The SPC Transmatch

Improved performance for 20 through 10 meters.

by L. B. Cebik W4RNL

With the abundance of reasonably priced commercial transmatches and an equally large number of articles on inexpensive home-brew units, there seems little that anyone could add to antenna tuner ideas. Little, that is, unless you use an all-band wire antenna. Then the limitations of commercial and general ham designs begin to show up. On 10 meters, one of the capacitors runs out of minimum capacitance a shade before the SWR drops to 1:1. The coil matches only as it hits the stop. Converting the 10:1 SWR to 50 ohms for the transmitter seems to exceed the unit's abilities, even though it performs well on every other band.

If you only wish to flatten a 2:1 or 3:1 SWR, you may never encounter these problems on any band. However, center-fed Zepp and variations on the G5RV antennas can present the transmatch with complex combinations of resistance and reactance. With enough reactance at the transmatch, normal all-band components and construction may provide a poor match at 10, 12 and 15 meters.

The problem is with the all-band design concept. My commercial transmatch covers 160 to 10 meters, with a 36 µH inductor and a pair of 240 pF air variables in a standard T circuit. This is all enclosed in a case allowing a half-inch space between the components and the chassis or case metal. Although the tuner is compact and versatile, the high-value components have high minimum values as well. The capacitors are rated at 40 pF minimum, which looks more like 45 or 50 pF with the case closed. Minimum inductance is not listed for the rotary inductor, but between 1 and 2 µH would be a good guess, especially with its 2½-inch external lead to ground.

Transmatch Performance

The standard T circuit (with series capacitors and a shunt coil) is a high-pass filter. It does little to suppress harmonic energy. The SPC circuit (as W1FB calls it), shown for comparison with the T in Figure 1, is claimed to provide an estimated 20 dB of harmonic suppression. Of course, we will only achieve the rated selectivity if we can maintain a high-loaded circuit Q. Normally, stray capacitance and inductance are low Q. Some designs use an additional fixed coil just for 10 meters, sacrificing variability for higher Q. In my commercial tuner, on 10 meters, most of the circuit capacitance and inductance come from stray sources in the wiring or the component construction. Just converting its design to the SPC circuit would not achieve much, but the conversion would lengthen the 14-inch long unit by another 10 inches by replacing the single-section capacitor with a split-stator version.

