BUILD THIS

AMATEUR TV TRANSMITTER

Get in the picture with our television transmitter.

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LAST MONTH WE ANALYZED THE TV transmitter circuitry in great detail, describing the function of virtually every transistor, capacitor, inductor, and resistor. Now we'll present the construction techniques in the same detail. They should pose no special problems, but your best bet is to duplicate the author's prototype as closely as possible. That's because when working with ultra-high-frequency RF, such things as PC-board layout, component placement, and especially lead lengths become critical.

Assembly hints

As long as the author's design is exactly duplicated, you shouldn't encounter any *off the wall* UHF problems, so follow these suggestions without compromise:

1. As you assemble this project, use only the parts specified in the Parts List because ultra-high frequency circuits are sensitive to changes in component type and value. Also follow the author's parts placement as closely as possible.

2. Lead lengths should be kept short. Handle the surface-mount components and ferrite beads with extra care. The ⅛-watt resistors and miniature NPO ceramics should have short leads, and close component spacing.

3. Wind your own slug-tuned coils with available materials, rather than using commercial, hard-to-get factory-made types. That gets rid of the coil headaches. If the dimensions are followed, no problems should result. As shown in Fig 1, you'll find that the coils are easy to wind, and the largest ones have only eight or nine turns of wire. In fact, several are only loops or pieces of wire because the inductors required at 420–500 MHz are usually in the 0.01 to 0.1-microhenry range. Complete technical data is compiled in Table 1.

4. Pay particular attention to supply bypassing. We have incorporated a tantalum chip capacitor to guarantee good bypassing. By keeping everything compact, and by using a shielded, double-sided PC board with good RF bypassing, all the possible "horrors" associated with VHF and UHF circuitry can be done away with.

5. The PC board is compact and parts are small, so a small iron with a pointed tip is recommended, especially for soldering the chip capacitors.

6. Use only 0.062-inch thick epoxy-fiberglass PC-board materials. Other materials and thicknesses could be used, but may result in different tuning conditions, and stray capacitances. Don't use paper-base phenolic materials; they're too lossy at UHF frequencies.

7. Transistor Q12 must be heat-sinked because it must dissipate up to 3 watts. The method shown in Fig. 2 has proven adequate if at least 1-ounce copper is used. On the other hand, Q7 is adequately heat-sinked if the metal case is soldered to the PC-board ground plane.

8. Solder as many component leads as possible (that pass through the ground plane) to the top and bottom of the board. In particular, the ground lugs on all trimmer capacitors should be soldered on both sides, and also the resistors that have one side connected to ground. The idea is to ground as much of the ground plane to the ground foil on the component side, in as many places as possible; that's especially important around Q4–Q7.

9. Use chip capacitors where specified. Do not substitute ordinary leaded capacitors.

10. Keep all component leads as short as possible, and as close to the board as possible.

11. Take care to make coils as accurately as possible. While some errors can be tolerated, accurate work will make tuneup easier.

Parts installation

Figure 3 shows the Parts-Placement diagram for the TV transmitter. First install all resistors and then diodes D1 and D3. Don't forget the ferrite beads on R15, R17, R19, and R21. Next install all disc ceramics (0.01 μF and 470 pF), and then the NPO capacitors. Now install potentiometers R22, R32, and R33, soldering the grounded side of R22 and R33 to both sides of the PC board. Install all trimmer capacitors. Note that C18 and C40 are different from the rest. Solder ground tabs of all trimmers to both top and bottom of the PC board. Install transistors Q1 through Q5, and Q8 through Q11, but don't install Q6, Q7, or Q12 yet.

