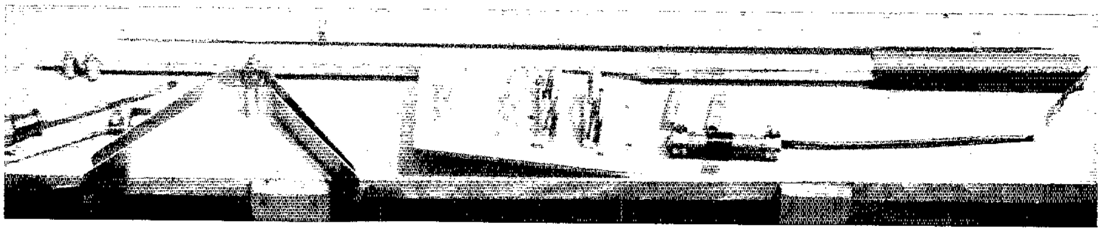
A Traveling Ham's Trap Vertical

If you're a wayfarer, you should be interested in this two-band trap vertical, which collapses to 39 inches for easy transport.

By Doug DeMaw,* W1FB



The traveling ham's trap vertical ready for final assembly. At the left foreground are two wing-shaped pieces of aluminum used experimentally during development of the antenna; they are not required for the model described in the text.

How effective is a trap type of antenna? That's a question the ARRL staff is asked repeatedly. Unfortunately, there is no simple answer we can offer. This is because the term "effective" is rather subjective. Effectiveness for one operator might mean the ability to work rare DX. Conversely, another amateur might consider the antenna effective if it helped him to break into pileups quickly. Some other operator might think of antenna effectiveness as a quality that would permit maintaining reliable communications over a specified ground-wave path.

Perhaps a better question to ask would be, "How *efficient* is a trap style of antenna?" But even that query is a tough one to address. The efficiency depends on many factors, such as the quality of the ground system, the Q of the traps (minimum losses) and the tuning of the system. The antenna performance also will depend on its height above nearby conductive or absorptive objects.

The best response to questions about trap-antenna performance is probably something like, "In theory, a full-size antenna will perform better than a short antenna with lumped constants." In other words, there is a certain trade-off to be expected in any "compromise" antenna. The performance degradation of a compromise antenna may, in some instances, be so minor that the operator would never recognize the difference between it and a full-size antenna. On the other hand, the performance difference can be startling. An example of the latter was seen during a DXpedition by W8JUY/8P6WM and W1FB/8P6EU. The two stations had equal transmitter power and were situated 100 feet (30.5 m) apart. The antennas of each station were erected over the ocean shore. W8JUY used a 4-band trap vertical at a height of 40 feet (12 m) above the sea shore. A complete radial system (factory specified) was erected for the vertical antenna. W1FB used a center-fed sloping dipole over the sea shore. It was approximately 25 feet (7.6 m) above the shoreline. During 20-meter operation over a two-week period, comparative signal reports from the USA and DX stations revealed that the sloping dipole of W1FB was consistently two to three S units better than the trap vertical. It is fair to say that at another time, and from some new QTH, the situation might be reversed. The inferior performance of the trap vertical did not, however, impair the ability of W8JUY to hold regular schedules or work DX, which brings us to the focal point of this discussion: Irrespective of the actual performance, a trap beam or trap vertical can be (and usually is) a suitable all-around amateur hf-band antenna.

Table 1

Dimensions for Various Frequency Pairings

Tubing (Fig. 1)	*Band (MHz)*	*A*	*B*	*C*	*D*	*E*	*F*	*C1 (pF)***	*L1 (Approx. μH)*
Tubing Length (inches)	21/28	25	16	25	25	25	33	18	1.70
	14/21	38	33	37	37	37	33	25	2.25
	10/14*	42	42	54	54	54	49	39	3.25
Tubing Length at Resonance (approx. inches)***	21/28	20	16	21.5	21.5	21.5	33	—	—
	14/21	33	33	33	33	33	33	—	—
	10/14*	37	37	49.6	49.6	49.6	49	—	—

in. × 25.4 = mm
*New WARC-79 band.
**See text.
***Midband dimensions. X_{C1}, $X_{L1} \approx 300\ \Omega$

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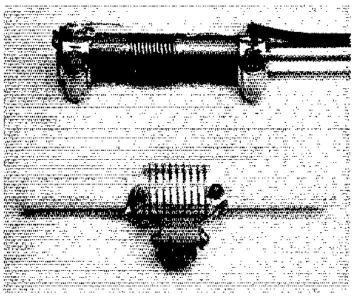

Fig. 1 — Photograph of two styles of traps. PVC tubing is used for the lower one (see text) and Teflon rod is used as the coil form for the other. The ends of the Teflon rod have been reduced on a lathe to fit inside the tubing sections above and below the trap. Teflon is too flexible for large verticals, but phenolic or fiberglass rod would be satisfactory. Miniductor stock comprises the coil in the upper trap. A ceramic transmitting capacitor is used in parallel with the coil.

