John Kerry

131 1/2 feet

top-loaded delta loop antenna

Design and construction of an efficient, low-frequency, vertically polarized antenna using wire elements

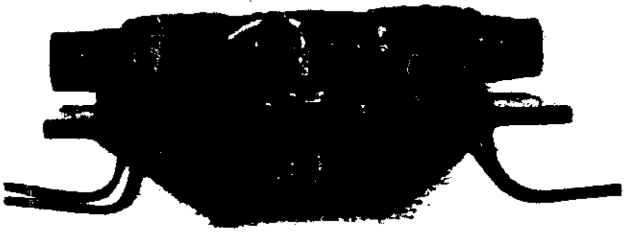
The vertically polarized full-wave loop has emerged as a popular antenna on the low-frequency bands. The most common form of this antenna is the triangular (delta) loop[1,2] with one of its vertices pointing skyward. Such an antenna can be suspended from a single point located on a tower or a tree.

The delta loop antenna is an interesting cousin of the popular inverted-V dipole. It has been around for quite a while and yet provides some pleasant surprises. For those interested in tracing its background I have provided references 1 and 2. Reference 1 is particularly informative and provides polar diagrams of the delta radiation pattern in three planes together with supporting mathematics. These references are available in most of the libraries in large cities.

Editor, W6NIF

On the 80- and 160-meter bands, height limitations can reduce the effectiveness of the delta loop. This article describes a method for reducing this problem by means of an easily implemented loading procedure. The case of a support height of 20 meters (65 feet) for an 80-meter antenna is shown in fig. 1. An interesting aspect of this comparison is that the top-loaded delta loop fig. 1B (TLDL) has more gain than a full delta loop. Experience since the end of 1976 at W1DTV has been that the antenna performs as well as an inverted V for short-range contacts and provides one to two S units better performance for DX contacts. In this article, I discuss the evolution of the TLDL and provide detailed design information for an 80-meter TLDL.

Two kinds of vertically polarized antennas are in



Homebrew matching transformer for the top-loaded delta loop antenna.

By Frank J. Witt, W1DTV, 20 Chatham Road,
Andover, Massachusetts 01810

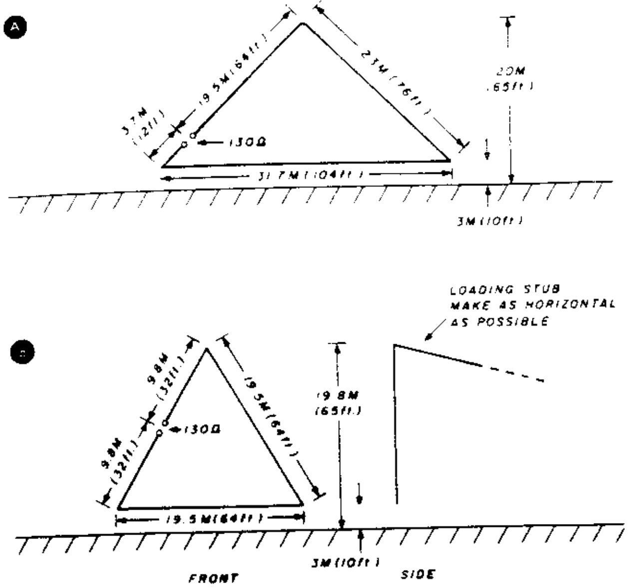


fig. 1. An 80-meter delta-loop antenna with apex at 20 meters (65 feet). Sketch A shows the classic delta loop for 3.825 MHz; B shows a top-loaded delta loop for the same resonant frequency. Loading-stub dimensions are discussed in the text.

common use on the low-frequency bands. One type is suspended above ground and fed directly; the other is erected from ground level and excitation occurs between ground or a simulated ground plane and the antenna. Both antennas would benefit from a highly conductive ground; but in the latter case, since ground resistance appears in series with the antenna at the drive point, efficiency is highly dependent on ground conditions. Therefore, the more successful monopole installations are those that use many radials. The TLDL is not fed against ground and hence ground plays only the role of a reflector. This is also true of full delta loops and sloping dipoles. Experience has shown that impressive performance may be obtained with such antennas without an elaborate system of radials.

evolution of the top-loaded delta loop

The signal at a distant point from a part of a transmitting antenna is proportional to the current in that part of the antenna. For a half-wave dipole, for instance, maximum radiation is received from the center of the dipole, where the current is greatest. The radiated contribution from the ends of the antenna is negligible.

