This month we wrap up the series on ununs by W2FMI. In this final part the author offers 14 variations on matching 50 ohm cable, which should satisfy just about any requirement.

The Ultimate Multimatch Unun

BY JERRY SEVICK*, W2FMI

The use of the adjective "ultimate" to describe one's design can be risky business. The author assumes that the design will meet one of the most common definitions for this adjective—namely, "beyond which it is impossible to go." To many of us, the classic use of this adjective was initiated by Lew McCoy in describing his popular Transmatch.[1] Although there have been some improvements in his design, his use of this definite (and strong) adjective can be said to have withstood the test of time. I hope my use has a similar success.

Recently I described a multimatch design[2] which had five broadband ratios matching 50 ohm cable to lower impedances. In fact, two of the lower ratios worked well in matching 50 ohm cable to higher impedances. Thus, this gave seven usable applications in matching 50 ohm cable to impedances as high as 112.5 ohms and as low as 5.56 ohms. But the design[3] in this article goes well beyond this. It offers ten broadband ratios, four of which work quite well in either direction! Therefore, this design offers 14 applications in matching 50 ohm cable to impedances as high as 112.5 ohms and as low as 3.125 ohms.

This achievement, however, comes at a price called *difficulty*. It uses a quadrifilar winding on the smallest feasible ferrite toroid in order to minimize the standing waves by using the shortest possible transmission lines. The 5-ratio unun used a trifilar winding which was considerably easier to wind. Furthermore, the 10-ratio unun has two of its windings tapped, while the 5-ratio unun had only one.

If you have had little experience in winding ununs or baluns, then a simplified version should be attempted first. This version would eliminate the tapping of the two windings, resulting in the following five broadband ratios matching 50 ohm cable to lower impedances: 1.78:1. 2.25:1, 4:1, 9:1, and 16:1. In fact, the 1.78:1 and 2.25:1 ratios can be used (quite successfully) in matching 50 ohm cable up to 89 ohms and 112.5 ohms.