Separate single-band, full-size vertical antennas would probably work slightly better than a multiband trap vertical, but the latter would cost less, occupy less space, be more convenient and do a pretty good job for the operator.

How do Traps Work?

A *trap* is pretty much what the name implies: It "traps" rf energy by blocking its passage to portions of the antenna that aren't used during operation in a specified band. A trap is a high-impedance device at the selected operating frequency, which enables it to block the passage of rf energy on the band for which it is a parallel-resonant circuit. At some lower frequency it becomes part of the antenna, and responds somewhat as a loading coil. Thus, if we were to build a two-band trap beam or vertical for, say, 40 and 20 meters, the part of the antenna from the feed point to the bottom of the trap would constitute the 20-meter radiator. The trap (tuned for 20 meters) would effectively "divorce" the portion of the antenna above the trap during 20-meter operation. When changing operations to 40 meters, all of the antenna would become a functional part of the system. The trap acts as a loading coil on 40 meters, which results in the overall antenna length being somewhat less than that of a full electrical quarter wavelength.

If the trap antenna were designed for more than two amateur bands, additional traps and antenna sections would be used, but the principle of operation would remain the same. The highest frequency section of the antenna is always nearest the feed point and progresses outward until all of the antenna is used for the lowest operating frequency.

Trap Design

There is no rigid formula for selecting a best L/C ratio for an antenna trap. Generally, the X_L and X_C values can range between 100 and 300 ohms, and since $X_L = X_C$ at resonance, they will be the same value in a trap.[1] We often select a standard capacitor value in that reactance range and "tailor" the coil X_L to equal it.

It is important to keep the trap losses as low as possible (high Q). This requires the use of a coil form with high dielectric quality, such as polystyrene, phenolic, fiberglass, ceramic, Teflon or Plexiglas. The material chosen should be capable of withstanding antenna stress during periods of wind and ice loading. Brittle materials should not be used in cold climates in order to prevent the coil form from shattering under stress.

For power levels below 200 watts dc input to the PA stage of the transmitter, it is okay to use PVC tubing. At high rf-power levels, the PVC may heat, melt and burn. Nylon insulating forms are subject to the same failure, and the condition worsens as the operating frequency is increased.

The coil conductor should be of large cross-sectional area to minimize trap loses. No. 14 AWG or heavier copper wire is recommended. For high-power work, it is helpful to use copper tubing as the coil.

The Q and voltage rating of the trap capacitor also is an important consideration. If a fixed-value capacitor is used, it should be a ceramic transmitting type of capacitor (Centralab 800 series or equivalent). These units are available with working voltages up to 20 kV. This style of capacitor is shown in Fig. 1.

A suitable length of 50- or 75-ohm coaxial cable can be used as a trap capacitor. RG-58/U and RG-59/U cable is suggested for rf power levels below 150 watts. RG-8/U or RG-11/U will handle a few hundred watts without arcing or overheating. The advantage in using coaxial line as the trap capacitor is that the trap can be adjusted to resonance by selecting a length of cable that is too long, then trimming it until the trap is resonant. This is possible because each type of coax exhibits a specific amount of capacitance between the conductors. *The Radio Amateur's Handbook* contains a table that lists the capacitance per foot for popular coaxial cables. For example, RG-58/U has approximately 25 pF per foot, whereas RG-8/U cable has approximately 30 pF per foot. A coax-cable capacitor is also shown in Fig. 1.

Additional Band Capability

Assuming that we have built a trap vertical for two or three bands, what might we do to obtain capability for one additional band without using the trap concept? The simple way to achieve this is to place a coil and capacitance hat on the top of the trap vertical. This is equivalent to "top loading" any vertical antenna. Suppose we had a trap vertical for 20, 15 and 10 meters, but also wanted to use the system on 40 meters. The popular way to do this is to construct a 40-meter loading coil which can be installed as shown in Fig. 2. A number of commercial trap verticals use this technique. The loading coil is called a "resonator" because it makes the complete antenna resonant at the lowest chosen operating frequency (40 meters in our example). The coil turns must be adjusted while the antenna is assembled and installed in its final location. The remainder of the antenna has to be adjusted for proper operation on all of the bands *before* the resonator is trimmed for 40-meter resonance. If the capacitance-hat wires are short (approximately 12 inches or 300 mm), we can assume a capacitance of roughly 10 pF, which gives us an X_C of 2275 ohms. Therefore, the resonator will also have an X_L of 2275 ohms. This becomes 51 μH for operation at 7.1 MHz, since $L_{\mu H} = X_L/2\pi f$. The resonator coil should be wound for roughly 10% more inductance than needed to allow some leeway for trimming it to resonance. Alternatively, the resonator can be wound for 51 μH and the capacitance-hat wires shortened or lengthened until resonance in the selected part of the 40-meter band is achieved.

