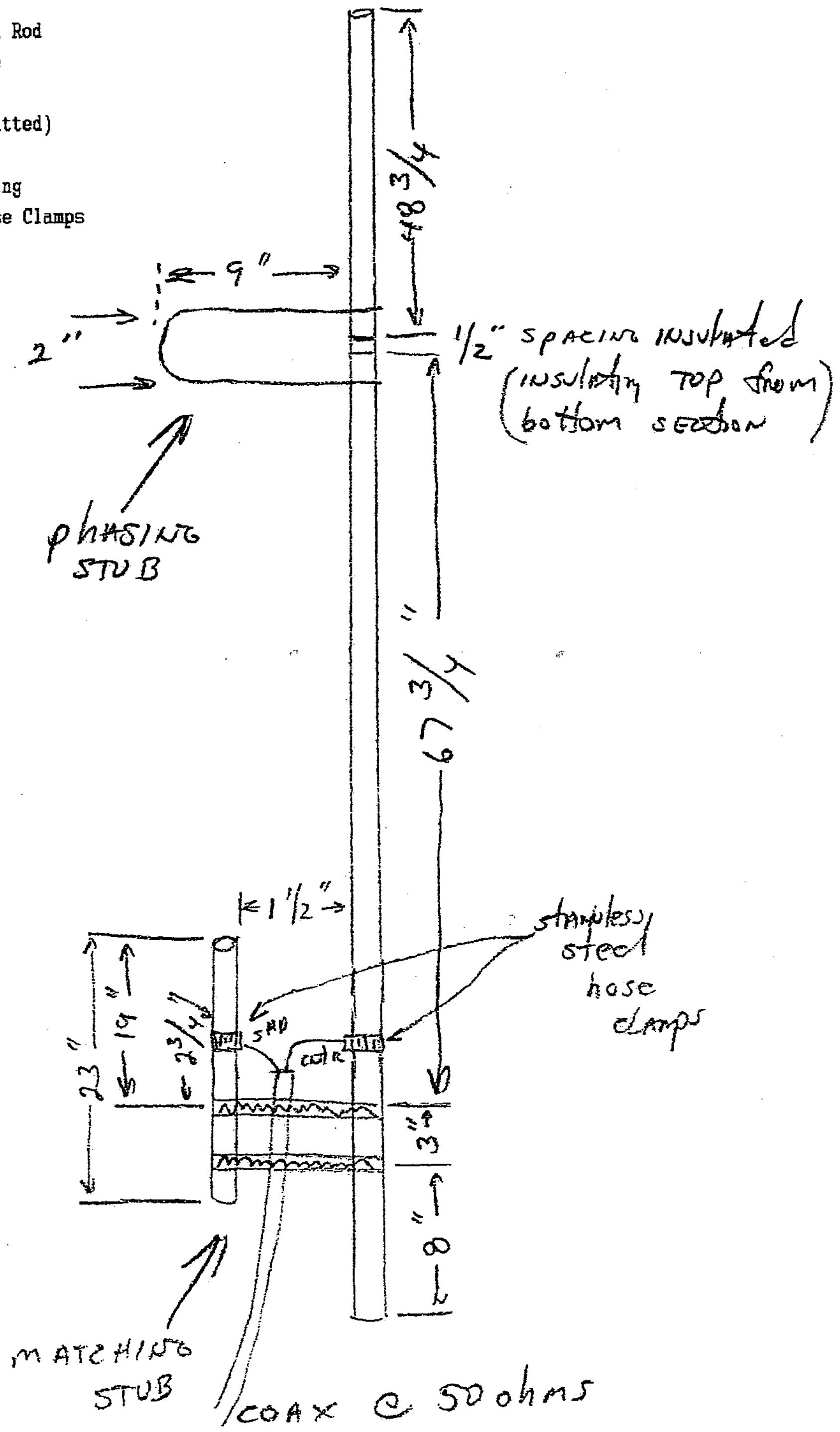
Parts List	Description
Upper Element	1" x 48-3/4" EMT
Lower Element	1" x 78-3/4" EMT
Matching Stub	1" x 23" EMT
Phasing Stub	1/4"-20 x 22" Threaded Rod
Insulator Section	3/4" x 14-18" PVC Pipe
1/4"-20 Nuts	12 (or 16 if double nutted)
1/4" Lock Washers	12
Insulated Spacer	3/4" PVC Female Coupling
Hose Clamps	2 1-1/4" Stainless Hose Clamps



Collinear 5/8-Wave Omni Antenna for 2 Meters

Commercial antenna performance at a home-brew price!

by John Conklin WD0O

Ready to try your hand at building an omnidirectional gain antenna? This may be just the project for you! Using ordinary hand tools, you can construct this antenna in one evening from common hardware store materials.

dB or Not dB?

What does all this gain stuff mean . . . really? An electronic amplifier has an absolute limit to the amount of power it can produce, regardless of the input level. Accordingly, amplifiers are often rated in watts—an absolute term. Antennas on the other hand, have no maximum theoretical output power—what you get out of them depends on what you put into them. Therefore, antenna performance is rated in relative, rather than absolute, terms. Enter the decibel (dB). A decibel is one tenth of a bel, named for Alexander Graham Bell (hence the little d and capital B). Originally established to express changes in sound levels, the decibel is a term of relative power. A change of 1 dB in power level is just barely detectable by the human ear.

The correlation between the dB and power ratio is:

dB = 10 log (output power/input power)

A gain of 3 dB corresponds to a doubling of power. Thus, an antenna with a gain of 3 dB will have the same effect on your signal strength as if you had doubled output power. As an added bonus, the gain of an antenna applies to received signals as well.

