We're coming into some prime antenna-building weather, and W6BNB has just the project for us. This one has been around for a long time and still works. Now we learn why.

A Close Look At The 40 Meter Zepp And Double-Zepp All-Band Antennas

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This is a story about, in my opinion, the best, simplest all-band, fixed, amateur, wire-type antenna there is, bar none! This is a strong statement, but one agreed with by many amateurs.

The Simple 40 Meter Zepp Antenna

Every 15 or 20 years the Zepp antenna makes a come-back appearance in one form or another to the benefit of the newest generation of radio amateurs. The term "Zepp antenna" comes from its early use as a trailing wire antenna for old Ferdinand von Zeppelin's gas-bag airships of the '20s and '30s. To keep the antenna wire away from the body of the zeppelin, a tuned, non-radiating, open-wire, 1/4-wavelength (or some multiple of that) transmission line was dropped down out of the cabin. To the bottom of this tuned feeder system was connected a flexible wire antenna with a weight attached to its end. The term "tuned" transmission line or feeder means two parallel wires that have been cut to some multiple of a 1/4-wavelength at the frequency to be used. If the dirigible was working CW traffic on 36 meters, a 1/2-wave antenna wire 18 meters long could be connected to the end of one of the wires of an 18 meter long 1/2-wave 2-wire feedline, as an example. The common "J antenna" used on VHF and UHF bands is actually a Zepp antenna, but it is erected vertically.

With any type of 2-wire transmission line the currents in the two parallel conductors will always be traveling in opposite directions at any point in time. These opposite currents produce opposite-polarity, expanding magnetic fields. Because they are always of opposite polarity, from any distance away the two resulting fields appear as being essentially equal and opposite, and therefore zero. Such a transmission line has little losses in comparison to the dielectric losses that may occur in coaxial cables, and very little radiation of RF from it if the antenna is mismatched.

From basic antenna theory you probably remember that both ends of a 1/2-wavelength

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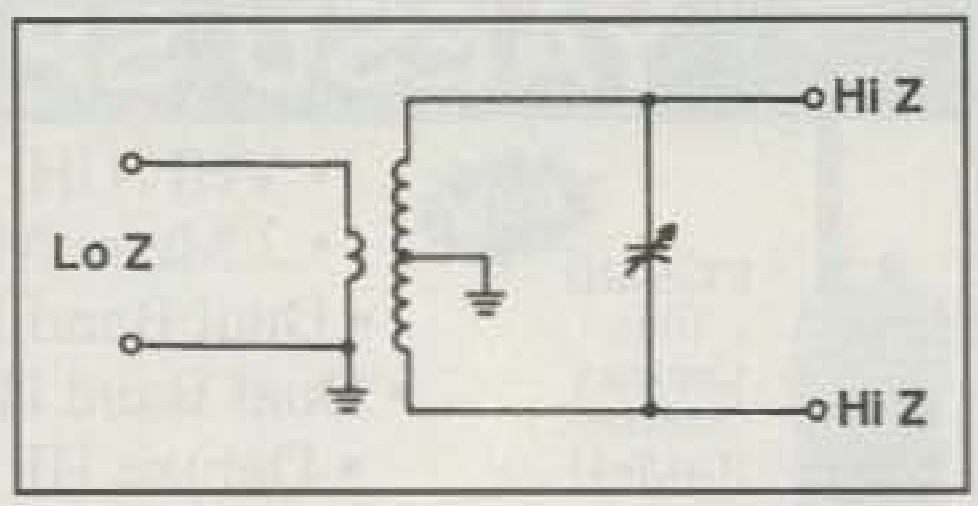

Fig. 1– A basic single-band antenna tuner.

antenna wire in free space are said to have high impedance (high-Z). An "antenna tuner" (fig. 1) the original name for today's matchbox, transmatch, etc., if coupled to the low-Z (50 ohm) output of a modern-day transmitter, can produce a balanced high-Z circuit across its center-tapped, tuned inductance/capacitance (LC) output circuit.

