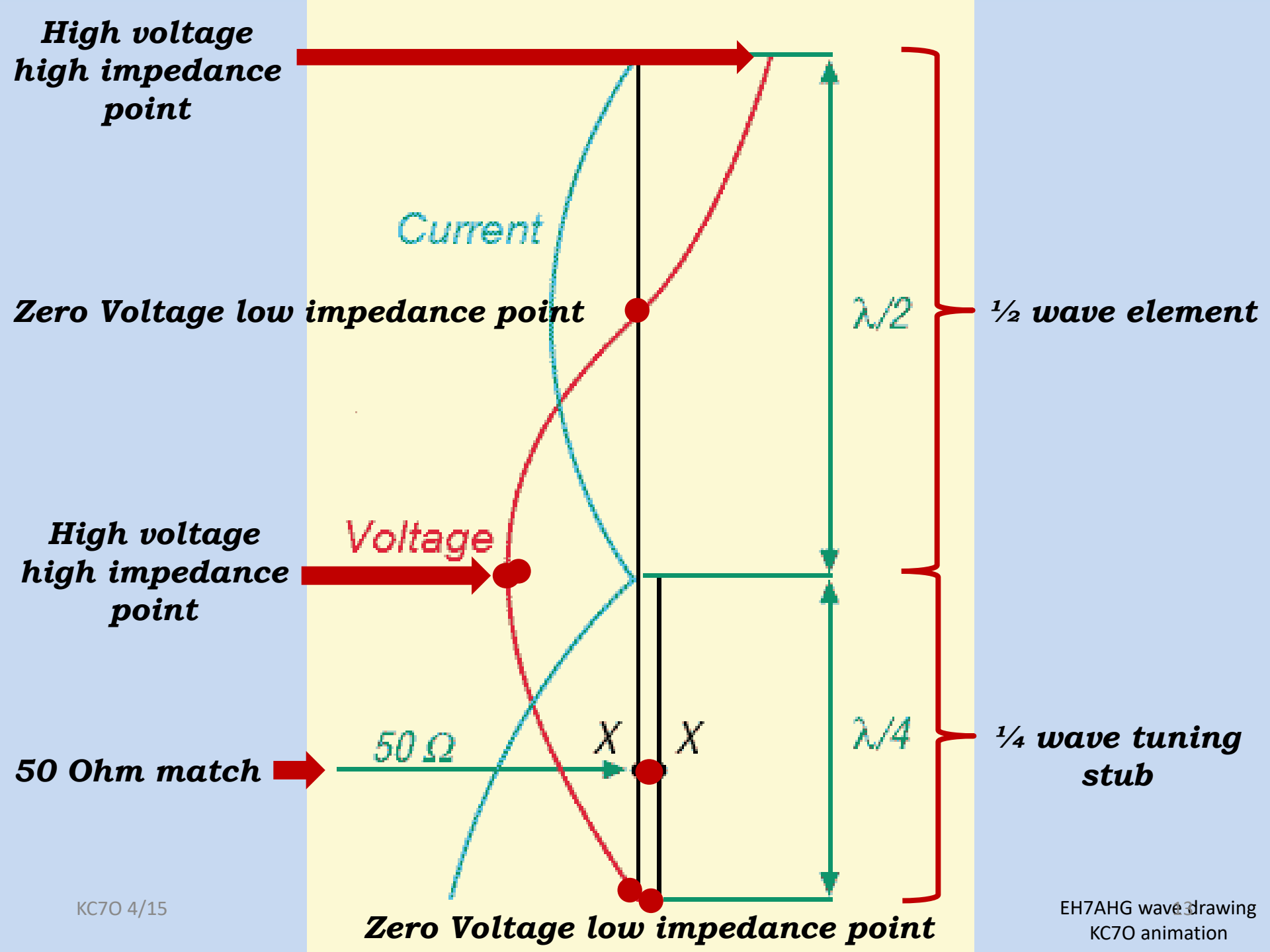
RF Voltage and Current

Remember the formula
E=IR – Voltage = Current times Resistance

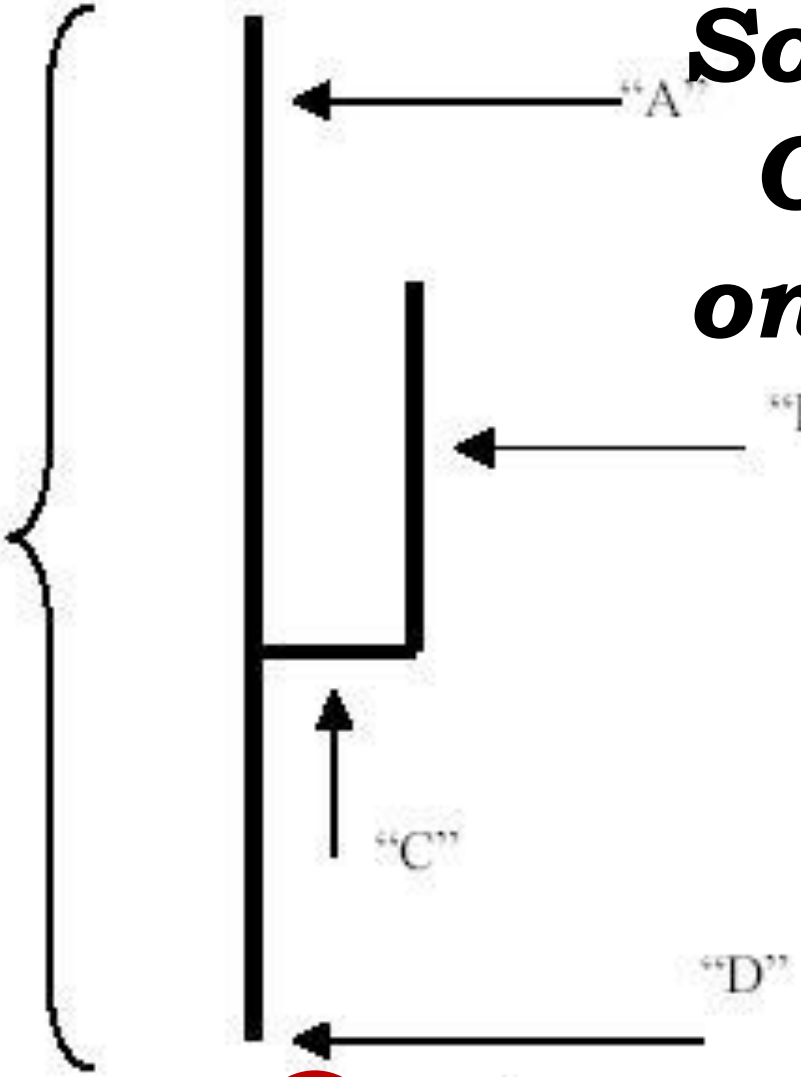
So R=E/I
Using hypothetical numbers

Dividing the voltage by the current



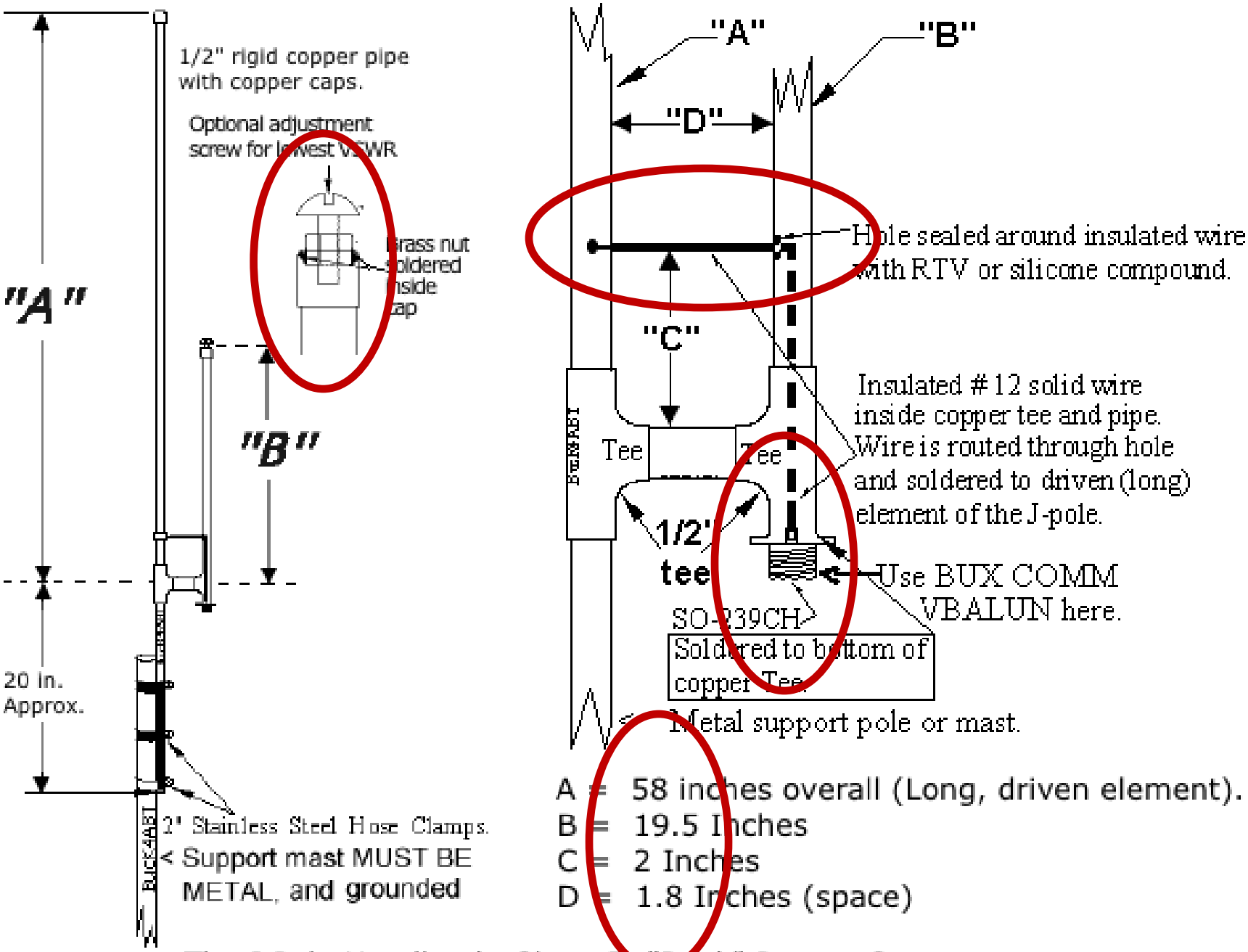

High voltage high impedance point
Current
Zero Voltage low impedance point
λ/2
½ wave element
High voltage high impedance point
Voltage
50 Ω
X
X
λ/4
¼ wave tuning stub
50 Ohm match
Zero Voltage low impedance point