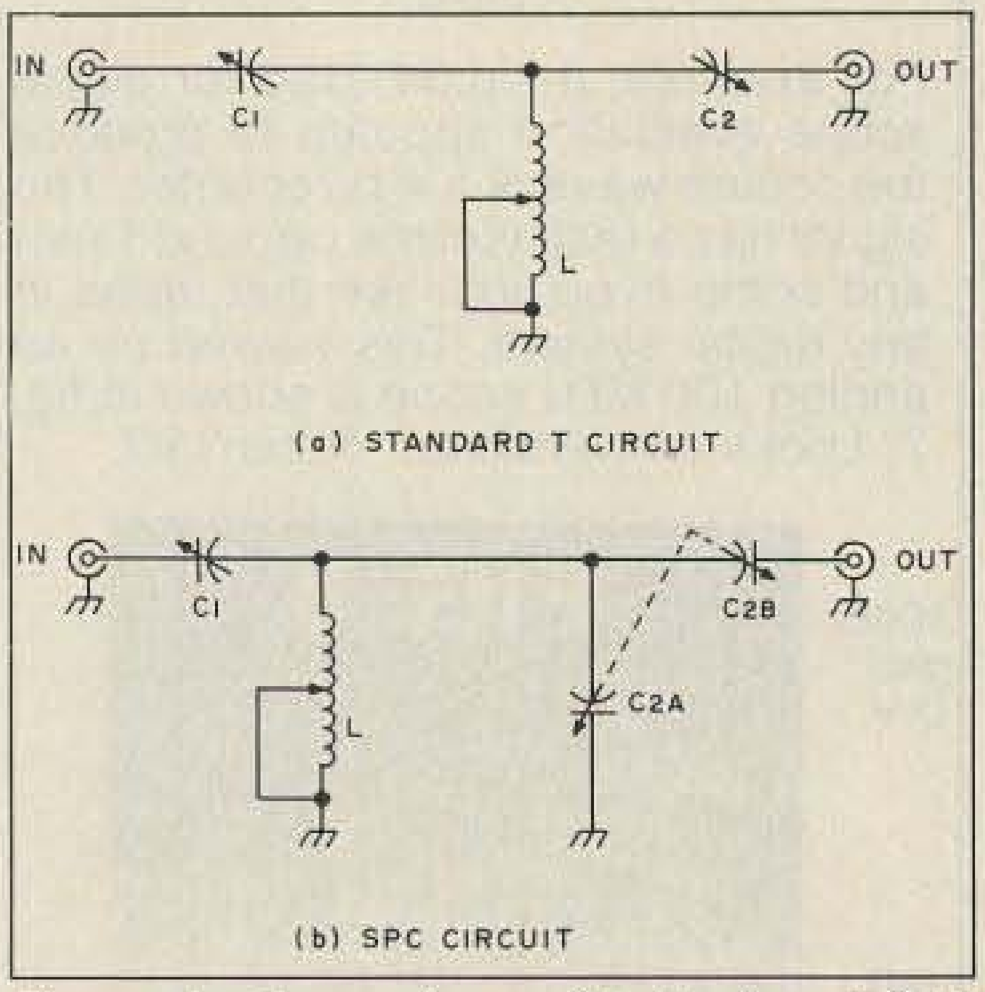

Figure 1. Comparison of T (1 a) and SPC (1 b) transmatch circuits.

Nonetheless, I consider my commercial unit a good tuner of its kind. To solve the problem of achieving high Q, high capability 10 meter matching, we may have to give up the idea of an all-band design. A 20-through-10 meter design to cover the "upper" HF bands offers a much better chance for nearly optimal performance. However, we can achieve that performance only if we remember all the hints various writers have given about component selection, layout, and materials. Since so many commercial and ham designs seem to have forgotten some of these tips, perhaps I should offer a few words about transmatches, even if only to jog the memory.