As was true of the traps, the resonator should be wound on a low-loss form. The

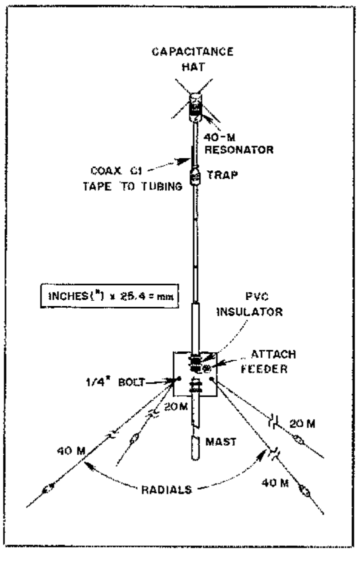

Fig. 2 — The assembled trap vertical, showing how a resonator can be placed at the top of the radiator to provide operation on an additional band (see text).

[1][Editor's Note: This is true only for one frequency band. All other dimensions being held equal, the lower the L/C ratio, the higher the resonant frequency will be on a lower frequency band. Of course the length of the outside end section can be adjusted for desired resonance on the lowest frequency band with a fixed L/C ratio.]

largest conductor size practical should be used to minimize losses and elevate the power-handling capability of the coil. Details of how a homemade resonator might be built are provided in Fig. 3. The drawing in Fig. 2 shows how the antenna would look with the resonator in place.

A Practical Two-Band Trap Vertical

The author needed a 20/15-meter antenna for use on his RV camper and to carry to the Caribbean for DXpeditions. Therefore, it seemed prudent to design an antenna that could be broken down into a small package for carrying or storage. The best approach seemed to be that of using short lengths of aluminum tubing that would telescope into one another. The longest of these is 39 inches (991 mm).

The ends of the sections are cut with a hacksaw to permit securing the joints by means of stainless-steel hose clamps. The trap is held in place by two hose clamps that compress the PVC coil form and the 1/2-inch (13-mm) tubing sections onto 1/2-inch dowel-rod plugs (Fig. 4). Strips of flashing copper (parts "G" of Fig. 4) slide inside sections B and C of the vertical. The opposite ends are placed under the hose clamps, which compress the PVC coil form. This provides an electrical contact between the trap coil and the tubing sections. The ends of the coil winding are soldered to the copper strips. Silicone grease should be put on the ends of straps "G" where they enter tubing sections B and C. This will retard corrosion. Grease can be applied to all mating surfaces of the telescoping sections for the same reason.

The trap (after final adjustment) should be protected against weather conditions. A plastic drinking glass can be inverted and mounted above the trap, or several coats of high-dielectric glue (Polystyrene Q-Dope) can be applied to the coil winding. If a coaxial-cable trap capacitor is used, it should be sealed at each end by applying noncorrosive RTV compound.

The trap is tuned to resonance prior to installing it in the antenna. It should be resonant in the center of the desired operating range, i.e., at 21,050 kHz if you prefer to operate from 21,000 to 21,100 kHz. Tuning can be done while using an accurately calibrated dip meter. If the dial isn't accurate, locate the dipper signal using a calibrated receiver *while the dipper is coupled to the coil and is set for the dip.*

A word of caution is in order here: Once the trap is installed in the antenna, it will not yield a dip at the same frequency as before. This is because it becomes absorbed in the overall antenna system and will appear to have shifted much lower in frequency. For the 20/15-meter vertical, the apparent resonance will drop some 5 MHz. Ignore this condition and proceed with the installation.

The Tubing Sections

An illustration of the assembled two-band trap vertical is shown in Fig. 5. The tubing diameters indicated are suitable for 15- and 20-meter use. The longer the overall antenna, the larger should be the tubing diameter to ensure adequate strength.

A short length of test-lead wire is used at the base of the antenna to join it to the coaxial connector on the mounting plate. A banana plug is attached to the end of the wire to permit connection to a uhf style of bulkhead connector. This method aids in easy breakdown of the antenna. A piece of PVC tubing slips over the bottom of section "F" to serve as an insulator between the antenna and the mounting plate.

