SECTION 3
INSTALLATION

3.1 VEHICLE INSTALLATION INFORMATION

3.1.1 Antenna

A good antenna installation is essential for satisfactory transceiver performance. Consider the easiest route for the transmission line when selecting the antenna location. A level unobstructed area, such as the roof, will generally provide the best ground plane. The trunk area can also be used. Avoid the hood area for antenna mounting.

3.1.2 Transceiver

Mount the transceiver with best maintenance accessability and operating convenience in mind. The dash mounting bracket necessary for vehicle installation is supplied with the transceiver. Refer to the instructions in section 3.2 when installing the dash mounting bracket.

3.1.3 Items Supplied for Installation and Operation

Check the items listed in Table 3-1 against the items supplied with the transceiver to insure that the necessary items are on hand for installation and operation.

3.1.4 Special Tools Required

The following tools should be on hand when installing the transceiver.

center punch

1/4" electric drill

No. 43 drill (0.089 inch diameter) for drilling starter holes for the No. 4 self-tapping sheet metal screws used to mount the microphone hanger if the holes provided in the cabinet shell are not used.

No. 21 drill (0.159 inch diameter) for drilling holes for the No. 10 transceiver mounting bracket screws.

TABLE 3-2
Items Supplied for Operation

	Part Number
Operating Manual	002-0058-001
Part 95 - FCC Rules	022-1635-001
FCC Form 505	022-1636-001
License application form	
Transmitter identification card	564-1001-001
Warranty registration card	041-0419-014
Schematic diagram	564-3001-153
VSWR warning notice	004-0022-001

TABLE 3-1
Items Supplied for Installation

Item in Figure 3-1	Qty.	Description	Part Number
1	1	Dash Mounting Bracket	017-1363-001
2	2	Screws, 1/4-20 (3/8" hex head) for dash mounting bracket.	011-0322-012
3	2	Cushion washers for dash mounting bracket.	018-0822-001
4	2	Screws, 10-32 x 5/8, for dash mounting bracket.	011-0229-020
5	2	Lockwashers, No. 10, for dash mounting bracket.	029-0001-003
6	2	Nuts, No. 10, for dash mounting bracket	012-0109-002
7	1	Microphone hanger	537-9004-002
8	2	Screws, No. 4 self-tapping, for microphone hanger	011-0807-006
9	1	Tap connector for connecting power lead from transceiver to ignition switch.	023-2209-001
10		Power cable, 12 VDC negative ground	023-1657-001

3.2 POWER CABLE INSTALLATION

WARNING

The power cable supplied with the transceiver can be used in 12 VDC negative ground systems only. Connecting this cable to a positive ground electrical system will damage the transceiver. An accessory power cable, part No. 023-1658-001, must be used in a positive ground electrical system.

a. Connect the cable to the accessory terminal of the vehicle ignition switch or to another 12 VDC source using the tap connector illustrated in Figure 3-1. Installation instructions are on the front of the tap connector package.

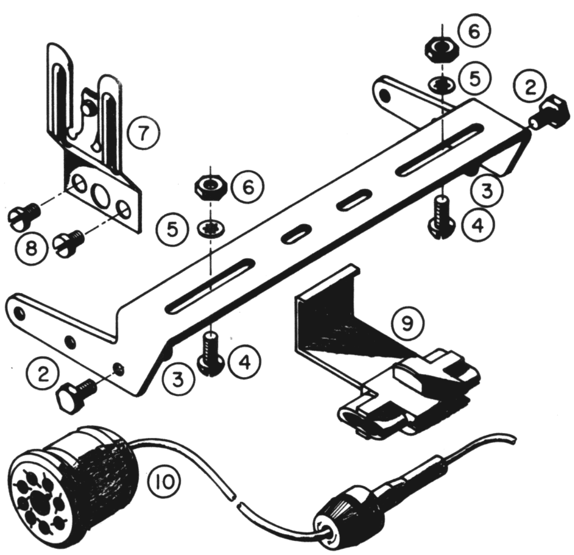
b. The power cable does not contain a ground lead. The ground is obtained through the outer connector of the transmission line or the dash mounting bracket.

3.3 ANTENNA INSTALLATION

a. Refer to the instructions included with the antenna for installation details.

b. Route the transmission line.

c. Install the coaxial connectors. Refer to Figure 3-3 for details.



