A high-gain J-pole? Impossible? Not if you follow KA4LBE's advice and add a little here, tweak a little there, until you have a . . . well, read the article!

The EZ-J High-Gain J-Pole Antenna

BY BENSON SMITH,* KA4LBE

Last month we learned how easy it is to design and build a J-pole antenna ("The EZ-J J-pole Antenna," page 58). This time you will learn how to convert that J-pole into a higher gain antenna by converting it into a collinear. We will look at two methods of making a collinear J-pole. The methods employed may be applied to converting other types of antennas into collinear versions. You will discover that the collinear is easy to make.

A collinear antenna is so named because it has two or more radiators which are in phase with each other. In a collinear the RF signal which appears at any point on one element is in exactly the same phase at the same point(s) on the other element(s). This creates RF fields from the separate radiators which are in phase and additive, thereby strengthening the radiated field. To achieve this phasing, there are "phase lines" at the junctions of elements which act as a kind of RF delay line, which delays the RF signal between the elements so that the RF signal arriving at the next element is in phase with the RF signal arriving at the previous element. Since it requires a certain time for the RF signal to travel from its input to its output. The trick in designing a phase line is to design it so that it is the required electrical length to produce the phase delay needed.

In so-called "free space" a radio (RF) signal travels at a speed of about 984,000,000 feet (about 300,000,000 meters) per second. A full wave in free space completes one cycle in the distance, which can be calculated using equation 1.

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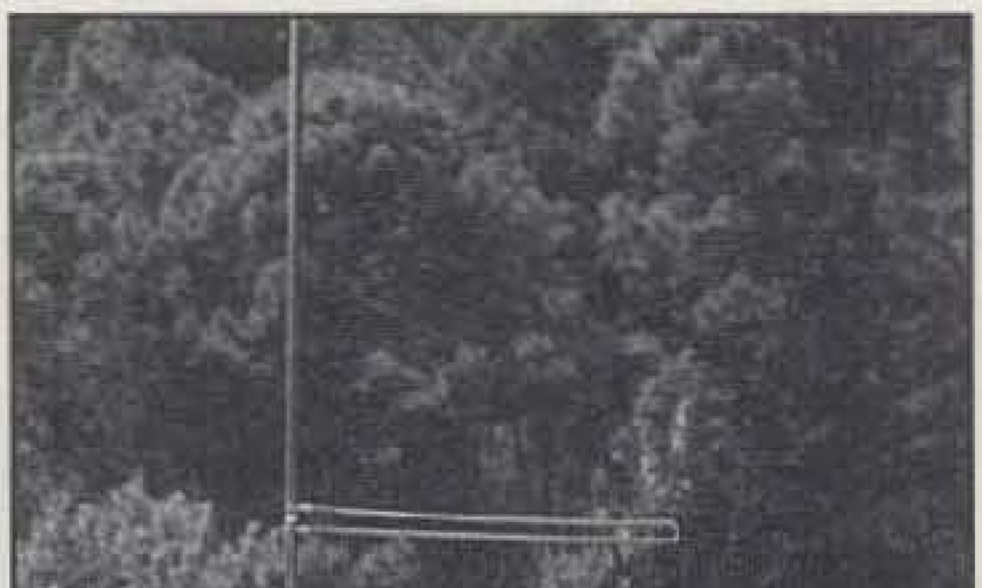


Lois, KA4LBD, holding the finished EZ-J high-gain antenna.

$$\text{Free-space wavelength in ft.} = 984/F_o \qquad \text{eq. 1}$$

where F_o is the frequency in MHz of the RF signal.

RF signals, as we know and use them, act a bit differently. When an RF signal is traveling on a conductor, such as a wire or metal rod, the speed at which it travels down the conductor's length is slower, or appears to be slower, than its speed in free space. To explain this we simply add a "K" factor to equation 1, producing equation 2. The "K" factor is usually less than 1.

$$\text{Feet} = [984/F_o] \times K \qquad \text{eq. 2}$$

Some of the properties that affect the speed of propagation include:

1. Diameter of conductor relative to wavelength.
2. Inductive coupling between conductors.
3. Dielectric of environment surrounding the conductor.
4. Capacitance between elements of antenna and/or ground.