Where does all this extra power come from? According to the first law of thermodynamics (conservation of energy), you can't get something for nothing. To create gain in any given direction, the power must be taken from some other direction. In the case of a beam, most of the RF is concentrated toward the front of the array and sacrificed at the sides and rear. An omnidirectional antenna, on the other hand, obtains its gain by reducing the amount of RF that is radiated upwards. Look at it this way: An omni antenna has a radiation pattern shaped like a doughnut. In order to increase its gain, the doughnut merely needs to be flattened, thus putting more signal out instead of up.

Gain must be expressed in relation to some standard for it to have any meaning. In antenna work, these values are usually ren-

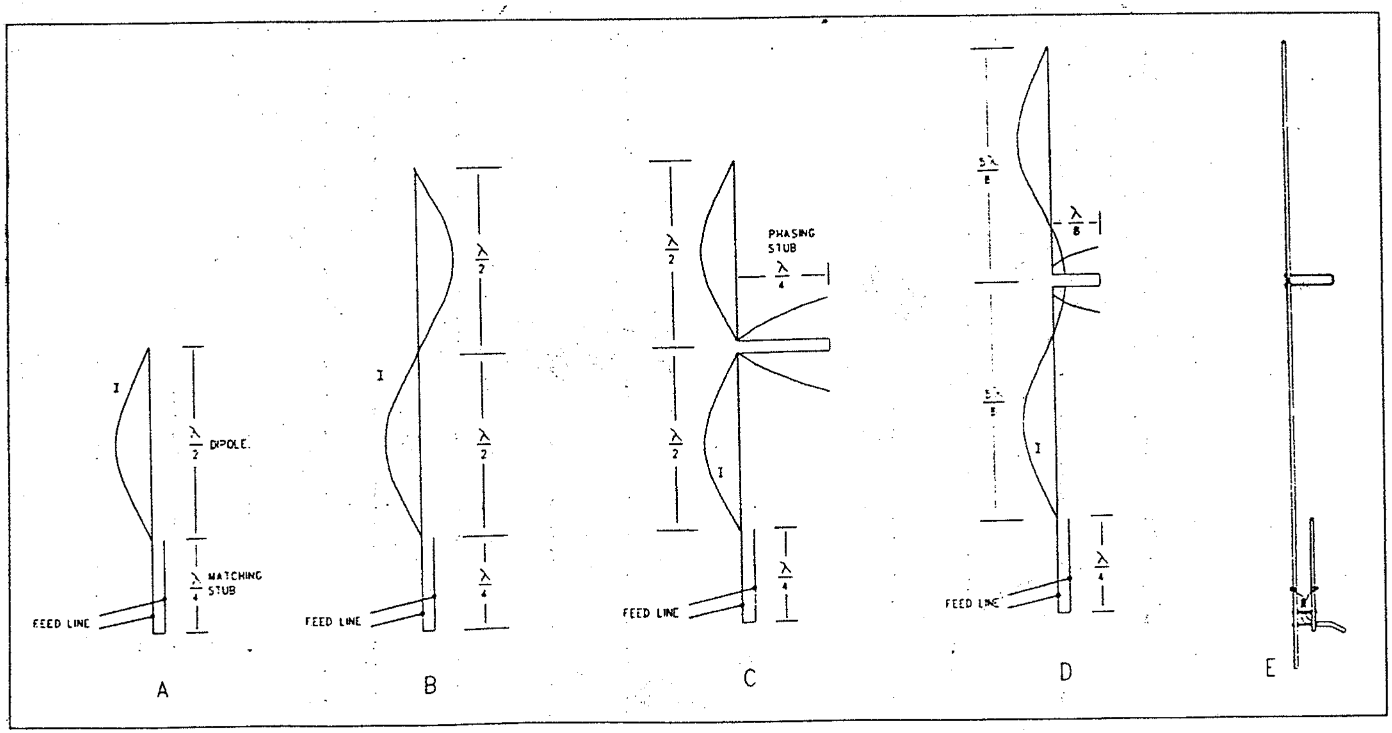


Figure 1. From dipole to deluxe. See this section of the text.

dered in terms of dBd (gain over a dipole), or less commonly, dBi (gain over isotropic). Since an isotropic radiator is a purely theoretical antenna, all measurements in this article are expressed in dBd. Incidentally, many manufacturers neglect to include any standard reference point in their advertising. There is no way of telling whether the purported gain is over a dipole, a ground plane, a dummy load or isotropic—even the venerable dipole has 2.1 dB gain over isotropic! It's wise to take advertised claims with a grain of salt

From Dipole to Deluxe

An assortment of aluminum and hardware can double your effective radiated power. Here's how.

As you probably know, a half-wave dipole is customarily fed at the center. This is where the current is highest and the voltage is lowest, thus providing a nice, low impedance point for connecting 52-ohm coax. At the ends of the half-wave antenna just the opposite situation exists—the current is lowest, and the voltage is highest, constituting a very high impedance feed point.

Some sort of matching device must be used in order to overcome the impedance mismatch if an antenna is to be end-fed. The quarter-wave closed stub, a continuously variable impedance matching device, performs this function rather nicely. Think of it as a dipole folded in half. The impedance is very low at the closed end of the matching stub (center of the dipole), and very high at the open end of the stub (ends of the dipole). Connect the antenna to the open end and the feedline near the closed end (Figure 1A). The impedance can now be changed by simply moving the feed point up or down the stub. As an added advantage, the closed end of the matching stub may be grounded, thus placing the entire antenna at DC ground potential and simplifying mounting problems.

Now for some gain. If the length of the antenna is increased to two half-wavelengths, the antenna will exhibit only slight (0.5 dBd) gain. This is because the currents along each element are out of phase and cancel each other out (Figure 1B). However, if each of the two half-wave elements are fed in phase, the gain will be 1.9 dBd because the RF currents reinforce, rather than cancel, each other. In order to achieve this phasing, the signal must travel an extra half wavelength before arriving at the second element. The phasing stub is a half-wavelength conductor folded so that the sides are parallel and closely spaced (Figure 1C). RF currents along the stub are then equal in intensity but opposite in polarity, causing the currents to cancel and preventing the stub itself from radiating.