Some J-Pole Offerings on the WEB



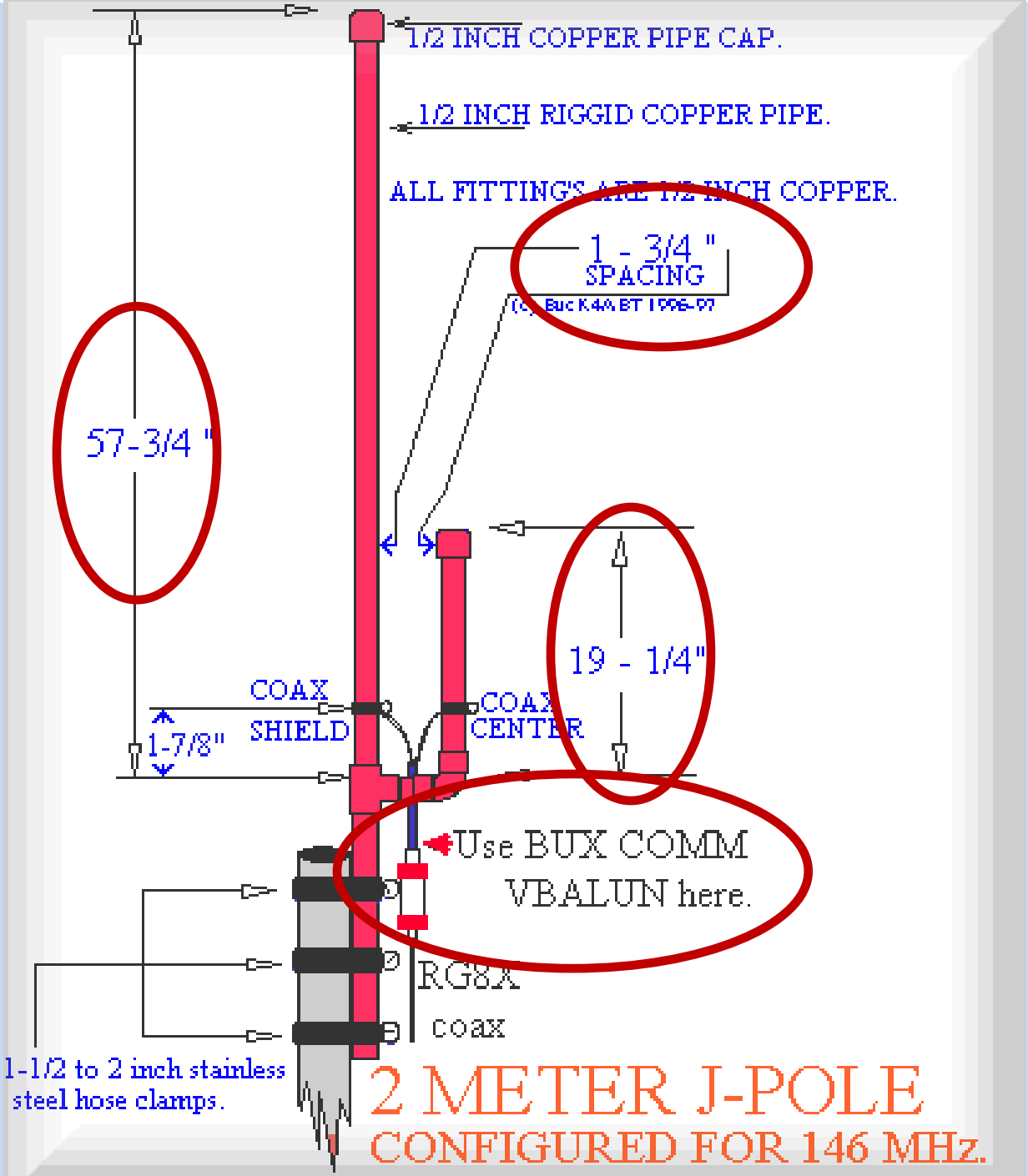
Section "A" measured out to 58 inches.
Section "B" measured out to 19 inches.
Section "C" measured out to 2 inches.
Section "D" measured out to 11 inches.

These measurements were taken from
www.martechsys.com/kb9vbr/jpole.htm

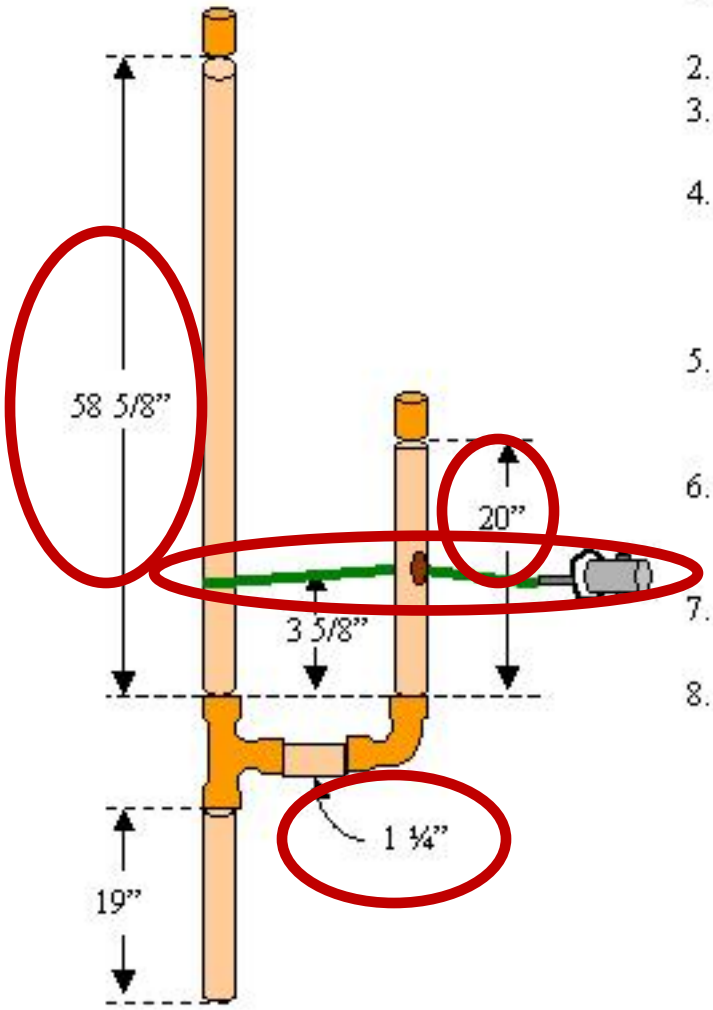


The J Pole Handbook Glynn E. "Buck" Rogers Sr K4ABT

 From my 1958 article in CQ magazine. www.packetradio.com/jpoles4ever.htm


1/2 INCH COPPER PIPE CAP.
1/2 INCH RIGGID COPPER PIPE.
ALL FITTINGS ARE 1/2 INCH COPPER.
1 - 3/4 "
SPACING
57-3/4 "
19 - 1/4"
COAX
SHIELD
COAX
CENTER
1-7/8"
Use BUX COMM
VBALUN here.
RG8X
coax
1-1/2 to 2 inch stainless
steel hose clamps.
2 METER J-POLE
CONFIGURED FOR 146 MHz.

½ Inch Copper Pipe Jpole



* Drawing not to scale

ASSEMBLY INSTRUCTIONS:

1. Cut a piece of ½" copper pipe to the following lengths: 58 5/8" radiating element, 20" matching stub, 19" anchor pipe, and 1 ¼" connector.
2. Solder ½" caps onto the 58 5/8" and 20" pieces as shown.
3. Solder the T-joint, 19" lower pipe, 1 ¼" pipe, and elbow joint to the 58 5/8" element as shown.
4. On the 20" capped pipe drill a ¼" hole at a point that is 3 5/8" from the uncapped end. Drill a 1/8" hole directly opposite the ¼" hole. These holes will be used later for mounting the male BNC connector and feeding the plenum-rated jumper wire through the 20" stub.
5. Carefully solder the 20" capped stub onto the elbow so that the drilled holes line up with the 58 5/8" radiating element, and so that the radiating element and the 20" stub are aligned in parallel with each other.
6. Strip off the insulation and outer shield from both ends of a 4 to 5" piece of plenum-rated cable (any type will do). Solder the center conductor of one end onto the center pin of the male BNC connector as shown.
7. Feed the BNC & cable assembly through the drilled holes and solder the BNC nut securely into the ¼" hole.
8. Trim the length of the free end of the jumper wire and solder its center conductor to the radiating element. Check the SWR and move the jumper up or down until a good match is found. Then solder the jumper securely in place on the radiating element.

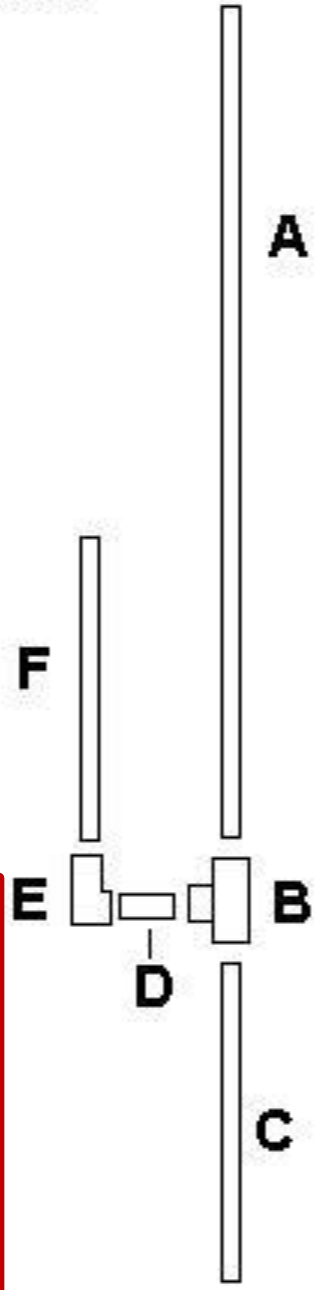
DISTRICT 24 DOUGLAS & ELBERT COUNTIES, COLORADO

2 METER J-POLE ANTENNA -- 1/2 inch Copper Pipe

Plans By: KB0VJY & K0KHZ Date: 15 October, 1999

2M/440 JPOLE PARTS SIZING

PARTS LIST
1 - 10' OF 1/2" COPPER TUBING
1 - 1/2" 90 DEGREE COPPER ELBOW
1 - 1/2" COPPER T
2 - STAINLESS STEEL HOSE CLAMPS
1 - SO-239 CHASSIS CONNECTOR
ROSIN CORE SOLDER
3" #12 SOLID COPPER WIRE
1 - 1" 4-40 BOLT AND NUT



CUT PIECES TO THESE SIZES
A - 60 1/2"
B - 1/2" COPPER T
C - 20"- LENGTH NOT CRITICAL
D - 1 1/2"
E - 1/2" 90 DEGREE ELBOW
F - 18 1/2"

2002 ARRL Handbook

AN ALL-COPPER 2-M J-POLE

Rigid copper tubing, fittings and assorted hardware can be used to make a really rugged J-pole antenna for 2 m. When copper tubing is used, the entire assembly can be soldered together, ensuring electrical integrity, and making the whole antenna weatherproof. This material came from an article by Michael Hood, KD8JB, in *The ARRL Antenna Compendium, Vol. 4*.

No special hardware or machined parts are used in this antenna, nor are insulating materials needed, since the antenna is always at dc ground. Best of all, even if the parts aren't on sale, the antenna can be built for less than $15. If you only build one antenna, you'll have enough tubing left over to make most of a second antenna.

Construction

Copper and brass is used exclusively in this antenna. These metals get along together, so dissimilar metal corrosion is eliminated. Both metals solder well, too. See **Fig 20.100**. Cut the copper tubing to the lengths indicated. Item 9 is a 1 1/4-inch nipple cut from the 20-inch length of 1/2-inch tubing. This leaves 18 3/4 inches for the λ/4-matching stub. Item 10 is a 3 1/4-inch long nipple cut from the 60-inch length of 3/4-inch tubing. The 3/4-wave element should measure 56 3/4 inches long. Remove burrs from the ends of the tubing after cutting, and clean the mating surfaces with sandpaper, steel

¾" pipe – heavy duty

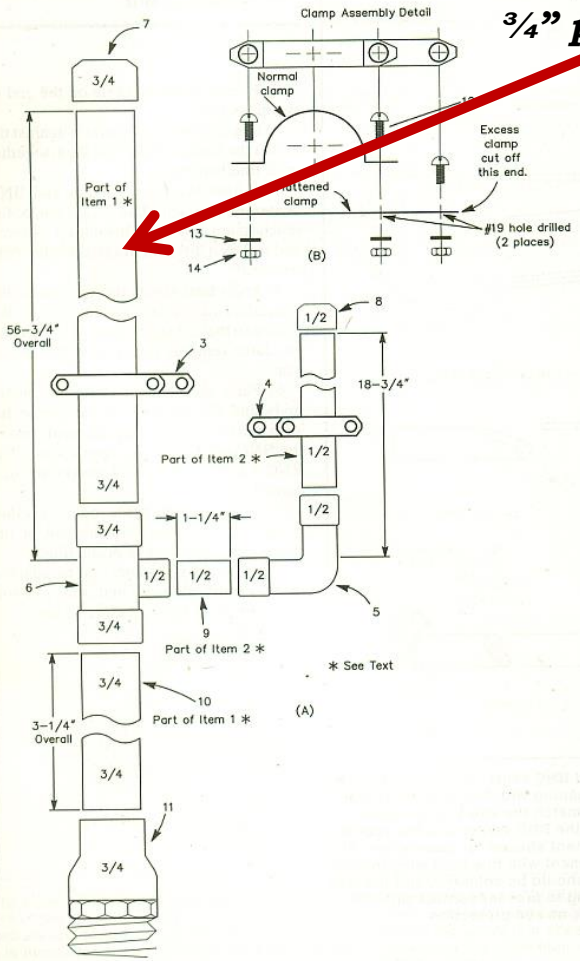


Fig 20.100—At A, exploded assembly diagram of all-copper J-Pole antenna. At B, detail of clamp assemblies. Both clamp assemblies are the same.