To create a phase line it seems that we simply should need to incorporate a certain combination of these properties into a conductor and place that conductor between two identical radiator elements to create a collinear combination. This cannot be done. The reason is that a phase line has one unique, yet quite important, characteristic: *A phase line should not radiate RF!*

Loop Phasing Method

One method of creating a phase line is to use "loops" as in the "Super-J." The Super-J uses two half-wave radiator sections with loop phasing between them (fig. 1). Loops have a total length needed for proper delay or "phasing" from the first driven element to next. The loop's fields cancel, since about half of the loop lies in one direction and an equal length is in the return direction. The loop end (exaggerated in fig. 1) does radiate

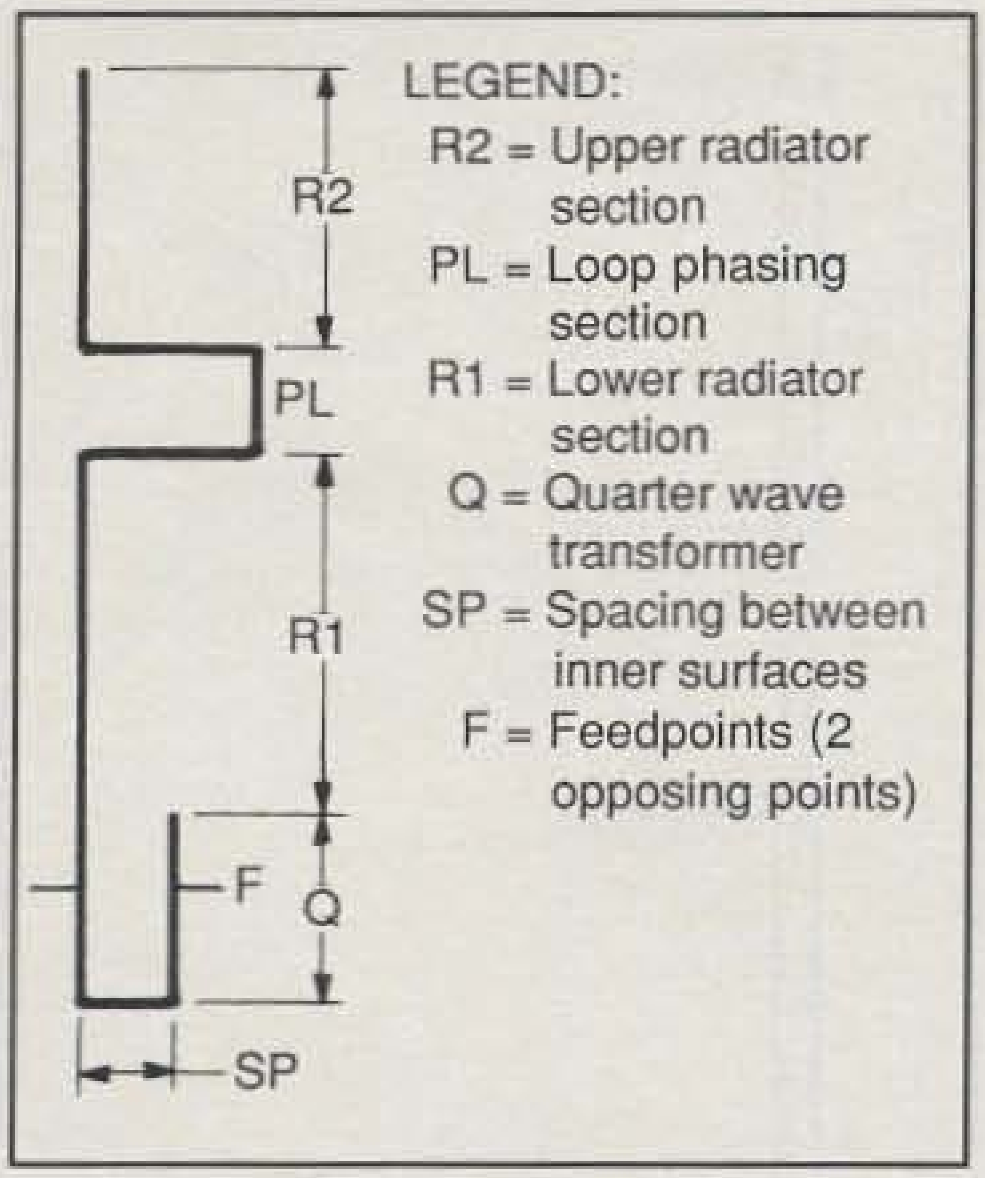


Fig. 1– The loop phasing method.

a very small amount. Loop spacing should be kept small—0.5 to 1 inch.

