NATIONAL RADIO COMPANY, INC. • 37 WASHINGTON ST., MELROSE, MASS. 02176

HRO-500 SOLID STATE COMMUNICATIONS RECEIVER

ONE YEAR GUARANTEE

You now own a product manufactured by one of the world's oldest and most highly respected manufacturers of quality communications equipment. National Radio Company, Inc. has manufactured superb communications devices for nearly half a century. Our experience is unequaled. More than 75 per cent of our highly skilled test and assembly people have been with us for more than 25 years — an astonishing record in the relatively young electronics industry. Our people know their business . . . take pride in their fine workmanship — workmanship so outstanding that many National Radio Company, Inc. receivers purchased over 30 years ago are still in daily use.

We manufacture most of the components used in our equipment . . . and, in fact, National Radio Company, Inc. has been a prime supplier of electronic components to other important electronic manufacturers and government agencies for many years. As a result, we enjoy unusual control of component part quality.

We strongly recommend that you carefully study the instruction manual before attempting to use your new equipment. We are sure you will find that maximum performance will be achieved with complete understanding of its controls and operating features.

Your new National Radio Company, Inc. equipment has undergone an intense series of rigid quality control tests. However, as with any complex electronic equipment, it is possible that a defect may appear as a result of rough handling during shipment or through circumstances beyond our immediate control. For this reason, we suggest that you inspect your new equipment for such damage as soon as it is unpacked. In all cases of in-transit damage a claim must be filed against the carrier.

The component parts of this equipment (exclusive of vacuum tubes and transistors) are guaranteed to be free from defective material and workmanship, and repair or replacement will be made on any part found to be defective upon examination, provided that the unit is delivered to your dealer, authorized service agency or to the company pursuant to

which has been subjected to misuse, neglect, accident, improper installations, or use in violation of instructions furnished by us. Nor does it extend to units which have been repaired or altered outside of our factory or its authorized agencies, nor to units where the serial number has been removed or defaced.

Should your new National Radio Company, Inc. equipment require servicing please do one of the following, whichever is most convenient:

1. Return it to the dealer from whom you purchased it.
2. Bring it to one of our authorized service agencies.
3. Write to the Service Manager, National Radio Company, Inc., 37 Washington Street, Melrose, Mass. and describe the difficulty. State type of unit and serial number. Describe as completely as possible the apparent defect. If we feel that the unit should be returned to the factory we will give you written authorization to ship the unit to us. Notify us that you are returning the unit and ship prepaid and fully insured in the original specially designed shipping carton.

Your unit will receive prompt and careful attention. If, in our judgment the unit is indeed defective, repair or replacement will be made at no cost to you if the unit is returned within 90 days after date of original purchase. Should the unit be returned to us after 90 days from date of purchase but before 365 days have elapsed, again, if in our judgment the unit is indeed defective, National Radio Company, Inc. will provide a replacement of any such defective part (except vacuum tubes or transistors). If you wish us to install the part, you will be billed only for labor costs involved. At the end of one year, after expiration of guarantee, service will be billed to you at cost of parts and labor only.

This extended guarantee supersedes all previous warranties of National Radio Company, Inc. and is in lieu of all other warranties expressed or implied. Damages arising out of a breach of this guarantee are

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SECTION 1
GENERAL DESCRIPTION

The National Radio Company, Inc. HRO-500 solid-state communications receiver is designed for highly reliable applications, both fixed and portable, demanding extreme tuning accuracy and stability over either a limited or an extraordinary frequency range. All facilities for reception of SSB, AM, CW, FAX or FSK signals are incorporated, and necessary outputs are provided for operation of ancillary equipment for use in unusual applications. Total transistorization of the HRO-500 results in a highly reliable equipment with superior performance as compared with existing tube receivers, but with power drain so small as to allow portable or field operation under previously difficult or impossible conditions.

FREQUENCY RANGE: The HRO-500 covers the entire VLF and HF spectrums continuously—from five kilohertz to 30 megahertz in 60 500-kHz bands. Tuning rate, stability and dial calibration/accuracy (one kHz) are identical throughout its tuning range. SSB sensitivity is better than 1.0 microvolt for 10 db signal plus noise-to-noise ratio in the 500 kHz—30 MHz range, with minimum image rejection of 50 db. Internal spurious responses between 500 kHz and 30 MHz are all less than the equivalent of two microvolts at the antenna terminals, with the exception of two discrete responses at 2.75 MHz and 3.0 MHz.

The 5-kHz to 500-kHz VLF range is incorporated in the HRO-500 receiver with frequency in kilohertz read directly from the main tuning dial. An external VLF antenna input is provided to the first mixer and incoming VLF signals are first up-converted to 26 MHz and then processed through a double-conversion scheme. Basic sensitivity in the VLF band is 25-50 microvolts without the optional LF-10 preselector. The LF-10 preselector may be used to provide one microvolt sensitivity in the 5-kHz to 500-kHz range with protection against possible overload when desired for critical VLF applications.

FREQUENCY DETERMINATION AND SYNTHESIZER: Frequency determination in the HRO-500 is performed by a phase-locked frequency synthesizer which provides all of the necessary oscillator injection signals to tune the 5 kHz to 30 MHz frequency range. The block diagram of the HRO-500 is similar to a conventional receiver with a crystal-controlled high frequency oscillator and tunable I.F., but the multiplicity of crystals usually required for the high frequency oscillator is replaced in the HRO-500 by a single highly stable 500 kHz master crystal oscillator, from which 60 crystal-stable H.F. oscillator inputs are synthesized. The synthesizer is internally phase-locked for high stability, and a **Phase-lock** warning lamp indicates when the output of the synthesizer has been tuned to the correct H.F. oscillator input frequency. Band changing is accomplished by setting the bandswitch to the desired band in megahertz and then tuning the front panel synthesizer control until the 500 kHz range within that band is indicated in the digital synthesizer window over the main tuning dial, and the **Phase-Lock** warning lamp extinguishes. The desired 500 kHz range is then continuously tuned by the epicyclic PW mechanism which is calibrated directly in one-kilohertz increments. The reading of the PW kilohertz dial is added to the synthesizer reading in megahertz to determine frequency within one kilohertz over the entire tuning range of the HRO-500.

The HRO-500 operates as a triple conversion receiver (to eliminate gaps in its tuning range) between 5 kHz and 4.0 MHz. Incoming signals in this region are up-converted to 26.0 MHz plus the signal frequency. The synthesizer output is then utilized to convert these signals to the tunable IF range of 2750-3250 kHz, where they are mixed with the 2980-3480 kHz VFO to produce the last IF of 230 kHz. Signals in the 4-30 MHz range are directly converted by the synthesizer to the tunable IF without the necessity for an intermediate up-conversion.

FREQUENCY STABILITY: The use of the phase-locked frequency synthesizer to generate crystal-stable high frequency oscillator signals, plus the use of crystal-controlled conversion and beat frequency oscillators, results in only one tunable oscillator in the HRO-500 —the VFO (or interpolation oscillator) which tunes only the 500 kHz range between 2980-3480 kHz. As a consequence, negligible drift is introduced in the conversion processes. VFO stability is particularly superior for four important reasons: The VFO frequency is quite low, making drift (as a function of oscillator frequency) a very small number; the tuning range of the VFO is limited to 500 kHz, allowing accurate temperature compensation over its range; the use of transistors in the VFO eliminates the warm-up drift characteristic of tube-type oscillators as the internal element structure of the tube expands with heat; and practically no heat is generated within the receiver itself because of its solid state circuitry. Changes in ambient temperature are well compensated, and the VFO transistor voltages are *electronically* regulated against changes in primary line voltage. Total drift of the HRO-500 from turn-on is 300 hertz per hour to two hours after turn-on, and better than 100 hertz/day (including a 40 volt change in A.C. input voltage) thereafter. Stability with respect to temperature is 50 hertz per °C.

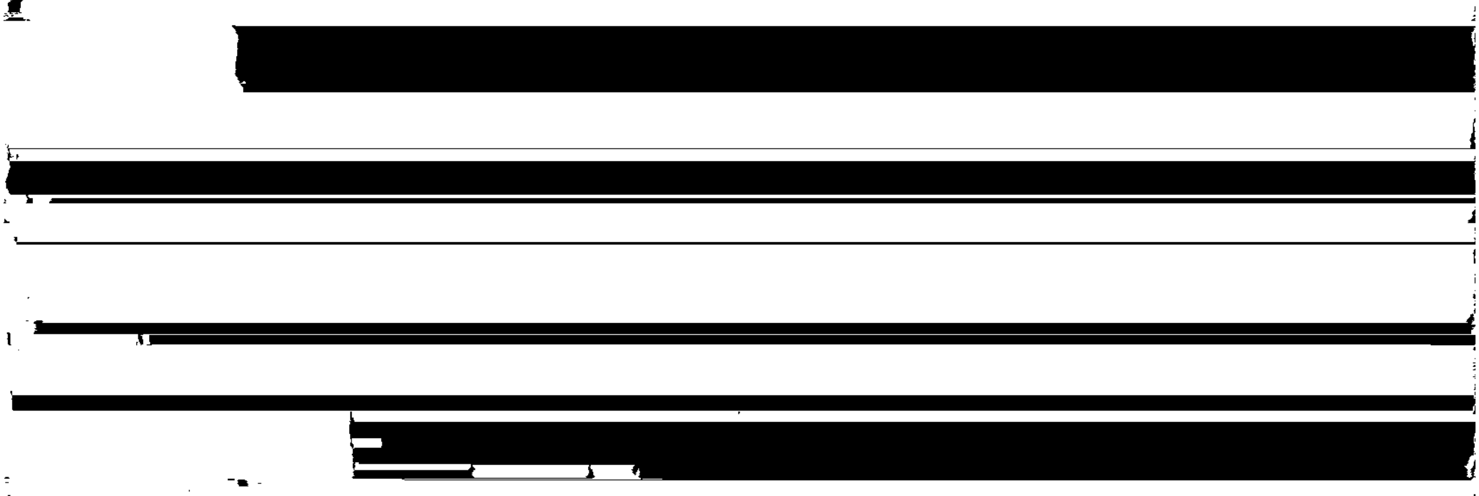
DIAL CALIBRATION: The use of synthesized output from a single master crystal to generate crystal-stable high frequency oscillator injection signals permits the HRO-500 to incorporate only one tunable oscillator; the linear VFO or interpolation oscillator. Since it [illegible]

the operator to "drop out" interfering signals *without changing the frequency of the desired signal.*

A **Rejection Tuning** filter with an extremely sharp rejection notch may also be controlled from the front panel to eliminate interfering heterodynes. Heterodyne rejection capability of this filter is 50 db.