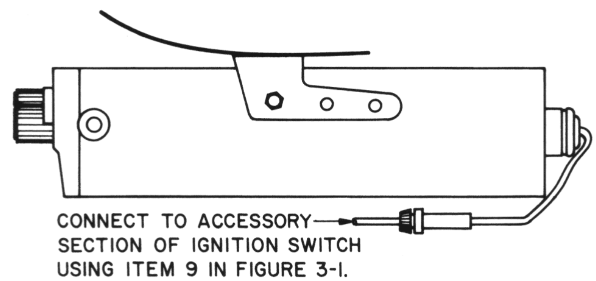
ITEMS SUPPLIED FOR INSTALLATION
FIGURE 3-1

3.4 DASH MOUNTING INSTALLATION

(Refer to Figure 3-2)

CAUTION

Avoid installing the transceiver in the direct air stream of the vehicle heater. Temperatures in this area can measure up to 150° F and can cause component failures.



TRANSCEIVER DASH MOUNTING DETAILS
FIGURE 3-2

a. Determine the transceiver location.

b. 1. Hold the transceiver in its proposed location with the mounting bracket (item 1 in Figure 3-1) attached. Mark the mounting bracket location.

2. Remove the mounting bracket from the transceiver.

3. Hold the mounting bracket up to the dash at the location you marked. Mark the mounting bracket slot positions. Check for a free space behind the dashboard in the area marked (no obstructions such as wires, brackets, etc.)

4. Center punch and drill two holes separated as much as the mounting bracket and area selected allow, using a No. 21 drill.

c. Install the mounting bracket. Use the No. 10 hardware illustrated by items 4, 5 and 6 in Figure 3-1.

d. Install the transceiver in the mounting bracket. Use items 2 and 3 illustrated in Figure 3-1.

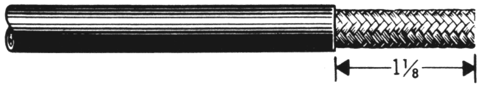
NOTE

Do not connect transmission line to the transceiver antenna terminal until after final checkout.

e. Attach the power cable plug to the transceiver power jack.

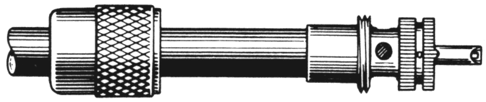
f. Perform the steps in section 3.7.

RG-8/U



Cut end of cable even. Remove vinyl jacket 1-1/8", except 83-1SP plug remove vinyl jacket 1-1/4".

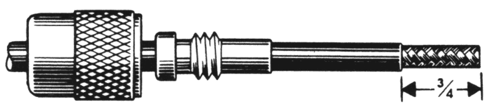
Bare 5/8" of center conductor. Trim braided shield. Slide coupling ring on cable. Tin exposed center conductor and braid.



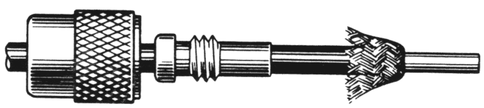
Screw the plug sub-assembly on cable. Solder assembly to braid through solder holes, making a good bond between braid and shell. Solder conductor to contact. Do not use excessive heat.

For final assembly, screw coupling ring on plug sub-assembly.

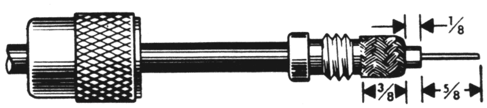
RG-58A/U



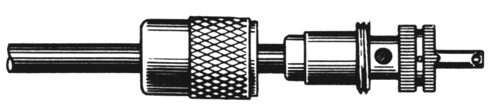
Cut end of cable even. Remove vinyl jacket 3/4". Slide coupling ring and adapter on cable.



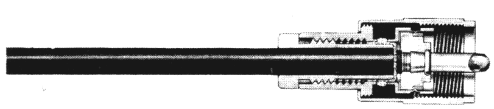
Fan braid slightly and fold back as shown.



Position adapter to dimension shown. Press braid down over body of adapter and trim to 3/8". Bare 5/8" of conductor. Tin exposed center conductor.



Screw plug sub-assembly on adapter. Solder braid to shell through solder holes. Use enough heat to create bond of braid to shell. Solder conductor to contact.



For final assembly, screw coupling ring on plug sub-assembly.

UHF COAXIAL CONNECTORS
ASSEMBLY INSTRUCTIONS
FIGURE 3-3

3.5 MICROPHONE HANGER INSTALLATION

a. Determine a location for the microphone hanger (item 7 in Figure 3-1).

b. Follow the procedure outlined in section 3.4 b. for drilling starter holes for the No. 4 sheet metal mounting screws, item 8 in Figure 3-1. Use a No. 43 drill.

