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HF Antennas: All Bands, All Wire

Coax-hater WØVM resurrects the versatile tuned doublet for nine-band HF use.

With eight high-frequency amateur bands (1.8, 3.5, 7, 10, 14, 21, 24, and 28 MHz) and one more band to be added soon (18 MHz), it is not practical to have a separate coax-fed dipole for each band. It would also be difficult to design a trapped antenna that would work on all of these bands. However, by using the kinds of antennas that were common in early days of amateur radio, *one* antenna can be made to provide good results on all of these bands.

If an historian were to write a history of amateur radio antenna design, he would divide this history into two periods. The first period would be the B.C. (before coax) period in which the objective of antenna design was to obtain the best possible performance. The second period would be called the A.C. (after coax) period. The convenience of coax, combined with human laziness, changed the course of amateur antenna design—antennas had to perform with coax feedlines. It has now become apparent that much performance was sacrificed in order to have coax feedlines. This was especially true with respect to multiband antennas. Now, many hams are using B.C.-type antennas.

Such an antenna can be built for very little money. Furthermore, on the higher bands, these antenna systems have *gain* as compared to a half-wavelength dipole. When erected in the form of an inverted vee, these antennas send and receive well in all directions.

The purpose of this article is to describe three nine-band antenna systems, to give approximate values of their gain for each band (as compared to a half-wave dipole for that band), and to present the directional patterns for each band.

All three of these antenna systems are fed with balanced tuned feeders and require a little work in adjusting an antenna tuner (or "transmatch") that has a balanced rf output. This little bit of work provides greatly improved performance as compared to a coax-fed antenna.

Antenna Number One

The first antenna to be discussed is a half-wavelength centerfed zepp for 3.5 MHz (the correct name for this type of antenna is a "tuned doublet," but it is commonly called a centerfed zepp). Each side of the center insulator should be approximately 66 feet long. (The exact length is not important so long as the wires on each side of the center are the same length; 60 feet could be used if that would be more convenient.) The tuned feedline can be made of either open-wire (ladder) line or of good quality twinlead (preferably of the heavy-duty transmitting type). It is often convenient to use open-wire line from the center of the antenna to the grounding switch outside of the shack and to use twinlead from

