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HANDBOOK  
OPERATION INSTRUCTIONS

**RADIO RECEIVER**

**MODEL SP-600-JX-21**

(HAMMARLUND)

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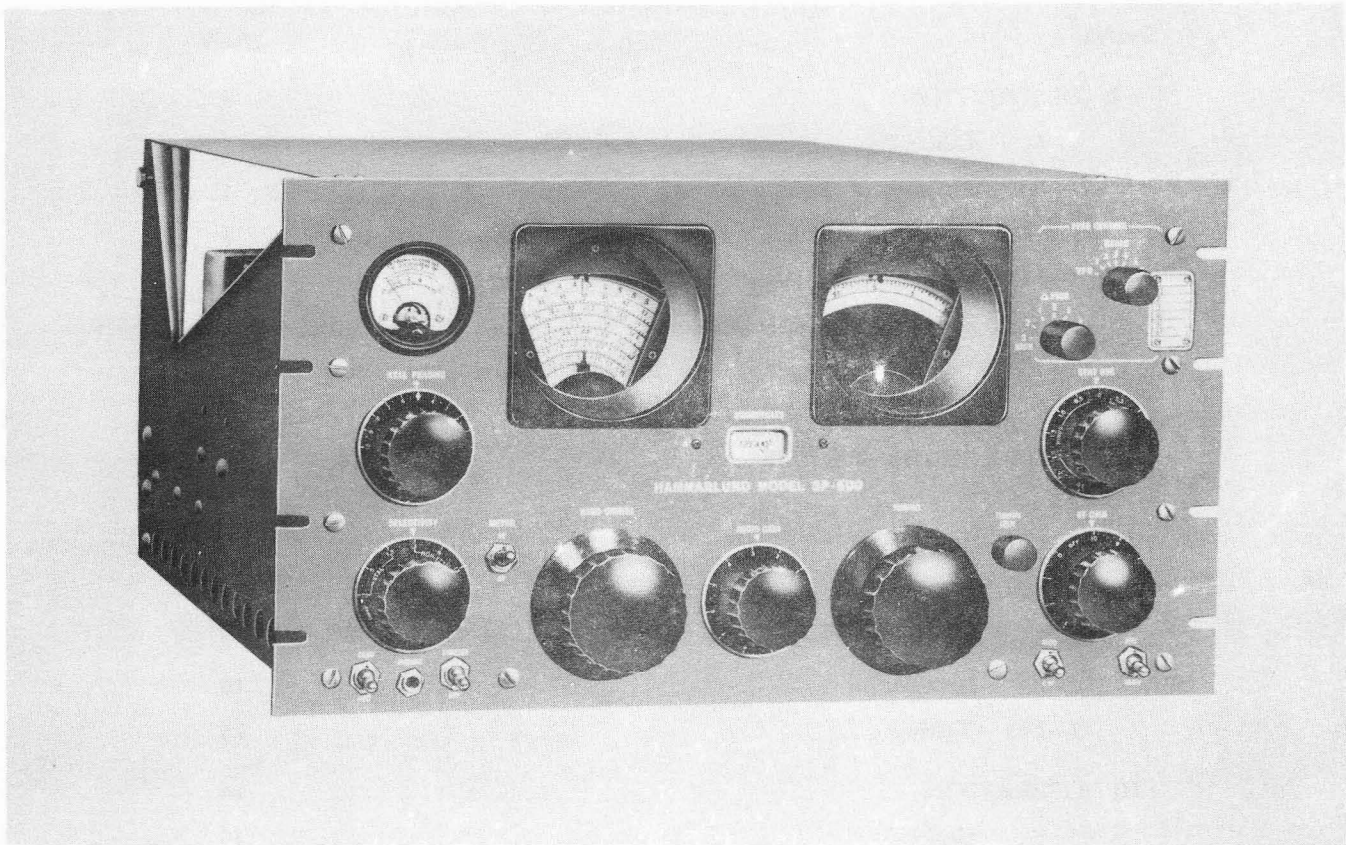


Figure 1-1. Radio Receiver, Model SP-600-JX-21

## SECTION I

## DESCRIPTION

**1-1. GENERAL.**

1-2. This handbook contains operation instructions for Radio Receiver, Model SP-600-JX-21, (figure 1-1) manufactured by the Hammarlund Manufacturing Co., Inc., New York 1, N. Y.

**1-3. PURPOSE OF EQUIPMENT.**

1-4. The radio receiver is designed for enclosed-station, fixed or mobile use. It is adaptable to shipboard, airborne, or field applications, and may be used in a two-way operational activity. The radio receiver provides for the reception of keyed, amplitude-modulated, and frequency-shift carrier signals. The carrier signal intelligence may be slow-speed (manual) or high-speed (automatic) telegraph, phone, teletype, facsimile, etc. For Morse code and teletype operation, use is made of c-w and single-tone carrier signals. For teletype operation, two-tone and frequency-shift carrier signals may also be used.

1-5. To render the signal intelligence audible and/or recordable, auxiliary components are required. When the receiver is to be used for the reception of phone or slow-speed telegraph signals, a headset and/or loudspeaker are used; in other modes of operation, these components are used to monitor the signal. To receive high-speed telegraph signals, a recorder driving unit and/or a tape ink recorder are required. For frequency-shift teletype reception, use is made of suitable frequency-shift converter equipment associated with a teletypewriter.

1-6. The output of the receiver, for signals other than phone, may be developed in the form of d-c output to denote a dot (mark) and no d-c output to denote a dash (space), the signal intelligence being contained in the succession of dots and dashes. Alternately, it may be developed in the form of a-c output wherein, for the interval of each dot (mark), or for the interval of each dot (mark) and each dash (space), keyed-tone signals result. The signal in the form of d-c output is suitable to operate applicable recording equipment such as a tape ink recorder, a line relay, or a tone generator. The signal in the form of a-c output provides the audible output of the system; or it is used to operate a recorder driving unit associated with the tape ink recorder, or to provide input to a suitable frequency-shift converter associated with a teletypewriter.

1-7. The tone generator keyed output may be used to provide the signal to the headset and/or loudspeaker monitor. It may also be fed to a transmission line to provide the signal at the remote end of the line. The keyed-tone used is in the voice frequency range, each signal requiring a frequency band of 170 cycles, and the line may be used for several such tone signals, as well as for phone signals.

1-8. The radio receiver provides for continuously variable reception within the frequency range of 0.54 mc to 54.0 mc, and for crystal-controlled fixed-frequency reception within the frequency range of 0.75 mc to 54.0 mc. The receiver uses single heterodyne conversion for its three lower frequency bands and double heterodyne conversion for its three higher bands (above 7.4 mc). The receiver signal-to-noise ratio and sensitivity characteristics provide for the reception of extremely weak signals and the receiver is well suited for the reception of short-wave signals which are inherently subject to nonselective and selective fading.

1-9. The radio receiver has an internal beat-frequency oscillator used in heterodyne detection of keyed-carrier signals to provide audio signal intelligence to the headset and/or loudspeaker monitor.

1-10. The radio receiver has a self-contained power supply designed to operate from a 50-cps to 60-cps, single-phase a-c source within the voltage range of 90 to 270 volts. The receiver power consumption is 130 watts. The power transformer primary and secondary are separately fused. The 1.6-ampere slow-blow primary fuse, and the  $\frac{3}{8}$ -ampere high-voltage secondary fuse are contained in cartridge-type fuseholders located on the rear apron of the receiver.

**1-11. DESCRIPTION OF EQUIPMENT.**

1-12. GENERAL. The radio receiver is a 20-tube radio-communications type designed for direct mounting in a standard 19-inch relay rack. It comprises a chassis and light grey front-panel assembly to which are mounted a top cover and a bottom plate.

1-13. RECEIVER CONNECTOR USES. With the exception of the headset "PHONES" jack (20, figure 3-1), located on the front panel, and the "ANT" input connector (8, figure 2-1), all receiver connectors and terminals are located on the rear apron. The a-c power cable of the receiver is also located on the rear apron.

1-14. The receiver input circuit is designed to accommodate a balanced doublet or straight-wire antenna. The input impedance of the receiver is designed to match a 95-ohm transmission line. Other suitable antenna installations specifically designed for the desired operating frequency may also be used. The antenna is connected to the receiver "ANT" input connector (8, figure 2-1) with type RG-22/U cable.

1-15. The "IF OUTPUT" connector (6, figure 2-2) provides a received signal (usually frequency-shift) at the receiver i-f output for frequency-shift converter use, usually as part of a space-diversity receiving system. The i-f output circuit in the receiver is isolated from the b-f-o circuits, therefore b-f-o injection voltage is not available at the "IF OUTPUT" connector.

1-16. The receiver "AUDIO OUTPUT" terminals (8, figure 2-2) are suited for a 600-ohm loudspeaker or transmission line. The receiver a-c signal output (phone, single-tone telegraph or teletype, or two-tone teletype) is available at the "AUDIO OUTPUT" terminals. To render high-speed telegraph and single-tone or two-tone signals intelligible, the tape ink recorder used for high-speed telegraph and the teletypewriter used for teletype reception are associated with demodulator equipment connected to the receiver by suitable transmission line. When a local teletypewriter is used to operate another teletypewriter remotely or locally connected to the transmission line, the send teletypewriter relay is connected to the jumpered "AUDIO OUTPUT" terminals so that the line current on "mark" balances out between the balanced split output transformer windings of the receiver, for which the jumpered connection provides a mid-point tap. This use of the line may be simultaneous to its other uses.

1-17. The receiver "DIODE OUTPUT" terminals (2, figure 2-2) and the "AVC" terminals (3) are used to interconnect two receivers in a space-diversity receiving system. The "AVC" terminal designated "G" is grounded for each receiver to a common ground while that designated "-" is interconnected between receivers. This is done to provide common avc between receivers for space-diversity reception of an amplitude-modulated or frequency-shift signal. With this arrangement, the avc due to the stronger signal received on one receiver decreases the weaker signal and the noise output of the other. To provide for space-diversity reception of phone, the audio output from only one receiver is used. To do this, the jumpered "DIODE OUTPUT" terminals are opened on one receiver and the "-" terminal connected to the other receiver, which provides the output. To provide for space-diversity reception of cw to a tone keyer (generator) or tape ink recorder, the receiver interconnections are as outlined for phone, but no avc and no bfo are used. This is the case when the d-c output from the three interconnected "DIODE OUTPUT" terminals is used. When the a-c output is used, the diversity demodulator, associated with the tape ink recorder, is provided with the a-c output from the "AUDIO OUTPUT" terminals (8) of each receiver. To provide for the space-diversity reception of frequency-shift carrier signals, the i-f output or the audio output from each receiver may be used to provide input to suitable frequency-shift converter equipment.

1-18. The "AC" power receptacle (12, figure 2-2) on the rear apron of the receiver may be used for operating an accessory, such as an electric clock or lamp. Power is available at the receptacle whenever the receiver is connected to a power source, regardless of the settings of the receiver controls.

1-19. RECEIVER OPERATION. All operational activities require that the receiver switches and controls be set properly for the mode of operation contemplated. These controls are all located on the front panel of the

receiver, with the exception of the "METER ADJ RF" control (5, figure 2-2) and the "METER ADJ AF" control (7) used to calibrate the tuning meter (1, figure 3-1) on the front panel, and the "BFO INJ" adjustment control (4, figure 2-2), all three of which are located on the rear apron of the receiver. These controls are factory adjusted, and are not to be moved from their adjustment positions.

1-20. The radio receiver is adaptable to a two-way operational activity through use of the "SEND/REC" switch (21, figure 3-1). With the receiver "RF GAIN" control (11) turned clockwise from its "OFF" position, when the a-c source is connected to the receiver, a-c power is applied for either position of the "SEND/REC" switch. When the switch is in its "SEND" position, the receiver is disabled for protection in the presence of a strong local carrier such as that produced by local transmission during a two-way communication activity. When the switch is in its "REC" position, the receiver provides for instant reception.

1-21. When the radio receiver "FREQ CONTROL" selector switch (8, figure 3-1) is set to the "VFO" position, the "TUNING" control (15) provides continuously variable tuning of any desired carrier within the frequency band selected by the "BAND CHANGE" switch (17). When the "FREQ CONTROL" selector switch is set to one of the "XTALS" positions, the receiver provides for fixed-frequency crystal-controlled reception of any signal within the frequency range of 0.75 mc to 54.0 mc, provided that the proper crystal has been inserted into the numbered crystal socket corresponding to the selected switch position. The "BAND CHANGE" switch functions as before, and the "TUNING" control is used to adjust the r-f amplifier circuits to the operating frequency. Exact tuning of the crystal-controlled first heterodyne oscillator is provided by the " $\Delta$  FREQ" control (7). The "TUNING LOCK" (14), when turned clockwise, provides optional locking means for the vernier dial (6), the main tuning dial (4), and the tuning mechanism, to prevent accidental detuning of the receiver due to vibration or accidental shift of the controls. The "TUNING" control itself remains free to turn even when the "TUNING LOCK" is locked.

1-22. The receiver "SELECTIVITY" switch (22, figure 3-1) provides a choice of six degrees of bandwidth or selectivity. The switch position chosen is that which provides optimum receiver performance for the existing quality of the received signal. When the switch is in one of its "XTAL" positions, the "XTAL PHASING" control (23) is used to highly attenuate any interfering signal, even when it is closely adjacent to the desired signal. The receiver "LIMITER/OFF" switch (19) in its "LIMITER" position provides for effectively reducing ignition noise and other pulse-type noise from the receiver audio output.