NOTE

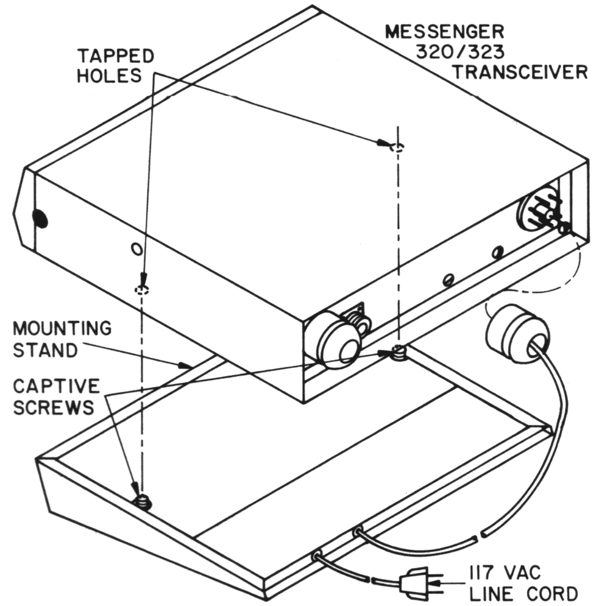
The microphone hanger can be attached to the transceiver cabinet. Holes are provided for the No. 4 screws on the side opposite the microphone.

3.6 BASE STATION INSTALLATION

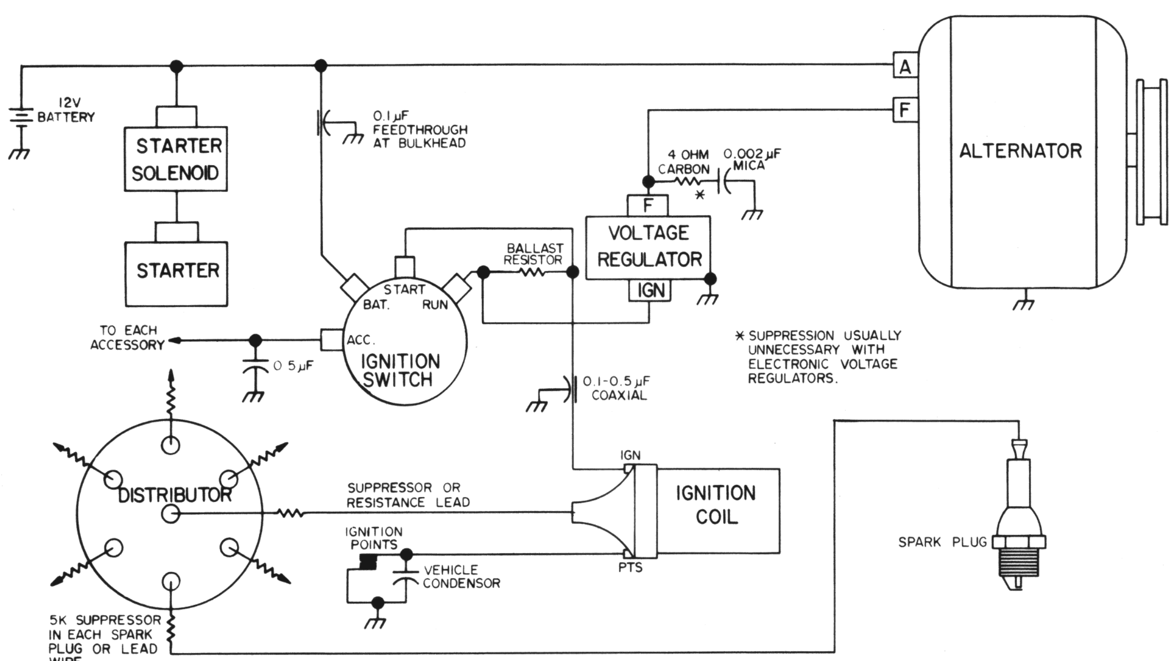
a. Select an operating location for the transceiver that allows air to circulate freely around the transceiver cabinet.

b. Attach the base station power supply to the transceiver. Refer to Figure 3-4 for details.

c. Ground the transceiver for safety. Attach one end of a No. 14 copper ground wire to one of the cabinet shell mounting screws located at the rear of the transceiver. Attach the other end of the ground wire to a cold water pipe or any other convenient grounded metallic material.



BASE STATION MOUNTING DETAILS
FIGURE 3-4



IGNITION SYSTEM NOISE SUPPRESSION
SCHEMATIC DIAGRAM
FIGURE 3-5

d. Perform the tune-up procedure and the frequency check outlined in section 3.7.