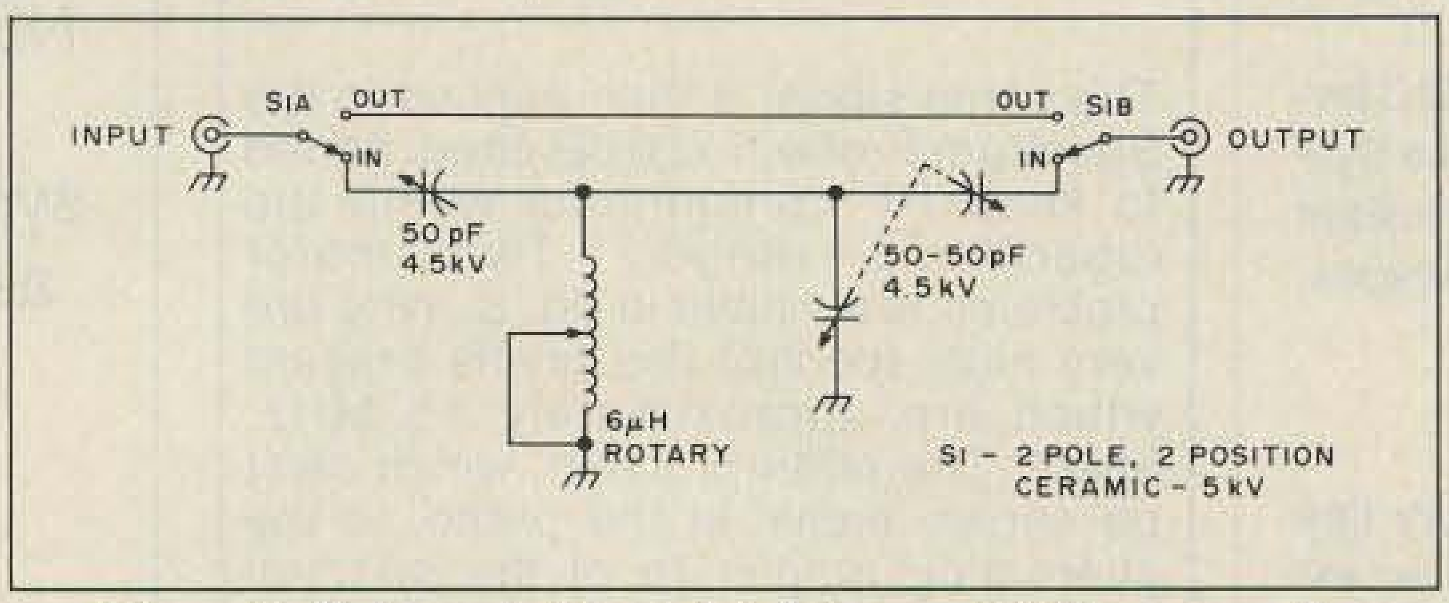

Figure 2. Schematic for the 20–10 meter SPC transmatch.

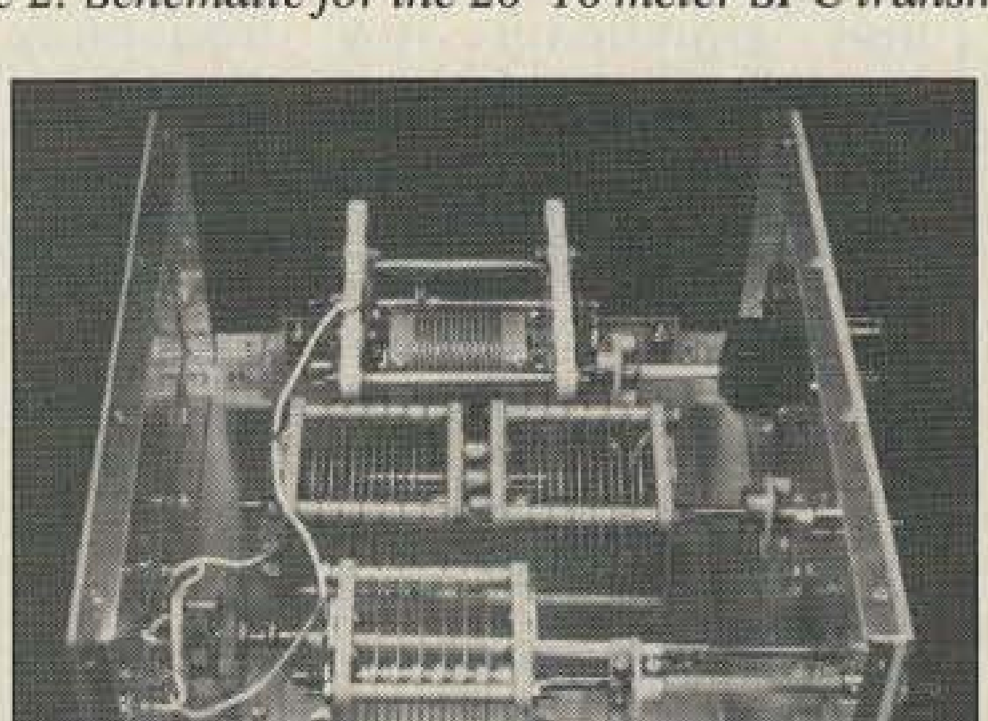

Photo A. Interior view of the 20–10 meter SPC transmatch.

Component Values and Construction

The first step to achieving better 10-meter performance while not losing all versatility in the transmatch was to scale down components for assured coverage from 20 through 10 meters. 50 pF capacitors with a 5 µH coil would provide more than enough range for 20 meters. They would also maximize chances for low enough minimum values to perform well on 10. The SPC circuit requires one single-section capacitor, one split-stator capacitor, and a rotary inductor for infinite tuning choices.