A pair of parallel wires held apart a short distance (perhaps 2 to 12 inches) by insulated-material spacers and cut to a 1/2-wavelength at 7 MHz (66 ft.) will present a high-Z between the two ends of the transmission-line wires. (A 1/2-wave transmission line can also be used to couple between two low-Z circuits.) Any electrical 1/2-wavelength feed line repeats its impedance, high at both ends or low at both ends, depending on the source and load impedances across which it is connected. A 1/4-wavelength transmission line, on the other hand, reverses its impedances, high-to-low or low-to-high. If one end of a "resonant" 1/2-wave 7 MHz, 66 ft. antenna wire (high-Z) is connected to the top end of one of the wires of a 66 ft. long 2-wire transmission line, a Zepp antenna is formed (fig. 2). Surprisingly, the transmission line's other wire just hangs out there, connected to nothing except insulators that hold it in place.

The Zepp antenna forms a matched-impedance system, with everything connected together at high-Z points. The transmitter antenna tuner's high-Z output circuit connects to the high-Z input of a 1/2-wave transmission line. The high-Z output of the 1/2-wave transmission line connects to the high-Z end of a 1/2-wave flattop antenna wire. Since everything matches impedance-wise, such an antenna should accept power and radiate it very well, and it does.

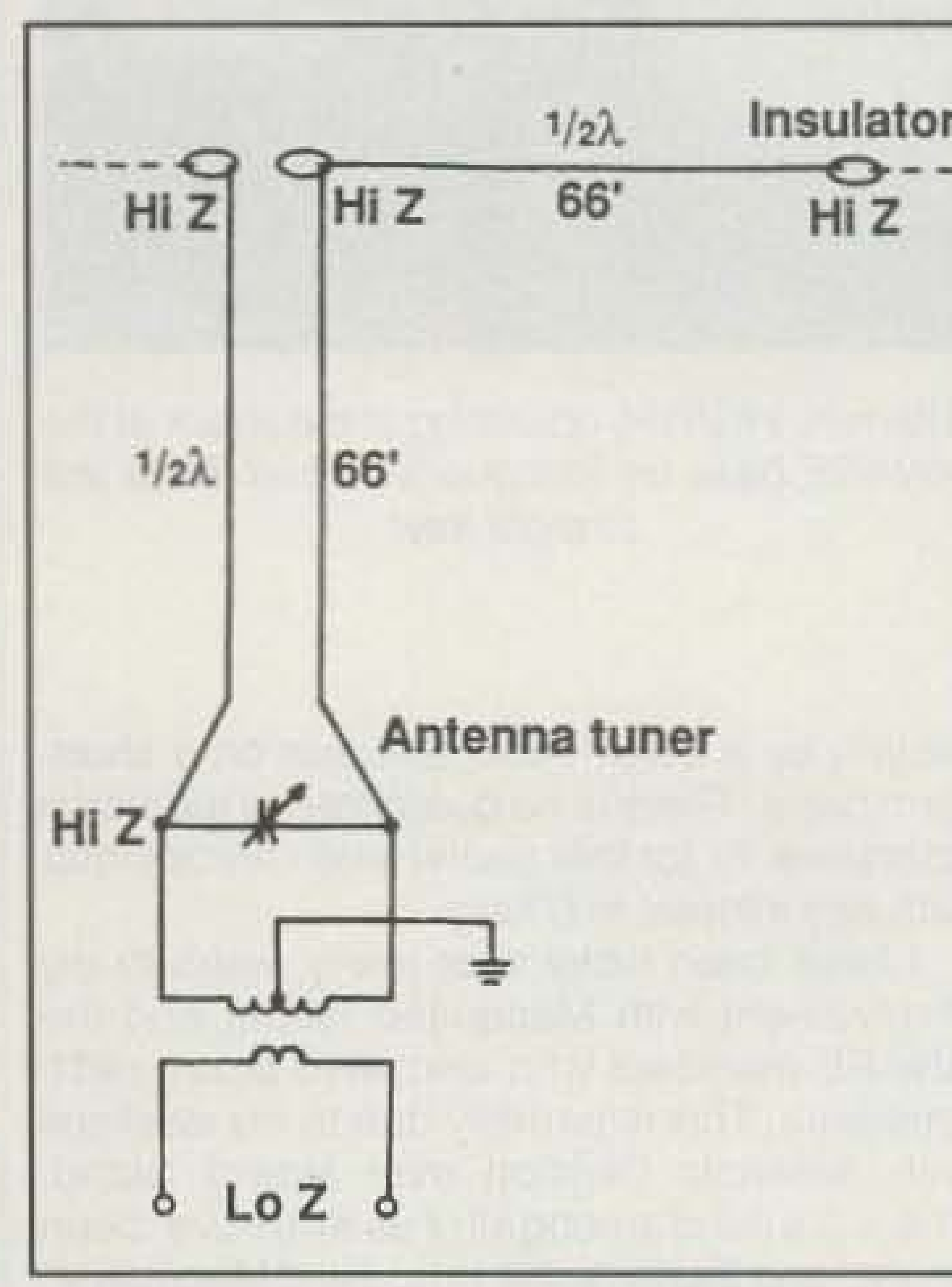

Fig. 2– The basic Zepp antenna for the 40 meter band.

If a Zepp were to be used on 7.05 MHz, in the CW portion of the 40 meter band, both the 1/2-wavelength transmission line and the 1/2-wavelength flattop would be about 66 ft. long. If you do the computations (length in feet of a 1/2-wavelength wire = $468/f_{MHz}$), it computes as 66.8 ft. long. But at 7.2 MHz, in the phone part of the band, it should be 65.0 ft. long. Actually, a 66 ft. flattop and 66 ft. feeder on 40 meters can have any slight improper length corrected merely by adjusting the antenna tuner knob a little whenever the transmitting frequency is changed. This can be accomplished by tuning for a minimum SWR indication on the transmitter's SWR meter, or on a separate SWR meter added between the transmitter and the antenna tuner. Tuning for a maximum indication on a field-strength meter in the shack (equidistant from both feed lines and as far away from them as possible) works quite well, too.

The radiation lobes for a horizontal 1/2-wave resonant antenna are known to be maximum

