# Put Your All-Mode 2-Meter Rig on 220!

Tired of crystal-controlled, fm-only, 220 rigs? This transceiving converter will make your "do-everything," 2-meter rig do it on 220!

By Wayne Overbeck,* K6YNB/N6NB

Of all our vhf bands, 220 MHz may be the most promising. For fm enthusiasts, it offers the same reliable mobile communications possibilities as 2 meters, but without the crowds. And for ssb/cw enthusiasts, it's an exciting new world of DX possibilities. Veteran 220-MHz DXers say the tropospheric propagation is often much better than it is on 2 meters — and yet the high-gain antennas needed for serious DXing are fully a third smaller than on 2 meters!

This article describes a self-contained unit that will put any of the popular 2-meter fm or ssb/cw rigs on 220. It will deliver about 30 watts of power output on 220. The receiver section offers a noise figure about 2 dB — better than most commercial 2-meter units. By itself, this transverter is ideal for local and medium-range work on fm, ssb or cw. For serious DXing, it offers sufficient output to drive an external amplifier to the legal limit.

## Design Approach

In this transverter the main goal was to keep things as simple as possible by staying with proven conventional circuits. In most stages tubes are used instead of solid-state devices. The dual tetrode specified here is self-neutralized, which makes it suitable for stable circuits that are somewhat forgiving of inexact construction methods and incorrect tuning. Also, these tube types are often found in surplus uhf-fm equipment, which means "pullouts" can often be bought at low prices. Moreover, the high-Q circuits built around these tubes are much less prone to have objectionable spurs than would be true in a solid-state design using the same conversion scheme.

## Circuit and Construction Details

A 7-1/2 × 11 × 8-inch (190 × 280 × 200-mm) cabinet houses the whole works, although a slightly larger enclosure may

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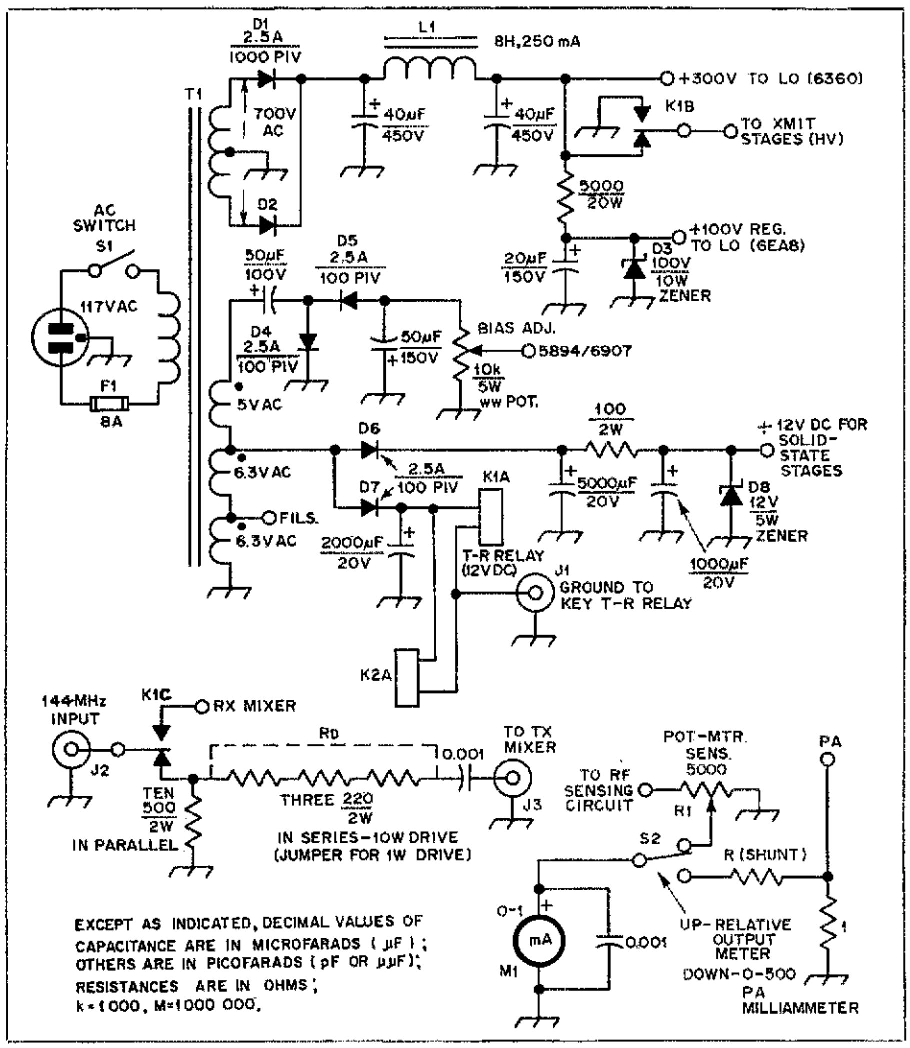