Front-end selectivity and image rejection in the HRO-500 is unusually high. Three tuned circuits are used in the RF stage instead of two, and intermediate frequencies are chosen so that image rejection is a minimum of 50 db throughout the tuning range. Unlike previous transistorized receivers, resistance of the HRO-500 to cross modulation and overload (dynamic range) is closely comparable to vacuum tube equipment. The excellent dynamic range of the HRO-500 has been achieved by means of careful attention to front-end selectivity, use of silicon transistors to allow higher injection voltages, a low noise RF stage to provide high sensitivity without excessive gain, and inclusion of high selectivity immediately after the first mixer.

AGC: The HRO-500 incorporates an AGC system of high relative merit (5 db change in output for input variation between 10 and 100,000 µv) with attack and release times optimized for SSB/CW/AM reception equipment, no attempt has been made to "miniaturize" the HRO-500 by the use of cordwood construction, printed circuits, etc. All transistors are mounted in plug-in sockets and all components are hand-wired. To further improve access and reduce component density, most components are mounted on sub-assembled vertical circuit boards. As a result, circuit-tracing and maintenance is easier than in most vacuum tube equipment of less sophistication. The use of total solid state circuitry in the design of the HRO-500 results in advantages never before realized in commercial communications receivers: greatly improved reliability over tube-type equipment because of the far longer life of transistors and the elimination of performance deterioration from tube "aging"; vastly increased versatility in terms of portable or field operation since the HRO-500 may be operated directly from a 12 V.D.C. source (without intermediate converters) as well as from 115/230 V.A.C. 50/60 hertz sources; practically zero internal heat generation and minuscule power drain—200 ma. @ 50 mw audio output from a 12 V.D.C. source or 15 watts from a 115/230 V.A.C. line; instantaneous operation from turn-on without the warm-up drift characteristic of tube



equipment.

REMOTE CONTROL AND AUXILIARY OUTPUTS: The HRO-500 will find wide use in remote control applications, and accordingly may be externally controlled for primary power, R.F. gain, Audio gain, and receiver mute.

All supply voltages and both NPN and PNP AGC are available at the rear panel as well as detector output. BFO, VFO, synthesizer, 230 kHz I.F. and 26 MHz oscillator outputs are also available at the rear panel. Audio output may be selected from 3.2 ohms or 600 ohms balanced center tapped terminals.

Antenna jacks are provided for 50 ohm unbalanced, high impedance, and VLF antenna inputs.

A two terminal jack with reverse polarity protection is provided on the rear panel for 12 V.D.C. input, which may be instantly selected instead of 115/230 V.A.C. input by means of a rear panel switch. The A.C. line cord is detachable for battery or portable operation.

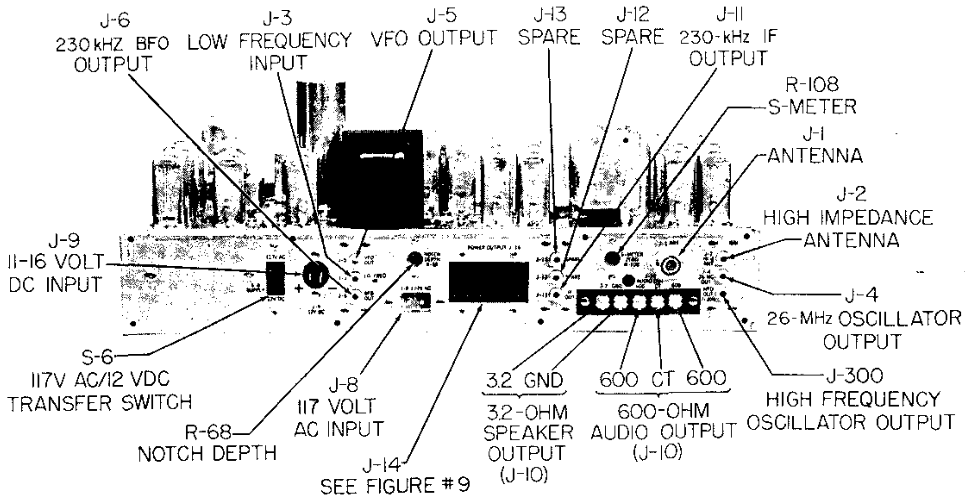
APPLICATIONS: The HRO-500 has been designed for any application requiring either limited or extraordinary frequency coverage with uniformly excellent dial calibration and frequency stability. All facilities necessary for superior SSB, CW, FSK and AM reception are incorporated. The use of solid state technology provides far greater versatility for portable or remote operation than previously available with tube-type equipment, and results in simplified power and cooling requirements where one or many receivers must [illegible]

The HRO-500 is designed for use in HF or VLF point-to-point communication systems, field monitoring applications, surveillance and direction-finding systems, and amateur radio installations. Its extraordinary frequency coverage, calibration, sensitivity and high image rejection makes the HRO-500 an ideal laboratory instrument for wide-range detection, calibration, spectrum analysis and frequency measurement.

SECTION 2

INSTALLATION

2-2 RACK-MOUNTED INSTALLATION:



HRO-500 RECEIVER, REAR PANEL

FIGURE 1

To internally connect the 117-volt AC supply, the 117V AC/12V DC change-over switch S-6 located at the rear of the chassis must be depressed in the upper position. Under idling conditions, the HRO-500 will draw approximately 10 watts. The AC supply drain at 1.5 watts of audio output will be approximately 15 watts with the DIAL lamp switch in the OFF position and the pilot lamps extinguished; 22 watts with the DIAL lamp switch in the ON position and the pilot lamps illuminated.

THE SUPPLY CONNECTIONS WILL SHORT CIRCUIT THE SUPPLY IF THERE IS AN EXTERNAL GROUND CONNECTION COMMON TO THE SUPPLY.

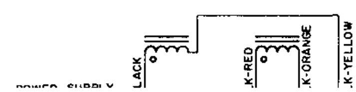
Internal reverse polarity protection is provided in the HRO-500 and will prevent damage to the receiver in the event of an accidental polarity reversal. To internally connect the 11-16 volt DC supply to the receiver, the 117V AC/12V DC change-over switch S-6 located at the rear of the chassis...

depressed in the downward position.

With the pilot lamps extinguished, the drain from a 12-volt DC source will be approximately 2.4 watts or 200 ma with 50-mw audio output; 9 watts or 750 ma with 2 watts of audio.

2.5.2 234-VOLT AC OPERATION

The receiver may be rewired for 234-volt AC operation as shown in figure 2. Under these conditions, the power drain is as given above with the exception that the current drains will be reduced to approximately one half of the amount for 117-volt operation. Operation and connections will be the same as discussed in paragraph 2.5.1 for 117-volt operation.



2.8 REMOTE CONTROL AND MUTING CIRCUITS:

2.8.1 TRANSMITTER CONNECTIONS

— CAUTION—

MANY TRANSMITTERS AND TRANSCEIVERS EMPLOY SPECIAL MUTING OUTPUTS IN WHICH A VOLTAGE IS PRESENT. TO PREVENT DAMAGE TO THE HRO-500 MUTING CIRCUITS, USE A VOLTMETER TO BE ABSOLUTELY CERTAIN THAT NO VOLTAGE IS PRESENT ON THE MUTING LEADS FROM ACCESSORY EQUIPMENT BEFORE CONNECTING THEM TO THE HRO-500.

Transmitter interconnections, including receiver muting and antenna switching of the HRO-500, may be accomplished as shown in figure 3. The HRO-500 may be muted by several methods. Ground-reference muting may be obtained by grounding terminal 12 of J-14 to the receiver chassis ground as shown in figure 4. The receiver may also be muted by connecting terminal 13 of J-14 (+12 volt DC muting) to a +12-volt DC supply available on terminal 4 of J-14 as shown in figure 5 and figure 6B. The receiver may also be muted by connecting terminal 13 to any external +12-volt DC source as shown in figure 6A. It should be noted that all the muting methods described herein will cause the PHASE LOCK indicator lamp to flash. Therefore, the PHASE LOCK indicator of the HRO-500 will serve as an indication that the transmitter is in operation or that the receiver is muted.

The optional monitor-normal switch shown in the transmitter interconnection diagram (see figure 7) provides a means of using the HRO-500 to monitor the transmitted signal as picked up from the open receiver antenna connection at the relay. If this monitoring feature is not desired, the monitor-normal switch may be eliminated and connections made according to figure 3.

2.8.2 REMOTE OPERATION

The HRO-500 may be installed in a position remote from the operator for fixed general use. For remote operation, it is necessary that the receiver be preprogrammed for the proper channel frequency and for the correct mode of operation. However, the operator may have complete control of RF gain and audio gain and the receiver muting. These features may be provided by making the required interconnections as shown in figure 8.

Remote audio gain control may be obtained by connecting a 10,000-ohm (logarithmic taper) audio gain control potentiometer to J-14 of the HRO. The audio gain control ground side should be connected to terminal 3; the center, to terminal 17; and the high side, to terminal 18.

Remote RF gain control of the HRO-500 may be obtained by connecting a 500-ohm RF gain control potentiometer to terminals 5 and 11 of J-14. Terminal 11 will be the remote RF gain line and terminal 5 will supply the +11-volt DC potential required for the RF gain control DC reference voltage. The remaining terminal of the potentiometer should be connected to Terminal 3 of J-14 through a 2200 ohm ½ watt resistor. The HRO-500 will have minimum RF gain when the potentiometer arm is at the +11-volt terminal.

Remote receiver muting may be accomplished by either ground-reference muting or +12-volt DC muting as described in paragraph 2.8.1.

2.8.3 REMOTE POWER CONTROL

The remote operator may have complete power control of the HRO-500 by installing a SPST switch at the operator's position. This switch should be connected in series with either the 117-volt AC or 12-volt DC line used to power the receiver, depending on the particular installation.

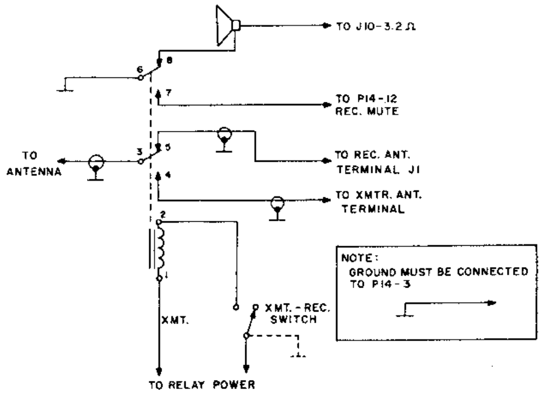
2.8.4 CONTROLLING OTHER EQUIPMENT

The HRO-500 FUNCTION switch, when placed in the STBY position, mutes the receiver and closes contacts 1 and 2 of J-14. These contacts may be used to close an external circuit to control other equipment. For example, these contacts could be used for the transmit-receive switch as shown in the transmitter diagram, figure 3.

