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DOUG'S DESK

CONSTRUCTION PROJECTS, TECHNIQUES, AND THEORY

VHF Transmatch Design

Why would anyone want to build an antenna tuner for VHF? After all, commercial verticals and beam antennas are designed to provide a 50 ohm feed impedance, which means they should be suitable for use with 50 ohm coaxial cable, sans a tuner. Indeed, this is the situation, so why a tuner? Those who experiment with VHF antennas often use low-loss open-wire line for feeding these antennas. This requires an LC network that provides a match between 50 ohms (unbalanced) and 300 or 450 ohm balanced feed lines. Some amateurs still may prefer open-wire balanced feeders in the interest of reducing transmission-line loss, especially when long runs of feed line are necessary.

Another advantage realized when using a tuner or Transmatch is the additional harmonic attenuation that is provided by the usually high-Q, parallel-resonant LC circuit. RFI and TVI can be minimized substantially by using a quality tuner at 6 or 2 meters. Those who use high power at VHF are especially prone to experiencing problems because of harmonic energy. A typical parallel-resonant tuner can add 25 dB or greater harmonic attenuation if the circuit Q_L (loaded Q) is 15 or higher.

Unbalanced VHF matching networks have also been used with coaxial feeders to ensure an SWR of 1 across an entire VHF band. Modern VHF transceivers have built-in protection circuits that limit the output power when the SWR rises above a specified level (typically above 2:1). A tuner will enable the transmitter to deliver full output power if there should be an SWR problem. This article describes various LC matching networks that you can adopt or experiment with.

Some Basic Circuits

Three examples of VHF matching networks are provided in fig. 1. Circuits A and B have been used for decades at HF and MF for antenna matching. Regardless of the LC configuration adopted, these circuits have many names. Terms such as Transmatch, antenna coupler, antenna tuner, and ATU (antenna tuning unit) are common today. The fundamental purpose of a tuner is to cancel existing X_L (inductive reactance) or X_C (capacitive reactance) that may be present at the transmitter end of the feed line. These and other networks have been used at the antenna feed point, especially at VHF and UHF, over the years to minimize feed-line losses caused by SWR. In this example alone we have a true "antenna tuner," although in some situations (depending upon the antenna system used) a tuner at the transmitter end of the line can also be considered an antenna tuner. A discussion about that application is beyond the intent of this article.

Circuit A in fig. 1 shows a matching network for balanced feeders. The feed line is tapped toward the center of L2 to ensure that adjustment of C1 and C2 results in an SWR of 1. The classical E. F. Johnson Matchboxes contained this type of circuit.