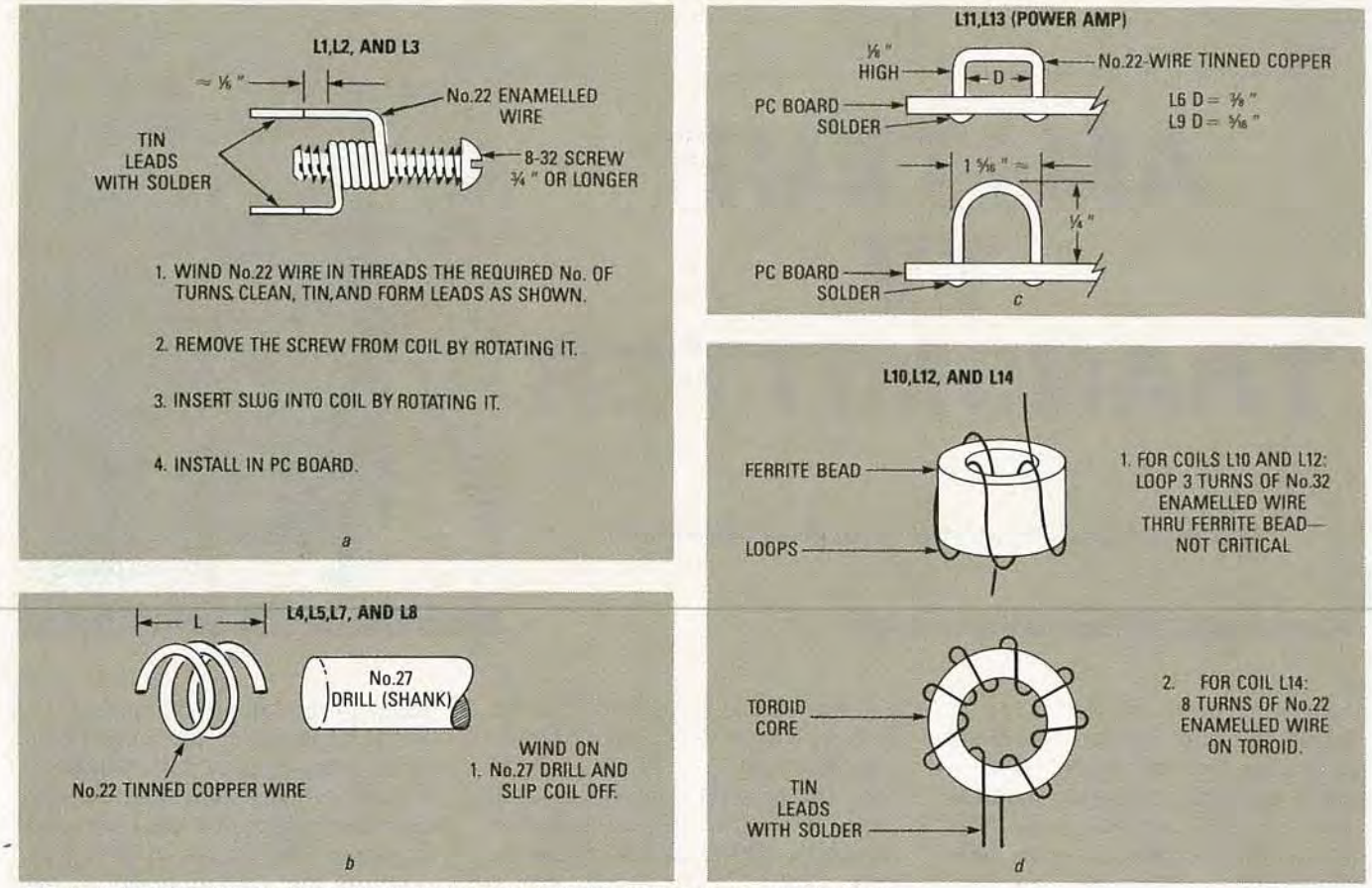


FIG. 1—IF YOU WANT TO CONSTRUCT THE COILS BY HAND, you have to wind them on the threads of a screw *(a)*, the shank of a drill bit *(b)*, using measured bends *(c)*, or around a ferrite bead *(d)*.

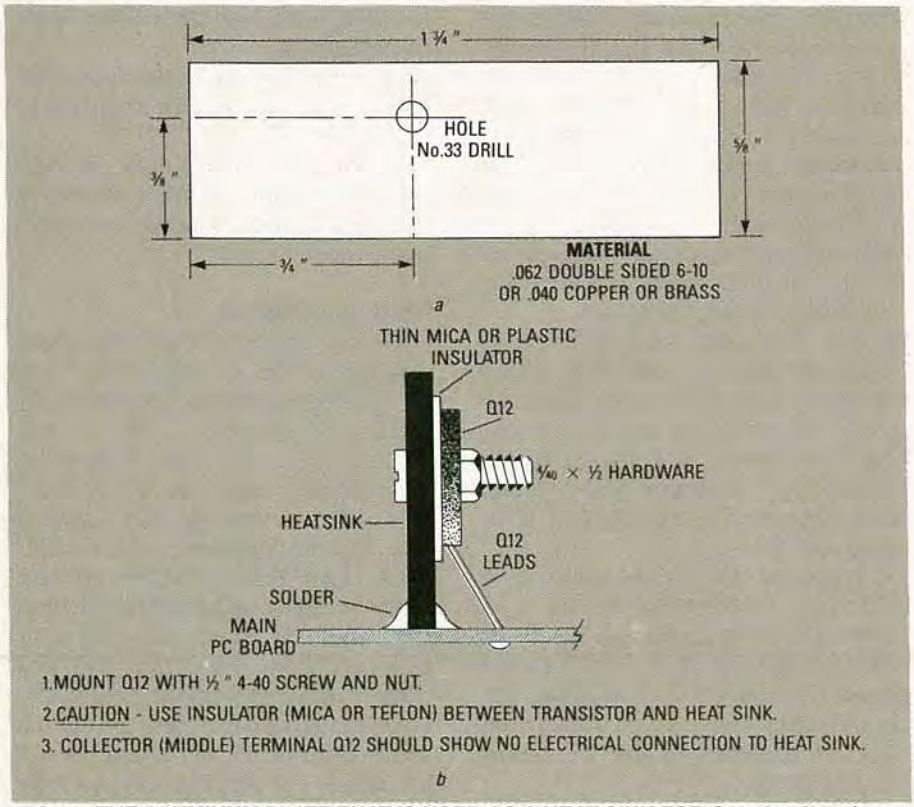


FIG. 2—THE ALUMINUM PLATE THAT IS USED AS A HEAT SINK FOR Q12 also functions as an RF shield for transistors Q6 and Q7.