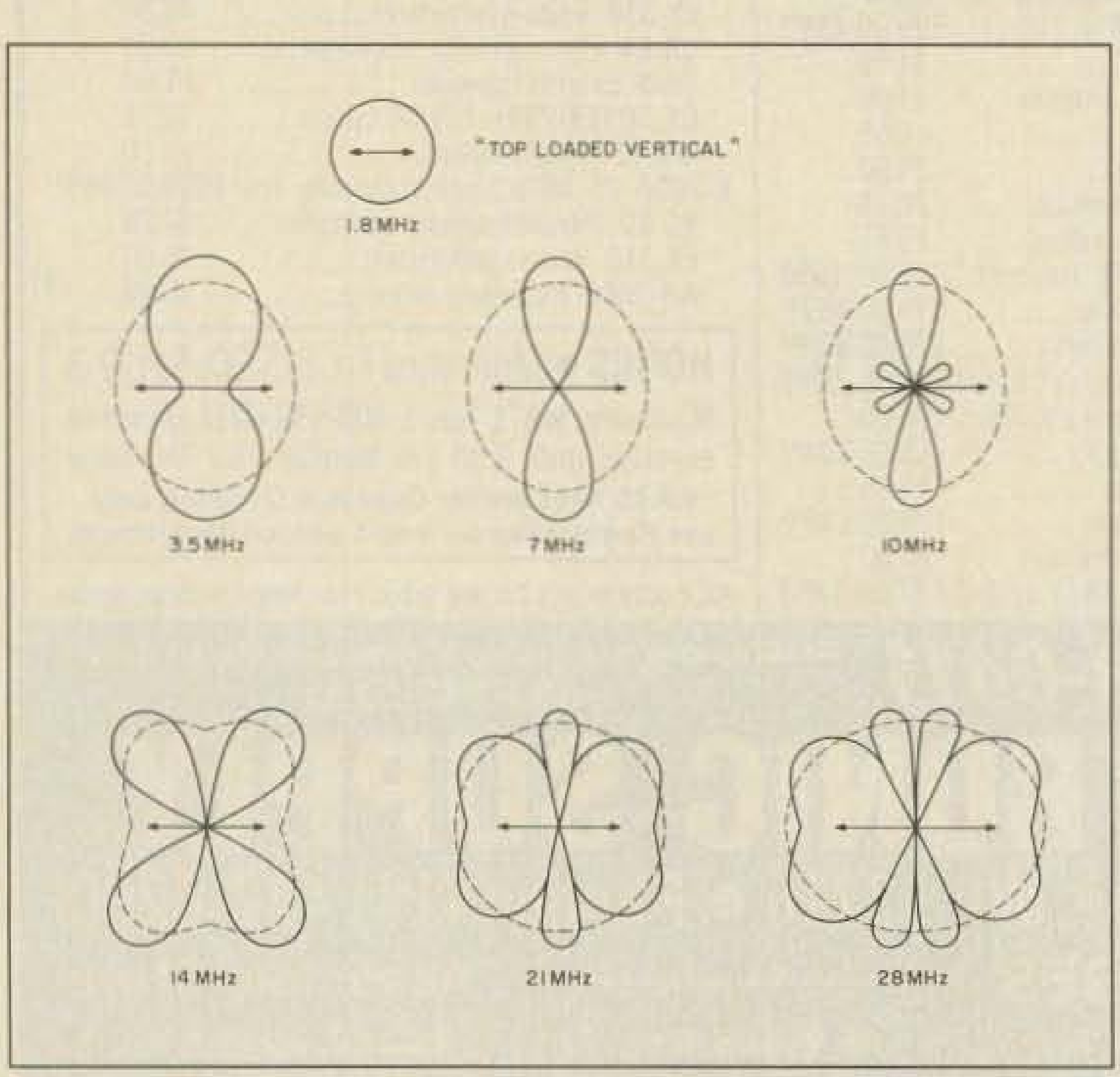

Fig. 1. Approximate directional patterns for antenna number one (66 feet each side of the center). The dotted lines show the patterns when the antenna is in the form of an inverted vee.