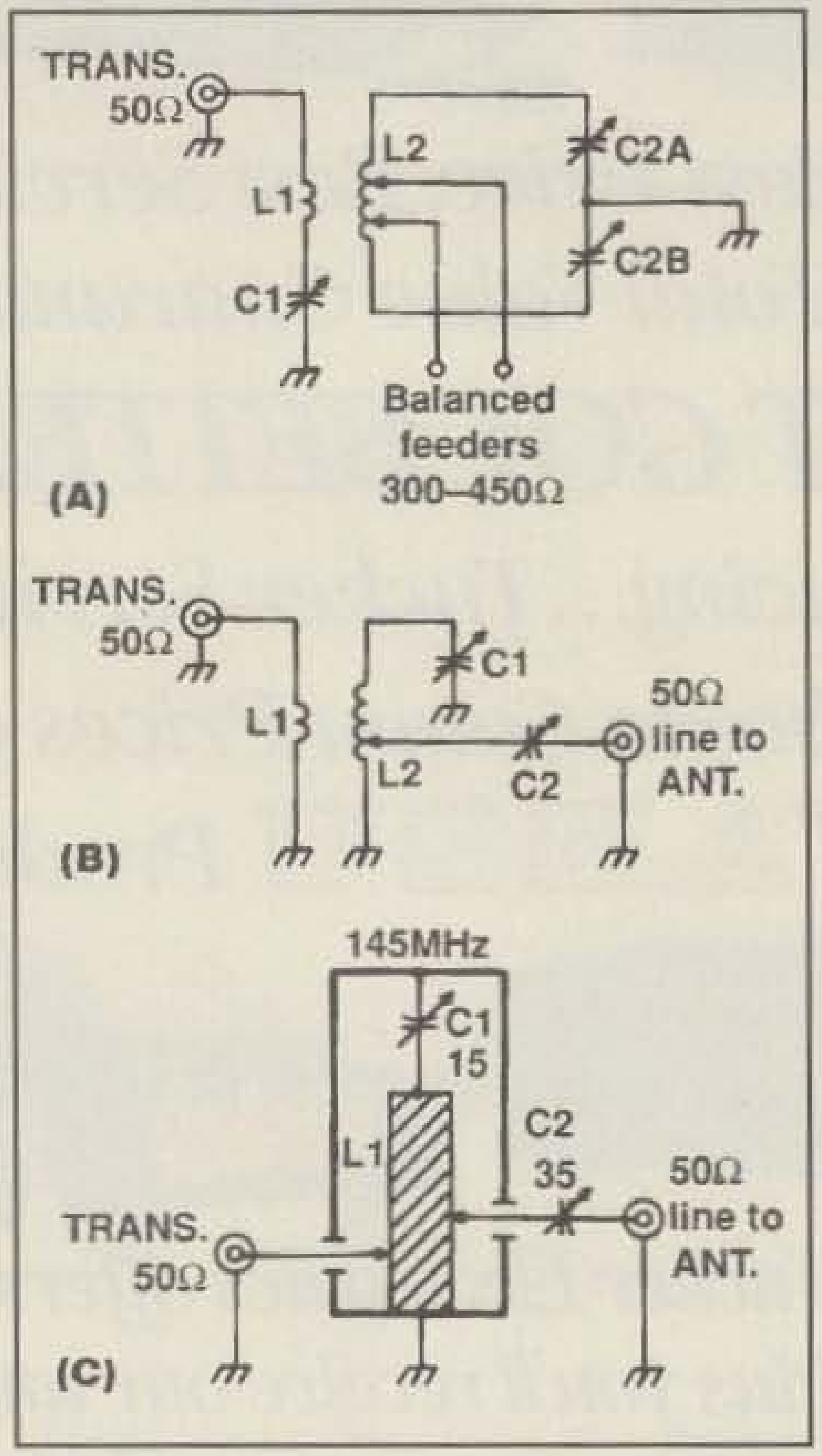

Fig. 1– Examples of matching networks that are suitable for use at VHF. Circuit A is for use with balanced feeders such as open-wire line. The arrangement at B may be used with coaxial feed lines, or between an exciter and a linear amplifier. A strip-line type of unbalanced tuner is shown at C. For 144 MHz use L1, which is a 9 inch length of 5/8-inch OD copper tubing (see text). The input and output taps on L1 are chosen experimentally to provide a wide matching range. C1 may be a small variable capacitor for low-power operation. A two-plate adjustable disc type of capacitor would be more suitable for high-power operation.

Example B in fig. 1 illustrates an unbalanced matching network for use in coaxial transmission lines. It is suitable also for matching the transmitter to an end-fed wire antenna. It may be used at the base of a 1/4-wavelength vertical antenna to ensure a match to 50 or 75 ohm coaxial line. The tap on L2 is chosen experimentally to arrive at the best point for matching a wide range of impedances.

Circuit C in fig. 1 may be employed at VHF and UHF to avoid the complications that can accompany the use of a lumped inductance for the tuner coil. L1 can be a flat strip line or a tubular conductor. Taps are placed near the grounded end of the inductor to ensure a wide matching range. This circuit is preferable for high-power operation because it allows the use of conductors with greater surface area (skin effect), and hence less heating and loss will occur. C1 (15 pF for 144 MHz) would be a large, adjustable two-plate disc capacitor. This would provide sufficiently wide plate spacing for high power. C2 can be a conventional tuning capacitor with moderate plate spacing, since at 1000 watts there would be a maximum of 224 RMS volts developed across a 50 ohm load. C1 and L1 of fig. 1(C) should be housed in a rectangular nonferrous metal box with 2 1/2 inch sides if L1 is a 5/8" × 9" copper tube for 2 meter operation. A wide strip line would require a larger box.