Among the best transmatch capacitors on the new and surplus market are a series of Johnson (now produced by Cardwell) 4.5k volt units. For high-power use, I prefer these units with 0.125-inch plate spacing to units with 0.075-inch or 2-mm spacing. The

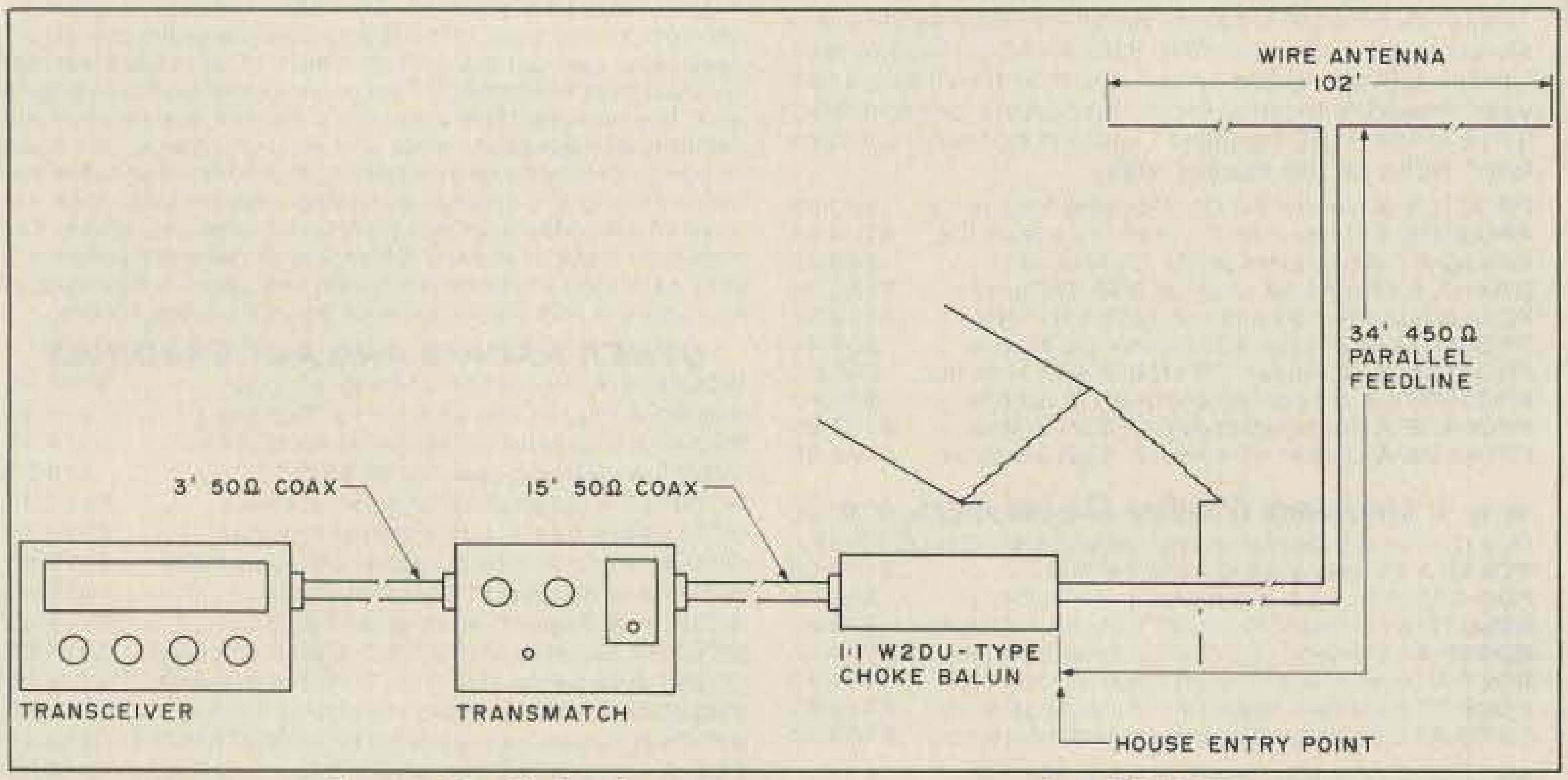

Figure 3. All-band wire antenna system used at W4RNL.