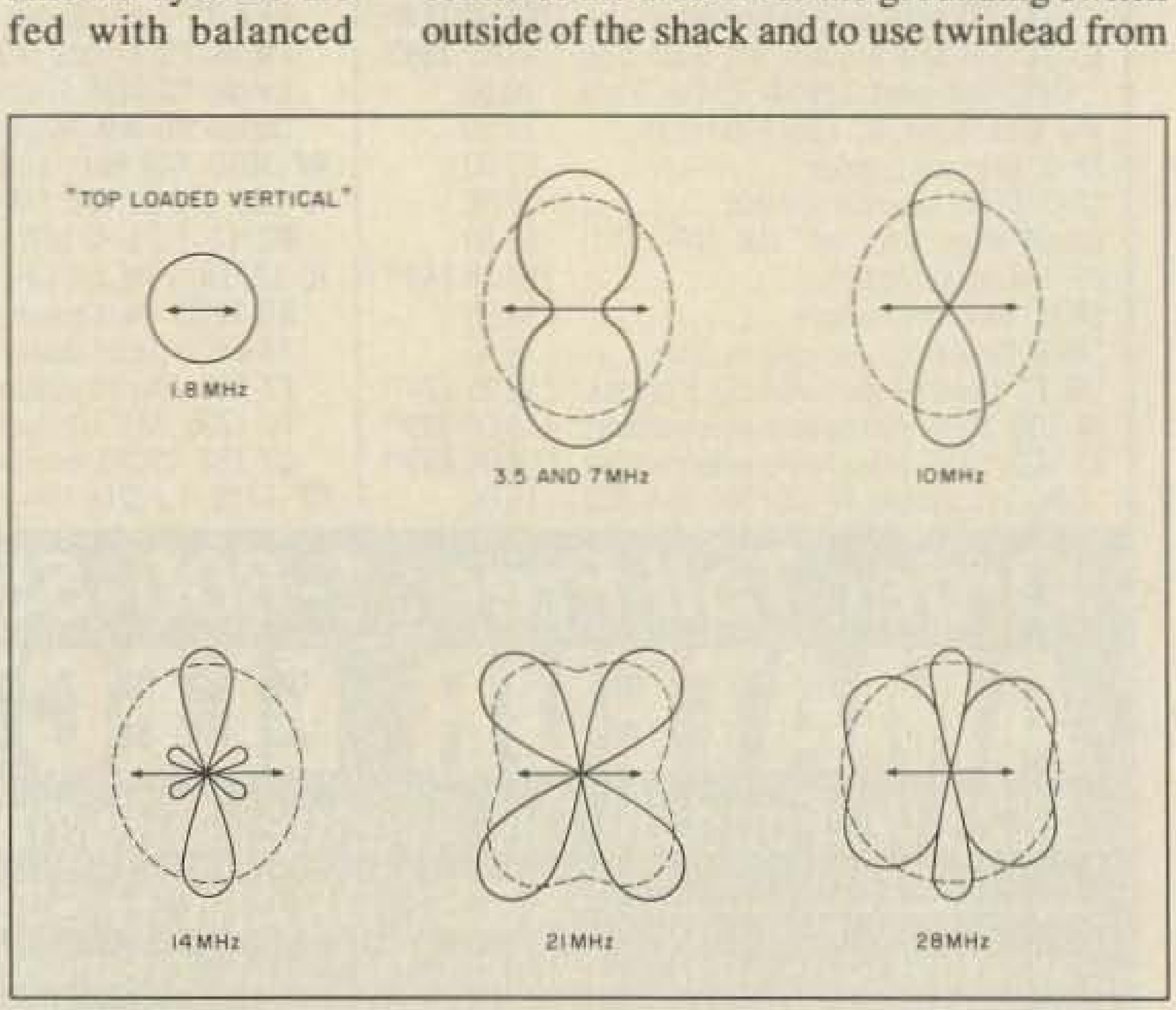

Fig. 2. Approximate directional patterns for antenna number two (51 feet each side of the center). The dotted lines show the patterns when the antenna is in the form of an inverted vee.

the grounding switch to the antenna tuner inside the shack.

Some amateur operators think that tuned feeders (or resonant lines) must be in the form of open-wire or ladder lines. This is not true. Excellent results can be obtained using good quality twinlead. The feedline to my big tuned doublet contains about 50 feet of homemade open-wire line and about 50 feet of three different kinds of twinlead, all in series.

The directional patterns and gains of this antenna (as compared to a dipole for each band) are shown in Fig. 1, and how to use the antenna system on the 1.8-MHz band will be explained later in the article.

On the 3.5-MHz band, the antenna system functions as a half-wavelength dipole. However, it will work much better than a coax-fed dipole because the antenna system can be tuned to resonance at the exact frequency being used, whether the frequency is near the low end of the CW band (3.500 MHz) or near the high end of the phone band (4.000 MHz). The antenna will send and receive best at right angles to the antenna wires. However, if the antenna is in the form of an inverted vee, it will send and receive reasonably well in all directions. For best east and west coverage, the antenna wires should run north and south.

Antenna engineers do not consider the inverted-vee configuration to be a good antenna design. Having the ends of the antenna nearer the ground than the center introduces losses not present when the antenna is horizontal. If the antenna is an inverted vee, it is a good idea to have the angle between the wires at the center of the antenna at least 120 degrees. In spite of the views of antenna engineers, many amateurs use inverted-vee antennas with good results.

On the 7-MHz band, the antenna will function as two half-wave antennas fed in phase. *It does not* function as a full-wave antenna, as was erroneously stated in a past *73* article ("So Why Do They Call It Wireless?" March, 1985). The gain as compared to a 7-MHz dipole will be 1.8 dB plus whatever gain can be attributed to the use of tuned feeders instead of coax feed. The strongest signals will be at right angles to the antenna, but an inverted-vee configuration will provide good coverage in all directions.

On the 10-MHz band, this tuned doublet will be even more effective. It will function as a long "extended double zepp" with a gain of nearly 3 dB as compared to a half-wavelength dipole, and with the greatest signal strength at right angles to the antenna wires.

