John J. Schultz, W2EEY/1
40 Rossie Street
Mystic, Connecticut 06355

Dual-Band Use of Single-Band Beams

W2EEY describes several ways the driven element of a single-band beam can be used on a higher frequency band without affecting beam performance on the band for which the beam is designed.

With the number of sunspots rapidly growing, many amateurs want to be able to use their present antennas on a higher band. Particularly, those with a 20-meter beam with a center-fed driven element might desire to have a radiator available on 15 or 10 meters and those with a 15-meter beam to have a 10 meter capability.

The purpose of this article is to present some simple ideas on how the center-fed driven element of a beam can be converted for use as an effective radiator on a higher band without in any way affecting performance on the basic band. Only the driven element is effected; no attempt is made to convert the entire beam to a dual-band affair. Methods of making dual-band beams have been well described before and the simple conversions mentioned in this article are meant only to give capability on a higher band perhaps as a preliminary step to later erecting another beam.

Basically, all that is done is to use the half-wave driven element as a three-quarter or full-wave element on a higher band with a simplified feed system. The three-quarter and full wave dipoles have a very minor amount of gain (about 1 to 2 dB), but the directivity is enough to make rotation worthwhile. With the exception mentioned later, a 20 or 15 meter wire dipole can also be converted for use as a dual-band antenna.

As shown in **Fig. 1**, as the ratio of the diameter of a linear conductor from which an antenna is constructed increases as compared to wavelength, the characteristics of the in-

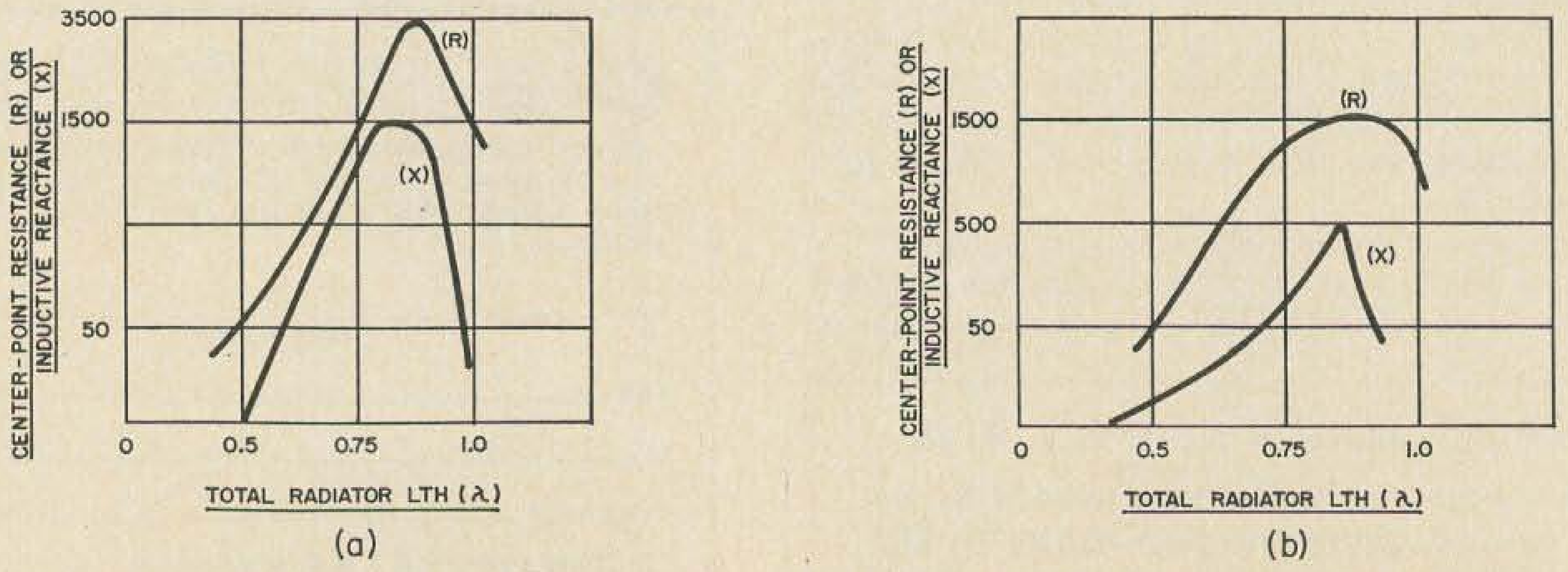

Fig. 1. The center-point impedance of a radiator for wavelength/conductor diameter ratios of λ/1000 (a) and λ/100 (b).