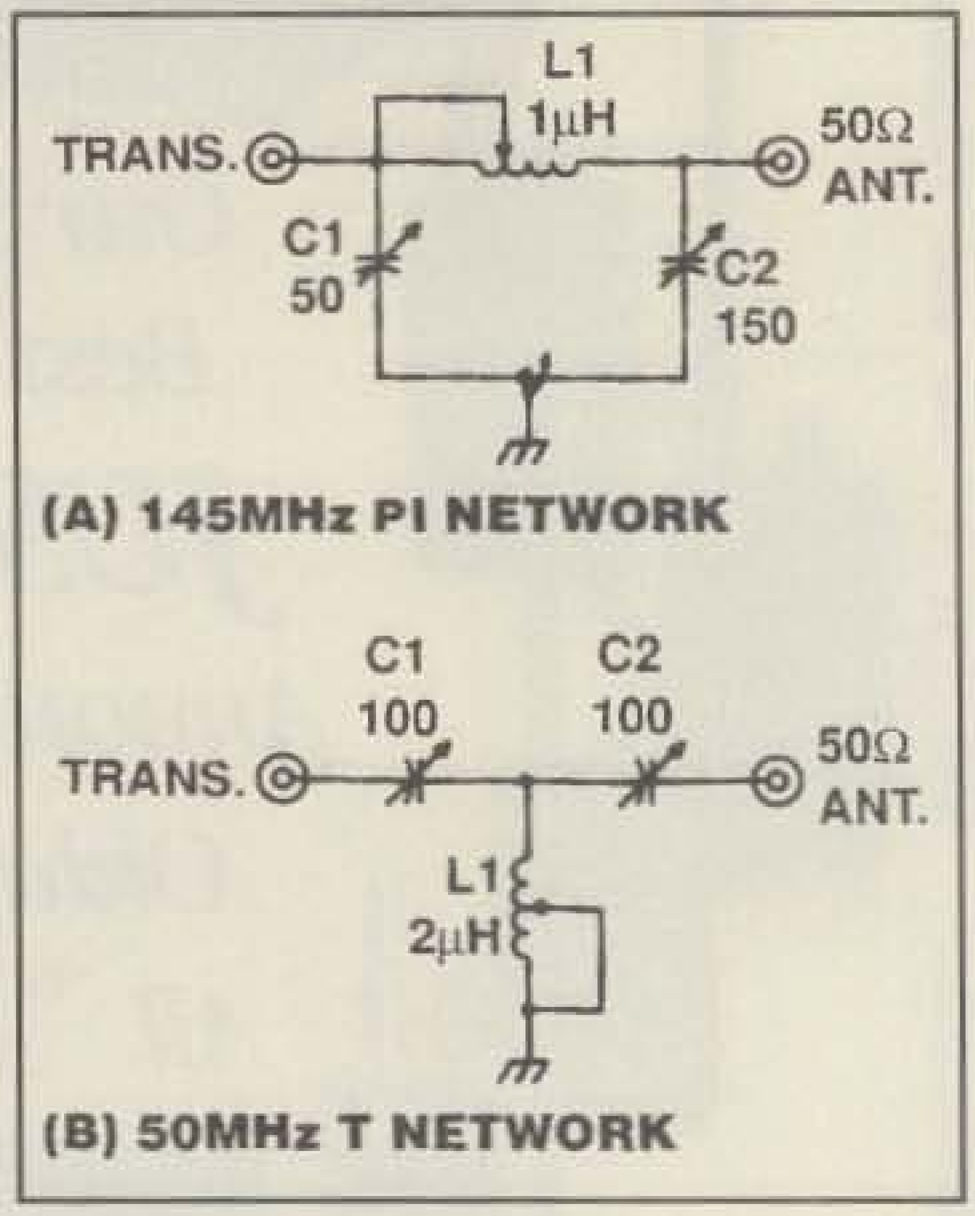

Fig. 2– Examples of pi and T matching networks (see text). Use L2 and L4 dimensions from fig. 3. Add or subtract turns as needed.

Circuits A and B in fig. 1 should have large conductors for the L2 coils in order to maintain a high Q and minimize heating and losses. No. 12 copper wire or 1/8 inch copper tubing is suitable for VHF powers up to 100 watts. Silver plating of L2 will aid conductivity and increase the Q; likewise for L1 in fig. 1(C).

Circuits B and C of fig. 1 may have additional functions as matching networks between VHF transmitters and linear amplifiers. These impedance matchers will ensure an SWR of 1, while attenuating harmonics before they reach the amplifier. In all of the fig. 1 examples it is essential to use a VHF SWR meter between the transmitter and the feed line to monitor the matching adjustments.

Pi and T Networks at VHF

Unbalanced matching networks for VHF can be fashioned along the lines of the familiar pi and T