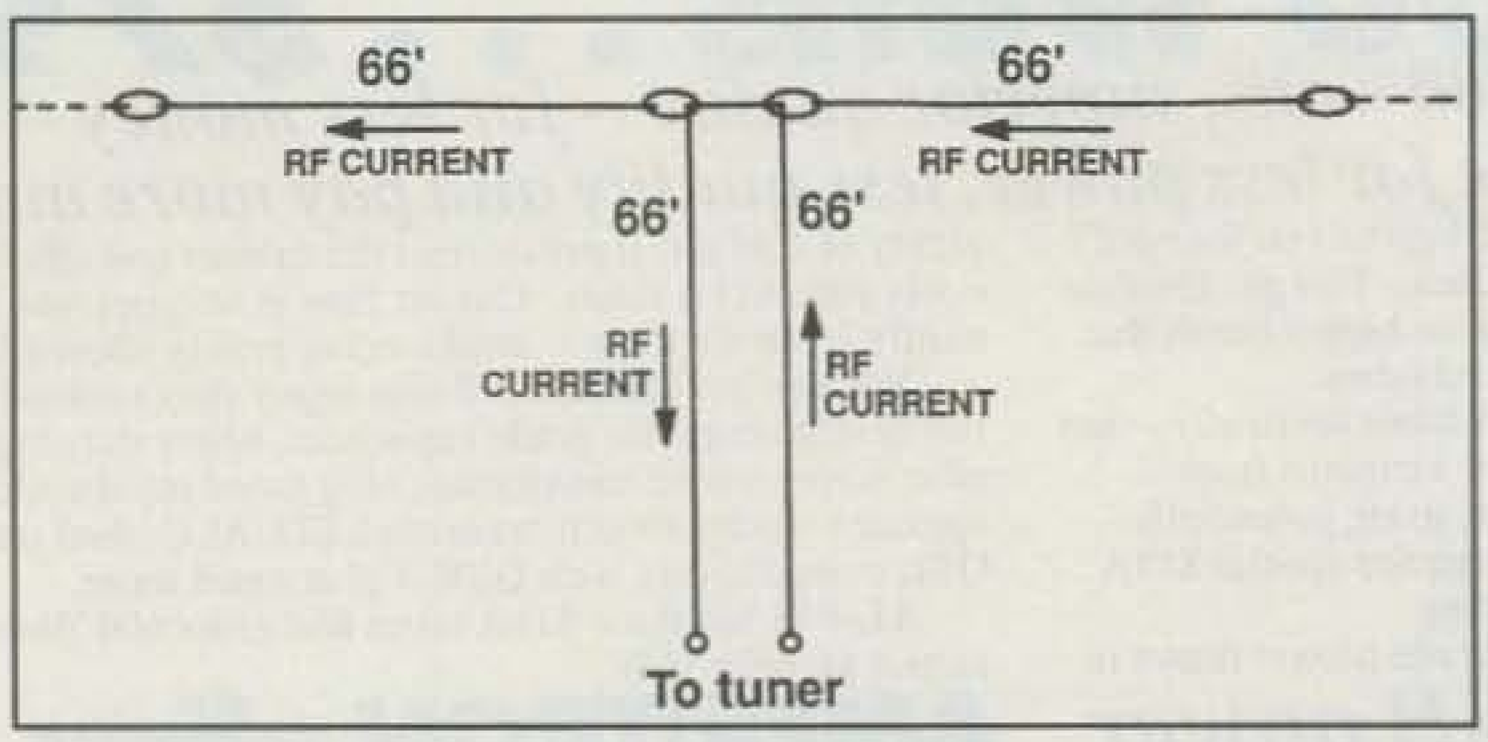

Fig. 3– A 40 meter Double-Zepp antenna. This drawing shows 1/2-wavelength flattop currents in phase, making it a 2-element beam.