On the 14-MHz band, the 3.5-MHz tuned doublet functions as two one-wavelength antennas fed with rf currents in phase. This provides a four-leafed-clover radiation pattern with lobes 52 degrees from the line of the wires. (As usual, the inverted-vee configuration will provide coverage in all directions.) The gain in the directions of the lobes should be at least 1 dB.

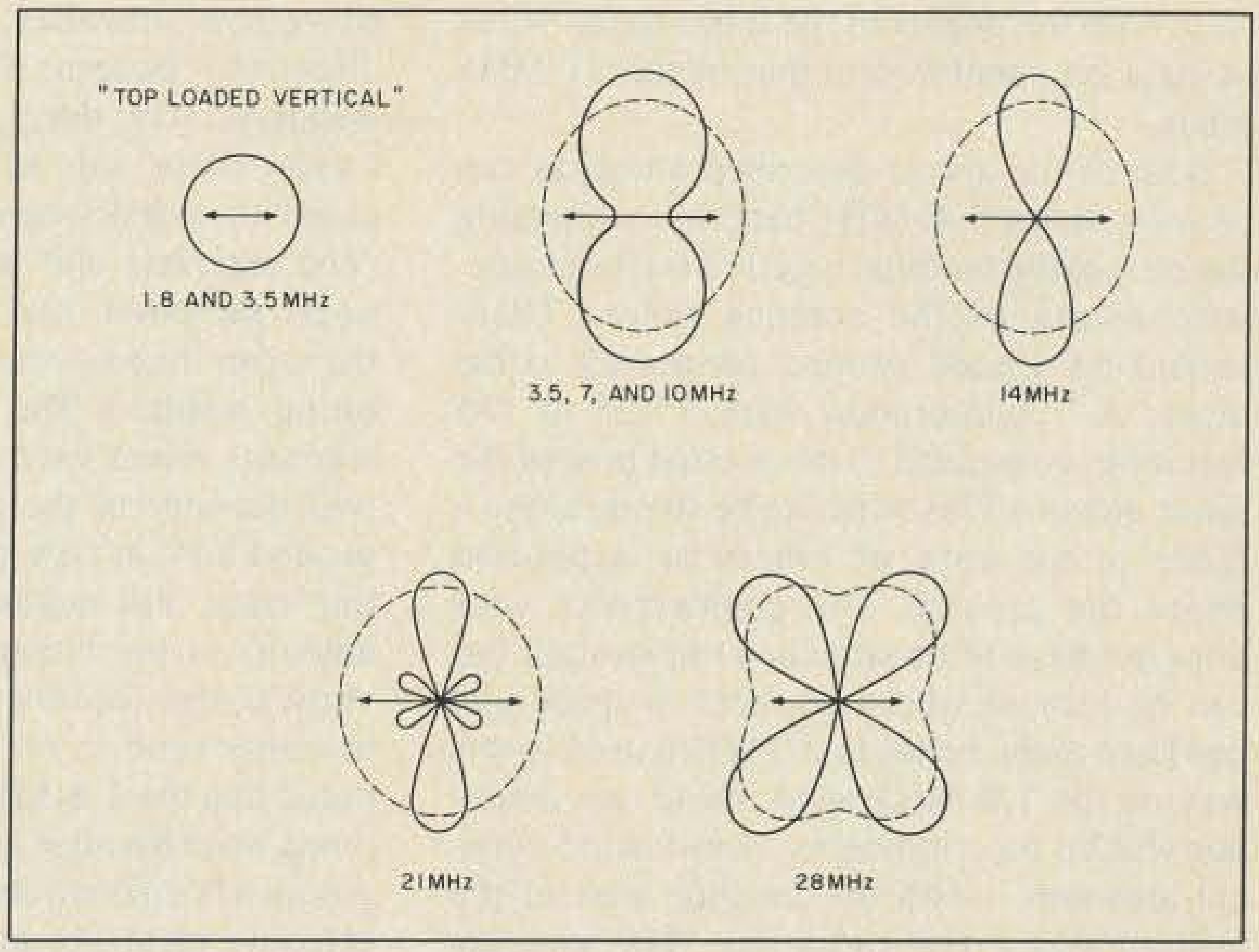

Fig. 3. Approximate directional patterns for antenna number three (33 feet each side of the center). The dotted lines show the patterns when the antenna is in the form of an inverted vee.