2.8.5 AUXILIARY OUTPUTS

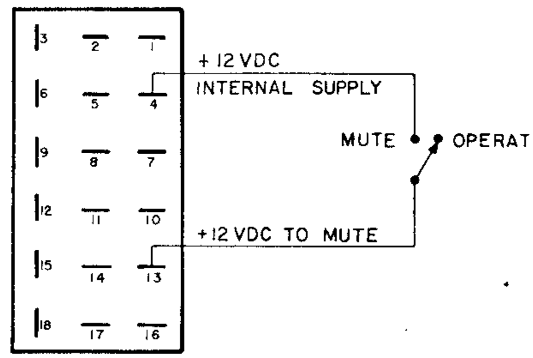
Auxiliary input and output jacks are located on the rear of the receiver to allow monitoring, controlling auxiliary equipment and troubleshooting. The location of these auxiliary inputs and outputs are shown in figures 1 and 9. The function, nominal output level, internal impedance and frequency range are listed in the table below.

JACK	FUNCTION	INPUT/OUTPUT NOMINAL LEVEL	INTERNAL IMPEDANCE	FREQUENCY RANGE



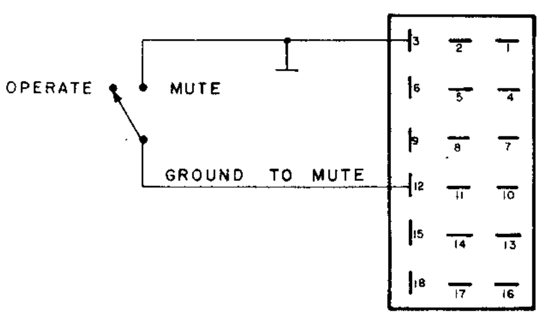
TRANSMITTER INTERCONNECTIONS WITHOUT MONITOR-NORMAL SWITCH

FIGURE 3



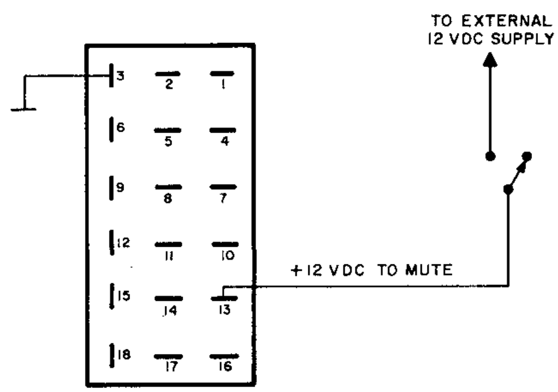
+12-VOLT DC MUTING, INTERNAL

FIGURE 5



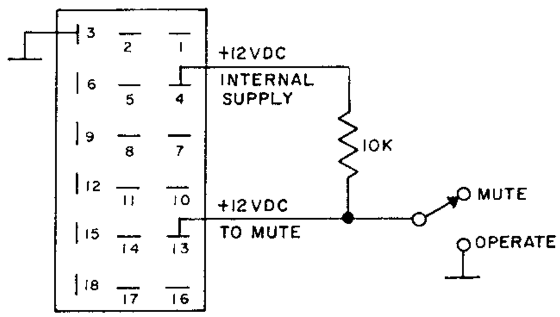
GROUND-REFERENCE MUTING

FIGURE 4



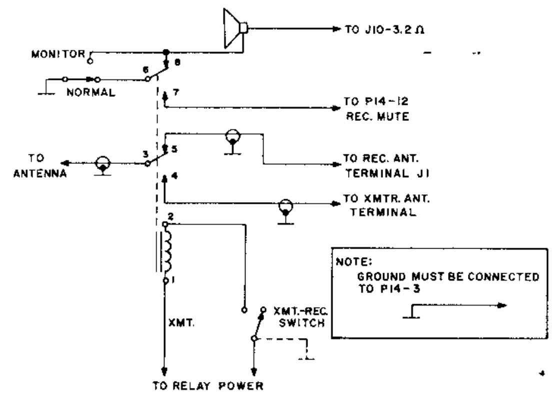
+12-VOLT DC MUTING, EXTERNAL

FIGURE 6A



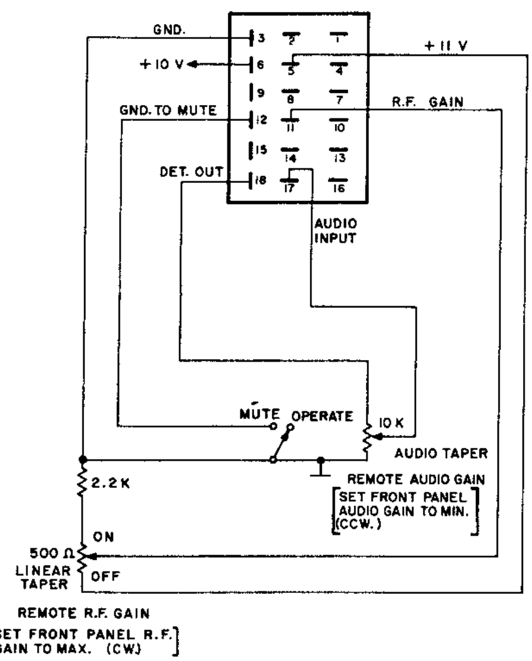
ALTERNATE METHOD OF MUTING FOR USE WITH AN EXTERNAL RELAY CONTACT WHICH IS GROUNDED TO OPERATE THE RECEIVER.

FIGURE 6B



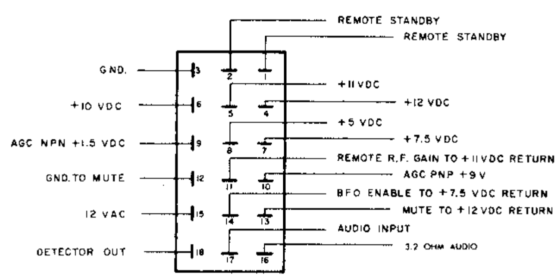
TRANSMITTER INTERCONNECTIONS WITH OPTIONAL MONITOR-NORMAL SWITCH

FIGURE 7



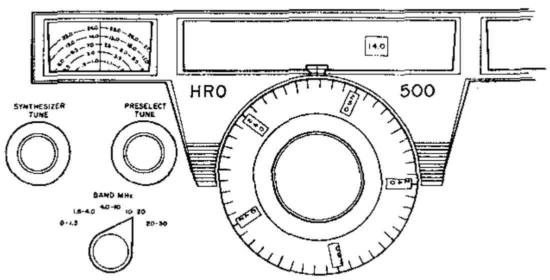
REMOTE RF-AUDIO GAIN CIRCUITS

FIGURE 8



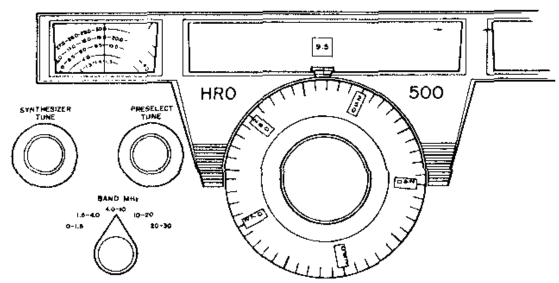
J-14 ACCESSORY SOCKET

FIGURE 9



RECEIVER TUNING (14,253.2 kHz)

FIGURE 10



RECEIVER TUNING (9753.2 kHz)

FIGURE 11

SECTION 3

OPERATION

3.1 GENERAL:

It is assumed that the HRO-500 receiver has been properly installed as specified in Section 2 (Installation) before operation is attempted. Check to make certain that the antenna and speaker are properly connected, that proper power has been supplied to the HRO-500, and that the power change-over switch on the rear panel has been properly set for the power source in use.

and is calibrated with linear 1-kHz divisions from zero to 500 kHz. The exact frequency to which the HRO-500 is tuned is determined by adding the kilohertz indication of the MAIN TUNING dial to the SYNTHESIZER TUNE dial indication in megahertz (as it appears in the center window). If the SYNTHESIZER TUNE dial indicates 14.0 megahertz and the MAIN TUNING dial indicates 253.2 kilohertz, then the HRO-500 receiver is tuned to 14,000 plus 253.2, or 14,253.2 kilohertz as illustrated in figure 10. If the SYNTHESIZER TUNE dial indicates 9.5 megahertz of the SYNTHESIZER TUNE dial window, the PHASE LOCK lamp is extinguished, and audio is heard from the speaker, providing the RF and AUDIO GAIN controls are properly set.

3. Adjust the MAIN TUNING dial to the frequency in kilohertz which must be added to the synthesizer frequency in megahertz for reception at the desired frequency.

4. Slowly rotate the PRESELECTOR TUNE control until incoming noise or signals are loudest, or until the S-meter indicates maximum amplitude. It will be noted that the PRESELECTOR TUNE control is ganged to the PRESELECTOR TUNE dial scale in the upper left window of the HRO-500 receiver. The calibrations on the PRESELECTOR TUNE dial are in five bands, corresponding to each of the bands selected by the BANDSWITCH.

— CAUTION —

ALWAYS SET THE PRESELECTOR TUNE DIAL TO THE OPERATING FREQUENCY WITHIN PLUS OR MINUS ONE-HALF DIAL DIVISION. THIS IS NECESSARY TO INSURE MAXIMUM SENSITIVITY OF THE HRO-500, AS WELL AS GREATEST FREEDOM FROM IMAGE AND SPURIOUS SIGNAL RESPONSE. GENERALLY SPEAKING, THE OPERATION OF THE PRESELECTOR TUNE CONTROL MAY BE CONSIDERED SIMILAR TO THAT OF A CALIBRATED ANTENNA TRIMMER CONTROL.

3.3 CONDENSED OPERATING INSTRUCTIONS:

The following instructions are intended to provide the operator with information necessary to quickly and easily adjust the HRO-500 receiver for reception of SSB, CW, or AM signals. Paragraphs 3.4 through 3.4.17 must be carefully studied for complete understanding of control operation.

Before operation of the HRO-500 receiver, the front panel controls should be set as follows:

AUDIO GAIN fully counterclockwise (ccw)

RF GAIN fully clockwise (cw)

AGC THRESHOLD: ON

DIAL lamp switch to the ON position (unless battery operation dictates economy of battery use)

BANDWIDTH switch at 5.0 kHz

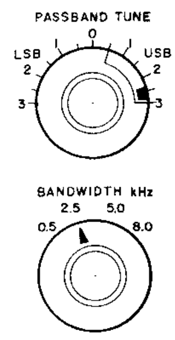
REJECTION TUNE: OFF

FUNCTION switch: OFF

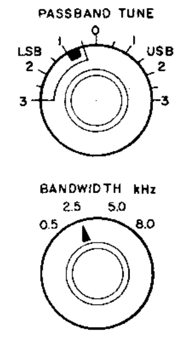
3.3.1 AM OPERATION

1. Turn the FUNCTION switch from OFF to AM. The dial lamps should illuminate, indicating that the receiver circuits are now energized.
2. Adjust the receiver to the desired frequency as described in paragraph 3.2 above.
3. Rotate the concentric AUDIO GAIN control clockwise until a comfortable listening level is achieved.
4. Carefully peak the preselector as described in paragraph 3.2 above.
5. Interfering heterodynes may be reduced or eliminated by slowly rotating the REJECTION TUNE control until the interference is minimized.
6. For greater fidelity, the BANDWIDTH control may be turned to 8.0 kHz.

