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Four Bands, One Whip

Quadruple your mobile operating pleasure, please, but don't blame us.

Did you ever want to change bands while operating mobile but didn't want to stop in the rain to change resonators? Now you can change bands without a thought about your mobile antenna. How about a bandwidth as much as one megahertz (see Fig. 8), with swr of no more than 1.5:1? You can build this mobile antenna for a fraction of the cost of a commercial mobile antenna. The materials are readily available and are not costly.

A Look at the Basics

The six-foot mast is constructed from ½" copper water pipe. The overall length is not critical, but signal reception will suffer at anything much less than a five-foot mast length. If you own a Hustler or similar mast, you already have the first part of your new multiband mobile antenna.

Multibanding is obtained by the use of multiple LC circuits—one for each band desired. A typical mobile antenna has resonators (LC circuits) with an adjustable whip. The adjustable whip is actually the C of the resonant LC circuit. You might think of such a mobile antenna as shown in Fig. 1.

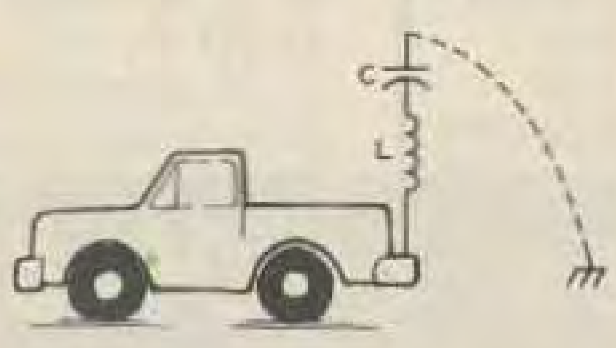

Fig. 1. Top-loaded mobile antenna.

Adjusting the whip changes the C and raises or lowers the resonant frequency. A tip: In general, a greater amount of capacitance will result in a greater bandwidth. These mobile antennas are "top-loaded," i.e., the LC circuit is at the top of the antenna and, for all practical purposes, the only part of the antenna that radiates is that portion *below* the resonator. That is the reason you should make the mast as long as is practical. Since the whip is basically C, why stick it up in the air where it will just give your antenna increased ability to reach all those nearby objects—trees, carports, etc.? You can actually place a typical resonator at a 90° angle to the mast and probably notice no difference in performance, although tuning may change slightly. This could present an eye hazard or you might even spear a bird. Let's look at this change as shown in Fig. 2.

Fig. 2. Resonator positioned at 90° (vertical polarization retained).

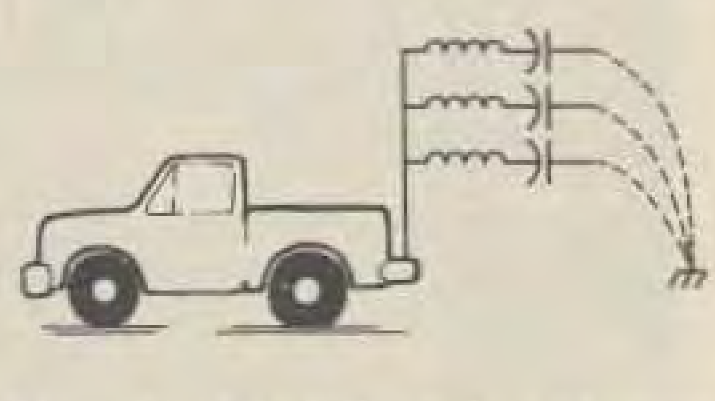

Fig. 3. Multiband antenna setup.