put impedance change. The resistive portion of the feed point impedance decreases in value and the peaks of the response broaden out. The reactive portion of the impedance decreases even more rapidly than the resistive portion and exhibits a sharper peak. There are also shifts in the exact radiator wavelength values at which the peaks occur but these are minor for the two wavelength/conductor ratios considered—λ/100 and λ/1000.

Most of the tubing used for beam construction on 20 and 15 meters will have wavelength/diameter ratios between these two extremes. Single wire antennas will have higher ratios—approximately λ/10,000 for number 14 wire. In order to utilize the dual-band feed system mentioned in this article, the ratio must be reduced by using two or more wires on each side of the dipole which are fanned out to at least a foot separation between them at the ends.

Matching a transmission line to the impedance presented at the center point of a dipole which is ½ wave long on one band and ¾ wave long on another band can be done in several ways. A double stub matching system can be used to produce an almost exact match to a transmission line on two bands but the adjustment procedure is unduly tedious, especially for the amateur who wants just occasional usage of an antenna on a higher band. The matching system actually used is a simple quarter-wave linear transmission line transformer. Such a transformer will not cancel the inductive reactance which a ¾ center fed dipole presents. It can only match a transmission line to the resistive portion of the antenna impedance. However, as the wavelength/diameter ratio becomes reasonably large, the reactive portion of the impedance comes down to a value which can be accepted by most transmitter output circuits and the SWR will be a reasonable value on the higher band.

Fig. 2 shows a 15-meter dipole which can also be used on 10 meters. Since the matching section is cut to ½ wavelength on 15 meters, the antenna terminals see exactly the same impedance as the coaxial transmission line and 15 meter performance is not changed in any manner. On 10 meters the matching section becomes approximately ¾ wave long (actually .7 λ on 28,500 kHz when cut to .5 λ on 21,000 kHz). The somewhat shortened length presents some capacitive reactance to the antenna terminals and seems to partly compensate for the inductive reactance of the ¾ λ long flat-top on ten.