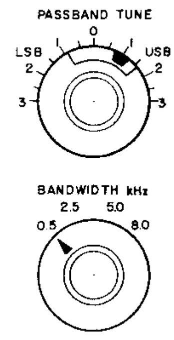
3.3.2 SSB OPERATION



PASSBAND TUNING
2.5 kHz – USB
FIG. 12



PASSBAND TUNING
2.5 kHz – LSB
FIG. 13



PASSBAND TUNING
1 kHz BEAT NOTE
FIG. 14

1. It is assumed that the HRO-500 receiver has been previously adjusted for AM operation.
2. Turn the FUNCTION switch to SSB.
3. Turn the BANDWIDTH switch to 2.5 kHz.
4. For single-sideband reception, turn the PASSBAND TUNE control until the wide sector outlined in white on the knob includes the 0.5 kHz to 3 kHz divisions on the panel (see figure 12). This sector on the PASSBAND TUNE control indicates the relative width and position of the 2.5 kHz filter with respect to the IF center (BFO) frequency. Zero on the front panel scale corresponds to this center frequency. The scale is calibrated in ½-kilohertz marks up to 3 kilohertz either side of zero.
5. For upper sideband reception, the PASSBAND TUNE control should be turned to the right of zero (USB); for lower sideband reception, the PASSBAND TUNE control should be turned to the left of zero (LSB) (see figure 13).

6. Interfering heterodynes may be rejected by use of the REJECTION TUNE control as described in paragraph 3.3.1 above.

3.3.3 CW RECEPTION

1. It is assumed that the HRO-500 receiver has been adjusted for SSB reception.
2. Turn the BANDWIDTH switch to 0.5 kHz (500-hertz filter bandwidth).
3. Turn the PASSBAND TUNE control to either side of zero so that the solid white sector of the PASSBAND TUNE knob spans the 1-kHz marking on the panel as shown in figure 14.

3.4 DETAILED USE OF HRO-500 CONTROLS:

3.4.1 DIAL LOCK

The HRO-500 DIAL LOCK control is a mechanical clutch which couples the MAIN TUNING (kilohertz) control to the linear tuning capacitor in the receiver. The DIAL LOCK may be used to adjust the MAIN TUNING dial for exact calibration, or may be used to prevent the MAIN TUNING control from being disturbed by either mechanical vibration or adjustment by unauthorized personnel.

To use the DIAL LOCK for calibration adjustment, turn the FUNCTION switch to CAL. In this mode of operation, the 50-kHz crystal standard oscillator provides calibrator signals every 50 kHz throughout the tuning range of the VFO. Adjust the MAIN TUNING dial to an exact multiple of 50 kHz and note whether or not it is zero beat with the output from the internal crystal calibrator. If not, adjust the MAIN TUNING dial to exact zero beat with the calibrator, and turn the DIAL LOCK knob 90° clockwise to lock the VFO tuning capacitor. The MAIN TUNING control may now be turned without changing the receiver frequency. It should be adjusted until the MAIN TUNING dial indicates the exact frequency of the 50-kHz calibrator signal. Now unlock

SIZER TUNE control. This control operates a drum dial calibrated in 60 500-kHz increments from 0.0 MHz to 29.5 MHz which appear on the SYNTHESIZER TUNE dial in the window directly above the MAIN TUNING (kilohertz) dial. As the SYNTHESIZER TUNE control is rotated, the 500-kHz increments will pass through the center of the SYNTHESIZER TUNE dial window and the PHASE LOCK indicator lamp will flash. These increments indicate the frequency in megahertz of the 500-kHz segment to which must be added the frequency in kilohertz indicated on the MAIN TUNING dial. When a number is correctly positioned in the center of the window, the PHASE LOCK indicator lamp will extinguish and receiver audio will be restored indicating that the synthesizer is locked to the frequency corresponding to the selected 500-kHz increment.

3.4.3 PHASE LOCK INDICATOR

The PHASE LOCK indicator lamp will flash and the receiver will mute when the synthesizer section of the HRO-500 receiver is not properly locked to a 500-kHz increment. When the SYNTHESIZER TUNE control is properly adjusted as described in paragraph 3.4.2, the PHASE LOCK indicator lamp will extinguish and the receiver output will become audible. As the SYNTHESIZER TUNE control is rotated to advance a new 500-kHz increment into the SYNTHESIZER TUNE dial window, the PHASE LOCK lamp will flash and the receiver output will be muted. When the new number is correctly positioned in the center of the SYNTHESIZER TUNE dial window, the PHASE LOCK indicator lamp will again extinguish and the receiver output signal will again become audible.

3.4.4 MAIN TUNING (KILOHERTZ)

The MAIN TUNING (kilohertz) control varies the output frequency of an accurate and stable linear VFO which is used as the second conversion oscillator in the HRO-500. The VFO is accurate to better than 1 kHz throughout its tuning range. The

LECTOR TUNE control is used to manually tune these circuits for maximum performance. The resonant frequency of the preselector is indicated on the PRESELECTOR TUNE dial which appears in the left window as shown in figures 10 and 11.

— CAUTION —

THE PRESELECTOR TUNE DIAL HAS BEEN CALIBRATED TO PREVENT ACCIDENTAL ADJUSTMENT TO IMAGE FREQUENCIES. ALWAYS SET THE PRESELECTOR TUNE DIAL TO THE SAME FREQUENCY THAT IS INDICATED BY THE SYNTHESIZER TUNE AND MAIN TUNING DIALS. CAREFULLY PEAK THE PRESELECTOR TUNE CONTROL IN THIS REGION FOR MAXIMUM SIGNAL RESPONSE. AFTER PEAKING, THE PRESELECTOR TUNE DIAL SHOULD INDICATE THE RECEIVER FREQUENCY ± ½ THE NEAREST CALIBRATION MARK. FAILURE TO SET THE PRESELECTOR TUNE CONTROL PROPERLY WILL RESULT IN EXTREMELY POOR IMAGE AND SPURIOUS SIGNAL REJECTION AND POOR SENSITIVITY. PRESELECTOR TUNE ACTION IS PARTICULARLY SHARP ON THE 0-1.5 AND 1.5-4.0 MHz BANDS. PARTICULAR CARE SHOULD BE TAKEN TO TRACK THE PRESELECTOR TUNE CONTROL ON THESE BANDS AS THE MAIN TUNING (KILOHERTZ) DIAL IS ADJUSTED. OTHERWISE, THE RECEIVER WILL SEEM INSENSITIVE.

3.4.6 BANDSWITCH

The BANDSWITCH selects the proper coil and tuning capacitor combinations to permit the HRO-500 receiver to tune the following frequency ranges:

is lost and it becomes necessary to "ride" the gain control. The AGC THRESHOLD control in the HRO-500 allows the operator to insert 10, 20, or 30 db of attenuation in the incoming signal path, thereby "dropping out" the weaker background signals without changing the amount or degree of AGC action. Full AGC action is retained, thereby eliminating the need to "ride" controls, and the S-meter continues to function. To determine the strength of attenuated signals, it is only necessary to add to the S-meter indication a number in decibels corresponding to the amount of attenuation inserted with the AGC THRESHOLD control. The AGC THRESHOLD control may also be used to minimize cross-modulation on the broadcast band. Unlike most general coverage receivers, which are artificially reduced in sensitivity by their manufacturers on the broadcast band because of the extremely high signal levels often encountered, the HRO-500 is designed to operate at full usable sensitivity on these frequencies, thereby providing the required sensitivity when needed. As a result, cross-modulation may be encountered with the HRO-500 receiver on the broadcast band, but can be minimized or eliminated by artificially reducing the HRO-500 sensitivity at the operator's discretion by insertion of front-end attenuation with the AGC THRESHOLD control.

The following AGC THRESHOLD control positions are available to the operator:

OFF: In the OFF position, all AGC is removed from the HRO-500 receiver. To prevent overloading the receiver, it is recommended that the RF GAIN control setting should be such that the received signal does not drive the S-meter off scale.

ON: In this position, the HRO-500 operates normally with full AGC action. It should be noted that the RF GAIN control will affect the S-meter. Correct S-meter indications will not be obtained if ground activity is encountered; without AGC compromise for clear channel operation.

3.4.8 FUNCTION SWITCH

The FUNCTION switch is a five-position selector switch. This switch controls main power to the receiver and determines the stand-by, single-sideband/CW, amplitude modulation, and calibration modes of operation as follows:

OFF: When in the OFF position, the FUNCTION switch removes all power from the receiver in both AC and DC power input conditions.

STBY: In the stand-by condition, B+ voltage is applied to all internal oscillators of the HRO-500 but not to other stages in the receiver. In addition, terminals 1 and 2 of power output connector J-14 at the rear of the receiver are shorted to permit control of other external devices.

SSB (used for operation in SSB and CW modes): In this position, the receiver is fully operative. When the FUNCTION switch is set to SSB, the product detector is connected between the last IF stage and audio stages to permit either SSB or CW reception, and the BFO is activated.

AM: In this position, the AM diode detector is connected between the receiver IF and audio stages to permit AM reception, and the BFO is disabled.

CAL: In this position, the receiver is fully operative. When the FUNCTION switch is set to CAL, the product detector, BFO and 50-kHz calibration oscillator are activated to permit calibration of the receiver. To check the calibration of your HRO-500 receiver, refer to paragraph 3.4.1 above. It should be noted that the calibration oscillator is heard in the tunable IF of the HRO-500, not in the front end, so that the calibrator should not be used to peak the preselector.

3.4.9 AUDIO GAIN

The AUDIO GAIN control is the smaller concentric knob located at the lower left-hand corner of the receiver front panel and varies the audio output of the receiver.

3.4.10 RF GAIN

The RF GAIN control sets the basic gain level of the HRO-500 receiver. Since this control operates on the RF, tunable IF, and the first and second 230-

The 8.0 kHz and 5.0 kHz filter positions are fixed-tuned, while in the 2.5 kHz and 0.5 kHz positions, the filter may be tuned over a range of approximately ±3 kHz (see paragraph 3.4.12 below).

The 8.0 kHz position is recommended for strong-signal, clear-channel AM reception. The 5.0 kHz position should be used for AM reception when weak-signal or crowded-band conditions prevail.

The 2.5 kHz position should be used for SSB operation, or AM operation when considerable adjacent channel interference is present. The excellent 6-60 db shape factor of 2.5:1, which is available through the six-pole ferrite cup-core filter, provides superior rejection of the unwanted sideband. The 2.5-kHz filter, in conjunction with the PASSBAND TUNE control (see paragraph 3.4.12), is continuously tunable over the IF passband of the receiver for USB or LSB mode of operation.