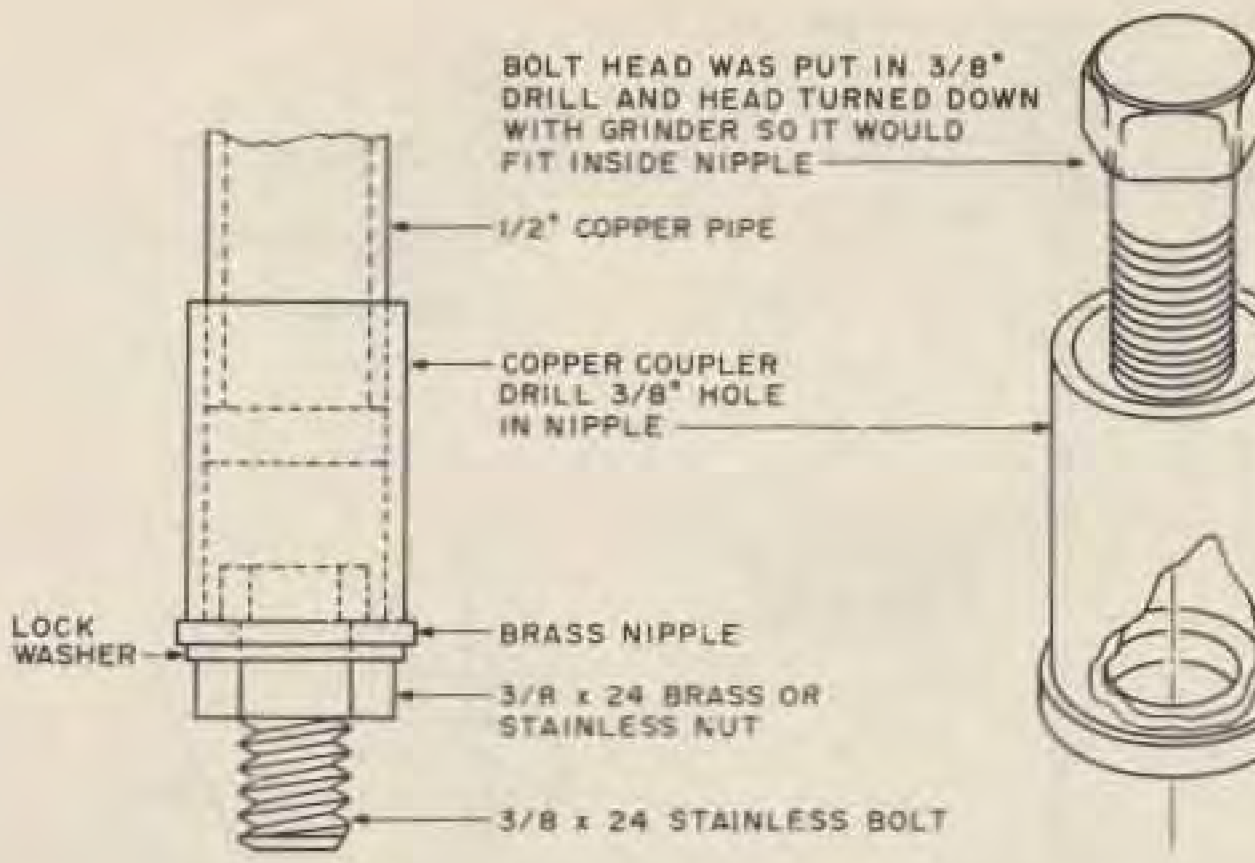

Fig. 4. Mast-to-mobile attachment.