1-23. The receiver "MOD/CW" switch (13, figure 3-1) in its "CW" position renders the bfo operative. The "BEAT OSC." control (10) provides the means of adjusting the tone output within a frequency range of  $\pm 3$

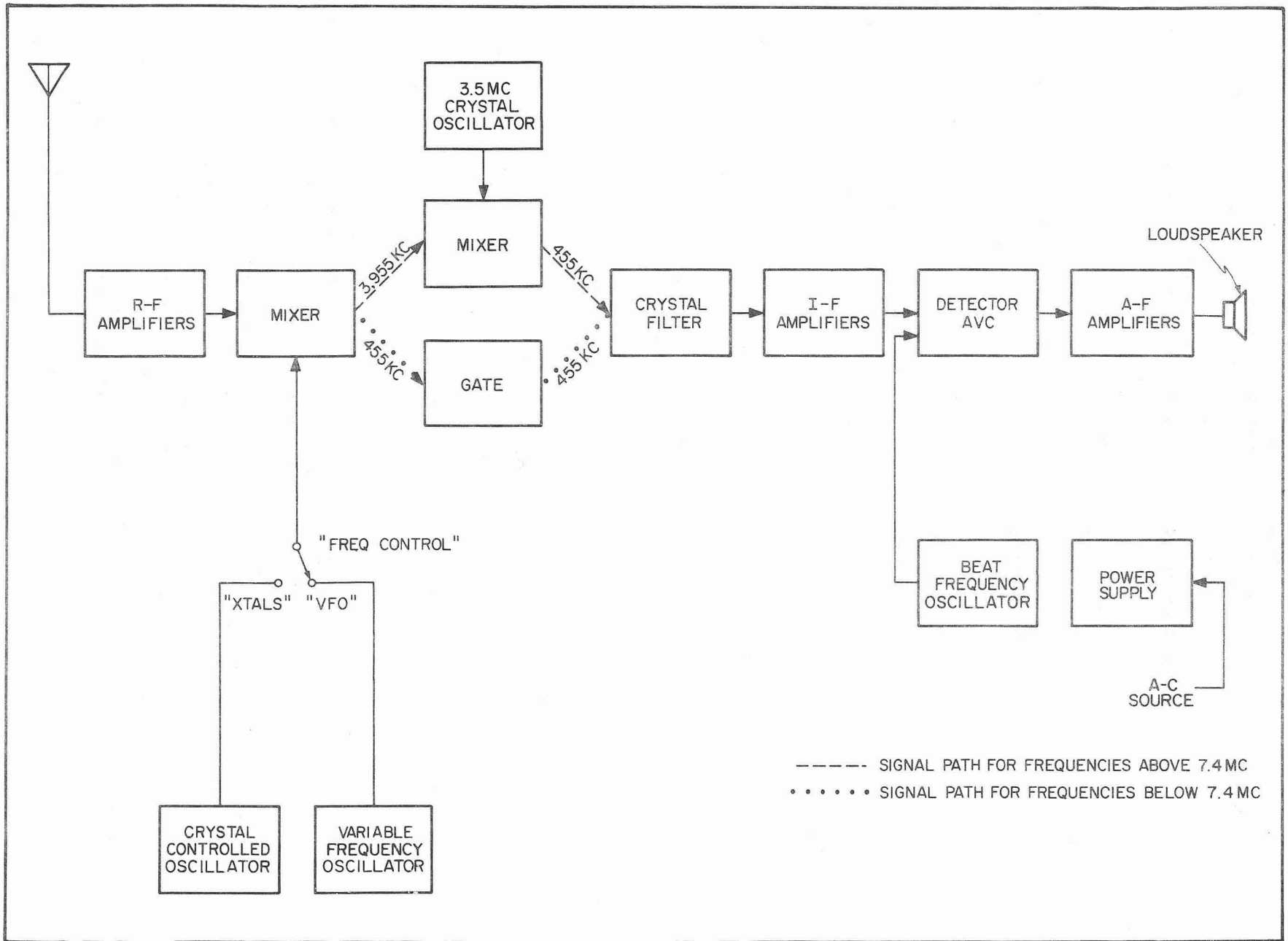


Figure 1-2. Radio Receiver, Simplified Block Diagram

## Paragraphs 1-24 to 1-29

kc. The "BEAT OSC." control may be turned in either direction on scale to provide the 3-kc range for the received c-w signal. When the "MOD/CW" switch is in the "MOD" position, the receiver provides for the reception of amplitude-modulated signals. When the receiver is to be used for the reception of a frequency-shift signal, the "MOD/CW" switch position is dependent upon whether the receiver i-f output or the receiver a-f output is to be furnished to the associated frequency-shift converter equipment. When the receiver i-f output is used, the use of the bfo provides optional receiver output for monitoring purposes. When the receiver a-f output is used, the bfo must be in operation. When the receiver is to provide suppressed-carrier (single or double sideband) reception, the bfo is used to reinsert the carrier at the receiver. For this application, the "BEAT OSC." control is set to a position providing a bfo frequency of 455 kc.

1-24. The receiver "RF GAIN" control (11, figure 3-1) is adjustable to compensate for wide variations encountered in the level of any carrier received. To maintain the receiver a-f output constant within narrow limits for the "RF GAIN" control setting chosen, the receiver incorporates automatic volume control. The receiver "AVC/MAN" switch (12), when set to the "AVC" position, provides this action. Provisions are included in the receiver for a-v-c operation even during the reception of slow-speed telegraph signals. The "RF GAIN" control is effective in either position of the "AVC/MAN" switch.

1-25. The receiver tuning meter (1, figure 3-1) provides a tuning indication for the desired signal, when the "AVC/MAN" switch (12) is set to the "AVC" position. When the "RF GAIN" control (11) is set to its maximum clockwise setting, the meter top scale indication is the ratio of the received signal level to a signal of one microvolt, expressed in db. When the "METER" switch (18) is held in its depressed "AF" position, the meter bottom scale indication is the ratio of the receiver audio output to the standard reference output of six milliwatts, expressed in db.

**1-26. OPERATIONAL THEORY.**

1-27. GENERAL. An analysis of the operation of the radio receiver is best evolved by considering the signal path through the receiver r-f, i-f, and a-f sections, into which the receiver may be considered theoretically subdivided. The self-contained power supply of the receiver is considered separately. The simplified block diagram (figure 1-2) indicates in block form the relationship between the various sections of the receiver.

1-28. R-F SECTION. The r-f section of the receiver provides selective circuitry for any selected signal within the receiver frequency range of 0.54 to 54.0 mc. It does this through the use of six sets of r-f tuner subassemblies housed in a rotary turret assembly. Each set is used for one frequency band of the receiver and comprises an antenna r-f tuner, two identical interstage r-f tuners, and an oscillator r-f tuner. The "BAND CHANGE" switch (17, figure 3-1) provides for indenting the rotary turret as-

sembly so that the r-f tuner subassemblies for a particular frequency band become part of the r-f section of the receiver. The antenna and two-stage r-f gain provided to the signal assures that the signal-plus-noise to noise ratio developed in the r-f section is high enough so that even very weak signals provide useful receiver output. The r-f section preselection assures that the gain available to the signal is greatly in excess of that provided any undesired signal. Since the receiver utilizes the principles of superheterodyne reception, a signal removed from the desired signal by twice the 455-kc intermediate frequency also provides an i-f signal acceptable to the i-f section of the receiver. This image frequency, like any other undesired signal, is greatly attenuated. However, for signals tuned in on the three higher frequency bands of the receiver, the image frequency for an intermediate frequency of 455 kc would be too close to the desired signal. To maintain high image-rejection ratios, the receiver provides for double superheterodyne reception on these bands. On the three lower frequency bands (below 7.4 mc), the signal tuned in is heterodyned to a 455-kc i-f signal. On the three higher frequency bands, it is first heterodyned to a 3955-kc i-f signal, which is then heterodyned to a 455-kc i-f signal. With the receiver "FREQ CONTROL" selector switch (8) in its "VFO" position, the receiver provides for continuously variable tuning. When the switch is in one of its "XTALS" positions, the receiver first heterodyne variable oscillator is replaced by a fixed-frequency crystal-controlled heterodyne oscillator. Doing this results in receiver frequency stability superior to that attainable for variable-frequency tuning. Its use pre-establishes the communication channel, even when receiving conditions are poor, without necessitating a time-consuming search by the operator.

1-29. I-F SECTION. The i-f section of the receiver incorporates the 455-kc i-f amplifier wherein practically all of the overall gain and selectivity of the receiver is developed. Also, it incorporates the single-double conversion switch, which assumes its single or double conversion position dependent on whether the rotary turret is indented respectively for one of its three lower or three higher frequency bands. For signals tuned in on one of the three lower frequency bands, the signal has access to the 455-kc i-f amplifier through a 455-kc i-f gate. For this condition the switch renders the double-conversion i-f channel inoperative. For signals tuned in on one of the three higher frequency bands, the signal reaches the 455-kc i-f amplifier through the 3955-kc i-f double-conversion channel. For this condition the switch renders the 455-kc i-f gate inoperative. The six choices of receiver selectivity provided by the "SELECTIVITY" switch (22, figure 3-1) are developed in the 455-kc i-f channel of the receiver. At the input to the 455-kc i-f amplifier is the 455-kc i-f crystal-filter circuit incorporated in the receiver. The use of the crystal filter enables the receiver to attain the three degrees of sharp "XTAL" selectivity. The precise antibacklash gear-train tuning mechanism provides for completely accurate resetability and calibration accuracy of the receiver so that maximum



benefit can be derived from the sharp, crystal passbands of the 455-kc i-f crystal filter. The "XTAL PHASING" control (23) is part of the crystal filter. The  $455 \pm 3$ -kc bfo and associated "BEAT OSC." control (10) and the "IF OUTPUT" connector (6, figure 2-2) are associated with the 455-kc i-f channel of the receiver.

1-30. A-F SECTION AND POWER SUPPLY. The a-f section of the receiver incorporates an a-f amplifier to develop the a-f power output of the receiver. The "AUDIO GAIN" control (16, figure 3-1) is used to control the receiver output to the "AUDIO OUTPUT" terminals (8, figure 2-2) and that to the "PHONES" jack (20, figure 3-1). The self-contained power supply develops all the a-c and the d-c supply voltages used by the receiver. The critical d-c supply voltages are regulated to maintain constant the sensitivity and frequency stability. The "RF GAIN" control (11) is part of the power-supply bias rectifier. Its chosen setting, in conjunction with the a-v-c system of the receiver, when used, determines the gain developed in the r-f and i-f sections of the receiver.

### 1-31. CAPABILITIES AND LIMITATIONS.

1-32. GENERAL. The radio receiver provides optimum receiver performance when properly installed and operated. The antenna input connector provides for connection to a balanced doublet or single-wire antenna system. The 95-ohm cable used provides flexibility as to the relative locations of the receiver and the antenna system. In use, the receiver may be subjected to temperatures within the range of  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ) to  $60^{\circ}\text{C}$  ( $140^{\circ}\text{F}$ ), at relative humidities as high as 95 percent. After a 15-minute warmup period, the frequency stability ranges from 0.001 percent to 0.01 percent of the signal frequency. The receiver incorporates advanced design and shielding to reduce radiation characteristics to a minimum. This enables the receiver to maintain performance in multi-receiver installations and to comply with shipboard regulations. The receiver embodies the necessary chassis rigidity to withstand severe vibration and shock. It is adequately treated with fungicidal varnish to condition it for tropical use.

1-33. PRESELECTION. The image frequency of any signal tuned in on the receiver is attenuated to the extent that if the desired signal strength were one microvolt, the strength of the image frequency signal would have to be at least 4000 microvolts (at 7.4 mc) to develop the same receiver output. At other signal frequencies the strength of the image frequency signal would have to be greater. Also, if the receiver is tuned to 600 kc, a 455-kc signal input to the receiver will have to be 2700 microvolts to produce the same effect as a one-microvolt signal at 600 kc. For frequencies other than 600 kc, this 455-kc i-f rejection ratio of the receiver is better. Likewise, the 3955-kc i-f rejection ratio of the receiver is at least 50,000 for any signal frequency on bands 4, 5, or 6, the frequency bands for which the 3955-kc i-f channel of the receiver is operative.

1-34. SENSITIVITY. The receiver threshold sensitivity (minimum signal input to develop its rated a-f output) is

two microvolts for an A-M signal, and 0.75 microvolt for a c-w signal, or better. The undistorted power output of the receiver at threshold sensitivity is two watts or better. This a-f output is provided at a signal-plus-noise to noise power ratio of ten to one. This provides for optimum receiver performance in the presence of a weak signal tuned in, since the background noise caused by the first electron tube and the antenna r-f tuner does not interfere with reception. The receiver sensitivity may be reduced in the presence of a strong signal by turning the "RF GAIN" control (11, figure 3-1) counterclockwise from its maximum clockwise position. This is done to prevent overloading of the r-f and i-f sections of the receiver. The receiver a-f output may be decreased by turning the "AUDIO GAIN" control (16) counterclockwise. This is done to prevent overloading of the a-f section of the receiver and to provide for comfortable reception at the desired a-f output level. When the receiver a-v-c system is operative and the "RF GAIN" control is set to its maximum clockwise setting, the receiver output remains constant within a one-to-four voltage ratio when the input is increased from 2 to 200,000 microvolts. The use of avc precludes excessive audio output when tuning through a carrier signal relatively strong compared to the setting of the "AUDIO GAIN" control, and compensates for the possible fading characteristics of the signal over long or short intervals of time.