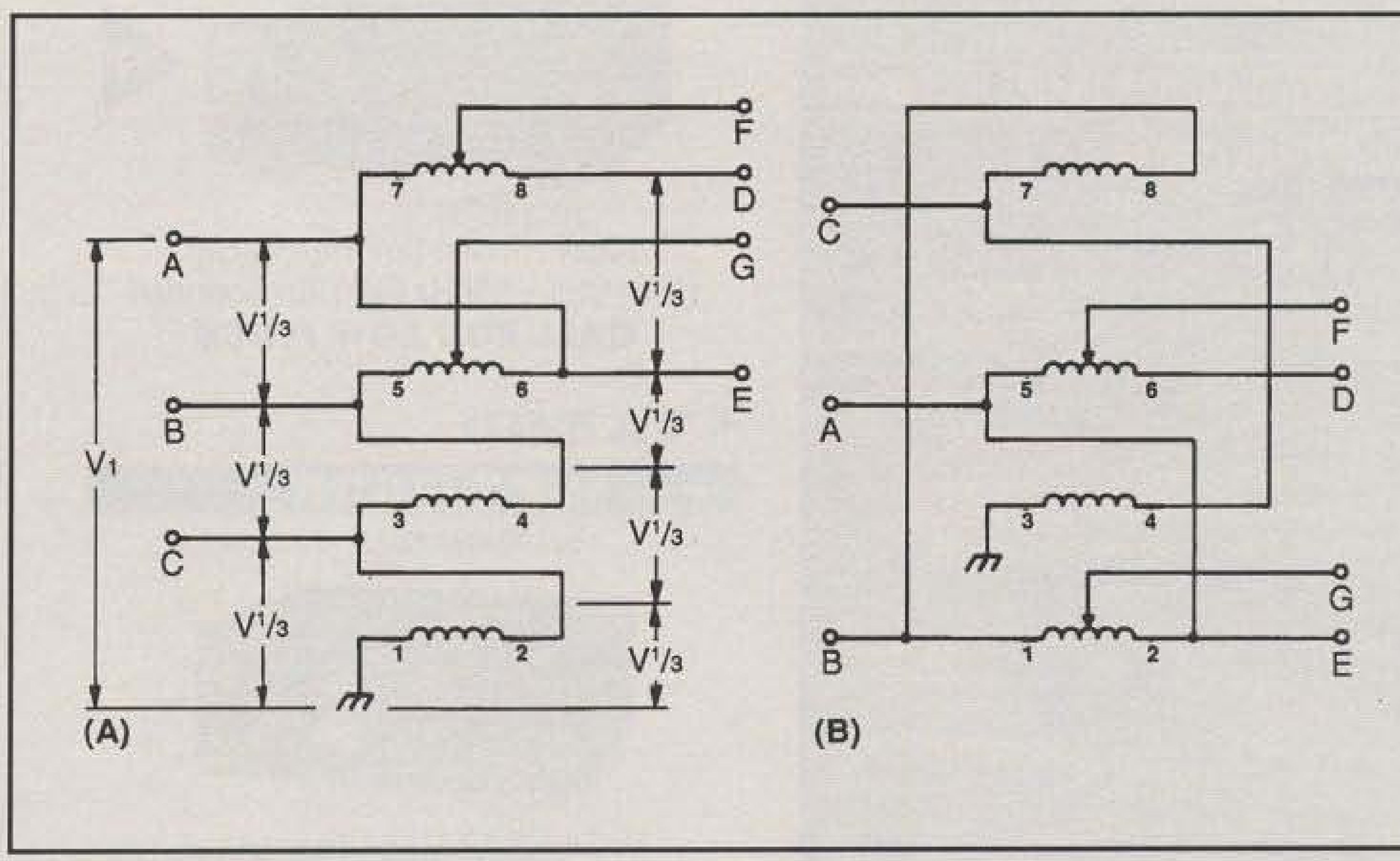

Fig. 1– Circuit diagrams for the 10-ratio unun: (A) diagram for analysis; (B) transposed windings for best overall performance.

Again, for those interested in the design considerations of this broadband multimatch unun, a brief review is presented in the first section. The second section presents a high-power design capable of handling the full legal limit of amateur radio power. The third, and the last, section includes a low-power design capable of handling the output of any HF transceiver.

Finally, I would like to conclude this introduction by referring to another popular application of the adjective *ultimate*. It is "to come to an end." This article presents the sixth, and quite likely my last, in the series on ununs. I think I have covered most of the important

