HAM TIPS

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Transistors and Nuvistors In a Two-Meter Transceiver

By R. M. Mendelson, W2OKO*

RCA Electronic Components and Devices

Part I

Dramatic strides in electronics attending the introduction and full growth of the transistor have been accompanied by far-reaching effects in the field of ham equipment, where — almost daily — radio amateurs are being advised of new, ingenious designs proclaiming the versatility, compactness, and high quality of advanced solid-state gear.

In a two-part article commencing with this issue and ending in the Summer, 1965, issue of HAM TIPS, W2OKO offers readers a novel departure from the more conventional, transistorized apparatus — a two-meter transceiver that utilizes both transistors and RCA nuvistors to achieve an effective compromise in all-around economy and operating efficiency.

Constructed more than seven months ago, this unique rig already has been used by the author in hundreds of successful QSO's at ranges up to, and exceeding, 100 miles.

Figure 1: W2OKO's two-meter transceiver features large dial with vernier for easy tuning. All operating controls of the unit are located on the front panel.

*Commercial Receiving Tube and Semiconductor Division, Somerville, New Jersey

Although a sufficient number of high-frequency transistor types are available to construct an all-transistor transceiver, the high cost of these types makes their use impractical — if not prohibitive. An investigation of RCA nuvistors by the author showed these tiny metal-ceramic tubes to be far more economical — even after due consideration of the high-voltage supply they require. As a result, nuvistors were employed in both the receiver and transmitter sections of the unit.

The block diagram and schematic drawing (Figures 2 and 3, respectively) reveal in detail the several features that are incorporated in the design of the transceiver. In addition to this, of course, a versatile power transformer is required to permit operation from either a 12-volt automobile or 117-volt residential source. Transformers meeting such requirements are readily available, and can serve very well in operating either directly from line voltage or from a 12-volt-DC source as part of a DC-to-DC converter. The proper circuitry is automatically chosen by the power plug that is used.

If a reasonably good antenna is employed, the transmitter power level is more than adequate for mobile operation, local net contacts, and field-day work.

[1]Mendelson, R. M., "Nuvistor Two-Meter Converter," Ham Tips, Volume 21, No. 2, May, 1961.

Basic Design Concepts

The 144-Mc receiver front-end is a well-proven unit previously described in HAM TIPS.[1]

The first intermediate frequency selected was 11.7 megacycles. This is sufficiently high to give good front-end image rejection and allow use of commercial transformers. It is also possible to broad-tune this stage for a 4-megacycle bandwidth from 9.7 Mc to 13.7 Mc.

Because the bandwidth of the first IF stage is broad enough to afford coverage of the entire 2-meter band, the front-end of the receiver is fixed-tuned. As a result, no tracking problems exist. Station selection is accomplished by tuning the second-converter variable-frequency oscillator.

The second intermediate frequency selected was one megacycle. Consequently, when the oscillator is set one megacycle above the 9.7-Mc signal (144 Mc), it is also possible to convert the signal at 11.7 Mc (146 Mc) down to one megacycle. In this way, use is made of the customarily rejected image to provide simultaneous reception of 144-146 megacycles and 146-148 megacycles. On most bands, this arrangement would be chaotic. On two meters, however, where most of the stations operate below 146 megacycles, it provides a simple way of tuning the entire band without tracking problems.

The transistor oscillator and buffer are ex-

(Continued on page 6)