Wind and install L1 through L9, and L14. If you're building the low-power version, leave out any components associated with Q6 and Q7, except L9; go ahead with the modification shown in Fig. 4, and be sure to omit C22. Install chip capacitors C22, C24, C44, and C20.

Check the PC board for shorts, solder bridges, and trim away any excess foil with a sharp knife (*X-acto* type or equal). Make sure that excess foil on the top side is not touching any component leads that are not intended to be grounded. Slight mis-registration of the top foil during PC fabrication may cause that.

Now install Q12 and its heat sink. Note that the heat sink also serves as an RF shield for Q6 and Q7 (if used). Be sure to solder the heat sink where it butts against the PC board. Note that Q12's case should be insulated from the heat sink. Use a TO-220 insulator (cut to size), or a scrap of mica, mylar, polyethylene, or teflon tape used in plumbing work.

You are now ready to test the main part of the board. If you're construct-

ing the 2-watt version, Q6, Q7, and any associated components will be installed only after the rest of the PC board is tested.

Testing

After checking your work, measure the DC resistance between V_{CC} and ground; it should be greater than 200 ohms. If it's lower than that, check your work again for the cause before proceeding any further.

Next, install the slugs in L1, L2, and L3 if you haven't already done so. The slugs should be initially set fully inside the coils. Set R22, R32, and R33 about halfway between extremes of rotation. Set trimmer C40 and all other trimmer capacitors to half mesh. Final settings will depend on the operating frequency, coil-construction technique, and application.

Apply +12 volts after connecting the negative-supply lead to the PC-board ground plane. Immediately observe power-supply current; if it's over 130 mA, there may be a problem. If anything smokes or gets too hot, immediately remove the power and find the problem before proceeding.

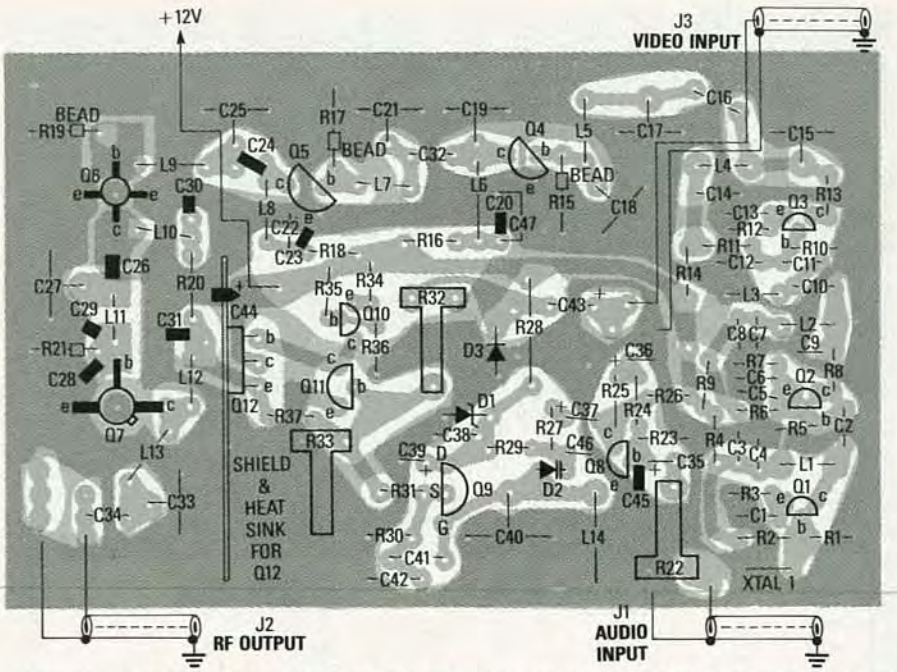


FIG. 3—PARTS PLACEMENT DIAGRAM shows capacitor chips (C20, C23, C24, C26, C28, C29, C30, C31, C45) mounted on the solder side, as is Q6.