3.7 FINAL CHECKOUT

a. Connect a Bird Model 43 with 10A element or equivalent wattmeter into the transmission line.

b. Trim the antenna for best VSWR. The transceiver has been tuned at the factory and the output network will not require tuning to match it to the antenna. The VSWR obtained should be 1.5 to 1 or less.

c. Check the transmitter power output. Typical power is 3.5 watts. Refer to the specifications in section 2 for minimum and maximum power output.

d. Check the transmitter frequency with a frequency meter. The maximum allowable deviation from the center frequency is 0.005%.

e. Check the modulation. Minimum acceptable is 70% upward and 80% downward. A suggested method is outlined in section 5.

f. Give the transceiver a complete operational checkout. Make several contacts with another unit. Correct any noise suppression problems that affect mobile transceiver performance.

3.8 NOISE SUPPRESSION

Vehicle electrical noise of some sort is a problem in almost all new mobile radio installations.

Before beginning any special noise suppression steps, be sure that the vehicle is well tuned. Clean and tighten all electrical connections, including alternator, battery, regulator and coil connections. Perform the following maintenance steps as necessary: solder crimped spark plug and distributor leads; clean and regap or replace spark plugs and ignition points and check ignition timing; check and clean alternator rings and brushes. Retune the engine every 10,000 miles or twice a year, whichever occurs first.

Ordinarily several sources of noise are present in any vehicle, with the strongest covering the others. Drive to a relatively quiet location (free of man-made electrical interference such as noisy power lines, industrial noise or other vehicles).

Test for ignition noise with a weak signal on channel. Vehicle may be standing still. Ignition noise will be present at all engine speeds and, if severe, may make a normally readable signal unreadable.

To reduce ignition noise, install resistor type spark plugs if these are not already installed and if non-resistance ignition wiring is used. Add a 10,000 ohm suppressor resistor in the center tower of the distributor and 5000 ohm suppressor resistors at each spark plug tower of the distributor. Install a coaxial capacitor at the ignition coil primary as close to the coil primary as possible.

A "whining" noise which varies with engine speed and continues with the ignition turned off with the vehicle coasting in gear is characteristic of the alternator. Check and clean the alternator rings and brushes.

An irregular "clicking" sound which disappears at a slow idle characterizes the voltage regulator. Install a 4 ohm carbon resistor as close to the field terminal of the regulator as possible, then a 0.002 μF mica capacitor in series with and as close to the resistor as possible: connect the capacitor to ground.

Irregular popping noises which vary with road surfaces indicate static discharge at any of several locations in the vehicle. Tighten loose nuts and bolts and bond large areas such as the fenders, exhaust pipe, firewall, etc. to the frame with lengths of heavy braid. Figure 3-5 illustrates these and a few other suggested noise suppression steps.

SECTION 4
CIRCUIT DESCRIPTION

4.1 GENERAL

The Messenger 320-323 is a frequency synthesizing transceiver that covers the entire 23 channel Citizens Band. The frequency synthesizer consists of ten crystals, two oscillators and a mixer. The synthesizer output is diode switched between transmit and receive.

The transmitter and receiver use a common audio-modulator. The single 50 ohm antenna input is switched through the relay between transmit and receive. The signal strength-relative power output meter (S/RPO meter) on the front panel indicates relative transmitter power and received signal strength.

Refer to the block diagram and the schematic while following the circuit description.

TABLE 4-1
SYNTHESIZER SCHEME

CHANNEL POSITION	HF CRYSTAL FREQUENCY	LF CRYSTAL FREQUENCY	SYNTHESIZER FREQUENCY
1	32.845	10.180	22.665
2	32.845	10.170	22.675
3	32.845	10.160	22.685
4	32.845	10.140	22.705
5	32.895	10.180	22.715
6	32.895	10.170	22.725
7	32.895	10.160	22.735
8	32.895	10.140	22.755
9	32.945	10.180	22.765
10	32.945	10.170	22.775
11	32.945	10.160	22.785
12	32.945	10.140	22.805
13	32.995	10.180	22.815
14	32.995	10.170	22.825
15	32.995	10.160	22.835
16	32.995	10.140	22.855
17	33.045	10.180	22.865
18	33.045	10.170	22.875
19	33.045	10.160	22.885
20	33.045	10.140	22.905
21	33.095	10.180	22.915
22	33.095	10.170	22.925
23	33.095	10.140	22.955

4.2 FREQUENCY SYNTHESIZER

4.2.1 LF OSCILLATOR

The low frequency oscillator is made up of Q12 and its associated circuitry, and crystals Y1-Y4 which operate at their fundamental frequencies. Switch SW1A selects one of these crystals. Refer to Table 4-1, synthesizer scheme, for the low frequency crystal frequencies. The output of the selected crystal is applied directly to the base of Q12. The signal from the emitter of Q12 is coupled through C53 to the base of the synthesizer mixer, Q13. A capacitive voltage divider consisting of C53 and C54, reduces the voltage at the base of Q13 and provides the proper impedance match.