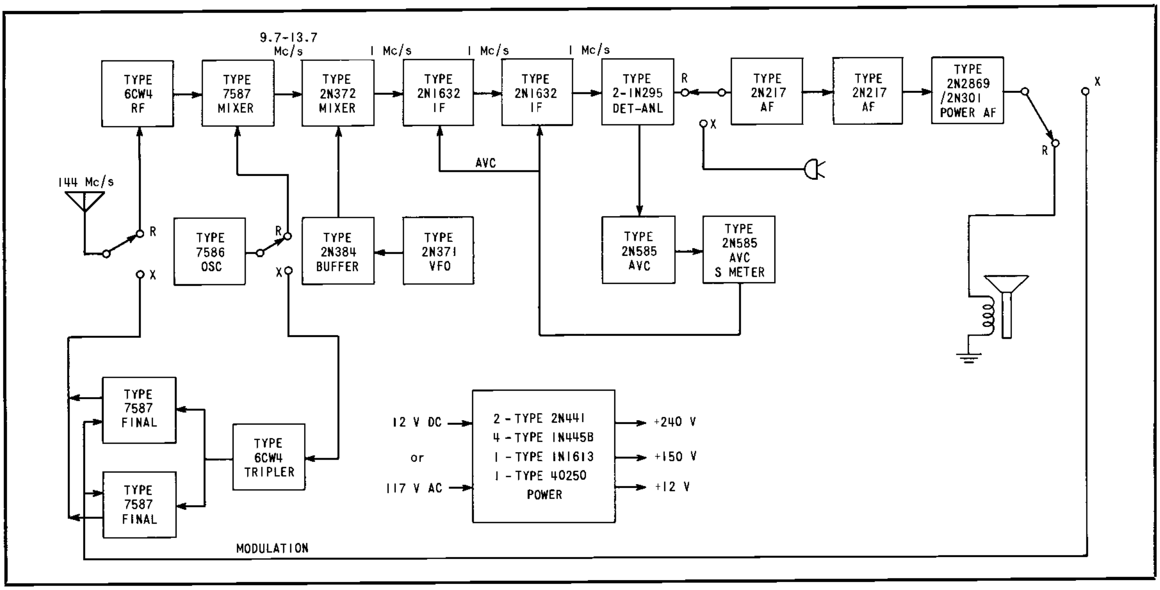
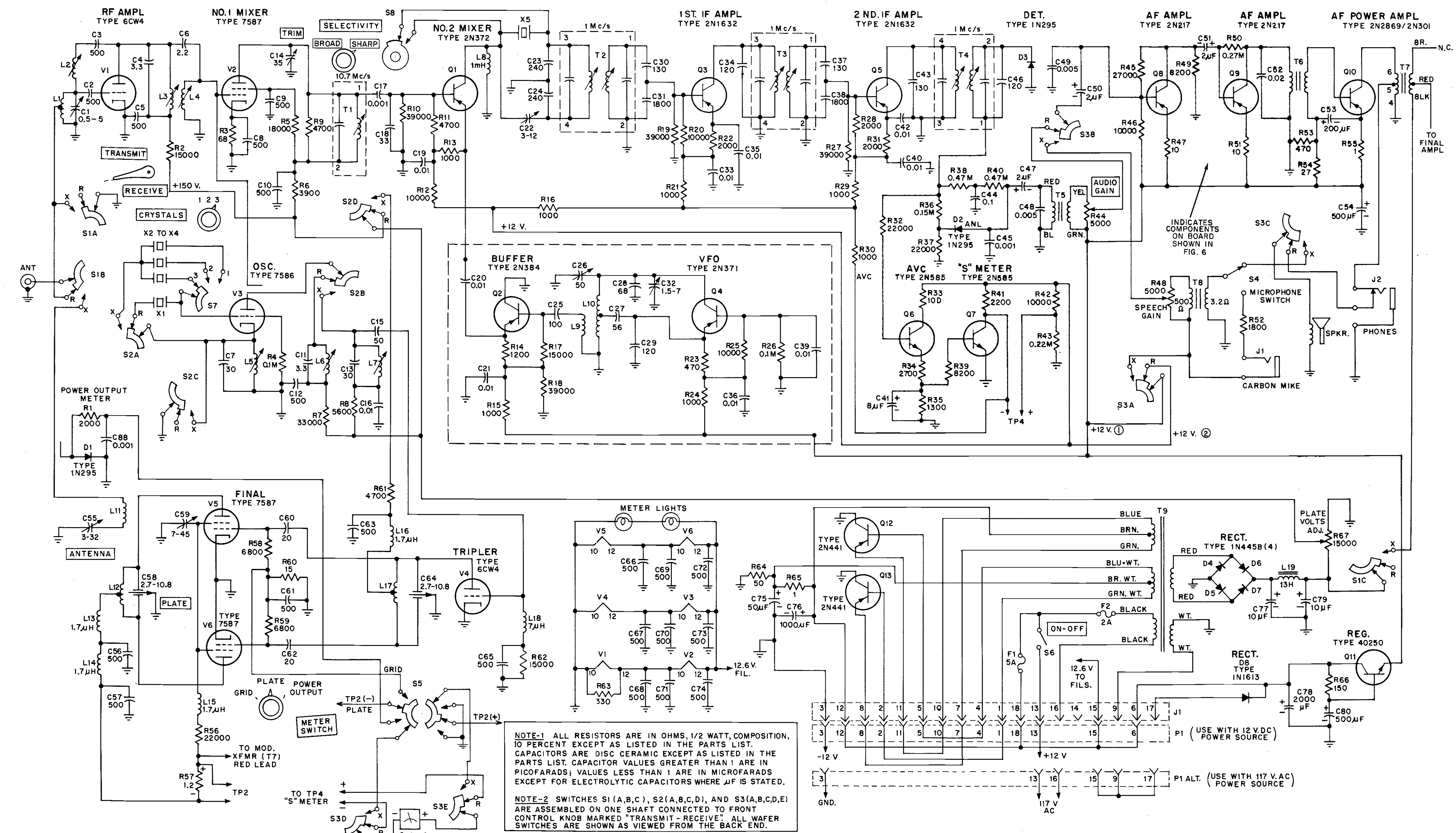