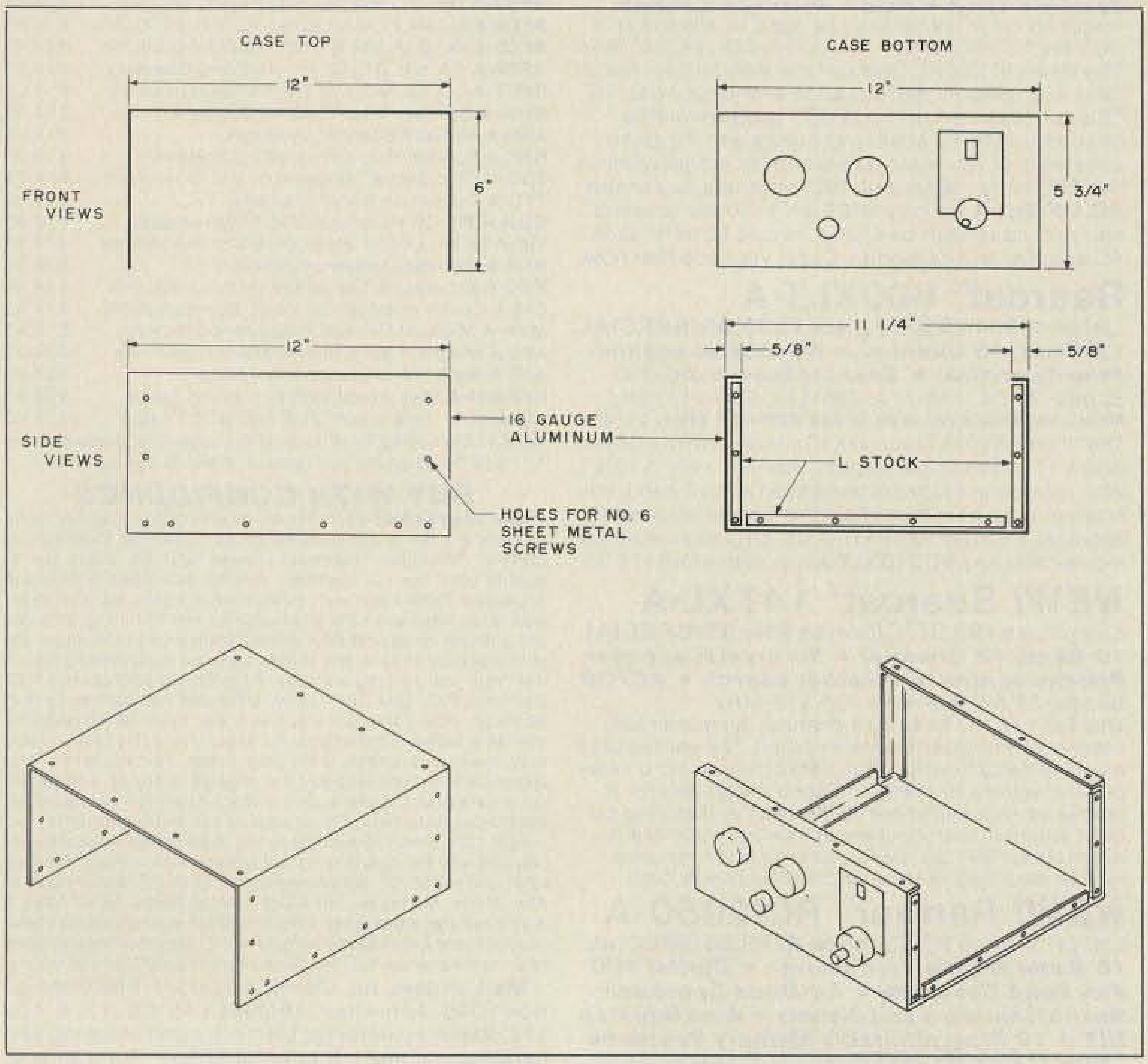

Figure 4. Simple 2-piece aluminum transmatch case.

present 154-12 unit is equivalent to the 1950s 50E45, while the 154-508 split-stator model is the old 50ED45. Both units have 52 to 53 pF as their maximum values and 10 to 11 pF as minimum values. Capacitance meter measurements confirmed the figures. New units cost above $35 and $60, respectively, but you may be able to find good quality units of either model at hamfests.