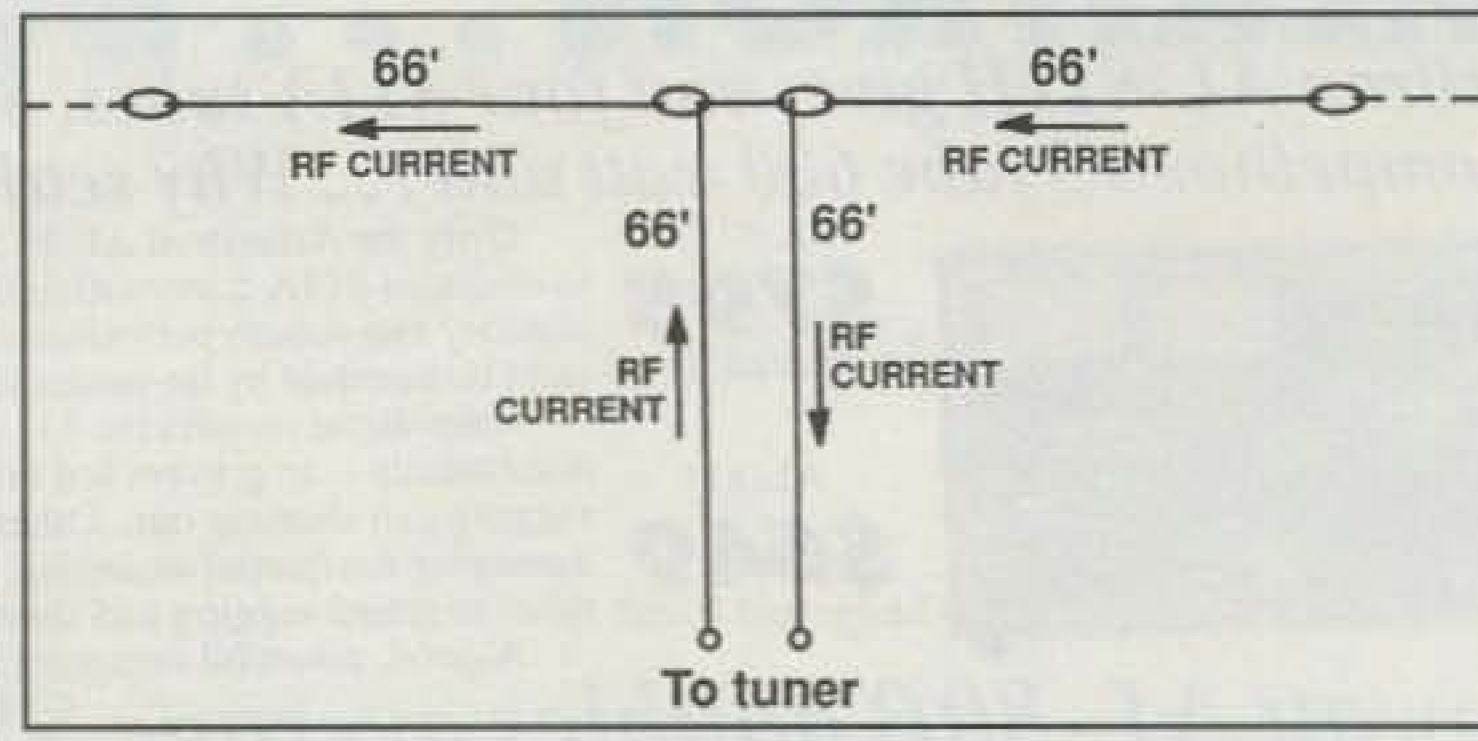

Fig. 4– The same antenna as fig. 3, but for 80 meters. This shows the flattop as a single 1/2-wavelength dipole antenna.

at right angles to the wire. Therefore, if your antenna wire runs north and south, you should transmit best east and west, right? Correct, but hold on. Distant amateurs to the north and south of you also will be receiving those parts of your radiated fields that travel upward at perhaps 20° to 80° and in line with your antenna wire. These are then either reflected or refracted (bent down) by the Heaviside layers. Any north/south amateurs theoretically will see your signals approaching them as vertically polarized waves from out of the Heaviside layers. You actually will be radiating a respectable amount of these vertically polarized signals in the north/ south directions for many hundreds or thousands of miles. Since the Heaviside layers tend to rotate the polarization of signals traveling through them, such refracted or reflected signals may be received at a distance as either horizontally or vertically polarized signals.

The Zepp on Higher Frequency Bands

One of the beauties of this antenna is that on the 20 meter band the same 66 ft. dimensions are now full-wavelengths. The full-wave flattop will still have high impedance at both ends (as well as also in the middle now). The same is true for the feeders. So everything still matches! Furthermore, all of the coupling points will also be high-Z points for the 15 and 10 meter bands. When operating as a full-wavelength antenna, there will be maximum radiation lobes at about 50° from the wire, and theoretically no radiation at 90° (at right angles to the wire). But here again the Heaviside layers get into the act. Radio waves hitting these constantly undulating layers may not only be shifted in polarity to some degree, but may be refracted in one direction or another. The radio waves wind up being dispersed into zones back on earth that simple antenna theory says should have no signal in them at all. This results in a fairly omnidirectional antenna.

On the higher frequency bands the antenna is progressively electrically longer and has more major radiation lobes. It begins to transmit most of its total radiated energy in the general directions of the antenna ends. However, it also develops minor lobes which radiate signals in other directions fairly well. As you can see, the Zepp should be quite a good all-band antenna when used on any HF band, but it does require an antenna tuner because it is using tuned feeders.

If the feeder is only a 1/4-wavelength long at a given frequency, its high-Z value end at the flattop will then appear as a low-Z at 1/4-wavelength away at the transmitter. To couple such a feedline's low-Z to the 50 ohm output of a transmitter a 1:1 balun could be used, or the tuner may have circuits in it that allow it to couple low-Z to low-Z.

