SECTION IV
PRINCIPLES OF OPERATION

4.1 GENERAL.

Transceiver 32RS-1 is a superheterodyne device using common oscillators, r-f amplifier, and tuned circuits for both transmit and receive functions. All tuned circuits are preset for appropriate channels and, together with channel crystal, are selected by the CHANNEL SELECTOR switch.

4.2 BLOCK DIAGRAM.

Figure 4-1 is a block diagram of the transceiver. The heavy, solid lines show transmit signal path, and the dashed lines show receive signal path. Other lines indicate controls and control voltages.

4.3 RECEIVE CIRCUITS.

Refer to figures 4-1 and 7-1. The receive signal from J5 or S5 is connected through normally closed contacts of K3 and K1, through S1 to the selected channel antenna coil. From the selected channel antenna coil, the signal is coupled through the selected channel r-f coil and channel switch, S11, to the grid of the r-f amplifier, V3. CHANNEL SELECTOR switch, S2, selects a channel r-f tuned circuit from which the amplified receive signal is coupled to the receive mixer, V11. The selected channel crystal oscillator signal is also coupled to the receive mixer. Since the channel crystal oscillator frequency is 455 kilocycles higher than the desired channel frequency and the mechanical filter FL1 selects the difference frequency, the sideband is inverted.

The single-sideband, 455-kilocycle signal from FL1 is amplified by two stages of i-f amplification, V12 and V13, and applied to the product detector, V14. In the product detector, the 455-kc lower sideband signal is beat with the 455-kc crystal oscillator (bfo) signal. The audible product is applied to the a-f amplifier, V15. Output from V15 is amplified by V16 for feeding the handset, speaker, or 600-ohm line.

4.4 TRANSMIT CIRCUITS.

Refer to figures 4-1 and 7-1. The handset-microphone signal modulates the cathode current of tube V7A. If a high-impedance microphone is used, the input is fed to the grid circuit of V7A. The amplified signal from V7A plate is connected to the grid of cathode follower, V8A, through TRANSMIT AUDIO gain control, R35, and coupling capacitor C62. Output from the cathode follower is applied to the diode-ring balanced modulator, CR4, CR5, CR6, and CR7. In the balanced modulator, the audio signal is switched at a 455-kc rate to produce both upper and lower sideband signals, but the mechanical filter passes only the lower sideband signal to the transmit balanced mixer. In the transmit balanced mixer, the 455-kc signal is mixed with the selected channel oscillator signal which is 455 kilocycles higher than the desired signal. The difference, or desired signal frequency (with sideband "flipped" to upper), is selected by the mixer plate tuned circuits. This channel frequency is amplified by V3 and V4 and applied to the grids of the power amplified stage, V5 and V6, in parallel. Output from the power amplifier is tuned by a double pi section. These tuned circuits will match the power amplifier to the antenna if the antenna feed-line system presents an swr that does not exceed 2.5 to 1.

4.5 OSCILLATOR CIRCUITS.

Both the 455-kc oscillator and the channel oscillator operate continuously. The 455-kc oscillator provides carrier generation signal to the balanced modulator during transmit and beat-frequency oscillator injection to the product detector during receive. Oscillator feedback is from the plate through C1 and Y5 to the grid. No tuned circuit is necessary. Oven HR1 maintains nearly constant temperature to hold Y5 frequency constant to better than 5 parts per million. Tube section V1B serves as a 455-kc isolation amplifier during transmit and is unused during receive.

The channel oscillator, V10A, provides injection frequency to transmit mixer V2 and receive mixer V11. Section B of V10 (phase inverter) provides push-pull oscillator injection to the cathodes of the balanced mixer, V2. Switch S6 selects the desired channel crystal and connects it into the screen and grid circuits of V10A. Ovens HR2 and HR3 maintain the channel crystals at constant temperature to provide either one or five parts per million stability, depending upon which oven is selected. Trimmer capacitors C67, C68, C69, and C70 trim channel crystals Y1, Y2, Y3, and Y4, respectively, to the exact channel frequency desired. This compensates for crystal grinding tolerances and circuit stray capacitances as well as for crystal aging.