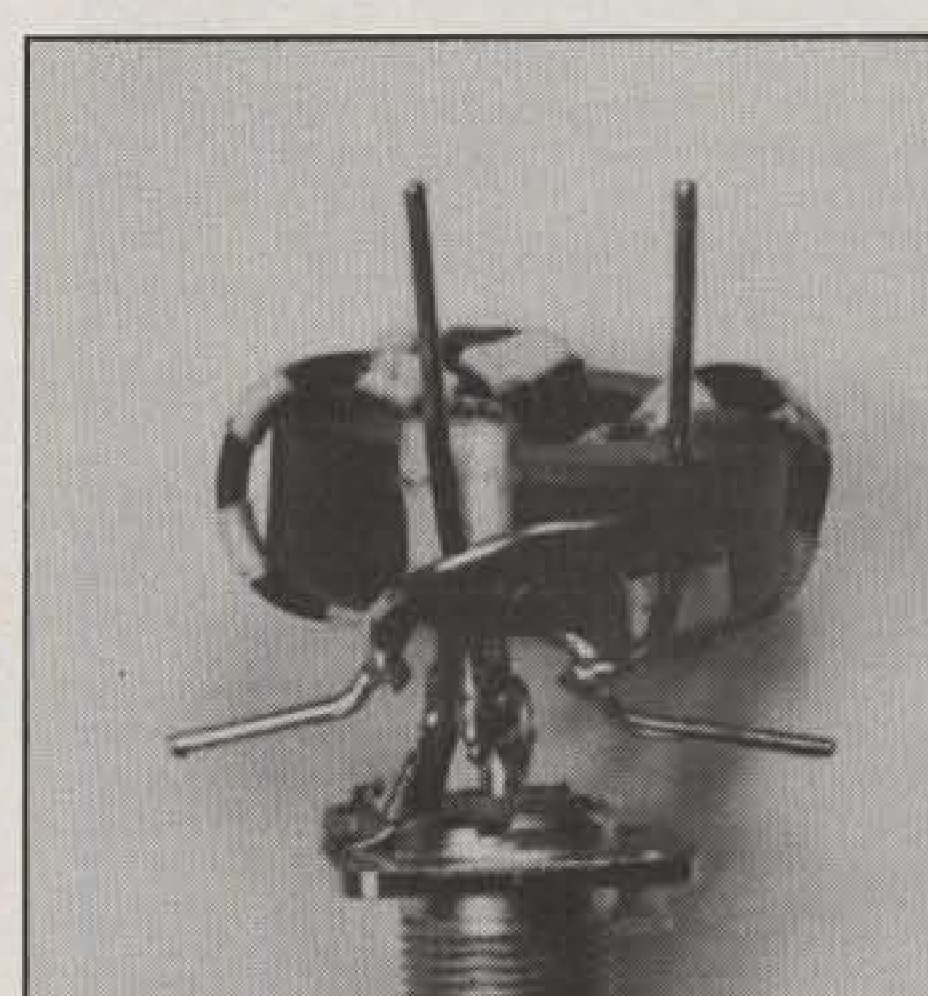

Photo A– Bottom view of the 10-ratio unun. The connector is on terminal A.

