SATELLITE TV RECEIVER

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Now that you know how a satellite-TV receiver operates, it's time to get to work and put one together.

Part 2 LAST MONTH WE looked at how satellite communications developed, and at some of the programming available on domestic satellites. We also discussed the mechanics of uplink/downlink transmission and reception and the theory of operation of the R2B satellite-TV receiver. This month we'll cover the construction of that receiver.

Due to the extremely high frequency of the signals involved, parts placement is critical and double-sided PC-board construction is required. The receiver uses two boards—a main board and a smaller mixer board that mounts at the rear of the main board.

Main board

The first step in building the receiver is to assemble the main PC board. Foil patterns for the top and bottom of that board, respectively, are shown in Figs. 9 and 10. A parts-placement diagram is shown in Fig. 11. Position the board so the side shown in Fig. 9 is facing up. Use a good grade of rosin-core solder and a fine-tipped iron rated at 40-50 watts. Install all of the resistors first, with the exception of R52—that will be mounted on the bottom of the board later.

(If you purchased a complete R2B receiver kit, you will have noticed that the 1170-MHz oscillator and the 2nd-IF sections were assembled and tested. That is because alignment of those sections requires specialized test equipment that the hobbyist may not have access to, such as a CATV-type sweep generator and a high-frequency spectrum analyzer; complete details will be given in the next installment of this article.)

Note that you will have to solder all ground leads on both the top and bottom sides of the board. (A ground does *not* have the ground plane on top of the board etched away from around its mounting hole.) Next, install IC sockets for IC4-IC7.

Now mount diodes D1-D7. Note that D7 is made from an NPN transistor that has been modified by soldering its base and collector leads together; the base-emitter junction works as a diode. That arrangement is used because D7 and Q12 together form a current mirror and its two components should be matched fairly well.

Install LED1, but do not solder it flush to the board—leave its leads long so that it can be mounted on the front panel later.

With that done, install all the transistors. You will notice that there are two possible ways to install the NEC 02136 transistors (Q1-Q3, Q5, Q6). Transistors Q1-Q3 should have their markings face-up; Q5 and Q6 should be installed with the markings facing down.

Installation of the capacitors is fairly straightforward and should be done next. One lead of C3 must be soldered to the leg of C4 before installation, as shown in Fig. 12. Similar preparation is required for capacitors C5 and C6, C8 and C9, and C10 and C11. That may seem odd, because the mounting tabs of

the trimmer capacitors are connected to ground; but there is an explanation. At the high frequencies involved, the bent legs of the trimmers actually act as inductors, and the C4-C5 and C9-C10 pairs form transformers. The capacitance of the trimmer in parallel with the inductance of its leg creates an L-C tank circuit that provides the selectivity of the first-IF section. Because the values are critical, it is important not to use substitutes for the Stettner trimmer capacitors.

Before installing the remaining capacitors, solder a shield around the 1170-MHz oscillator and first-IF sections as shown in the parts-placement diagram and in Fig. 13. Don't forget to include a partition between C5 and C9; it will sit over resistors R3 and R4, and Q2. Use ¾-inch-wide strips of 28-gauge tin to make the shield and be sure to solder all the seams completely. Then install all the remaining capacitors, except for C1, paying special attention to the polarity of electrolytics.

Install trimmer potentiometers R13 and R37, and insulated jumper JU1, being careful not to cause a short between the jumper and the ground plane. Mount L1, L8, and L9 in their respective positions and also solder the constant-current source, IC8, into position. Solder IC1-IC3 to the board, taking care to orient them properly. Pin 1 of IC1 is identified by a colored dot on the underside of the package. Integrated circuits IC2 and IC3 are in SIP (*S*ingle *I*n-line *P*ackage) types and pin 1 is on the far left when the IC's are held so that the identification number can be read. Don't forget that you should still be soldering ground leads on both the top and bottom sides of the board.

Install the slug-tuned coils, L2-L6, and mount shield cans over them. (If you're wondering what happened to L7, it's formed by the lead of R51.) Install the Berg test jacks TP1 and TP2 along with the AC-power jack, J5. Also mount the rear-panel RCA jacks, J2-J4. You may want to solder the bodies of those jacks to the top of the board for added mechanical integrity. Install voltage regulators IC11-IC13 (a heat sink is required for IC12) and power switch S1. Solder R52 in place on the bottom side of the board between pins 2 and 10 of IC7.