Item	Qty	Part or Material Name
1	1	3/4 inch × 10 ft length of rigid copper tubing (enough for 2 antennas, 60 inches per antenna)
2	1	1/2 inch × 10 ft length of rigid copper tubing (enough for 6 antennas, 20 inches per antenna)
3	2	3/4 inch copper pipe clamps
4	2	1/2 inch copper pipe clamps
5	1	1/2 inch copper elbow
6	1	3/4 × 1/2 inch copper tee
7	1	3/4 inch copper end cap
8	1	1/2 inch copper end cap
9	1	1/2 × 1 1/4 inch copper nipple (Make from item 2. See text)
10	1	3/4 × 3 1/4 inch copper nipple (Make from item 1. See text)
11	1	Your choice of coupling to mast fitting (3/4 × 1 inch NPT used at KD8JB)
12	6	# 8-32 × 1/2 inch brass machine screws (round, pan, or binder head)
13	6	# 8 brass flat washers
14	6	# 8-32 brass hex nuts

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wool, or emery cloth.

After cleaning, apply a very thin coat of flux to the mating elements and assemble the tubing, elbow, tee, endcaps and stubs. Solder the assembled parts with a propane torch and rosin-core solder. Wipe off excess solder with a damp cloth, being careful not to burn yourself. The copper tubing will hold heat for a long time after you've finished soldering. After soldering, set the assembly aside to cool.

Flatten one each of the 1/2-inch and 3/4-inch pipe clamps. Drill a hole in the flattened clamp as shown in Fig 20.100B. Assemble the clamps and cut off the excess metal from the flattened clamp using the unmodified clamp as a template. Disassemble the clamps.

Assemble the 1/2-inch clamp around the 1/4-wave element and secure with two of the screws, washers, and nuts as shown in Fig 20.100B. Do the same with the 3/4-inch clamp around the 3/4-wave element. Set the clamps initially to a spot about 4 inches above the bottom of the "J" on their respective elements. Tighten the clamps only finger tight, since you'll need to move them when tuning.

Tuning

The J-Pole can be fed directly from 50 Ω coax through a choke balun (3 turns of the feed coax rolled into a coil about 8 inches in diameter and held together with electrical tape). Before tuning, mount the antenna vertically, about 5 to 10 ft from the ground. A short TV mast on a tripod works well for this purpose. When tuning VHF antennas, keep in mind that they are sensitive to nearby objects—such as your body. Attach the feed line to the clamps on the antenna, and make sure all the nuts and screws are at least finger tight. It really doesn't matter to which element (3/4-wave element or stub) you attach the coaxial center lead. The author has done it both ways with no variation in performance. Tune the antenna by moving the two feed-point clamps equal distances a small amount each time until the SWR is minimum at the desired frequency. The SWR will be close to 1:1.

Final Assembly

The final assembly of the antenna will determine its long-term survivability. Perform the following steps with care. After adjusting the clamps for minimum SWR, mark the clamp positions with a pencil and then remove the feed line and clamps. Apply a very thin coating of flux to the inside of the clamp and the corresponding surface of the antenna element where the clamp attaches. Install the clamps and tighten the clamp screws.

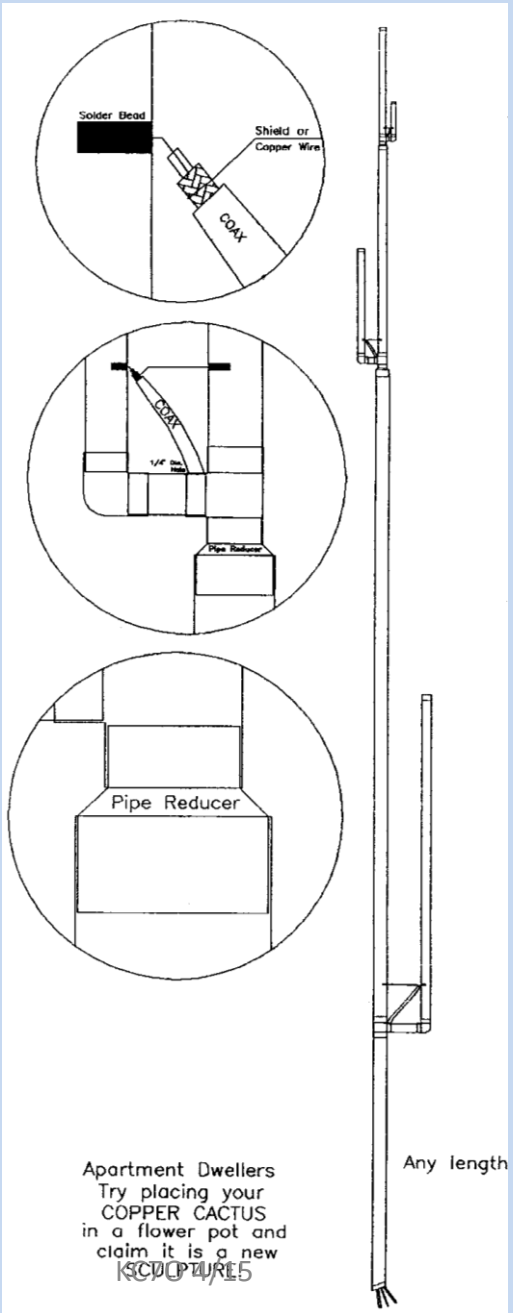
Solder the feed line clamps where they are attached to the antenna elements. Now apply a small amount of solder around the screw heads and nuts where they contact the clamps. Don't get solder on the screw threads! Clean away excess flux with a non-corrosive solvent.

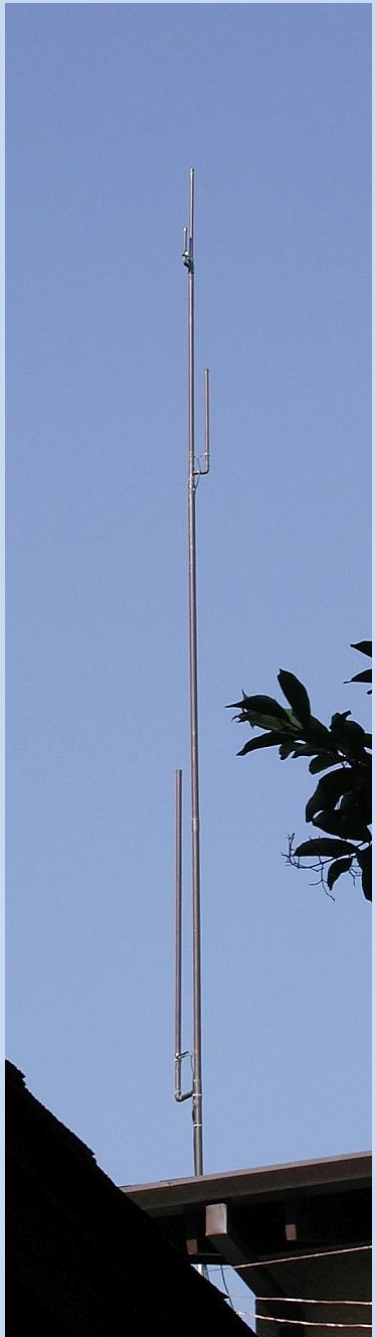
After final assembly and erecting, mounting the antenna in the desired location, attach the feed line and secure with the remaining washer and nut. Weatherseal this joint with RTV. Otherwise, you may find yourself repairing the feed line after a couple years.

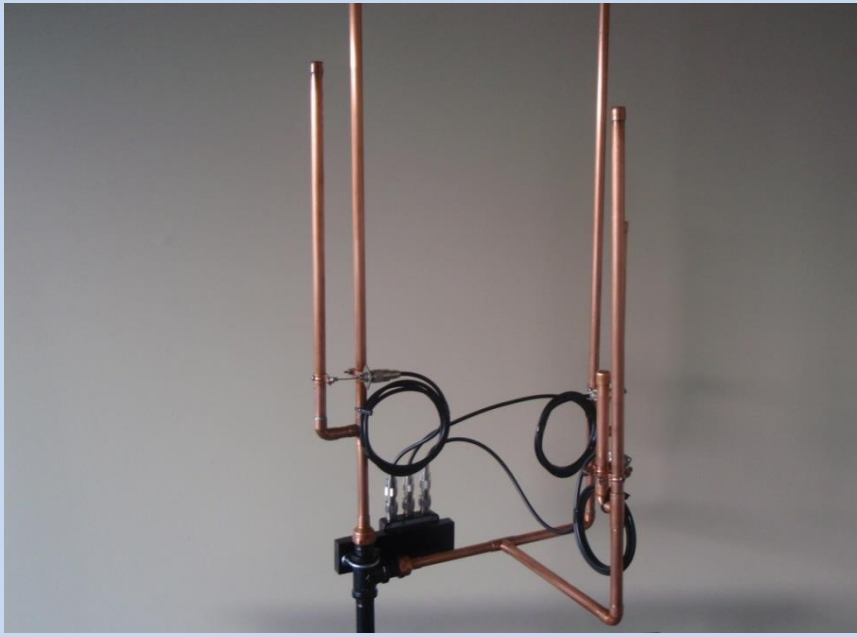
On-Air Performance

Years ago, prior to building the first J-Pole antenna for this station, the author used a standard 1/4-wave ground plane vertical antenna. While he had no problem working various repeaters around town with a 1/4-wave antenna, simplex operation left a lot to be desired. The J-Pole performs just as well as a Ringo Ranger, and significantly better than the 1/4-wave ground-plane vertical.

Multi-Band J-Poles – Thanks Dave W6JDG







DUAL BAND J-POLE 144/440Mhz

Orginal Plans By: Allen Lowe (N0BMW)

Simple to create yet effective 144/440 Mhz Antenna.

Materials Needed (Refer to parts list below)

- 8ft (96in) of 3/8" Aluminum Rod
- 1 5-1/2" of Aluminum Angle (1-1/2"X1-1/2"X3/16" THICK)
- 1 SO-239 Female to 3/8"-24 Thread (Available At Radio Shack)
- 4 3/8"-24 Stainless Steel Nuts
- 3 Pliable Vinyl Caps (Optional)

Tools Needed (Basic Version)

- Tape Measure (Vernier/Caliper prefered)
- Marker (Automatic center punch prefered)
- Drill W/ Drills bits (up to 1/2")
- Saw (Hacksaw or Bandsaw with metal blade)
- File And/Or Sandpaper
- 3/8"-24 Tapping Die (With holder)
- 3/8"-24 Tapered Tap (With holder)
- Vise Grips with protective caps (Can use a rag instead of caps)

Instructions (Instructions are not exact, please use good judgement and saftey)

1.) Using your measuring device and marking device layout the holes on the angle as shown on page 2.

2.) Drill the holes to 1/8" as pilot holes. Then drill to hole sizes listed on page 2. If your using a different SO-239 Than what is listed here. please check the dimension of the plastic washer that fits into the angle and check it's size (it might differ from each manufacture) If different please change the 1/2" hole to the proper size for the plastic washer to fit snug.

3.) Use the 3/8"-24 Tap and thread the two smaller holes in the angle

4.) Using the saw cut the aluminum rod to the dimensions of 58", 18-5/8" and 6-3/4" These Dimensions Might vary a little bit depending on the Jam nuts that are being used.

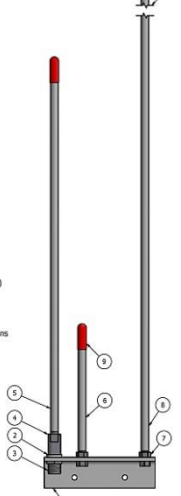
5.) Using the threading DIE, Thread the ends of the aluminum rod to around the dimensions listed on page 2. Try not to over make the threads.

6.) Using a file/sander to take off any sharp edges or metal burrs.