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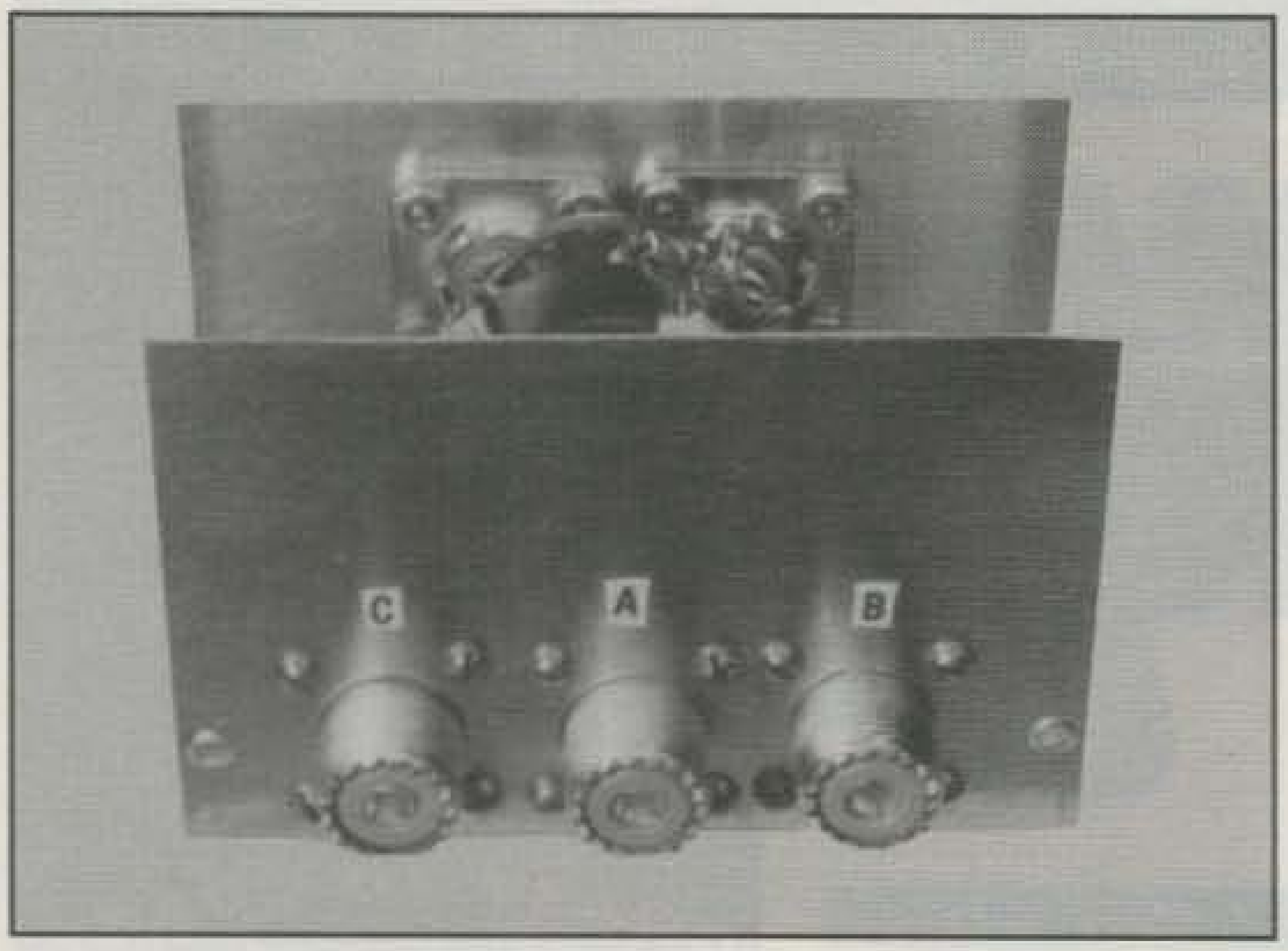