4.2.2 HF OSCILLATOR

The high frequency oscillator, Q15, operates with third overtone crystals, Y5-Y10. Switch SW1B selects one of the HF crystals at the same time as SW1A selects an LF crystal. Refer to Table 4-1, synthesizer scheme, for the HF oscillator crystal frequencies. The signal from the selected series resonant crystal is applied directly to the base of the HF oscillator, Q15. The signal from the collector of Q15 is coupled through the oscillator transformer, T9, to the emitter of the synthesizer mixer, Q13.

4.2.3 SYNTHESIZER MIXER

The output of the LF oscillator, Q12, is applied to the base of the synthesizer mixer, Q13. The output of the HF oscillator is coupled through T9 to the emitter of Q13. The output of Q13 is tuned for the difference frequency. For example, when the channel switch is in position 1, the HF crystal frequency is 32.845 MHz and the LF crystal frequency is 10.180 MHz. The difference (mixer output) frequency is 32.845 MHz - 10.180 MHz = 22.665 MHz. Refer to Table 4-1 for a list of the crystal combinations used for each channel. The mixer output frequency is coupled through double tuned transformer T8 to D6 and D13, the synthesizer diode switch. The synthesizer output frequency is always 4.3 MHz less than the desired channel frequency. On channel 1 the synthesizer output frequency is: 26.965 MHz - 4.3 MHz = 22.665 MHz.

4.2.4 SYNTHESIZER DIODE SWITCH

The diode switch (SPDT) consists of D6 and D13 which are used to couple the synthesizer output to the emitter of Q2 during receive and Q21 during transmit.

During receive D13 is reverse biased and D6 is forward biased, allowing the synthesizer output to pass through D6 to the emitter of Q2. D13 isolates the synthesizer signal from the transmitter.

During transmit, D6 is reverse biased and D13 forward biased allowing the synthesizer output to pass through D13 to the emitter of Q21. D6 is cut off and blocks the synthesizer output signal path to the receiver first mixer.

4.3 RECEIVER

4.3.1 RF

During receive, relay RY1 connects the antenna to the base of Q1, the RF amplifier, through T1. Q1 amplifies the incoming signal which is then coupled to the base of the first mixer, Q2 through T2.

4.3.2 FIRST MIXER

The signal from the RF amplifier is coupled to the base of Q2, the first mixer. At the same time, the signal from the synthesizer mixer (Q13) is coupled to the emitter of Q2 by conduction of D6. The output of Q2 is tuned to the difference between the incoming antenna frequency and the output from the synthesizer. For example, when the channel selector is in the channel 1 position, the received frequency is 26.965 MHz and the synthesizer frequency is at 22.665 MHz. The first mixer output frequency then is 26.965 MHz - 22.665 MHz = 4.300 MHz. Synthesizer frequencies are chosen to insure that the first mixer output frequency will always be 4.300 MHz.

4.3.3 CRYSTAL FILTER (Messenger 323 only)

The Messenger 323 crystal filter is a high Q selective circuit which produces a narrow peaked, very steep sided, IF selectivity curve. The filter consists of crystals Y11 - Y14 which make up two half latices in series. The output of the first mixer is coupled to the second mixer stage through the crystal filter network. The 4.300 MHz IF frequency is centered in the crystal filter band pass by variable capacitor C10.

4.3.4 OSCILLATOR

The receive oscillator, Q8, is a colpitts type circuit with a common collector to provide a high input impedance. The oscillator operates at 4.755 MHz, the crystal's fundamental frequency. The signal from the emitter of Q8 is coupled through C28 to the base of Q3, the second mixer.

4.3.5 SECOND MIXER

The second mixer, Q3, produces the 455 kHz IF frequency. The 4.3 MHz signal from the crystal filter is coupled to the base of Q3, as is the 4.755 MHz signal from the receiver oscillator, Q8. The output transformer of the second mixer is tuned to the difference frequency of the two inputs or 455 kHz.