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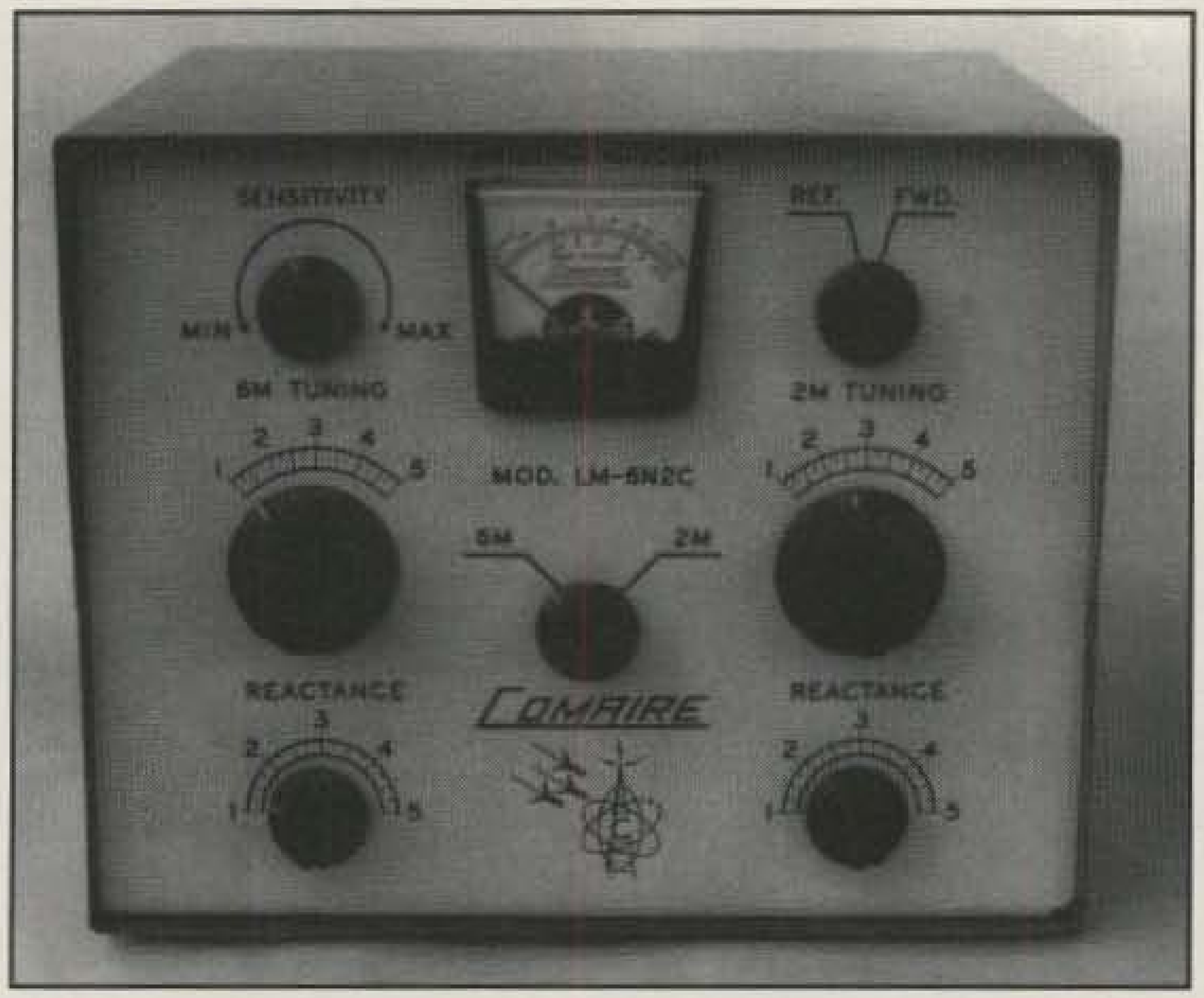

Photo A– The Comaire Electronics commercial 6 and 2 meter tuner designed and built by W1FB in the early 1960s. The line was discotinued in 1965. (See text for details.)