What gives these units their low minimum values is the use of trapezoid end plates presenting the least capacitance to stator plates. Until RF-rated acrylic end-plate units become generally available in a variety of values, the Johnson-Cardwell units are among the best high-power units around. A British firm (Nevada Communications) has introduced 250 pF, 2-mm plate spacing units that have minimum values of 13 pF per section. Millen 16000-series (e.g., the 16550 and 16100) capacitors (now distributed by Caywood) are also promising if you must purchase new units. These 6 kV, 0.171-inch air gap units will handle any amateur power. They cost slightly more than new Johnsons. Their minimum values are barely higher than the Johnson units. (At hamfests, be careful with old battleship capacitors, i.e. units heavily framed in metal. One of my 35 pF maximum units only goes down to 17 pF minimum. It may be useful for something, but not for this transmatch.)

For the rotary inductor, I had to settle for something a bit larger than 5 μH. The same Knoxville hamfest that provided the two needed capacitors (through the sharp eyes of my friend, KA4SAL, who got them for only $5 each) also produced an old military antenna tuner coil. It probably came from a TN-339 military tuner, which is similar to the BC-939. Fair Radio Sales has recently listed the 339 at $125 used and the coil at about $16. Measurements on the inductor with a grid dip meter yielded about 0.6 to 6.5 μH from one end to the other.

The inductor appears to be like the current B & W 3851, which lists new in the $80 range. Ceramics may have improved since WWII. The physical size of the end plates and

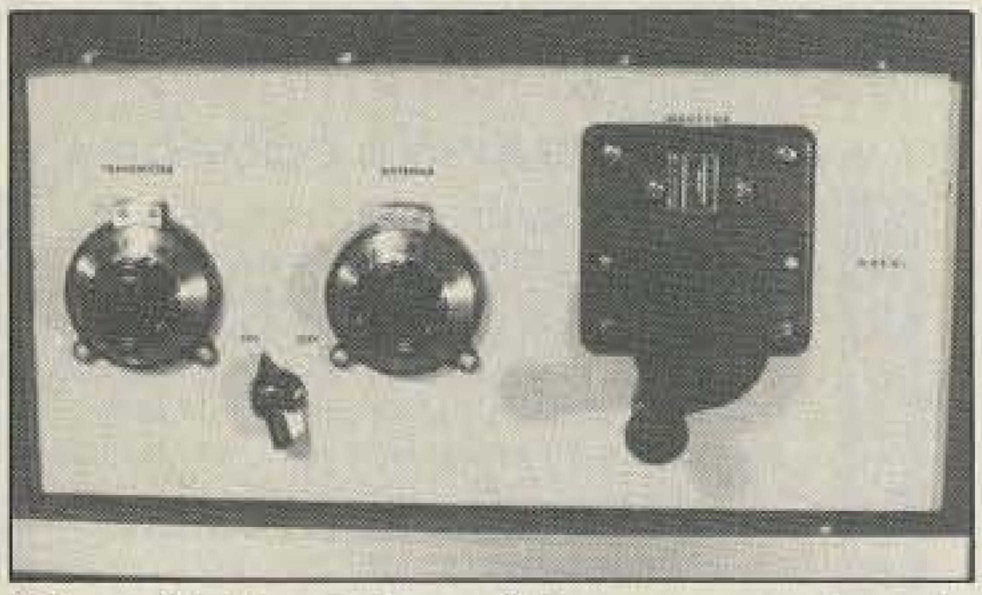

Photo B. Panel view of the transmatch at the W4RNL operating position.

braces is greater than planned, with outside dimensions of about 3" x 5" x 6". However, the range of the roughly 2" diameter, 2" long, 12-turn rotary inductor inside the frame is just about right. The #12 tinned copper wire is sized for high power.