Working 80 and 160 Meters With a 40 Meter Zepp

At first one might think that this would be impossible. However, if you connect the two 66 ft. feedline wires together at the shack and attach them to **one end** of the balanced antenna tuner output, you now have a wire antenna **1/2-wave** long for 80 meters (132 ft.). This provides a resonant high-Z end of the antenna for either of the high-Z points on the antenna tuner, and it works!

If the two feeders are connected together at the shack end, the whole antenna can also be used as a **1/4-wave** conductor for 160 meters, providing a ±37 ohm impedance to the transmitter. This can be plugged directly into the 50 ohm output connector of most modern transceivers and should provide a 50÷37, or 1:1.35 SWR match, which is very acceptable. If you want to tune to minimum SWR over the complete 160 meter band, add a 30-turn, 2 inch diameter, tapped coil to the bottom end of the feeder wires and in series with this a ±200 pF variable capacitor. Feed this into the transmitter output connector. By selecting the desired tap and varying the capacitor, you should be able to obtain a low SWR at any frequency on the 160 meter band. You will need a good ground for 160 meter work, though. This usually means at least 4 or more 1/4-wave radials connected to a 6 to 8 foot driven ground-rod as close to the transmitter as possible.

So far no mention has been made of one important point. Because the flattop wire is connected to only one of the simple 40 meter Zepp's two balanced 1/2-wave feed lines, the system is somewhat unbalanced. Some out-