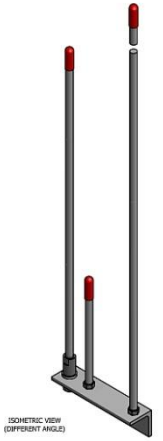
7.) (Optional) Place protective caps over the 3/8" Rods

8.) Assemble the antenna to the pictures shown. Maintain lengths of rod to the dimensions shown

Break Shown To Fit Part On Sheet



VIEW1
SCALE 1 / 2

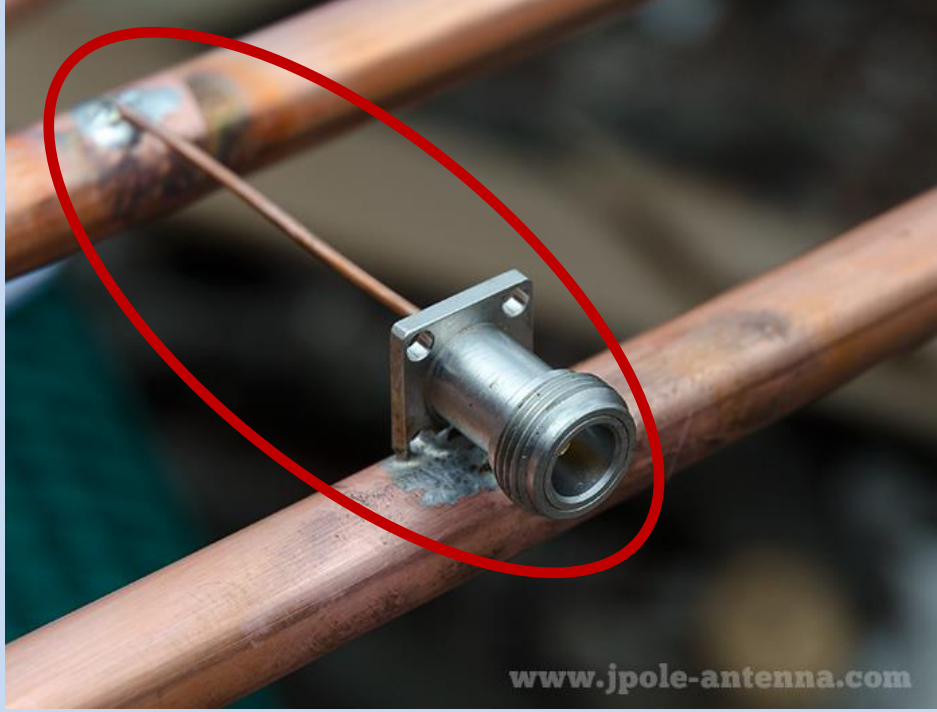


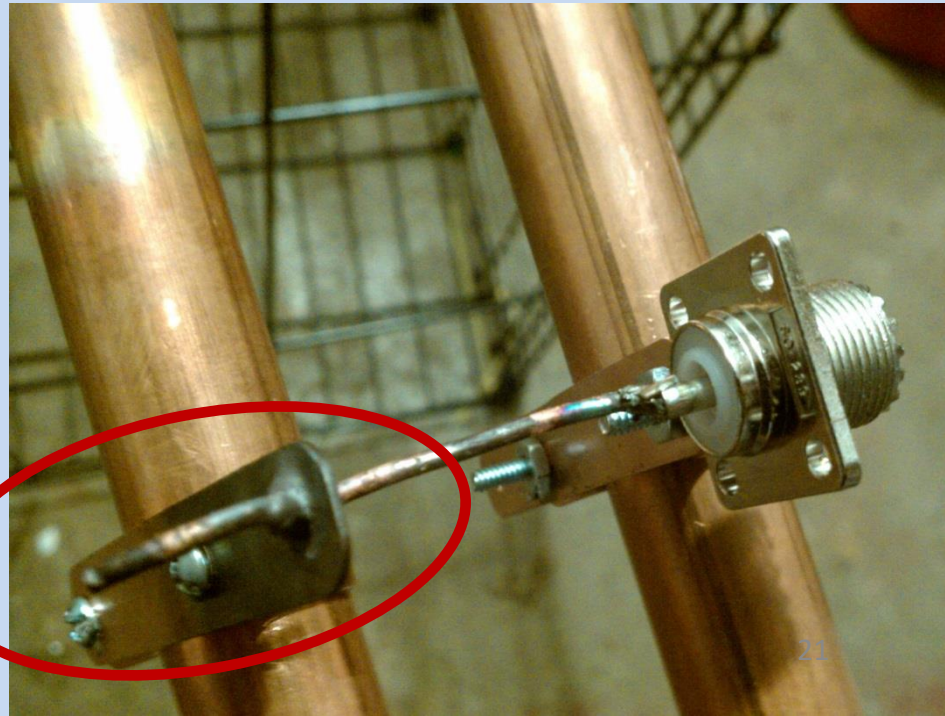
ISOMETRIC VIEW
(DIFFERENT ANGLE)

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	5-1/2" ALUM ANGLE	1.5X1.5X.188 ALUM ANGLE
2	1	SO-239 SPACER	Plastic Spacer
3	1	SO-239-STUD	UHF W/ 3/8"-24 STUD
4	1	SO-239-COLLAR	3/8"-24 Threaded Coupling
5	1	19-1/4" Alum Rod	3/8" Rd. 19-1/4" Long Alum Rod
6	1	6-1/4" Alum Rod	3/8" Rd. 6-1/4" Long Alum Rod
7	4	3/8" SS NUT	3/8"-24 Stainless Nut
8	1	57in Alum Rod	3/8" Rd. 57-1/2" Long Alum Rod
9	3	Optional Protective Cap	Red Protective CAP

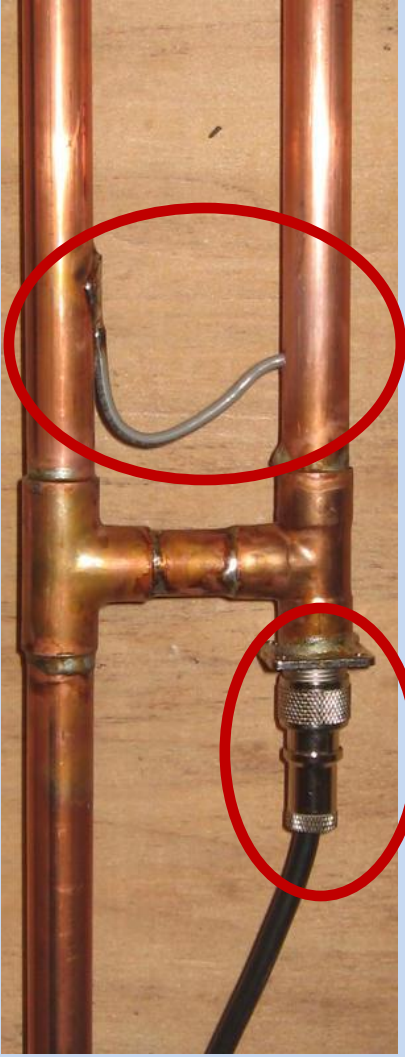
Edited By: Jeffrey Bail - N1BMX
Http://www.N1BMX.com