1-35. SELECTIVITY. The bandwidth, or selectivity, of the receiver is adjustable to provide for the reception of a signal under varying conditions of propagation. Since noise, regardless of its origin, is of the pulse type and comprises all frequencies, the noise level in the audio output of the receiver depends upon the overall selectivity of the receiver. The "BROAD" settings of the "SELECTIVITY" switch (22, figure 3-1) produce more noise output than the "SHARP" settings. In the presence of noise, it is advantageous to restrict the overall receiver bandwidth to the narrowest possible, consistent with intelligible reception. However, the bandwidth requirements vary with the type of signal being received. For phone reception, the i-f channel bandpass requirements are  $455 \text{ kc} \pm 2500 \text{ cps}$ . This is also the requirement for single-tone telegraph reception. For keyed c-w operation such as slow-speed telegraph, teletype (60 words per minute), and high-speed telegraph (400 words per minute), the requirements are  $455 \text{ kc} \pm 50 \text{ cps}$ ,  $455 \text{ kc} \pm 75 \text{ cps}$ , and  $455 \text{ kc} \pm 600 \text{ cps}$ , respectively. When two tones, one for "mark" and another for "space", or two channels are used, the bandwidth requirements are doubled. The bandwidth requirements also depend upon the frequency stability of the received signal and the frequency stability of the receiver itself. For reception of a c-w signal, a narrow bandwidth can be used. To provide for reception of phone signals, the bandwidth may be reduced to reduce noise output; however, the use of a narrower bandwidth results in loss of the higher-frequency audio components in the received signal and may impair the intelligibility of reception. To provide for reception of telegraph or teletype signals,

full advantage should be taken of the "SELECTIVITY" switch positions to reduce interfering noise. The "SELECTIVITY" switch provides a choice of six degrees of overall bandwidth. The sharp, crystal-derived bandwidths are 0.2 kc, 0.5 kc, and 1.3 kc. The broad, non-crystal bandwidths are 3.0 kc, 8.0 kc, and 13.0 kc.

**1-36. EQUIPMENT REQUIRED FOR PHONE OR SLOW-SPEED TELEGRAPH RECEPTION.**

1-37. The tabulation of the complete equipment required for reception of phone or slow-speed telegraph signals is subdivided into two tables. The equipment supplied and covered by this publication is listed in table I. The components and auxiliary equipment of the receiving system, required but not supplied, are listed in table II.

**TABLE I. EQUIPMENT SUPPLIED**

Quantity	Name	Government Designation
1	Radio Receiver, Model SP-600-JX-21	
1	Plug, antenna connector	UG-102/U
1	Adapter, angle plug	UG-104/U
1	Plug, i-f output connector	PL-259

**TABLE II. COMPONENTS AND AUXILIARY EQUIPMENT REQUIRED BUT NOT SUPPLIED**

Quantity	Name	Government Designation
*AR	Crystal, Specification MIL-C-3098	CR-18/U
1	Headset	Navy Type -49507
1	Cord, headset	Navy Type -49534
1	Loudspeaker	LS-3
AR	Cable, lead-in	RG-22/U
1	Antenna system, balanced doublet or single wire	
1	Source, a-c, single-phase, 90 to 270V, 50 to 60 cps, 130 watts	

\*One crystal required for each operational signal frequency.

## SECTION II

## PREPARATION FOR USE

**2-1. UNCRATING.**

2-2. Carefully remove the receiver from its shipping container, using the following procedure:

- a. Remove the two steel straps from the wooden case.
- b. Remove the cover nailed to the case.
- c. Remove the excelsior from around the cartoned receiver.
- d. Remove the cartoned receiver from the case.
- e. Remove the waterproof tape from the folds of the waterproof paper wrapped around the cartoned receiver, and remove the waterproof paper wrapper.
- f. Open the carton and remove the inner carton containing the receiver.
- g. Remove the vapor-proof bag from around the inner carton.
- h. Unflatten the corners of the inner carton, open it, and remove the silica gel.
- i. Remove the wood frame from the carton, and the corrugated interiors comprising two side pieces, one front, one back, and one top, each accordion folded.
- j. Remove the receiver and set it out of the way in a convenient place near its final location.
- k. Put all packing material in the wooden case and store.

**2-3. INSPECTION.**

2-4. When the receiver has been removed from its shipping container, carefully inspect it for any signs of damage that may have occurred in shipment. Inspect the front panel controls, the tuning dial windows, and the meter for any defects. Inspect the tubes to make sure that they are firmly seated in their sockets and that none are broken. Inspect the fuses in the fuseholders on the rear apron of the receiver to make certain that fuses of the proper ratings are inserted in the fuseholders.

**2-5. REPLACEMENT OF DEFECTIVE PARTS.**

2-6. ELECTRON TUBES. If defective electron tubes are discovered during inspection, replacement must be made before operation is attempted. To replace defective electron tubes use the following procedure. (See figure 2-1.)

- a. To remove electron tubes V17 and V19, the top-hat-type tube clamp must first be removed. To remove the clamp, press inward on the spring, while lifting the clamp off the tube. Remove the tube by drawing it out from its tube socket. Replace the top-hat clamp by seating it on the top of the tube so that the vertical bolt adjacent to it can be threaded through the hole in the spring, with pressure providing a ratchet motion until the clamp is firmly seated in place.

- b. To remove electron tube V4, loosen the knurled screw holding the tube shield. Then turn the tube shield counterclockwise, while exerting inward pressure, and remove the tube shield. The tube is of the pin type and is removed preferably with a suitable tube remover.

- c. To remove any electron tube other than V4, V17, or V19, first remove the tube shield by twisting counterclockwise while exerting inward pressure. All tubes except V17 and V19 are of the pin type, and are preferably removed with an appropriate tube remover.

2-7. FUSES. To remove either the 1.6-ampere fuse or the  $\frac{3}{8}$ -ampere fuse, located respectively in the "LINE" fuseholder (11, figure 2-2) and the "-B" fuseholder (1) on the rear apron of the receiver, press in the top of the fuseholder while turning it approximately 45 degrees in a counterclockwise direction. Removing the pressure in this position will release the fuse which is spring-clamped to the top of the fuseholder. The fuse and the top of the fuseholder may now be pulled apart. To replace either fuse, follow the reverse procedure.

**CAUTION**

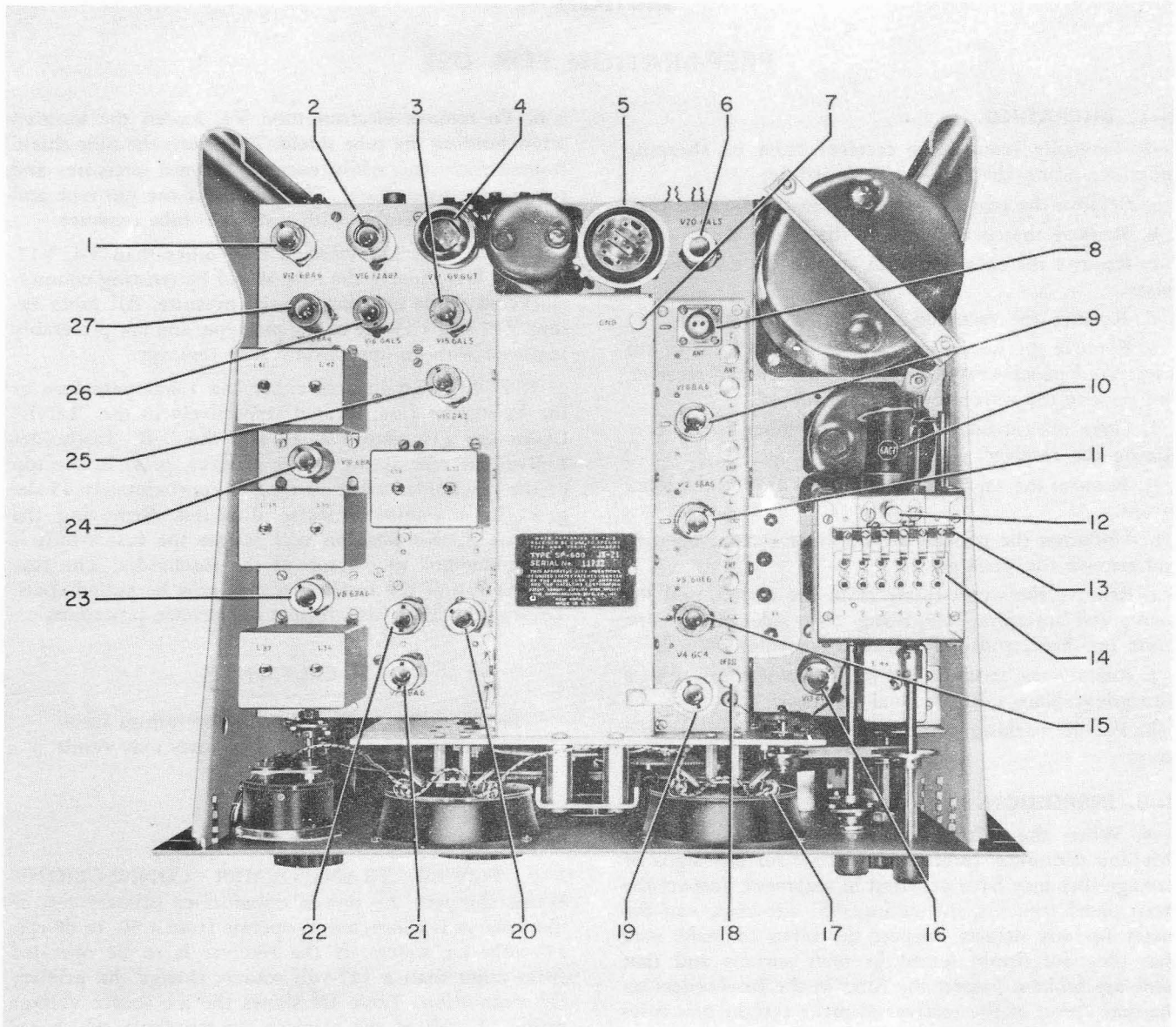
Be certain to use fuses having the ratings specified above. Use of any other fuses may result in damage to the receiver.

**2-8. SETTING UP THE RECEIVER.**

2-9. POWER TRANSFORMER CONNECTIONS. When shipped, the power transformer primary tap of the receiver is connected to operate from a 50- to 60-cps, 117-volt, a-c source. If the receiver is to be operated from other than a 117-volt source, change the primary tap connection. Table III shows the a-c source voltage rating of each of the primary tap terminals, which are

**TABLE III. POWER TRANSFORMER  
TAP VOLTAGE RATINGS**

Tap No.	Voltage Rating
2	95
3	105
4	117
5	130
6	190
7	210
8	234
9	260



- |                          |                              |                       |
|--------------------------|------------------------------|-----------------------|
| 1. Electron tube V12     | 10. Electron tube V3         | 19. Electron tube V4  |
| 2. Electron tube V16     | 11. Electron tube V2         | 20. Electron tube V8  |
| 3. Electron tube V15     | 12. Knurled thumbscrew       | 21. Electron tube V7  |
| 4. Electron tube V17     | 13. Retainer spring assembly | 22. Electron tube V6  |
| 5. Electron tube V19     | 14. Crystal sockets          | 23. Electron tube V9  |
| 6. Electron tube V20     | 15. Electron tube V5         | 24. Electron tube V10 |
| 7. "GND" terminal        | 16. Electron tube V13        | 25. Electron tube V18 |
| 8. "ANT" input connector | 17. Pilot lamp               | 26. Electron tube V14 |
| 9. Electron tube V1      | 18. Metal buttons            | 27. Electron tube V11 |

**Figure 2-1. Radio Receiver, Top View of Chassis**

identified by numerical designation on the bottom of the power transformer (13, figure 2-2).

### CAUTION

Choose the power transformer primary tap whose voltage rating is closest to the available a-c source voltage.

#### 2-10. CRYSTAL SELECTION AND MOUNTING.

When fixed-frequency, crystal-controlled operation is to be utilized, the proper type CR-18/U crystal(s) must be obtained and inserted into the crystal socket(s) (14, figure 2-1). When ordering a crystal, the crystal frequency and the signal frequency should be specified. For bands 1, 2, and 3, the crystal frequency can be calculated by adding 455 kc to the signal frequency; for band 4, in the signal-frequency range of 7.4 mc to 12.045 mc, the crystal frequency can be calculated by adding 3955 kc

to the signal frequency; for signal frequencies above 12.045 mc, on bands 4, 5, and 6, the crystal frequency can be calculated by adding 3955 kc to the signal frequency and dividing the sum by three.