If all seems OK, connect a VOM (preferably an analog meter) across R3, and then R7. You should read between 1.5 and 3-volts DC. Next connect the VOM across resistor R12 Q3;you should read 1 volt or less. Now connect the VOM between point A (emitter of Q12) and ground. Verify

TABLE 1—COIL DESCRIPTIONS L1–L14

COIL	FREQ. RANGE MHz	NO. TURNS & LENGTH	WINDING FORM	NOTES
L1	420-450 (HAM TV) 450-500 (VIDEO LINK)	9½ 8½	8-32 SCREW THREAD	NO. 22 ENAMEL WIRE
L2	420-450 450-500	4½ 3⅓		
L3	420-450 450-500	5½ 3½		
L4	ALL	3 TURNS ¼" LONG	NO. 27 DRILL (O.144" DIA) SPACE TURNS	MADE WITH NO. 22 TINNED COPPER
L5	ALL	4 TURNS ¼" LONG		
L7	ALL	1½ TURNS 1/16" LONG		
L8	ALL	2½ TURNS ⅛" LONG		
L6, L9, L11, L13	ALL	PER FIG. 1	NONE (PC BOARD)	
L10, L12	ALL	PER FIG. 1	FERRITE BEAD	NO. 32 ENAMEL WIRE
L14	4.5 MHz (NTSC SOUND SUBCARRIER)	8 TURNS NO. 22 ENAMEL	TOROID	NO. 22 ENAMEL WIRE

NOTE: Due to individual winding technique and normal circuit tolerances, L1, L2, L3 and L14 may require one turn more or less than shown in Table 1. L4, L5, L7 and L8 may have to be squeezed or spread lengthwise. All dimensions are taken from average of several working units. Individual units vary somewhat from given dimensions due to tolerances, winding techniques, and installation.

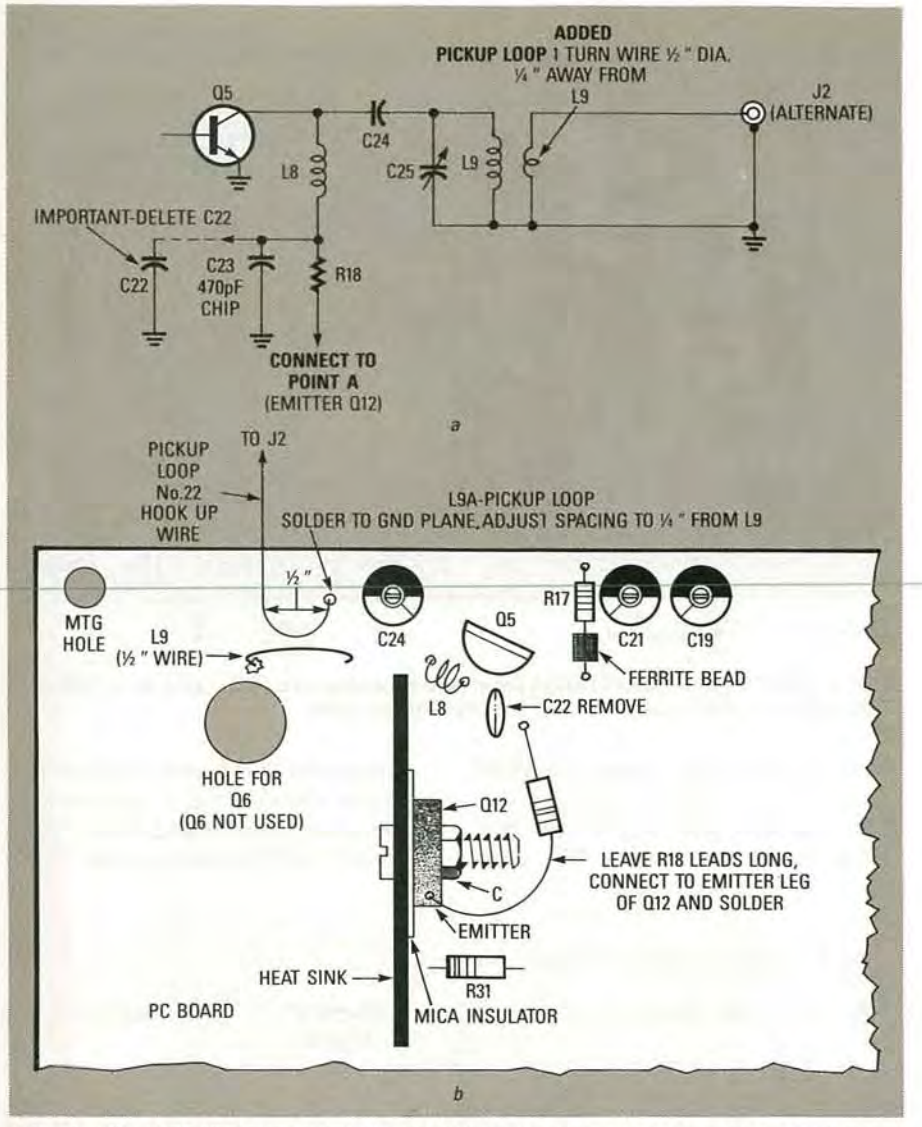


FIG. 4—TO OPERATE THE UNIT AT LOW POWER you should follow schematic *(a)* and assembly modification *(b)*.