Figure 2: Block diagram of W2OKO's two-meter transceiver shows all RCA nuvistor and transistor types employed in the unit, together with their individual circuit assignments.



C_1—0.5 to 5.0 pf tubul
(Erie 532A or equiv.)
C_4, C_{11}—3.3 pf ceram
Centralab TCZ 3R3 or
C_5, C_8, C_9, C_{10}—500 pf
ton (Erie 662-003-501
C_6—2.2 pf ceramic tu
tralab TCZ-2R2 or equ
C_{13}—30 pf tubular cer
tralab TCZ-30 or equ
C_{14}—35 pf air variable
lund HF35 or equiv.)
C_{15}—50 pf tubular cer
tralab TCZ-50 or equi
C_{22}—3 to 12 pf ceram
(Erie 557-17R or equiv
C_{24}, C_{25}—240 pf silve
menco DM10-241 or e
C_{26}—50 pf air tuning
(Hammarlund MC-50S
C_{27}—56 pf silver mica
DM10-560 or equiv.)
C_{28}—68 pf silver mica
DM10-689 or equiv.)
C_{29}, C_{34}, C_{46}—120 pf
(Elmenco DM10-121 c
C_{30}, C_{37}, C_{43}—130 pf
(Elmenco DM10-131 c
C_{32}—1.5-7.0 pf ceram
NPO (Erie 503-10R or
C_{41}—8 µf electrolytic
(Sprague TE-1149 or e
C_{44}—0.1 µf paper (Aer
V161 or equiv.)
C_{47}, C_{50}, C_{51}—2 µf ele
volt (Sprague TE-1149
C_{53}—200 µf electroly
(Sprague TE-1064 or
C_{55}—3 to 32 pf air capa
son 160-130 or equiv
C_{58}, C_{64}—2.7 to 10.8
air capacitor (Johnso
or equiv.)
C_{59}—7 to 45 pf ceram
(Erie 503-33R or equi
C_{60}, C_{62}—20 pf ceram
(Centralab TCZ-20 or
C_{75}—50 µf electrolyti
(Sprague TE-1160 or
C_{76}—1,000 µf electroly
(Cornell BR-2000-15 o
C_{77}, C_{79}—10 µf, 450 v
FP234 Dual or equiv.)
C_{78}—2,000 µf electroly
(Cornell BR-2000-15 o
C_{80}—500 µf electrolyt
(Cornell BR-500-15 or
L_1—5 turns, No. 16 ba
inch (spaced wire) di
2 turns up from bott
L_2—12 turns, No. 26
wire on ¼-inch-diam
form (Miller No. 43
or equiv.)