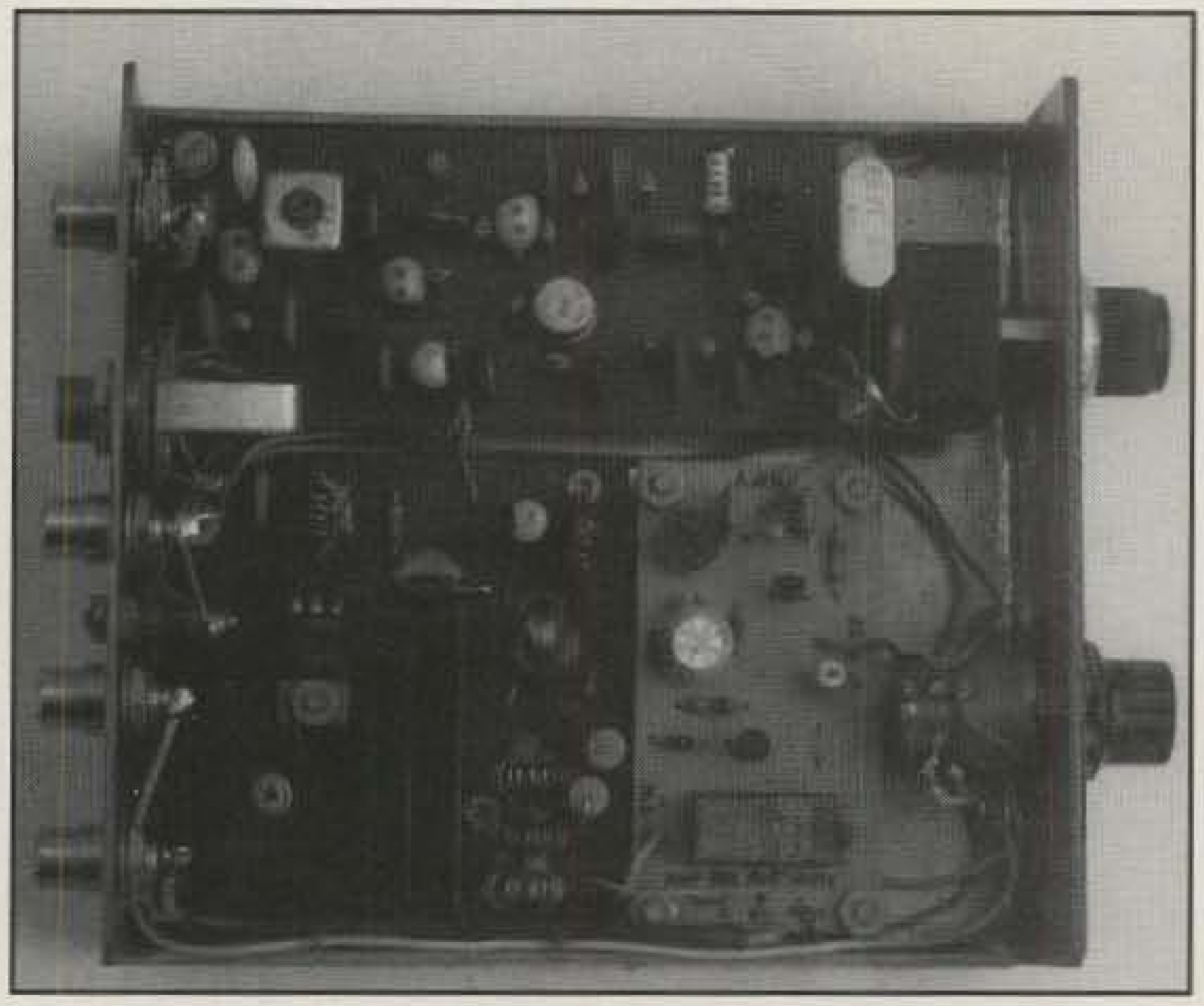

Photo B– Interior view of the discontinued commercial Comaire 6 and 2 meter tuner.

networks used at HF and MF. They are more tricky to adjust than the circuits in fig. 1, because things happen fast when the capacitors are rotated! Also, the builder must keep stray inductance (connecting leads) at a minimum so that it does not become part of the coil and spoil the Q and/or increase the overall circuit inductance.

Examples of pi and T networks are given in fig. 2. Circuit A is a pi network with a limited matching range. Since it is a low-pass filter in principle, it will help to attenuate harmonic currents from the transmitter. The pi-network tuner is well suited for use between an exciter and a linear amplifier.

Fig. 2(B) is a T network of the type used in most commercially made tuners. It is an adaptation of the Ultimate Transmatch described by W1ICP some years ago in *QST*. L1 is a fixed-value coil that is tapped to select the inductance required for providing an SWR of 1 when adjusting C1 and C2.

A Practical Tuner For 6 and 2 Meters

Photos A and B show a commercial 6 and 2 meter tuner I designed and sold (Comaire Elec-