The 0.5 kHz position should be used for CW operation. This position also incorporates passband tuning of the filter which permits selection of the desired CW signal in the presence of other undesired signals without any change in the beat note frequency.

3.4.12 PASSBAND TUNE

The HRO-500 receiver incorporates a highly selective six-pole filter in the 0.5-kHz and 2.5-kHz bandwidth positions. The filter may be continuously tuned throughout the IF passband. The ability to tune the filter passband enables the operator of the HRO-500 to select either upper or lower sideband without changing the frequency of the incoming signal, or to "sort out" the CW signals in the IF passband of the HRO-500 without affecting their frequency or the pitch of their beat notes. In either the 2.5 kHz or 0.5 kHz selectivity positions, interfering signals may be "dropped off" the side of the filter while retaining the desired signal.

It will be noted that the PASSBAND TUNE control knob is marked with a wide sector (outlined in white) indicating the relative bandwidth of the 2.5-kHz filter. The panel is marked with divisions indicating relative frequency. These divisions extend to 3 kilohertz above and below the center of the passband. When the PASSBAND TUNE knob is rotated, the relative position of the 2.5-kHz filter in the passband is thereby indicated. Correspondingly, the narrow sector (solid white) on the PASSBAND TUNE

Normally, the 0.5-kHz sector (solid white) on the PASSBAND TUNE control knob will be set approximately 1 kHz away from the BFO as indicated on the panel calibration (see figure 14). This will result in a 1-kHz beat note when the desired signal is centered in the 0.5-kHz passband.

Adjustment of the filter to pass a CW beat note to suit the operator's preference is accomplished by using a strong steady carrier such as that from the crystal calibrator to produce an artificial beat note. The BANDWIDTH switch is set to the 2.5 kHz or 5.0 kHz position, and the MAIN TUNING (kilohertz) dial is adjusted until the desired beat note is heard. The BANDWIDTH switch is then turned to the 0.5 kHz position and the PASSBAND TUNE control slowly rotated until the beat note is loudest. At that setting of the PASSBAND TUNE control, all received signals will be loudest when their beat note is tuned to that frequency. Other undesired beat notes will be extremely low in amplitude, and true single-signal CW reception will be enjoyed. Should undesired interference from other CW signals be encountered, the PASSBAND TUNE control may be adjusted to tune the filter away from them without affecting the frequency of the desired signal. Using the PASSBAND TUNE control in this manner, it is possible to move the filter throughout the passband of the receiver to drop out interfering signals and select the desired signals—all without changing their relative frequency in the passband or the frequency of their beat notes. It is suggested that some time be taken to familiarize the operator with the operation of this control—preferably in a portion of the spectrum where there is considerable adjacent channel CW operation—since its use will frequently make the difference between no communication and solid copy. It may be pointed out that the operation of the 0.5-kHz filter and the use of the PASSBAND TUNE control may be dramatically illustrated by easily selecting the mark or space tones of an RTTY signal by use of the PASSBAND TUNE control alone.

3.4.12.2 PASSBAND TUNING WITH THE 2.5-kHz FILTER

The 2.5-kHz filter will normally be used for single-sideband operation, and should be adjusted so that the wide 2.5-kHz sector (outlined in white) on the PASSBAND TUNE control knob is offset approximately one-half kHz on either the upper-sideband or lower-sideband side of the crystal-controlled BFO frequency as shown in figures 12 or 13. The position of the 2.5-kHz filter in the passband to suit the individual operator's preference may be determined by tuning in an SSB signal in the 5.0 kHz position of the BANDWIDTH switch for most pleasing fidelity and response. The BANDWIDTH switch should then be turned to the 2.5 kHz position, and the PASSBAND TUNE control rotated until the audio response most closely approximates that obtained in the 5.0-kHz bandwidth. This position should be noted for future reference. It should be understood that the further the filter is moved away from the BFO frequency, the greater will be the attenuation of the unwanted sideband. This may be important, for example, in making sideband suppression checks of received signals. In such instances, the 2.5-kHz sector (outlined in white) on the PASSBAND TUNE control knob should be moved 1 to 1.5 kHz way from zero. This position will provide maximum rejection of the unwanted sideband. Such performance is only obtained in a conventional receiver by actually tuning the receiver away from the signal with the main tuning control, thereby reducing intelligibility. It will be noted that adjacent channel "splatter" and heterodyne interference may be minimized or completely eliminated by moving the filter away from the interfering signal with the PASSBAND TUNE control. The PASSBAND TUNE control may easily be adjusted until a compromise between fidelity and adjacent channel rejection is obtained.

The combination of passband tuning in the HRO-500 plus the extremely effective REJECTION TUNE control described in the next paragraph offers a remarkable degree of freedom from adjacent channel interference.

3.4.12.3 REJECTION TUNE

The REJECTION TUNE control positions an extremely narrow rejection notch in the IF passband of the HRO-500. This control has a range of approximately ±10 kHz about the receiver IF. The width of the notch is several hertz wide at −50 db, and several hundred hertz wide at −6 db. The REJECTION TUNE control also incorporates a 3:1 vernier for ease in positioning the rejection notch. The notch is completely outside the receiver passband when the control is in the OFF position. THE NOTCH SHOULD BE LEFT IN THIS POSITION WHEN NOT IN USE. This control may be used for removing interfering heterodynes or unwanted CW signals without materially affecting the intelligibility of the desired signal. Care should be taken to move the control very slowly, since the rejection notch is very narrow.

— CAUTION —

IN AM RECEPTION, CAREFULLY POSITION THE REJECTION TUNE CONTROL TO REMOVE THE UNDESIRED SIGNAL HETERODYNE AND NOT THE CARRIER OF THE DESIRED SIGNAL. IF THE WRONG REJECTION POINT IS SELECTED, THE DESIRED SIGNAL CARRIER WILL BE REMOVED AND THE RESULTING AMPLITUDE-MODULATED, SUPPRESSED-CARRIER SIGNAL WILL BE UNINTELLIGIBLE.

When severe distortion of AM signals is encountered due to "selective fading" of the carrier, it is sometimes helpful to use exalted carrier reception. Set the FUNCTION switch to the SSB position and zero beat the carrier of the AM signal with the MAIN TUNING control. Set the filter with the PASSBAND TUNE control to receive only one sideband of the AM signal. Then set the rejection notch to remove the AM carrier with the REJECTION TUNE control. Since the product detector BFO signal now supplies the necessary carrier frequency for complete demodulation of the AM side-

has been removed and an improvement in fidelity and intelligibility will be obtained.

3.4.13 NOTCH DEPTH (REJECTION TUNE BALANCE)

The NOTCH DEPTH control, located on the rear panel of the receiver, determines the balance of the rejection tune circuit for best results. This control has been carefully positioned at the factory for maximum balance and usually will need no attention by the operator. If rejection of greater than −50 db cannot be obtained with the REJECTION TUNE control, the NOTCH DEPTH (rejection tune balance) control may require repositioning. This should be accomplished by tuning in a steady, strong carrier, such as the 50-kHz calibrator signal, and simultaneously adjusting the rear panel NOTCH DEPTH control and front panel REJECTION

3.4.16 117V AC/12V DC SWITCH

The 117V AC/12V DC switch, located on the rear panel of the receiver, controls the input power connections to the HRO-500. For 117-volt AC operation, the top portion of the switch should be depressed. If 12-volt DC operation is desired, the bottom portion of the switch should be depressed. Correct power connections to the HRO-500 are required for either type of operation.

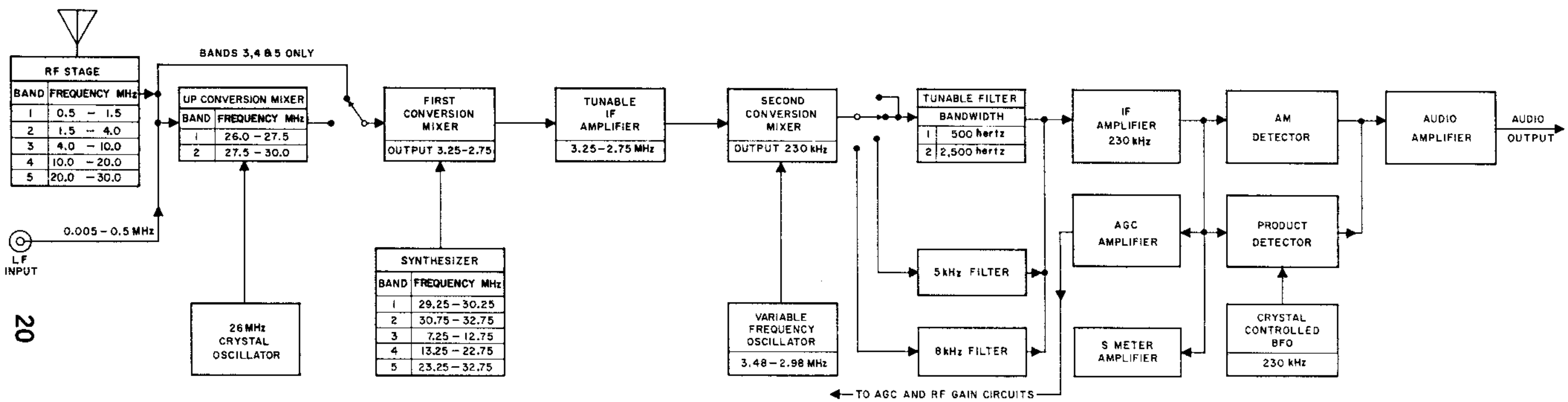
ADJUST

The S-METER ZERO adjust control is located on the rear panel of the HRO-500. To zero the S-meter, set the receiver FUNCTION switch to the AM position. The antenna connection to the receiver should be disconnected, or the receiver should be tuned to an unused frequency and the PRESELECTOR TUNE control tuned off resonance to insure minimum noise pickup on the antenna circuit. The S-METER ZERO adjust may then be used to set the S-meter pointer to zero on the S-units scale.