Antenna gain is further boosted to 3 dBd by increasing the spacing between elements. This is accomplished by lengthening the radiating elements to 5/8 wavelength and shortening the phasing stub by an equal amount (Figure 1D). The added length of antenna is out of phase, and causes some signal cancellation. However, since the current on the added length is small, and the section is short, the radiation is insignificant. Further lengthening of the elements will cause more cancellation, and the gain will actually decrease. The finished antenna is shown in Figure 1E.

Construction

Figure 2 illustrates the dimensions and layout of the antenna. Construction is straightforward and requires only the use of common hand tools. The majority of the antenna is made from 3/4" aluminum tubing, although any diameter from 1/2" to 1" should work fine.

Start by cutting the matching stub (23"), the lower radiating element (78-3/4"), and the upper radiating element (48-3/4") to length. Use a hacksaw to cut a 1-1/2"-long slit into the bottom end of the upper radiating element, and the top end of the lower radiating element. This will allow the tubing to clamp firmly around the insulator.

Next, drill the mounting holes in the matching stub and lower element. Position the top of the matching stub 48-3/4" down from the top of the lower radiating element and tape them together. This will keep them lined up while drilling the mounting holes. Make drilling marks on the matching stub 10" and 22" down from the top of the stub. Clamp the assembly in a vise (being careful not to crush the tubing) and drill through both pieces at the same time. Mount the matching stub to the lower radiating element with 3/16" galvanized washers, nuts and bolts (you'll need bolts that are threaded all the way to the head).

The insulator is a plastic or Fiberglas rod (obtainable at plastics supply houses) or wooden dowel waterproofed with either urethane or spar varnish. The insulator should be at least 9" long to provide good mechanical support between the two radiating elements and should be of a diameter that provides a snug fit inside the tubing. Slide the upper and lower elements over the insulator, leaving 1/2" exposed between sections.

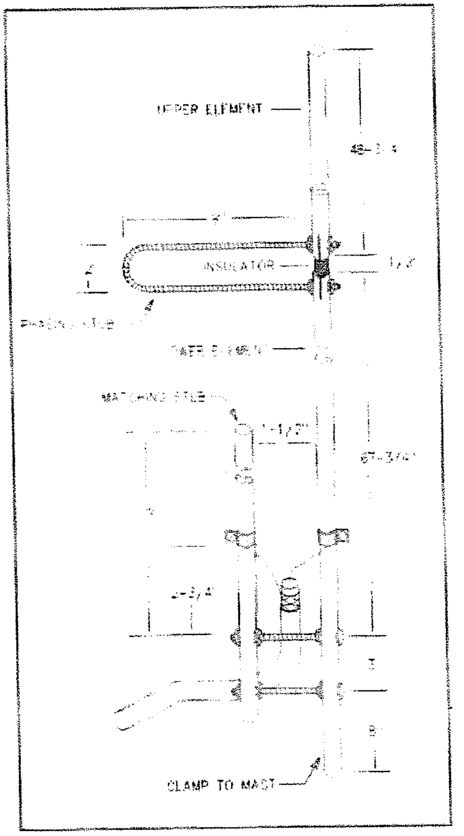


Figure 2. Construction details.

Next, drill a phasing stub mounting hole in each element. The holes must be parallel and spaced 2" apart. The phasing stub is made from a 22" length of 10-24 threaded rod. Bend the center of the rod over a 2"-diameter pipe to produce a smooth bend. Then fasten the phasing stub to the antenna with 10-24 hardware. Stainless steel hose clamps are used to connect the coax to the matching stub, and the end of the coax is sealed with RTV sealant or electrical tape.

Adjustment

This antenna delivers good performance and has a respectable SWR curve over the entire 2 meter band. Tuning is accomplished by sliding the feed point (where the coax is clamped to the antenna) either up or down to secure the best match.

Bibliography

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1991 *ARRL Handbook*.
DeMaw, Doug, *W1FB's Antenna Notebook*, 1987.
Honeycutt, Richard A., *Popular Electronics*, August 1992, p. 65.

Parts List

Upper element	3/4" x 48-3/4" aluminum tubing
Lower element	3/4" x 78-3/4" aluminum tubing
Matching stub	3/4" x 23" aluminum tubing
Phasing stub	10-24 x 22" threaded galvanized rod
Insulator	Plastic, Fiberglas or wooden dowel, 9" long, diameter to fit tubing
4	10-24 nuts
4	#10 lock washers
2	3/16" x 3-1/2" bolts
6	3/16" nuts
6	3/16" lock washers
2	1" stainless steel hose clamps

the hatchback of the vehicle to be opened with the antenna installed, Fig 37.

A ½-inch galvanized iron pipe supports the antenna so the radiating portion of the J is above the vehicle roof line. This pipe goes into a bakelite insulator block, visible in Fig 37. The insulator block also holds the bottom of the stub. This block was first drilled and then split with a band saw, as shown in Fig 38. After splitting, the two portions are weatherproofed with varnish and rejoined with 10-32 stainless hardware. The corners of the insulator are cut to clear the L sections at the shorted end of the stub.

The quarter-wave matching section is made of ¼-inch type L copper tubing (5/16-inch ID, 3/8-inch OD). The short at the bottom of the stub is made from two copper L-shaped sections and a short length of ¼-inch tubing. Drill a 1/8-inch hole in the bottom of this piece of tubing to drain any water that may enter or condense in the stub.

A 5/16-inch diameter brass rod, 1½ to 2 inches long, is partially threaded with a 5/16 × 24 thread to accept a Larsen whip connector. This rod is then sweated into one of the legs of the quarter-wave matching section. A 40-inch whip is then inserted into the Larsen connector.