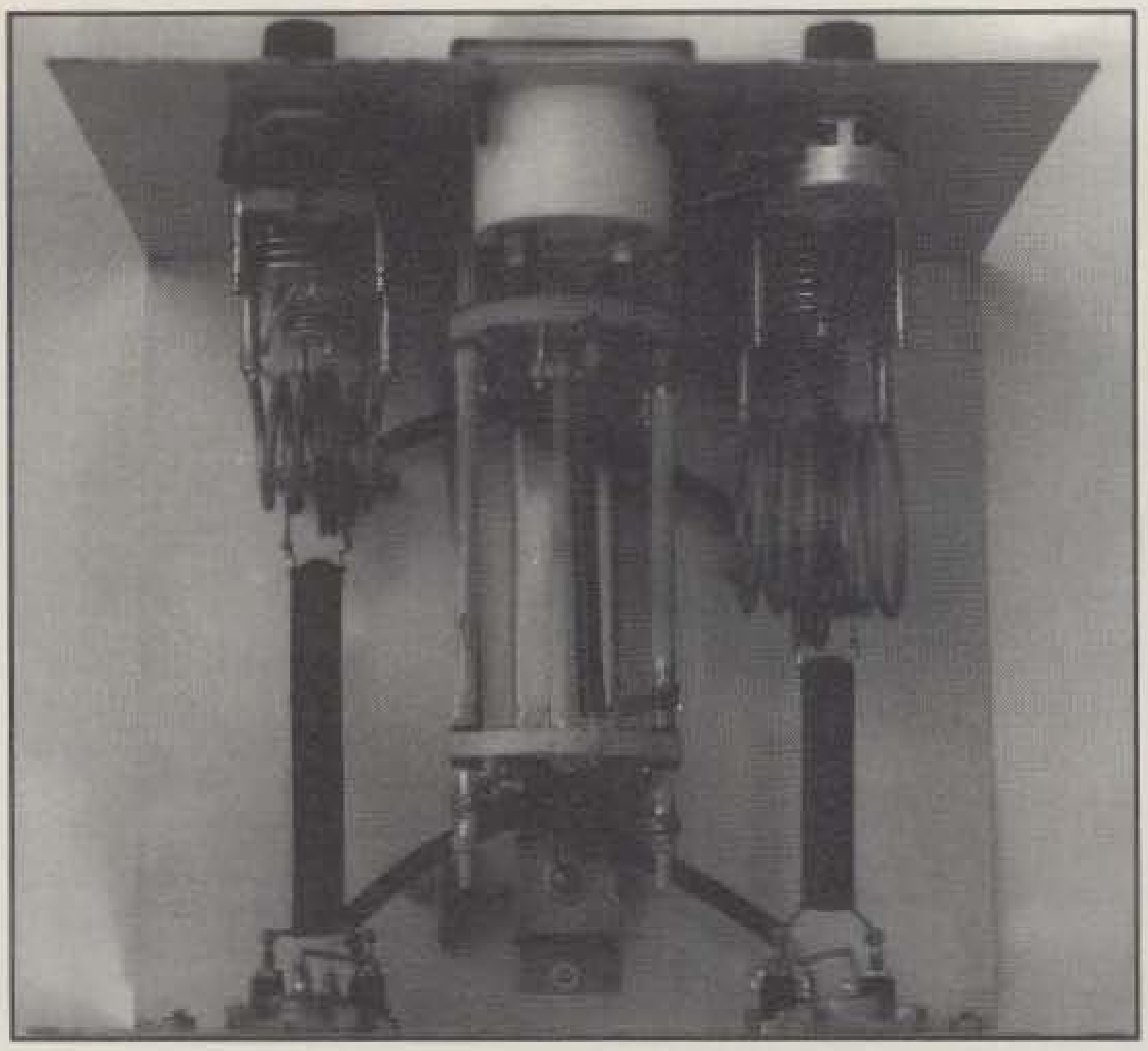

Photo C– Interior view of the assembled 6 and 2 meter tuner of fig. 3. The SWR sampling circuit is enclosed in the channel at the lower center of the picture. Tubular 300 ohm TV ribbon is used for leads in the balanced circuitry. RG-58 is used for all 50 ohm lines.