Coax Phasing Method

A second phasing method employs a straight- length delay line. As we have mentioned, a phase line should not radiate. If we used a simple straight piece of conductor, that line would radiate, becoming part of an undefined and unwanted antenna radiator design. What could be done to overcome the problem?

1. Shield the conductor.
2. Place the conductor in a dielectric to produce a small "K" value which will shorten the coax length, avoiding resonance length.

In other words, use lengths of coax as the phasing lines.

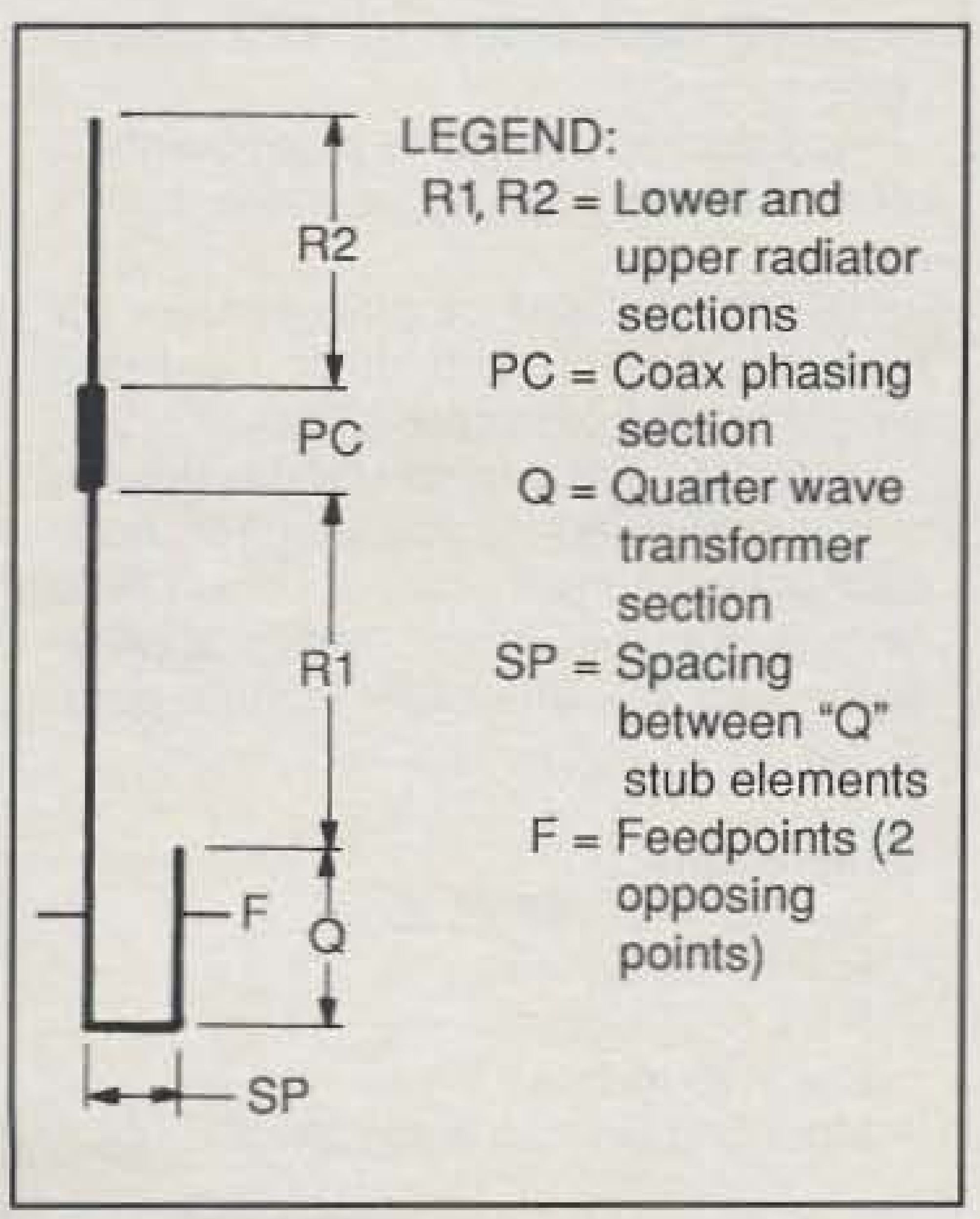


Fig. 2– A collinear J-pole phased with coax sections.