The TLDL concept resulted from a recognition of the fact that for a conventional, vertically polarized delta loop, much of the antenna where high currents exist is horizontal and near ground. The objective of the TLDL design is to get these parts of the antenna away from ground and at least partly vertically oriented to increase antenna gain. **Fig. 2A** shows a typical vertically polarized conventional delta loop designed for 3.825 MHz. Actually, this antenna can only be said to be mostly vertically polarized because of the position of the feed point. True vertical polarization (in a direction perpendicular to the plane of the loop, *i.e.*, the direction of maximum gain) is obtained when the feed point is one-quarter wavelength away from the peak of the triangle as shown in **fig. 2B**. You can see that the polarization is vertical by noting the current flow; the vertical components from the currents in the two upper sides of the triangle add, while the horizontal components cancel.

The objective of the loading is to "lift" the current nodes higher in the vertical space available for the antenna and to make the vertically radiating sides of the antenna more vertical. Both actions will increase

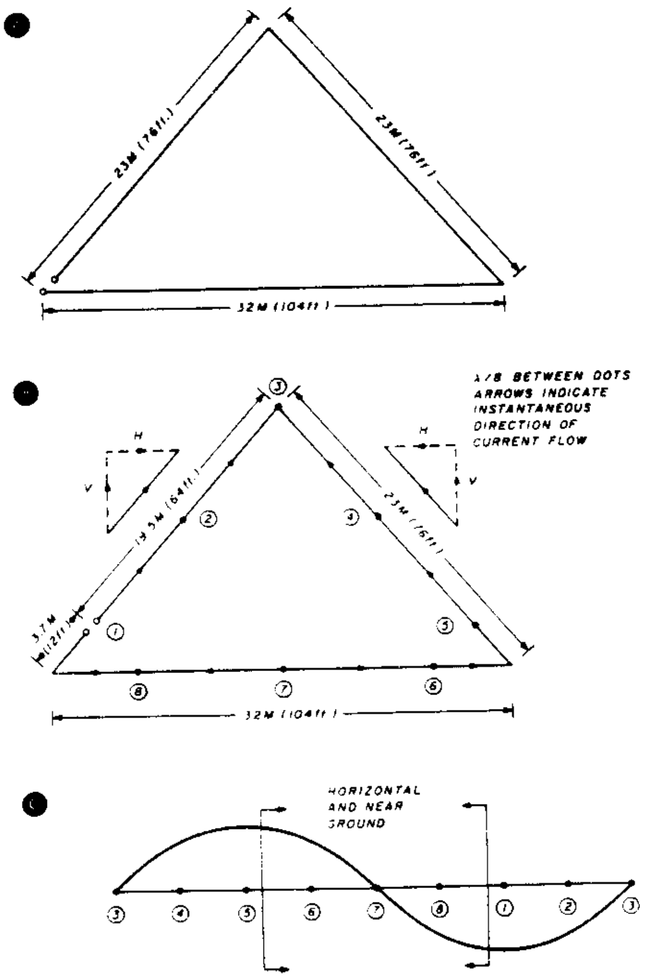


fig. 2. Physical dimensions of a typical corner-fed delta loop antenna (A). True vertical polarization occurs when the feedpoint is one-quarter wavelength from the apex (B). Sketch C shows current distribution.

the low-angle gain for vertically polarized signals. The derivation of the TLDL from a conventional delta loop is shown in **fig. 3**.