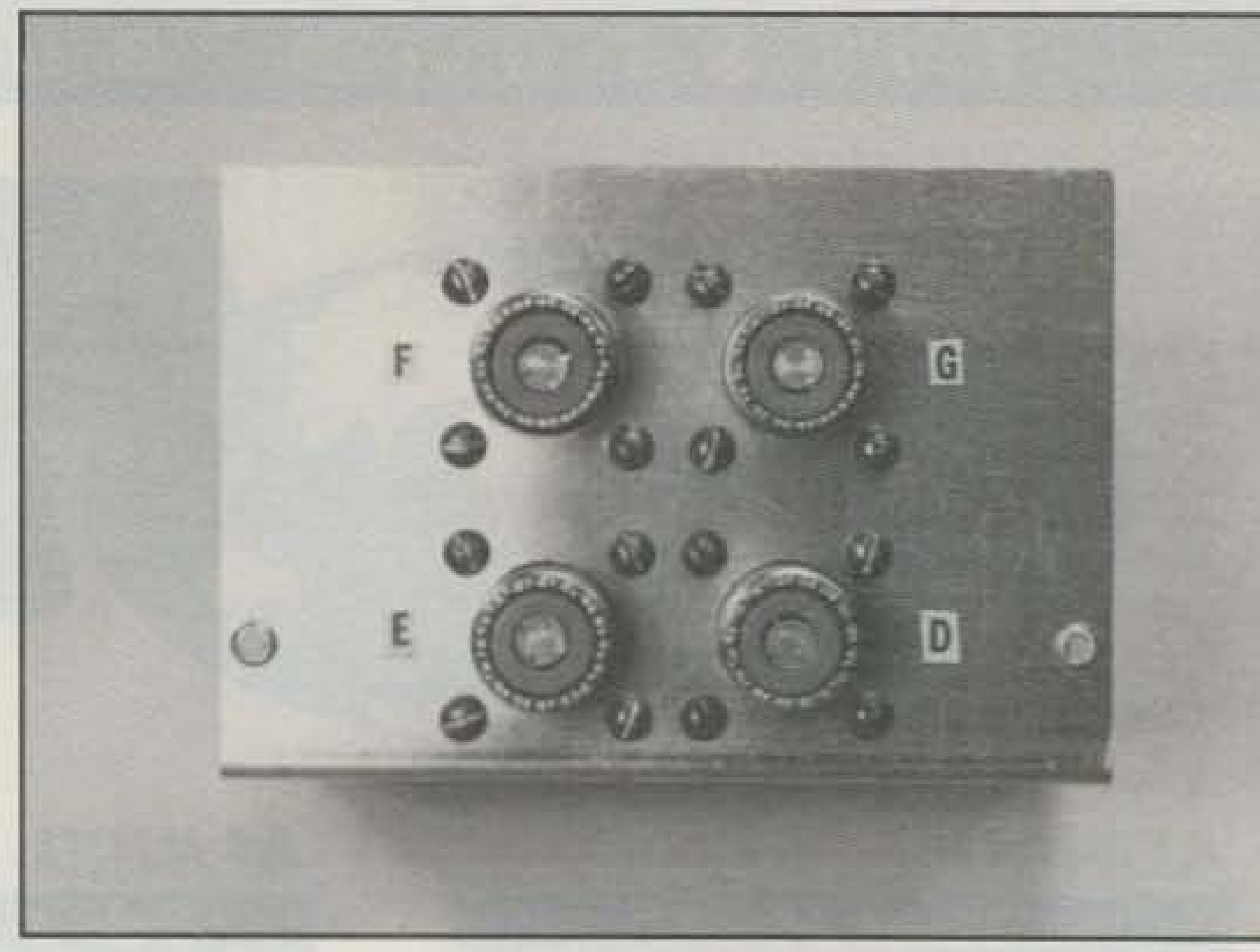
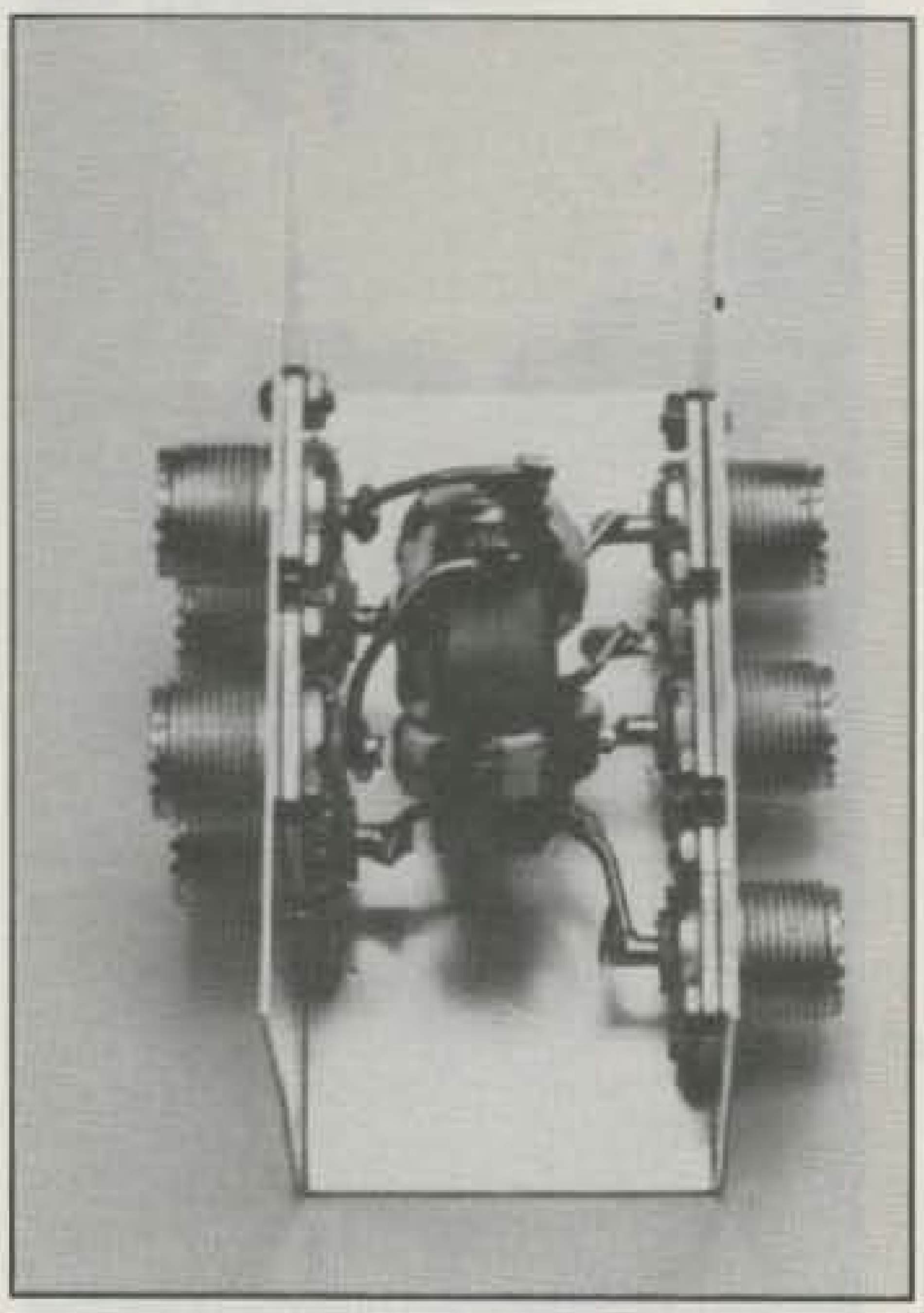