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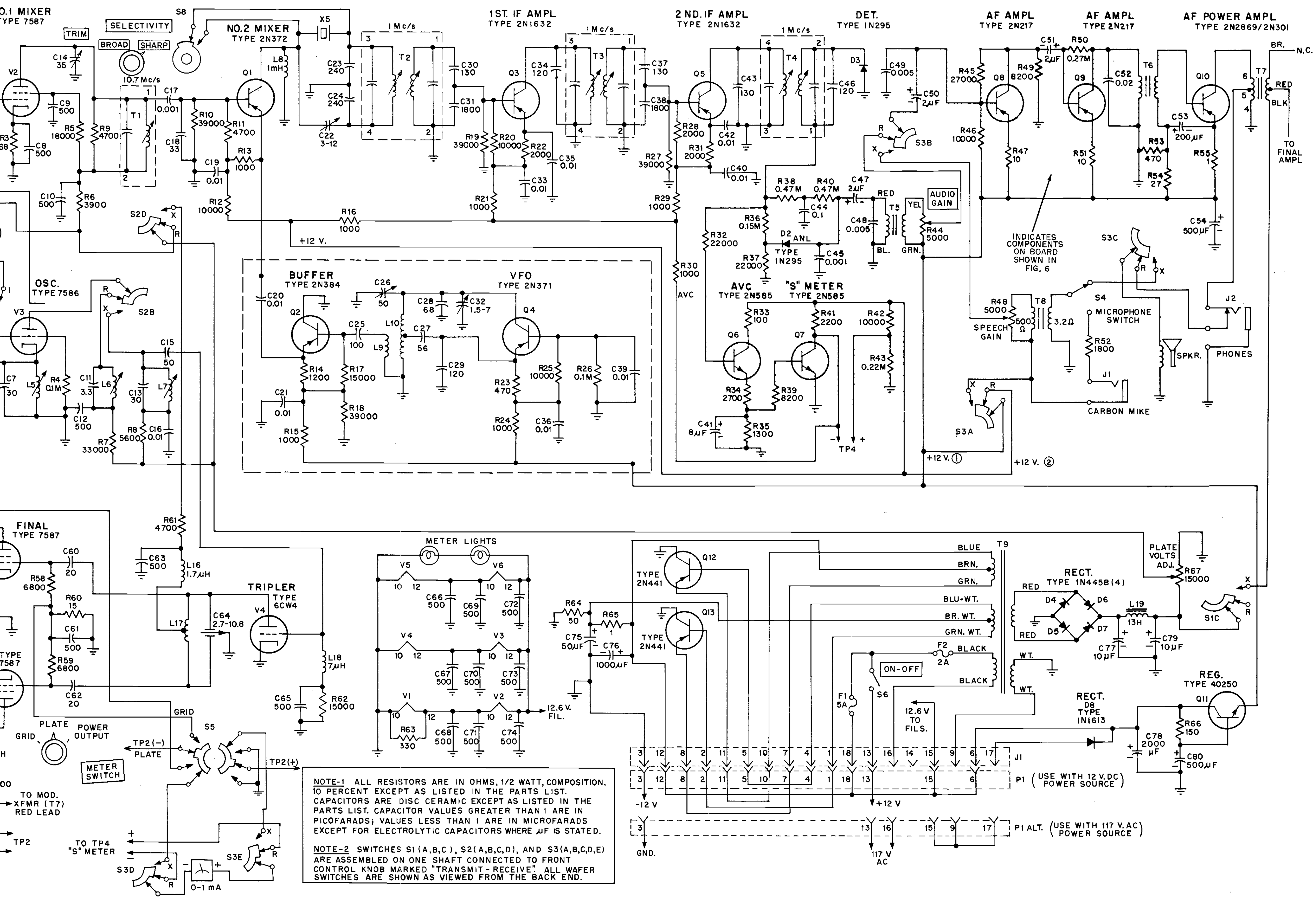
Figure 3: S
W2OKO's t