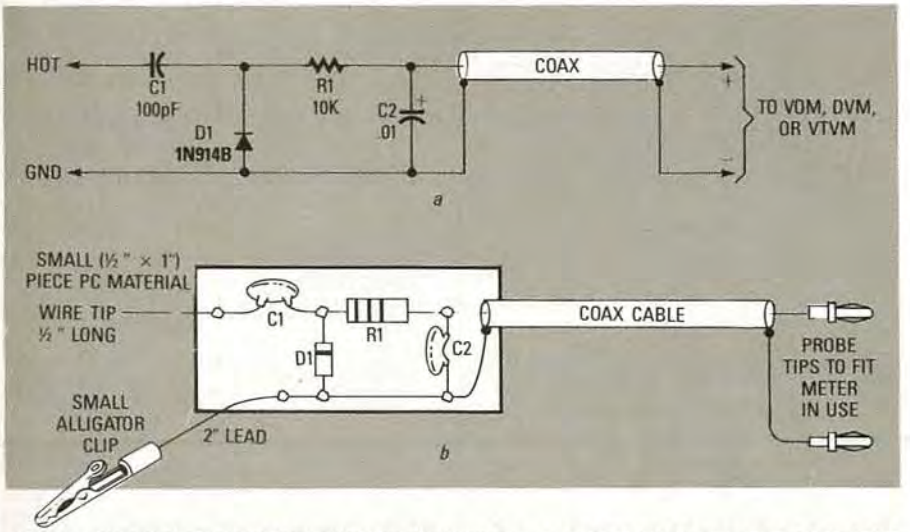


FIG. 5—HERE'S AN RF PROBE YOU CAN BUILD for your DMM, VOM, or scope. It's helpful in adjusting the transmitter for peak power.

that adjusting R33 through its full range will vary the voltage at point-A between less than 5 volts to greater than 11 volts. Set R3 for full voltage (greater than 11 volts) at point A for now.

Measure the voltage at Q8's collector; about 4 to 7 volts is OK. Next measure the voltage across D1; it should be between 8- and 10-volts DC. If it is more or less, that indicates a problem in Q8, Q9, or the associated circuitry. Check for 8- to 10-volts across D2. If it reads 1 volt, D2 is installed backwards or is shorted.

If all is good up to this point, install crystal XTAL1, connect a VOM across R7, and apply power. Tuning the oscillator is done as follows: Slowly back L1's slug out of the winding. You'll find that the voltage across R7 will suddenly increase, then slowly decrease as the slug is tuned. Adjust

PARTS LIST

All resistors are ⅛ or ⅒-watt, 5%.
R1, R5—3900 ohms
R2, R6, R11, R31—15,000 ohms
R3, R7, R15—330 ohms
R4, R9, R12, R14, R16–R19, R35—100 ohms
R8, R13—10 ohms
R10—680 ohms
R20—10 ohms, ¼-watt
R21—22 ohms
R22—100,000-ohms potentiometer
R23—22,000 ohms
R24, R29—100,000 ohms
R25—33,000 ohms
R26—4700 ohms
R28—470 ohms, ¼-watt
R30—2200 ohms
R32, R33—1000-ohm potentiometer
R34—15 ohm
R36—1000 ohms
R37—3300 ohms

Capacitors
C1—56 pF, NPO, ceramic disc
C2, C12—33 pF, NPO, ceramic disc
C3, C7, C19, C22, C38, C47—0.01μF, ceramic disc
C4, C6, C8, C13, C14—470 pF, NPO, ceramic disc
C5—82 pF, NPO, ceramic disc
C9, C11—15 pF, NPO, ceramic disc
C10—2.2 pF, NPO, ceramic disc
C15, C17, C19, C21, C25, C27, C33—2–10-pF, trimmer
C16, C32—1 pf, NPO, ceramic disc
C18—2–18 pF, or 2–20-pF trimmer
C20, C23, C24, C45—470 pF, ceramic chip
C26, C30, C31—100 pF, ceramic chip
C28, C29—22 pF, ceramic chip
C34—5 pF, silver mica
C35–C37—1 μF, 50 volt, electrolytic
C39—10 μF, 16 volt, electrolytic
C40—3–40 pF, trimmer
C41—220 pF, NPO, ceramic disc

C42—470 pF, NPO, ceramic disc
C43—220 μF, 16 volt, electrolytic
C44—10 μF, 16 volt, chip tantalum
C46—100 pF, NPO, ceramic disc
C47—0.01μF, ceramic chip

Semiconductors

Q1, Q2—2N3563, transistor
Q3–Q5—MPS3866, transistor
Q6—MRF559 or MRF627 transistor
Q7—MRF630, transistor
Q8—2N3565, transistor
Q9—MPF102, transistor
Q10—2N3906, transistor
Q11—2N3904, transistor
Q12—MJE180, transistor
D1—1N757A, diode
D2—MV2112, varactor diode
D3—1N914, diode
D4—1N4007, diode

Inductors

L1–L14—See table 1

Other components

XTAL1—52.5-62.5 MHz

Notes: The following kits are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804: Low-Power Kit w/ATV crystal for operation on 439.25 MHz, $79.95 plus $2.50 shipping and handling; 2-Watt Kit w/ATV crystal for operation on 439.25 MHz, $104.95 plus $2.50 S/H; extra crystals for CH14, CH15 operation, $6.50 plus $1.50 S/H; PC board only plus Cores, chip capacitors, and D2, (partial kit), $49.95 plus $2.50 S/H; Crystals can be purchased separately from Crystek Corporation, PO Box 06135, Fort Myers, FL 33906. Kits do not include jacks, connectors, batteries, power-supply components, or case.