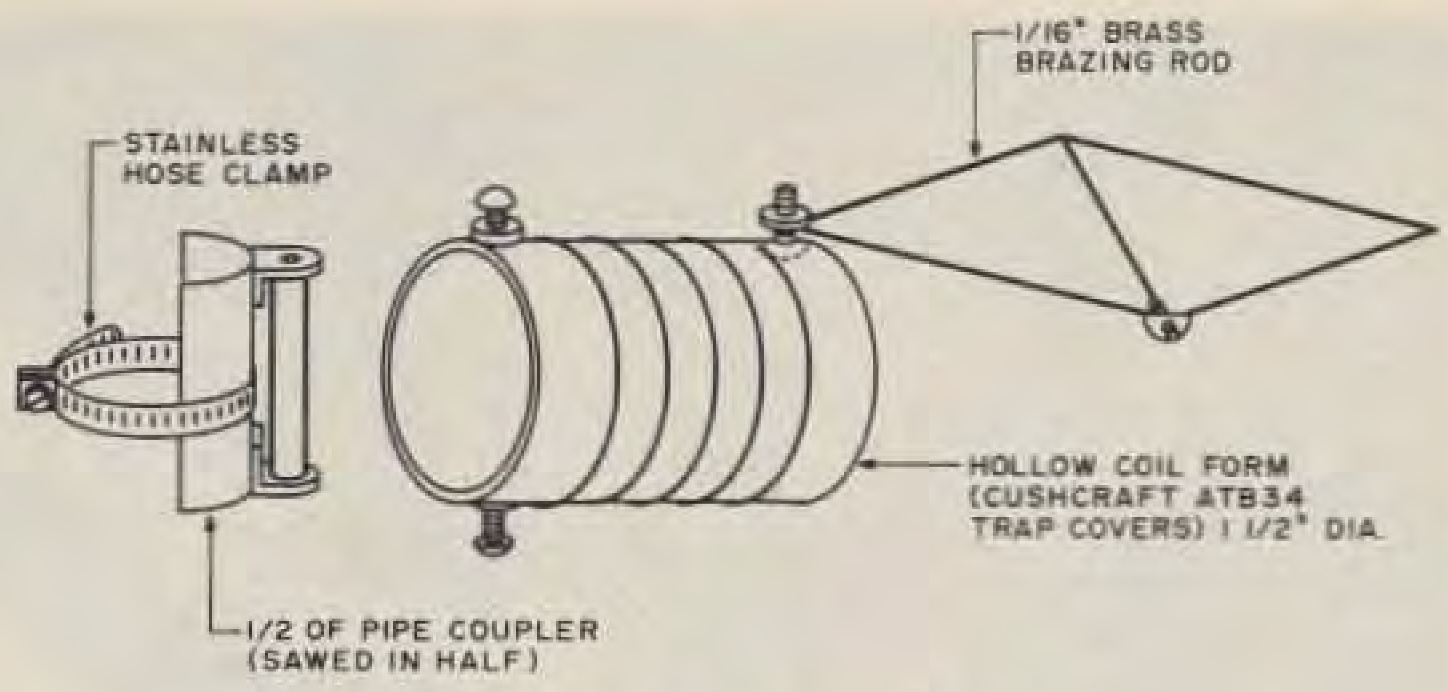

Fig. 5. Details of mounting bracket.

Capacitance does not have to come in the form of a whip. Two wires in the shape of a V form a capacitor proportional to the area within the V. The V is easy to adjust (change C). In fact, I used exactly this method in my initial experiments. It doesn't work too well for actual mobile use because the V is not rigid during vehicle motion and the vibration of the V causes fairly wide and constant changes in resonance.

Now that I had decided to place the LC in a horizontal position, I also decided to multiband the antenna by using more than one LC circuit. The configuration now becomes that shown in Fig. 3.

I am currently using four LC circuits on my mobile antenna, but you can use one, two, three, four, or more. I haven't tried five yet, but that's one of the next steps. The LC for the lowest frequency should be at the top of the mast with the next higher frequency below that and so on.

Mechanical Construction

The idea for the mast came from an article in *73 Magazine* (February, 1979, p. 42). I used non-ferrous materials to avoid any rust problems. The mast itself is a six-foot length of ½" copper water pipe. The details of the fitting which attaches the mast to your mobile mount are shown in Fig. 4. I used a brass end cap through which I drilled a 3/8" hole for the 3/8" × 24 stainless steel bolt. The brass end cap is considerably stronger than the copper end cap used in the *73 Magazine* article. However, it does require that the head of the bolt be reduced to allow it to fit in the inner diameter of the brass end cap. I simply chucked the 3/8" × 24 bolt in my 3/8" electric drill and used my shop grinder on the bolt head while letting the drill rotate the bolt for a nice even "machining." The end cap is assembled with a bronze or stainless steel lock washer and a brass or stainless steel nut. If you have any difficulty in finding a stainless steel bolt, you might try a local boat or marine dealer.