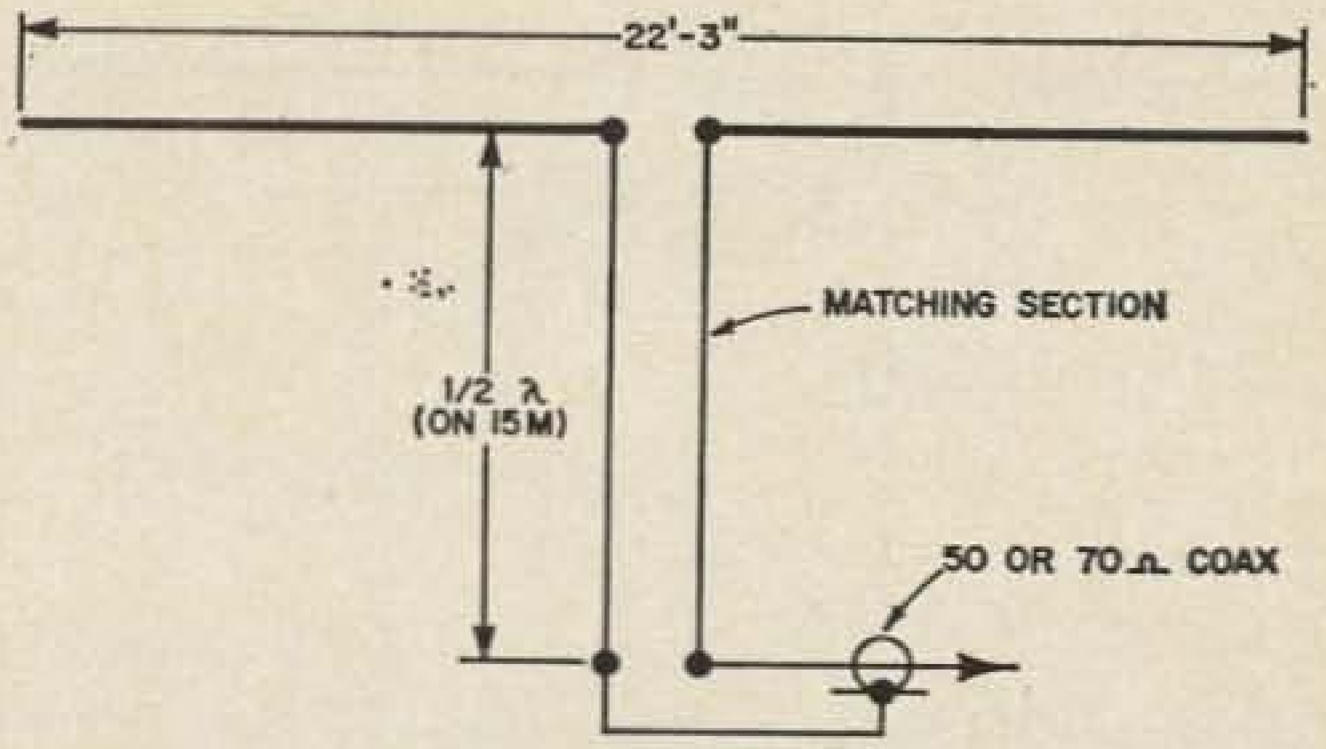

Fig. 2. A 15-meter dipole with a matching section for use on 10 meters. The impedance of the matching section depends upon the physical characteristics of the antenna as explained in the text.

The impedance of the matching section is determined from the standard formula:

$$Z = \sqrt{Z\ (\text{coax}) \times Z\ (\text{ant})}.$$

The impedance of the antenna on 10 meters can be estimated from **Fig. 1** by taking the average antenna conductor diameter to estimate the wavelength/diameter ratio. For instance, for an average diameter of one inch, a matching section of 300 ohms would be used to match the approximate 2,000 ohm input impedance. In most cases, a 150 or 300 ohm matching section will suffice for the range of impedance encountered to produce a SWR of 2 to 1 or less on the higher band. The physical length of the matching section must take into account the velocity factor of the transmission line used (for instance, a ½ λ line of 300 ohm twinlead on 15 meters would be 17′2″).

Using a 20 meter driven element on 15 meters presents almost exactly the same situation except that a ½ wave matching section on 14,000 kHz becomes almost exactly ¾ wave on 21,000 kHz and no effective com-