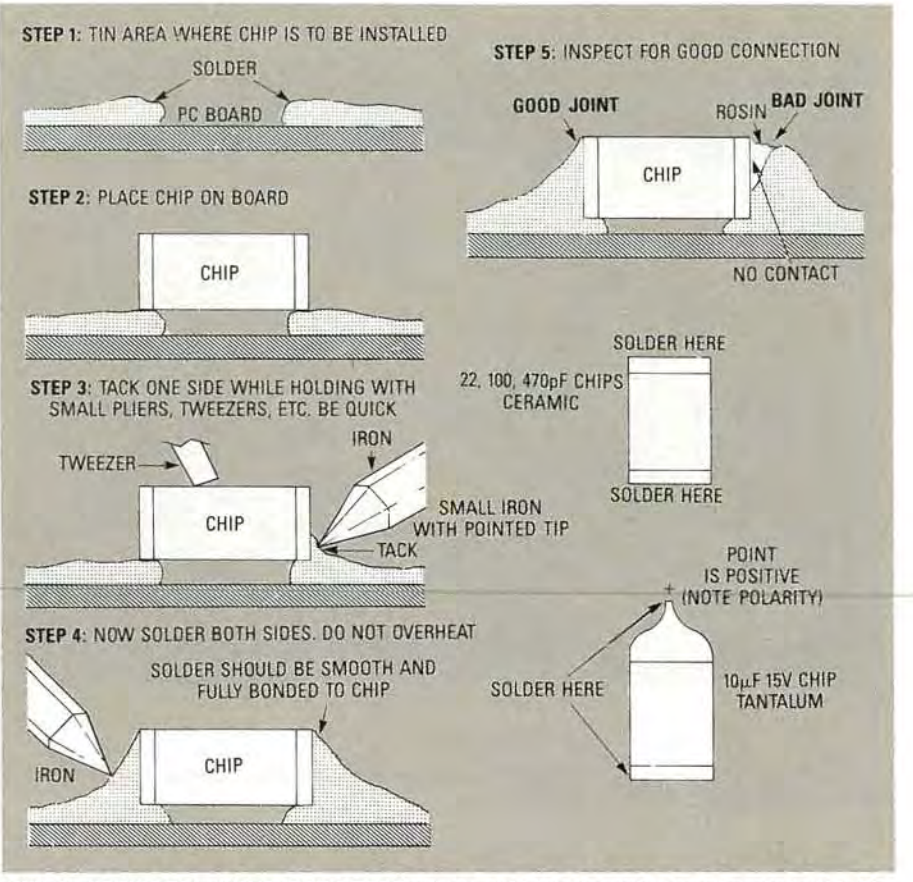


FIG. 6—IF YOU FOLLOW THESE STEPS when soldering the chip components to the PC board, you'll have no problems with them.

the slug for maximum voltage (3 to 5 volts), then back out the slug for about a 10% drop to ensure stable oscillation. As a check, a frequency counter connected to the junction of C2 and C5 should indicate the crystal frequency. An unstable reading indicates that the crystal is not controlling the frequency. If that's the case, try readjusting L1.

Here's how to tune the 1st doubler. Connect the VOM across R12, and adjust L2 and L3 for maximum voltage (about 1 to 2 volts). If adjusting the L1 and L2 slugs doesn't peak the voltage, then add or subtract a turn from the coil as required, after first checking C9, C10, C11, and C12 for correct values.

Here's how to tune the 2nd and 3rd doublers. Connect an RF probe to the junction of L9 and R19, or to the junction of C25 and L9 if you're building the low-power version. Figure 5 shows you how to build an RF probe if you don't already have one. Adjust C15, C17, C18, C19, C21, and C25 for a maximum reading. You should be able to obtain at least 1.5 volts of RF energy at the junction of R19 and L9 for the high-power version, and about 2 volts at the junction of C25 and L9 for the low-power version. If everything looks good, that checks out stages Q1 through Q5.

To adjust the RF output for the low-power version connect a 47-ohm resistor to J2A (*Alternate*). Adjust C25 and the position of L9A (*Alernate*) with respect to L9 for maximum output. Don't couple L9A too close to L9—just enough for about 1 volt across the 47-ohm resistor.