C_1—0.5 to 5.0 pf tubular trimmer (Erie 532A or equiv.)
C_4, C_{11}—3.3 pf ceramic tubular Centralab TCZ 3R3 or equiv.)
C_5, C_8, C_9, C_{10}—500 pf silver button (Erie 662-003-501J or equiv.)
C_6—2.2 pf ceramic tubular (Centralab TCZ-2R2 or equiv.)
C_{13}—30 pf tubular ceramic (Centralab TCZ-30 or equiv.)
C_{14}—35 pf air variable (Hammarlund HF35 or equiv.)
C_{15}—50 pf tubular ceramic (Centralab TCZ-50 or equiv.)
C_{22}—3 to 12 pf ceramic trimmer (Erie 557-17R or equiv.)
C_{24}, C_{25}—240 pf silver mica (Elmenco DM10-241 or equiv.)
C_{26}—50 pf air tuning capacitor (Hammarlund MC-50S or equiv.)
C_{27}—56 pf silver mica (Elmenco DM10-560 or equiv.)
C_{28}—68 pf silver mica (Elmenco DM10-689 or equiv.)
C_{29}, C_{34}, C_{46}—120 pf silver mica (Elmenco DM10-121 or equiv.)
C_{30}, C_{37}, C_{43}—130 pf silver mica (Elmenco DM10-131 or equiv.)
C_{32}—1.5-7.0 pf ceramic trimmer NPO (Erie 503-10R or equiv.)
C_{41}—8 μf electrolytic, 15 volt (Sprague TE-1149 or equiv.)
C_{44}—0.1 μf paper (Aerovax V84C-V161 or equiv.)
C_{47}, C_{50}, C_{51}—2 μf electrolytic 15 volt (Sprague TE-1149 or equiv.)
C_{53}—200 μf electrolytic, 3 volt (Sprague TE-1064 or equiv.)
C_{55}—3 to 32 pf air capacitor (Johnson 160-130 or equiv.)
C_{58}, C_{64}—2.7 to 10.8 pf butterfly air capacitor (Johnson 160-211 or equiv.)
C_{59}—7 to 45 pf ceramic trimmer (Erie 503-33R or equiv.)
C_{60}, C_{62}—20 pf ceramic tubular (Centralab TCZ-20 or equiv.)
C_{75}—50 μf electrolytic, 15 volt (Sprague TE-1160 or equiv.)
C_{76}—1,000 μf electrolytic, 15 volt (Cornell BR-2000-15 or equiv.)
C_{77}, C_{79}—10 μf, 450 volt (Mallory FP234 Dual or equiv.)
C_{78}—2,000 μf electrolytic, 15 volt (Cornell BR-2000-15 or equiv.)
C_{80}—500 μf electrolytic, 15 volt (Cornell BR-500-15 or equiv.)
L_1—5 turns, No. 16 bare wire, ¼-inch (spaced wire) diameter, tap 2 turns up from bottom
L_2—12 turns, No. 26 enamelled wire on ¼-inch-diameter slug form (Miller No. 4300 Ceramic or equiv.)
L_3, L_4—4 turns, No. 26 enamelled wire closewound on ¼-inch-diameter slug form (Miller 40A000-CBI Ceramic or equiv.)
L_5—4 turns, No. 26 enamelled wire closewound on ⅜-inch-diameter phenolic slug form (Miller 21A-000RBI or equiv.)
L_6—5 turns, No. 26 enamelled wire closewound on ¼-inch-diameter slug form (Miller 40A000CBI or equiv.)
L_7—4 turns, No. 26 enamelled wire, ⅜-inch (spaced wire) diameter phenolic slug form (Miller 21A-000RBI or equiv.)
L_8—1 mh (National or equiv.)
L_9—2 turns, air wound ½-inch diameter from same miniductor as L_{10} (B & W 3003 or equiv.)
L_{10}—21 turns, air wound, ½-inch diameter, tap 2 turns up from ground (B & W Miniduct 3003 or equiv.)
L_{11}—1 turn, No. 14 bare wire, ¾-inch diameter and "spaghetti" insulated
L_{12}—5 turns, No. 14 bare wire, ½-inch diameter, ⅝-inch long and tapped at center
L_{13}, L_{14}, L_{15}, L_{16}—1.7 μh choke (Ohmite Z144 or equiv.)
L_{17}—4 turns, No. 16 bare wire, ½-inch diameter ⅝-inch long and tapped at center
L_{18}—7μh choke (Ohmite Z-50 or equiv.)
L_{19}—13h 65 ma choke (Stancor C1708 or equiv.)
Meter—0 to 1.0 ma, with 0-5 and 0-10 scales and "S"-meter scale (Lafayette 99G 2513 or equiv.)
R_2—Composition, 15,000 ohm, 1 watt
R_7—Composition, 33,000 ohm, 1 watt
R_8—Composition, 5,600 ohm, 1 watt
R_{44}, R_{48}—5,000 ohm, carbon potentiometer
R_{53}—Composition, 470 ohm, 1 watt
R_{54}—Composition, 27,000 ohm, 1 watt
R_{55}—1 ohm, 1 watt (Ohmite axial lead 4330 or equiv.)
R_{56}—Composition, 22,000 ohm, 1 watt
R_{57}—Composition (5%), 1.2 ohm, ½ watt
R_{63}—Composition, 330 ohm, 1 watt
R_{64}—50 ohm, 10 watt, wirewound (Ohmite Brown Devil 1718 or equiv.)
R_{65}—1 ohm, 5 watt (Ohmite Axial Lead 4530 or equiv.)