The antenna is fed with 52-ohm coaxial line and a coaxial 4:1 half-wave balun. This balun is described in Chapter 26. As with any VHF antenna, use high quality coax for the balun. Seal all open cable ends and the rear of the SO-239 connector on the mount with RTV sealant.

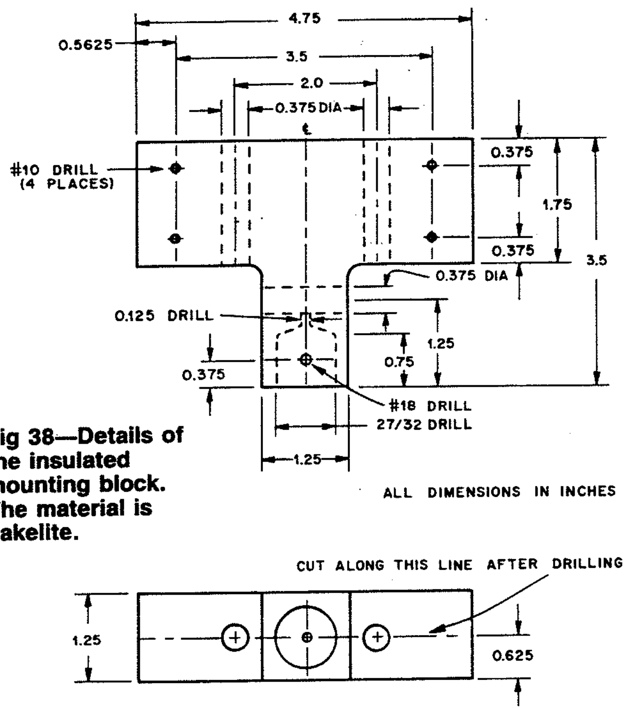


Fig 38—Details of the insulated mounting block. The material is bakelite.

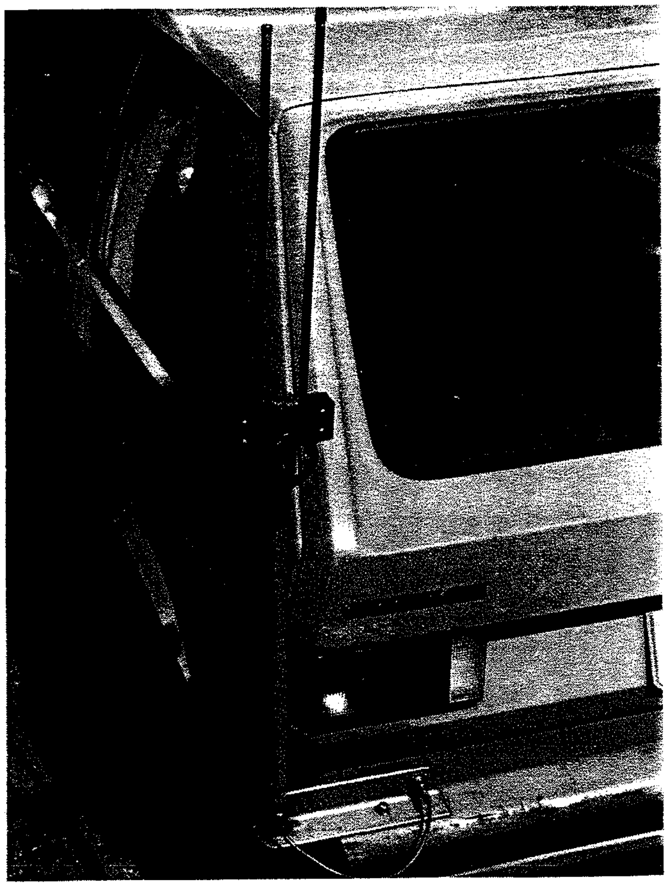


Fig 37—The J antenna, ready for use. Note the bakelite insulator and the method of feed. Tie wraps are used to attach the balun to the mounting block and to hold the coax to the support pipe. Clamps made of flashing copper are used to connect the balun to the J antenna just above the insulating block. The ends of the balun should be weatherproofed.

Adjustment is not complicated. Set the whip so that its tip is 41 inches above the open end of the stub, and adjust the balun position for lowest SWR. Then adjust the height of the whip for the lowest SWR at the center frequency you desire. Fig 39 shows the measured SWR of the antenna after adjustments are completed.

THE SUPER-J MARITIME ANTENNA

This 144-MHz vertical antenna doesn't have stringent grounding requirements and can be made from easy to find parts. The material in this section was prepared by Steve

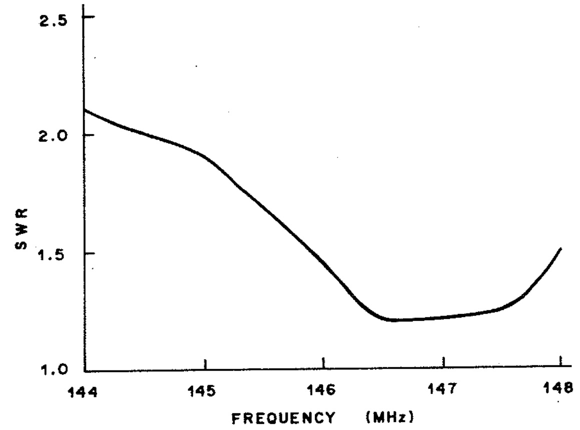


Fig 39—Measured SWR of the mobile J antenna.

Cerwin, WA5FRF, who developed the Super-J for use on his boat.

Antennas for maritime use must overcome difficulties that other kinds of mobile antennas normally do not encounter. For instance, the transom of a boat is the logical place to mount an antenna. But the transoms of many boats are composed mostly of fiberglass, and they ride some distance out of the water—from several inches to a few feet, depending on the size of the vessel. Because the next best thing to a ground plane (the water surface) is more than an appreciable fraction of a wavelength away at 144 MHz, none of the popular gain-producing antenna designs requiring a counterpoise are suitable. Also, since a water surface does a good job of assuming the earth's lowest mean elevation (at least on a calm day), anything that can be done to get the radiating part of the antenna up in the air is helpful.