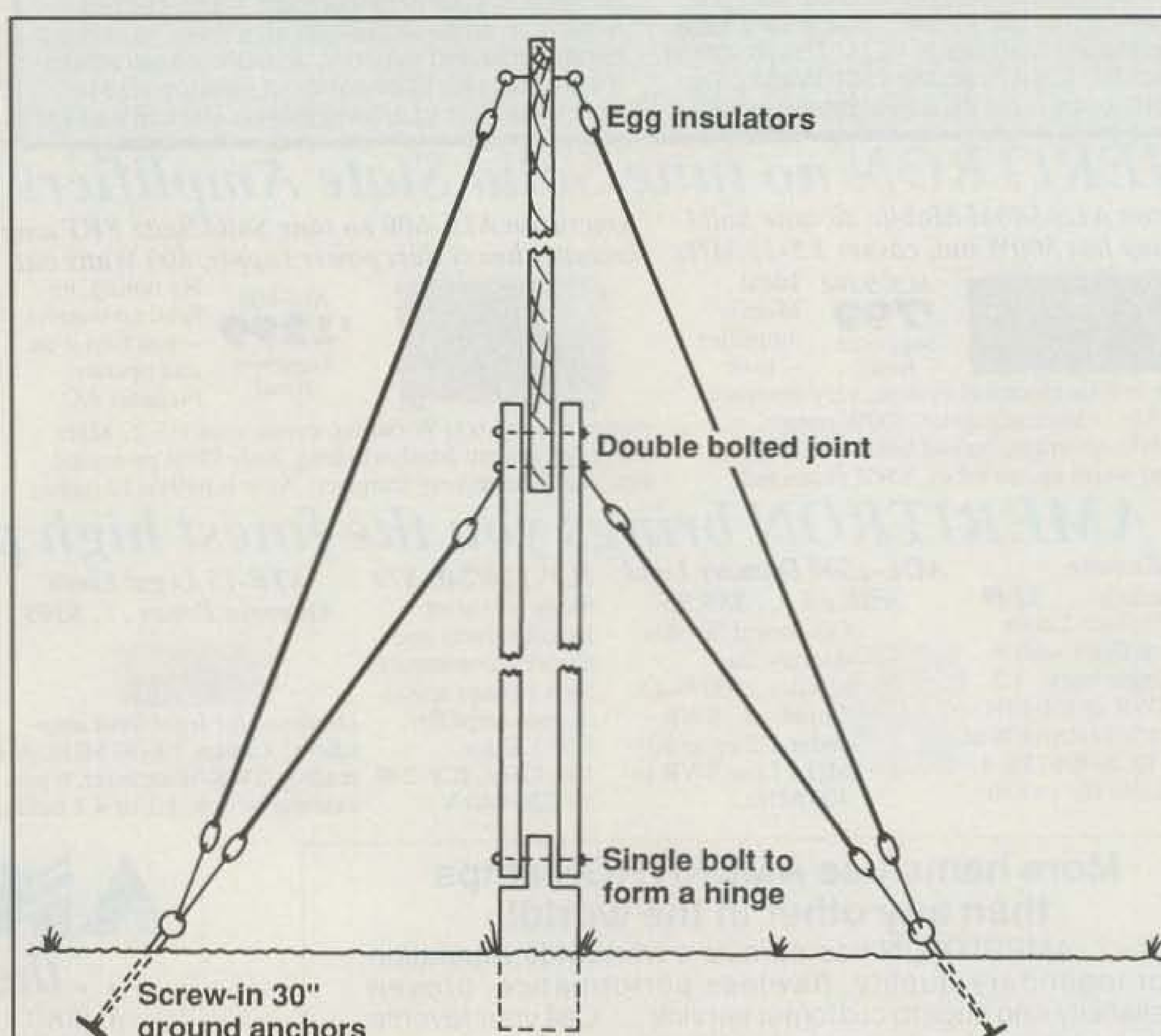

Fig. 5– Suggested design for antenna support pole, using 22 ft. 2 × 3 lumber.

of-phase RF voltage and current will be reflecting back down the unterminated feedline and not all of the RF will be radiated from the flattop out into the atmosphere. Because of the slightly unbalanced feedline currents, there is some radiation from the feeder. More important probably, there may be some increase in power-line noise (which is mostly vertically polarized) when receiving with the simple Zepp antenna. What can be done to prevent this unbalance?

The 40 Meter Double-Zepp

If connecting one 66 ft. flattop to the top of the tuned transmission line results in a somewhat unbalanced system, how about balancing the antenna by adding another similar 66 ft. flattop to the other top terminal of the feed-line (fig. 3). Now you have a really great antenna! This antenna can be called a 40 meter double-Zepp, or two 1/2-waves in phase, or a fixed 2-element beam on 40 meters. It also tunes and works well on the 80, 30, 20, 15, 17, 12, and 10 meter bands. Because currents at the top of the feeders are always 180° out of phase, they drive inphase currents into the two halves of the flattop. Of course, the double-Zepp does require twice the real estate of a simple Zepp, but because its feedline is balanced, it does not pick up vertically polarized noises—a real advantage when listening for DX!