The feedpoint resistance for both a conventional delta loop and a TLDL has been measured at W1DTV to be 130 ohms. From this information and from the geometry of the two antennas (and if one assumes sinusoidal current distribution), the TLDL has a gain of 2.3 dB over a conventional delta loop. The dimensions of **fig. 1** have been assumed for this calculation. See reference 3 and **fig. 4** for an explanation of the methods used to arrive at this result.

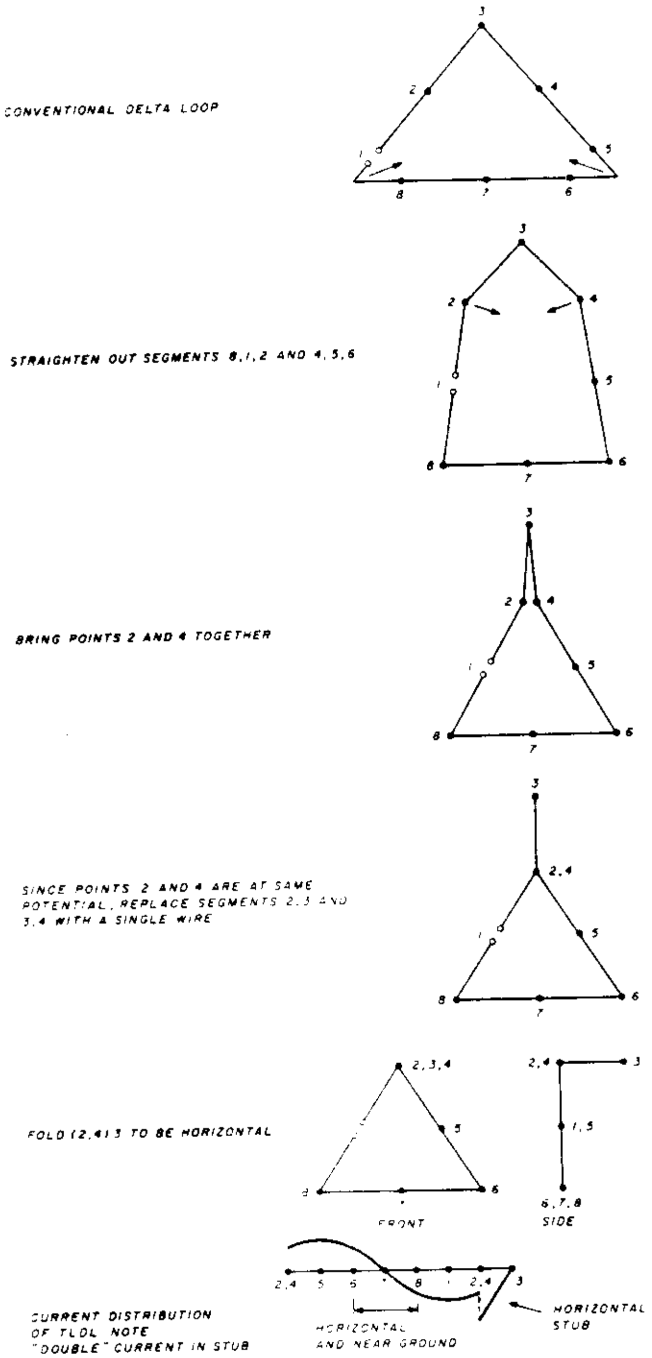


fig. 3. How the top-loaded delta loop (TLDL) is derived from the conventional delta loop. The top loading makes the current nodes higher with respect to ground and increases the vertical polarization from the antenna sides. This improves low-angle radiation.