Photos B– Three different views of the 10-ratio unun mounted in a 4"L × 2"W × 2.75"H CU-3015A minibox.



applications for amateur radio use. If not, I would entertain any suggestions.

The Circuit

Fig. 1(A) is presented here because it is the easiest form of a quadrifilar-wound unun to explain. With the input voltage, V/1\, connected to the various terminals on the left (the low-impedance side), and with very short transmission lines compared to the wavelength, we have the following transformation ratios:

1. V_1 connected to terminal A
 a) At terminal D the output voltage V_o is $4/3V_1$. Therefore, the transformation ratio, g, with connection A–D is

$$g = (4/3)^2 = 1{:}1.78 \qquad (1)$$

 b) At terminal F the output voltage is

$$V_o = V_1(1 + n/3N) \qquad (2)$$

where N = total number of turns and n = number of turns from terminal 7.

The transformation ratio with connection A–F then becomes

$$g = (V_o/V_1)^2 = (1 + n/3N)^2 \qquad (3)$$

2. V_1 connected to terminal B
 a) At terminal E the output voltage is $3/2V_1$. Thus, the transformation ratio with connection B–E is

$$g = (3/2)^2 = 1{:}2.25 \qquad (4)$$

 b) At terminal G the output voltage is

$$V_o = V_1(1 + n/2N) \qquad (5)$$

where n = number of turns from terminal 5.

The transformation ratio with connection B–G becomes

$$g = (V_o/V_1)^2 = (1 + n/2N)^2 \qquad (6)$$

 c) At terminal D the output voltage is $2V_1$. The transformation ratio with connection B–D is

$$g = (2)^2 = 1{:}4 \qquad (7)$$

 d) At terminal F the output voltage is

$$V_o = V_1\,(3/2 + n/2N) \qquad (8)$$

where n = number of turns from terminal 7.

The transformation ratio with connection B–F then is

$$g = (V_o/V_1)^2 = (3/2 + n/2N) \qquad (9)$$

3. V_1 connected to terminal C
 a) At terminal E the output voltage is $3V_1$. The transformation ratio with connection C–E becomes

$$g = (3)^2 = 1{:}9 \qquad (10)$$

 b) At terminal G the output voltage is

$$V_o = V_1(2 + n/N) \qquad (11)$$

where n = number of turns from terminal 5.

The transformation ratio with connection C–G is

$$g = (V_o/V_1)^2 = (2 + n/N)^2 \qquad (12)$$

 c) At terminal D the output voltage is $4V_1$. The transformation with connection C–D becomes

$$g = (4)^2 = 1{:}16 \qquad (13)$$

 d) At terminal F the output voltage is

$$V_o = V_1(3 + n/N) \qquad (14)$$

where n = number of turns from terminal 7.

The transformation ratio with connection C–F is

$$g = (V_o/V_1)^2 = (3 + n/N)^2 \qquad (15)$$

A High-Power 10-Ratio Unun

After several attempts at rearranging the windings of fig. 1(A) for best overall performance (optimizing the effective characteristic impedances of the windings), fig. 1(B) evolved. Photo A shows the bottom view of an unmounted unun using the circuit of fig. 1(B). The top-left