4.3.6 IF CIRCUITS

The two IF amplifiers, Q4 and Q5, amplify the 455 kHz IF signal produced in the second mixer. The three IF transformers, T5, T6 and T7, are double tuned for additional selectivity. The amplified IF signal is coupled from the collector of Q5 through T7 to the detector diode, D2.

4.3.7 AUDIO CIRCUITS

The detected audio from D2 is coupled through the noise limiter, D3, and the volume control, R14, to a set of contacts on the relay. During receive, the audio is coupled through the relay contacts to the base of the first audio amplifier, Q16. The schematic diagram shows the relay contacts in the receive (normally closed) position. The amplified audio is coupled to the base of Q17, the audio driver, for further amplification and then coupled through T10 to the bases of the class B audio output stage, Q18 and Q19. The driver transformer T10, provides the correct impedance match between the collector of the driver transistor and the bases of the class B stage. The output of the class B amplifier is coupled through T11 to the speaker during receive. T11 is a combination audio output and modulation transformer. The black and light green leads are the 3.2 ohm speaker winding and the blue and brown leads are modulation leads.

One side of the speaker is connected to the audio output-modulation transformer, T11, through the external speaker and the PA jacks. The other side of the speaker is connected to T11 through a set of contacts on the relay. When the PTT switch on the microphone is depressed, the relay is energized, opening the speaker windings (terminals 4 and 7) and connecting the microphone audio output to the first audio amplifier, Q16. Audio modulation is explained in the transmitter theory section.

4.3.8 AGC CIRCUIT

The AGC detector, D1, produces an AGC voltage which is applied to the base of Q4, Q6 and Q7 through a thermistor-resistor assembly, Z4. The AGC voltage is amplified by Q6 and Q7, then applied to the emitter of the RF amplifier, Q1, and the first mixer, Q2, to reduce the receiver gain on strong signals. The AGC voltage applied to the base of Q4, the first IF amplifier, is used to further reduce receiver gain. The thermistor-resistor network, Z4, provides temperature compensation by reducing the effect of temperature changes on the transceiver.

4.3.9 SQUELCH

The squelch amplifiers, Q9 and Q10, receive their signal from the emitter of Q6, the AGC amplifier, through a 5000 ohm potentiometer, R16, which determines the input signal level at the base of Q10. The output of the squelch circuit at the collector of Q10 is coupled through D7 to the emitter of Q16, and biases off the audio when no signal is received. The thermistor-resistor assembly, Z7, in the squelch circuit provides temperature compensation by reducing squelch circuit's sensitivity to changes in temperature.

4.4 TRANSMITTER

4.4.1 AUDIO CIRCUITS

When the PTT bar on the microphone is depressed, one set of contacts on the PTT switch energizes the relay RY1, closing the normally open contacts shown on the schematic. Audio from the microphone is coupled through one set of relay contacts to the base of the first audio amplifier, Q16. The audio signal is amplified by Q16 and Q17 and coupled through T10 to the class B audio stage, Q18 and Q19. The amplified audio signal from Q18 and Q19 is coupled through T11, leads 3 and 4, to provide modulation of the RF Driver, Q23, and the RF output, Q24. The RF Driver and output stages are both modulated for higher modulation capabilities.

Audio compression is provided ahead of the class B audio stage by coupling part of the audio signal appearing at T11 back to the emitter of Q16. A high signal level from the microphone (caused by operator whistling or shouting into the microphone, for example) will cause a high signal level at the secondary of T11. The high level at T11 will cause a higher voltage at the emitter of Q16, biasing the stage to reduce the gain for the duration of the high signal level condition. Thus the audio compressor circuit maintains a relatively constant audio output level over a wide range of input levels.

4.4.2 OSCILLATOR

The transmit oscillator, Q20, operates with the transmit crystal, Y16, in parallel resonant circuit to produce a 4.3 MHz signal. The 4.3 MHz output of Q20 is coupled to the base of transmit mixer, Q21.

4.4.3 TRANSMITTER MIXER

The 4.3 MHz signal from the transmit oscillator, Q20, is coupled to the base of Q21. At the same time, the signal from the synthesizer mixer, Q13, is coupled through the synthesizer diode switch, D13, to the emitter of Q21. At Q21, the signal from Q20 and the signal from Q13 are added. Assuming operation on channel 1, the signal from the synthesizer is 22.665 MHz (exact frequency determined by the channel selector switch - refer to Table 4-1). The transmitter output frequency then is the synthesizer frequency plus 4.3 MHz, or for channel 1 it is 22.665 MHz + 4.3 MHz = 26.965 MHz. The transmitter frequency is determined by the synthesizer output frequency.

