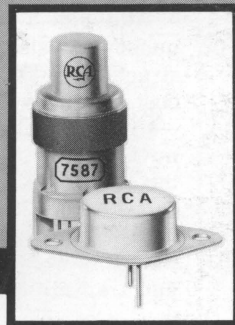




HAM TIPS



A PUBLICATION OF RCA ELECTRONIC COMPONENTS AND DEVICES

VOL. 25, NO. 2

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SPRING, 1965

Transistors and Nuvistors In a Two-Meter Transceiver

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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.

¹Mendelson, 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)

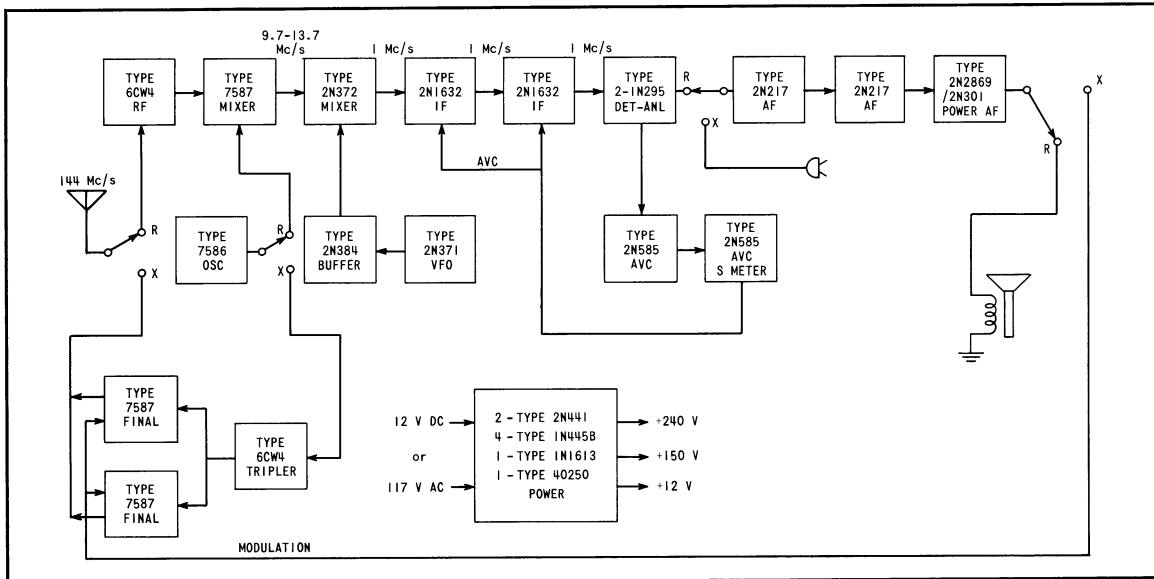
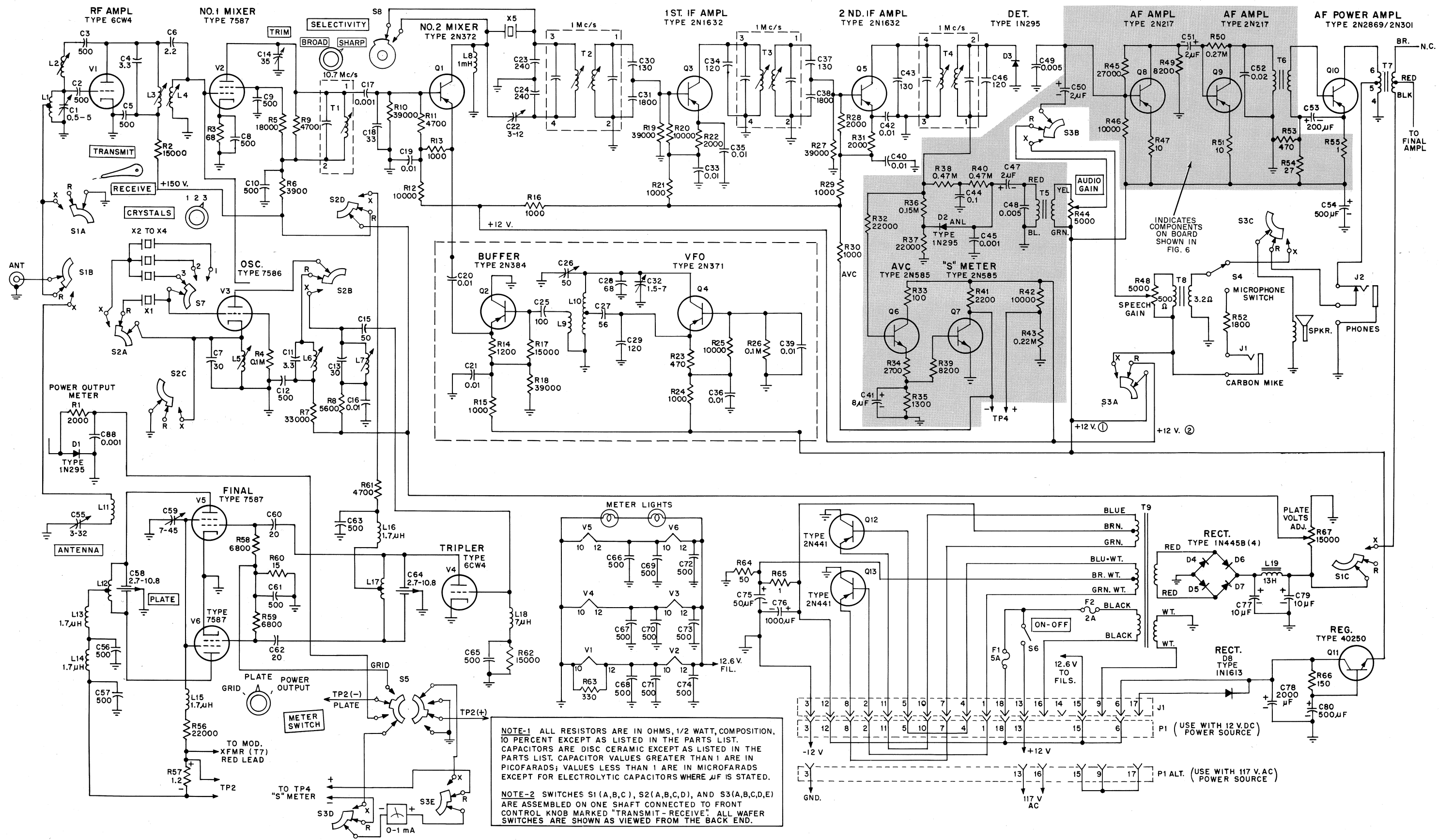