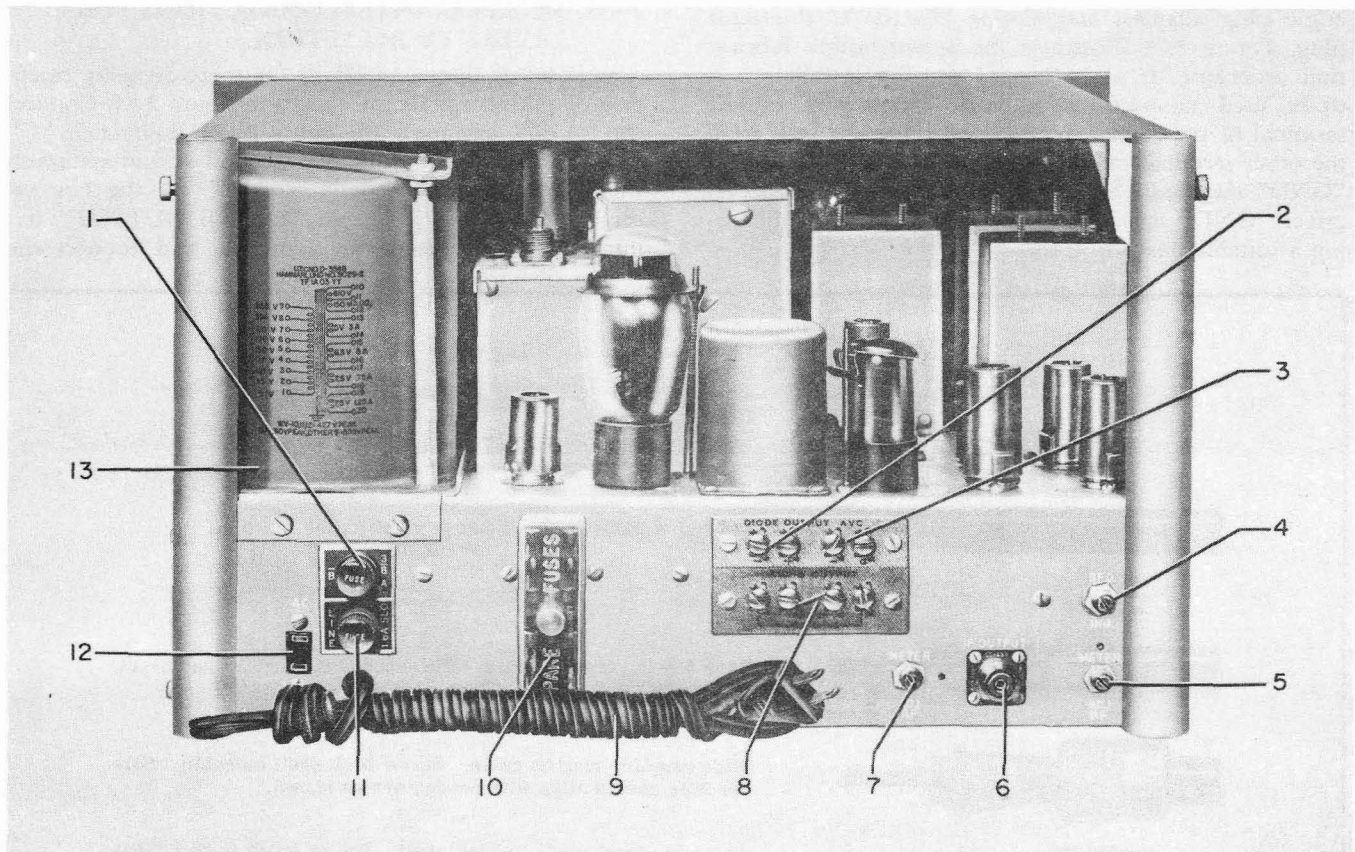
2-11. To mount the crystal units in the crystal sockets, proceed as follows:

a. Loosen the knurled thumbscrew (12) on top of the frequency-control unit, and push the retainer spring assembly (13) to the rear.

b. Insert the crystals into the crystal sockets (14), numbered 1 through 6, on the frequency-control unit.

c. Bring the retainer spring assembly forward until the springs are over the tops of the crystals in the sockets, and tighten the knurled thumbscrew.

d. Using a pen or pencil, mark on the plastic chart (9, figure 3-1) the signal frequencies for which the crystals are intended.



- |                             |                             |
|-----------------------------|-----------------------------|
| 1. "-B" fuse                | 7. "METER ADJ AF" control   |
| 2. "DIODE OUTPUT" terminals | 8. "AUDIO OUTPUT" terminals |
| 3. "AVC" terminals          | 9. Power cord               |
| 4. "BFO INJ" control        | 10. "SPARE FUSES" cover     |
| 5. "METER ADJ RF" control   | 11. "LINE" fuse             |
| 6. "IF OUTPUT" connector    | 12. "AC" power receptacle   |
|                             | 13. Power transformer       |

Figure 2-2. Radio Receiver, Rear View

**2-12. INSTALLATION.**

2-13. **MOUNTING.** The receiver is designed for rack mounting in a standard 19-inch rack. The receiver front panel is 10½ inches high. Mount the receiver in a position which permits the free access of air.

2-14. **POWER.** Make sure that the primary-tap lead at the bottom of the power transformer is connected to the tap which most nearly agrees with the 50-cps to 60-cps power source voltage; refer to paragraph 2-9. Plug the receiver into the power source using the receiver power plug.

2-15. **ANTENNA AND GROUND CONNECTIONS.** The antenna input circuit of the receiver is designed to accommodate a balanced doublet or single-wire antenna installation; however, other suitable antenna systems specifically designed for the desired operating frequency may be used. The input impedance of the receiver is designed to match a 95-ohm transmission line. Connect the antenna to the "ANT" input connector (8, figure 2-1) using type RG-22/U cable, a type UG-104/U angle plug adapter, and a type UG-102/U connector plug. Figure 2-3 illustrates the antenna-cable fabrication procedure. If a single-wire antenna installation is to be used, connect the antenna lead-in wire to one terminal of the connector plug and a ground lead from the other terminal of the connector plug to the receiver "GND" terminal (7). In all installations, bond the receiver "GND" terminal to the installation ground, using a suitable bonding strap.

2-16. **HEADSET.** For monitoring purposes, plug a headset into the "PHONES" jack (20, figure 3-1). Either a high-impedance or a low-impedance headset may be used; however, the high-impedance (8000-ohm) type is recommended.

2-17. **LOUDSPEAKER.** Connect a permanent-magnet, dynamic-type, loudspeaker with a suitable 600-ohm matching transformer across the "AUDIO OUTPUT" terminals (8, figure 2-2). For applications requiring the insertion of d-c control or indicating voltages, remove the jumper connecting the two balanced sections of the 600-ohm output at the "AUDIO OUTPUT" terminals, and connect the insertion circuit in its place.

**CAUTION**

When the 600-ohm output is not used, connect a 600-ohm, 2-watt resistor across the "AUDIO OUTPUT" terminals to avoid component damage from high transient peak voltages.

**2-18. RECEIVER INTERCONNECTIONS FOR DIVERSITY RECEPTION.**

a. Receiver interconnections for space-diversity reception of phone signals are shown in figure 2-4. Connect the "AVC" terminals (3, figure 2-2) designated "G" on each receiver to a common ground and interconnect the "AVC" terminals designated "-" on the two receivers. Open the jumpered "DIODE OUTPUT" terminals (2) on one of the receivers, and connect the