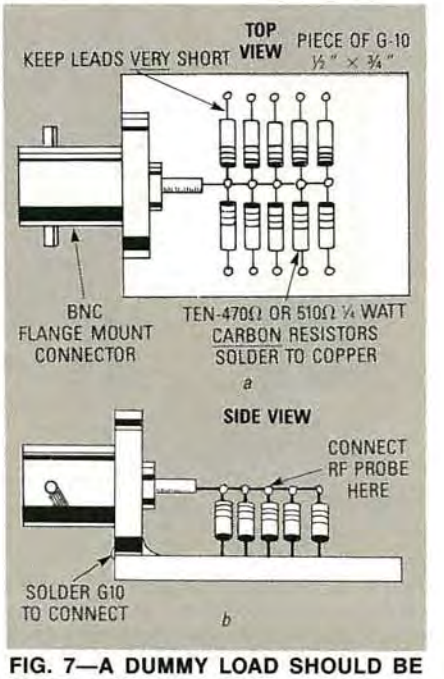


FIG. 7—A DUMMY LOAD SHOULD BE USED while adjusting the power output.

Final assembly

If you're building the 2-watt version, now is the time to install Q6 and Q7, and then L10 through L13. You may now install the chip capacitors C26, C28, C29, C30, and C31, but don't overheat them! Make sure that the PC board is tinned in the areas where chips are installed. The best way to install them is to first tack-solder one side to hold it down, solder the other side, and then go back and

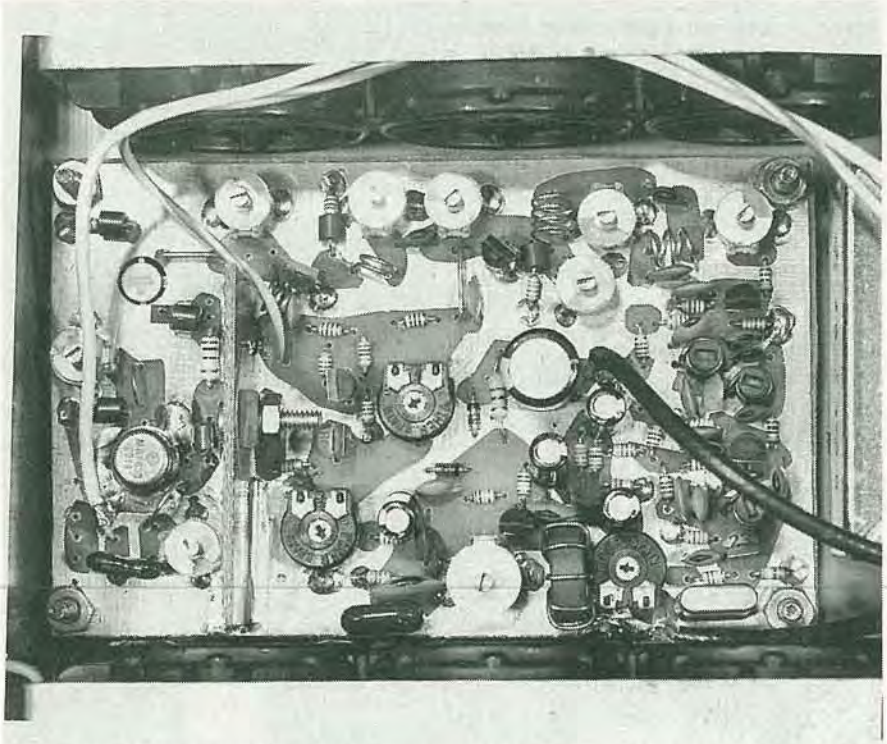


FIG. 8—THE FINISHED PC BOARD has a neat, clean appearance. Sloppy workmanship can not be tolerated on this circuit layout.

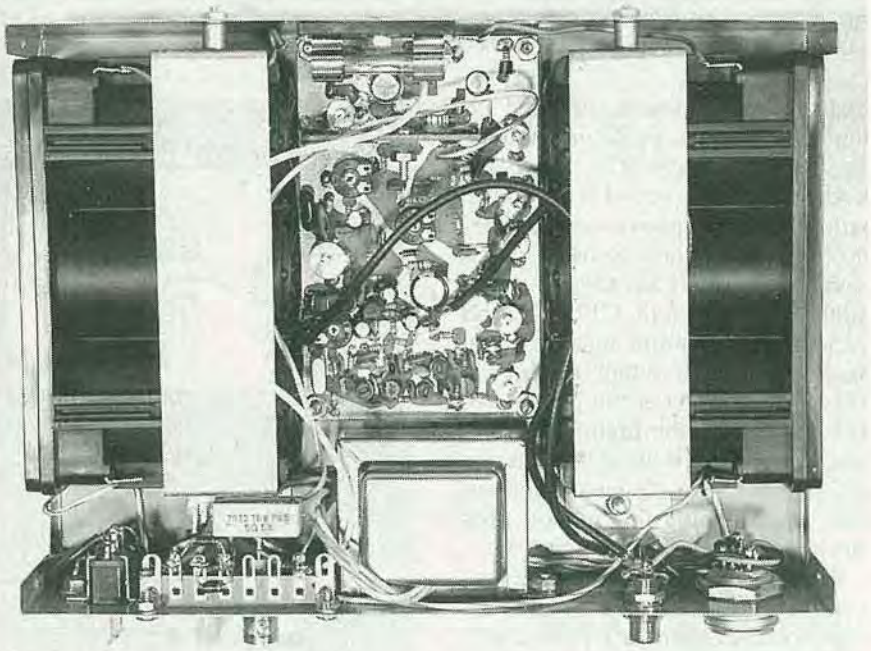


FIG. 9—The AUTHOR'S PROTOTYPE USED 2-Ni-Cd BATTERY PACKS, one on either side of the PC board, which makes the transmitter portable. You'll also notice a power transformer and associated circuitry used for running the transmitter off household AC-line voltage.

resolder the first (tack-soldered) side.