4.4.4 FIRST RF AMPLIFIER

The output of the transmit mixer, Q21, is coupled from its collector through a double-tuned transformer, T12, to the base of the first RF amplifier, Q22. The signal is amplified, then coupled through T13 to the RF Driver.

4.4.5 RF DRIVER

The RF driver, Q23, operates class C, and amplifies the RF signal from Q22. The signal is then coupled to the RF output transistor, Q24, through T14. Modulation is applied at the final RF output stage to improve modulation linearity and increase transmitter efficiency.

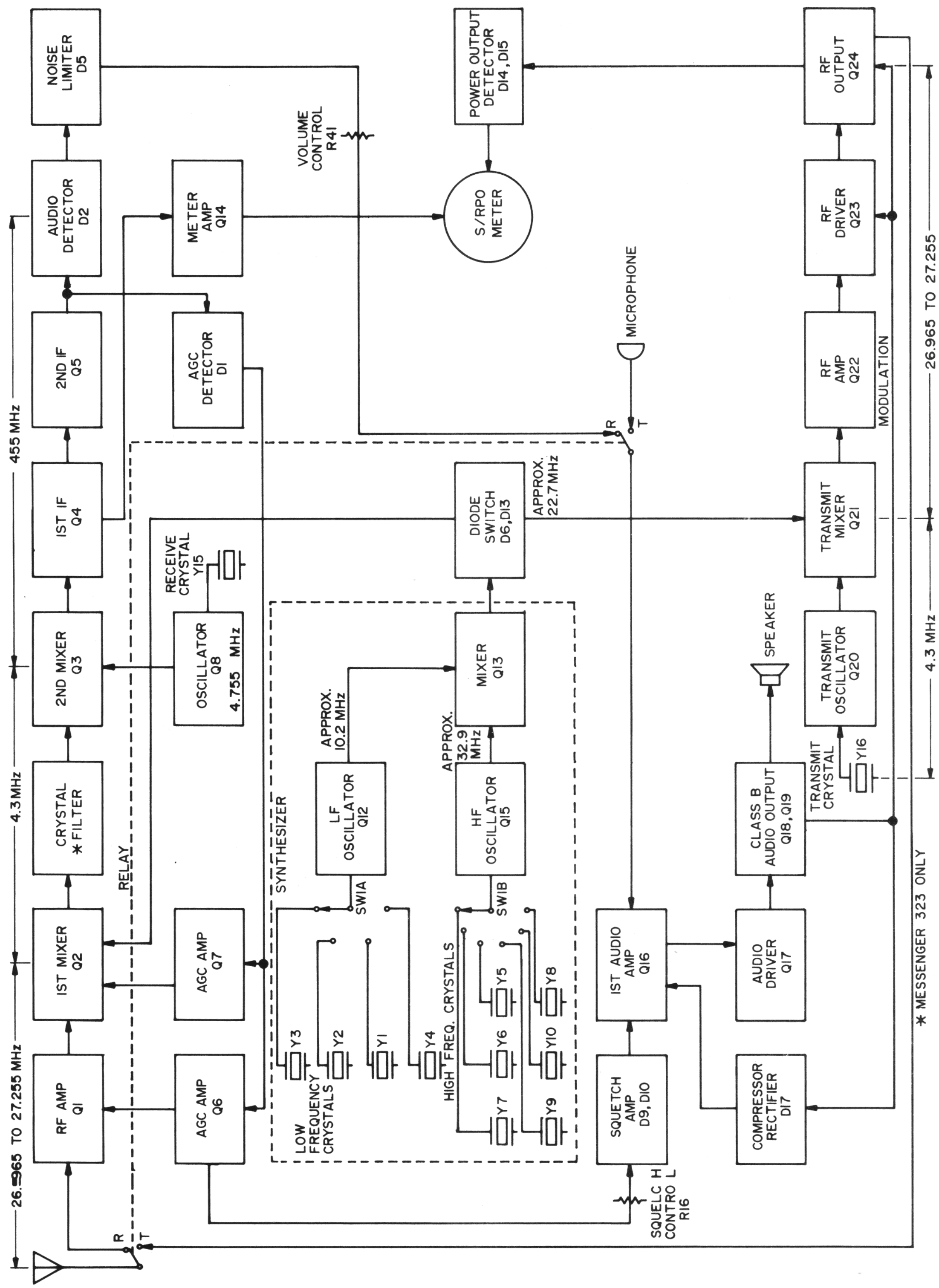
4.4.6 RF OUTPUT

The grounded collector power amplifier, Q18, is designed to operate at 5 watts DC power input. The power amplifier drives a 50 ohm antenna through a pi network and a set of contacts on the relay.