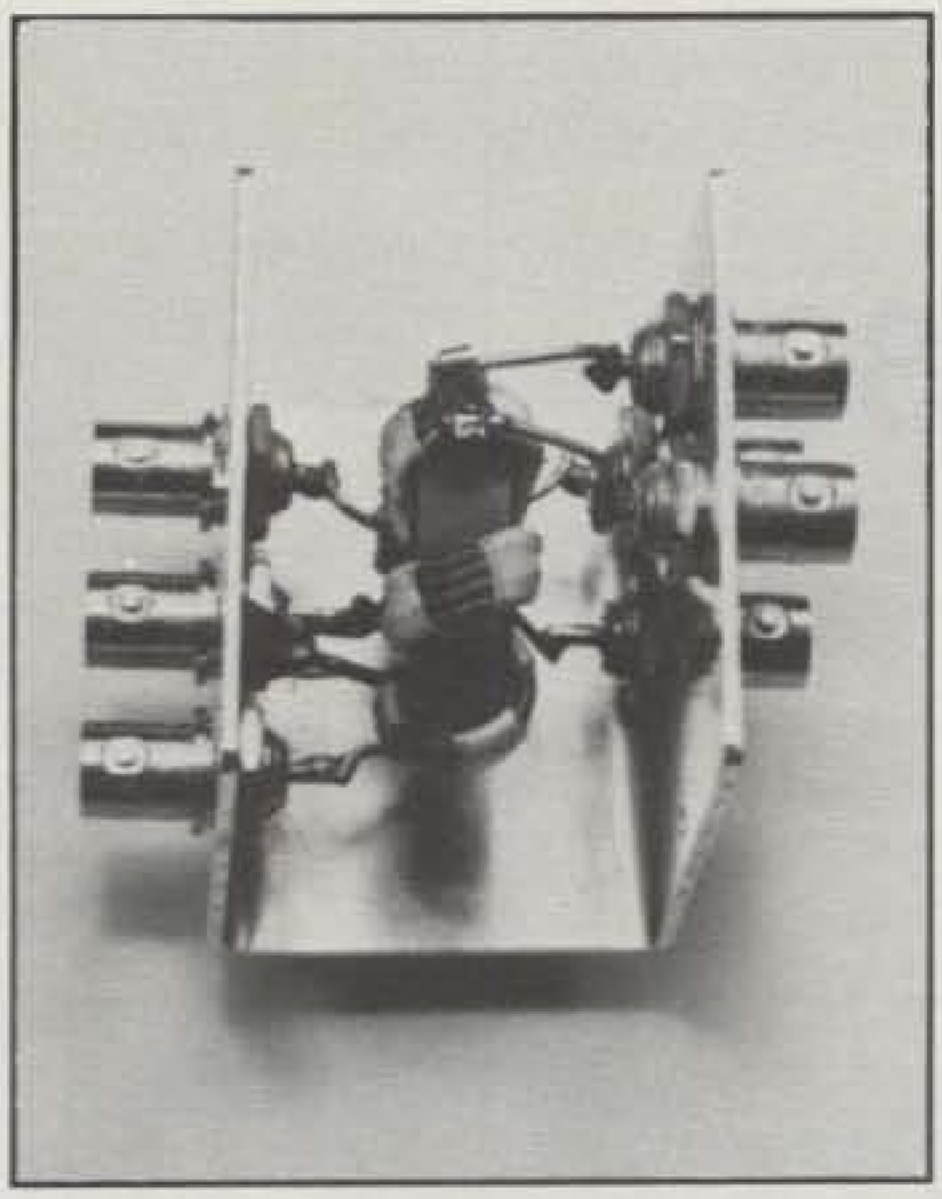


Photo C– The low-power 10-ratio unun mounted in a homemade 2.25"L × 1.5"W 2.25"H minibox.

lead is terminal E. The top-right lead is terminal D. The bottom-left lead is terminal B. The center lead (connected to the SO-239 connector) is terminal A.

The bottom-right lead is terminal C. Below these three leads is a ground connection (terminal 3 in fig. 1[B]) to the SO-239 connector. Photo B shows three different views of this high-power unit mounted in a 4"L × 2"W × 2.75"H CU-3015A minibox.

This 10-ratio unun has four quadrifilar turns of No. 14 H Thermaleze wire on a 1.5 inch OD ferrite toroid with a permeability of 250. Winding 5–6 is tapped at 2 turns from terminal 5 and winding 7–8 is tapped at 2 turns from terminal 7.

If the 9:1 ratio (connection C–E), the 12.25:1 ratio (connection C–F), and the 16:1 ratio (connection C–D) are to be used at the full legal limit of amateur radio power, then it is suggested that winding 3–4 be replaced with No. 12 H Thermaleze wire. If not, then these three ratios should be used at lower power levels (of 500 watts continuous and 1 kW peak). It should also be mentioned that using No. 12 wire for winding 3–4 adds some more difficulty in the construction process.