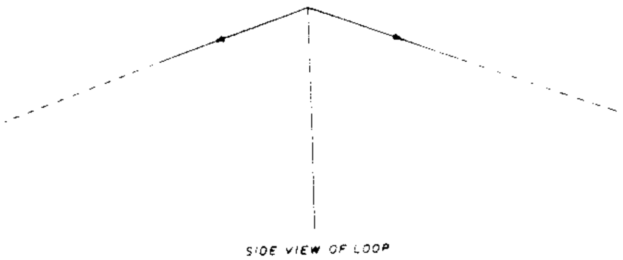


fig. 4. Method of adding the stubs on both sides of the delta loop to reduce horizontally polarized radiation.

The TLDL is truly vertically polarized in a direction perpendicular to the plane of the loop. It is mostly vertically polarized in other directions and exhibits an almost omnidirectional pattern.

loading stub

The loading (or matching) stub is shown in **fig. 3** to be horizontal, but this is rarely possible. At W1DTV it runs to the farthest point on the property and makes about a 60-degree angle with the plane of the loop. The stub should be $\lambda/8$ or 9.8 meters (32 feet) at 3.825 MHz. However, it was necessary to lengthen it to 13 meters (43 feet) for resonance at that frequency. The probable reason for this is that the stub is severely folded back toward the loop; the consequent detuning is overcome by lengthening the stub. This effect is observed in inverted V antennas, where the length must be made longer than would be necessary for a straight dipole.

The stub could be added on both sides of the loop as shown in **fig. 4**. This would virtually eliminate the effect of the stub on the radiated pattern. This method hasn't been tried, and the practical effects are unknown.

The stub can be shortened considerably by means of a loading coil installed in series with the stub at the point where the stub is connected to the triangle apex. See **fig. 5**. The 13-meter (43 foot) stub was reduced to 4.9 meters (16 feet) by the use of a 32-μH loading coil. The loading coil reduces radiation from the stub, but it results in a reduction in antenna bandwidth. The loading coil is a B&W 3029/3905-1,* which is 63.5 mm (2 1/2 inches) diameter by 254 mm

---

*Barker and Williamson, Inc., Canal Street and Beaver Dam Road, Bristol, Pennsylvania 19007.

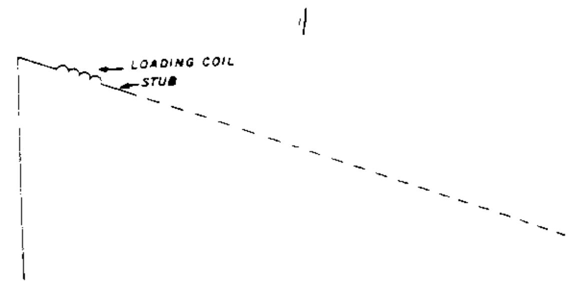


fig. 5. Using a loading coil to reduce stub radiation.

(10 inches) long (6 turns per 25 mm). This coil with the 4.9-meter (16-foot) stub allows the TLDL to resonate anywhere in the 80-meter band by changing the tap position.

matching methods

A common method for feeding delta-loop antennas is to use a quarter wavelength of 75-ohm transmission line between a 50-ohm transmission line and the feedpoint. For a feedpoint resistance of 130 ohms, the vswr at resonance would be

$$\frac{130}{75^2/50} = 1.16:1 \qquad (1)$$

which is quite acceptable. Since the conventional delta loop and the TLDL are essentially balanced antennas, it's desirable to use a 1:1 balun at the antenna to prevent antenna currents on the coax feedline.

At W1DTV, a transformer (shown in **fig. 6** and the photo) accomplishes both impedance matching and the unbalanced-to-balanced transformation; it handles the legal power limit quite satisfactorily. The transformer has been evaluated only on 80 meters, but the design could be trimmed to work over several bands. See reference 4 for details on optimizing such designs.