(Parts list continued on page 6)

Figure 3: Schematic diagram and parts list of W2OKO's two-meter transceiver.

(Parts list continued from preceding page)

R_{66}—Composition, 150 ohm, 1 watt
R_{67}—15,000 ohm, slide wire, 25 watt (Ohmite 0387 or equiv.)
S_1—3 pole, 5 position, non-shorting, ceramic (Centralab PA5 Section)
S_2—5 pole, 3 position, non-shorting, ceramic (Centralab PA7 Section)
S_3—5 pole, 3 position, shorting, ceramic (Centralab PA6 Section)
(Note: S_1, S_2, and S_3 joined on same 6-inch shaft assembly—Centralab PA302)
S_4, S_6—SPST Toggle
S_5—2 pole, 3 position, miniature (Grayhill Series 5000 or equiv.)
S_7—1 pole, 3 position (Centralab 1461 or equiv.)
S_8—1 pole, 2 position (Centralab 1460 or equiv.)
T_1—10.7-Mc transformer (use primary only), (Miller 1601 or equiv.)
T_2, T_3, T_4—1.5-Mc transformer (tuned to 1.0 Mc by extra capacitors in circuit), (Miller 13-W1 or equiv.)
T_5—Audio transformer, 20,000 ohms to 800 ohms (Lafayette Argonne AR151 or equiv.)
T_6—Audio transformer, 10,000 ohms to 15 ohms (Lafayette Argonne AR110 or equiv.)
T_7—Audio universal transformer, used in reverse, 8 watt (Stancor A3850 or equiv.)
T_8—Audio transformer, 500 to 3.2 ohms (Lafayette Argonne AR119 or equiv.)
T_9—Power transformer: primaries 12-volt DC or 117-volt AC; secondaries 280-volt DC at 150 ma and 12.6-volt AC at 3 amps (Stancor P8195 or equiv.)
X_1—Crystal, third overtone 44.766 Mc, style FA5 holder for receivers
X_2, X_3, X_4—Crystals for transmitter, 48.0000 to 49.3333 Mc, third overtone, style FA5 holders
X_5—1-Mc fundamental for filter