The end cap is assembled to the mast with an ordinary copper sleeve and soldered with a propane torch. Do a good job here because there is a lot of force at the base of the mast. I use a rigid mount and do not tie or guy my antenna. Now we close the end of the mast to keep out water. I soldered a flat piece of copper to the end of the mast.

LC Construction

I used some spare trap covers from my Cushcraft HF antenna for the supporting structure for the inductor and capacitor. These trap covers are thin and do not offer much wind resistance as the wind flows through them. They are probably a phenolic material, which is very suitable for an inductor form.

The part which kept me from building the antenna for over a year (I love to procrastinate) was deciding how to fasten the LC circuits to the mast. Fig. 5 and Photo A show the construction details of the mounting bracket. I cut a copper sleeve in half longitudinally and brazed copper tabs to the half coupling. Copper for the tabs was obtained by splitting a short length of copper pipe, opening it up, and flattening it with a hammer. (I had four feet of copper pipe left after cutting six feet off for the mast, so the material was handy.) The tabs were bent 90° and a piece of ¼" copper tubing was brazed between the 90° tabs so that the inductor form would not be crushed when attaching it to the bracket. Brass nuts, 6" × 32, were soldered to the top and bottom of the bracket. You might want to use one long screw to attach the whole assembly and not be bothered with the brass nuts.

A word about brazing the copper parts: The high heat anneals the copper. It becomes soft and I have had one bracket fail due to the vibration. It lasted over eight months and over 20,000 miles. The 15-meter LC was made with #12 copper wire and was quite heavy. You might solder or silver solder your bracket or find an even better method of attaching the LC assembly to the mast.

I have made inductors using #12, #18, and #20 wire. The #12 wire is quite heavy for a 20-meter LC circuit and probably impractical for a 40-meter LC circuit. The #20 wire gets warm when using a steady carrier but has caused no problem with SSB. If you run a kilowatt mobile, the #12 wire should do just fine.

The capacitance was added by using 1/16" brass welding rods. I chose the modified rhombic because it did

Photo A. Disassembled mounting bracket.

Photo B. Grid-dip meter position.

not have a sharp end as would a V and should avoid some static problems. I had hoped to adjust the C by bending the rhombic (increasing or decreasing its area). I found that vibration and vehicle motion caused erratic changes in resonance, so I added the adjustment spanner to the center of the rhombic. This allows easy adjustment of the resonant frequency.

Determining LC Values

If you like to experiment by trial and error, you'll love this. I spent many hours removing one turn at time, varying capacitance, and trying to find where the LC was resonant. I would be looking for a 15-meter or 20-meter resonance and would all of a sudden find myself in the 10-meter range. This is not the best way to start, although you will probably have to use this cut and try method for the 10-meter LC.

I found that I could use my Heathkit® grip-dip oscillator (gdo) to find the resonant frequency of the LC. The secret is to put a pickup coil at the base of the antenna and insert the gdo coil inside the coil (see Photo B). The Heathkit gdo is a handy piece of equipment but hardly a laboratory-grade instrument. I first found a resonant frequency of 14.2 MHz, so I connected the antenna to the transmitter and checked swr. It was not resonant anywhere in the 20-meter band! Suspecting something funny, I used the same pickup coil and connected it to my frequency counter and, since a gdo is actually a signal generator, the counter showed that the