Figure 2: Block diagram of W2OKO's two-meter transceiver shows all RCA nuvistors and transistor types employed in the unit, together with their individual circuit assignments.

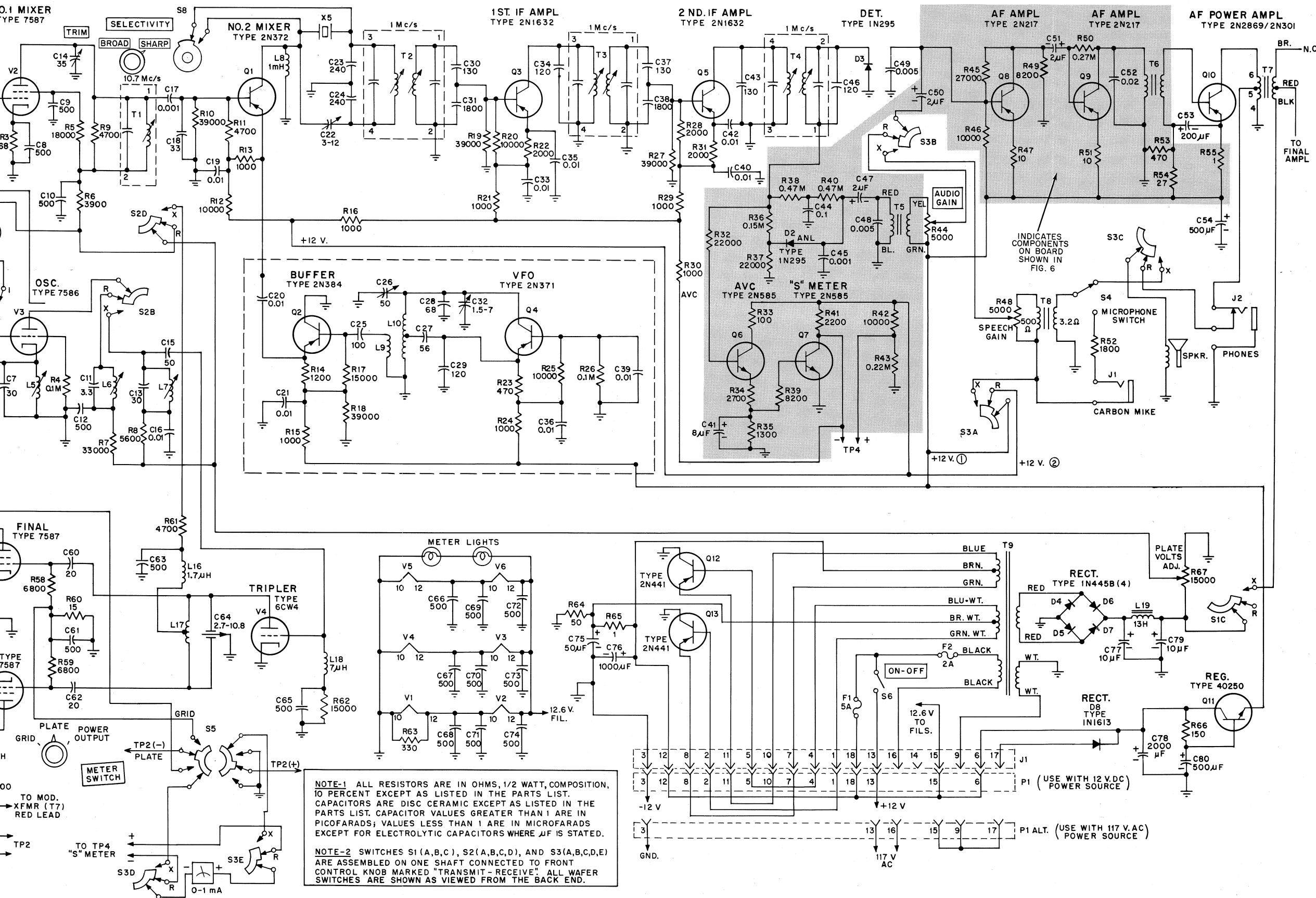


NOTE-1 ALL RESISTORS ARE IN OHMS, 1/2 WATT, COMPOSITION, 10 PERCENT EXCEPT AS LISTED IN THE PARTS LIST. CAPACITORS ARE DISC CERAMIC EXCEPT AS LISTED IN THE PARTS LIST. CAPACITOR VALUES GREATER THAN 1 ARE IN PICOFARADS; VALUES LESS THAN 1 ARE IN MICROFARADS EXCEPT FOR ELECTROLYTIC CAPACITORS WHERE μ F IS STATED.

NOTE-2 SWITCHES S1 (A,B,C), S2 (A,B,C,D), AND S3 (A,B,C,D,E) ARE ASSEMBLED ON ONE SHAFT CONNECTED TO FRONT CONTROL KNOB MARKED "TRANSMIT-RECEIVE". ALL WAFER SWITCHES ARE SHOWN AS VIEWED FROM THE BACK END.

- C₁—0.5 to 5.0 pf tubular (Erie 532A or equiv.)
- C₄, C₁₁—3.3 pf ceramic Centralab TCZ 3R3 or
- C₅, C₈, C₉, C₁₀—500 pf ton (Erie 662-003-501)
- C₆—2.2 pf ceramic tubularab TCZ-2R2 or equiv.
- C₁₃—30 pf tubular ceramicab TCZ-30 or equiv.
- C₁₄—35 pf air variable (lund HF35 or equiv.)
- C₁₅—50 pf tubular ceramicab TCZ-50 or equiv.
- C₂₂—3 to 12 pf ceramic (Erie 557-17R or equiv.)