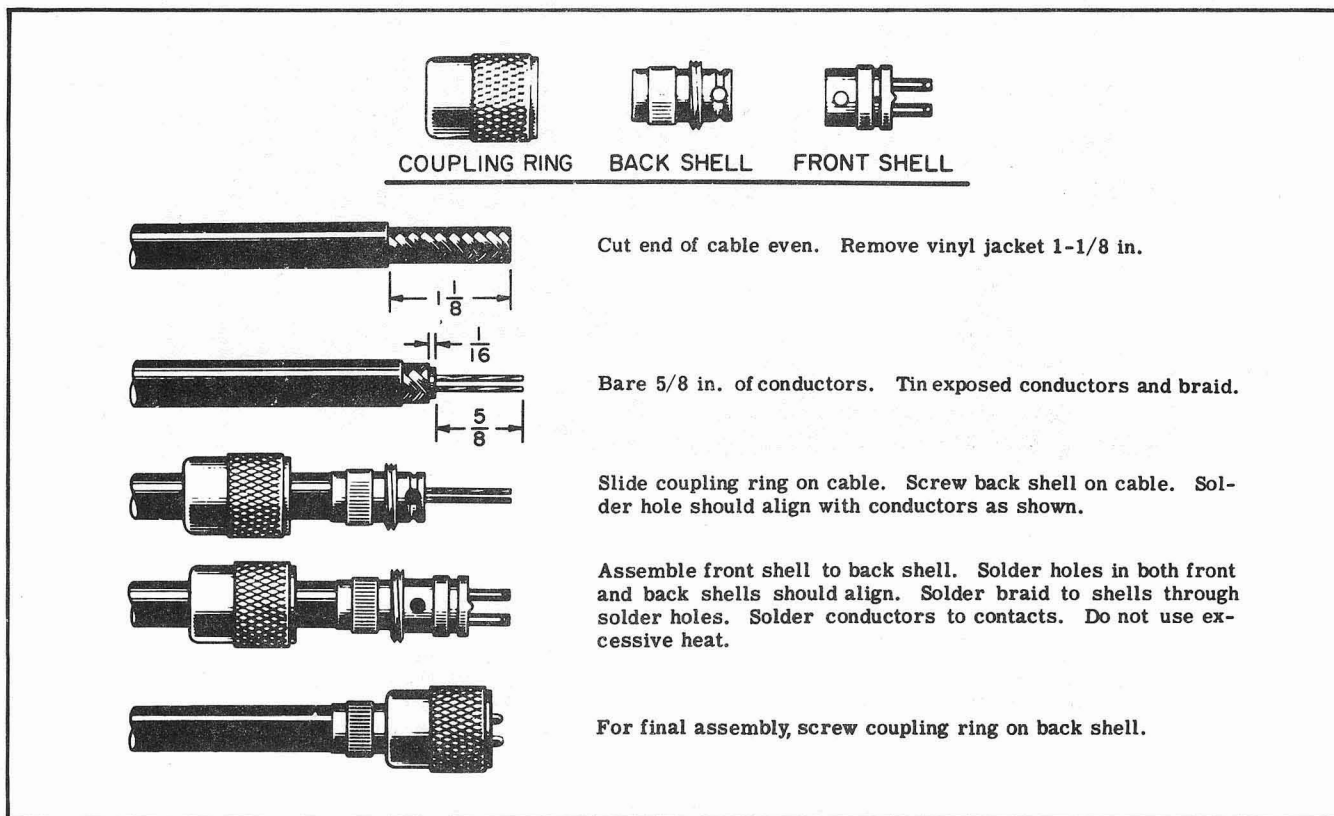


Figure 2-3. Fabrication of Antenna Cable

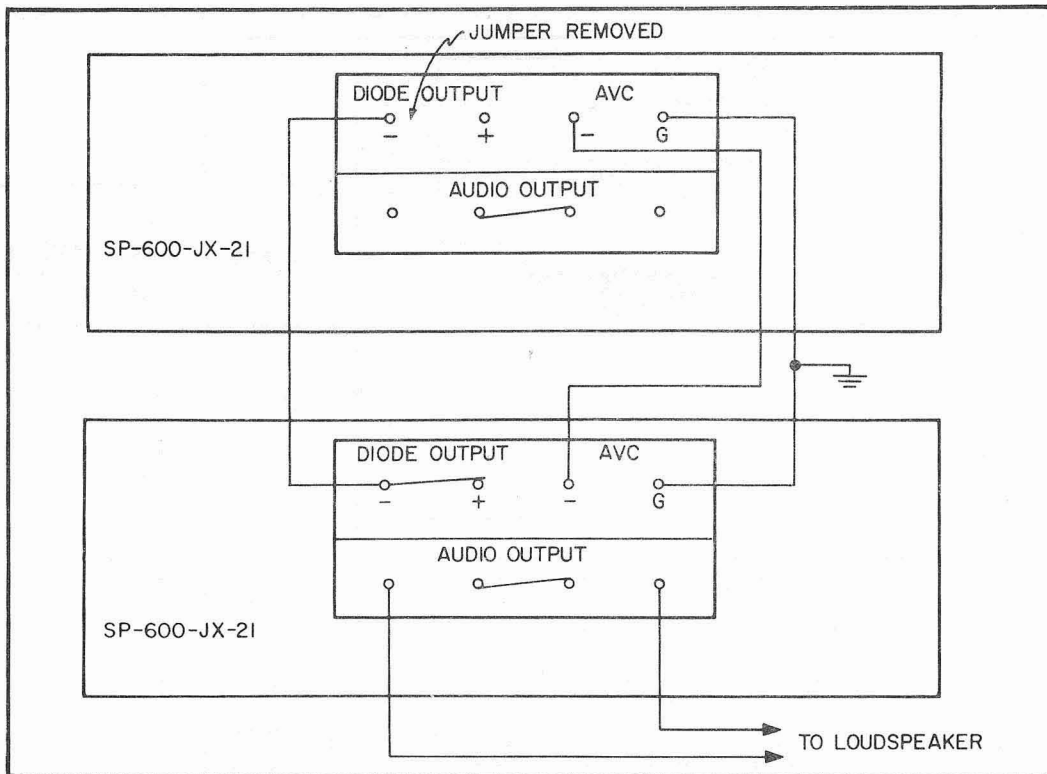


Figure 2-4. Receiver Interconnections for Phone Space-diversity Receiving System

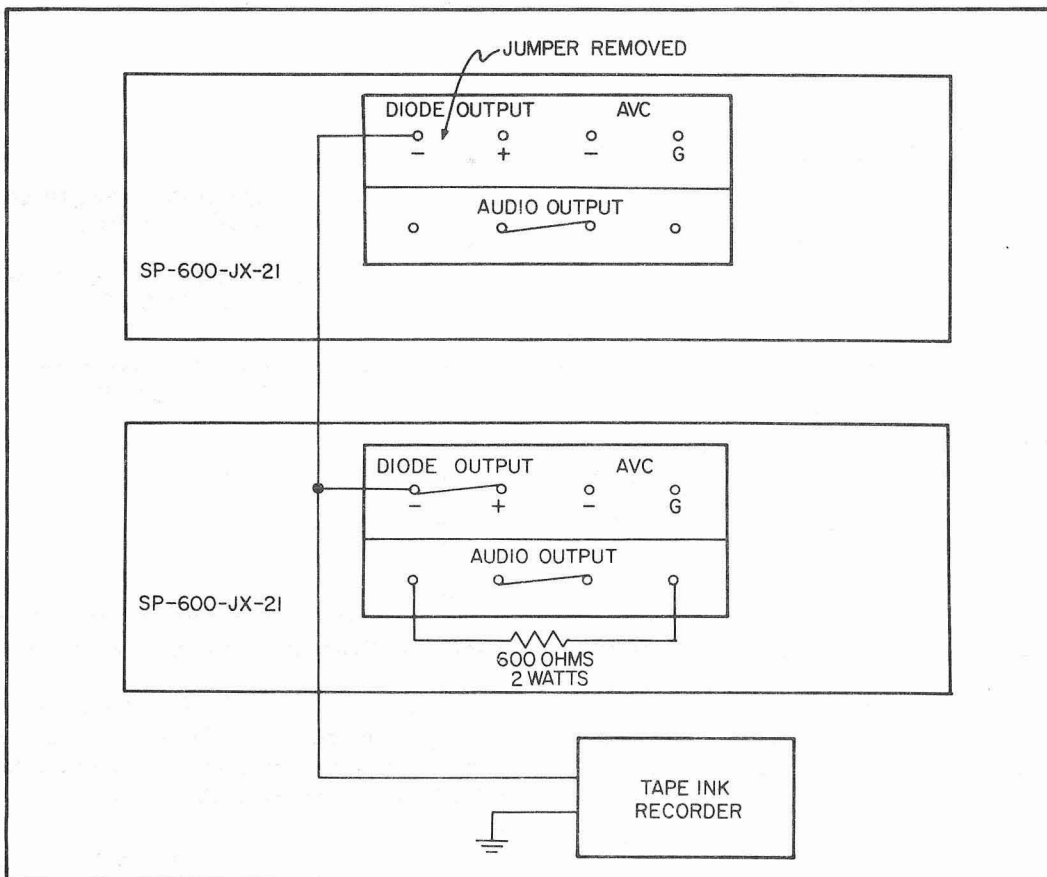


Figure 2-5. Receiver Interconnections for Space-diversity D-C Output Receiving System

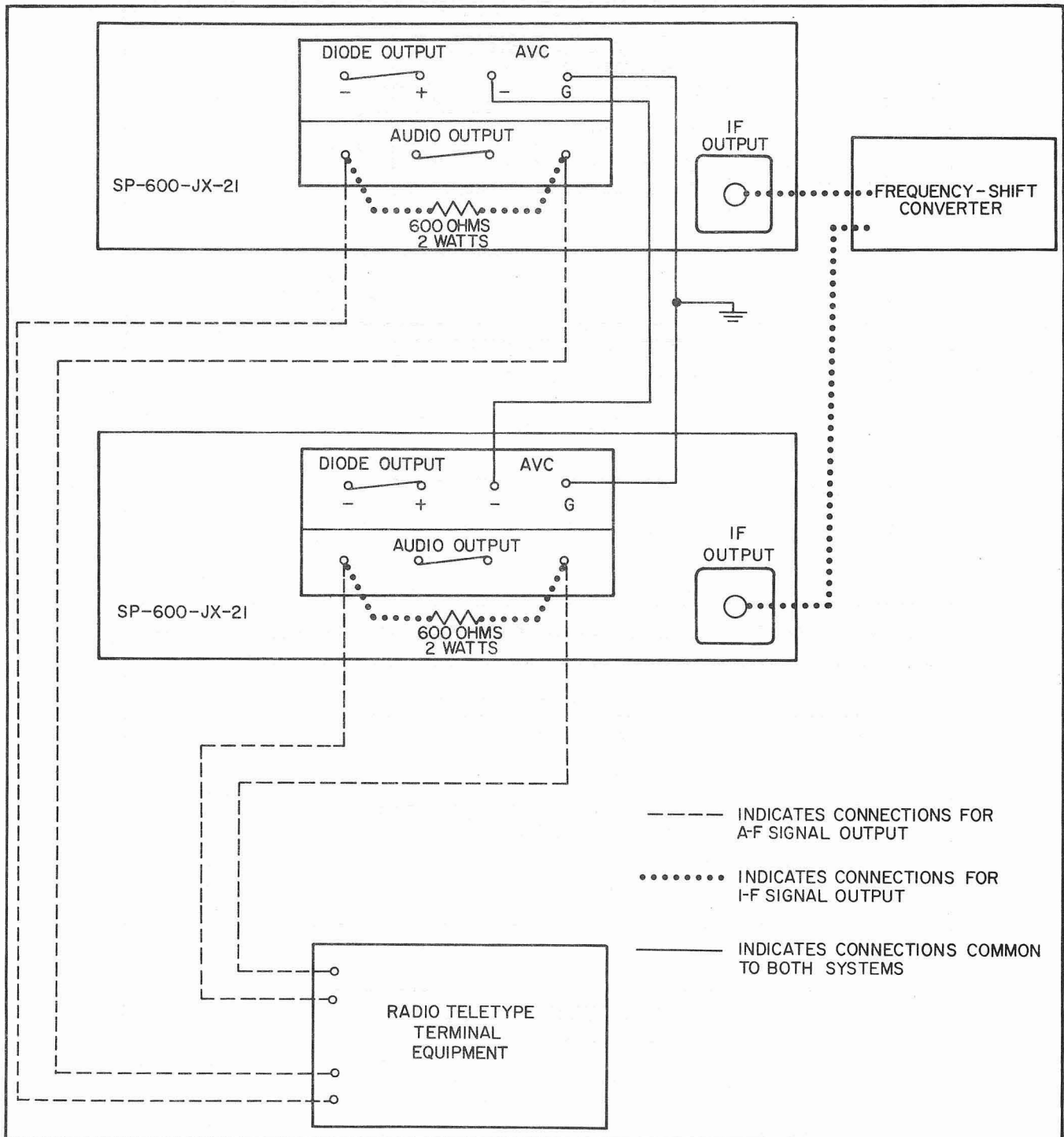


Figure 2-6. Receiver Interconnections for Frequency-shift Space-diversity Receiving System

"DIODE OUTPUT" terminals designated "-" to the like terminal of the second receiver. Connect the loudspeaker across the "AUDIO OUTPUT" terminals (8) of the second receiver.

b. For space-diversity reception of c-w signals, interconnect the two receivers as shown in figure 2-5. Open the jumpered "DIODE OUTPUT" terminals of one of

the receivers, and connect the "DIODE OUTPUT" terminal designated "-" to the like terminal of the second receiver. Connect the three interconnected "DIODE OUTPUT" terminals to the associated recording equipment.

c. The interconnections required for space-diversity reception of frequency-shift carrier signals are shown in figure 2-6. Interconnect the "AVC" terminals of the



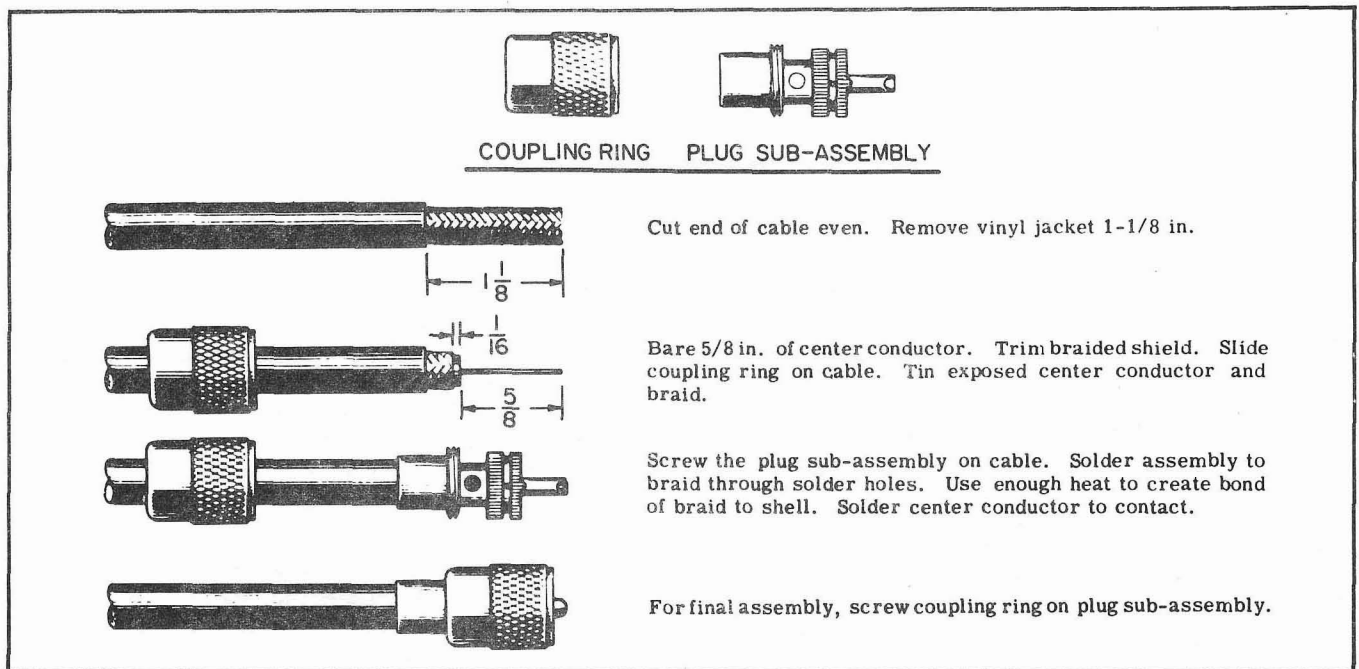


Figure 2-7. Fabrication of I-F Output Cable

two receivers as per step "a" of this paragraph. Keep the jumpers across the "DIODE OUTPUT" terminals of the receivers. Connect the frequency-shift converter equipment to the "AUDIO OUTPUT" terminals of each receiver if an audio signal is to be applied to the associated terminal equipment, or if a 455-kc signal is to be used, connect the "IF OUTPUT" connector (6, figure 2-2) of each receiver to the associated frequency-shift converter equipment, using RG-11/U cable and PL-259 plugs. For fabrication instructions applicable to the i-f output cable, refer to figure 2-7.

#### 2-19. TESTING.

2-20. When the equipment has been installed, check the complete installation for proper operation. Turn the receiver on by rotating the "RF GAIN" control (11, figure 3-1) in a clockwise direction from its "OFF" position and set the "SEND/REC" switch (21) to its "REC" position. Allow the receiver to warm up for 15 minutes. Then check the operation of the receiver in the various possible modes of operation on each of the six bands, following the operating procedures outlined under paragraph 3-25 as applicable.

## SECTION III

### OPERATION

#### 3-1. GENERAL.

3-2. For optimum receiver performance, proper operating procedures must be observed. The complexity of the operating procedures depends primarily upon the type of signal to be received, and also upon the quality of the communications link between transmitter and receiver. The receiver is adjusted for its various modes of operation by means of the appropriate operating controls.

#### 3-3. DESCRIPTION OF CONTROLS.

3-4. The controls used in normal receiver operation are all located on the front panel and are shown in figure 3-1. All references to the controls conform to the front panel designations.

3-5. POWER. A-c power is applied to the receiver circuits by rotating the "RF GAIN" control (11), clockwise from its "OFF" position. The power switch is an integral part of the "RF GAIN" control assembly and its actuation is indicated by an audible click and by the illumination of the main tuning dial (4) and the vernier dial (6).

#### CAUTION

Once power has been applied to the receiver, do not switch it off momentarily and then back on. The high initial filter-capacitor charging current may cause the  $\frac{3}{8}$ -ampere fuse to fail.

3-6. "SEND/REC". The "SEND/REC" switch (21) disables the r-f section of the receiver when actuated to the "SEND" position. This position is used during transmission intervals in a two-way communication system to prevent possible damage to the receiver from the strong local transmission. When the switch is returned to its "REC" position, normal receiver operation is restored.

3-7. "BAND CHANGE". The "BAND CHANGE" switch (17) is used to select the frequency band which includes the desired signal frequency. The selected band is indicated at the "MEGACYCLES" window (5) and the top of the main-dial movable pointer (2) is automatically positioned to indicate the main-tuning-dial frequency band being used.

3-8. "TUNING". For variable-frequency operation, the "TUNING" control (15) is used to tune the r-f amplifier section of the receiver and the variable-frequency first heterodyne oscillator to provide for reception of the desired signal. In the fixed-frequency, crystal-controlled mode of operation, a separate fixed-frequency, crystal-controlled first heterodyne oscillator is used, and the "TUNING" control is used to tune only the r-f circuits for acceptance of the desired signal. The "TUNING" control drives the vernier dial (6),

visible through the window at the right side of the front panel, and the main tuning dial (4) to indicate the frequency selected.