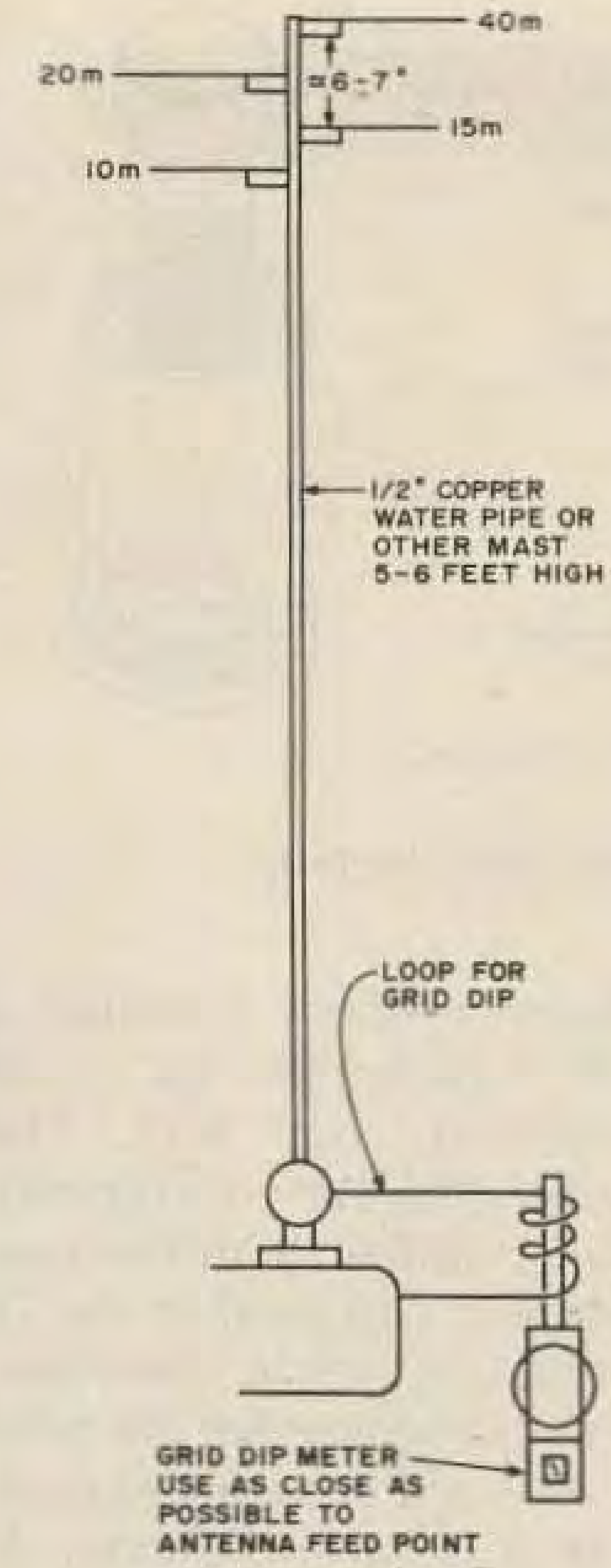

Fig. 6. Grid-dip meter positioning.

indicated 14.2 MHz was actually 13.8 MHz. It was convenient that the error was on the low side because I had to remove only one turn to raise the frequency of the LC circuit (or decrease capacitance, which would not be as desirable as it would reduce bandwidth). You don't need a frequency counter to check your gdo. Just use a short antenna on your HF rig and sweep the frequency with the gdo until