Finally, connect the TUNING and AUDIO front-panel potentiometers. (Use ribbon cable to keep things neat.) Viewing the TUNING pot (R47) from the front with the solder lugs at the top, connect the rightmost lug to the hole marked "1" on the parts-placement diagram and the center tab to the hole marked "2." Similarly, connect the rightmost tab of the AUDIO potentiometer (R48) to the hole marked "3," the center tab to the one marked "4," and the leftmost tab to the hole marked "5." Be sure to make the cables long enough for the controls to reach the front panel. Plug IC4-IC7 into their sockets, and the main board will be complete.

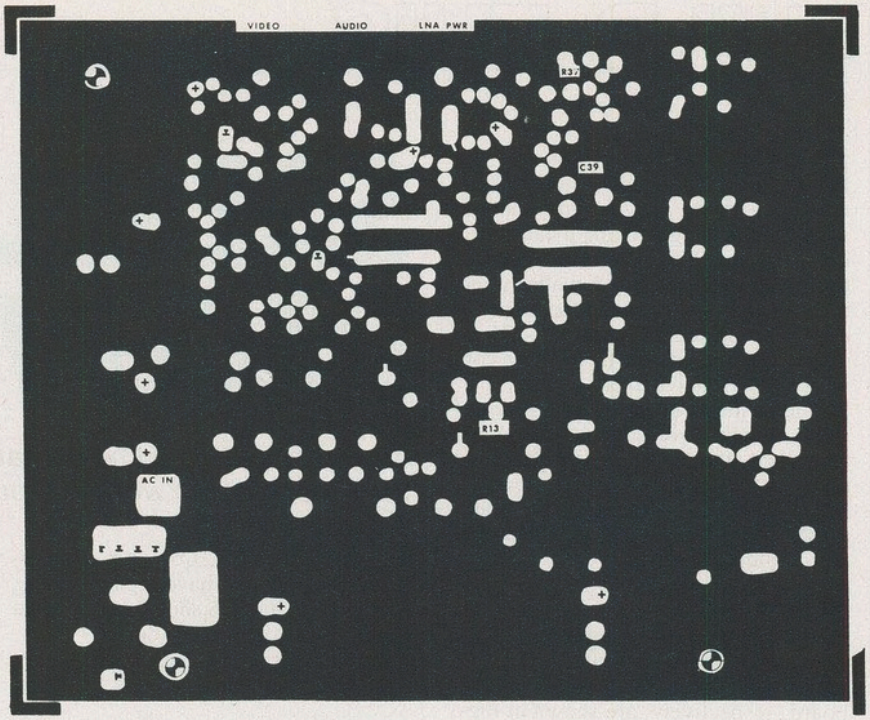

FIG. 9—TOP OF MAIN receiver board is a large ground plane with foil-free areas to provide clearance for component leads that pass through board.

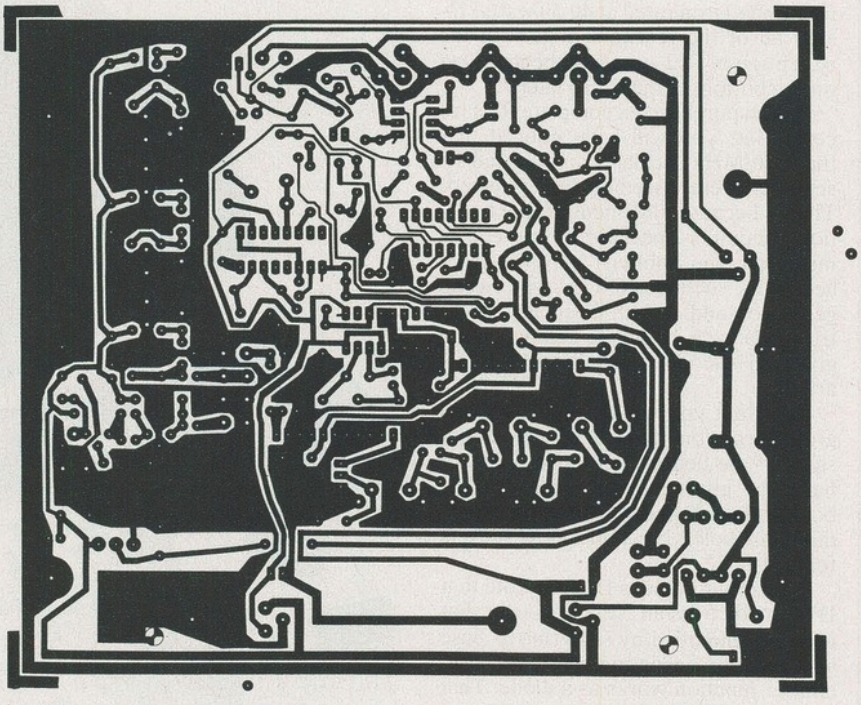

FIG. 10—BOTTOM OF MAIN receiver board. All components connected to ground must be soldered to ground plane on *both sides* of board.