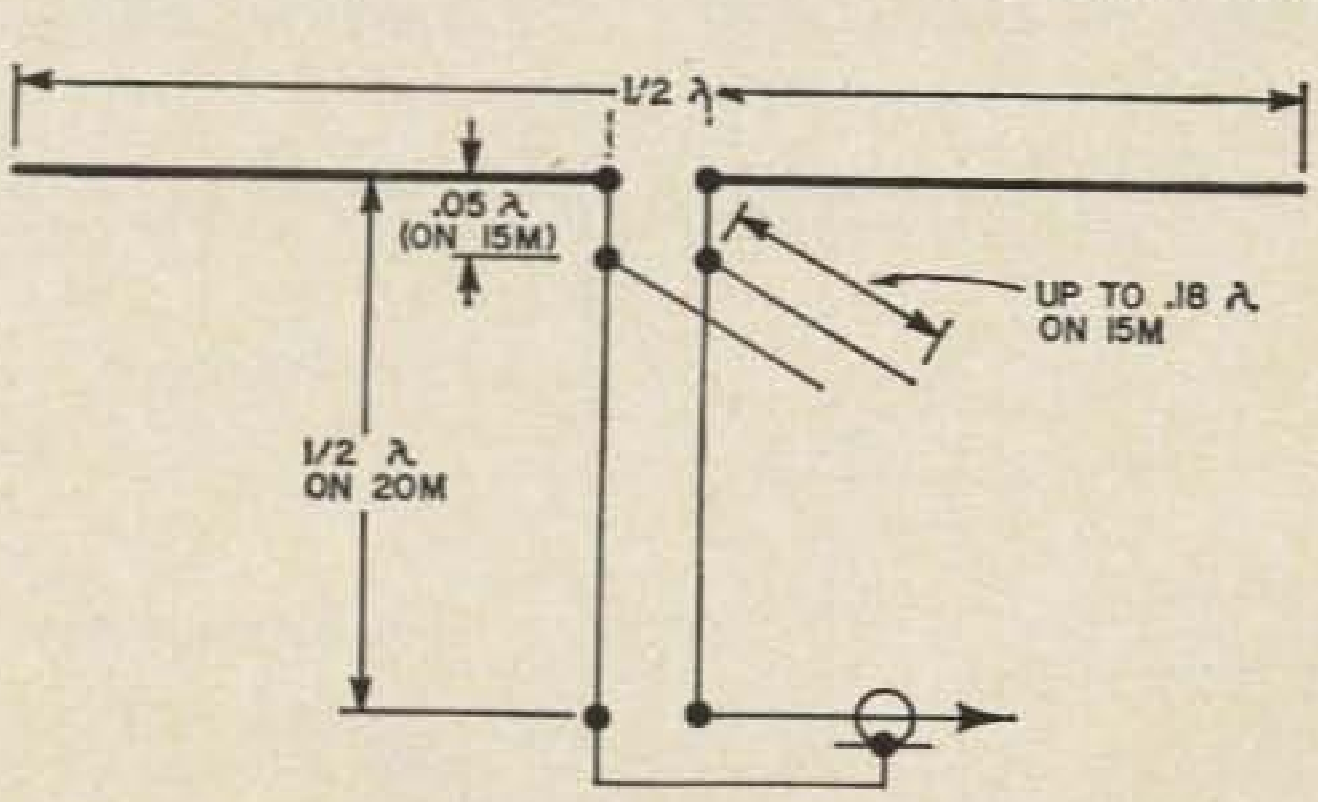

Fig. 3. The use of a 20-meter dipole on 15 meters may require the use of a small capacitive stub across the matching section.