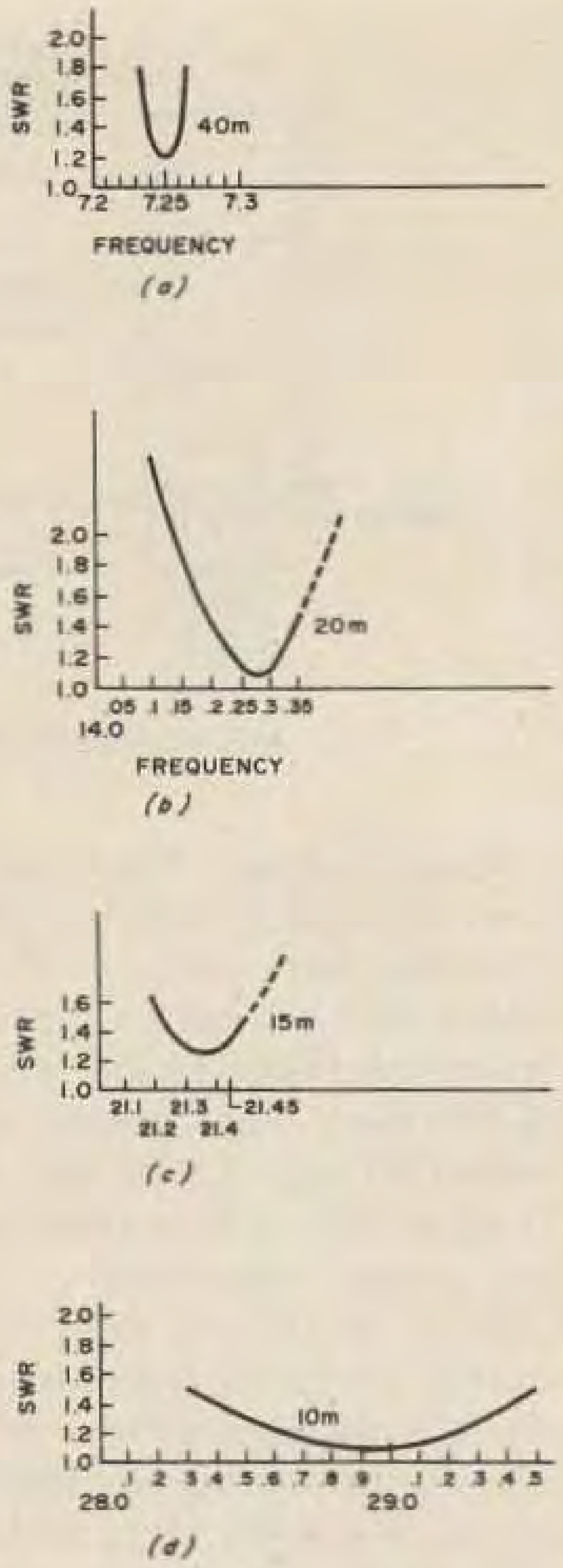

Fig. 8. Typical swr and bandwidth. (a) 40m swr (approx. 25 kHz @ 1.5 or less swr). (b) 20m swr (approx. 150 kHz @ 1.5 or less swr). (c) 15m swr (approx. 300 kHz @ 1.5 or less swr). (d) 10m swr (approx. 1.3 MHz @ 1.5 or less swr).

you hear its signal on your HF receiver. This is an easy method to calibrate or compensate your gdo.