Coax has an inner conductor surrounded by a dielectric material which "slows" the velocity of travel of the RF signal. This results in a section of coax with an overall physical length shorter than a plain conductor producing the same phase delay length. Coax has an outer shield conductor such as braid or foil or both which shields (or prohibits) most radiation occurring from the center conductor.

Since the phase-line shield is not conducting RF current, it should not be terminated or grounded to any other conductor or ground. Leave both ends of the shield open. Connecting the shield to any other conductor probably would result in an RF current flow on it, which would create a totally different device and not be the collinear antenna originally desired.

Since the physical length of the section of coax is shorter than a plain piece of conductor having the same phase delay, it probably would not be resonant at or near the operating frequency. This protects against outer-shield-induced current radiation.

Fig. 2 is a sketch of a collinear J-pole phased with coax sections. The upper and lower radiators are connected by the center conductor of the coax phase section, "PC." The shield of the coax must not connect to anything. A length of "PC" is selected to achieve the correct phase delay for the radiator pair chosen. Radiator pairs other than half-wave lengths are possible, requiring a unique length of coax phase section.

The following equations may be used to determine the dimensions of the various half-wave collinear J sections.

Half-Wave Radiators (inches)

$$R1 = R2 = [(492 / F) \times K] \times 12 \qquad \text{eq. 3}$$

where "F" is in MHz

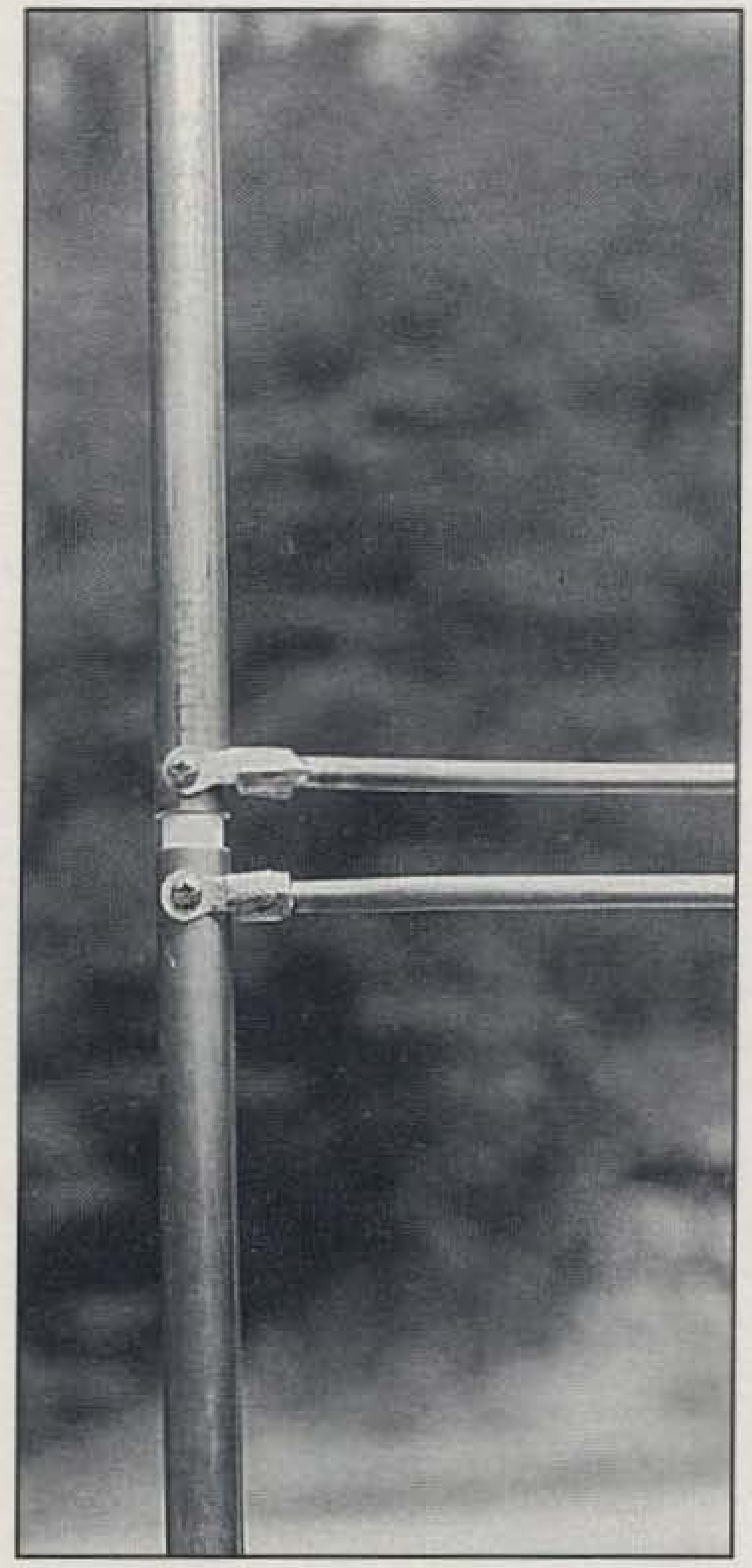
The value of "K" can be found in *The ARRL Antenna Book.* See last month's article on J-poles for information on determining "K."