Fig. 1 — Power supply, control and metering circuits. T1 may be a TV-receiver power transformer or equivalent, provided the secondary can handle 450 to 500 mA. The shunt resistor (R shunt) in the metering circuit has a value determined by $R_s$ = 500 ohms less the internal resistance of the meter. The series-drive resistor, $R_d$, consists of three 220-ohm 2-watt resistors in series for a 10-watt drive. A jumper across these resistors is used for 1-watt drive. Placing S2 in the up position permits the meter to read relative output. In the down position the meter serves as a 0- to 500-mA meter for the PA. See Fig. 3 for other connections for K2.

D1, D2 — Diode rectifier, 2.5 A, 1000 PIV.

D3 — Zener diode, 100 V, 10 W.

D4-D7, incl. — Diode rectifier, 3A, 100 PIV.

D8 — Zener diode, 12 V, 5 W.

J1-J3, incl. — BNC connector.

L1 — Filter choke, 8 H, 250 mA.

M1 — 0-1 milliammeter.

R1 — 5000-ohm, linear taper, carbon potentiometer.

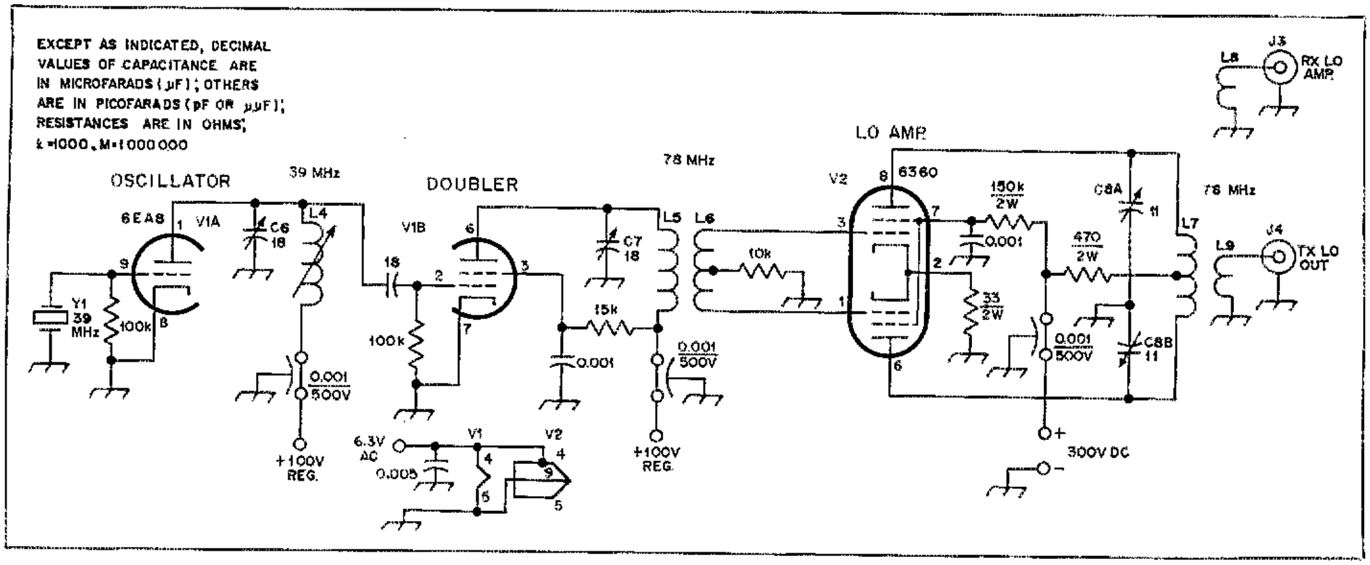



Fig. 2 — The transceiving converter local-oscillator chain. The 39-MHz crystal may be obtained from sources appearing in the *QST* Ham-Ads.
C6, C7 — 2- to 18-pF variable capacitor (E. F. Johnson type 160-110 or equiv.).
C8 — 2- to 11-pF butterfly variable capacitor (E. F. Johnson type 160-211 or equiv.).
J3, J4 — BNC connector.
L4 — 7 turns, no. 28 enam. on 3/8-inch dia form, ceramic, iron core.
L5 — 3 turns, no. 18 solid-covered, 5/8-inch dia, air wound.
L6 — 5 turns, no. 18, solid covered, air wound, 5/8-inch dia, center tapped.
L7 — 8 turns, no. 18, solid covered, air wound, 5/8-inch dia, center tapped.
L8 — 1 turn, no. 18, solid covered, 3/4-inch from either end of L7.