The 40 Meter Double-Zepp On 80 Meters

On 80 meters each of the flattop sections is only a 1/4-wave long, making the whole flattop a 1/2-wave fed at the center with a 66 ft. 1/4-wave transmission line (fig. 4). All impedances match on 80 meters because the feeder is now high-Z at the antenna tuner and low-Z at the center of the 80 meter dipole. It makes an excellent resonant, low-loss, horizontal-radiation *dipole* on 80 meters.

The 40 Meter Double-Zepp On 160 Meters

It may tune up and work, but not as well as one would like. On 160 meters the whole system, end to end, is 264 ft. long, or a 160 meter 1/2-wavelength. The center of this 1/2-wave wire, if opened, represents low-Z points. It can be coupled to the transmitter's 50 ohm output through a 1:1 balun. But the flattop, the only radiating portion of the antenna, is only a 1/4-wave long on this band. The antenna is a more efficient radiator if only one of the transmission lines is coupled to the transmitter's 50 ohm output fitting (as was done with the simple Zepp). The other feeder wire can be connected to the first, or left disconnected. Only a 1/4-wavelength wire is operating as the antenna now. For 160 meter operation, the transmitter must be connected to an adequate radial system as mentioned above. How well this antenna will radiate depends on its height and how good its ground-radial system is.