On the 18-, 21-, 24-, and 28-MHz bands, there will be four main lobes and two or more minor lobes. As the frequency gets higher, the angles that the four main lobes make with the direction of the wires become smaller and smaller, and minor lobes (at nearly right angles to the wires) appear. On the 21-MHz band, the antenna functions as two 3/2-wavelength antennas with rf currents in phase, and the gain in each major lobe should be at least 1.5 dB.

On the 28-MHz band, the antenna functions as two two-wavelength antennas with currents in phase, with gains in the major lobes of at least 3 dB. (In spite of extensive reading of antenna articles, I have been unable to find gain figures for the 14-, 21-, and 28-MHz bands using the 3.5-MHz tuned-doublet antenna, so the gain figures presented are guesstimates. The actual gains probably would not be less than these figures and might be more. One antenna authority wrote that the gain on the 28-MHz band should be 4 dB in the main lobes.)

Antenna Number Two

A tuned-doublet antenna system does not necessarily have to have its wires any particular length so long as each wire is exactly the same length as the other one. Moreover, a length can be chosen that will favor certain bands. A good length to have each side of the center is 51 feet. This is the length made popular by G5RV. An antenna with 51 feet each side of the center is slightly less effective on the 3.5-, 7-, and 10-MHz bands than the antenna with 66 feet each side of the center, but it is more effective on the 14-MHz band because it is a long (3/4-wavelength) extended-double-zepp antenna with a gain of nearly 3 dB on that band. The antenna sends and receives best at right angles to the antenna wires on the 3.5-, 7-, 10-, and 14-MHz bands. The four-leafed-clover radiation pattern does not develop until it is used on the 21-MHz band.

The gain figures for this antenna on the 3.5-, 7-, 10-, and 14-MHz bands are as follows: 3.5 MHz—none, 7 MHz—1.5 dB (guesstimate), 10 MHz—at least 1.8 dB, and 14 MHz—nearly 3 dB.

On the 21-MHz band, the main lobes would be in a four-leafed-clover pattern with the angles of the lobes 52 degrees from the line of the wires, and the gain in the main lobes estimated to be at least 1.5 dB. There would be a similar pattern on the 28-MHz