Mixer board

The mixer board performs the job of mixing the 4-GHz input from the LNA with the first local-oscillator signal. It is the most critical part of the entire receiver, so extra care must be taken in its construction.

To assure proper operation, the PC board used for this section must be made

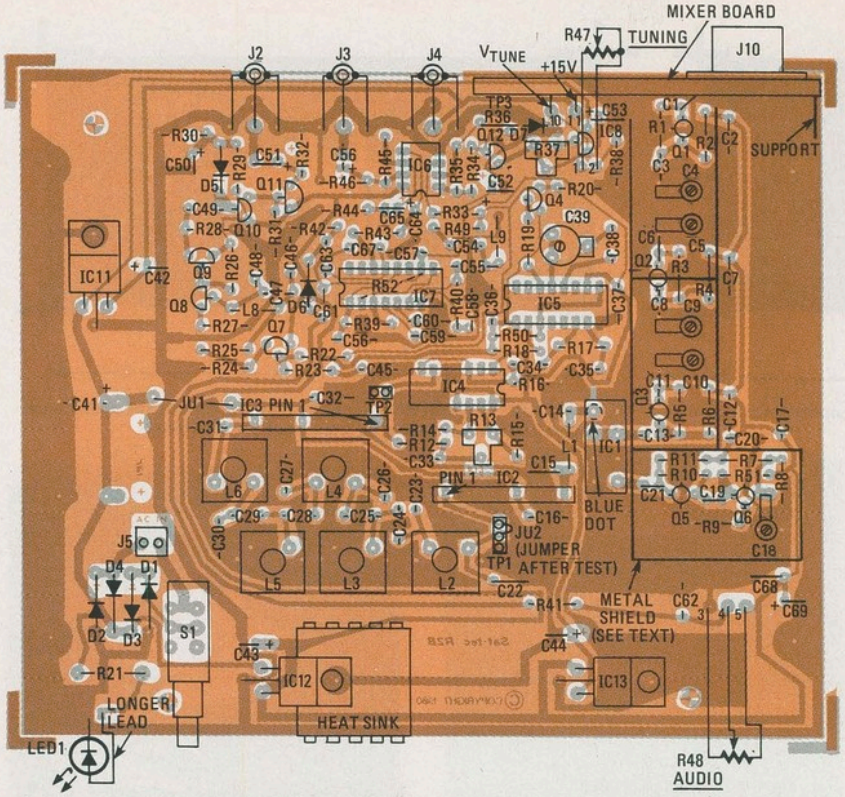

FIG. 11—NOTE THAT IC1 AND IC2 are in SIP (Single *In*-line *P*ackage) packages. Pin-1 end is on left when package is viewed from side with markings.

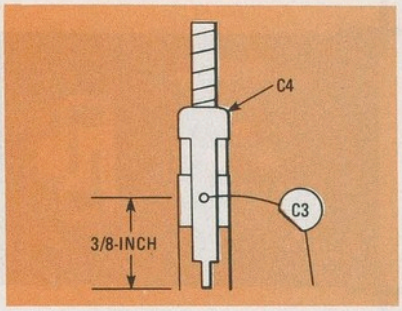

FIG. 12—CAPACITOR C3 should be soldered to leg of trimmer C4 before it is mounted on board. Capacitors C5/C6, C8/C9, and C10/C11 should be prepared the same way.

The following are available from Ramsey Electronics, 2575 Baird Rd., Penfield, NY 14526: Complete Sat-tec R2B satellite-TV receiver kit with pre-aligned 70-MHz IF and 1170-MHz oscillator sections, $495.00; completely wired and tested Sat-tec R2B satellite-TV receiver, $749.95; RM3 RF modulator, $69.95; Watkins-Johnson V815 oscillator IC (IC10), $125.00; Avantek 120°K, 50-dB gain LNA, $595.00.