Figure 6 shows you how to solder chip components. Use a 25-watt iron with a pointed tip. Fine-point needle-nose pliers or tweezers should be used to manipulate the chip capacitors.

Finally, install C34 and a suitable length of small-diameter 50-ohm coax to J2. Check all joints for solder bridges. Make sure that the metal case of Q7 is soldered to the ground plane (top side), and connect its leads to the PC-board underside using as little lead length as possible.

Apply power and quickly adjust C25, C27, and C33 for maximum power into a 50-ohm load connected to J2. You can use a 47-ohm, 2-watt carbon resistor, or the dummy load which can be assembled as shown in Fig. 7. An RF probe can be connected to the hot side of the resistors (center conductor of connector) to read the RF voltage, but an RF power meter is nice to have.

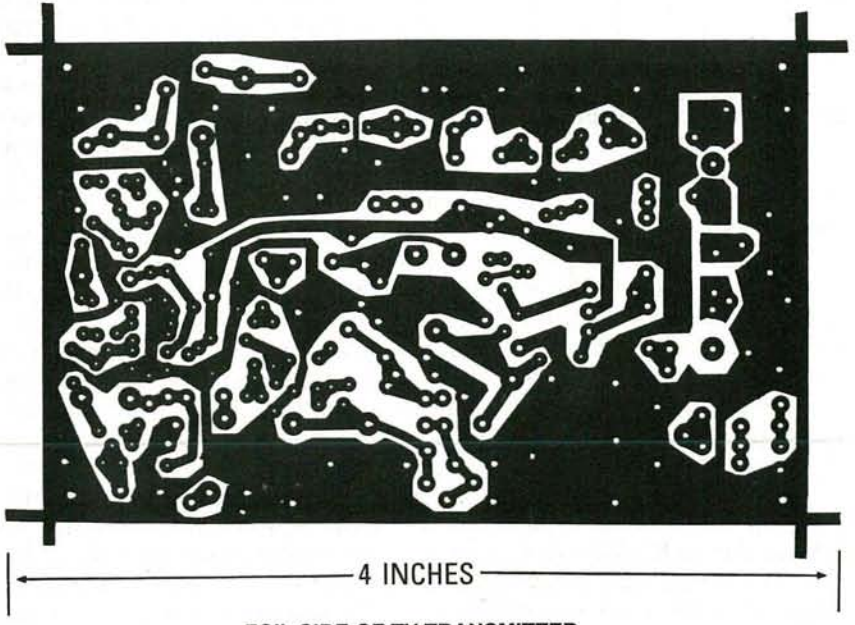
You should get at least 1.5 watts (about 8.5-volts RMS) into the 50-ohm load, which should become warm when operating. Power-supply current will be about 500 mA. Now adjust R33 for an output voltage about half that, or a quarter the power as read on the power meter, if used. Leave the RF load connected as you proceed to the next step.

For either the low- or high-power unit, adjust R33 for about +6 volts at point A (emitter of Q12). Connect a frequency counter to point A, and adjust C40 for exactly 4.500 MHz. Now apply video and audio signals to J3 and J1, respectively. Watch the transmitted image on a TV receiver tuned to the transmitter frequency; adjust the video gain (R32) for best picture contrast and stability, then adjust the audio level (R22) until its level is comparable to a commercial station. Now alternately adjust R32 and R33 for maximum video contrast without seeing any side effects such as instability, audio buzz, or other evidence of clipping. You may also wish to go over all tuning adjustments again for best results. The finished PC board is shown in Fig. 8

Enclosure

Mount the PC board in a shielded metal-case, as shown in Fig. 9, and connect leads from the board to suitable jacks for J1, J2, or J2A, and J3. Also provide a suitable connector for the 12-volt supply, if desired. The transmitter case can house an AC supply, or batteries for portable operation. Use the right size *Ni-Cd* batteries to handle the 100-mA drain (low power), or 500-mA drain (2-watt unit). Use a BNC-type fitting for the antenna jack, J2.

A suitable antenna would be a 6-inch whip or a center-fed dipole, 12-inches long. For amateur TV, a linear amplifier may be installed between J2 and the antenna for greater power output. For the low-power version, use the 6-inch whip antenna. **R-E**



FOIL SIDE OF TV TRANSMITTER.

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