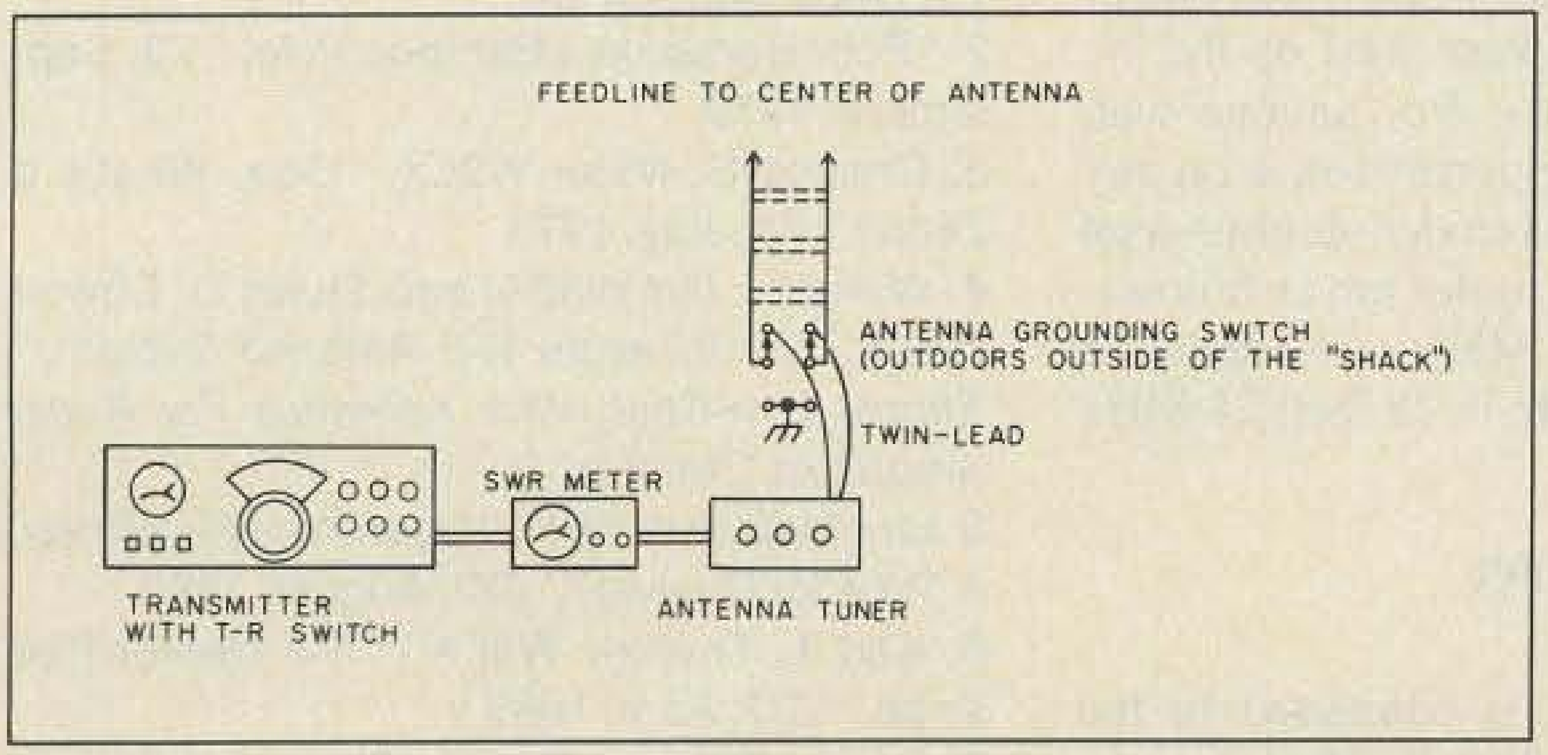

Fig. 4. The antenna system's connections to the transmitter.