Page 1 Of 2

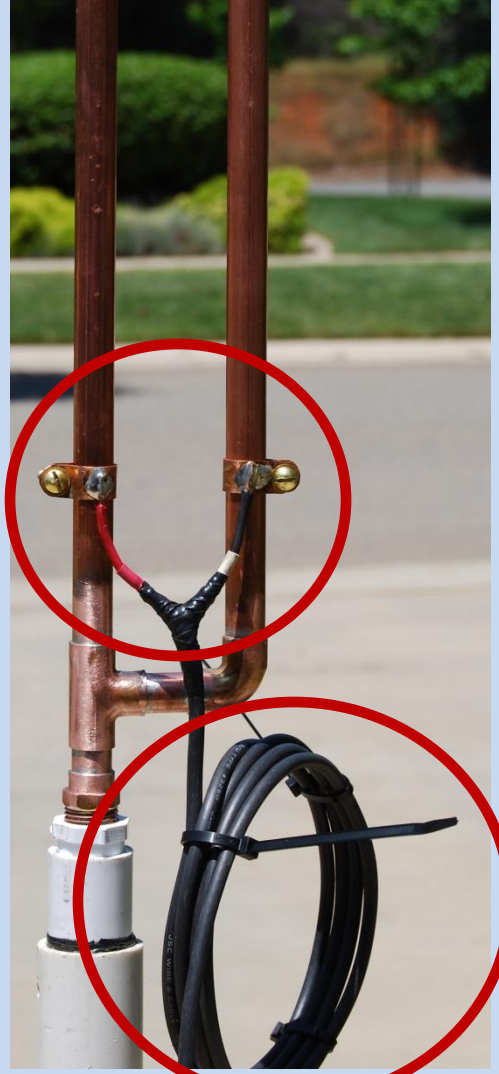




Coax Attachment Methods

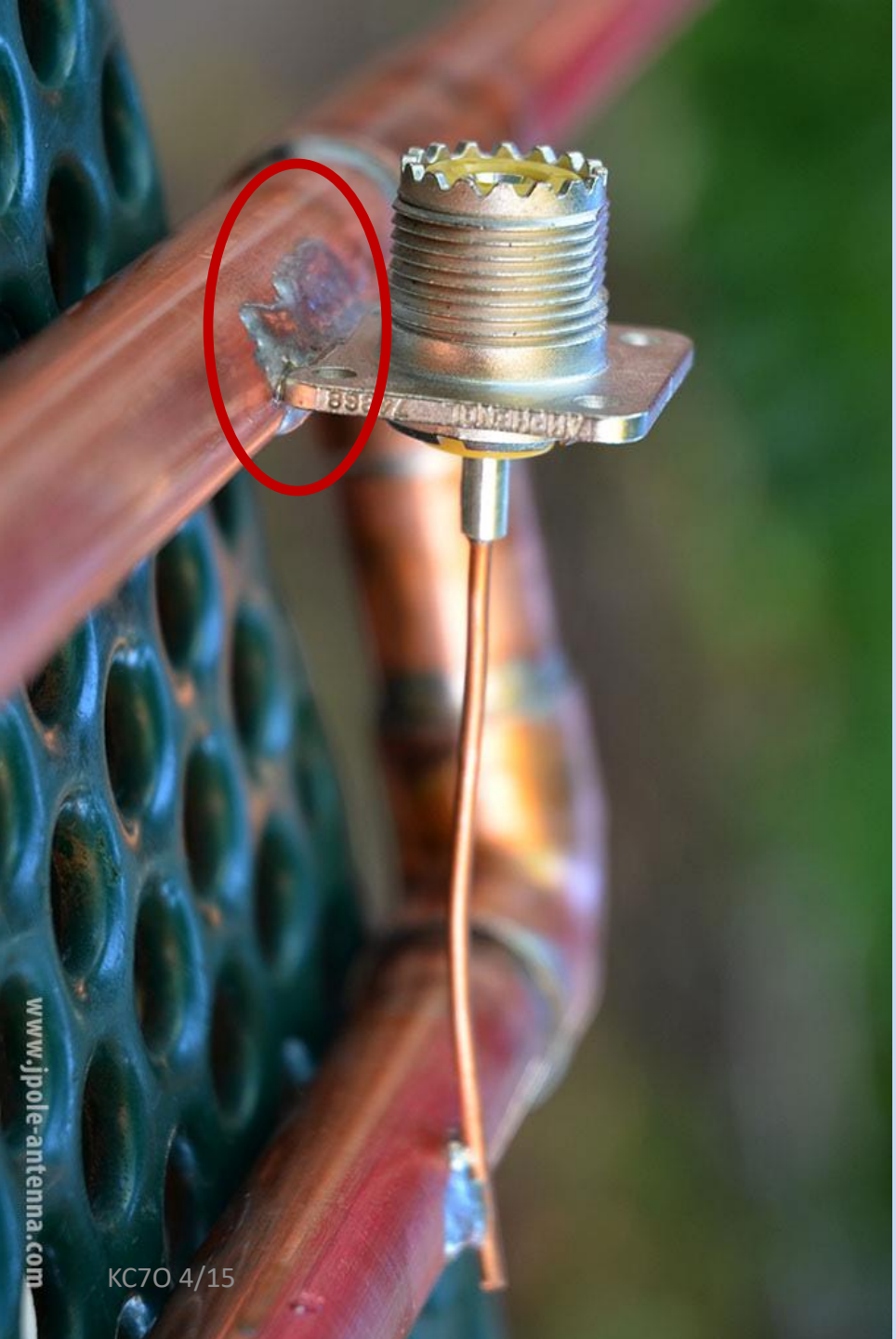


forums.radioreference.com



edcarc.net

KF4EOK

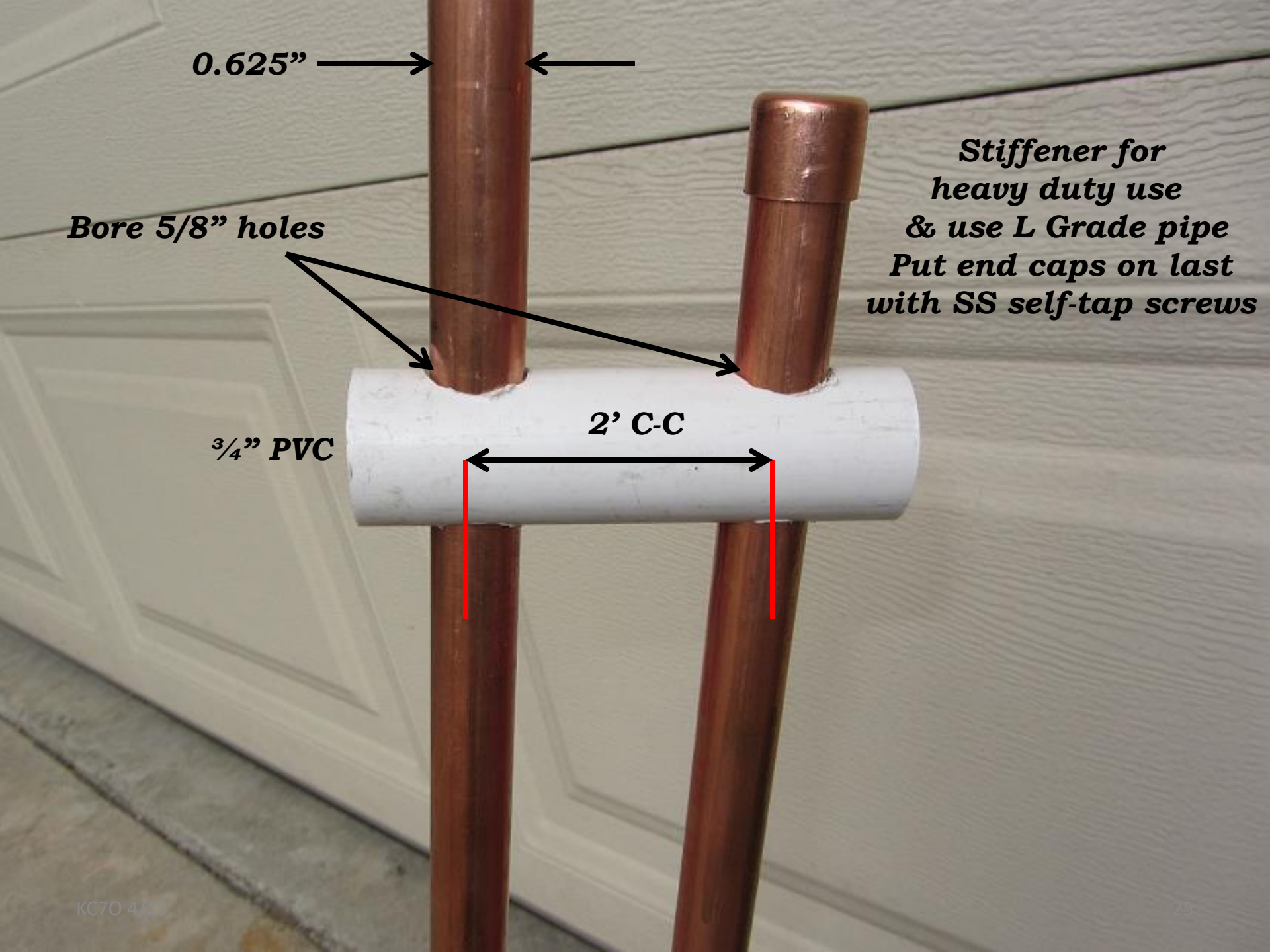


~~K8 9VBR ANTENNAS EST. 2001~~

No Way!!!

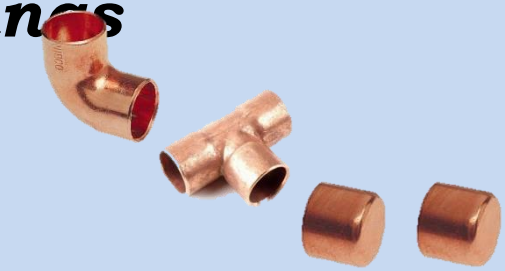
Solder should NEVER be the mechanical connection

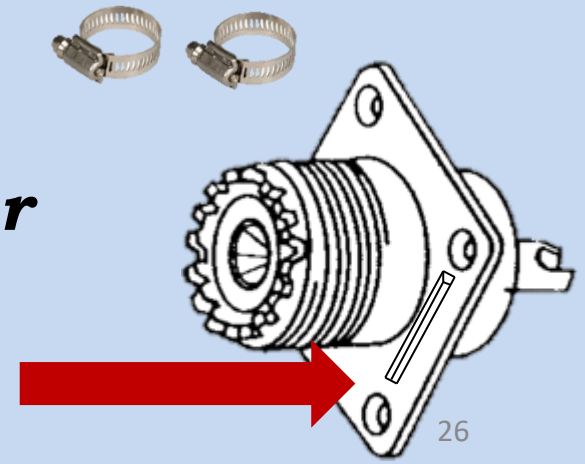

Now to find
the dimensions
that will work
& be repeatable
Tested J-Pole
with
SS Screws
& no Solder


0.625”
Bore 5/8” holes
¾” PVC
2’ C-C
Stiffener for
heavy duty use
& use L Grade pipe
Put end caps on last
with SS self-tap screws

Materials

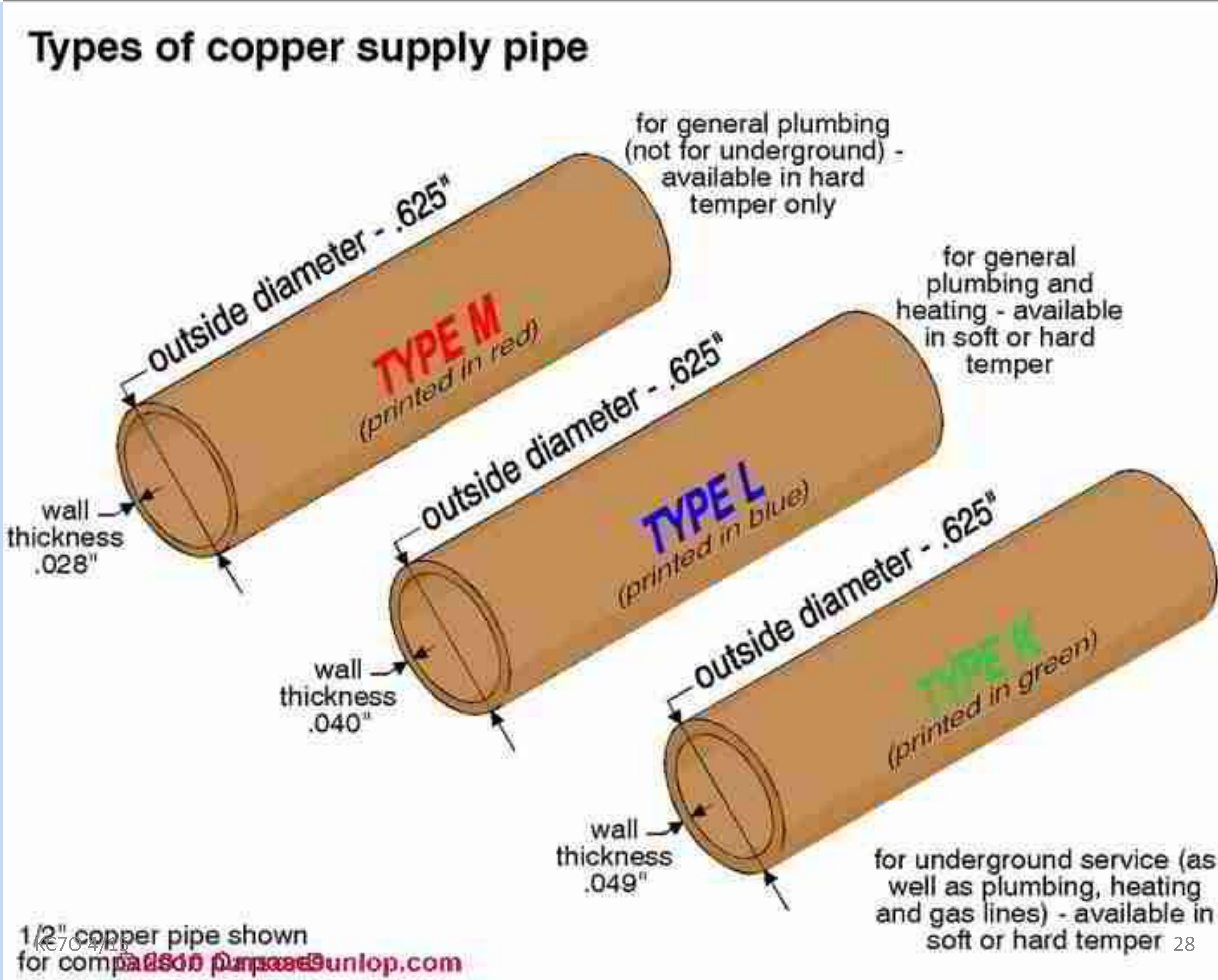
- 10’ ½” copper pipe – Grade L
- Cut sizes for 146 MHz
  - 58 1/2”
  - 21 1/8”
  - 1 3/8”
  - Length for the support ~ 12”
- ½” copper fittings
  - 1 – 90° elbow
  - 1 – “T” fitting
  - 2 – end caps
- 2 - SS hose clamps (3/8” to 7/8”)
- ~ 6” #14 bare house wire
- SO-239 bulkhead mount connector
  - modified with slot for mounting
    - Jim, NW6B, design