- C₂₄, C₂₅—240 pf silver menco DM10-241 or equiv.
- C₂₆—50 pf air tuning (Hammarlund MC-50S)
- C₂₇—56 pf silver mica DM10-560 or equiv.)
- C₂₈—68 pf silver mica DM10-689 or equiv.)
- C₂₉, C₃₄, C₄₆—120 pf (Elmenco DM10-121 or
- C₃₀, C₃₇, C₄₃—130 pf (Elmenco DM10-131 or
- C₃₂—1.5-7.0 pf ceramic NPO (Erie 503-10R or
- C₄₁—8 μ f electrolytic (Sprague TE-1149 or equiv.)
- C₄₄—0.1 μ f paper (Aer V161 or equiv.)
- C₄₇, C₅₀, C₅₁—2 μ f electrolytic (Sprague TE-1149 or
- C₅₃—200 μ f electrolytic (Sprague TE-1064 or
- C₅₅—3 to 32 pf air capacitor 160-130 or equiv.
- C₅₈, C₆₄—2.7 to 10.8 μ f air capacitor (Johns or equiv.)
- C₅₉—7 to 45 pf ceramic (Erie 503-33R or equiv.)
- C₆₀, C₆₂—20 pf ceramic (Centralab TCZ-20 or
- C₇₅—50 μ f electrolytic (Sprague TE-1160 or
- C₇₆—1,000 μ f electrolytic (Cornell BR-2000-15 or
- C₇₇, C₇₉—10 μ f, 450 volt FP234 Dual or equiv.)
- C₇₈—2,000 μ f electrolytic (Cornell BR-2000-15 or
- C₈₀—500 μ f electrolytic (Cornell BR-500-15 or
- L₁—5 turns, No. 16 bare inch (spaced wire) dia. 2 turns up from bottom
- L₂—12 turns, No. 26 bare wire on 1/4-inch-dia. form (Miller No. 43 or equiv.)