3-9. "TUNING LOCK". The "TUNING LOCK" (14), when turned in a clockwise direction, clamps the vernier dial (6), the main tuning dial (4), and the tuning mechanism at the desired setting. The "TUNING" control (15) remains free to turn. The "TUNING LOCK" prevents accidental detuning of the receiver due to severe vibration or accidental shifting of the "TUNING" control.

3-10. "FREQ CONTROL". The "FREQ CONTROL" selector switch (8) establishes the mode of operation of the first heterodyne oscillator section of the receiver and also, when set to its various "XTALS" positions, establishes the oscillator frequency. When the "FREQ CONTROL" selector switch is set to the "VFO" position, the variable-frequency first heterodyne oscillator is selected, and its frequency is determined by the setting of the "TUNING" control (15). When the "FREQ CONTROL" selector switch is set to any of its six "XTALS" positions, a separate fixed-frequency, crystal-controlled first heterodyne oscillator is selected. The frequency of the oscillator is determined by the frequency of the crystal inserted into the numbered crystal socket corresponding to the selected switch position.

3-11. " $\Delta$  FREQ". The " $\Delta$  FREQ" control (7) is used to tune the crystal selected by the "FREQ CONTROL" selector switch (8) precisely to the proper frequency. The calibration of the " $\Delta$  FREQ" control is arbitrary; however, advancing the control from the "HIGH" setting to the "LOW" setting decreases the frequency of oscillation. The crystals employed have a frequency tolerance of 0.005 percent, and the " $\Delta$  FREQ" control has adequate range to compensate for deviations in crystal frequency within these limits.

3-12. "RF GAIN". The "RF GAIN" control (11), when turned from its "OFF" position, is used to control the gain of the r-f and i-f sections of the receiver. When the control is turned to the "OFF" position, the a-c power switch associated with the control removes power from the receiver as described in paragraph 3-5. The "RF GAIN" control functions in either position of the "AVC/MAN" switch (12).

3-13. "AVC/MAN". The "AVC/MAN" switch (12) establishes the type of gain control used in the r-f and i-f sections of the receiver. When the switch is actuated to the "MAN" position, the gain of the r-f and i-f sections is established by the "RF GAIN" control (11) alone. In the "AVC" position of the switch, a delayed a-v-c system of control is selected. For any fixed setting of the "AUDIO GAIN" control (16), the receiver output

is maintained reasonably constant at a level predetermined by the "RF GAIN" control setting, provided that the input signal level is sufficient to overcome the delay voltage in the a-v-c system. A minimum carrier level of two microvolts at the receiver antenna input connector is required for normal a-v-c operation.

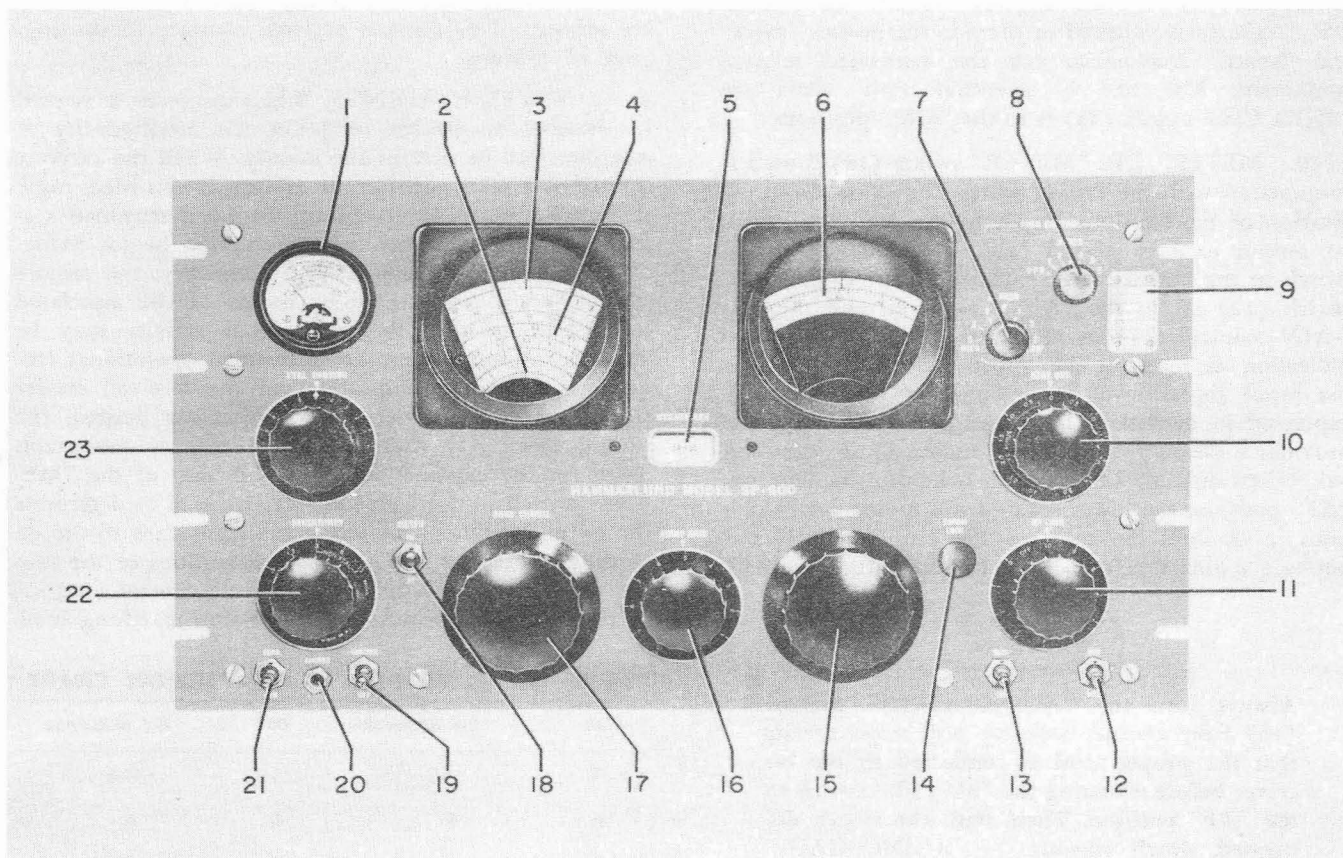
3-14. "AUDIO GAIN". The "AUDIO GAIN" control (16) is used to provide comfortable headset and/or loudspeaker reception or to provide the means for adjusting the audio output to a level suitable for operating auxiliary equipment associated with the receiver.

3-15. "SELECTIVITY". The "SELECTIVITY" switch (22) has six positions which establish receiver bandwidths of 0.2 kc, 0.5 kc, or 1.3 kc ("XTAL"), or 3 kc, 8 kc, or 13 kc ("NON-XTAL"). A crystal filter incorporated in the i-f section of the receiver is utilized in the three "XTAL" positions of the "SELECTIVITY" switch. In the three "NON-XTAL" positions, the crystal filter is shorted out. The three "XTAL" positions provide

narrow bandwidths useful in the rejection of adjacent-channel interference and are used under conditions of extreme interference where quality or fidelity of the receiver output is secondary to continuity of service.

3-16. "XTAL PHASING". The "XTAL PHASING" control (23) is part of the crystal filter referred to in paragraph 3-15, and functions only when the "SELECTIVITY" switch (22) is set to one of its three "XTAL" positions. When adjacent-channel interference is encountered, the "XTAL PHASING" control is adjusted in conjunction with the "SELECTIVITY" switch to provide attenuation of the interfering carrier.

3-17. "LIMITER/OFF". The "LIMITER/OFF" switch (19) is used under conditions of ignition or similar pulse-type noise interference. When the switch is set to the "LIMITER" positions, the limiter circuit in the receiver is operational, and noise (and desired audio) is removed from the receiver output for the interval of each noise pulse. The internal limiter circuit is disabled by actuating the switch to its "OFF" position.



- |                                   |                         |                            |
|-----------------------------------|-------------------------|----------------------------|
| 1. Tuning meter                   | 9. Plastic chart        | 16. "AUDIO GAIN" control   |
| 2. Movable pointer                | 10. "BEAT OSC." control | 17. "BAND CHANGE" switch   |
| 3. Fixed pointer                  | 11. "RF GAIN" control   | 18. "METER" switch         |
| 4. Main tuning dial               | 12. "AVC/MAN" switch    | 19. "LIMITER/OFF" switch   |
| 5. "MEGACYCLES" window            | 13. "MOD/CW" switch     | 20. "PHONES" jack          |
| 6. Vernier dial                   | 14. "TUNING LOCK"       | 21. "SEND/REC" switch      |
| 7. "Δ FREQ" control               | 15. "TUNING" control    | 22. "SELECTIVITY" switch   |
| 8. "FREQ CONTROL" selector switch |                         | 23. "XTAL PHASING" control |

Figure 3-1. Radio Receiver, Front Panel Controls and Indicators

3-18. "MOD/CW". The "MOD/CW" switch (13) is used to control operation of the internal bfo of the receiver. For reception of amplitude-modulated signals, the "MOD/CW" switch is set to its "MOD" position and the bfo is disabled. When the switch is operated to the "CW" position, plate voltage is applied to the bfo through the switch, and b-f-o operation is restored to provide for the reception of unmodulated signals. Additionally, a separate capacitor is switched into the a-v-c circuit to increase the circuit time constant and permit a-v-c operation during c-w reception.

3-19. "BEAT OSC.". The "BEAT OSC." control (10) is used to adjust the nominal 455-kc frequency of the receiver bfo within the range of  $\pm 3$  kc, thus providing a variable tone output during c-w reception. The setting of the control is optional, and is normally set to provide the most intelligible reception. When set exactly to 455 kc, the control is useful for locating and tuning in weak signals of any kind, as well as for carrier reinsertion at the receiver when suppressed-carrier, single- or double-sideband signals are being received. For the reception of frequency-shift radio teletype signals, the "BEAT OSC." control is adjusted to provide the proper "mark" and "space" frequencies for the associated teletype equipment. The bfo is operative only when the "MOD/CW" switch (13) is in the "CW" position.

3-20. "METER". The "METER" switch (18) is used in conjunction with the tuning meter (1) to obtain an indication of the r-f signal input to the receiver and the a-f output to a connected load. With the "METER" switch in the normal "RF" position, the "AVC/MAN" switch (12) set to the "AVC" position, and the "RF GAIN" control (11) set at maximum, the tuning meter indication as read on the upper scale is the ratio of the input signal level to a signal of one microvolt, expressed in decibels. The meter "RF" indication also provides a means for accurately tuning in an input signal. When the "METER" switch is held in its depressed "AF" position, the lower scale of the tuning meter indicates in decibels the ratio of the receiver audio output to a standard reference of six milliwatts.

**CAUTION**

Always turn the "AUDIO GAIN" control (16) fully counterclockwise and make certain that the proper load is connected to the receiver before actuating the "METER" switch to the "AF" position. Then, with the switch depressed, slowly advance the "AUDIO GAIN" control to its proper setting. Failure to observe this precaution may result in damage to the tuning meter.

3-21. "PHONES". The "PHONES" jack (20) provides the means for connecting a headset to the audio output section of the receiver. Either high-impedance or low-impedance head phones may be plug-connected to the receiver. The high-impedance type is recommended.

**3-22. PRESENTATIONS AND READINGS.**

3-23. TUNING PRESENTATION. The main tuning dial (4, figure 3-1) and the vernier dial (6) are used to accurately set the receiver to a desired signal frequency. The main tuning dial has six frequency scales calibrated in megacycles, and an arbitrary outer scale. The movable pointer (2) is used to read the scale corresponding to the frequency band chosen and the fixed pointer (3) is used to read the arbitrary outer scale. The vernier pointer is used to read the vernier dial (6), which has an arbitrary 0-to-100 scale. The numeral under the fixed pointer of the main tuning dial indicates the number of revolutions that have been made by the vernier dial at any setting. EXAMPLE: When the fixed pointer of the main tuning dial indicates 4 and the vernier dial indicates 87.6, the reading to log for this setting is 487.6. The precise mechanical vernier system divides the rotation of the main tuning dial over each frequency band into approximately 600 vernier divisions, with one-half-division calibration points. Since one-tenth divisions on the vernier dial may be estimated accurately, each frequency band is divided into approximately 6000 readable settings. This permits extreme accuracy in the logging of stations.

3-24. METER READINGS. When the receiver is used for headset or speaker reception, the intelligibility of reception can be determined aurally. When the receiver is used for teletypewriter or telegraph recorded copy, the intelligibility of reception can be determined visually. In either instance, when reception begins to deteriorate on a particular station frequency, the remote station should be notified by means of the associated transmitter so that the operational activity may be switched to some other predetermined operational frequency. If accurate indications of the received carrier strength or the receiver audio output are desired, the tuning meter (1) may be used [Refer to paragraph 3-20 for the explanation of the function of the "METER" switch (18).] Table IV may be used to determine the r-f microvolts or a-f milliwatts equivalent to the db readings of the r-f and a-f scale calibrations of the tuning meter. With the "AUDIO GAIN" control (16) set to provide 500 milliwatts to a 600-ohm matching load,

**TABLE IV. METER DECIBEL CONVERSION CHART**

DB	R-F Microvolts	DB	A-F Milliwatts
-6	0.5	-10	0.6
0	1	0	6
+6	2	+6	24
+20	10	+10	60
+40	100	+15	190
+60	1,000		
+80	10,000		
+100	100,000		

15 milliwatts are provided to an 8000-ohm headset connected to the "PHONES" jack (20). A minimum of 0.6 milliwatt of 455-kc i-f output is provided at the "IF OUTPUT" connector (6, figure 2-2).