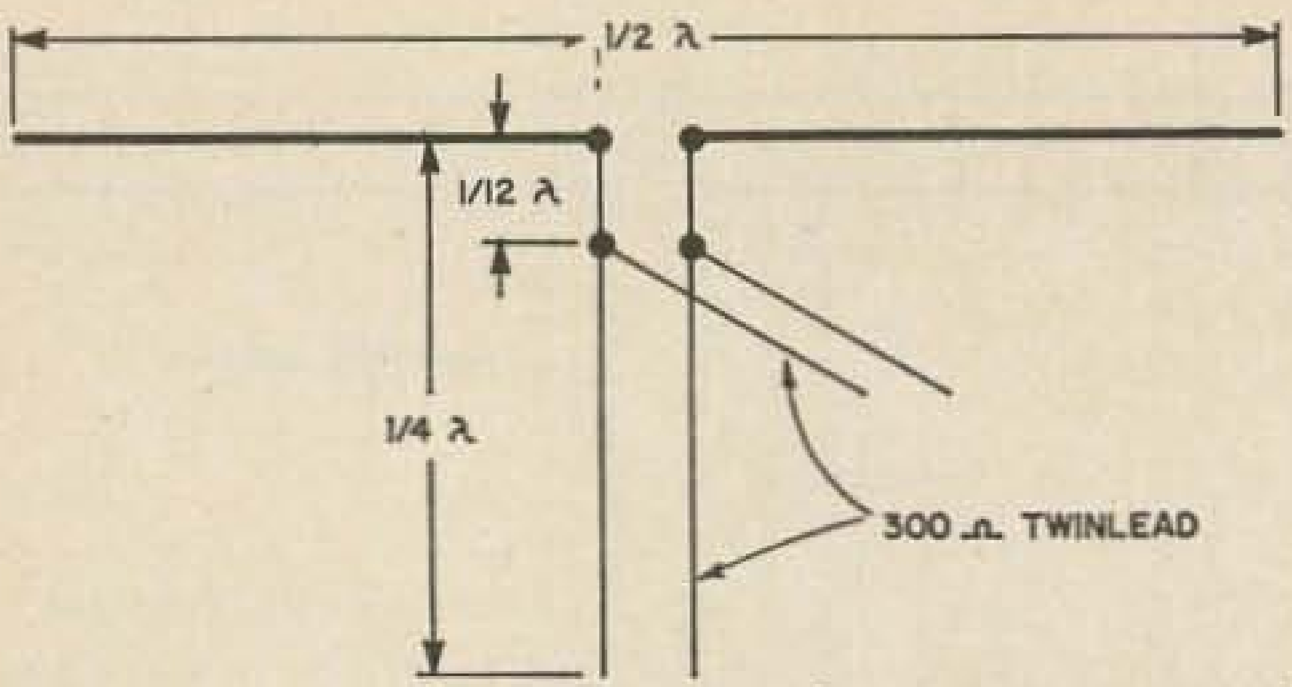

Fig. 4. Using a 20-meter dipole on 10 meters by matching with a 1/4 λ stub. The 300-ohm twinlead to the transmitter can be replaced with coaxial cable if a 4:1 wideband balun is used where the twinlead is attached to the stub.

pensation is provided for the reactive portion of the antenna impedance on 15 meters. Whether the reactance is sufficient to cause tuning difficulties depends upon the exact installation and operation of the transmitter output circuit. If difficulties are encountered, a stub of the same type line as the matching section can be added to the matching section as shown in **Fig. 3** and trimmed for proper tuning. The position of the stub is not exactly correct as shown, but will suffice in most cases where antenna operation must not be effected on the fundamental frequency.

The use of a 20 meter dipole element on 10 meters cannot be accomplished by the use of a simple through-line ½ wave transmission line transformer because of the even multiple harmonic relationship of the two bands. Again, there would be various possibilities to match the antenna to the transmission line by use of multiple stub arrangements. However, the easiest scheme is an old one from the 1930's which gained popularity as a multiband antenna matching method, long before trap antennas were popularized.

A quarter-wave open stub is connected to the center of a half-wave dipole and the transmission line is connected across the stub one third the distance along it from the antenna. If the voltage and current distributions are drawn, it will be seen that almost the same impedance is presented at the one third point for the fundamental and all even harmonic frequencies; certainly for the fundamental and second harmonic, they are the same. **Fig. 4** shows the arrangement using a 300 ohm transmission line. It should be noted that since essentially no reactance is present at the antenna terminals, the considerations regarding wavelength/conductor diameter ratio are not as important as in the previous matching methods.