Figure 3: S W2OKO's tv



NOTE-1 ALL RESISTORS ARE IN OHMS, 1/2 WATT, COMPOSITION, 10 PERCENT EXCEPT AS LISTED IN THE PARTS LIST. CAPACITORS ARE DISC CERAMIC EXCEPT AS LISTED IN THE PARTS LIST. CAPACITOR VALUES GREATER THAN 1 ARE IN PICOFARADS; VALUES LESS THAN 1 ARE IN MICROFARADS EXCEPT FOR ELECTROLYTIC CAPACITORS WHERE μ F IS STATED.

NOTE-2 SWITCHES S1 (A,B,C), S2 (A,B,C,D), AND S3 (A,B,C,D,E) ARE ASSEMBLED ON ONE SHAFT CONNECTED TO FRONT CONTROL KNOB MARKED "TRANSMIT-RECEIVE". ALL WAFER SWITCHES ARE SHOWN AS VIEWED FROM THE BACK END.

- C₁—0.5 to 5.0 pf tubular trimmer (Erie 532A or equiv.)
- C₄, C₁₁—3.3 pf ceramic tubular Centralab TCZ 3R3 or equiv.)
- C₅, C₈, C₉, C₁₀—500 pf silver button (Erie 662-003-501J or equiv.)
- C₆—2.2 pf ceramic tubular (Centralab TCZ-2R2 or equiv.)
- C₁₃—30 pf tubular ceramic (Centralab TCZ-30 or equiv.)
- C₁₄—35 pf air variable (Hammarlund HF35 or equiv.)
- C₁₅—50 pf tubular ceramic (Centralab TCZ-50 or equiv.)
- C₂₂—3 to 12 pf ceramic trimmer (Erie 557-17R or equiv.)
- C₂₄, C₂₅—240 pf silver mica (Elmenco DM10-241 or equiv.)
- C₂₆—50 pf air tuning capacitor (Hammarlund MC-50S or equiv.)
- C₂₇—56 pf silver mica (Elmenco DM10-560 or equiv.)
- C₂₈—68 pf silver mica (Elmenco DM10-689 or equiv.)
- C₂₉, C₃₄, C₄₆—120 pf silver mica (Elmenco DM10-121 or equiv.)
- C₃₀, C₃₇, C₄₃—130 pf silver mica (Elmenco DM10-131 or equiv.)
- C₃₂—1.5-7.0 pf ceramic trimmer NPO (Erie 503-10R or equiv.)
- C₄₁—8 μ f electrolytic, 15 volt (Sprague TE-1149 or equiv.)
- C₄₄—0.1 μ f paper (Aerovax V84C-V161 or equiv.)
- C₄₇, C₅₀, C₅₁—2 μ f electrolytic 15 volt (Sprague TE-1149 or equiv.)
- C₅₃—200 μ f electrolytic, 3 volt (Sprague TE-1064 or equiv.)
- C₅₅—3 to 32 pf air capacitor (Johnson 160-130 or equiv.)
- C₅₈, C₆₄—2.7 to 10.8 pf butterfly air capacitor (Johnson 160-211 or equiv.)
- C₅₉—7 to 45 pf ceramic trimmer (Erie 503-33R or equiv.)
- C₆₀, C₆₂—20 pf ceramic tubular (Centralab TCZ-20 or equiv.)
- C₇₅—50 μ f electrolytic, 15 volt (Sprague TE-1160 or equiv.)
- C₇₆—1,000 μ f electrolytic, 15 volt (Cornell BR-2000-15 or equiv.)
- C₇₇, C₇₉—10 μ f, 450 volt (Mallory FP234 Dual or equiv.)
- C₇₈—2,000 μ f electrolytic, 15 volt (Cornell BR-2000-15 or equiv.)
- C₈₀—500 μ f electrolytic, 15 volt (Cornell BR-500-15 or equiv.)
- L₁—5 turns, No. 16 bare wire, 1/4-inch (spaced wire) diameter, tap 2 turns up from bottom
- L₂—12 turns, No. 26 enamelled wire on 1/4-inch-diameter slug form (Miller No. 4300 Ceramic or equiv.)
- L₃, L₄—4 turns, No. 26 enamelled wire closewound on 1/4-inch-diameter slug form (Miller 40A000-CBI Ceramic or equiv.)
- L₅—4 turns, No. 26 enamelled wire closewound on 3/8-inch-diameter phenolic slug form (Miller 21A-000RB1 or equiv.)
- L₆—5 turns, No. 26 enamelled wire closewound on 1/4-inch-diameter slug form (Miller 40A000CBI or equiv.)