The S-meter has been carefully calibrated at the factory to indicate S-9 with a 50-uv input when the receiver is tuned to 4 MHz on the 1.5-4 MHz band. The S-meter Calibration Control, C-156, located under the receiver chassis, determines the S-meter sensitivity and normally will require no adjustment in the broadcast band. Because of the extremely high signal levels in metropolitan areas, often exceeding 1.0 *volt* at the antenna terminals, general coverage receivers are frequently designed so that broadcast band sensitivity is only 10-50 μv or less to reduce cross-modulation resulting from high signal levels. Incorporation of the AGC THRESHOLD control in the HRO-500 (discussed in paragraph 3.4.7) allows the HRO-500 to be run at full sensitivity on the broadcast band in remote areas, with reduced sensitivity *at the operator's discretion* in metropolitan locations. In areas of high signal level, it will be found that the HRO-500 will tune most easily with at least 10 or 20 db of attenuation inserted in the signal path by means of the AGC THRESHOLD control. Care should also be taken to peak the PRESELECTOR TUNE control accurately on the desired station, since cross-modulation will be increased

3.5.3 LOW-FREQUENCY OPERATION

As delivered, the HRO-500 will tune the 5 kHz-500 kHz band with 25-50 μv sensitivity, but without preselection against interfering signals in the 500 kHz-1500 kHz region. In many applications, the LF-10 preselector, which provides full sensitivity and preselection, may not be necessary for satisfactory performance in the VLF region. To use the HRO-500 without the LF-10 preselector, it is necessary to attach a long wire antenna to the VLF input jack (J-3) on the rear apron, and adjust the SYNTHESIZER TUNE control so that 0.0 MHz appears in the synthesizer window. Antennas should not be connected to the 50-ohm or high-impedance inputs. It will be noted that the PRESELECTOR TUNE control has no effect in the 5 kHz-500 kHz region. The MAIN TUNING (kilohertz) dial now reads frequency di-

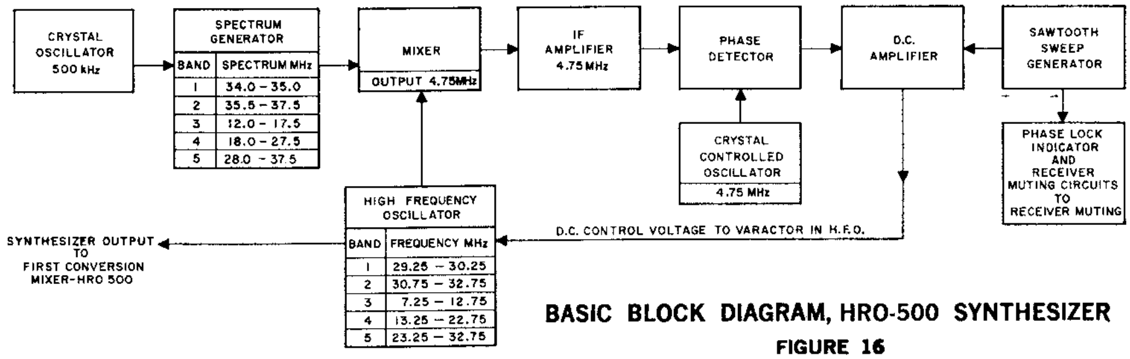


HRO-500 RECEIVER, BASIC BLOCK DIAGRAM

FIGURE 15

SECTION 4

THEORY OF OPERATION



BASIC BLOCK DIAGRAM, HRO-500 SYNTHESIZER

FIGURE 16

4.1 THE RECEIVER: BASIC DESCRIPTION

Figure 15, a basic block diagram of the HRO-500 receiver, illustrates the major functional sections of the receiver and the signal and oscillator frequencies throughout the system. The HRO-500 receiver functions as a triple-conversion receiver for frequencies between 5 kHz and 4 MHz. In this frequency range, the incoming signal frequency is first up-converted to 26 MHz plus the signal frequency. The resulting signal between 26.005 MHz and 30 MHz is mixed with the synthesizer output to produce the tunable IF frequency of 3.25 MHz to 2.75 MHz. A tracked oscillator then converts this tunable IF signal to the final IF frequency of 230 kHz. Frequencies between 4 MHz and 30 MHz are directly converted to the tunable IF and, in turn, to the final 230 kHz IF. The receiver functions as a double-conversion superheterodyne in the frequency range between 4 MHz and 30 MHz.

Incoming signals between 500 kHz and 30 MHz are fed through the RF stage, which is switched in five ranges. The output of the RF stage is coupled to the up-conversion mixer on Bands 1 and 2 and is coupled directly to the first conversion mixer on Bands 3, 4, and 5. The separate low-frequency input used between 5 kHz and 500 kHz by-passes the RF stage and is for proper operation and selection of signals in the basic preselector band. In the event that low-frequency reception is desired, the BANDSWITCH must be placed in position 1 for proper up-conversion mixer and synthesizer operation even though the RF stage is not used.

The tunable IF amplifier output lying between 3.25 MHz and 2.75 MHz is coupled to the second conversion mixer together with the output of the variable frequency oscillator operating between 3.48 MHz and 2.98 MHz. The tunable IF amplifier and variable frequency oscillator are tracked. The output of the second conversion mixer is at 230 kHz.

Output from the second conversion mixer is fed to the various IF filter circuits. The BANDWIDTH switch selects the tunable filter, the 5-kHz filter, or the 8-kHz filter, depending on the operator's preference. Output from each of these filters is coupled to the input of the 230-kHz IF amplifier.

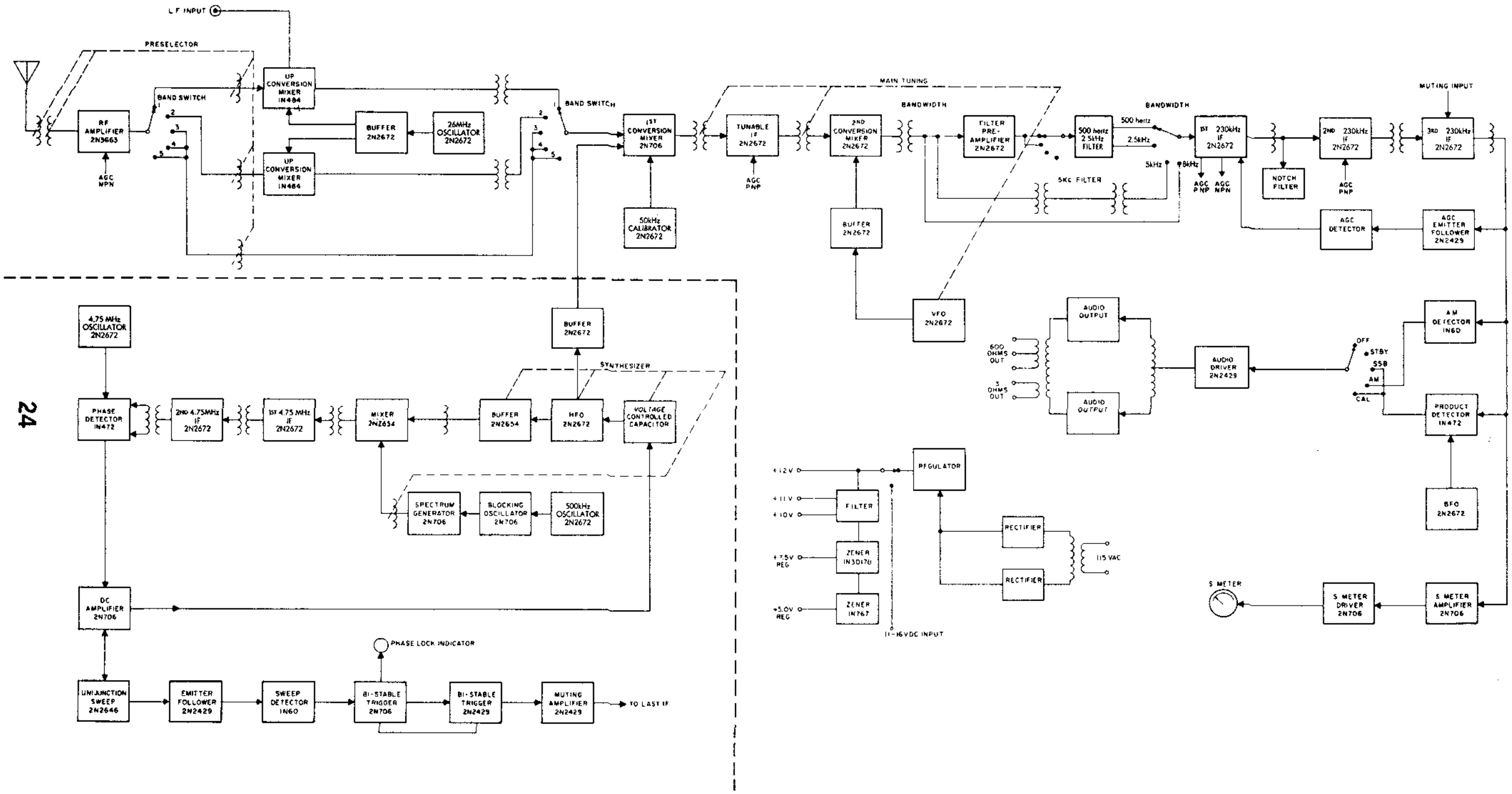
Output from the 230-kHz IF amplifier feeds the AM detector, the product detector, the AGC amplifier, and the S-meter amplifier. The output of a crystal-controlled BFO is also fed to the product detector. The front panel FUNCTION switch then that the synthesizer circuits are out of lock. Receiver muting circuits prevent reception of unwanted or annoying signals until such time as proper high-frequency oscillator injection has been restored.

The stable 500-kHz crystal oscillator drives a spectrum generator providing a coherent burst of energy. The coherent nature of the spectrum generator signal insures that the output will contain only harmonics of the original 500-kHz reference frequency. The harmonic content will, however, have an amplitude distribution around the tuned frequency of the spectrum generator with the harmonics of maximum amplitude always occurring at the spectrum generator frequency. The nature of the frequency and time domain of the spectrum generator signal is illustrated in figure 17. The spectrum generator is

When phase lock control is lost, the high-frequency oscillator signal may be widely removed from that required to phase lock with the desired spectrum generator output harmonic. A sweep generator is incorporated to vary the varactor voltage from +3 to +8 volts by the sweep generator sawtooth, thus insuring a wide frequency scan of the high-frequency oscillator until a 4.75-MHz IF amplifier output again occurs at the phase detector. The 4.75-MHz output will cause the phase loop to lock and the sawtooth generator to cease operation.