A listing of the expected performance across the band from 1.7 MHz to 30 MHz, with the various ratios, is as follows:

16:1 (D–C); 50:3.125 ohms
Ratio is constant up to 21 MHz. It then decreases by 15 percent.
12.25:1 (F–C); 50:4.08 ohms
Ratio is constant.
9:1 (E–C); 50:5.56 ohms
Ratio increases by 5 percent.
6.25:1 (G–C); 50:8 ohms
Ratio is constant.
4:1 (D–B); 50:12.5 ohms
Ratio decreases by 5 percent.
3.06:1 (F–B); 50:16.3 ohms
Ratio decreases by 10 percent.
2.25:1
a) (E–B); 50:22.22 ohms
Ratio increases by 4 percent.
b) (B–E); 50:112.5 ohms
Ratio increases by 50 percent (the greatest deviation across the band of any of the ratios).
1.78:1
a) (D–A); 50:28.1 ohms.
Ratio is constant.
b) (A–D); 50:89 ohms.
Ratio increases by 15 percent.
1.56:1
a) (G–B); 50:32 ohms
Ratio increases by 10 percent.
b) (B-G); 50:78 ohms
Ratio increases by 40 percent.
1.36:1
a) (F–A); 50:36.8 ohms
Ratio decreases by 9 percent.
b) (A–F); 50:68 ohms
Ratio increases by 1.5 percent.

A Low-Power 10-Ratio Unun

Photo C shows a low-power unit mounted in a home-made 2.25"L × 1.5"W × 2.25"H minibox. It has five quadrifilar turns of No. 16 H Thermaleze wire on a 1.25 inch OD ferrite toroid with a permeability of 250. The tap on winding 5–6 (fig. 1[B]) is at three turns from terminal 5, and on winding 1–2 it is three turns from terminal 1. Since the number of turns is different from the high-power unit, so are the ratios which use the taps. In this case they are a little larger. Specifically, the tapped ratios are now as follows: 1:12.96, 1:6.76, 1:3.24, 1:1.69, and 1:1.44. If the taps were at two turns from terminals 5 and 1, the ratios would be a little less than those of the high-power unit. You can play with the equations in the first section in this article and arrive at many different ratios.

Since this unun has shorter transmission lines than its high-power counterpart, the deviations of the ratios across the HF band are generally less. Also, if winding 3–4 (in fig. 1[B]) were replaced with No. 14 H Thermaleze wire, this low-power unit could well be rated at 500 watts of continuous power for all ratios!

References

1. Lew McCoy, W1ICP, "The Ultimate Transmatch," *QST*, July 1970, pp. 24–27, 58.

2. Jerry Sevick, W2FMI, "A Multimatch Unun," *CQ*, April 1993, pp. 28–30.

3. Kits and finished units are available from Amidon Associates, Inc., 2216 East Gladwick Street, Dominguez Hills, CA 90220.

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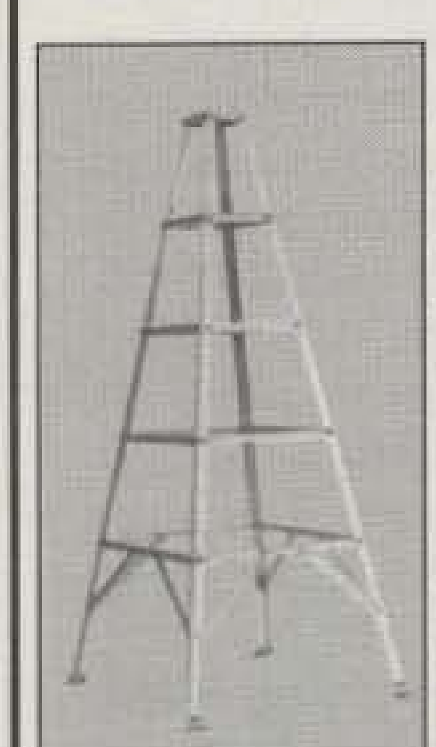

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