Coax Phase Line (inches)

Important: To determine the length of coax phase sections you must know the true value of the velocity of propagation (Vf) of the coax to be used. Again, *The ARRL Antenna Book* has a table listing the velocity factors of most common coax cables.

The following equation allows calculation of the length of a coax phase line, "PC," for use in conjunction with half-wave radiators.

$$PC = [(492 / F) \times Vf] \times 12 \qquad \text{eq. 4}$$



Phase loop attachment. Note the insulator rod.

Loop Phase Line (inches)

The Loop Phase Line, "PL," is calculated for an overall length dimension. It is then bent into a loop having a small, uniform spacing of 0.5 to 1 inch. The length determined will be from the point of contact of the end and beginning, respectively, of the two radiators. Length includes both sides and end segment of the loop.

$$PL = [(492 / F) \times K] \times 12 \qquad \text{eq. 5}$$

where "K" is determined by the diameter of the loop conductor.

Quarter-Wave "Q" Section (inches)

$$Q = [(246 / F) \times Vf] \times 12 \qquad \text{eq. 6}$$

Our "Q" section is of open parallel conductor design so that the value of Vf we will assign is 0.98.

Converting the Sample J-pole Into a Loop-Phased "Super-J"

Let's design a collinear J-pole based on the standard half-wave "J" we discussed last month. We will use 1/2 inch thin-wall copper pipe and make a "loop phased collinear." The material for the loop will be 1/4 inch copper pipe. The dimensions of the radiator and "Q" section will be the same as in the previous sample. This means that for the same frequency of design and materials our existing J-pole will be used "as is" by only removing the top pipe cap. For those needing to start from scratch, the steps are as follows:

1. Determine design frequency. We will use 146.5 MHz.

2. Determine "K" of radiators. Refer to Chapter 2 of *The ARRL Antenna Book.* The outside diameter of 1/2 inch thin-wall copper is about 0.625 inch. The free-space wavelength at 146.5 MHz is:

L_{fs} (in.) = (984 / 146.5) × 12 (eq. 1 in in.)
~ 80.6 inches
L / D = 80.6 / 0.625
~130

From the chart, "K" is about .96.

3. Radiator sections. Insert required values into equation 3.

R1 = R2 = [(492 / 146.5) × .96] × 12
= 38.7 inches

4. "Q" section. Insert required values into equation 6.

Q = [(246 / 146.5) × .98] × 12
= 19.75 inches

5. Phase loop. Using the ARRL Chart again, we find the "K" value of 1/4 inch pipe at 146.5 MHz is about 0.97. Insert the appropriate values into equation 3 (this is also a half-wave element).

PL = [(492 / 146.5) × .97] × 12
~ 39.1 inches overall length

Add a bit to make connections. Remember, length is from points where the loop leaves and arrives at the radiators.