During such times that the phase loop is sweeping, the output of the sawtooth generator is detected and amplified to light the PHASE LOCK indicator lamp on the front panel. Additional circuits filter the lamp information and generate a muting signal to

Bandswitch RF Amplifier	*26-MHz Osc.*	*Up Conversion Mixer Output*	*First Conversion Mixer Input*	*High-Frequency Oscillator Tuned Buffer, Untuned Buffer*	*Synthesizer Tune*	*Spectrum Generator Output*
0.0 MHz to 1.5 MHz	26 MHz	26 MHz	26.0 MHz	29.25 MHz	0.0 MHz	34.0 MHz
		to	to	29.75 MHz	0.5 MHz	34.5 MHz
		27.5 MHz	27.5 MHz	30.25 MHz	1.0 MHz	35.0 MHz
1.5 MHz to 4.0 MHz	26 MHz	27.5 MHz	27.5 MHz	30.75 MHz	1.5 MHz	35.5 MHz
		to	to	31.25 MHz	2.0 MHz	36.0 MHz
		30 MHz	30 MHz	31.75 MHz	2.5 MHz	36.5 MHz
				32.25 MHz	3.0 MHz	37.0 MHz
				32.75 MHz	3.5 MHz	37.5 MHz
4.0 MHz to 10 MHz	OFF	None	4.0 MHz	7.25 MHz	4.0 MHz	12.0 MHz
			to	7.75 MHz	4.5 MHz	12.5 MHz
			10 MHz	8.25 MHz	5.0 MHz	13.0 MHz
				8.75 MHz	5.5 MHz	13.5 MHz
				9.25 MHz	6.0 MHz	14.0 MHz
				9.75 MHz	6.5 MHz	14.5 MHz
				10.25 MHz	7.0 MHz	15.0 MHz
				10.75 MHz	7.5 MHz	15.5 MHz
				11.25 MHz	8.0 MHz	16.0 MHz
				11.75 MHz	8.5 MHz	16.5 MHz
				12.25 MHz	9.0 MHz	17.0 MHz
				12.75 MHz	9.5 MHz	17.5 MHz
			to	13.75 MHz	10.5 MHz	18.5 MHz
			20 MHz	14.25 MHz	11.0 MHz	19.0 MHz
				14.75 MHz	11.5 MHz	19.5 MHz
				15.25 MHz	12.0 MHz	20.0 MHz
				15.75 MHz	12.5 MHz	20.5 MHz
				16.25 MHz	13.0 MHz	21.0 MHz
				16.75 MHz	13.5 MHz	21.5 MHz



HRO-500 RECEIVER, DETAILED BLOCK DIAGRAM

FIGURE 19

When operating on Band 1, the BANDSWITCH connects the RF amplifier output to an up-conversion mixer whose output is a double-tuned bandpass circuit operating in the frequency range from 26 MHz to 27.5 MHz. When the BANDSWITCH is placed on band 2, the output of the RF amplifier is coupled to an up-conversion mixer whose output is connected to a double-tuned bandpass circuit operating between 27.5 MHz and 30 MHz. A 26 MHz crystal oscillator operates on Bands 1 and 2 and feeds a buffer amplifier, and in turn, each of the up-conversion mixers. A separate low-frequency input connection is provided to the up-conversion mixer used for Band 1 operation, by-passing the RF amplifier to allow low-frequency signals to be directly converted to the frequency range between 26 MHz and 26.5 MHz. The up-converters are discussed in paragraph 4.3.2.

When the BANDSWITCH is placed in positions 3, 4, or 5, the output of the RF amplifier is directly

A single-tuned circuit and rejection notch filter are employed between the first and second IF amplifiers. A double-tuned circuit provides selectivity between the second and third 230-kHz IF amplifiers and a single-tuned circuit is used in the output of the third 230-kHz IF amplifier. IF circuits are discussed in paragraph 4.3.7. The IF output is coupled to the AGC emitter follower, the AM detector (see paragraph 4.3.9), the product detector (see paragraph 4.3.10), and the S-meter amplifier. The FUNCTION switch connects the audio amplifier to either the AM detector or product detector as required. A separate crystal-controlled BFO provides oscillator injection to the product detector at 230 kHz. The audio driver feeds the push-pull audio output stages and, in turn, the loudspeaker or 600-ohm audio line. Paragraph 4.3.11 describes the audio amplifier.

The S-meter amplifier and driver directly feed the S-meter independently of AGC system action (see

The RF amplifier collector coils L-2, L-3, L-4, L-5, and L-6 serve as the collector load for the RF amplifier. They are tuned by the preselector tuning capacitor section C-4C together with suitable padding and trimming capacitors selected by the BAND-SWITCH section S1-3R. Low-impedance taps on these collector coils are also selected by the BAND-SWITCH to match and feed the following stages.

frequency information which may arrive from the synthesizer channel. The choke L-28 also represents a very low impedance in the emitter return path to the desired tunable IF signal between 3.25 MHz and 2.75 MHz. The collector of the first conversion mixer is coupled directly to a matching tap in the primary of transformer T-8, the input to the tunable IF amplifier.

4.3.2 THE UP-CONVERTERS

L-8 and capacitor C-64 are selected to provide a high-impedance emitter return to the oscillator injection signal occurring between 3.48 MHz and 2.98 MHz and a very low-impedance return in the emitter circuit to the mixer output frequency of 230 kHz.

The collector of the second conversion mixer is impedance matched to the double-tuned 8-kHz transformer T-10. A high impedance output is obtained from the secondary of T-10 through capacitor C-76 to the double-tuned 5-kHz transformers T-11 and T-12. The four tuned circuits contained in trans-

When the BANDWIDTH switch is placed in the 5 kHz position, the filter output is disconnected and output is obtained from the capacitive divider composed of C-81 and C-82 on the secondary of the 5-Kc bandwidth transformer T-12. When the BANDWIDTH switch is placed in the 8 kHz position, output is obtained from the resistive attenuator previously discussed on the secondary of the 8-kHz bandwidth transformer T-10.

Typical bandwidth and filter curves for all settings of the BANDWIDTH switch are illustrated in

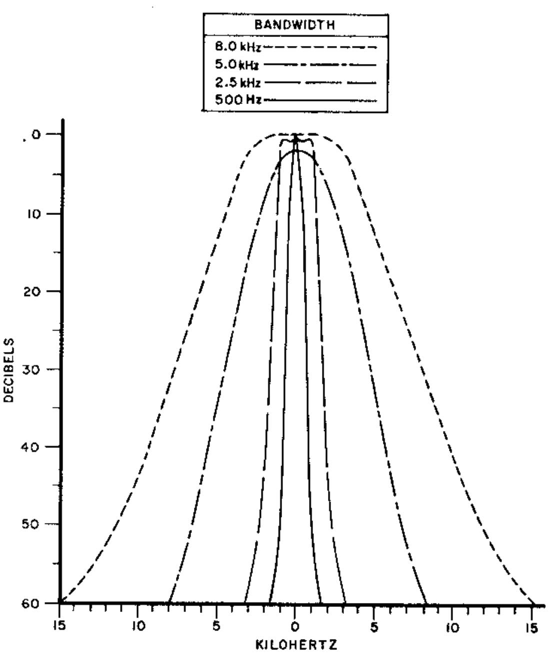
width of the HRO-500 receiver.

A low-impedance tap is also provided in the secondary of the 8-kHz transformer T-10. A 230-kHz IF signal is coupled from this low-impedance tap through the resistive attenuator made up of R-32 and R-33 to provide a basic 8-kHz bandwidth for the final 230-kHz IF amplifier. The output from the tap on the secondary of T-10 is also coupled directly to the base of the filter preamplifier Q-9 through coupling capacitor C-109.

4.3.6. THE 230-kHz FILTER AND FILTER PREAMPLIFIER

The filter preamplifier Q-9 operates at 230 kHz and provides gain to overcome the insertion loss of the 230-kHz tunable filter. The collector of the filter preamplifier is matched to the collector load L-17 which resonates with capacitor C-112 at 230 kHz. Output from the filter preamplifier is coupled through capacitor C-112 to the six-pole tunable IF filter.

The six-pole tunable IF filter uses six LC-tuned circuits. The inductors L-11, L-12, L-13, L-14, L-15, and L-16 are wound in ferrite cup-cores for extremely high Q and are carefully matched for precise control of filter tuning and bandwidth. The inductors in each case are resonated by the filter tuning capacitor sections C-89A through C-89F and by the additional trimming and padding capacitors associated with each coil. Coupling between the filter elements is accomplished by a series of capacitive taps such as that composed of C-90 and C-91 and similar



IF SELECTIVITY

FIGURE 20

4.3.7. THE 230-kHz IF AMPLIFIER

The selected 230-kHz output from the BANDWIDTH switch is coupled through capacitor C-137 to the base of the first 230-kHz IF amplifier Q-12. A single-tuned coil L-120 in the collector circuit serves

L-21. The 230-kHz IF signal is, in turn, coupled through capacitor C-147 to the base of the second 230-kHz IF amplifier Q-13. Capacitor C-146 serves as a terminating impedance for the bifilar notch circuit. The double-tuned transformer T-13 operating at 230 kHz serves the collector load of the second 230-kHz IF amplifier Q-13. The collector of the IF amplifier is impedance matched to the primary of T-13. A low-impedance tap on the secondary of T-13 provides impedance matching to the third 230-kHz IF amplifier Q-14.

The single-tuned coil L-23 serves as the collector load for the third 230-kHz IF amplifier. The collector is matched to L-23 by an inductive tap. An output is obtained through capacitor C-191 directly from the collector of the third 230-kHz IF amplifier and fed to the AGC emitter follower. An output from the top of the 230-kHz coil L-23 is also coupled to the AM detector and through capacitor C-161 to the product detector. An additional output is obtained directly from the collector of the third 230-kHz IF amplifier for the S-meter detector. A low-impedance tap on coil L-23 provides a 230-kHz IF output signal at jack J-11 on the rear apron of the HRO-500.

4.3.8 THE AGC CIRCUITS

The 230-kHz IF signal from the collector of the third 230-kHz IF amplifier Q-14 is coupled through capacitor C-191 to the base of the AGC emitter follower. The amplified signal appears across R-56 in the emitter circuit and is coupled through capacitor C-134 to the AGC voltage doubler composed of CR-7 and CR-8. The low-impedance feed from the emitter follower permits rapid charging of the AGC capacitor C-130 in a positive polarity with respect to the AGC return reference. This positive potential cannot discharge backwards through the AGC voltage doubling diode CR-8, and must discharge through resistor R-51. This results in effective fast-attack, slow-release AGC action. The AGC voltage doubler return path is connected to the RF GAIN control which operates in a voltage divider network between the +12 volt source and ground in such a manner that adjustment of the RF GAIN control

AGC information is applied to the base return of the first 230-kHz IF amplifier Q-12. A change in AGC or RF gain control information will cause a change of current in the first 230-kHz amplifier. This will develop a change in voltage across R-64 and R-66 in the first 230-kHz IF amplifier collector circuit. Increasing signal strength will result in positive-going AGC information relative to the RF gain reference level. This will move the first 230-kHz IF amplifier Q-12 towards cutoff and reduce its gain. The decreasing current will result in a positive-going change across the emitter resistor, R-62, which is coupled to the tunable IF amplifier Q-5, and the base of the second 230-kHz IF amplifier Q-13.

The same signal change will result in a negative-going voltage change across resistor R-64 in the collector of the first 230-kHz IF amplifier Q-12. This voltage is applied to the base of the RF amplifier Q-1 and will reduce the gain of the RF amplifier. The positive-going AGC potential for PNP transistors is referenced to approximately +8.5 volts and is connected to J-14, pin 10, on the rear apron of the HRO-500. The negative-going AGC potential for use with NPN transistors is referenced to approximately +1.5 volts and is available at J-14, pin 9, for use with external NPN transistors.