L9 — 2 turns, no. 18, solid covered, 3/4-inch dia around L7.
Y1 — 39-MHz crystal.

simplify the packaging job. The power-supply components are the dominant influence on the cabinet dimensions.

A good place to start in a project such as this is to build the power supply and relay circuitry as a foundation for the more critical rf work to follow. As Fig. 1 shows, the power supply uses a television-replacement power transformer that has two 6-volt filament windings along with its 5-volt winding. These windings should be connected in series to derive 12 and 17 volts ac. These voltages are rectified (and the 17 volts is doubled) for the relay, receiver and bias supplies. A simple ground-to-transmit T-R switching arrangement is used which is compatible with most multimode transceivers. When the T-R relay is energized, high voltage is applied to the transmit stages, the 2-meter input is switched, and a coaxial relay switches for antenna changeover.

The input swamping network shown in Fig. 1 is suitable for 10 to 15 watts of drive. The three 200-ohm resistors in series may be jumpered for use with 1-watt rigs.

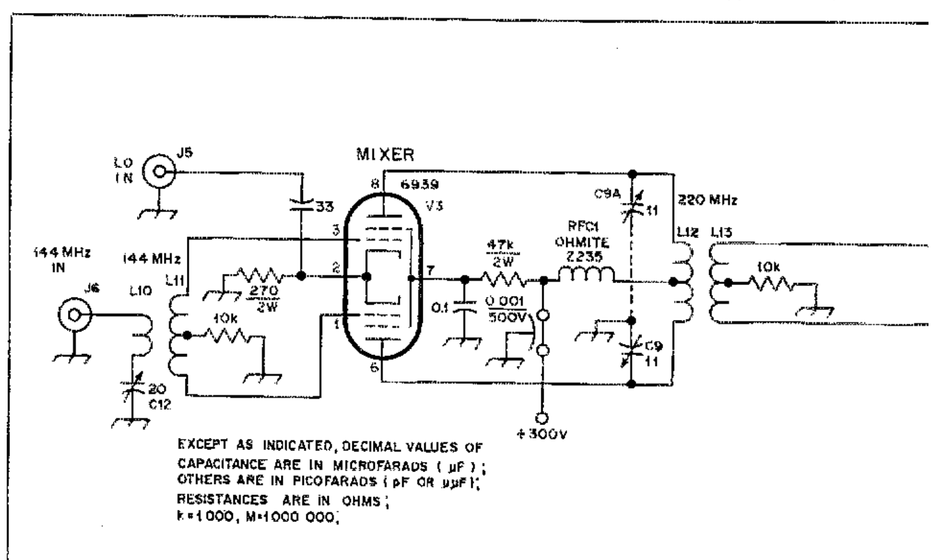
Once the power supply and relay systems are working, build the local oscillator chain, as shown in Fig. 2. Select a suitable crystal frequency from Table 1 and build the chain in a small box. The author made all the boxes for his subassemblies by soldering together pieces of double-sided pc board. The LO circuitry is generally noncritical, except that the 6360 output should be isolated from the input with a shield across the tube socket — just as is done in the transmitter stages shown in the accompanying photograph.