6. Miscellaneous

• We will use a "Q" element spacing of 1 to 1.5 inches.

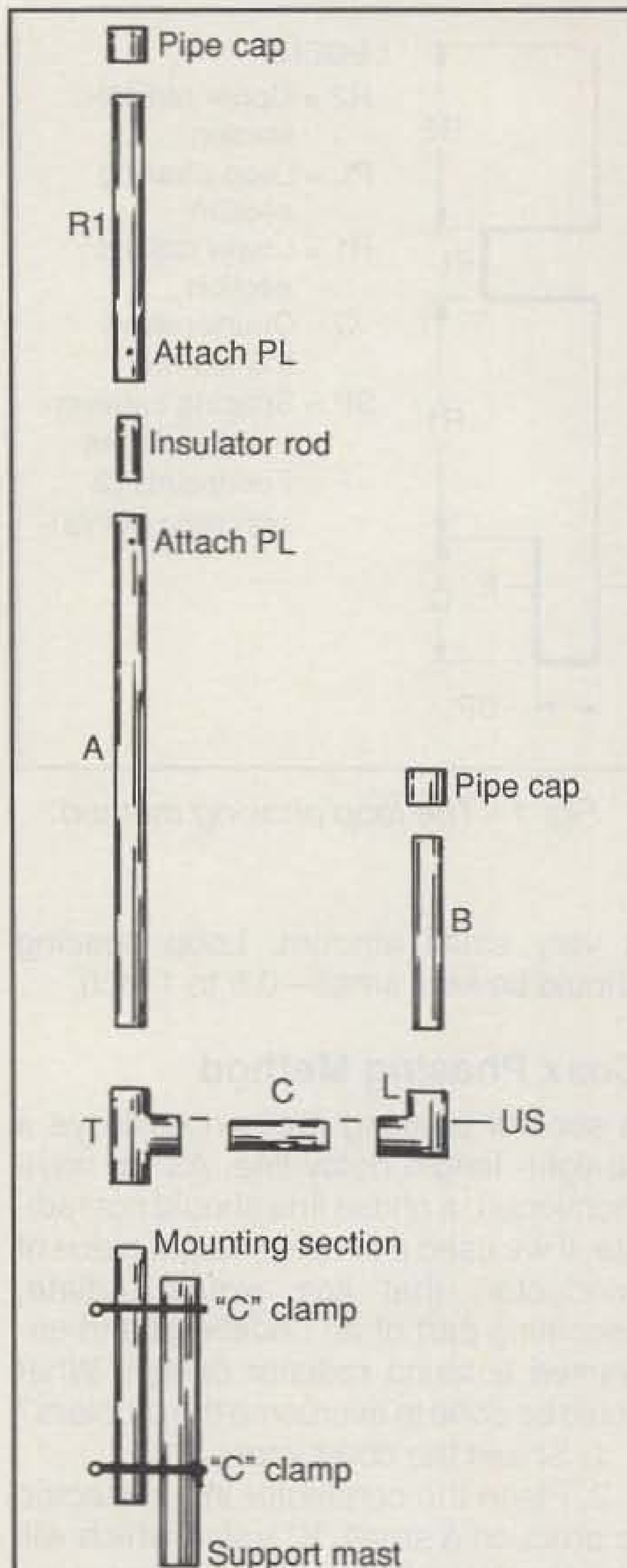
• Add an RF choke-balun at the feed point and "tune" as in last month's J-pole article.

• Be certain that the separation in the "Q" section is held firmly and uniformly. A narrow piece of clear plastic could be used at the top of "Q" to hold it. I used 1/2 inch CPVC parts to make a separator (see photo).

Assembly of the Collinear "J"

Temporarily assemble all parts (do not solder yet). Slip on caps and recheck measurements referenced to "US" (upper surface of cross-over). Disassemble and clean all ends and then flux joints. Assemble and solder carefully. Attach the phase loop, referring to fig. 4.

Attach the feed coax to a set of stainless hose clamps. Add the RF choke-



Materials:

R1, A, B, C, Pipe Caps, L, T, and mounting section are 1/2 inch copper pipe.

Insulator rod used is 3/8 inch fiberglass electric fence post, 10 or more inches long.