One answer is the venerable J-pole, with an extra in-phase half-wave section added on top . . . the Super-J antenna. The two vertical half waves fed in phase give outstanding omnidirectional performance for a portable antenna. Also, the "J" feed arrangement provides the desired insensitivity to height above ground (or water) plus added overall antenna height. Best of all, a ¼-wave CB whip provides enough material to build the whole driven element of the antenna, with a few inches to spare. The antenna has enough bandwidth to cover the entire 144-MHz band, and affords a measure of lightning protection by being a "grounded" design.

Antenna Operation

The antenna is represented schematically in Fig 40. The classic J-pole antenna is the lower portion shown between points A and C. The half-wave section between points B and C does most of the radiating. The added half-wave section of the Super-J version is shown between points C and E. The side-by-side quarter-wave elements between points A and B comprise the J feed arrangement.

At first glance, counterproductive currents in the J section between points A and B may seem a waste of element material, but it is through this arrangement that the antenna is able to perform well in the absence of a good ground. The two halves of the J feed arrangement, side by side, provide a loading mechanism regardless of whether or not a ground plane is present.

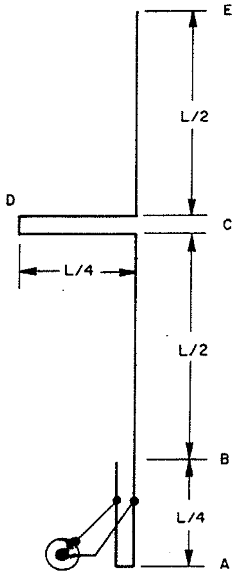


Fig 40—Schematic representation of the Super-J maritime antenna. The radiating section is two half waves in phase.

CENTER TO MAST
SHIELD TO STUB

The radiation resistance of any antenna fluctuates as a function of height above ground, but the magnitude of this effect is small compared to the wildly changing impedance encountered when the distance from a ground plane element to its counterpoise is varied. Also, the J section adds ¼ wavelength of antenna height, reducing the effect of ground-height variations even further. Reducing ground-height sensitivity is particularly useful in maritime operation on those days when the water is rough.

The gain afforded by doubling the aperture of a J-pole with the extra half-wave section can be realized only if the added section is excited in phase with the half-wave element B-C. This is accomplished in the Super-J in a conventional manner, through the use of the quarter-wave phasing stub shown between C and D.

Construction and Adjustment

The completed Super-J is shown in Fig 41. Details of the individual parts are given in Fig 42. The driven element can be liberated from a quarter-wave CB whip antenna and cut to the dimensions shown. All other metal stock can be obtained from metal supply houses or machine shops. Metal may even be scrounged for little or nothing as scraps or remnants, as were the parts for the antenna shown here.

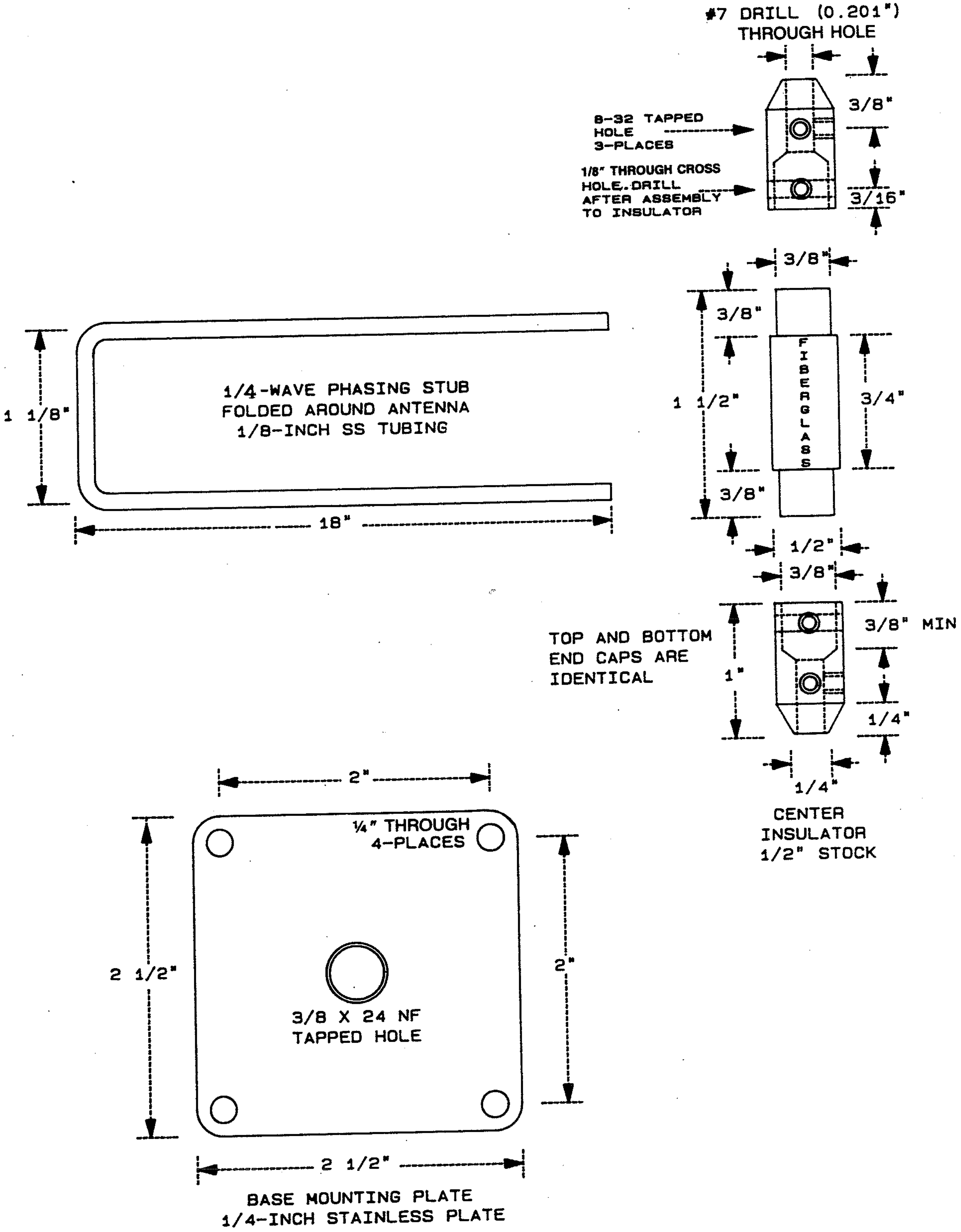
Fig 41—Andy and the assembled Super-J antenna.