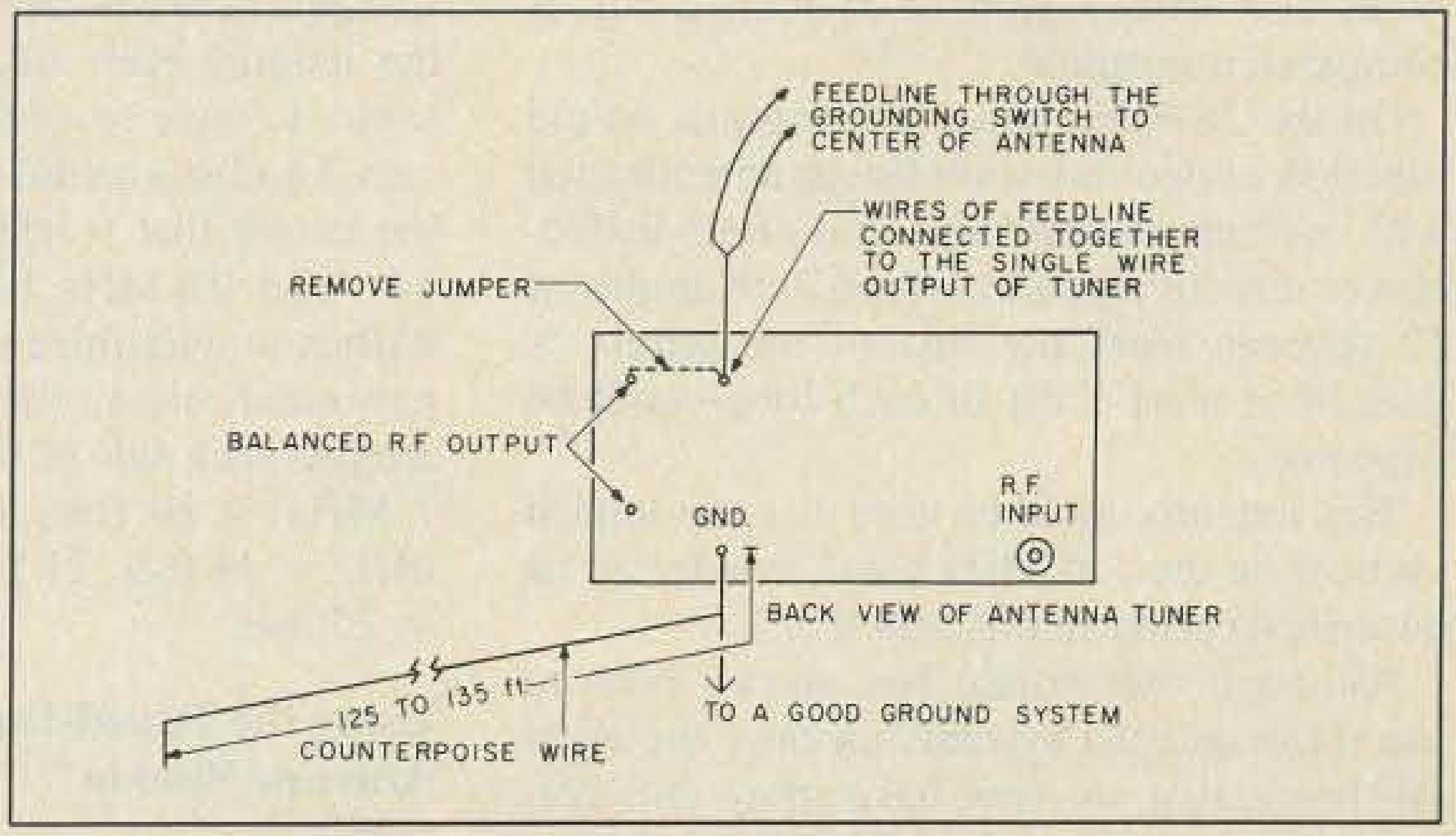

Fig. 5. Connections for using the antennas as top-loaded vertical antennas.

band with the angles of the lobes to the wires being a bit smaller than that of the 21-MHz lobes.

Both of the above-described antennas can be used on the 1.8-MHz band by connecting the ends of the feedline together on the single-wire output of the antenna tuner. There should be a good ground connected to the tuner. A "counterpoise wire," 125 to 135 feet long, connected to the ground post of the tuner, helps. (This wire can be strung along a fence in the yard or otherwise supported above the ground. The counterpoise wire does not have to be stretched out straight but can be located wherever there is space and can have many bends in it.) When used in this way on the 1.8-MHz band, these two antennas will be functioning as "top-loaded vertical antennas" with the feedline part of the system doing the radiating. The antenna wires provide the "top loading." This top-loaded vertical will send well in all directions with perhaps a bit more in the directions of the wires.

Antenna Number Three

Where space is limited, an antenna with shorter wires can be used. This third tuned-doublet antenna has wires 33 feet long on each side of the center. Although it will load up and make contacts on the 3.5-MHz band, it probably would work better as a top-loaded vertical antenna on that band. (This was the experience of NØEVQ.)

On the 7-MHz band, this antenna system functions as a half-wavelength dipole with best directions at right angles to the antenna wires. (An inverted-vee configuration provides coverage in all directions, as is the case with the other two antennas.)

On the 10-MHz band, the antenna could be considered an elongated half-wave dipole or a much shortened "two half waves in phase" with best directivity at right angles to the antenna wires and with some gain as compared to a half-wave dipole.

On the 14-MHz band, the antenna would be "two half waves in phase" with a gain of 1.8 dB as compared to a dipole and best directivity at right angles to the antenna wires.

On the 21-MHz band, the antenna would be two 3/4-wavelength wires fed in phase. This would be an elongated extended double zepp with best directivity at right angles to the wires and with a gain of at least 2 dB as compared to a dipole.

On the 28-MHz band, the antenna would function as two full-wavelength antennas fed with currents in phase and with a four-leafed-clover directivity pattern with lobe angles of 52 degrees from the line of the wires. A gain of at least 1 dB in each lobe could be expected.

This antenna could be used as a top-loaded vertical on the 1.8-MHz band, connected as described earlier in this article.

Although this article has shown how to use these antenna systems on only the eight HF bands that we now have, they will certainly work well on the 18-MHz band after we get it.