The use of ceramic rather than metal end plates helps to reduce stray capacitance between coil turns and ground. In fact, none of the metal bars between end plates will be grounded. Every source of stray capacitance will be minimized. As with capacitors, RF-rated acrylic-supported rotary inductors are beginning to appear. Again, Nevada has introduced a 30 μH coil with a minimum inductance of about 1 μH. Properly designed, only these types of units will surpass the ceramic unit in minimum inductance value and in potential circuit strays. For the $5 price, the surplus ceramic inductor is quite adequate.

Transmatch Construction

To minimize stray inductance and capacitance, the transmatch uses the simplest possible design. (See Figure 2.) It contains no SWR circuit, since there is already one in the line. The one concession to convenience is an "in-out" switch, a ceramic unit capable of handling fairly high power. Having a ham dad (W1BUK) with a good junk box helped here.

The circuit also contains no balun transformer. My particular antenna system makes one unnecessary, as Figure 3 demonstrates. The 102-foot antenna uses 34 feet of 450 ohm parallel feeder to reach the side of the house. However, that is about 15 feet from the equipment. Using a home-brew version of the W2DU choke-style balun (not a transformer), I convert directly to coaxial cable at the house entry. Radio Works sells a choke balun of similar design. My calculations suggest that, at the highest SWR levels, I can lose no more than 1 dB of pow-

Parts List

1	50-50 pF dual section, 4.5 kV air variable capacitor (Johnson 154-508 or equivalent)
1	50 pF, 4.5 kV air variable capacitor (Johnson 154-12 or equivalent)
1	5 to 6 µH rotary inductor (B&W 3851 or equivalent)
1	2-pole, 2-position, 5 kV ceramic rotary switch
1	Turns counting dial for inductor (B&W 3902 "Cyclometer" or equivalent)
2	6:1 vernier dials for capacitors
3	Insulated flexible couplings for capacitors and inductor
4	Insulated shaft extensions for capacitors, inductor, and switch
1	Through-panel shaft for switch
1	Switch knob
2	SO-238 panel mounted coax receptacles
1	11" x 12" x 5¾" case or materials for case
	Miscellaneous paint, lettering, hardware

Suppliers of Transmatch Parts

Barker and Williamson, 10 Canal Street, Bristol PA 19007 (Inductors, turns counters.)

Caywood Electronics, Inc., P.O. Drawer U, Malden MA 02148-0921 (Millen capacitors and other components.)

Fair Radio Sales, P.O. Box 1105, 1016 E. Euraka Street, Lima OH 45802 (Surplus parts and equipment.)

Kilo-Tec, Box 1001, Oak View CA 93022 (Nevada acrylic-supported variable capacitors and inductors, B & W components, and antenna supplies.)

Nevada Communications, Telecomms, 189 London Road, North End, Portsmouth, Hants., PO2 9AE, United Kingdom (Acrylic-supported variable capacitors and inductors.)

Radiokit, P.O. Box 973, Pelham NH 03076 (Variable capacitors, inductors, dials, turns counters, insulators, switches, etc.)

Radio Works, Box 6159, Portsmouth VA 23703 (Baluns, antennas, feedline.)

er at 10 meters. However, I gain freedom from all the unbalancing effects of metal conduit and other house fixtures. Hence, I do not radiate indoors. The system works well for me, however controversial the ideas behind it.

The photograph shows the essential elements of transmatch construction. The capacitors and the inductor mount on an acrylic plate. Within the limits of component size, wiring is as short and direct as possible. The front-panel end of the inductor, the same end of the coil-contact bar, and the grounded stator section connect together with short leads of #14 silver-plated Teflon™-insulated wire from an old project. The ground terminal is actually a threaded metal spacer the same length as the base plate corner supports (one inch). The rear inductor contact bar terminal also goes to a spacer. The cabinet provides the ground points. Use a lock washer with the machine screws to ensure good screw-to-case contacts.