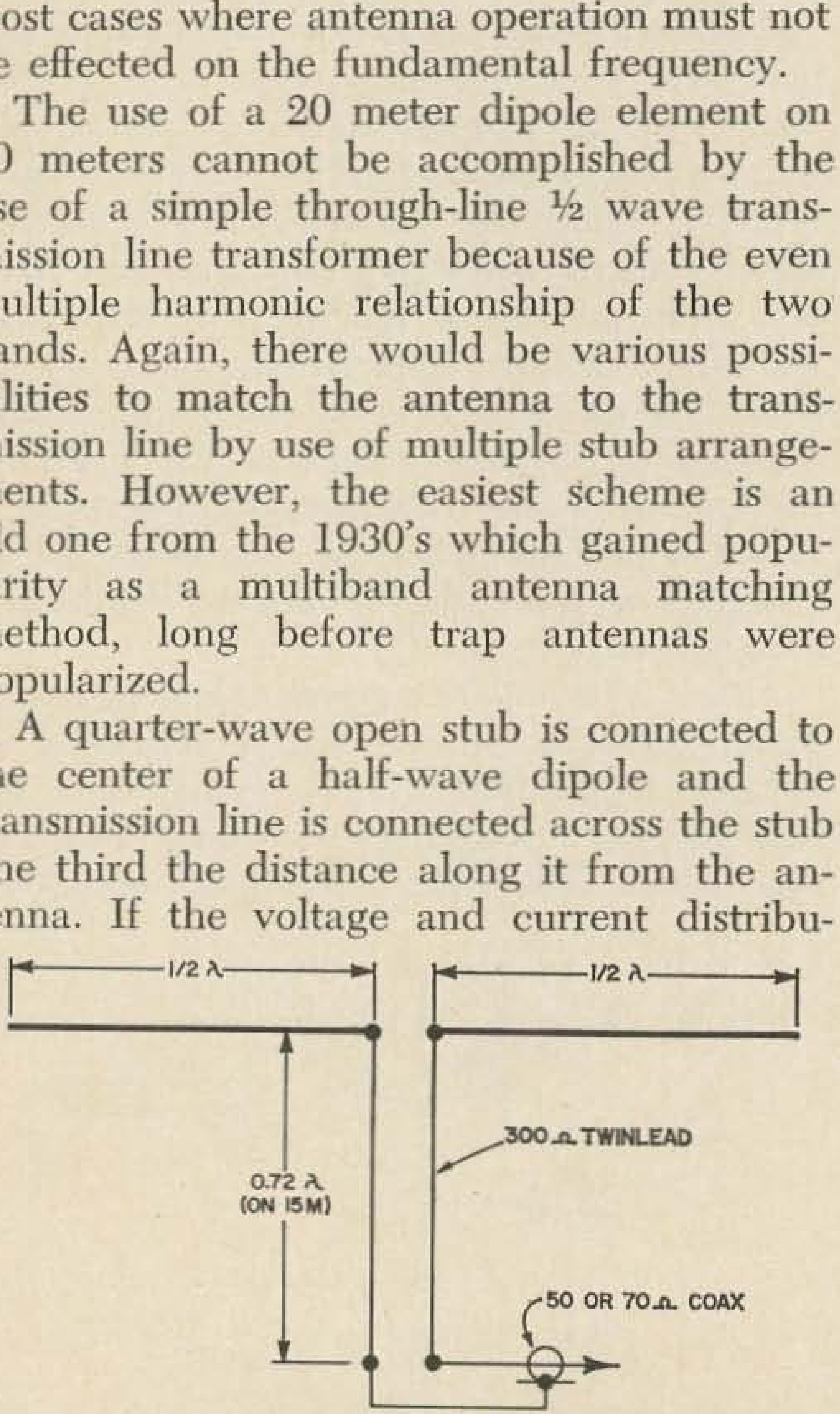

Fig. 5. A full-wave antenna for 15 meters can also be used on 10 meters if a 0.72 λ matching section is used.

A relatively simple matching system for a full-wave wire antenna for use on 15 and 10 meters can also be developed using a transmission line transformer in a fashion similar to our first scheme. **Fig. 5** shows the matching arrangement. The matching section is cut slightly shorter than ¾ wavelength on 15 meters and acts as a ¼ wave transformer to match the low coaxial cable impedance to the high center impedance of the full-wave antenna. On 10 meters, the antenna flat-top portion becomes 3/2 λ long and the matching section is essentially 1 λ long. Since the latter is a multiple of ½ λ, the low center impedance of the 3/2 λ flat-top is reflected directly to the coaxial transmission line.

It should be noted that although the ¾ λ matching section performs as a ¼ λ transformer (½ λ section which performs no impedance transformation plus a ¼ λ section which acts as the transformer), a ¼ λ matching section cannot be used directly on the 10 meter band because its length (.35 λ) would not be close enough to ½ λ to be suitable.

It should also be noted that since this antenna is 3/2 λ long on 10 meters, the horizontal radiation pattern changes from a maximum lobe broadside to the wire to a cloverleaf pattern. This is in contrast to the previously described antenna systems which produce a maximum length of 1 λ so that a collinear array of two ½ λ elements was formed and maximum radiation remained broadside to the antenna, the same as for a ½ λ dipole.

The ideas presented in this article are not really new since transmission line transformers and stubs have been used for multiband antennas since the early 1920's. However, these ideas should enable most amateurs to at least quickly and simply provide themselves with a dual-band antenna from a simple one-band dipole.

. . . W2EEY/1