The above prices include shipping and insurance charges to points in the U.S. and Canada. Overseas orders please add 15% to cover shipping. MC and Visa accepted.

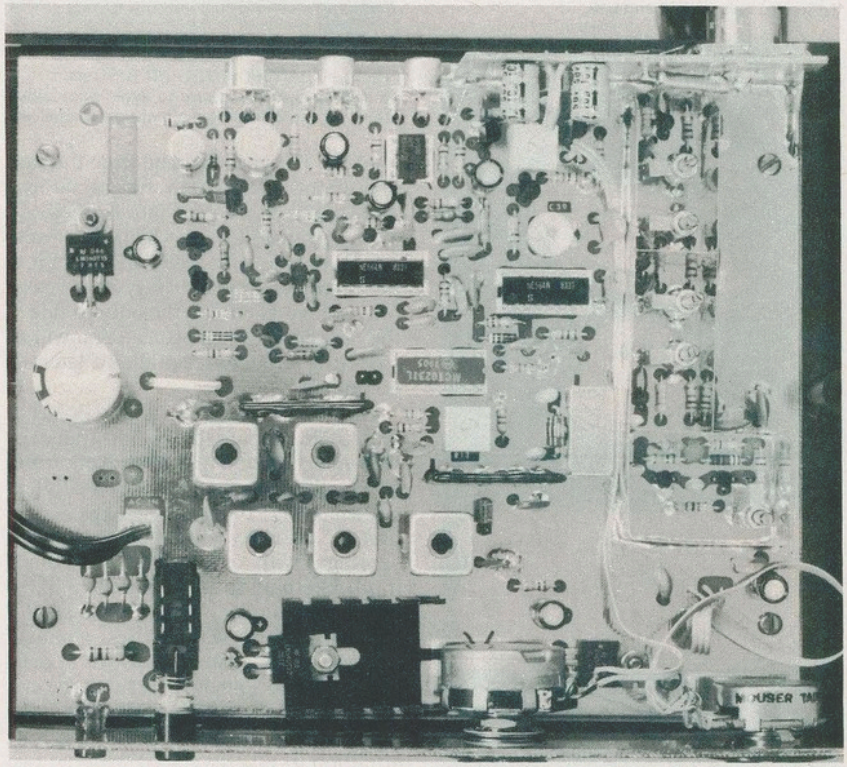

FIG. 13—SHIELD AROUND 1170-MHz oscillator and first-IF sections is made from ¾-inch-wide strips of 28-gauge sheet tin.

of .062-inch thick FR-4 material with special plating and a dielectric constant of 4.84 ±.15 (see Parts List). One important reason for that requirement is that two of the capacitors used in the mixer circuit, C72 and C73, are actually formed by the copper and plating on both sides of the PC board, with the board material acting as their dielectric.

Foil patterns for both sides of the mixer board are shown in Figs. 14 and 15. Figure 15 also shows where component mounting holes are to be drilled; there are only a few of them—most components are soldered directly to the foil of the board or to other components. Note that J10 will need a large mounting hole. Figure 16 shows component placement on both sides of the board. Refer also to Figs. 17 and 18 for further details of component placement. We'll refer to the side of the board on which the capacitors are mounted as the *bottom* side, and the side on which the diodes are mounted as the *top* side.

Begin assembly by soldering J10 to the top side of the board. Run a solder bead all around the flange and also solder the connector on the bottom side of the board. You may need to use a 100-watt soldering gun or iron for this.

While the board cools, prepare quarter-wave transmission-line balun L11 from .141-inch diameter Teflon hardline (Cablewave Systs. type CT-.141-50). Use a small tubing cutter to cut the hardline to the dimensions shown in Fig. 19-a. Solder the inductor into place on the bottom of the board with the longer end of the center conductor facing J10. Solder that end to J10 and the other to the foil pad indicated in the parts-placement diagram. The copper jacket of L11 should be soldered to the PC board only at the extreme ends, not along its entire length.