voltage standing-wave ratio

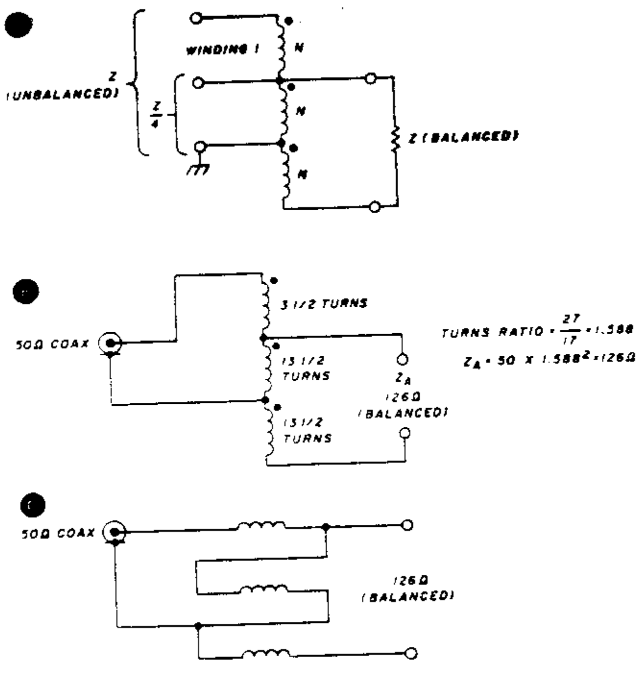
The vswr using the transformer of **fig. 6** and 50-ohm coax is shown in **fig. 7** for the conventional delta loop, the TLDL using a wire stub only, and the TLDL with a wire stub and loading coil. Note that an excellent midband match is obtained for all three cases, but the bandwidth depends on the configuration. The bandwidth of the worst TLDL case (using the loading coil) is substantially better (6.6 times wider) than that of a loaded 20-meter (66-foot), 80-meter sloping dipole,[5] which would require about the same mounting height. The vswr plot of the latter is also shown in **fig. 7** for comparison.

Note from **fig. 7** that the vswr of the TLDL with a loading coil is not unity. The reason is that the inductive loading modifies the current distribution at the top of the antenna, and the feedpoint resistance is changed. For the purist, a more optimum transformer for this case would be one where the 3-1/2-turn winding of **fig. 6** is reduced to 2-1/2 turns. In all cases, the installation involved a steel tower with the antennas supported 1.2 meters (4 feet) from the tower on a boom at the 19.8-meter (65-foot) level. All guy wires were broken with insulators to avoid resonance, and no guying was used above the 10.7-meter (35-foot) level.

concluding remarks

The TLDL antenna performs as well as other similar antennas requiring higher points of support. The design is based on the positioning of the high-current parts of the antenna so that they will provide a primarily vertically polarized radiated signal. The TLDL has substantially more bandwidth than its nearest low-height competitor, the λ/4 sloping dipole (loaded). Calculations indicate that the antenna should be a good performer, and on-the-air experience has substantiated these results.

A point of caution — if you try this antenna, or any new antenna, take steps to convince yourself that