**Table 1**
**Local Oscillator Crystal Plan**

| *For output on:* | *With an i-f of:* | *Use xtal for:* |
|---|---|---|
| 220.0 MHz[1] | 144.0 MHz | 38.0 MHz |
| 224.0 | 148.0 | 38.0 |
| 222.0 | 144.0 | 39.0 |
| 225.0 | 147.0 | 39.0 |
| 223.5[2] | 146.52 | 38.49 |

Note 1: Most ssb/cw activity is at 220 MHz on the East Coast, but at 222 MHz on the West Coast.
Note 2: 223.5 is the national simplex frequency.

Fig. 3 — Transmitting stages of the 220-MHz transverter. The screen resistor may be adjusted to keep the screen voltage for the 6907/5894 at the rated level. All plate rf chokes are Ohmite type Z235. See Fig. 1 for other connections for K2.
C9, C10 — 2-11 pF per section butterfly variable capacitor (E. F. Johnson type 160-211 or equiv.).
C11 — 2-10 pF per section butterfly variable capacitor (E. F. Johnson type 167-201 or equiv.).
C12, C13 — 2-20 pF single-section variable capacitor (E. F. Johnson type 160-110).



In building the entire transverter, follow normal vhf construction practices. Keep all leads as short as possible and separate input and output tuned circuits as much as possible in each stage. There are two output loops for the 6360 LO amplifier stage — a tightly coupled one for the transmit mixer and one loosely coupled for the receive mixer.

The receiving mixer is a prepackaged broadbanded unit. One suitable model is the SRA-1, sold by Mini-Circuits Laboratory, 2625 East 14th Street, Brooklyn, NY 11235, at $9.95 each (at the time of this printing) in single quantities. The receiving preamplifier consists of two WB6NMT grounded-source JFET stages.[1]

The transmitter section should be built with a layout similar to that shown in the photograph, using a shield across each tube. If this layout is followed, there should be no instability problems. The author used a 3 × 3 × 11-inch (76 × 76 × 280-mm) sub-chassis for the transmitter section with a small enclosure on top for the final amplifier plate circuitry.

In the transmit mixer stage, it is important to inject the LO signal at the cathode and not at the more sensitive control grid. This is to help suppress the third harmonic of the LO, which falls near 234 MHz. Care must also be exercised in the tune-up process to avoid the false peak at that frequency. With proper tune-up, the spur is attenuated sufficiently to satisfy the "good engineering practice" requirement.

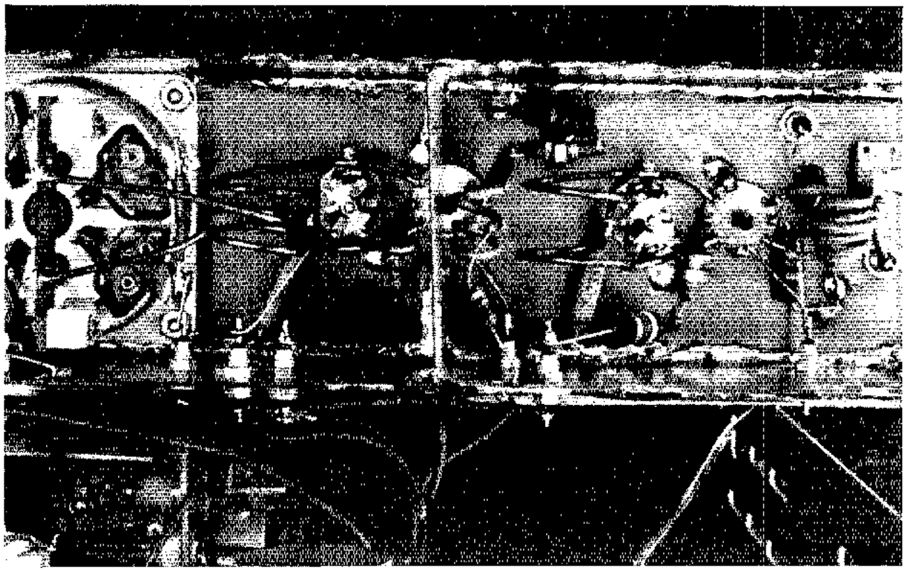
A 5894 tube with 600 volts on the plates can be used in the PA instead of the 6907 shown here. About 75 watts output is attainable with this configuration, although the PA enclosure will have to be enlarged to accommodate the taller tube.