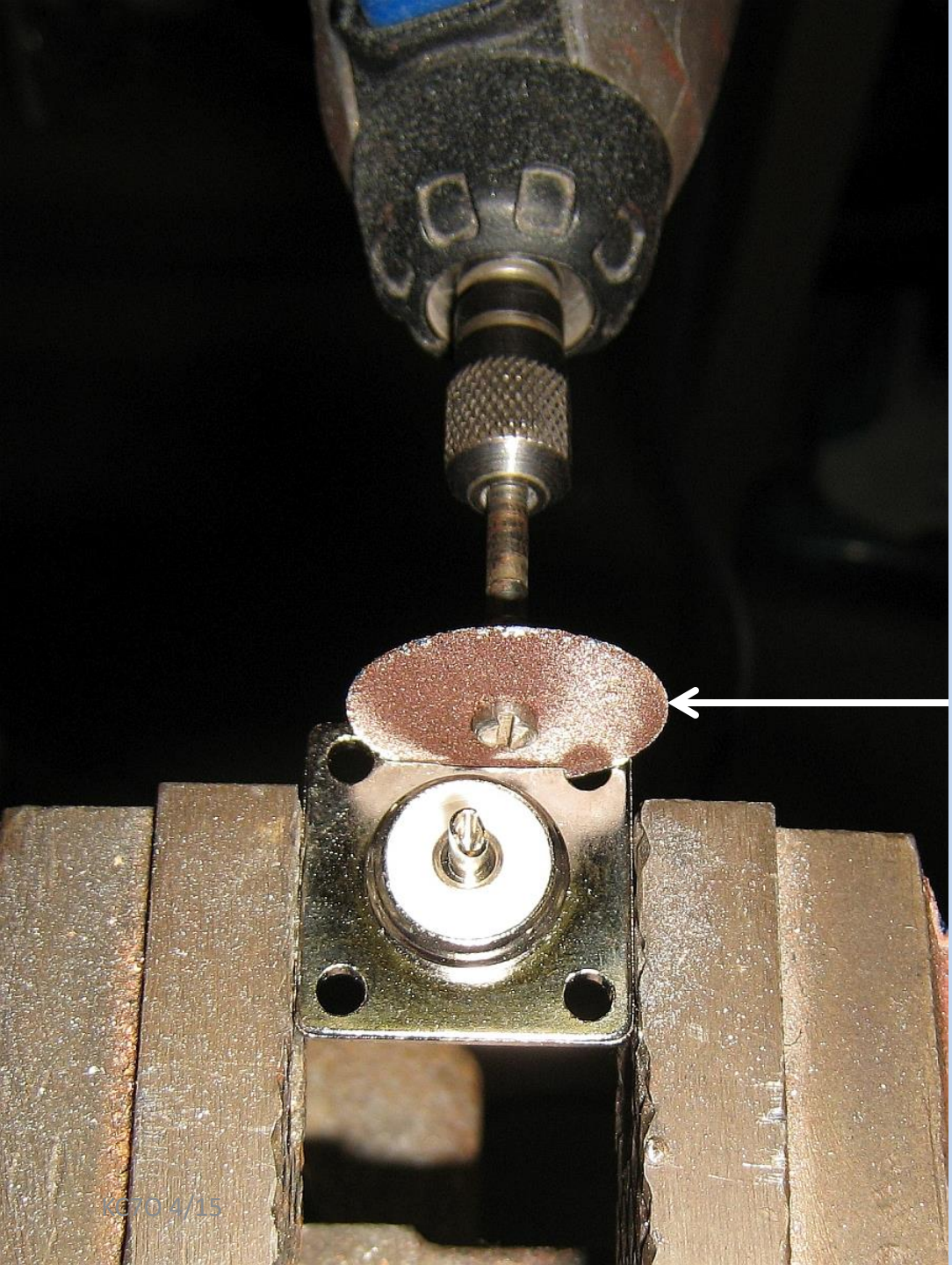


Note

- ***Copper pipe Grades***
  - ***Wall thickness and cost for a ½" 10' pipe***
    - ***2015 Prices***
      - ***M=0.028" ~ $10***
      - ***L=0.040" ~ $15***
  - ***L is more rugged and heavier***
  - ***M is adequate for inside or attic mount***
    - ***May want to use a piece of L for the support pipe***
  - ***Use L for heavy duty outside use***

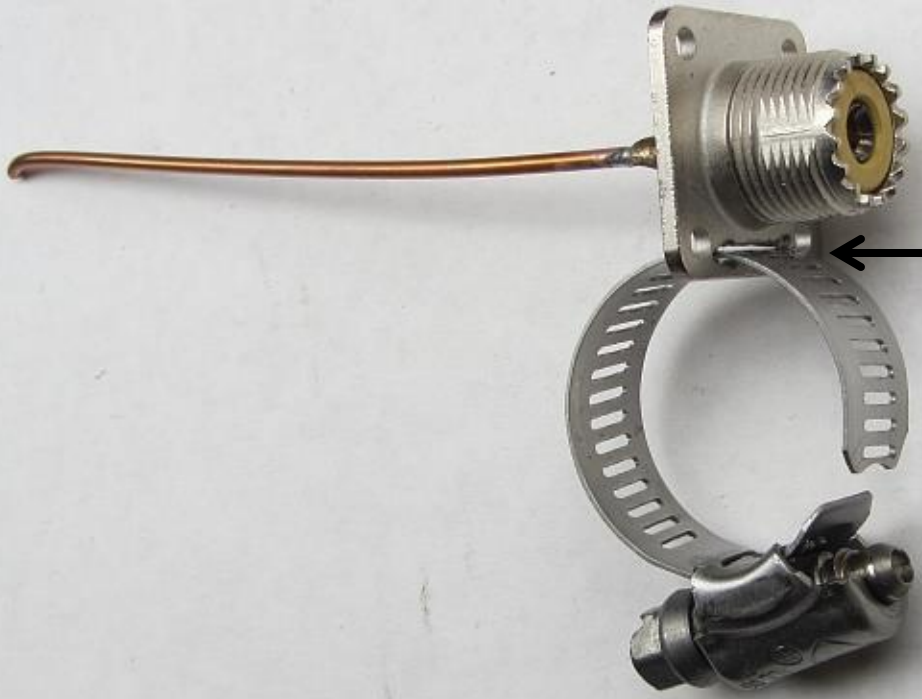

Types of copper supply pipe
outside diameter - .625"
TYPE M
(printed in red)
for general plumbing (not for underground) - available in hard temper only
wall thickness .028"
outside diameter - .625"
TYPE L
(printed in blue)
for general plumbing and heating - available in soft or hard temper
wall thickness .040"
outside diameter - .625"
(printed in green)
wall thickness .049"
for underground service (as well as plumbing, heating and gas lines) - available in soft or hard temper
1/2" copper pipe shown


L
M

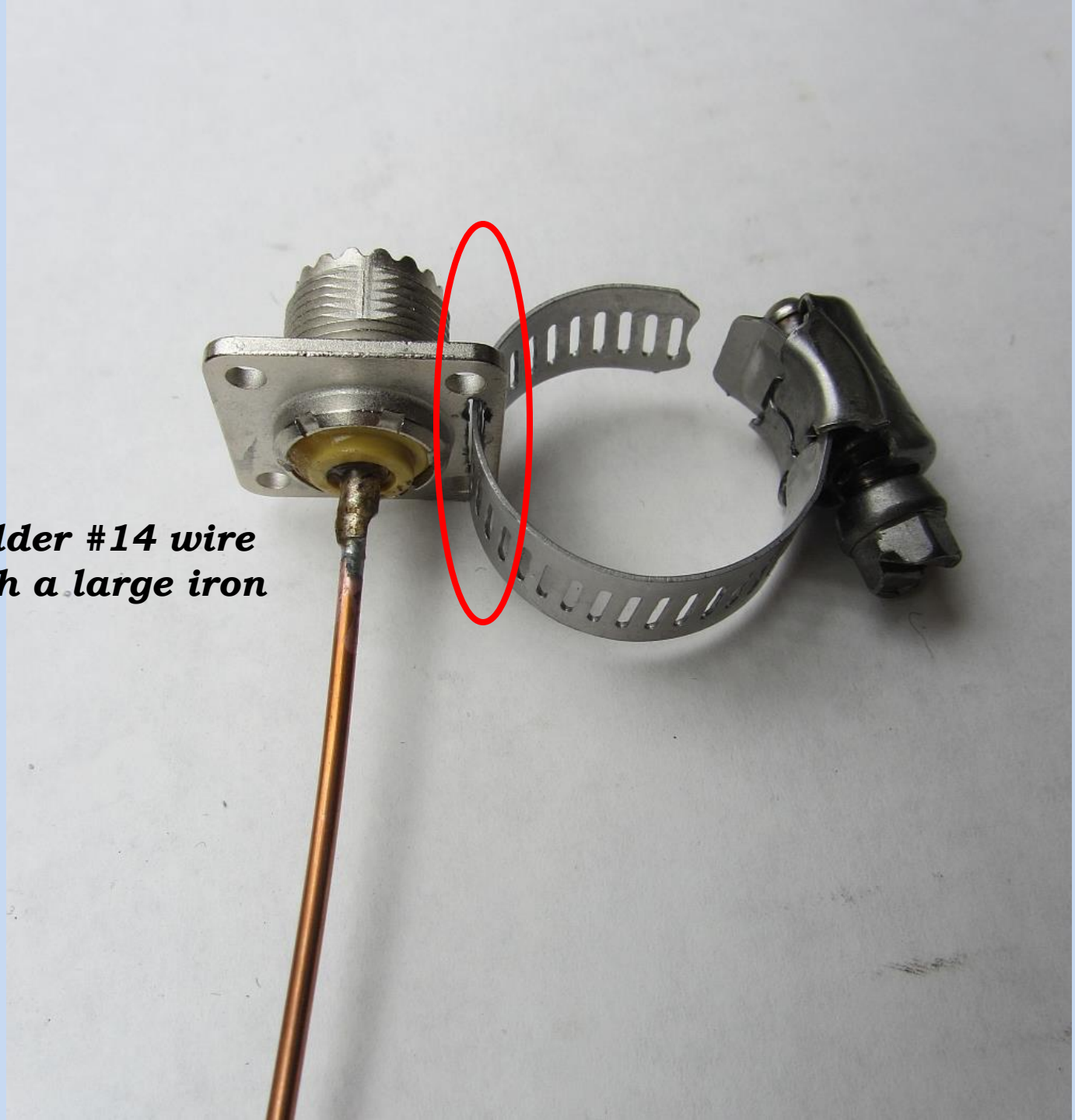


Cutting the Slot

15/16” diameter .040” thick cut-off wheel on a Dremel tool



SO-239 Chassis mount modified with a slot


Solder #14 wire
with a large iron

Tools

- ***Pipe Soldering***
  - ***Solder***
  - ***Flux & brush***
  - ***Torch***
  - ***Sparker***
  - ***Steel wool/Scotch-Brite***
  - ***Wire brushes***
  - ***Tubing cutter***







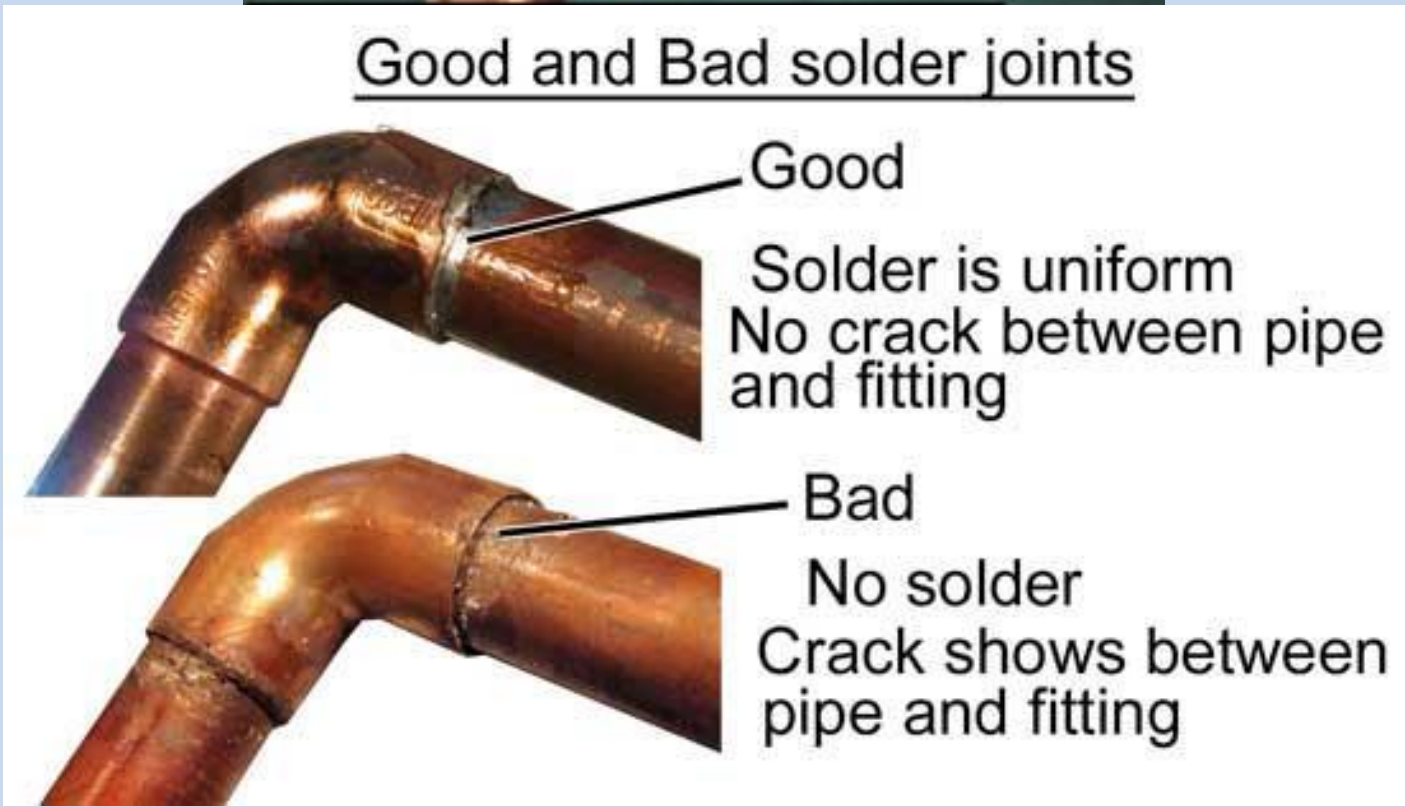

- ***5/16” Nut driver for hose clamps***

- ***Holding fixture for assembly and alignment***
  - ***If needed***
- ***Safety - PPE***
  - ***Gloves & eye protection***