Everything, including the switch, mounts on the base plate. Scrap acrylic provides blocks for the capacitors and a mounting plate for the switch. Ultimately, only the four corner-mounting bolts and the two ground spacer-lugs will make contact with the cabinet.

The acrylic base plate is about 11" x 7". Insulated shaft couplings and shaft extensions, plus the switch at the rear of the plate, enlarge the space requirements. Therefore, the unit requires a cabinet about 12" wide, 5¾" high, and 11¼" inches front-to-back. Figure 4 shows an idealized cabinet made from two 12" x 24" pieces of 16-gauge aluminum. The result is a shadow cabinet with a wide front lip and a quarter-inch side overlap.

More important than appearance is the fact that the cabinet provides at least one inch or more of clearance in every direction from the transmatch components. As noted, my commercial unit uses only about a half-inch of clearance, but requires extensive readjustment on the upper HF bands between open and closed cabinet use. Additional clearance makes the home-brew panel larger than the commercial one, but that is not much of a price to pay for lower strays.

Since I did not have access to the ideal 16-gauge aluminum, I used thinner utility aluminum from a home improvement center. Again, the photograph of the interior shows the additional material used to strengthen the sheet stock. L-stock, ½" x ½" x 1/16" thick, forms a ring around the front and rear panels, which have an extra 5¾" x 12" sheet to strengthen the panels. The bottom of the cabinet has 1" wide by 1/16" thick strips running from front to back. They carry the cabinet feet and the corner-mounting bolts from the base plate. Four short strips of ⅛" thick strap lock the feet and longer strap to the L-stock at the front panel. More L-stock along the sides of the cabinet bottom provides a place for sheet-metal screws to hold the top.

The front panel capacitor knobs are Japanese verniers available from several sources. (Verniers are necessary with the sharp tuning of the SPC design.) The inductor turns counter costs nearly $60 new or about $25 at some hamfests. To save me money, W1BUK came to the rescue again. Dismantling an old beat-up counter from his junk box allowed me to clean the counter face and the hardware, paint the bezel, clean and grease the gears, and replace the metal shaft with a plastic one. A large combination crank-knob finished the rejuvenation. The switch required only a panel through-shaft and an insulated extension to the switch shaft itself.

The rear panel has only two coax receptacles. Each is mounted to provide a short lead to the switch. After fitting and drilling and trial mounting all components, disassemble everything for painting. Several thin coats of spray paint, a little rub-on lettering, and several thin coats of clear acrylic complete the job. Before painting, place small pieces of tape over the two bottom holes for the screws that connect the base-plate ground point spacers to the case. The unpainted aluminum will provide a surer ground contact.

The Results

The results were everything I had hoped for. A serious test engineer would caution that, without extensive laboratory tests, we cannot specify precisely the effect of each effort to improve performance. However, the combination works. Striving for the lowest component minimum values, reducing wiring strays, and reducing cabinet strays produces a transmatch that has spare capability at 10 meters.

Although we cannot directly compare an SPC design with a standard T design, the new unit has more than a half-turn of coil and 15 percent of capacitor left in the "worst" case at the top of 10 meters. Settings for other bands fall into just about predictable positions. The amount of required readjustment between lid-on and lid-off operation is insignificant. The band-pass characteristic of the design shows up in the ability to make initial settings by listening to receiver noise. Only minor peaking is necessary to null the SWR. All settings are repeatable. In short, the transmatch does everything I asked of it.

And a bit more. As an added bonus, the unit matches my wire antenna on both 30 and 40 meters, as well as on the higher bands. Because the SPC design provides greater harmonic reduction than the standard T design, the commercial unit is now labeled for 80 and 160 meters only.

The lesson is that "all-band" is not always best. Designing a transmatch with 10 meters in mind, and sacrificing the lowest bands, resulted in superior performance where I needed it. Even new, the capacitors and coil would cost less than the 240 pF and 36 µH units used in low-band tuners. Of course, only luck, family, and friends kept the total cost of this project well under $50. But with a little patience, you can be that lucky, too. 73

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