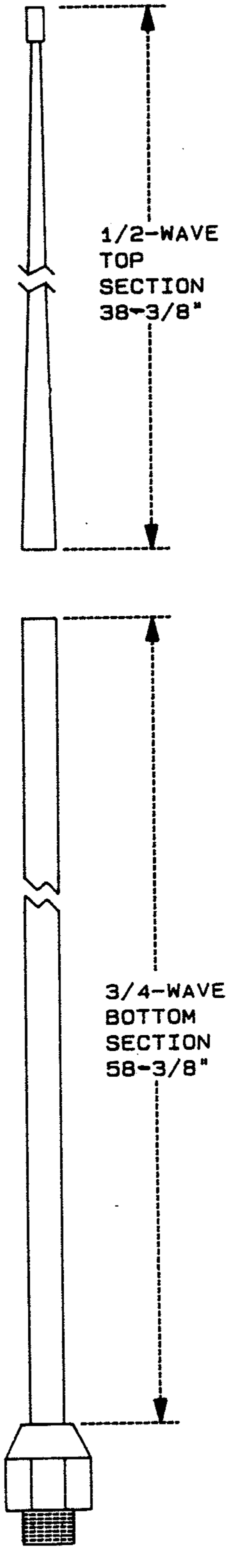
The center insulator and the two J stub spacers are made of ½-inch fiberglass and stainless steel stock, and the end caps are bonded to the insulator sections with epoxy. If you don't have access to a lathe to make the end caps, a simpler one-piece insulator design of wood or fiberglass could be used. However, keep in mind that good electrical connections must be maintained at all joints, and strength is a consideration for the center insulator.

The quarter-wave phasing stub is made of 1/8-inch stainless steel tubing, Fig 43. The line comprising this stub is bent in a semicircular arc to narrow the vertical profile and to keep the weight distribution balanced. This makes for an attractive appearance and keeps the antenna from leaning to one side.

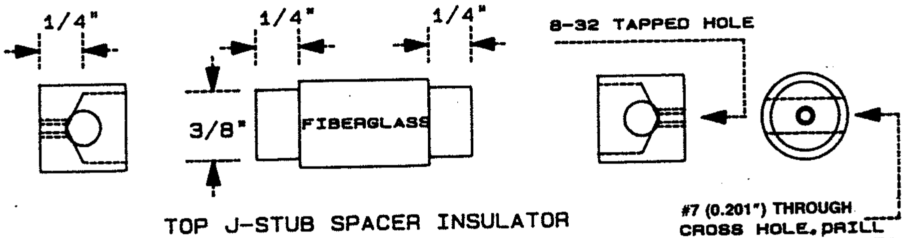
The bottom shorting bar and base mounting plate are of ¼-inch stainless steel plate, shown in Fig 44. The J stub is made of 3/16-inch stainless steel rod stock. The RF connector may be mounted on the shorting bar as shown, and connected to the adjustable slider with a short section of coaxial cable. RTV sealant

Fig 42—Details of parts used in the construction of the 144-MHz Super-J. Not to scale.

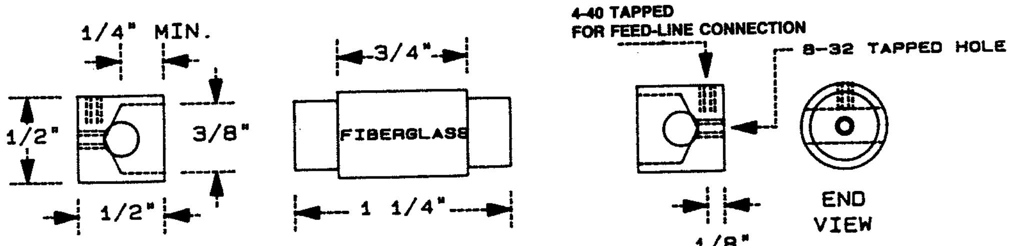




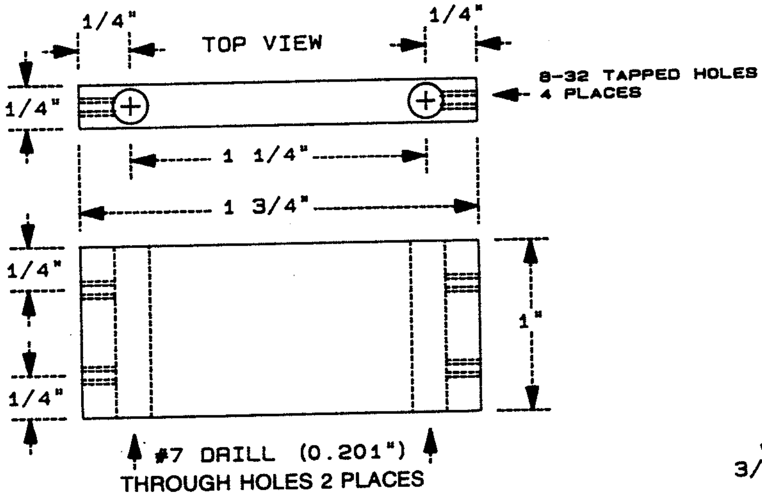
DRIVEN ELEMENT OBTAINED
FROM 1/4-WAVE CB WHIP