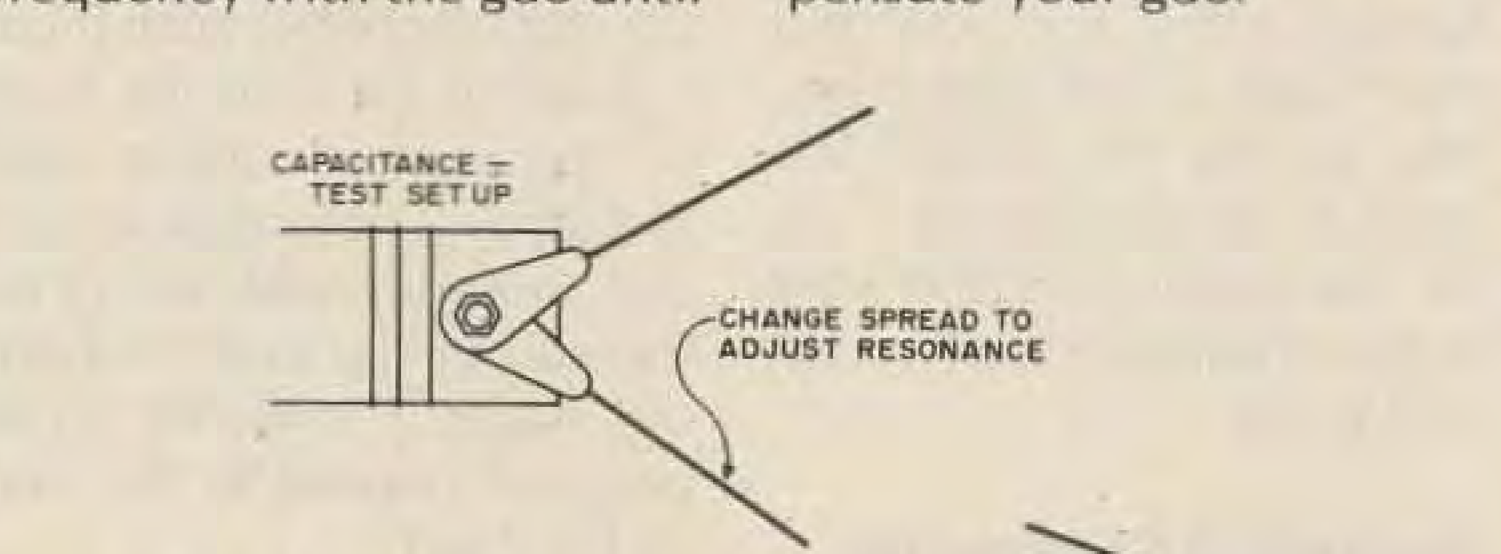

Fig. 7. Resonance adjustment assembly. Inductance—any diameter, any wire size (to suit power level), number of turns to suit frequency.

1-19/32"-Diameter Inductor Forms

	Band	# Turns	L × W
#12 Wire	20m	32	10" 2-1/8"
	15m	16	11-1/4" 1-3/8"
	10m	11	9-1/4" 1-1/8"
#20 Wire	40m	55	14-1/4" 1-1/2"
	20m	22-1/2	13-1/4" 1-1/2"

Additional data using #20 wire

92 turns = 5.5 MHz
83 turns = 5.9 MHz
67 turns = 6.6 MHz
62 turns = 6.8 MHz
59 turns = 7.1 MHz
55 turns = 7.25 MHz
38.5 turns = 11 MHz

Note: L and W are the length and width of the rhombic (C).

Table 1. Inductor winding data.

Photo C. Resonator test assembly.

As previously mentioned, I used a V configuration (Photo C) for the initial capacitance as it could be easily changed to adjust the resonant frequency. Work on one LC circuit at a time. Table 1 gives some dimensions which are intended to be a guide and give you a place from which to start. Differences in form diameter, wire size, and materials will require that you find your own right combination.

Weatherproof

Your LC assembly must be weatherproof. I learned from experience what a little rain will do to the resonant frequency. I guess I just figured out why commercial antennas use trap covers! My first attempt at weatherproofing was by dipping the LC assembly in polyurethane varnish. This lowers the resonant frequency about 500 kHz and is heavy. I have used epoxy resin, the type used to make fiberglass repairs, with good results. There is no appreciable frequency change; it is tough, medium in weight, easy to apply (pipe cleaners make excellent disposable paint brushes), and cures in about 30 minutes.

My preferred method is to put some silicone seal at the end of the LC assembly and enclose the inductor in heat-shrink tubing (obtained surplus or at a hamfest, in case you don't know how much a piece of new 2"-diameter heat-shrink tubing costs!).

Assembly and Adjustment

When you have completed the desired number of LC assemblies, they are attached using stainless steel worm-type hose clamps. The LC assemblies should be positioned fore and aft very carefully to minimize wind resistance. They should be carefully aligned or you may have one big rudder and a very "mobile" antenna. I have used care in alignment and have watched the antenna at highway speeds—it does not whip around. Proper positioning may actually create a stabilizing effect.

Fig. 6 shows the positioning I am presently using. There is some interaction between the LC assemblies, and "four in a row" caused some swr problems, particularly on 15 meters.

Adjust each LC circuit to the frequency you desire. Start with the highest frequency first (10 meters) and adjust each until you have adjusted the LC circuit of your lowest band.

More Thoughts

You don't have to make a multiband antenna. You may make an LC assembly for only one band. It might be used on a four-foot mast when height is a consideration such as on a motor home or tractor-trailer. You might combine two or more LC circuits on a single inductor form. You might use a circle instead of a rhombic for capacitance. You might leave the circle or rhombic open at the end and adjust the spread with a movable insulator. You might use a ferrite core to reduce the size of the inductor. You might use the LC assemblies for a temporary or space-restricted base antenna (with proper radials or counterpoise). You might build a small beam or rotating shortened dipole. You might . . .

Thanks to Bo Owen K4QKH, senior staff engineer at Teledyne Avionics in Charlottesville, Virginia, for the fundamentals and basic ideas.

CU on 10 . . . or 15 . . . or 20 . . . or 40 . . . or . . . ■

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