Next, install IC10, the VCO (*V*oltage-*C*ontrolled *O*scillator) from the bottom side of the board. Note that one lead (pin

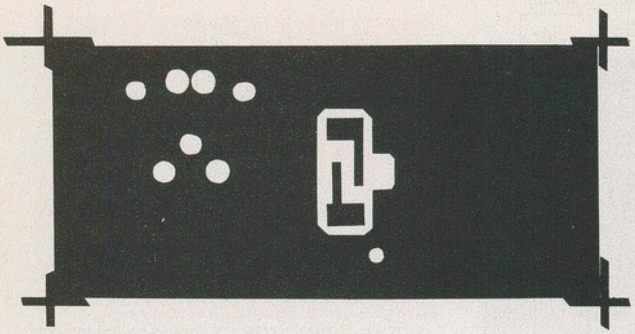

FIG. 14—BOTTOM OF MIXER BOARD shows two capacitors (C72 and C73) formed from PC-board material.

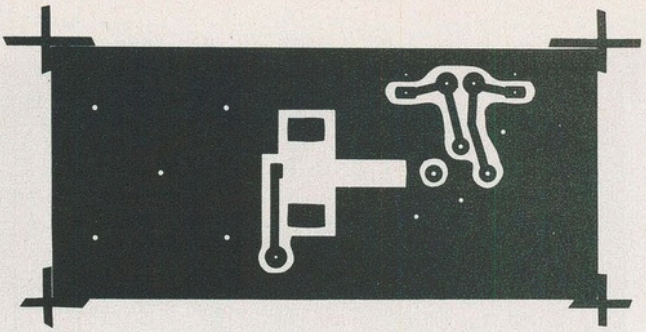

FIG. 15—TOP OF MIXER BOARD shows where holes are to be drilled. Jack J10 will require large hole so that it can pass through board.

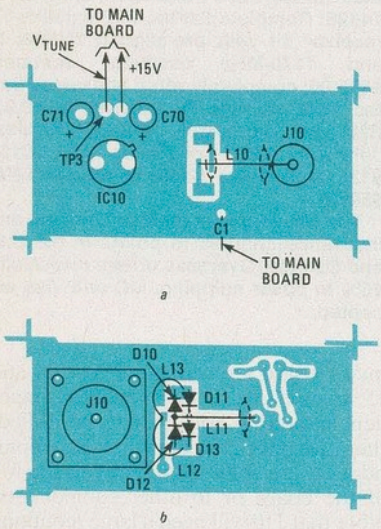

FIG. 16—CAPACITORS AND IC10 are mounted on bottom of mixer board (*a*); diodes on top (*b*).

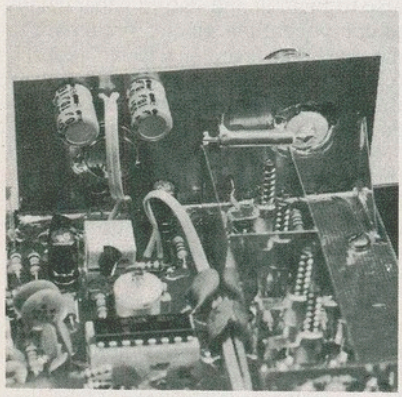

FIG. 17—QUARTER-WAVE HARDLINE BALUN is soldered to board only at its ends.

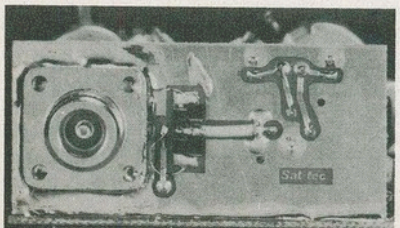

FIG. 18—DIODES D10-D13 are connected at one end to Teflon balun on top of mixer board. Wire loops L12 and L13 are described in text.

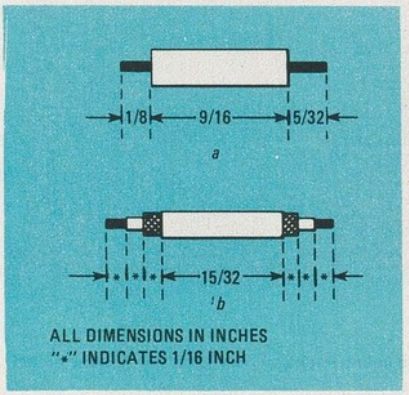

FIG. 19—TRIMMING GUIDES for hardline (*a*) and Teflon (*b*) baluns, L11 and L10.