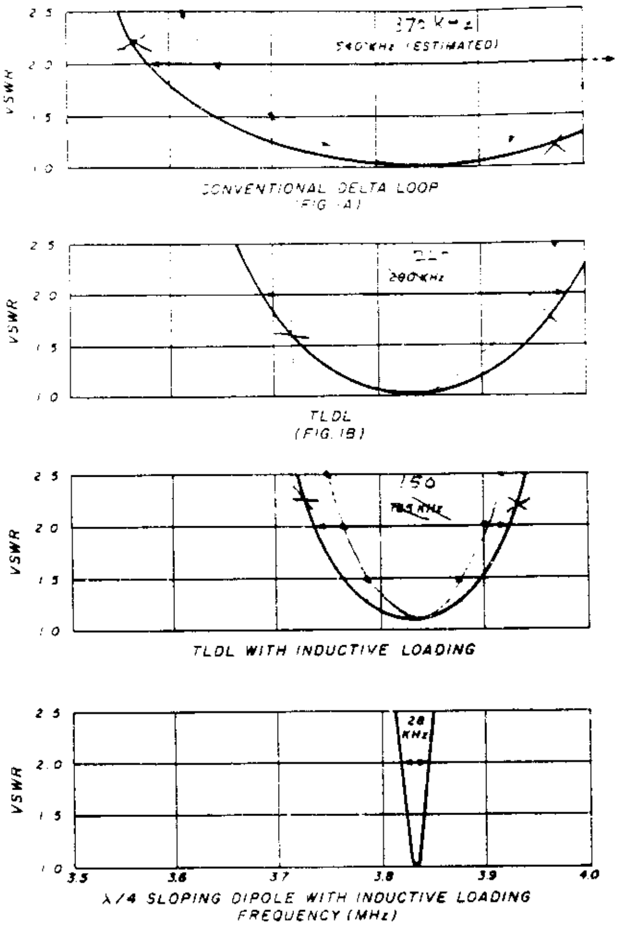


WIRE: 1mm (AWG 18) HOOKUP WIRE

CORE AMIDON FERRITE ROD, 12mm DIAMETER, 100mm LONG, μ = 125 (AMIDON ASSOCIATES, 12033 OTSEGO STREET, NO. HOLLYWOOD, CA, 91607)

CONSTRUCTION: 13 1/2 TRIFILAR TURNS WITH 10 TURNS REMOVED FROM ONE WINDING WRAP WITH VINYL ELECTRICAL TAPE AND TAPE TO THE FEEDPOINT INSULATOR NO OTHER PROTECTION NECESSARY.

fig. 6. Construction of the matching transformer for the top-loaded delta loop antenna. Sketch A shows the basic principle. Any impedance ratio between 1:1 and 1:4 may be obtained by tapping winding 1. The basic configuration is shown in B. Sketch C shows the schematic and winding logic.



CONVENTIONAL DELTA LOOP
(FIG. 1A)

TLDL
(FIG. 1B)

TLDL WITH INDUCTIVE LOADING

λ/4 SLOPING DIPOLE WITH INDUCTIVE LOADING

FREQUENCY (MHz)

fig. 7. Voltage standing wave ratio and bandwidth of the conventional delta loop, the TLDL, the TLDL with inductive loading, and a quarter-wavelength sloping dipole antenna with inductive loading. Resonant frequency is 3.825 MHz in this model.

other nearby antennas are not significantly influencing its behavior. A considerable amount of interaction between a TLDL, an inverted V, and a sloping dipole, all supported by the same tower, has been observed. The data in this article were taken with the inverted V and sloping dipole removed from the tower.

references

1. H.E. Green, "On the Delta Aerial," *IEEE Transactions on Antennas and Propagation*, January 1963, pages 98-100.

2. J.S. Hall, "Nonresonant Sloping Vee Aerial," *Wireless Engineer*, vol. XXX, September 1953, pages 223-226.

3. F. Witt, "Simplified Antenna Gain Calculations," *ham radio*, May 1978, page 78.

4. J. Sevick, "Broadband Matching Transformers Can Handle Many Kilowatts," *Electronics*, November 25, 1976.

5. G. Hall, "Off-Center Loaded Dipole Antennas," *QST*, September 1974, pages 28-34, 58. (The antenna shown in fig. 5 of the referenced article is the one referred to as the λ/4 dipole. It's a popular radiator for sloping-dipole installations.)

HEATH CW Ops NEW! Join the YAESU-KENWOOD CROWD!

250 & 400 Hz 8-pole xtal filters

WIN YOUR BATTLE AGAINST QRM
GET THE BEST AND SAVE

ONLY $55
AIRMAIL POSTPAID
OVERSEAS ADD $3

"Fantastic!" is the word K2TK uses in summarizing the performance of the new Fox-Tango 8-pole 250 Hz CW crystal lattice filter in comparison with that of his standard 4-pole Heath unit. "Remarkably free from ringing...exceptional ultimate rejection...superior shape factor...easy installation..." are other quotes from his enthusiastic report. While gratifying, his remarks come as no surprise — they merely echo those of hundreds of satisfied Yaesu and Kenwood purchasers of Fox-Tango filters who have decided to up-grade their present sets instead of purchasing new ones at today's inflated prices.