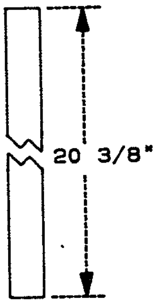
TOP J-STUB SPACER INSULATOR
END CAPS IDENTICAL
ASSEMBLE WITH EPOXY



SLIDING FEEDER INSULATOR



BASE SHORTING BAR
1/4-INCH STAINLESS PLATE



J STUB
3/16 SS ROD

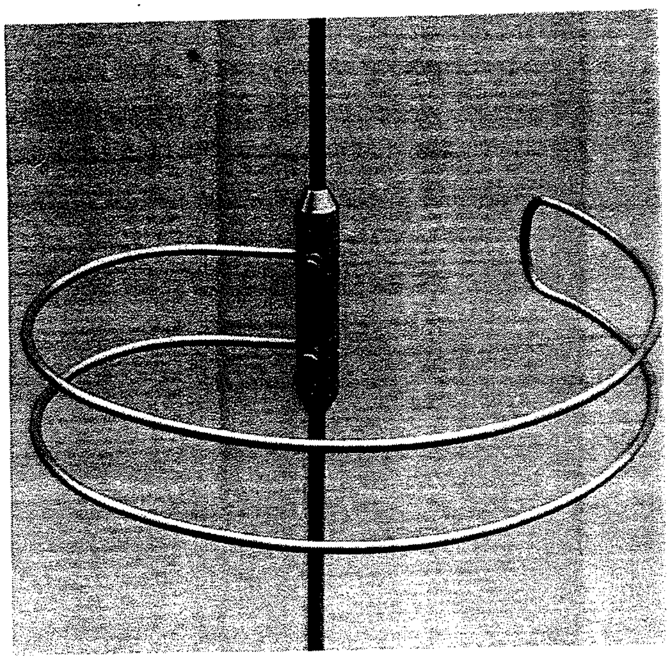


Fig 43—A close-up look at the ¼-λ phasing section of the Super-J. The insulator fitting is made of stainless steel end caps and fiberglass rod.

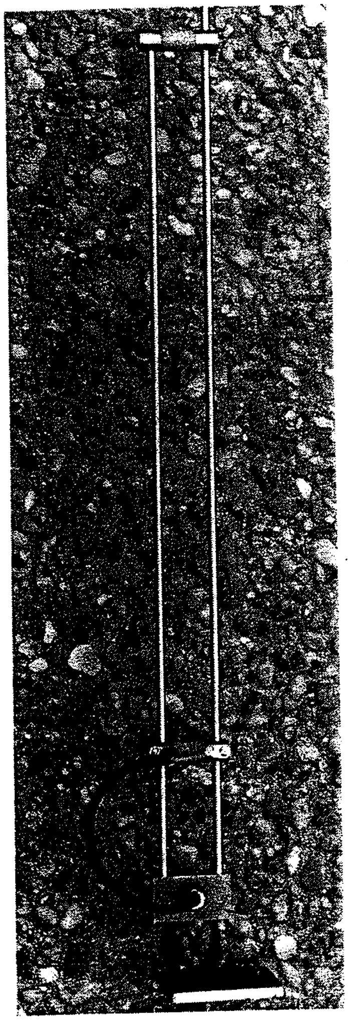


Fig 44—The bottom shorting bar and base mounting plate assembly.

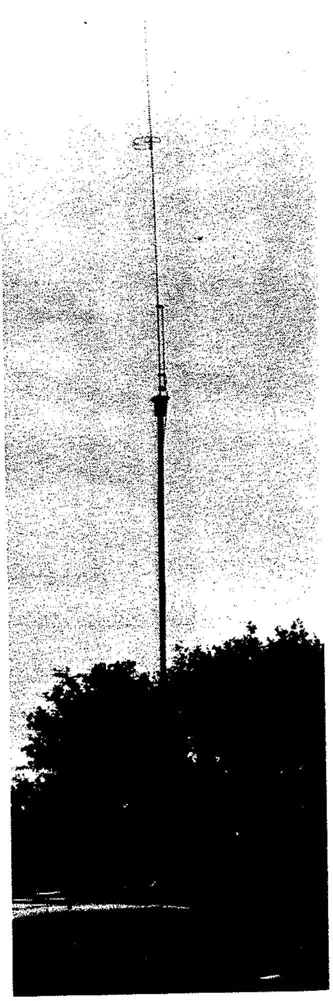


Fig 45—The Super-J in portable use at a field site.

should be used at the cable ends to keep out moisture. The all-stainless construction looks nice and weathers well in maritime mobile applications.

The antenna should work well over the whole 144-MHz band if cut to the dimensions shown. The only tuning required is adjustment of the sliding feed point for minimum SWR in the center of the band segment you use most. Setting the slider 2-13/16 inches above the top of the shorting bar gave the best match for this antenna and may be used for a starting point.

Performance

Initial tests of the Super-J were performed in portable use and were satisfactory, if not exciting. Fig 45 shows the Super-J mounted on a wooden mast at a portable site. Simplex communication with a station 40 miles away with a 10-watt mobile rig was full quieting both ways. Stations were worked through distant repeaters that were thought inaccessible from this location.

Comparative tests between the Super-J and a commercial 5/8-wave antenna mounted on the car showed the Super-J to give superior performance, even when the Super-J was lowered to the same height as the car roof. The mast shown in Fig 45 was made from two 8-foot lengths of 1 × 2-inch pine. (The two mast sections and the Super-J can be easily transported in most vehicles.)