The metering circuitry uses a 0- to 1-mA meter as a final amplifier cathode current monitor and a relative output indicator. Meter shunt values are determined from information given in the measurements section of *The Radio Amateur's Handbook.*

## Tune-up and Initial Testing

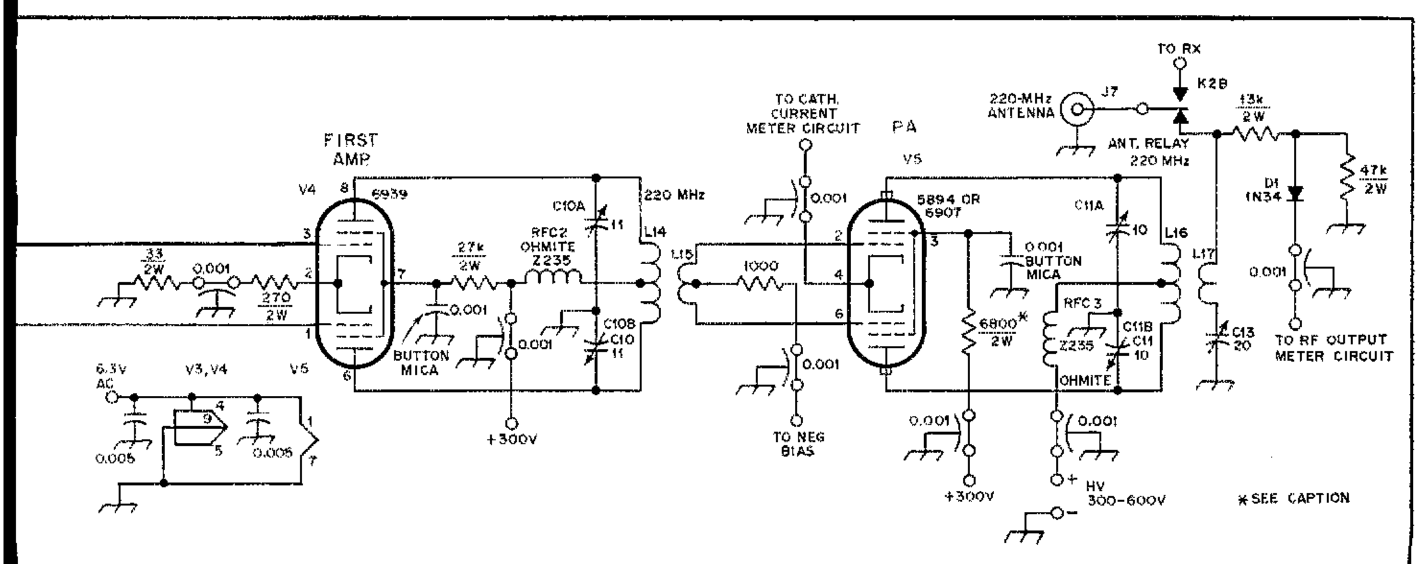
As soon as the power supply and local oscillator chain are built, testing can begin. With a dip meter, set the tuned circuits to the correct frequency and apply dc power. Place the meter in the diode-detector mode. Check for the 38-MHz oscillator signal. Adjust C6 and L4 for the point of maximum output that does not cause the stage to stop oscillating. Next, peak C7 and C8 for maximum indicated output at 78 MHz. The 6360 LO amplifier should deliver 1-3 watts for the transmit mixer and about 5 mW (+7 dBm) for the receive mixer. It may be necessary to adjust the output links to obtain these output levels. If in doubt, couple the LO output very loosely to the receive mixer at first, and only increase the coupling if the LO injection is clearly inadequate. The

[1] "WB6NMT Low-Noise 220-MHz Preamplifier," The World Above 50 Mc., *QST*, March, 1972, page 100.



Construction of the transmit mixer (left), and driver circuitry. Note the manner in which the i-f signal is coupled into the mixer grids. The LO signal is capacitively coupled to the cathode of the 6939. Several feedthrough capacitors are soldered to the pc board to provide low inductance rf ground paths. The 6939 driver stage is loosely coupled to the mixer plate circuit.