4.5 S/RPO METER

On receive, the signal strength/relative power output (S/RPO) meter circuitry is connected to the emitter of the first IF amplifier, Q4. The signal goes to the base of Q14, the meter amplifier, where it is amplified to operate the meter. The meter reading is adjusted by R48 to indicate "0" with no signal present and by R47 to indicate "S9" with a 50μV unmodulated signal into the receiver.

On transmit, the meter indicates relative power output. The meter circuitry samples the RF output without further amplification. Diodes, D14 and D15, make up a voltage doubling circuit to sample a portion of the output signal and increase the voltage available to drive the meter when the transceiver is operating.



MESSENGER 320/323 BLOCK DIAGRAM
FIGURE 4-1

SECTION 5
SERVICING

5.1 GENERAL SERVICING INFORMATION

The information in this section serves as a guide for servicing the Messenger 320 and 323 transceivers. Carefully read this information before attempting to isolate malfunctions. A little beforehand knowledge is always an asset when troubleshooting.

Refer to the circuit description, block diagrams, and the schematics at the back of this manual to familiarize yourself with the transceiver circuitry.

5.1.1 IDENTIFICATION OF PARTS

The parts list in this service manual is in alphabetical and numerical order by item number, i.e., capacitors first, chassis parts second, etc.

5.1.2 PREVENTIVE MAINTENANCE

The transceiver should be placed on a regular maintenance schedule, and an accurate record of its performance should be maintained. Important items to check are receiver sensitivity, transmitter power output, and frequency output. Use the performance test procedures in the receiver and transmitter servicing sections as guides.

5.1.3 REPLACEMENT TRANSISTORS

You will notice when referring to the parts list that the transistors used in this unit are listed with E. F. Johnson house numbers. These transistors are specially selected for specific parameters. They must be replaced with transistors listed in the parts list of this service manual. Refer to Section 1 in this service manual for detailed instructions on ordering replacement parts.

5.1.4 TUNING INFORMATION

The Messenger 320 and 323 generally require tuning of only those stages that have been repaired. Unnecessary tuning wastes valuable servicing time and can actually degrade the performance of a unit if not ascomplished by an experienced technician. The alignment section includes detailed tuning instructions and illustrates the tuning tools required.

5.1.5 GENERAL SOLDERING INFORMATION

The same basic soldering practices used on other printed circuit boards can be used on the Messenger 320 and 323 circuit boards. Avoid using small wattage soldering irons. Apply the amount of heat that will cause the solder to flow quickly. No iron smaller than 47 watts should be used. Use a vacuum bulb desoldering device, such as a "solder sipper", to remove excess old solder from the circuit board.

Use a heatsink pliers on RG-174 (subminiature) coaxial cable shields when unsoldering and soldering the center conductor. Do this by grasping the shield with needlenose pliers when heat is applied. This method will prevent melting the coax center conductor insulation.

5.1.6 REMOVING CABINET SHELL

a. Remove the four No. 6 screws that retain the cabinet shell at the rear of the chassis rail.

b. Grasp the front panel with one hand and the cabinet shell with the other.

c. Carefully slide the cabinet shell away from the front panel.

5.1.7 GENERAL TROUBLESHOOTING INFORMATION

Always give a malfunctioning unit a quick visual check before attempting to isolate troubles. A visual check may spot an overheated or burned component. Most transceiver malfunctions will probably be the result of transistor or diode failures.

Always check transistor emitter voltages first when troubleshooting. They will usually give the first indication of trouble.

5.2 TRANSISTOR TROUBLESHOOTING

5.2.1 GENERAL

The following information is intended to aid troubleshooting and isolation of transistor circuit malfunctions.

5.2.2 TRANSISTOR OPERATING CHARACTERISTICS

For all practical purposes the transistor base-emitter junction and the transistor base-collector junction can be considered to be diodes. For the transistor to conduct collector to emitter its base-emitter junction must be forward biased in the same manner as a conventional diode. In a germanium transistor the typical forward biased junction voltage is 0.2 to 0.4 volts. A typical silicon transistor will have forward biased junction voltage of 0.5 to 0.7 volts. When collector current is high the base-emitter voltage of both germanium and silicon transistors increases from 0.1 to 0.2 volts. The base-emitter bias voltage in the forward biased condition is then 0.4 to 0.5 volts for a germanium transistor and 0.7 to 0.9 volts for a silicon transistor. High current silicon transistors may go up 2 volts under load.