- L₇—4 turns, No. 26 enamelled wire, 3/8-inch (spaced wire) diameter phenolic slug form (Miller 21A-000RB1 or equiv.)
- L₈—1 mh (National or equiv.)
- L₉—2 turns, air wound 1/2-inch diameter from same miniductor as L₁₀ (B & W 3003 or equiv.)
- L₁₀—21 turns, air wound, 1/2-inch diameter, tap 2 turns up from ground (B & W Miniduct 3003 or equiv.)
- L₁₁—1 turn, No. 14 bare wire, 3/4-inch diameter and "spaghetti" insulated
- L₁₂—5 turns, No. 14 bare wire, 1/2-inch diameter, 5/8-inch long and tapped at center
- L₁₃, L₁₄, L₁₅, L₁₆—1.7 μ h choke (Ohmite Z144 or equiv.)
- L₁₇—4 turns, No. 16 bare wire, 1/2-inch diameter 5/8-inch long and tapped at center
- L₁₈—7 μ h choke (Ohmite Z-50 or equiv.)
- L₁₉—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.)
- R₂—Composition, 15,000 ohm, 1 watt
- R₇—Composition, 33,000 ohm, 1 watt
- R₈—Composition, 5,600 ohm, 1 watt
- R₄₄, R₄₈—5,000 ohm, carbon potentiometer
- R₅₃—Composition, 470 ohm, 1 watt
- R₅₄—Composition, 27,000 ohm, 1 watt
- R₅₅—1 ohm, 1 watt (Ohmite axial lead 4330 or equiv.)
- R₅₆—Composition, 22,000 ohm, 1 watt
- R₅₇—Composition (5%), 1.2 ohm, 1/2 watt
- R₆₃—Composition, 330 ohm, 1 watt
- R₆₄—50 ohm, 10 watt, wirewound (Ohmite Brown Devil 1718 or equiv.)
- R₆₅—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 ₆ —Composition, 150 ohm, 1 watt	T ₁ —10.7-Mc transformer (use primary only), (Miller 1601 or equiv.)	and 12.6-volt AC at 3 amps (Stancor P8195 or equiv.)
R ₆₇ —15,000 ohm, slide wire, 25 watt (Ohmite 0387 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.)	X ₁ —Crystal, third overtone 44.766 Mc, style FA5 holder for receivers
S ₁ —3 pole, 5 position, non-shorting, ceramic (Centralab PA5 Section)	T ₅ —Audio transformer, 20,000 ohms to 800 ohms (Lafayette Argonne AR151 or equiv.)	X ₂ , X ₃ , X ₄ —Crystals for transmitter, 48.0000 to 49.3333 Mc, third overtone, style FA5 holders
S ₂ —5 pole, 3 position, non-shorting, ceramic (Centralab PA7 Section)	T ₆ —Audio transformer, 10,000 ohms to 15 ohms (Lafayette Argonne AR110 or equiv.)	X ₅ —1-Mc fundamental for filter
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)	T ₇ —Audio universal transformer, used in reverse, 8 watt (Stancor A3850 or equiv.)	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.)
S ₄ , S ₅ —SPST Toggle	T ₈ —Audio transformer, 500 to 3.2 ohms (Lafayette Argonne AR119 or equiv.)	
S ₅ —2 pole, 3 position, miniature (Grayhill Series 5000 or equiv.)	T ₉ —Power transformer: primaries 12-volt DC or 117-volt AC; secondaries 280-volt DC at 150 ma	
S ₇ —1 pole, 3 position (Centralab 1461 or equiv.)		
S ₈ —1 pole, 2 position (Centralab 1460 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 (X₅), 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, S₂. Extra crystal sockets and a switch (S₇) 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 cir-