4.6 CONTROL CIRCUITS.

4.6.1 TRANSMIT-RECEIVE CONTROLS.

Refer to figures 4-1, 7-1, and 4-2. Figure 4-2 is a partial schematic showing voice-operated control (vox) circuits with all relays. When TUNE-OPERATE switch S9 is in TUNE position, tube section V7A is connected as a phase-shift audio oscillator operating at approximately 1.4 kc. When S9 is in OPERATE position. V7A is connected as a conventional microphone amplifier. The cathode current passes through R29 and the carbon microphone in handset HS1 when HS1 is off the cradle. The handset cradle switch. S10. shorts the microphone when HS1 is on the cradle. If a high-impedance microphone is used. it is connected to the grid of V7A through capacitor C57.

The output from V7B plate is rectified by the vox rectifier. V9B. The positive output of V9B is applied to the grid of the vox relay control tube, V8B, through resistor R44. Some of the receive audio output from V16 is coupled to the anti-vox rectifier. V9A. The negative output from V9A is connected through resistor R43 to the grid of vox-relay control tube V8B. The level of this negative voltage is set by ANTI-VOX control R88 and keeps the loudspeaker output from tripping the transmit circuits. When enough voice input is present at the handset or microphone, the positive vox voltage from V9B exceeds the negative anti-vox voltage from V9A at the grid of V8B. Application of positive voltage to the grid of V8B causes the tube to conduct current and therefore energize relay K1.

When relay K1 is energized, normally closed contacts 3 and 4 open and disconnect receive audio from the grid of V16. Normally open contacts 5 and 6 close to complete the coil circuit for relays K2 and K3. energizing both. Normally closed contacts 8 and 9 of K1 open to disconnect the antenna from the receive circuits. Contacts 7 and 8 close and short the receive input circuits to ground. Contacts 1, 2, and 3 of relays K2 and K3 select the proper timing capacitor for the alc/agc bus and discharge the one not in use. Contacts 4, 5, and 6 of K2 switch the driver and PA screen circuits from 0 to +275 volts d-c. Contacts 7, 8, and 9 of K2 open the cathode circuits of V11, V12, and V13 and remove cutoff bias from grid circuits of V1B and V2 by grounding the grid-circuit end of R105. Contacts 10, 11, and 12 of K2 remove the signal short from V8B by connecting R114 to ground. Contacts 4, 5, 6, 10, 11, and 12 of K3 are all used in switching antenna connections from receive to transmit function. Contacts 7, 8, and 9 remove the cathode circuit of switching diode CR1 from ground and apply it to a +250 volts d-c. This reverse-biases CR1 and thus removes the channel oscillator signal from the receiver mixer, V11.

4.6.2 OPERATING CONTROLS.

Normally used controls consist of power supply on-off switches, the meter switch, TUNE-OPERATE switch, and CHANNEL SELECTOR. The functions of these switches are described in section III. Switches S1, S2, S3, S4, S5, S6. and S11 are ganged to the CHANNEL SELECTOR control. All except S5 select channel crystals or channel tuned circuits. Switch S5A gives channel position information for remote switching or indication, such as to control Antenna Coupler 180V-1. Space and mounting holes are provided for custom installation of four additional coaxial receptacles. These may be wired to S5B and connected to separate antenna so that the appropriate antenna is selected when the CHANNEL SELECTOR is set to the desired channel.

4.7 DIRECTIONAL WATTMETER 302E-2.

Refer to figure 7-3. Transmission line current flows through the line center conductor and through the center of a toroid coil. The conductor forms the primary. and the coil the secondary of a toroidal transformer, T1. Induced toroid current produces a voltage that divides equally across series resistors R1 and R2. Since the junction of R1-R2 is grounded, voltages across R1 and R2 are opposite in phase with respect to ground and proportional to line current. Line voltage is applied across two capacitive voltage dividers, C1-C3 and C2-C4, resulting in equal voltages of the same phase across C3 and C4.

When the transmission line is mismatched. the voltages across R1 and R2 represent the vector sum of two components. one proportional to the current in the forward wave and the other proportional to the current in the reflected wave. Similarly, the voltages across C3 and C4 represent the vector sum of forward and reflected voltage components. Capacitors C1 and C2 are factory adjusted so that the magnitudes of forward voltage and current components are equal; the reflected components are then equal. The settings of C1 and C2 are correct for a 52-ohm transmission line only.

The phase relationship between the various voltage components is such that the r-f voltage across diode CR1 is equal to the sum of the two forward voltage components. Also, the r-f voltage across diode CR2 is equal to the sum of the two reflected components.