If portable operation isn't planned, fewer tubing sections will be required. Only two sections need be used below the trap, and two sections will be sufficient above the trap. Two telescoping sections are necessary in each half of the antenna to permit resonating the system during final adjustment.

Other Bands

It's unlikely that everyone would want to build this antenna for 20 and 15 meters. Those who are interested in other frequency pairings will find pertinent data in Table 1. We have included information on building a trap vertical for the new 10-MHz WARC-79-sanctioned band, plus 20 meters. One additional band can be accommodated for any of the combinations shown by using a top resonator.

A Universal Mounting Plate

Field operation requires a variety of antenna-mounting schemes such as porch-rail attachment, window-sill mounting,

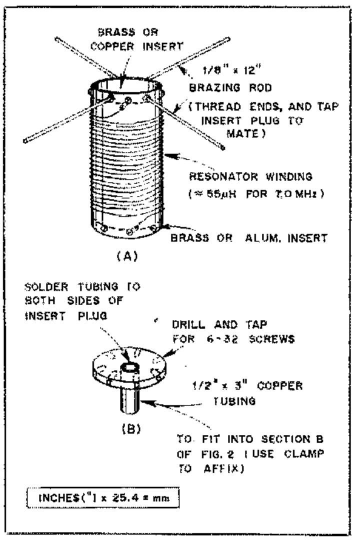

Fig. 3 — Details for building a homemade top-loading coil and capacitance hat. The completed resonator should be protected against the weather to prevent detuning and deterioration.

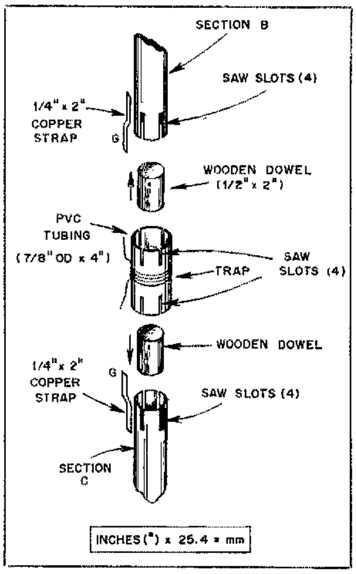

Fig. 4 — Break-down view of the PVC trap. The hose clamps that go on the ends of the PVC coil form are not shown.

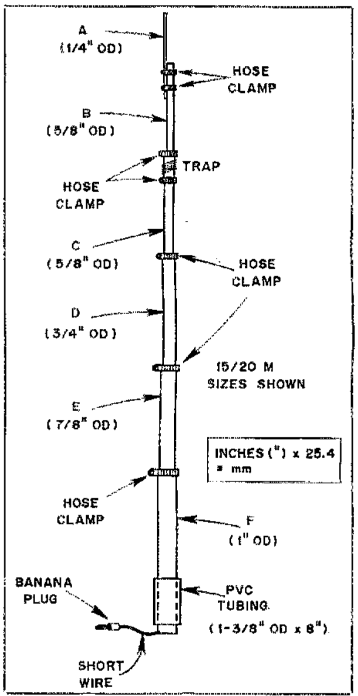

Fig. 5 — Assembly details for the two-band trap vertical. The coaxial-cable trap capacitor is taped to the lower end of section "B."

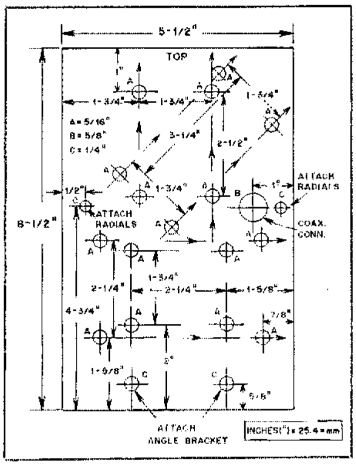

Fig. 6 — Suggested layout for a universal mounting plate. U bolts or muffler clamps can be used to attach the vertical to the plate, and to affix the supporting mast to the antenna. The arrows show the angles at which the antenna and the mast can be mounted to meet a host of mechanical conditions. Hole "B" is for a uhf bulkhead coax connector.

etc. For this reason it is helpful to have a mounting plate which will satisfy many unknown conditions. Fig. 6 shows the layout for a plate that is made from 1/4 inch (6.3 mm) thick aluminum plate. Steel, copper or brass plate is also suitable. The top half of the plate contains two sets of U-bolt holes for mounting the radiator vertically. A second set of holes permits 45-degree mounting from a window sill.