The Zepp, the double-Zepp, and the 80 meter dipole are Hertzian antennas. The ground system for Hertzian antennas is relatively unimportant. On the other hand, 1/4-wave antennas are Marconi types and use the earth as the other 1/4-wave needed to make them resonant 1/2-waves. (The earth can be considered a nearly infinite number of 1/4-waves.)

Erecting The Antennas

If you can get two ±66 ft. poles up and guyed, you will have a real winner. If you are like many of us, you may have to get along with perhaps a 4 × 4 redwood post sticking up a foot or so out of the ground, to which you can single-bolt two 22 ft. 2 × 3s, making a simple bottom hinge providing fairly easily pushed-up and lowered poles. At the end, between the two 2 × 3s, you can overlap by about 12 inches and double-bolt another 22 ft. 2 × 3, making the poles about 43 ft. high (fig. 5). I find that 30 inch screw-in ground anchors obtained from a vineyard supply store make excellent points to which guy wires can be tied. Guys should be insulated a couple of places using egg insulators, using wires **not measuring** 1/2-wavelength at any of the bands to be used. Only two poles would be required for a simple Zepp. The weight of the feeders attached to the middle of a double-Zepp 132 ft. long wires tends to pull the center of the antenna down too much. I use three poles in line, with about 70 ft. spacings between them for my double-Zepp. To the top of my center pole I nail a 12 inch 1 × 2 with insulators at both ends. The two flattops are attached to these insulators, as are the two transmission line wires. With the center pole taking all of the downward pull of the transmission line and flattops, none of the flattops or the three-each top and middle guy wires on the three poles have much strain on them, so they never have to be taut. If you are in an area where erecting an antenna requires a building permit, you might consider just hanging the antenna from properly spaced trees or buildings. I am out in the country and don't have to worry about little things like that.

Spacing of the Transmission Line

The amount of spacing between the feed-line wires is not critical. If closely spaced, 2 inches perhaps, the wires might conceivably vibrate in the wind and short together. If too wide apart, 18 inches perhaps, there may be a little radiation from them on higher frequency bands. Since a constant impedance along the feed lines is not important, the wires don't even have to be the same distance apart all along the line. Spacers should be inserted about 5 to 6 feet apart if the wires are spaced 5 to 6 inches—3 feet apart if the wires are spaced 3 inches—and so on. Spacers may be ceramic or plastic rods with holes at the ends to which the feeder wires are tied. Many a Zepp has worked well for many years using 6 inch wooden dowel spacers, if well dried and then boiled in wax, or oven-dried and then sprayed with several coats of clear acrylic enamel.

If you are pushed for space, you can always bend down the ends of any flattop-type antenna. Suppose you want a 132 ft. flattop for your 40 meter double-Zepp but you only have 100 ft. of real estate available. You could bend down the last 16 ft. at each end. Will it still be resonant at the same frequency? No, because when you bend an antenna wire back on itself completely (180°), by 16 ft. for example, you lose 16 ft. of its length. If you bend the wire down at a 90° angle toward ground (or to the east or west, etc.) you will be cancelling some of the inductance of the wire, so you will have to add a few feet of wire to make up for this loss. Also, if you bend your open-wire feeders at a sharp angle, you will find that you have to add a few feet to them to produce their desired resonant length. (This is not true with coaxial feeders, of course.)

If a north/south flattop double-Zepp wire antenna is erected in the shape of an "inverted-V" (tall antenna pole in the middle, much shorter poles at the ends of the flattop) there will be the normal horizontally polarized signals going east/west plus some augmented vertically polarized signals going north/south, producing a nearly omnidirectional energy radiation pattern.

You should be very pleased with the results obtained from the highly efficient open-wire-line fed 40 meter Zepp or the 40 meter double-Zepp. If you can double the lengths to produce an 80 meter Zepp, or an 80 meter double-Zepp, you will have an even better antenna. It all depends on whether you have 66 ft., 132 ft., or 264 ft. of real estate available. Any of these antennas is well worth a try. ■