D1 — Signal diode, 1N34.
J5, J6 — BNC connector.
L10 — 1 turn, no. 18, 1/2-inch dia, closely coupled to L11.
L11 — 4 turns, no. 18, 3/8-inch dia, center tapped.
L12, L14, L16 — 2 turns, no. 12 solid copper, 1-1/8-inch dia, spaced 1/2 inch, center tapped.
L13 — 3 turns, no. 18, 3/8-inch dia, center tapped.
L15 — 1 turn no. 12, 1-inch dia.
L17 — 1 turn, no. 18, 7/8-inch dia, closely coupled to L16.
RFC1-RFC3, incl. — Ohmite no. Z235.



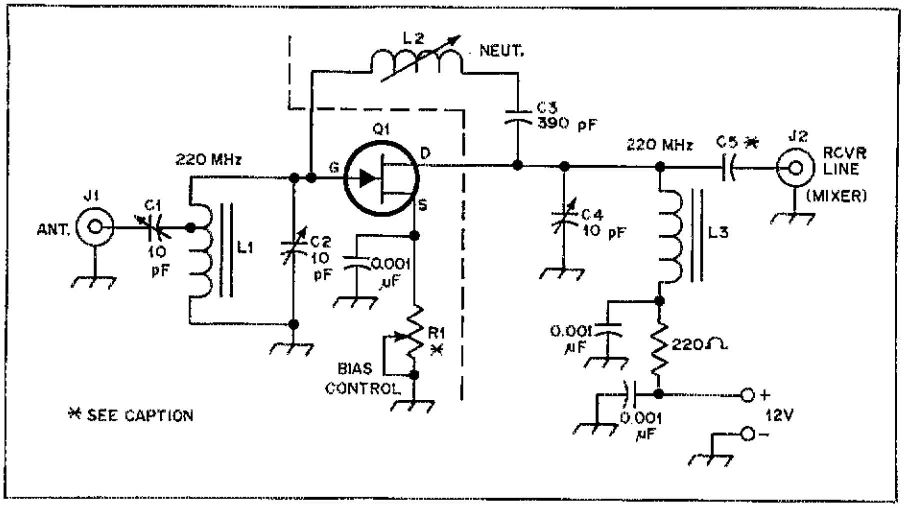



Fig. 4 — The WB6NMT low-noise 220-MHz preamplifier (March 1972 *QST*). Two of these are required, as shown in the block diagram.

C1 — 0.8 or 1- to 10-pF glass trimmer (Johanson 2950 or JFD VAM or MVM series).
C2 — Like C1, or Corning Direct Traverse CGW, 0.8 to 10 pF.
C3 — 390-pF, silver mica.
C4 — Like C1, C2 or less-expensive type with 1- to 10-pF range.
C5 — Experiment with values 1 to 5 pF, for maximum gain in system as it will be used.
J1, J2 — BNC connector.
L1 — 4 turns no. 22 enam. wire on Micrometals T-30-0 toroid core (Amidon Associates). Tap one turn from top, subject to adjustment for lowest NF. (Air-wound coils also usable, but toroids preferred.)
L2 — 9 turns no. 28 enam. wire on 1/4-inch, (6 mm) slugtuned form (Miller 4500, brass slug). Do not ground the slug.
L3 — Like L1, but no tap.
Q1 — 2N5245, 2N5486, MPF107 or TIS-88.
R1 — 200- or 250-ohm control, linear taper potentiometer, 1 watt.