The Super-J offers a gain of about 6 dB over a quarter-wave whip and around 3 dB over a 5/8-wave antenna. Actual performance, especially under less-than-ideal or variable ground conditions, is substantially better than other vertical antennas operated under the same conditions. The freedom from ground-plane radials proves to be a real benefit in maritime mobile operation, especially for those passengers in the back of the boat with sensitive ribs!

A TOP-LOADED 144-MHz MOBILE ANTENNA

Earlier in this chapter, the merits of various loading schemes for shortened whip antennas were discussed. Quite naturally, one might be considering HF mobile operation for the application of those techniques. But the principles may be applied at any frequency. Fig 46 shows a 144-MHz antenna that is both top and center loaded. This antenna is suitable for both mobile and portable operation, being intended for use on a handheld transceiver. This antenna was devised by Don Johnson, W6AAQ, and Bruce Brown, W6TWW.

A combination of top and center loading offers improved efficiency over continuously loaded antennas such as the "stubby" pictured at the beginning of this chapter. This antenna also offers low construction cost. The only materials needed are a length of stiff wire and a scrap of circuit-board material, in addition to the appropriate connector.

Construction

The entire whip section with above-center loading coil

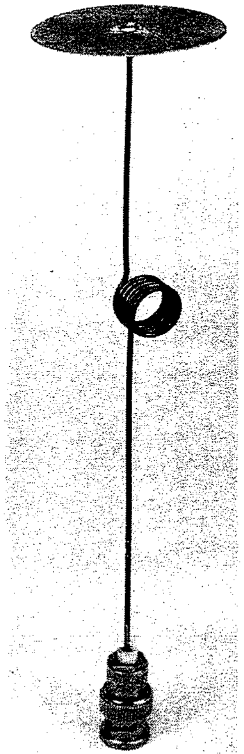


Fig 46—This 144-MHz antenna uses a combination of top and center loading. It offers low construction cost and improved efficiency over continuously loaded antennas.

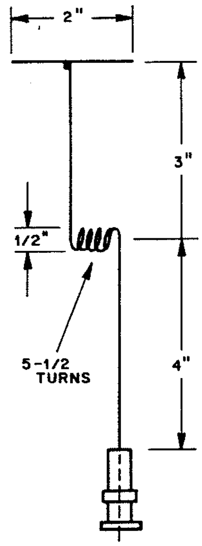


Fig 47—Dimensions for the top-loaded 144-MHz antenna. See text regarding coil length.

is made of one continuous length of material. An 18-inch length of brazing rod or no. 14 Copperweld wire is suitable.

In the antenna pictured in Fig 46, the top loading disk was cut from a scrap of circuit-board material, but flashing copper or sheet brass stock could be used instead. Aluminum is not recommended.

The dimensions of the antenna are given in Fig 47. First wind the center loading coil. Use a ½-inch bolt, wood dowel, or other cylindrical object for a coil form. Begin winding at a point 3 inches from one end of the wire, and wrap the wire tightly around the coil form. Wind 5½ turns, with just enough space between turns so they don't touch.

Remove the coil from the form. Next, determine the length necessary to insert the wire into the connector you'll be using. Cut the long end of the wire to this length plus 4 inches, measured from the center of the coil. Solder the wire to the center pin and assemble the connector. A tight-fitting sleeve made of Teflon or Plexiglas rod may be used to support and insulate the antenna wire inside the shell. An alternative is to fill the shell with epoxy cement, and allow the cement to set while the wire is held centered in the shell.

The top loading disk may be circular, cut with a hole saw. A circular disk is not required, however—it may be of any shape. Just remember that with a larger disk, less coil inductance will be required, and vice versa. Drill a hole at the center of the disk for mounting it to the wire. For a more rugged antenna, reinforce the hole with a brass eyelet. Solder the disk in place at the top of the antenna, and construction is completed.

Tune-Up

Adjustment consists of spreading the coil turns for the correct amount of inductance. Do this at the center frequency of the range you'll normally be using. Optimum inductance is determined with the aid of a field-strength meter at a distance of 10 or 15 feet.

Attach the antenna to a handheld transceiver operating on low power, and take a field-strength reading. With the transmitter turned off, spread the coil turns slightly, and then take another reading. By experiment, spread or compress the coil turns for the maximum field-strength reading. Very little adjustment should be required. There is one precaution, however. You must keep your body, arms, legs, and head in the same relative position for each field-strength measurement. It is suggested that the transceiver be placed on a nonmetal table and operated at arm's length for these checks.

Once the maximum field-strength reading is obtained, adjustments are completed. With this antenna in operation, you'll likely find it possible to access repeaters that are difficult to reach with other shortened antennas. W6AAQ reports that in distant areas his antenna even outperforms a 5/8-λ vertical.

VHF QUARTER-WAVELENGTH VERTICAL

Ideally, a VHF vertical antenna should be installed over a perfectly flat reflector to assure uniform omnidirectional radiation. This suggests that the center of the automobile roof is the best place to mount it for mobile use. Alternatively, the flat portion of the trunk deck can be used, but will result in a directional pattern because of car-body obstruction.

Fig 48 illustrates how a Millen high-voltage connector can be used as a roof mount for a VHF whip. The hole in the roof can be made over the dome light, thus providing accessibility through the upholstery. RG-59 and the ¼-wave matching section, L (Fig 48C), can be routed between the car roof and the ceiling upholstery and brought into the trunk compartment, or down to the dashboard of the car. Instead of a Millen connector, some operators install an SO-239 coax connector on the roof for mounting the whip. The method is similar to that shown in Fig 48.

It has been established that in general, ¼-λ vertical antennas for mobile repeater work are not as effective as 5/8-λ