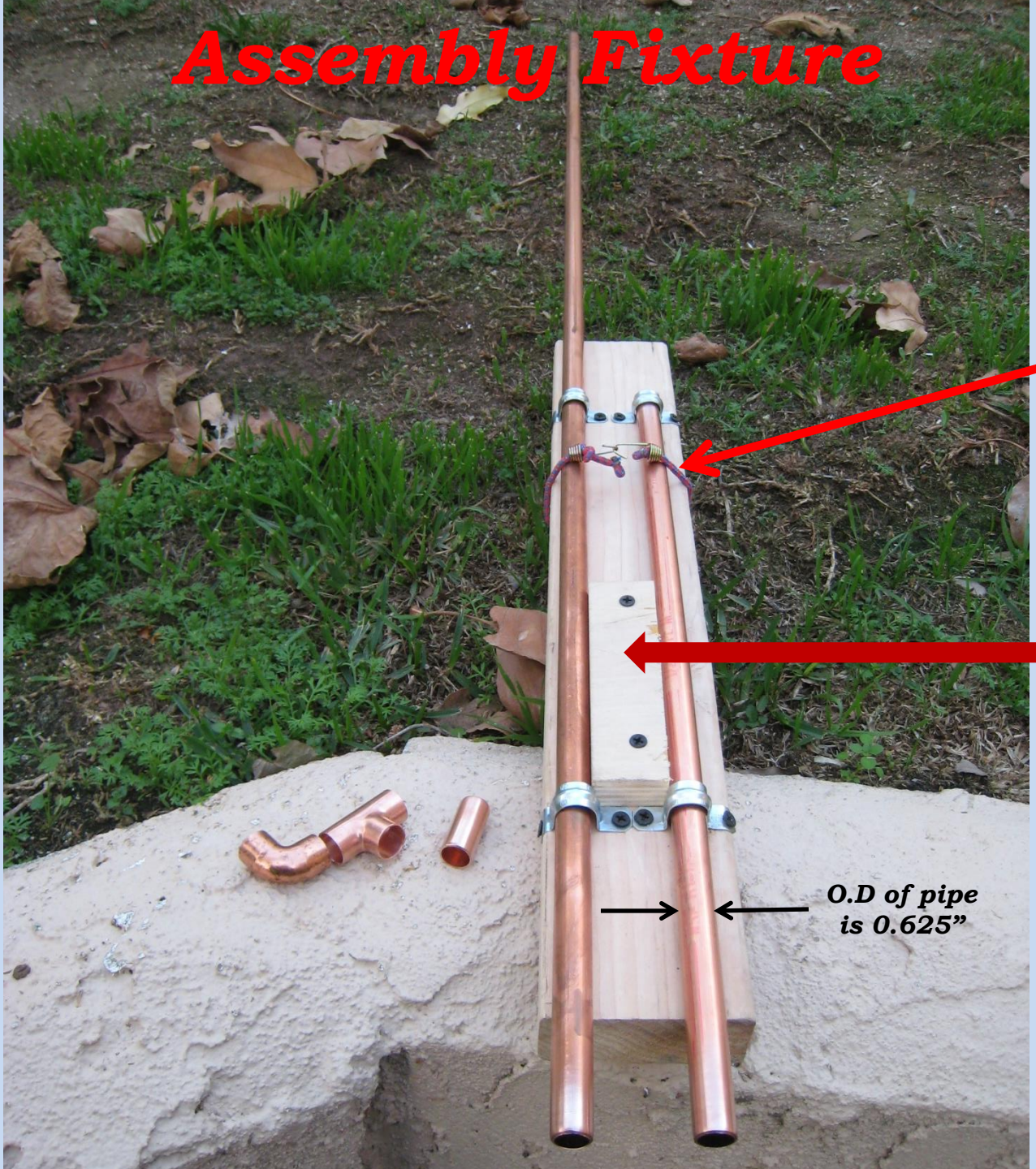

Build

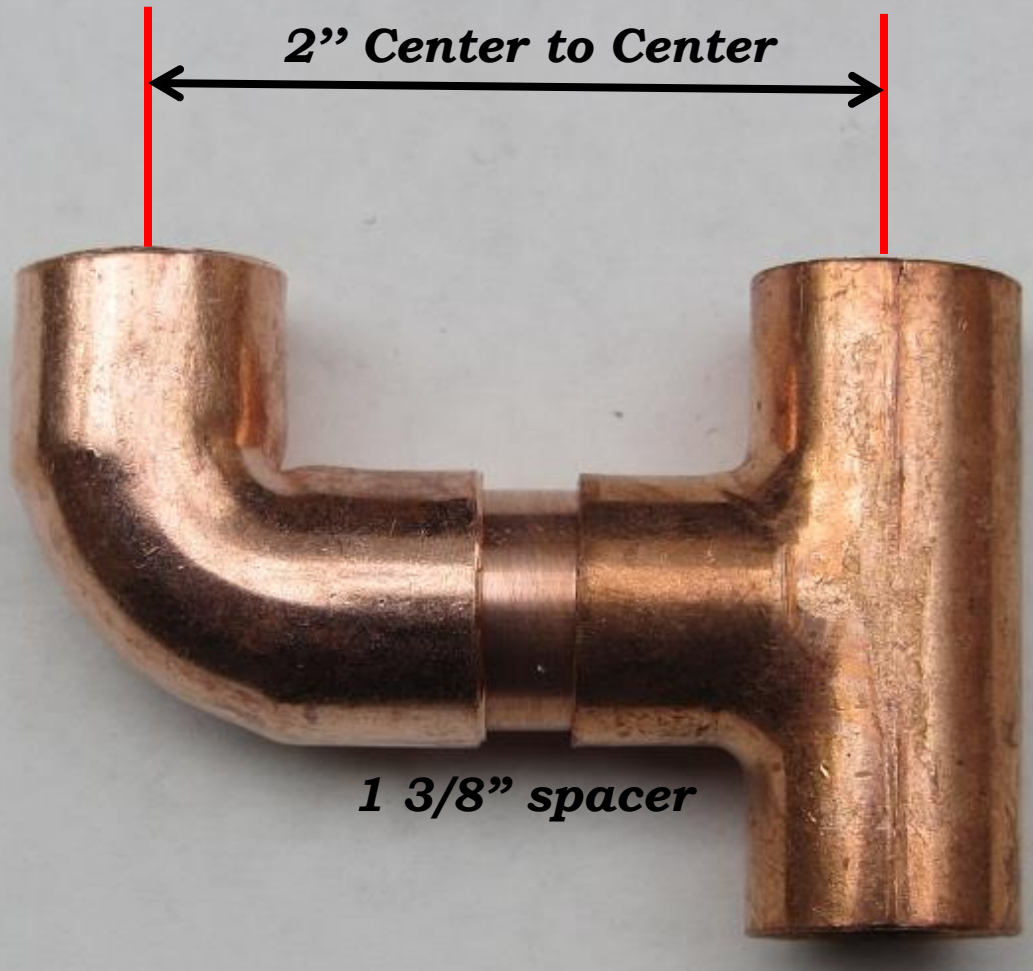
- ***Dimensions***
  - ***Spacing between elements - critical***
    - ***Controls VSWR***
  - ***Length of elements - critical***
    - ***Controls resonant frequency***
  - ***Coax placement***
    - ***Some VSWR control***
    - ***Some resonant frequency control***
    - ***Cannot fix length issues***
- ***Adjustment***
  - ***Some builders solder a brass nut with a brass screw on top of the ¼ wave section for frequency adjustment***


Solder
Tip of cone
Handyman


Good and Bad solder joints
Good
Solder is uniform
No crack between pipe and fitting
Bad
No solder
Crack shows between pipe and fitting

Assembly Fixture





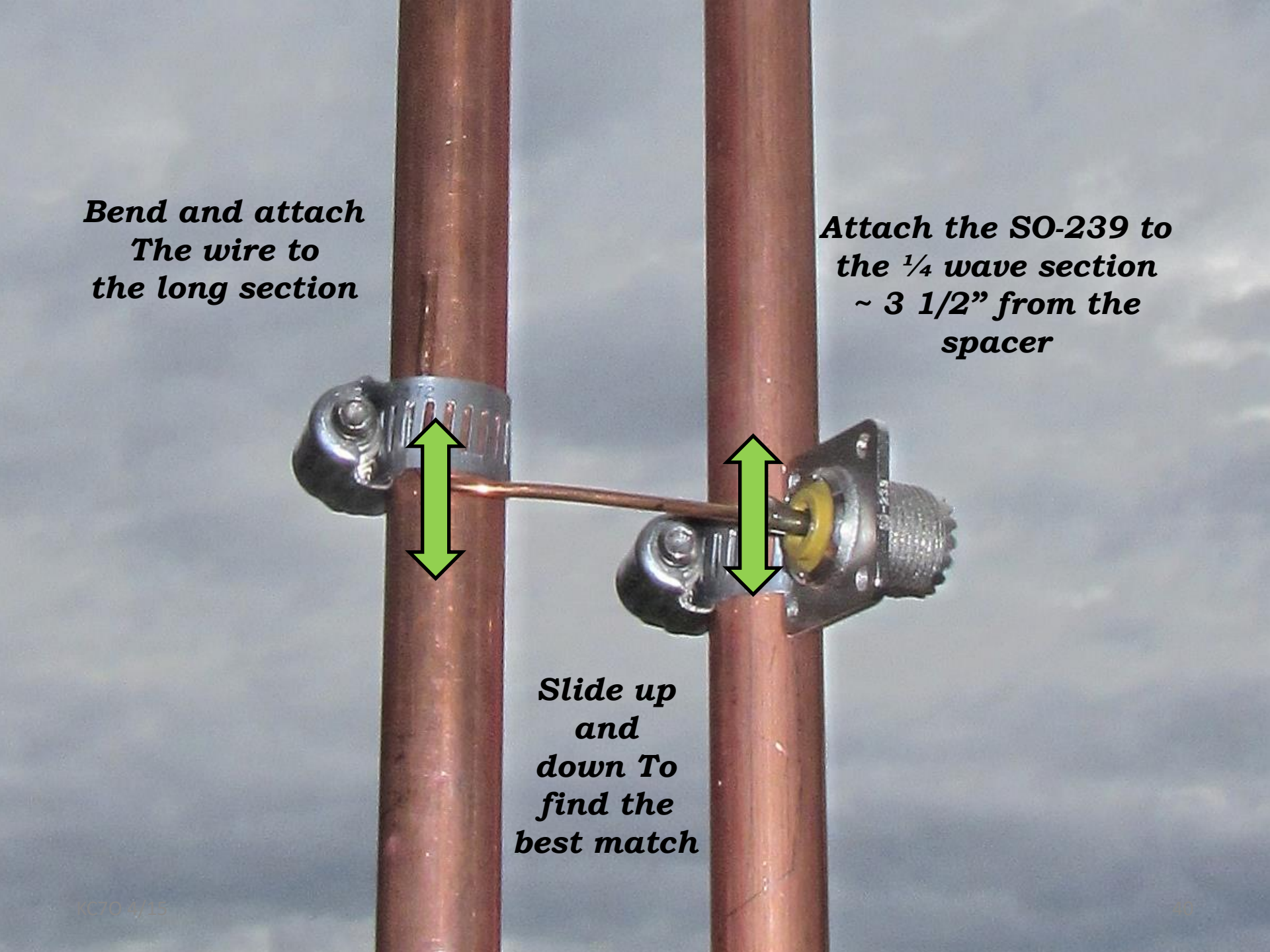
Clean ~ 2 ½” of the pipe before cutting the 1 3/8” spacer

Clean parts, flux, slide together,
install on the elements in the fixture
<u>then</u> solder all joints
End caps are soldered after tuning

Testing & Tuning

RG8-X coax & Antenna analyzer

Some way to hold the antenna for tuning


Bend and attach
The wire to
the long section
Attach the SO-239 to
the ¼ wave section
~ 3 1/2” from the
spacer
Slide up
and
down To
find the
best match

It is suggested that a 3-turn coil of coax, 8” in diameter* is placed by the feed point as a choke to prevent RF on the feed line