When the transmission line is terminated in its own impedance. the voltage across C3 and R1 are equal in magnitude and opposite in phase. Being on opposite sides of CR1 with respect to ground, the voltages across C3 and R1 add to one another. Also, the voltages across C4 and R2 are equal in magnitude and of the same phase; being on opposite sides of CR2 with respect to ground, their voltages cancel. These relationships are used for adjusting C1 and C2 under laboratory conditions.

Derived r-f voltages are rectified and filtered by CR1-L1 and CR2-L2 to produce d-c currents through meter M1. Resistors R3 and R4 are meter calibrating resistors selected in factory tests to give accurate indications of forward and reverse power levels.

4.8 PHONE PATCH 152J-1.

Refer to figure 7-4. The operation of the 152J-1 is clarified by tracing the audio signal voltages from the transceiver to the telephone line and from the telephone line to the transceiver as follows: When the

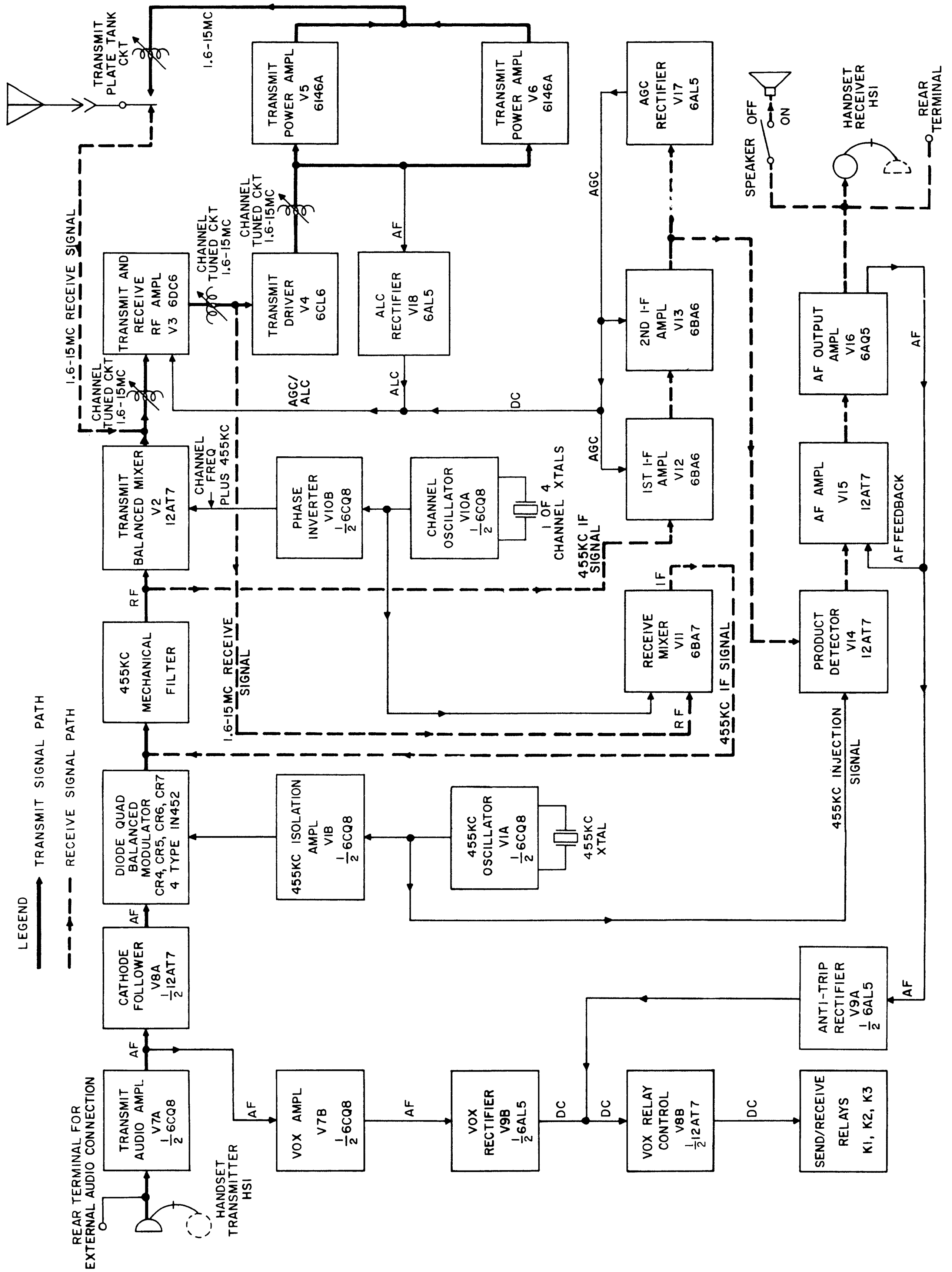

Figure 4-1. Transceiver 32RS-1, Block Diagram

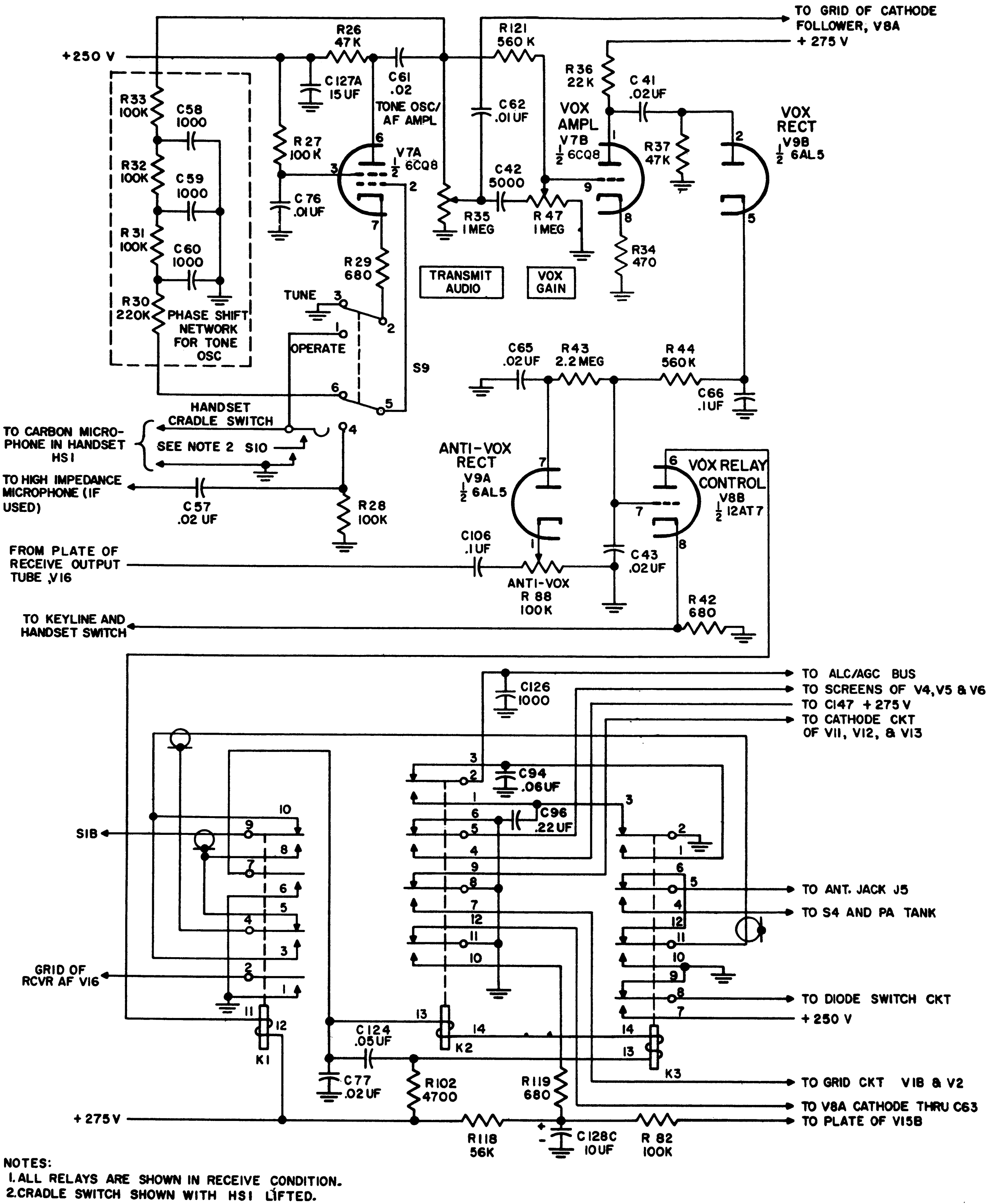

Figure 4-2. Partial Schematic, Vox Circuits

PHONE PATCH switch, S2, is set to ON and the STATION CONTROL switch, S1, is turned to VOX OPERATE, audio output voltage from the 32RS-1 passes through an attenuating pad (R13, R14, and R15) to the primary of T2. The secondary of T2 is connected across a bridge circuit. Output from the bridge circuit is passed through a resistive pad and an r-f filter to the telephone line. Audio input voltage from the telephone line is passed through an r-f filter and the resistive pad to the bridge circuit, impressed across T1, and coupled through the STATION CONTROL switch, S1, to the microphone input of the 32RS-1.