The lower half of the plate has two sets of U-bolt holes for attaching a mast vertically. A second set of holes permits horizontal mast mounting, should that format be necessary.

The bottom two holes in the plate are for attaching a length of angle stock. There is a second piece of angle stock the same length. The angle brackets can be used with a pair of C clamps to attach the antenna to a variety of foundations.

Hole "B" is for the uhf female-to-female coaxial bulkhead connector. Holes "C" at the left and right center of the plate are for attaching the radials by means of large bolts and washers. The holes marked "A" are for the U bolts or muffler clamps. The hole diameters and spacings will depend upon the size and brand of U bolts used. The arrows indicate the mounting angle of the antenna element and the mast. A photograph of the base plate and related hardware is given in Fig. 7.

Ground System

There's nothing as rewarding as a *big* ground system. That is, the more radials the better, up to the point of diminishing returns. Some manufacturers of multiband trap verticals specify two radial wires for each band of operation. Admittedly, an impedance match can be had that way, and performance will be reasonably good. So during temporary operations where space for radial wires is at a premium, use two wires for each band. We prefer a minimum of four wires for each band, and generally use that many. The slope of the wires will affect the feed-point impedance. The greater the downward slope, the higher the impedance. This can be used to advantage when adjusting for the lowest VSWR. When the radials are perfectly horizontal, the feed impedance will be on the order of 30 ohms. This suggests the use of a 1.6:1 broadband transformer at the feed point to assure a good match — assuming horizontal radials must be used in a particular installation.

The radial wires are cut to an electrical quarter wavelength for the band of operation. Some operators argue that making the radials 5% longer will increase the antenna bandwidth. The author has not found this to be true, but did observe some changes in feed-point impedance when that was done.

If the antenna is to be ground-mounted, make certain that the lower end of section "F" is only a few inches above ground. Bury as many radials in the earth as practical, using no less than 20 wires that are the length of the overall vertical antenna, or longer.

Tune-up

An SWR indicator will be necessary when adjusting the antenna. Apply rf

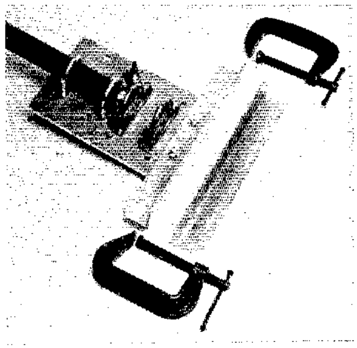

Fig. 7 — Photograph of the mounting plate showing two angle brackets and C clamps, which provide additional mounting possibilities.

energy at the center of the desired operating range of the highest operating band of the antenna. Adjust the length of the section below the trap for the lowest VSWR.

Next, set the transmitter for a frequency in the center of the lowest frequency operating range. Adjust the length of the section above the trap for the lowest obtainable VSWR. Repeat both adjustments to compensate for interaction of the adjustments. If a top resonator is used for a third band, it should be adjusted last for the lowest attainable VSWR.

Summary Comments

The antenna can be broken down to form a compact assembly for transport. A heavy-duty cardboard mailing tube, or a 2-inch (51-mm) ID piece of aluminum tubing will serve nicely as a container for shipping or carrying. Iron-pipe thread protectors can be used as plugs for the ends of the carrying tube. The trap, mounting plate and coaxial feed line should fit easily into a suitcase with the operator's personal effects.

If you haven't been a radio-operating wayfarer thus far, perhaps this antenna will inspire you to become one! If you want to hear this antenna in operation, look for W1FB on 20 and 15 meters from the camp site, or from Tortola, British Virgin Islands during late October and early November of 1980.

Strays

NOVICE DX NET

☐ A Novice DX net is being formed. Planned starting date is October 11 at 1430 UTC on 28.103 MHz. Write Al Fetzer, WD9EJE, 1444 Wilmette Ave., Wilmette, IL 60091, for details.

LIBRARY OF CONGRESS WANTS AMATEUR TV PUBLICATION

☐ Henry B. Ruh, K2VCU, assistant chief engineer for Indiana University Radio and Television Services, has been asked to provide a copy of *Amateur Television Magazine*, which he publishes, to the permanent collection of the Library of Congress. Ruh has been publisher of the magazine, which has an international circulation of 2100, since 1975.

I would like to get in touch with . . .

☐ amateurs who practice the Transcendental Meditation technique or who are interested in TM. A net meets on 14.340 MHz Sundays at 1630 UTC, or contact Barbara Sweet, WA2KCL.

☐ anyone who could donate some old DX *Callbooks*, dating back to 1945. Carl Mitchell, K1JDJ, Box 1003, Fairfield, CT 06430.