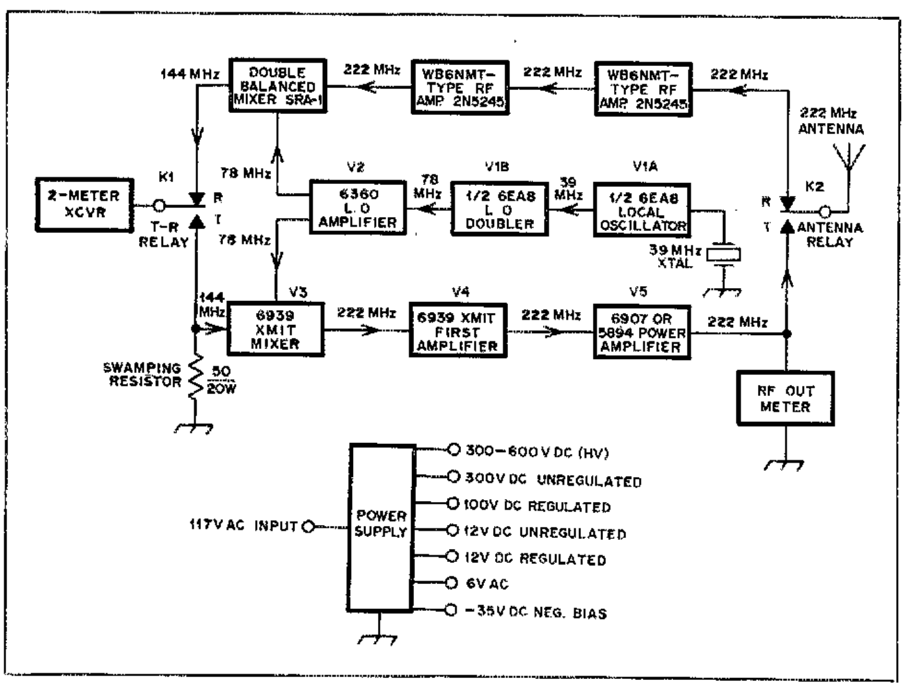



Fig. 5 — This block diagram of the 144- to 220-MHz transverter is a fourth-generation design, the latest in a series of transverters the author has built over a number of years. High-Q circuits reduce the possibility of objectionable spurs.

mixer can be destroyed by excessive LO input. As a final check of the LO chain, unplug the crystal. The output should disappear completely, indicating freedom from spurious oscillations.

When the transmitter section has been constructed and the tubes plugged in, resonate each tuned circuit to 220 MHz while observing the dip meter. Then connect the LO and i-f injection cables and a dummy load. Now key the T-R relay with no drive present and quickly adjust the final amplifier bias to produce 50 mA of idling current. Apply a 144-MHz signal and tune the mixer plate circuit for maximum indicated signal at 220 MHz, again using the dip meter as a detector. Peak each transmitter stage in succession for maximum output at 220 MHz, varying the interstage coupling if necessary. Once a wattmeter indicates substantial power output, remove the drive and be sure there is no indicated output. If there is, you have probably tuned up on the third harmonic of the LO. If this has happened, increase the capacitance in all LC circuits and go through the tuning process again.

### Operating and Application Notes

After it is properly tuned up on the desired frequency, the transverter may be moved up or down about 500 kHz without retuning the transmit or receive stages. Those wishing broadband coverage at the expense of maximum power output and receiver sensitivity may want to stagger-tune the transmit and receive rf stages.

If the unit is to be used primarily to work through fm repeaters, it may be desirable to peak the transmit stages around 223 MHz while peaking the receive stages 1.6 MHz higher. To access repeaters using the 1.6-MHz split, there are two approaches with this unit. One is to add a second local oscillator at a frequency 1.6 MHz higher than the one used for transmitting. For occasional repeater users, a simpler method is to set the 2-meter rig for a 600-kHz offset and then switch the megahertz dial on the transceiver one position when going from transmit to receive.

For DX work, most operators will probably prefer to mount the receiving preamplifier at the antenna relay of a kilowatt final and disable the antenna changeover relay in the transverter. This avoids the losses inherent in the additional cabling and relays.

### Conclusion

Should someone offer you an all-mode all-frequency 220-MHz rig with the performance range of your new 2-meter pride and joy, you most assuredly would not turn the offer down. The likelihood of such a generous proposition becoming a reality in your amateur radio life, in all probability, may be rather remote. Nevertheless, if the concept of having your "do everything" 2-meter rig do its thing on 220 MHz appeals to you, then begin your equipment building plans now. The rewards justify the effort. In fairness, however, I must caution that this is not an endeavor for the beginner.

What has been described here is not a one-evening project, but neither should it be overwhelming if the builder attacks one section at a time. As 220-MHz DX enthusiasts and those who have discovered the quiet world of 220 fm will tell you, building such a system is well worth the effort!