### 3-25. OPERATING PROCEDURES.

#### 3-26. GENERAL.

3-27. The operating procedures for the receiver involve a sequence of operations prior to, during, and following its use in an operational activity. These operations are outlined in paragraphs 3-28 through 3-56 for each possible mode of receiver operation. In each instance, the control or switch referred to is identified by its front panel designation. (See figure 3-1.) A performance check chart, table V, is provided to indicate normal receiver operation.

#### 3-28. RECEPTION OF A-M PHONE OR SINGLE-TONE TELEGRAPH SIGNALS.

#### 3-29. PRELIMINARY ADJUSTMENTS.

a. Plug the headset into the "PHONES" jack (20) or connect a loudspeaker across the "AUDIO OUTPUT" terminals (8, figure 2-2).

b. Set the "SEND/REC" switch (21, figure 3-1) to the "REC" position.

c. Set the "FREQ CONTROL" selector switch (8) to the "VFO" position.

d. Set the "LIMITER/OFF" switch (19) to the "OFF" position.

e. Set the "SELECTIVITY" switch (22) to its "NON-XTAL" 3-kc position.

f. Set the "AVC/MAN" switch (12) to the "AVC" position.

g. Set the "XTAL PHASING" control (23) to the position indicated by the diamond between positions "4" and "6".

h. Unclamp the "TUNING LOCK" (14) by turning it counterclockwise.

i. Rotate the "RF GAIN" control (11) clockwise from its "OFF" position. A click should be heard, indicating that the power switch has been actuated, and the pilot lamps should light, illuminating the main tuning dial (4) and the vernier dial (6). Allow the receiver to warm up for a period of 15 minutes.

j. Set the "MOD/CW" switch (13) to the "MOD" position.

k. Rotate the "BAND CHANGE" switch (17) until the frequency band indicated at the "MEGACYCLES" window (5) includes the desired signal frequency.

TABLE V. PERFORMANCE CHECK CHART

Test	Procedure	Normal Indication
A-C power source, "LINE" fuse	Rotate "RF GAIN" control clockwise from its "OFF" position.	Pilot lamps light.
Amplifier circuits, "-B" fuse	Advance "RF GAIN" control and "AUDIO GAIN" control to maximum.	Noise output in headset or loud speaker.
A-M reception	Loosely couple A-M signal from frequency meter or accurately calibrated signal generator to receiver antenna terminals. Tune receiver as per paragraphs 3-29 and 3-30. Repeat on each of the six bands.	Tone in output of receiver. With "AVC/MAN" switch set to "AVC", tuning meter pointer deflects as signal is tuned in.
Dial calibration	Same as A-M reception procedure. Tune receiver accurately using tuning meter. Note main tuning dial indication.	Indication on main tuning dial should be accurate to within 0.25 percent of signal frequency.
C-W reception	Loosely couple c-w signal from frequency meter accurately calibrated signal generator to receiver antenna terminals. Tune receiver as per paragraphs 3-35 and 3-36. Repeat on each of the six bands.	Beat note heard in output of receiver. Pitch of note varies as "BEAT OSC." control is varied. Zero beat obtained when "BEAT OSC." control is set to "0".
Audio output	Same as A-M reception procedure. With loudspeaker connected across "AUDIO OUTPUT" terminals and "AUDIO GAIN" control setting reduced, depress "METER" switch to "AF" position.	Power output in db indicated on lower scale of tuning meter. Meter indication varies as "AUDIO GAIN" control setting is varied.

l. Turn the "RF GAIN" control to its maximum clockwise setting. The tuning meter (1) pointer should move upscale and noise should be heard in the headset or loudspeaker.

m. Turn the "AUDIO GAIN" control (16) to adjust the receiver noise output to a suitable level.

n. Turn the "TUNING" control (15) until the main-tuning-dial indication corresponds to the desired signal frequency.

**Note**

Reduce the "RF GAIN" control (11) setting slightly to avoid excessive receiver noise output while the "TUNING" control (15) is rotated through positions at which there are no signal transmissions.

3-30. RECEPTION USING VARIABLE-FREQUENCY OSCILLATOR. To tune in an A-M signal, perform the preliminary adjustments outlined in paragraph 3-29, and continue as follows:

a. Rotate the "TUNING" control (15) in the proper direction to tune in the signal. Proper tuning is indicated by a maximum indication of the tuning meter (1). The main-tuning-dial (4) reading should be within 0.25 percent of the frequency of the desired signal.

b. Clamp the "TUNING LOCK" (14) by turning it clockwise.

c. Readjust the "AUDIO GAIN" control (16) as desired, to obtain a suitable audio output level.

3-31. RECEPTION OF A WEAK SIGNAL USING VARIABLE-FREQUENCY OSCILLATOR. When the desired signal is weak and obscured by interference of any kind, the preliminary adjustments outlined in paragraph 3-29 and the tuning procedure outlined in paragraph 3-30 may not suffice to provide usable signal reception. Under those conditions, tune in the desired signal by use of the following procedure:

a. Set the "MOD/CW" switch (13) to the "CW" position.

b. Rotate the "BAND CHANGE" switch (17) until one of the lower frequency bands is indicated at the "MEGACYCLES" window (5).

c. Locate a strong A-M or c-w signal. This signal is required to accurately set the "BEAT OSC." control (10) for a b-f-o frequency of 455 kc, since the dial of the "BEAT OSC." control may not be accurately calibrated.

d. Tune in the signal by turning the "TUNING" control (15) in either direction until the tuning meter (1) indication is maximum.

e. Adjust the "BEAT OSC." control to obtain a zero-beat audio output and maintain this setting.

f. Rotate the "BAND CHANGE" switch until the frequency band indicated at the "MEGACYCLES" window includes the desired signal frequency.

g. Turn the "TUNING" control in the proper direction until the main tuning dial (4) indicates the desired signal frequency; then readjust the "TUNING" control slightly to obtain a zero beat in the output of the receiver.

h. Return the "MOD/CW" switch to the "MOD" position.

i. Clamp the "TUNING LOCK" (14) by turning it clockwise.

j. Readjust the "AUDIO GAIN" control (16) as desired, to obtain a suitable audio output level.

3-32. RECEPTION USING CRYSTAL-CONTROLLED OSCILLATOR. When fixed-frequency crystal-controlled reception of phone or single-tone telegraph is desired, follow the preliminary adjustments outlined in paragraph 3-29, and continue with the step sequence that follows:

a. Set the "FREQ CONTROL" selector switch (8) to the numbered "XTALS" position whose numeral corresponds to that of the crystal socket which holds the crystal of the proper frequency. The proper switch position can be determined from the plastic chart (9) on which should have been recorded the switch positions and the corresponding signal frequencies.

b. Turn the "TUNING" control (15) until the main tuning dial (4) indicates the desired operating frequency and carefully readjust the "TUNING" control to obtain a maximum indication on the tuning meter (1).

c. If desired, clamp the "TUNING LOCK" (14) by turning it clockwise.

d. Turn the " $\Delta$  FREQ" control (7) in the proper direction to accurately adjust the crystal oscillator frequency. The proper setting for this control is that at which a maximum indication is obtained on the tuning meter.

e. Readjust the "AUDIO GAIN" control (16) as desired to maintain the proper audio output level.

3-33. NOISE SUPPRESSION. To provide for the best possible reception under noisy atmospheric or man-made static conditions, follow the preliminary adjustments outlined in paragraph 3-29 and the tuning procedure outlined in paragraphs 3-30, 3-31, or 3-32, as applicable, and continue as follows:

a. Set the "SELECTIVITY" switch (22) to the switch position which provides the most intelligible reception for the desired mode of operation.

b. If the "SELECTIVITY" switch (22) is used in one of its "XTAL" positions, turn the "XTAL PHASING" control (23) for best attenuation of any interfering signal.

c. Set the "LIMITER/OFF" switch (19) to the "LIMITER" position to reduce ignition noise or any other pulse-type noise from the audio output.

d. During standby periods in the transmission, when the desired signal is off the air, turn the "RF GAIN" control (11) down from its maximum clockwise setting to cut down on the receiver noise output.

e. During reception, when the signal fluctuates or fades so that at intervals the signal level is low, the receiver signal output may be favored, relative to the receiver noise output, by careful readjustment of the "RF GAIN" control (11).

## 3-34. RECEPTION OF C-W TELEGRAPH SIGNALS.

3-35. PRELIMINARY ADJUSTMENTS. Perform the procedures outlined in paragraph 3-29 for reception of A-M signals, except, in step "j", set the "MOD/CW" switch (13) to the "CW" position. Set the "BEAT OSC." control (10) to "0".

3-36. RECEPTION USING VARIABLE-FREQUENCY OSCILLATOR. To tune in a c-w signal, proceed as follows:

a. Rotate the "TUNING" control (15) in the proper direction to tune in the signal. Proper tuning is indicated by a zero beat in the audio output or maximum indication on the tuning meter (1). When the signal is properly tuned in, the main-tuning-dial (4) reading should be accurate to within 0.25 percent of the desired signal frequency.

b. If desired, clamp the "TUNING LOCK" (14) by turning it clockwise.

c. Turn the "BEAT OSC." control (10) in either direction to obtain a tone output, preferably around 1000 cps. Reception may be better with the control turned in one direction than in the other. In any case, choose the position in either direction which provides the most intelligible reception.

d. Readjust the "RF GAIN" control (11) for the clearest signal and the "AUDIO GAIN" control (16) to the position providing the desired audio output level.

3-37. RECEPTION OF A WEAK SIGNAL USING VARIABLE-FREQUENCY OSCILLATOR. When the desired signal is weak and obscured by interference of any kind, the preliminary adjustments referred to in paragraph 3-35 and the tuning procedure outlined in paragraph 3-36 may not suffice to provide usable signal reception. Under those conditions, tune in the desired signal by use of the following procedure:

a. Follow the instructions outlined in steps "b" through "g" of paragraph 3-31.

b. Clamp the "TUNING LOCK" (14) by turning it clockwise.

c. Turn the "BEAT OSC." control (10) in either direction to obtain a tone output, preferably around 1000 cps, as outlined in step "c" of paragraph 3-36.

d. Readjust the "RF GAIN" control (11) for the clearest signal and the "AUDIO GAIN" control (16) to the position providing the desired audio output level.

3-38. RECEPTION USING CRYSTAL-CONTROLLED OSCILLATOR. When fixed-frequency crystal-controlled reception of c-w telegraph signals is desired, perform the preliminary adjustments referred to in paragraph 3-35, and continue as follows:

a. Follow the instructions outlined in steps "a" through "d" of paragraph 3-32.

b. Turn the "BEAT OSC." control (10) in either direction to obtain a tone output, preferably around 1000 cps. Reception may be better with the control turned in one direction than in the other. In any case, select the position which provides the most intelligible reception.

c. Readjust the "RF GAIN" control (11) for the clearest possible signal and the "AUDIO GAIN" control (16) to provide the desired audio output level.

3-39. NOISE SUPPRESSION. To provide for the best possible c-w reception under noisy atmospheric or man-made conditions, perform the preliminary adjustments referred to in paragraph 3-35, follow the tuning procedure outlined in paragraphs 3-36, 3-37, or 3-38, as applicable, and continue as follows:

a. Set the "SELECTIVITY" switch (22) to the "XTAL" switch position which provides the best reception.

b. Turn the "XTAL PHASING" control (23) to a position which provides best attenuation of any interfering signal.

c. Set the "LIMITER/OFF" switch (19) to the "LIMITER" position to reduce ignition noise or any other pulse-type noise from the audio output.

d. Readjust the "RF GAIN" control (11) for clearest signal reception and the "AUDIO GAIN" control (16) to provide the desired audio output level.

## 3-40. RECEPTION OF FREQUENCY-SHIFT TELETYPE SIGNALS.

3-41. PRELIMINARY ADJUSTMENTS. Perform the procedures outlined in paragraph 3-29 for A-M signals, except, in step "j", set the "MOD/CW" switch (13) to the "CW" position. Set the "BEAT OSC." control (10) to "0".

3-42. RECEPTION USING VARIABLE-FREQUENCY OSCILLATOR. To tune in a frequency-shift signal, proceed as follows:

a. Turn the "TUNING" control (15) in the proper direction so that the two-tone output signal, heard when the receiver is slightly detuned, is changed to a single-tone output signal, or adjust the control for a maximum indication on the tuning meter (1). Either procedure may be used to tune the receiver properly. When the receiver is properly tuned, the main-tuning-dial (4) frequency indication should be accurate to within 0.25 percent of the signal frequency.

b. If desired, clamp the "TUNING LOCK" (14) by turning it clockwise.

c. Adjust the "BEAT OSC." control (10) to obtain a two-tone output at 2500 cps plus or minus the carrier shift. Reception may be better with the control turned in one direction than in the other.