Miscellaneous—Sockets for nuvistors and transistors; terminal board pre-punched with lugs (see text); chassis 12 inches by 8 inches by 3 inches; cabinet (Bud SB2140); heat sink for 2N2869; speaker (3½-inch diameter, 3.2 ohm); 18-pin male socket (Jones P318SB or equiv.); and two 18-pin female plugs (Jones S318CCT or equiv.)

(Continued from page 2)

tremely stable in this transceiver; the RCA-2N371 was originally designed and tested especially for stable oscillator operation at even higher frequencies. The 2N384 buffer prevents loading of the oscillator.

The six tuned circuits in the IF stages, together with the 1-Mc crystal filter (X_5), provide adequate selectivity. If a high degree of selectivity is not deemed necessary, the builder may omit the crystal unit from the circuit.

A simple, yet important, innovation in the transceiver is the use of the receiver speaker as a microphone in the transmit position. *No longer need the amateur be concerned over the fact that he forgot his microphone at home!* The transceiver, however, also incorporates a jack for a conventional carbon microphone.

Use of the same nuvistor crystal oscillator for receiving and transmitting eliminates the need for a socket and tube. The proper crystal is chosen by the send-receive switch, S_2. Extra crystal sockets and a switch (S_7) are provided to allow a choice of three transmitting frequencies.

Initial operation of the transceiver from AC power lines led to the presence of excessive ripple in the 12 volts supplied to the transistors. The additional filtering capacitance required to eliminate the ripple was subsequently provided by the regulator circuit utilizing transistor, Q_{11}. This circuit acts as a capacitance multiplier and adds approximately 10,000 microfarads of capacitance to the filter circuit.

The multi-scale-type meter is used both for transmitter tuning and for measuring signal strengths. In the transmit position of S_3, the meter can be switched to measure the grid or plate current or the power output from the final amplifier. In the receive position, the meter functions as an "S" meter.

Construction

As in all VHF circuitry, the layout of this transceiver requires proper parts-orientation and short leads. If the general layout shown in Figures 4 and 5 is followed, no trouble should be encountered in either the transmitter or the receiver units. Special care should be taken to make certain that the parts are located so as not to interfere with the send-receive switch mounted on the main chassis.

A good solder joint between the nuvistor sockets and the brass plate will ensure solid grounding of the nuvistor shell to provide noise-and-oscillation-free operation.

The author took full advantage of the small size and low-voltage requirements of transistors by mounting all audio circuits — except the power amplifier — on a phenolic board, thus utilizing space under the chassis that otherwise might have been wasted. Detailed in Figure 6, this terminal board was hand