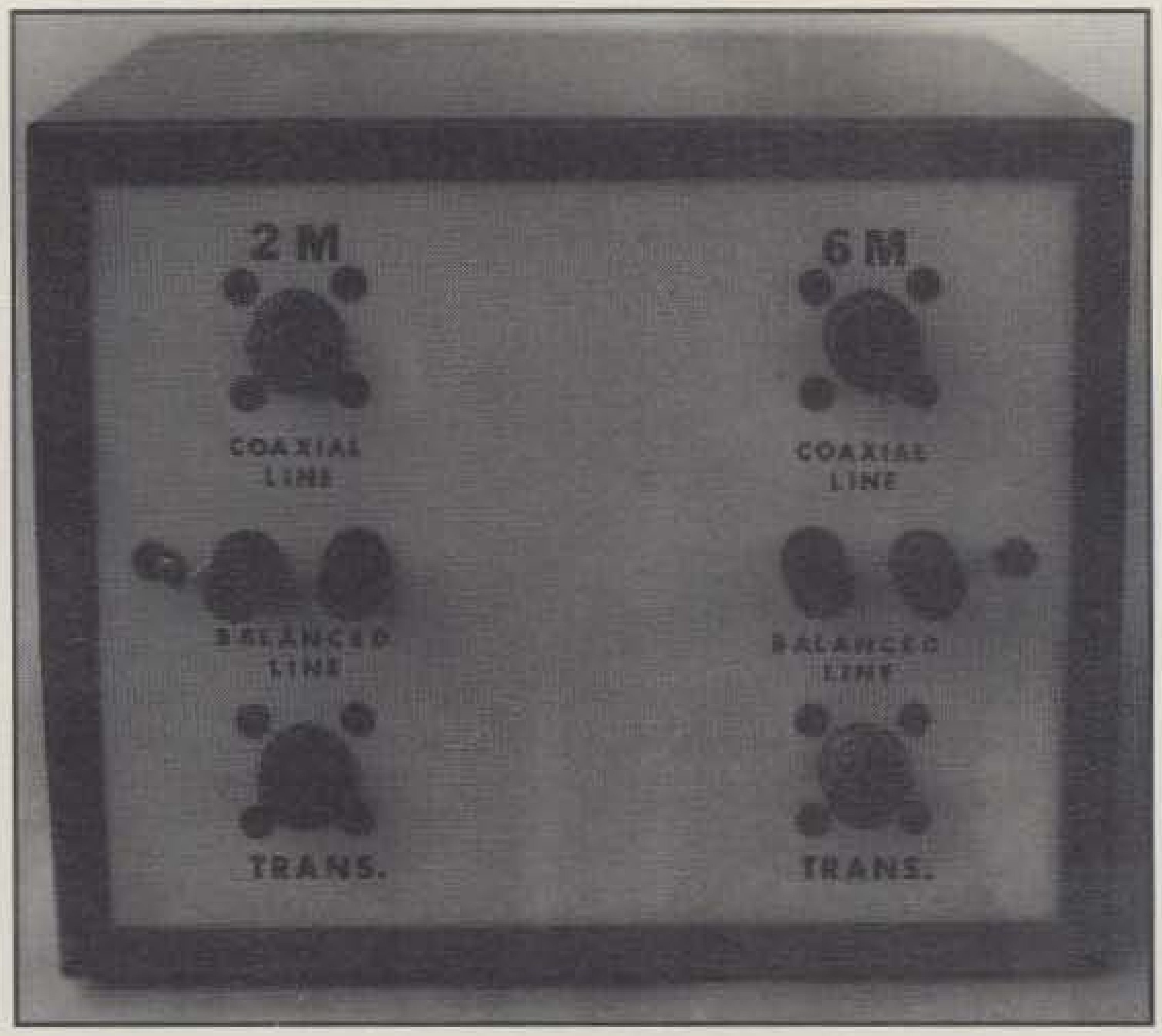

Photo D– Rear view of the assembled tuner. Solder lugs are adjacent the outer binding posts to permit grounding them when the tuner is used with coaxial lines.

tronics) in the early 1960s. The product line was discontinued in 1965. The tuner accommodates coaxial and balanced feed lines. It will handle up to 100 watts of power. It contains an SWR indicator that was featured in a NASA *Tech Brief* in the 1950s. The circuit was popularized in February 1957 *QST* by W1ICP. Lew McCoy dubbed it "The Monomatch." Modern VHF SWR bridges are worth considering for use in the fig. 3 circuit. Those wishing to duplicate this tuner may opt to omit the SWR indicator and use a store-bought unit externally.

C2 and C4 in fig. 3 (see photo C) are butterfly variable capacitors. They were used in the interest of good circuit balance and overall symmetry. It is unlikely that such devices can be found on the market today. A conventional dual-section variable capacitor can be used at C2 and C4. As an alternative, the builder may use a single-section variable and ground the center turns of L2 and L4. This would necessi-

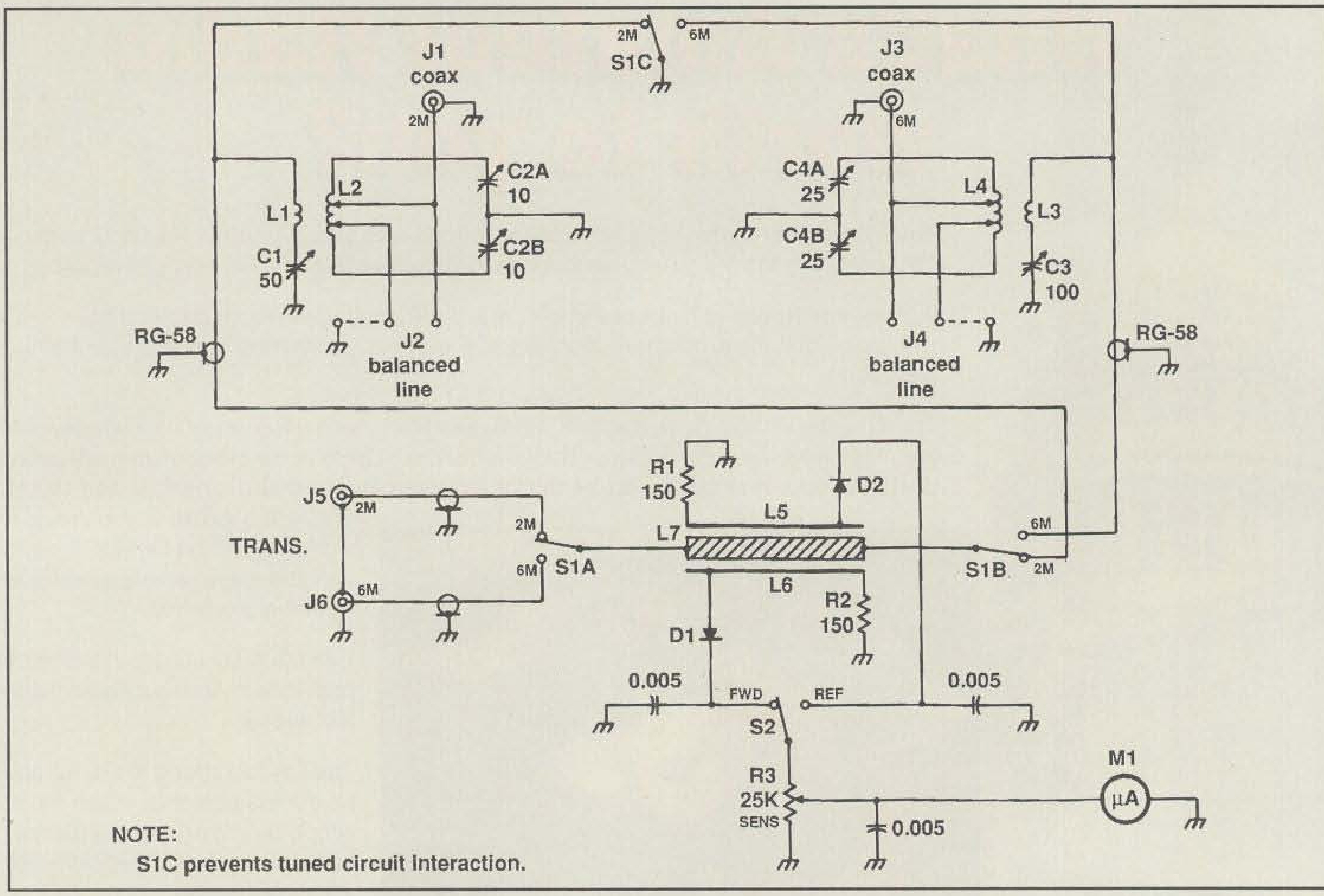

Fig. 3– A practical circuit for a 6 and 2 meter antenna tuner with a built-in SWR indicator. This circuit is rated for 100 watts maximum.