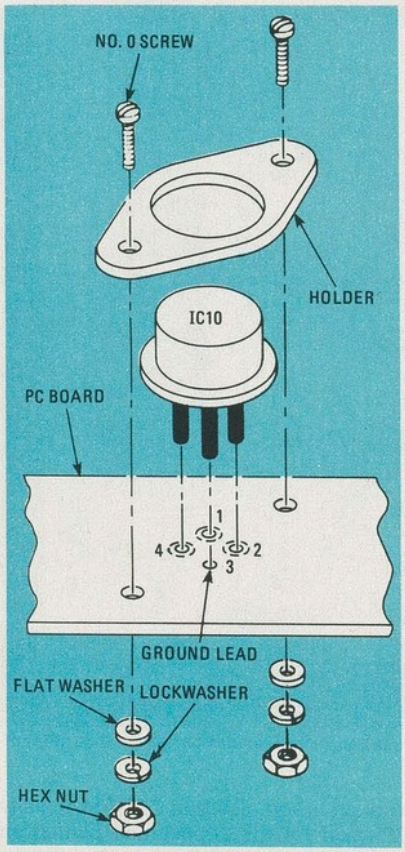

FIG. 20—OSCILLATOR IC, IC10, can be mounted using hardware shown, or secured by soldering case to board.

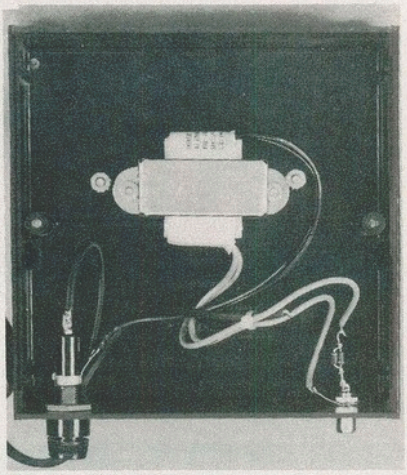

FIG. 21—TRANSFORMER AND FUSE are mounted in their own enclosure to avoid heat generated by transformer from affecting the receiver.

3) of the IC is not isolated from the case like the others. That is the ground lead and should be inserted into the hole going to ground. Use the hardware package that came with the IC to mount it to the board as shown in Fig. 20, or carefully solder its case to the bottom side of the board in several places. You will be soldering L10 to pin 4 of the IC later, so do not cut it off.

Install C70 and C71, noting polarity, and then prepare the other transmission-line balun, L10, from Teflon coaxial cable (Alpha type R6179B/U) as shown in Fig. 19-b. It is perhaps easiest first to cut away the outer sleeving by scoring it with a sharp knife and pulling it off. Do that for the wire braid and the inner insulation as well, being careful not to nick any of the wires. Connect one end of the center conductor to pin 4 of IC10. Also solder the braid at the end to the foil. Solder diodes D10-D13 to the other end of the piece of coax, paying attention to polarity. Start with the two diodes that are connected to the braid. Keep the diode leads as short as you can. The ends of the diodes that are not connected to the coax are soldered to the two rectangular pads on the board. Those connections can be seen in Fig. 18.

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To complete the mixer board, form L12 and L13 from a single 1⅛-inch piece of 28-gauge enameled wire. Bend the wire in half and tin a ⅛-inch section in the middle. Then tin ⅛-inch at both ends. Solder the middle section to the small pad located next to the diodes and the ends of the wire to the rectangular diode-pads. Raise the two loops so that they form about a 45-degree angle with the board to avoid capacitive effects.

The final step in assembly is to solder the two PC boards together. The mixer board mounts vertically at the rear of the main board, with the "bottom" side facing in, about ⅛-inch in from the rear and flush with the side. Solder the ground planes of the two boards together along the entire length and on both sides of the mixer board. Also solder a triangular piece of tin to both boards at their outer edges for added support. Insert C1 between the mixer board and main board. To finish up, connect holes 10 and 11 on the mixer board to the corresponding holes on the main board. The receiver is much easier to work on while it is out of its case, so final assembly will be postponed until after alignment.

Power supply

The power transformer is housed in its own case (Fig. 21) to keep the size of the receiver itself comfortably small. Isolating it from the components of the receiver also reduces drift and other heat-related problems.

A schematic for the transformer and its associated components is shown in Fig. 8 in Part 1 of this article in the April 1982 issue of **Radio-Electronics.** The cable connecting the transformer to the receiver should terminate in a two-pin Molex connector to mate with J5 on the main board.

Before plugging anything in, check all the wiring of both units and verify that all the components are in the correct positions and properly oriented. Also check for solder bridges on the PC boards. In the next part of this article, we will cover the final assembly of the receiver. We will also discuss alignment procedures and—just in case you need them—provide some troubleshooting hints. **R-E**