cuit utilizing transistor, Q₁₁. 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 S₃, 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

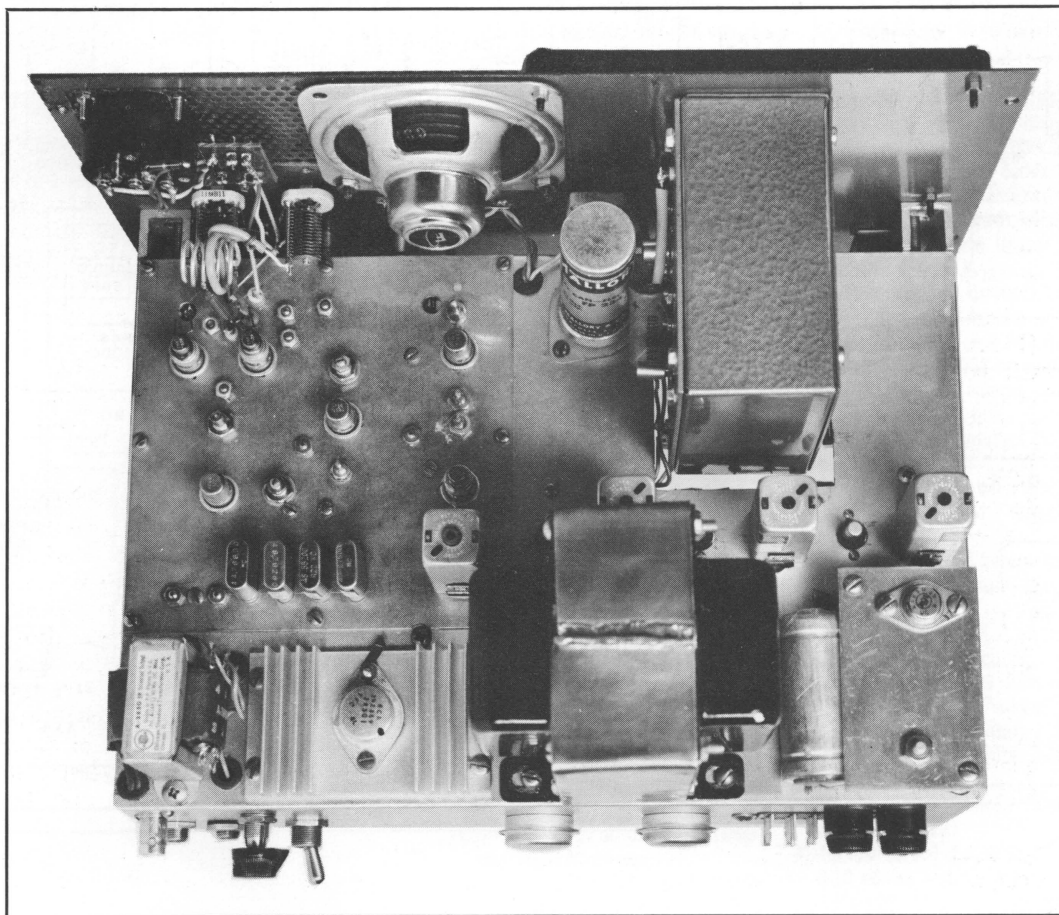


Figure 4: Top view of transceiver shows locations of nuvistors, transistors, and other major components. Incorporated on back of chassis are the microphone jack, speech-gain control, microphone switch, earphone jack, antenna connection, and the transceiver's power plug and fuses.

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 recom-

mended 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- $\frac{1}{8}$ -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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