When these antennas are used as top-loaded vertical antennas, the gain (or loss) and directivity patterns will vary with each installation. On the 1.8-MHz and 3.5-MHz bands, there will actually be loss as compared to a half-wave dipole for the band. (The antennas will work as top-loaded verticals on other bands, and trying this on the other bands could provide some interesting results.) The effectiveness of these antennas when used as top-loaded verticals will depend on the antenna's height above ground and on how nearly vertical the feedline (now the radiator) is. The higher the antenna is the better, and the more nearly vertical the feedline is the better. Vertical antennas send in all directions. It should be noted that the 1.8-MHz band is a vertical-antenna band because it is extremely difficult to put up a horizontal antenna high enough to be effective on this band (250 feet). As one writer put it, "On the 160-meter band, a horizontal antenna compares favorably with a dummy load."

Choosing Antenna Size

The choice of which nine-band antenna system an operator should build will depend on the space available, which bands are his favorites, and what other antennas, if any, he may have. For example: If space is available and the operator already has a triband beam antenna for the 14-, 21-, and 28-MHz bands, a tuned-doublet antenna system 66 feet each side of the center is the logical choice. It provides 1.8-MHz operation when used as a top-loaded vertical. The 3.5-MHz performance is much better than a coax-fed dipole on that band. The antenna provides a gain of 1.8 dB on the 7-MHz band and a gain of nearly 3 dB on the 10-MHz band. The triband beam can take care of the 14-, 21-, and 28-MHz bands.

If the operator's favorite band is the 14-MHz band and he does not have a beam antenna, the antenna with 51 feet each side of the center is the logical choice. The gain on the 14-MHz band would be nearly 3 dB because the antenna is a long, extended double zepp on that band.

The smallest of the three antennas would be used where there is not enough space for either of the larger antennas. There is nothing sacred about the lengths of 66 feet, 51 feet, and 33 feet each side of the center. Lengths between these can be used as long as the lengths each side of the center are the same. Longer wires favor the lower frequencies. I had an antenna with 40 feet each side of the center that worked very well on the 7-, 14-, and 21-MHz bands. For anyone who wishes to maximize the performance on any particular band, the extended-double-zepp lengths each side of the center are as follows: 7 MHz = 84 feet; 10 MHz = 60 feet; 14 MHz = 44 feet; 21 MHz = 28 feet; 28 MHz = 25 feet.

Using the Tuned-Doublet Antenna System

The antenna system is connected to the transmitter as shown in Fig. 4. The transmitter's output is connected through the T-R switch (built into transceivers and most transmitters) by a short piece of coax to the input of the swr meter. The output of the swr meter is connected to the input of the antenna tuner (or transmatch) by another short piece of coax. The feedline from the antenna is connected to the balanced output of the antenna tuner.

Using low-power output from the transmitter, the antenna tuner is adjusted until the swr meter shows little or no reflected power. The transmitter is next loaded up to the desired power, and the antenna tuner's dials are "touched up" to provide minimum reflected power showing on the swr meter. With a good antenna tuner, it is usually possible to tune up so that there is practically no reflected power. After this has been done, the frequency and tuner settings should be recorded for future use. Finding the correct tuner settings for several frequencies in each amateur band takes time. However, once these frequencies and tuner settings have been recorded, the operator can quickly tune his antenna system to resonance at the desired frequencies by looking at the recorded dial settings.

Conclusions

It would be difficult, if not impossible, to design and build a coax-fed trapped antenna that would work on all nine bands. If such an antenna could be designed, it would have *loss* on each band compared to a half-wave dipole for the band being used. Besides not being very good, the cost of such an antenna would be outrageous. (A trapped antenna for *only three bands* costs in the neighborhood of $130.) Any of the three nine-band antenna systems in this article could be built for less than $50. The performance on each band would be much better than could be obtained from a nine-band coax-fed antenna, even if such could be designed and were available.

If you prefer the *best possible performance*—and don't mind a little extra—then the antenna systems described in this article are for you.

Build one of these antennas, use tuned feeders, and experience the excellent results you can obtain on all bands by using *one* well-designed antenna system. ■

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