"C" clamps, self-tapping screws for loop attachment, and other hardware should be stainless steel.

Note: R1 = R2 in length for this design.

It is convenient to use stainless hose clamps for feed-point connections. These clamps are used in automobile applications and are available in auto-parts stores.

Dimensions:

A = R2 + Q = 58.45 inches
B = 19.75 inches
R1 = 38.7 inches
C = 1.25 inches
Mounting Section = any length

Fig. 3– Assembly of the collinear "J."

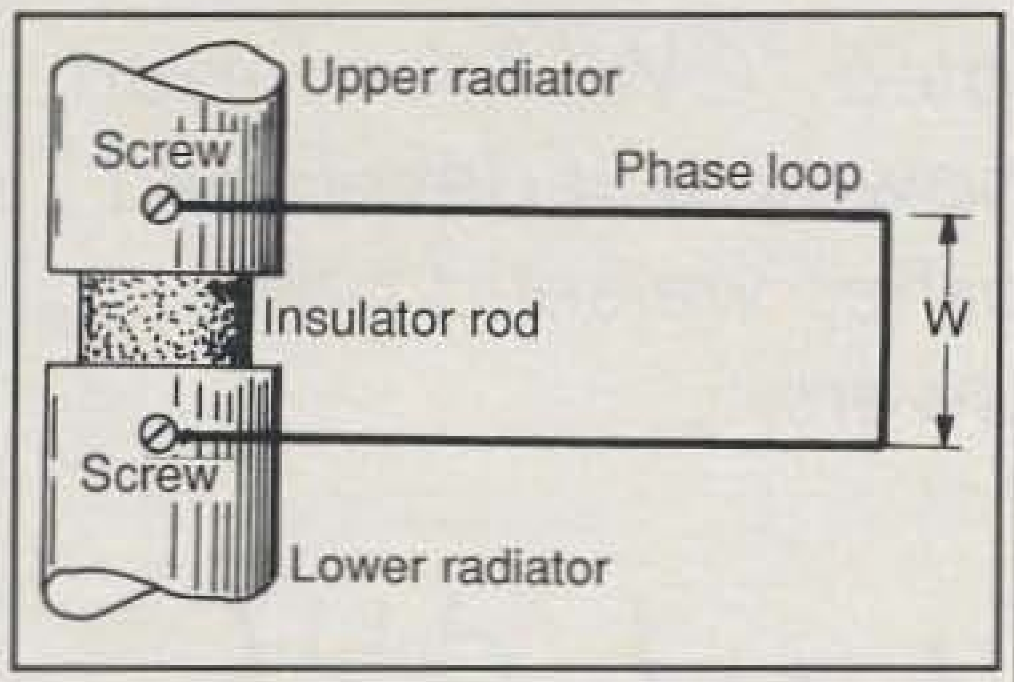


Fig. 4– The phase loop.

balun to the feed line and slide the clamps over the "Q" section areas.

Mount the J-pole away from any grounds or interference and check the VSWR. Slide the clamps up or down and repeat measurement. Continue to slide the clamps (by small increments) in the direction of reduced VSWR. When tuning is completed, thoroughly clean the entire antenna. Add a small amount of anti-oxidant at the hose- clamp connection. Finally, give the "Super-J" a thin coat of clear acrylic spray paint.

As with any antenna or mast installation, be extremely careful, especially when working around power lines. (***Never*** *install an antenna where it, or you, could fall onto a power line—ed.)*

Phase Loop

Referring to fig. 4, the two radiators, upper and lower, are connected together using an insulator such as PVC or, as in this drawing, a piece of fiberglass electric fence rod.

The Phase loop vertical end dimension dictates the dimension of the separation between the two radiators. The dimensions for our example are:

Loop width = 1 inch = W
Separation of radiators = 1/2 inch
Length of sides ~ 19 inches

Make the loop so that the two sides are straight, parallel, and secure. The loop may be formed into a circle around the radiator axis. If this is done, the circle should not be small, less than one rotation (see photo).

Summary

Which phasing method is best—loops, sometimes called "hairpins," or coax lines? There is no simple answer. The coax method can result in a slightly tighter vertical pattern if no shield radiation occurs. The coax method can also result in a very tall antenna! The loop type tends to be a bit easier to build for me. Try them both and make your own comparisons. ■