PARTS LIST

C1—Miniature 50 pF air variable.
C2—Dual-section 10 pF variable (see text).
C3—Miniature 100 pF air variable.
C4—Dual-section 25 pF variable (see text).
D1, D2—Silicon diode, type 1N914 or equiv.
J1, J3, J5, J6—SO-239 or type N chassis connector.
J2, J4—Two 5-way binding posts at each site.
L1—Two turns of No. 14 enam. wire, 1 3/8 inch ID, over center of L2 winding.
L2—5 turns of No. 12 copper wire, 7/8" ID × 1 1/4" long. Tap 1 1/2 turns in from each end.
L3—2 turns of No. 14 enam. wire, 2 inch ID, over center of L4.
L4—7 turns of No. 12 copper wire, 1 3/8" ID × 1 1/4" long. Tap 1 1/2 turns in from each end.
L5, L6—3 3/8 inches of No. 14 wire. Space 1/8 inch away from L7.
L7—4 1/2 inch length of 1/4 inch copper tubing. Center in a 5 inch U-shaped aluminum or copper channel with 5/8 inch sides. Use plastic spacers to support L5, L6, and L7.
M1—100 microampere DC meter.
R1, R2—150 ohm, 1/2 watt carbon resistor.
R3—25K ohm, linear-taper potentiometer.
S1—3-pole, double-throw rotary wafer switch.
S2—SPDT toggle or slide switch.

tate insulating C2 and C4 from ground and using an insulated shaft coupler or an insulated tuning shaft to the front panel.

L2 and L4 are wound from No. 12 solid copper house wiring from which the insulation is stripped. I silver-plated the coils, but plating is not essential for good operation. Four insulated five-way binding posts (J2 and J4) are located on the rear panel (photo D) for attaching balanced feeders. One of these terminals for each band of operation is shorted to ground when the tuner is used with coaxial feed line. The coaxial feeder is then attached at J1 or J3.

Adjustment of the tuner is accomplished while observing the reflected power via M1 and adjusting the two variable capacitors, alternately, until the SWR is 1. Adjustment should be done at low power in order to prevent arcing at S1, or between the plates of C2 or C4. The SWR indicator diodes and terminating resistors may also be damaged at high power levels before the SWR is reduced.

Practical Considerations

Open-wire, balanced feeders are less lossy than coaxial cable. Therefore, it is not the product of archaic or eccentric thinking to use balanced feeders of this kind. Furthermore, open-wire line is less costly than quality coax. It is not difficult to make this type of feed line from No. 14 antenna wire and spacers that consist of sections cut from inexpensive plastic coat hangers. The latter items are available at low cost in most variety stores, such as WalMart or K-Mart. Information concerning how to make open-wire feed line is provided in *W1FB's Antenna Notebook* and in *The ARRL Antenna Book*. Low-loss 300 ohm UHF TV ribbon can be used for VHF balanced feeders in lieu of open-wire line, but the losses will be greater. This type of feed line is affected by rain and ice, thereby requiring readjustment of the antenna tuner when moisture is present.

Feed-line loss should be a concern at VHF, depending upon the type of transmission line used. A 100 foot length of open-wire line has a loss of 0.25 dB at 150 MHz. An identical length of 300 ohm tubular TV ribbon exhibits a 1.25 dB loss at 150 MHz. If foam-filled RG-8 coax is used, there will a 2 dB loss for 100 feet of line at 150 MHz. RG-58 causes a loss of 6 dB per 100 feet at 150 MHz. It is important to realize that a 3 dB signal loss is equivalent to reducing the transmitter power by 50 percent. The same losses affect the received signal. It is for this reason that some VHF operators prefer open-wire feeders. If, for example, the operator uses 100 feet of RG-58 to feed a 2 meter antenna with 200 watts of RF power, only 50 watts of energy will reach the antenna. If there is SWR on the line, additional power will be lost because of the mismatch.

In Conclusion

It is not my intention to imply that VHF operators should scrap their existing feed lines and switch to open-wire line. Rather, the tuners described in this article will be useful to those who are experiencing SWR problems. Low-loss hardline coax is a viable alternative to open-wire line with respect to minimizing losses, but the former product, along with suitable hardline connectors, is a costly approach to antenna system efficiency.

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