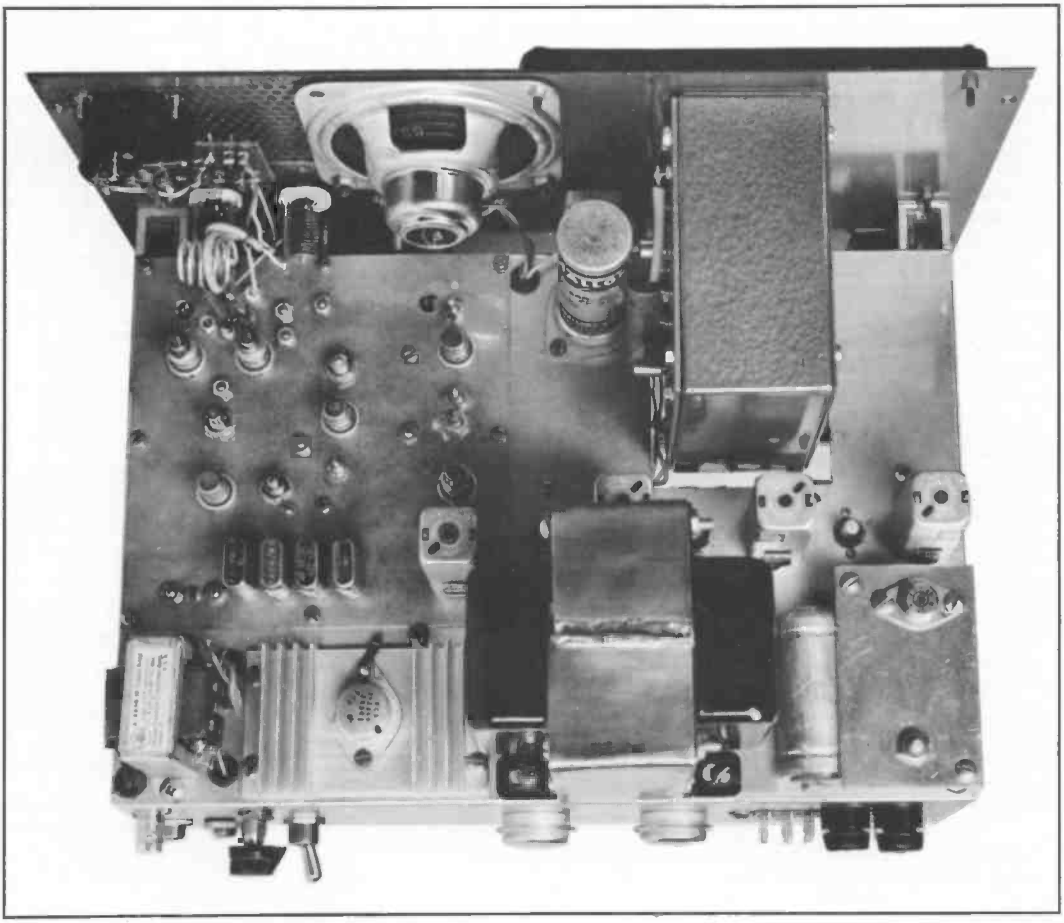


Figure 4: Top view of transceiver shows locations of nuvistors, transistors, and other major components. Incorporated on back of chassis are the microphone jack, speech-gain control, microphone switch, earphone jack, antenna connection, and the transceiver's power plug and fuses.

drilled and fitted with Alden #651T lugs. It can be duplicated by use of pre-drilled boards and lugs made by Vector (85F24EP board and T 9.4 lugs) or any other such manufacturer. To prevent local motorboating or feedback howls, it is recommended that no appreciable deviation in layout be made. For example, audio transformer T_5 — originally mounted on the audio-AVC-ANL terminal — was relocated near the front of the chassis to eliminate a hum caused by magnetic pickup from the power transformer above the chassis. Relocation of T_5 greatly reduced the hum; but the placement of a shorted loop of copper around the outside of the power transformer core virtually eliminated the disturbance through dissipation of the radiated energy.

To minimize the magnetic coupling between the two transformers (T_5 and T_9), an aluminum chassis and cabinet are recommended to all builders of the transceiver.

The 12-volt rectifier and the regulator transistor, Q_{11}, are mounted on a 2-inch-by-3-inch-by-1/8-inch aluminum plate that is insulated (electrically) from the main chassis, and is an adequate heat sink for those components.

To dissipate the heat generated in the audio power stage, Q_{10} — especially during its operation as a modulator in the transmit mode — a much larger heat sink is required. This transistor, in which the collector is internally connected to the case, is thermally grounded but electrically insulated from the chassis through the use of mica or anodized aluminum washers between the case and the chassis.

Because the collectors of Q_{12} and Q_{13} operate at circuit ground, these transistors are mounted directly on the main chassis.

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