3-43. RECEPTION OF WEAK SIGNAL USING VARIABLE-FREQUENCY OSCILLATOR. When the desired signal is weak and obscured by interference of any kind, the preliminary adjustments referred to in paragraph 3-41 and the tuning procedure outlined in paragraph 3-42 may not suffice to provide usable signal reception. Under those conditions, tune in the desired signal by use of the following procedure:

a. Follow the instructions outlined in steps "b" through "f" of paragraph 3-31.

## Paragraphs 3-44 to 3-50

b. Turn the "TUNING" control (15) in the proper direction until the main-tuning-dial (4) reading corresponds to the frequency of the desired signal. Then carefully readjust the "TUNING" control so that the two-tone output signal, heard when the receiver is slightly detuned, is changed to a single-tone output signal, or adjust the control for a maximum indication on the tuning meter (1). Either procedure may be used to properly adjust the "TUNING" control. When the receiver is properly tuned, the main-tuning-dial frequency indication should be within 0.25 percent of the desired signal frequency.

c. If desired, clamp the "TUNING LOCK" (14) by turning it clockwise.

d. Adjust the "BEAT OSC." control (10) to obtain a two-tone output at 2500 cps plus or minus the carrier shift. Reception may be better with the control turned in one direction than in the other.

e. Readjust the "RF GAIN" control (11) to provide the clearest signal and the "AUDIO GAIN" control (16) to provide the desired audio output level.

**3-44. RECEPTION USING CRYSTAL-CONTROLLED OSCILLATOR.** When fixed-frequency, crystal-controlled reception of frequency-shift signals is desired, perform the preliminary adjustments referred to in paragraph 3-41, and continue as follows:

a. Follow the instructions outlined in steps "a" through "d" of paragraph 3-32.

b. Turn the "BEAT OSC." control (10) in either direction to obtain a two-tone output at 2500 cps plus or minus the carrier shift. Reception may be better with the control turned in one direction than in the other.

c. Readjust the "RF GAIN" control (11) to provide the clearest signal and the "AUDIO GAIN" control (16) to provide the proper audio output level.

**3-45. NOISE SUPPRESSION.** To provide the best possible frequency-shift reception under noisy atmospheric or man-made static conditions, perform the preliminary adjustments referred to in paragraph 3-41, follow the tuning procedure outlined in paragraphs 3-42, 3-43, or 3-44, as applicable, and then follow the instructions outlined in steps "a" through "d" of paragraph 3-39.

**3-46. RECEPTION OF SUPPRESSED-CARRIER MULTICHANNEL PHONE, TELEGRAPH, AND TELETYPE SIGNALS.**

**3-47. GENERAL.** To provide for single- or double-sideband reception, the signal carrier, suppressed at the transmitter, must be reinserted at the receiver. This is done by use of the internal bfo of the receiver to provide a 455-kc carrier which can be added to the single- or double-sideband signals prior to detection.

**3-48. PRELIMINARY ADJUSTMENTS.**

a. Perform the procedures outlined in steps "a" through "d" of paragraph 3-29.

b. Set the "SELECTIVITY" switch (22) to its "NON-XTAL" 3-kc, 8-kc, or 13-kc position, depending upon

the bandwidth required for the mode of operation contemplated. Channel separations in multichannel operation are usually 170 cps, and the 3-kc position suffices for single-sideband reception; for double-sideband reception, either the 8-kc or the 13-kc position may be required. For double-sideband transmissions, the signal intelligence for each side band is independent of the other.

c. Set the "BEAT OSC." control (10) to "0".

d. Perform the procedures outlined in steps "f" through "n" of paragraph 3-29, except, in step "j", set the "MOD/CW" switch (13) to the "CW" position.

**3-49. RECEPTION USING VARIABLE-FREQUENCY OSCILLATOR.** To tune in a suppressed carrier signal, perform the preliminary adjustments outlined in paragraph 3-48, and continue as follows:

a. Turn the "TUNING" control (15) in the proper direction to accurately resonate the receiver circuits to the desired signal frequency. Proper adjustment of this control is indicated by maximum deflection on the tuning meter (1). At resonance, the main-tuning-dial (4) reading should be within 0.25 percent of the suppressed carrier frequency. When it is desired to tune the receiver by listening to the audio output, attenuate all but one channel of the transmission by setting the "SELECTIVITY" switch (22) to its "XTALS" 1.3-kc position. Then turn the "TUNING" control (15) in either direction until the receiver audio output from one circuit is clearly intelligible as phone, as two-tone teletype signals (595 cps for "mark" and 425 cps for "space"), or as automatic Morse-code keying of a 1000-cps tone, as applicable. Then reset the "SELECTIVITY" switch (22) to the required position as determined in step "b" of paragraph 3-48.

b. If desired, clamp the "TUNING LOCK" (14) by turning it clockwise.

c. Readjust the "AUDIO GAIN" control (16) to provide the desired audio output level.

**3-50. RECEPTION USING CRYSTAL-CONTROLLED OSCILLATOR.** When fixed-frequency crystal-controlled multichannel reception of a single- or double-sideband suppressed-carrier signal is desired, perform the preliminary adjustments outlined in paragraph 3-48, and continue as follows:

a. Set the "FREQ CONTROL" selector switch (8) to the numbered "XTALS" position whose numeral designation corresponds to the crystal holder which carries the crystal for the desired suppressed-carrier signal frequency. The correct switch position may be determined from the plastic chart (9) on which the switch positions and the corresponding suppressed-carrier frequencies should have been recorded.

b. Turn the " $\Delta$  FREQ" control (7) in either direction to resonate the crystal oscillator precisely. Resonance is indicated by a maximum deflection on the tuning meter (1). When it is desired to resonate the circuit by listening to the receiver audio output, attenuate all



but one channel of the transmission by setting the "SELECTIVITY" switch (22) to its "XTAL" 1.3-kc position. Then turn the " $\Delta$  FREQ" control in either direction until the receiver audio output is clearly intelligible as phone, as two-tone teletype signals (595 cps for "mark" and 425 cps for "space"), or as automatic Morse-code keying of a 1000-cps tone, as applicable. Then reset the "SELECTIVITY" switch to the required position as determined in step "b" of paragraph 3-48.

c. Turn the "TUNING" control (15) in the proper direction to resonate the r-f section of the receiver to the suppressed-carrier single- or double-sideband frequency. Proper adjustment of this control is indicated by maximum deflection on the tuning meter (1). Maintain the " $\Delta$  FREQ" control (7) as set in step "b".

d. If desired, clamp the "TUNING LOCK" (14) by turning it clockwise.

e. Readjust the "AUDIO GAIN" control (16) to provide the proper audio output level.

3-51. NOISE SUPPRESSION. To provide the best possible single- or double-sideband suppressed-carrier reception under noisy atmospheric or man-made static conditions, perform the preliminary adjustments outlined in paragraph 3-48, follow the tuning procedure outlined in paragraphs 3-49 or 3-50, as applicable, and continue as follows:

a. Set the "SELECTIVITY" switch (22) to the "NON-XTAL" position which provides the best reception.

b. Set the "LIMITER/OFF" switch (19) to the "LIMITER" position to reduce ignition noise and other pulse-type noise from the audio output.

c. Readjust the "RF GAIN" control (11) to provide the clearest signal and the "AUDIO GAIN" control (16) to provide the proper audio output level.

### 3-52. PERIODIC AND SPECIAL OPERATING ADJUSTMENTS.

3-53. To maintain the communication link in a condition providing for optimum reception, repeat the following operating procedures, as applicable, when required.

a. When the operational activity is two-way, set the "SEND/REC" switch (21) to the "SEND" position during transmission intervals to prevent damage to the receiver from the strong local transmission. When the transmission has been completed, return the switch to the "REC" position to provide for normal reception.

b. When the receiver is used for reception of A-M signals, unclamp the "TUNING LOCK" (14), and retune the receiver as outlined in step "a" of paragraph 3-30 or in steps "b" and "d" of paragraph 3-32, as applicable. Do this periodically at 15-minute intervals, or at longer intervals, depending upon the frequency

drift noted. When noise impairs the quality of reception, repeat the procedures outlined in paragraph 3-33.

c. When the receiver is used for the reception of c-w signals, unclamp the "TUNING LOCK" (14) and retune the receiver as outlined in step "a" of paragraph 3-36 or in steps "b" and "d" of paragraph 3-32, as applicable. Do this periodically at 15-minute intervals, or at longer intervals, depending upon the frequency drift noted. When noise impairs the quality of reception, repeat the procedure outlined in paragraph 3-39. Also reset the "BEAT OSC." control (10), if necessary, as outlined in step "c" of paragraph 3-36.

d. When the receiver is used for the reception of frequency-shift teletype signals, unclamp the "TUNING LOCK" (14) and retune the receiver in accordance with step "a" of paragraph 3-42 or in steps "b" and "d" of paragraph 3-32, as applicable. Do this periodically at 15-minute intervals, or at longer intervals, depending upon the frequency drift noted. When noise impairs the quality of reception, repeat the procedures outlined in paragraph 3-39. Reset the "BEAT OSC." control (10), if necessary, as outlined in step "c" of paragraph 3-42.

e. When the receiver is used for the reception of suppressed-carrier multichannel signals, unclamp the "TUNING LOCK" (14) and retune the receiver in accordance with step "a" of paragraph 3-49 or in steps "b" and "c" of paragraph 3-50, as applicable. Do this periodically at 10-minute intervals, or at longer intervals, depending upon the frequency drift noted. When noise impairs the quality of reception, repeat the procedures outlined in paragraph 3-51.

### 3-54. DE-ENERGIZING THE EQUIPMENT.

3-55. Upon completion of the operational activity, when advised to do so, do the following:

a. Turn the receiver off by turning the "RF GAIN" control (11, figure 3-1) counterclockwise to its "OFF" position.

3-56. Deleted.

### 3-57. PRECAUTIONS TO BE OBSERVED.

3-58. The receiver is precisely aligned and adjusted at the factory for optimum performance. The metal buttons (18, figure 2-1) cover the chassis openings used to provide access to the various inductance tuning cores and capacitor trimmers. These alignment adjustments, as well as the "BFO INJ" (4, figure 2-2), "METER ADJ RF" (5), and the "METER ADJ AF" (7) screwdriver adjustment controls, are not operating controls and cannot be manipulated without impairing the receiver performance and the meter scale calibrations.

## SECTION IV

## EMERGENCY OPERATION

## 4-1. GENERAL.

4-2. In an emergency, when a defect develops in the receiver, the operator should attempt to determine the extent of the defect through manipulation of the front-panel controls. In many instances, while a section of the receiver may be disabled and prevent reception using the desired mode of operation, other receiver circuits may remain operational and provide a means of maintaining the communications link. If a defect develops in the crystal-controlled first heterodyne oscillator when the fixed-frequency crystal-controlled mode of operation is being used, operation may be maintained by using the variable-frequency first heterodyne oscillator. If the b-f-o circuits of the receiver are disabled, reception of A-M signals may still be possible. Trouble may develop in the r-f section of the receiver and affect only one of the six bands of the receiver. In this case, if alternate operating frequencies have been assigned, the communications link may be maintained using a frequency on one of the operative bands of the receiver. The operator should

become thoroughly familiar with his equipment, so that these and other alternate operational procedures may be resorted to in an emergency.

## 4-3. ANTENNA SYSTEM.

4-4. For optimum results, a properly designed balanced doublet or straight-wire antenna should be used. In an emergency, when the antenna system has been damaged, reception may be possible using a short piece of insulated wire stripped at one end for connections to the "ANT" input connector (8, figure 2-1).

## 4-5. EMERGENCY TUBE REPLACEMENT.

4-6. The type and reference symbol designation of each electron tube within the receiver is stamped on the chassis, adjacent to each tube. Figure 2-1 may be used to rapidly identify the location of each specific electron tube used in the receiver. In the instance of unavailability of spare tubes and specific tube failure, table VI, when applicable, may be used in an emergency to maintain continuity of service.

TABLE VI. EMERGENCY TUBE REPLACEMENT

Tube Identification		Emergency Procedure		Results	
JAN Tube Type	Complement of Specified Tube Type	Remove	Replace For	Operation Limited To	Effect on Limited Operation
5726/6AL5W/6097	V14, V15 V20	V15	V14 or V20	Any	Limiter and meter af nonoperative
		V14	V20	I-F output	No avc
6C4	V4, V8, V13	V4	V8 or V13	Fixed freq reception	None
		V8	V4 or V13	Any below 7.4 mc	None
		V13	V4 or V8	AM.	None
		V8 and V13	V4	AM below 7.4 mc	None None
5749/6BA6W	V1, V2 V7, V9, V10, V11, V12	V7	V1, V2, V9, V10, V11, or V12	Any above 7.4 mc	None
		V12	V1, V2, V7, V9, V10, or V11	AM.	None
		V11	V1, V2, V9, V10, V7	I-F output	No avc
6BE6	V5, V6	V6	V5	Any below 7.4 mc	None

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		V14	V20	I-F output	No avc
6C4	V4, V8, V13	V4	V8 or V13	Fixed freq reception	None
		V8	V4 or V13	Any below 7.4 mc	None
		V13	V4 or V8	AM.	None
		V8 and V13	V4	AM below 7.4 mc	None None
5749/6BA6W	V1, V2 V7, V9, V10, V11, V12	V7	V1, V2, V9, V10, V11, or V12	Any above 7.4 mc	None
		V12	V1, V2, V7, V9, V10, or V11	AM.	None
		V11	V1, V2, V9, V10, V7	I-F output	No avc
6BE6	V5, V6	V6	V5	Any below 7.4 mc	None