Resistors R6, R7, R8, R9, and R10 along with capacitors C6 and C7 form a balancing circuit that operates with the 32RS-1 VOX GAIN control to prevent transceiver audio output voltages from operating the transceiver audio input circuits. The VOX GAIN control on Transceiver 32RS-1 and the 152J-1 balance adjustments, C7 and R10, are adjusted so that with normal receiver output voltages, the voltage appearing across T2 secondary is not strong enough to couple to the microphone input and trip the vox relays in the 32RS-1.

The TRANSMIT and RECEIVE positions of the STATION CONTROL switch, S1, allow transceiver operation when telephone input voltages will not permit normal vox operation or when it is desired to override the vox circuits. The TRANSMIT position of S1 grounds the grid and cathode of vox amplifier V8 in the 32RS-1 and couples audio input signals from T1 of the 152J-1 bridge circuit to the microphone input of the 32RS-1. The RECEIVE position of S1 grounds the grid of vox amplifier V8 in the 32RS-1 and shorts microphone input signals from the 152J-1.

The STATION MUTE position of the PHONE PATCH switch, S2, grounds the 32RS-1 microphone input, disconnects the received input signals from the 32RS-1, and disconnects the phone line. The OFF position of the PHONE PATCH switch, S2, disconnects the phone line and returns a ground to the 32RS-1 speaker. The 32RS-1 may be keyed, however, by turning the STATION CONTROL switch to TRANSMIT. The 152J-1 exerts no control on the 32RS-1 when the STATION CONTROL switch is in VOX OPERATE position and the PHONE PATCH switch is in the OFF position.

SECTION V
MAINTENANCE

5.1 GENERAL.

This section contains trouble-shooting procedures, alignment instructions, and performance tests for Transceiver 32RS-1.

5.1.1 TEST EQUIPMENT.

The following test equipment items (or equivalents) are suggested for testing Transceiver 32RS-1.

a. R-f signal generator, capable of 1.0 volt output.
b. Audio signal generator, Heathkit AG-9.
c. Vacuum-tube voltmeter, Hewlett-Packard 410B.
d. 52-ohm load, Bird Model 820.
e. Communications receiver - general coverage with S-meter, 51J-4.
f. One 600-ohm, 4-watt resistor (two 270-ohm, 2-watt resistors in series).

5.2 INSPECTION AND LUBRICATION.

5.2.1 GENERAL.

It is suggested that at the beginning of station operation that the operator make a log of meter readings and output power level and that the operator continue keeping this log up to date. A comparative check of meter indications and output power level over a period of time will give an indication of over-all transceiver operation. Also, trading log information with other stations within the radio net helps in determining over-all equipment operation.

5.2.2 VISUAL INSPECTION.

Remove the covers from the 32RS-1, and make a visual inspection of circuit components and relay and switch contacts. Remove any dust or dirt that may have accumulated.

5.2.3 PA CATHODE CURRENT CHECK.

Check power amplifier cathode current periodically by turning the meter selector to PA CATH MA. The meter should indicate S-1.5 to S-2 when unit is keyed and kick up to S-9 when talking into the handset. Abnormal meter readings indicate aging PA tubes, incorrect bias or plate voltage, possible alc circuit malfunction, PA screen or high-voltage fuses blown, or antenna changes.

5.2.4 LUBRICATION.

Lubricate blower motor and band-switch bushings, link, and detent every 2,000 hours. Use any good quality of motor oil.

5.3 TROUBLE ANALYSIS.

5.3.1 GENERAL.

Trouble analysis of Transceiver 32RS-1 is accomplished easily by measuring stage gain, checking for normal voltage and resistance readings, and other common trouble-shooting methods. Stage gain and voltage and resistance readings are incorporated on the 32RS-1 schematic diagram, figure 7-1. The following text provides trouble-shooting procedures for faults that could be encountered in the 32RS-1. It should be noted that voltage and resistance readings given in this section are nominal and may vary slightly from equipment to equipment.