Fox-Tango filters are designed to match the mounting holes in the most popular Heath rigs like the HW-101, SB-301, etc., exactly. For the others, the drilling of a few small holes will pose no problem for Heath owners who have "built their own". K2TK mounted his new 250 Hz unit in the space reserved for an AM filter in his SB300 thus making use of existing front panel controls for selecting either of his two CW filters. For those whose models lack this facility, it will be easy to improvise mechanical or electromagnetic switching arrangements if dual filters are desired. Of course, for those satisfied with one filter, installation usually consists of tightening two nuts and soldering two connections.

Our complete line of filters is listed below. Note that we offer both 250 and 400 Hz bandwidths for Heath rigs. Although the latter **appears** to be the same as the standard Heath CW filter, the difference in 8-pole performance has to be heard to be believed. The 400 Hz unit is ideal for routine CW operation even though it lacks the needle-sharp response (and critical tuning requirements) of the 250 Hz filter.

All units are $55 except as indicated. Order with confidence — satisfaction is guaranteed.

	Rig	Filter No. YF	Used for	Center Freq. kHz.	No. of Poles	Band Width	Notes
YAESU SERIES	FT-101 FR-101	31H250	CW	3179.3	8	250 Hz	Sharp unit for DX and contest work
		31H500	CW	3179.3	8	500 Hz	Use instead of standard 600 Hz unit
		31F600	CW	3179.3	6	600 Hz	Same as standard XF-30C unit. $45
		31H1.8	SSB	3180	8	1.8 kHz	For narrow SSB to reduce QRM
		31H2.4	SSB	3180	8	2.4 kHz	Substitute for XF-30A(6 pole) in early units
		31F6.0	AM	3180	6	6.0 kHz	Same as standard XF-30B unit. $45
	FT-7 FT-301	89H250	CW	8999.3	8	250 Hz	Sharp unit for DX and contest work
		89H500	CW	8999.3	8	500 Hz	Use instead of standard 600 Hz unit
		90H1.8	SSB	9000	8	1.8 kHz	For narrow SSB to reduce QRM
		90H2.4	SSB	9000	8	2.4 kHz	For use in speech processor
	FT-901	89H250	CW	8988.3	8	250 Hz	Sharp unit for DX and contest work
		89H500	CW	8988.3	8	500 Hz	Use instead of standard 600 Hz unit
KENWOOD	TS-520 R-599	33H250	CW	3395	8	250 Hz	Sharp unit for DX and contest work
		33H400	CW	3395	8	400 Hz	Use instead of standard 500 Hz unit
		33H1.8	SSB	3395	8	1.8 kHz	For narrow SSB to reduce QRM
	TS-820	88H250	CW	8830.7	8	250 Hz	Sharp unit for DX and contest work
		88H400	CW	8830.7	8	400 Hz	Use instead of standard 500 Hz unit
		88H1.8	SSB	8830.0	8	1.8 kHz	For narrow SSB to reduce QRM
HEATH	All except SB/HW104	33H250	CW	3395.4	8	250 kHz	Sharp unit for DX and contest work
		33H400	CW	3395.4	8	400 kHz	Use instead of standard Heath CW filters

To avoid error due to similarity of some filter numbers, specify desired unit completely when ordering. Include make and model of set, filter number, and center frequency.

Diode Switching Boards permit easy mounting (without drilling) of up to two crystal filters of any type in addition to those for which the manufacturer provides space. These boards will accommodate any of the filters listed **except Heath**. Specify make of set with which board is to be used. $20 airmail postpaid.

VISA and Master Charge accepted.

FT®

FOX-TANGO CORP.
Box 15944, W. Palm Beach, FL 33406