A snap-on ferrite could also be used

Try the 2 meter J-Pole on 450 it will probably be less than 3:1

2002 ARRL Handbook – Page 20.58

Mounting

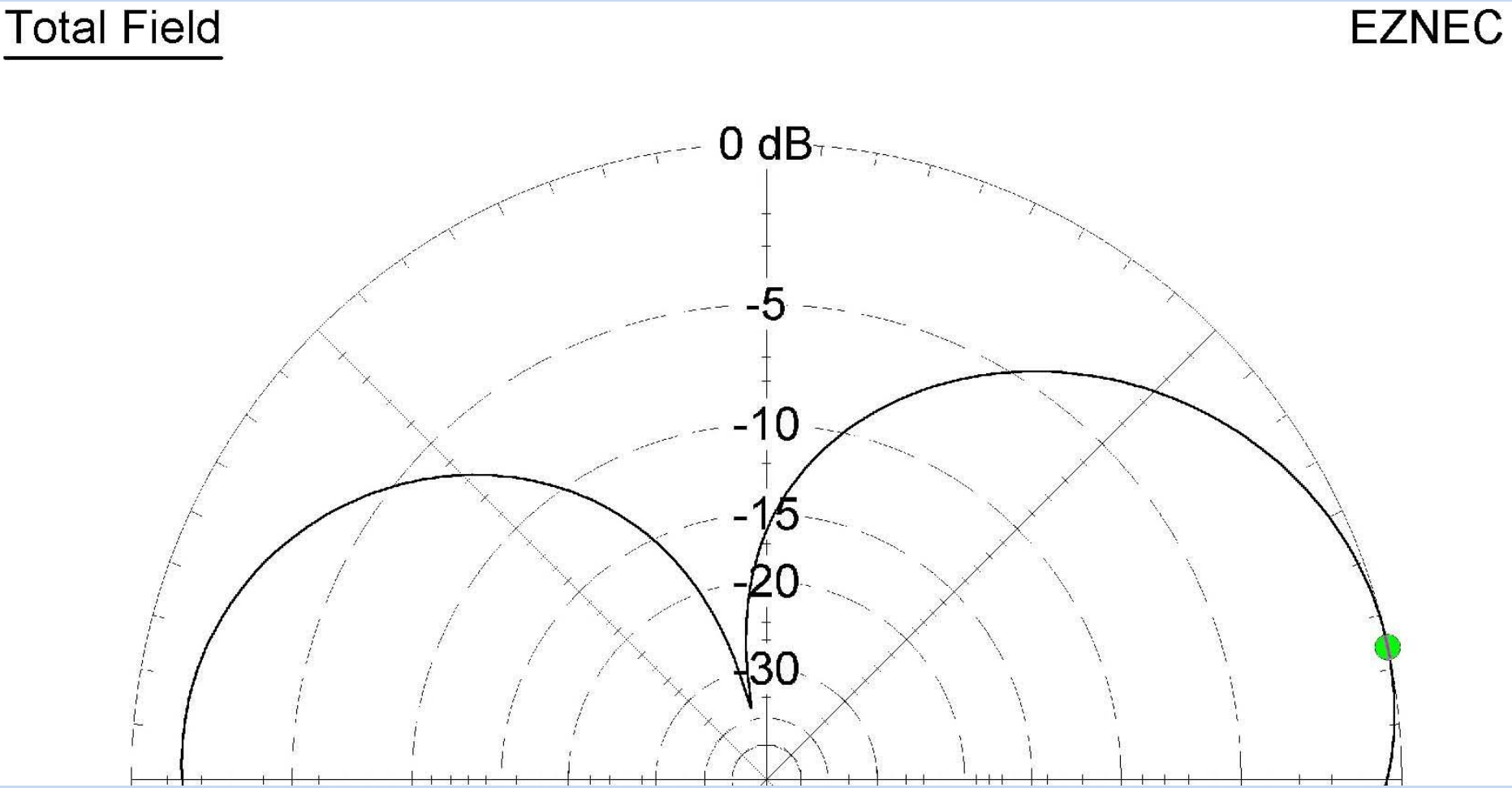
- ***PVC is OK for temporary or inside mounting***

Mounting

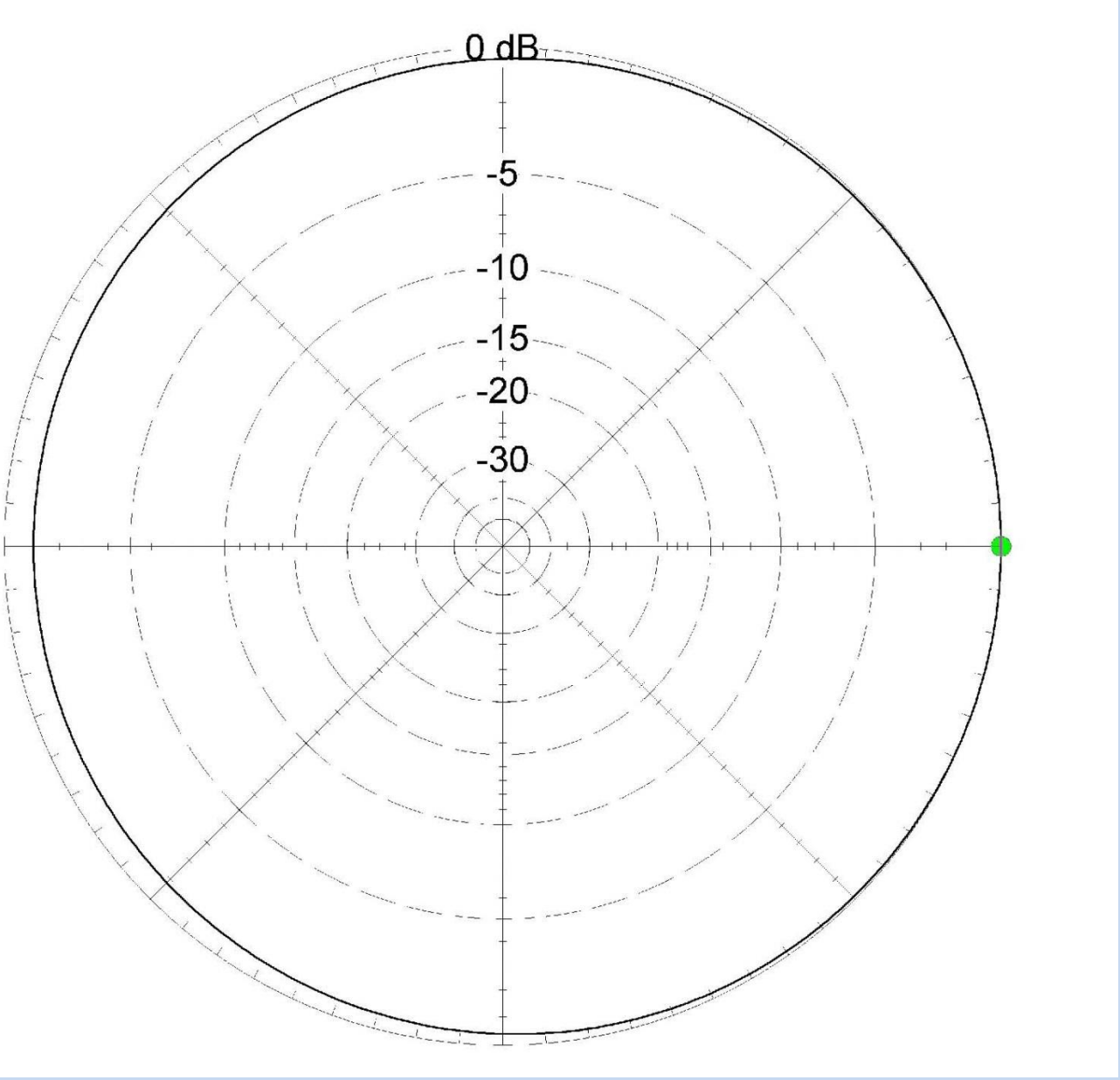
- ***PVC is OK for temporary or inside mounting***
- ***A major advantage of the J-pole is that it is DC grounded and affords good lightning protection for outdoor mounting***

Antenna Model for this J-Pole

@ 146 MHz



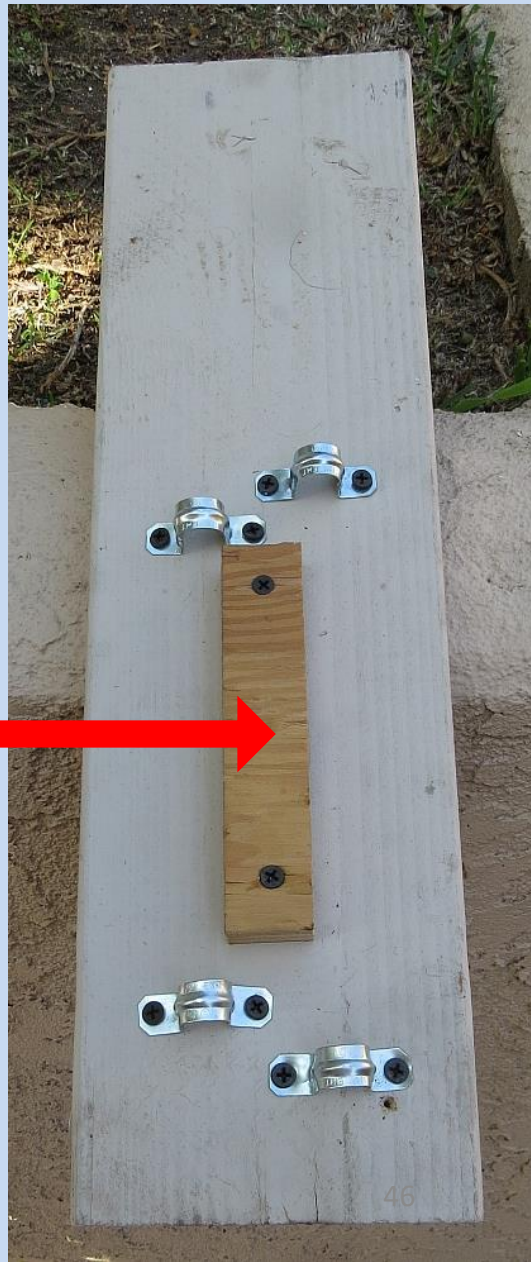
By Terry – WU6N



By Terry – WU6N

220 J-Pole

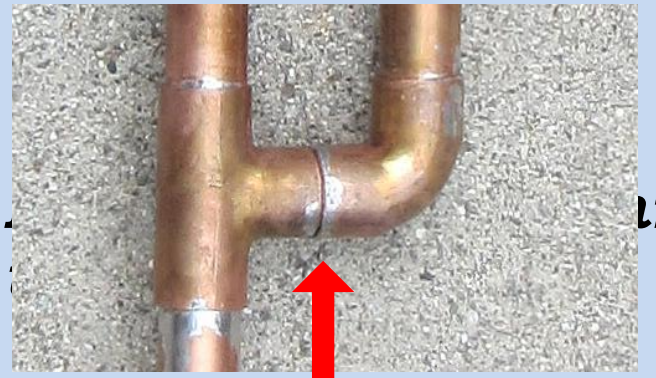
- ***Materials are the same***
  - ***Cut sizes for 223.5 MHz***
    - ***37 7/8”***
    - ***12 5/8”***
    - ***1 1/8”***
    - ***Spacing between elements is 1.2” metal to metal***



www.hamuniversity.com – pretty close to their numbers

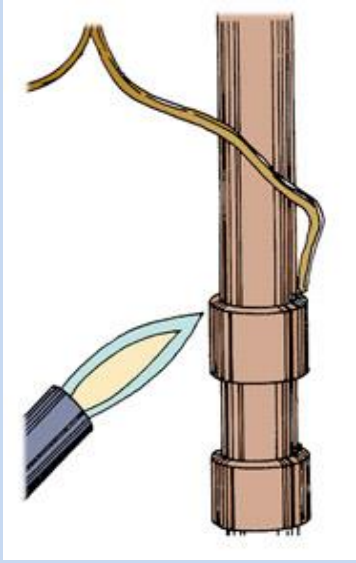
440 J-Pole

- ***Materials are the same***
  - ***Cut sizes for 446.0 MHz***
    - ***19.2” (19 13/64)***
    - ***6.4” (6 25/64)***
    - ***7/8”***
    - ***Butt the T and Elbow together***
    - ***…nector is on***



440 J-Pole Solder Fixture

Remove before use ☺



Let's Cut it, Heat it & Melt Solder!