4.3.9 THE AM DETECTOR

A 230-kHz signal from L-23, the IF output coil, is coupled to CR-9, the AM detector. Capacitor C-157 provides RF by-passing and the AUDIO GAIN control R-98 serves as the detector load. AM detector output is directly available on J-14, pin 18, on the rear apron of the HRO-500.

4.3.10 THE PRODUCT DETECTOR AND BFO

The BFO transistor Q-15 functions as a crystal-controlled Pierce oscillator. L-24, together with capacitors C-167 and C-168, provide the collector load. Feedback is accomplished through the 230-kHz crystal, X-3, to the base of Q-15. A BFO output is obtained from the capacitive divider composed of C-167 and

The BFO is enabled through the FUNCTION switch S-4 in the single-sideband (SSB) and calibrate (CAL) positions by application of +7.5 volts. In the OFF, STBY, and AM positions, the BFO is disabled. The BFO enabling circuit is also connected to J-14, pin 14, on the rear apron to permit remote BFO enable-disable when desired.

4.3.11 THE AUDIO AMPLIFIER

The audio signal on the AUDIO GAIN control is coupled through capacitor C-174 to the base of the audio driver Q-22. An external audio input is provided on J-14, pin 17, to allow input from external audio sources or to permit the use of an external AUDIO GAIN control connected between the detector output J-14, pin 18, and the audio input.

The audio driver transformer T-16 serves as collector load for the audio driver stage. The secondary of this transformer is center-tapped to drive the push-pull audio output stage. The center-tapped audio output transformer T-17 matches the load to the audio output transistor pair Q-20 and Q-21. The secondary of the audio output transformer contains a 3.2-ohm winding and a balanced center-tapped 600-ohm winding which permits use of center-tapped ground, single-ended ground, or ungrounded 600-ohm line termination. In addition, the PHONES jack J-7 permits insertion of high- or low-impedance headphones across the 3.2-ohm speaker winding. All audio output connections are made on the audio terminal strip J-10.

4.3.12 THE S-METER CIRCUITS

230-kHz output is obtained directly from the collector of the third 230-kHz IF amplifier Q-14 through trimmer C-156, the S-meter calibration adjustment. This signal is applied directly to the base of the S-meter detector Q-24. The S-METER ZERO adjustment, R-108, is connected in the S-meter detector base return to vary the bias on this circuit. Adjustment of the S-METER ZERO potentiometer will alter DC current flow in the S-meter detector and provide for zero set. The 230-kHz IF signal is rectified in the base-to-emitter junction of the S-meter detector transistor Q-24 and results in a DC output signal at the junction of C-172 and R-109. The S-meter information is then coupled through R-109 and R-110 to the base of the S-meter amplifier Q-23. Resistors R-113, R-114, R-115 and transistor Q-23 form a bridge circuit with the S-meter connected across the arms. This bridge circuit is essentially balanced when the S-meter is at zero. Incoming signals will unbalance the bridge through transistor Q-23 and cause proper S-meter indication. The S-meter is calibrated in db above 1 microvolt input and in S units from S-1 to S-9.

4.3.13 THE CRYSTAL CALIBRATOR

Transistor Q-10 is used as separate 50-kHz crystal calibrator. The calibrator circuit functions in a modified Pierce configuration. Inductor L-18 and capacitor C-126 form the collector load for the calibrator transistor Q-10. Feedback is obtained through the 50-kHz crystal X-2 to the transistor base. Trimming capacitor C-125 permits accurate adjustment of the 50-kHz calibrator frequency.

4.4 THE SYNTHESIZER: DETAILED DESCRIPTION

Examination of the detailed block diagram, figure 19, will help in understanding the detailed synthesizer discussion to follow. Basically, a 500-kHz crystal-controlled reference oscillator is coupled to a blocking oscillator for pulse shaping. The output pulse is used to key the burst generator, providing the necessary coherent output burst. These stages are referred to as the spectrum generator as discussed in paragraph 4.4.1.

The high-frequency oscillator has two buffer stages: the first, an untuned buffer inserted between it and the first conversion mixer of the receiver proper; and the second, a tuned buffer provided between the high-frequency oscillator and the mixer preceding the comparison IF circuits as discussed in paragraph 4.4.5.

The mixer at the input to the 4.75 MHz comparison IF receives signals from the high-frequency oscillator by way of the tuned buffer and directly from the spectrum generator. The mixer output at 4.75 MHz is amplified through two IF amplifier stages and fed as a balanced signal to the phase detector. The mixer and two IF stages are considered in paragraph 4.4.2.

The separate 4.75 MHz oscillator which feeds the phase detector is considered as part of the phase detector circuit in paragraph 4.4.3.

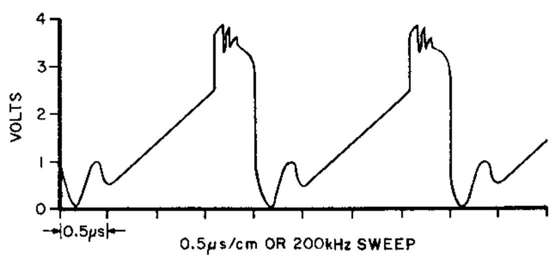
Output from the phase detector is fed to the DC amplifier. The amplified output is applied to the varactor for control of the high-frequency oscillator as discussed in paragraph 4.4.4.

The sweep circuit functions as part of the DC amplifier circuit, but will be considered separately in paragraph 4.4.6.

Finally, the output from the sweep circuit is connected to the sweep detector through an emitter follower. The output of the sweep detector is used to trigger a bi-stable trigger circuit and to operate the PHASE LOCK indicator on the front panel. An output is also derived from this bi-stable trigger circuit to supply information to the muting amplifier which controls the gain of the last 230-kHz IF amplifier in the receiver proper, as discussed in paragraph 4.4.7.

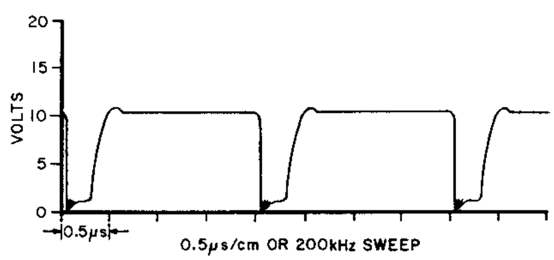
500-KC SYNCHRONIZING PULSE WAVEFORM

FIGURE 21



BLOCKING OSCILLATOR, BASE WAVEFORM

FIGURE 22



BLOCKING OSCILLATOR, COLLECTOR WAVEFORM

FIGURE 23

4.4.1 THE SPECTRUM GENERATOR

The crystal-controlled 500-kHz reference oscillator is a conventional Pierce circuit. L-301 functions as the collector load. Feedback is obtained through the 500-kHz crystal, X-300, to the base of the transistor Q-300. This oscillator has been designed to be well overdriven so that collector current flows during a small percentage of the 500-kHz repetition rate. The resistor R-305 in the collector return path is used to develop a short positive pulse coincident with periods of collector current conduction. The waveform is illustrated in figure 21.

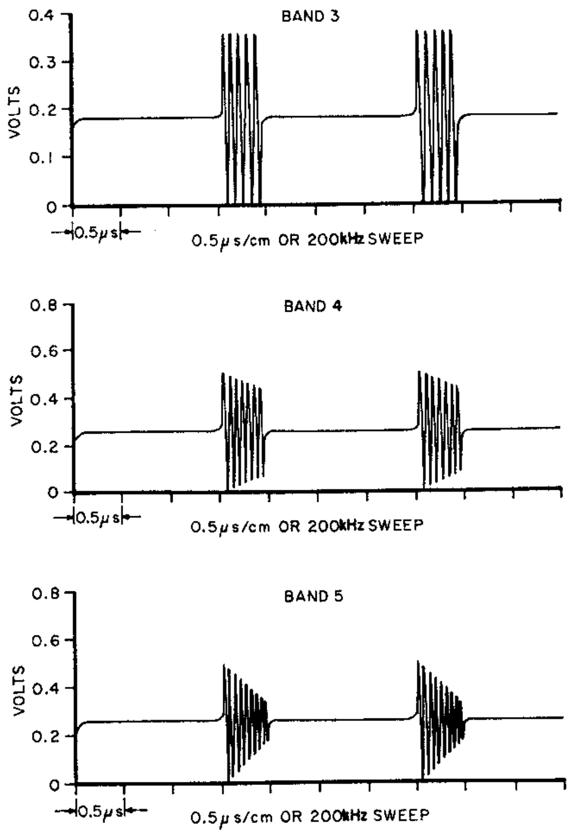
Q-301 is a blocking oscillator adjusted to free-run at a frequency just below 500 kHz. The pulse from the 500-kHz crystal oscillator is coupled to the blocking oscillator base circuit through the blocking oscillator transformer T-300. This pulse synchronizes the blocking oscillator frequency to the frequency of the crystal-controlled oscillator. Capacitor C-300 and resistor R-306 determine the basic blocking oscillator repetition rate. The blocking oscillator base waveform is illustrated in figure 22. Limiting diodes are used on the primary and secondary of the blocking oscillator transformer to prevent inductively induced voltage transients which might harm the blocking oscillator transistor. A large amplitude negative pulse illustrated in figure 23 is available from the collector winding of the blocking oscillator transformer.

The negative pulse is coupled to the base of the burst generator transistor Q-302 through capacitor C-401. The collector of the burst generator is connected to a high Q tuned circuit. The burst generator is biased to that high-collector current flows at all times, except when a pulse is present. When current flows the collector impedance is very low. This impedance combined with a resistor R-310 in the collector path places heavy damping on the tuned circuit. When the blocking oscillator pulse arrives at the base of the burst transistor, the system is driven to cutoff, collector current flow ceases, and damping is removed from the tuned circuits. The stored magnetic energy in the tuned circuit will cause a high-amplitude oscillation which is interrupted at the 500-kHz reference frequency. The coils L-305, L-306, and L-307 in association with padding and trimming capacitors, a tuning capacitor section C-373 and a bandswitch section S-301-IF, provide bandswitching and tracking of the burst generator free-running frequency to the frequency of desired harmonic output. The spectrum generator output waveform is illustrated in figure 24 for three bands.

The blocking oscillator coil and circuit are constructed so that the output pulse width has approximately a 15.8 percent duty cycle. This duty cycle causes a harmonic output from the spectrum generator which is essentially zero at all frequencies which are nineteen harmonics removed from the desired harmonic frequency. Harmonics occur every 500 kHz, therefore, the harmonic which is removed from the desired harmonic by 9.5 MHz is eliminated. This frequency corresponds to the image frequency of the 4.75-MHz IF operating in conjunction with the high-frequency oscillator. Thus, the system is relatively free of images and no additional selectivity or harmonic filtering is needed prior to use of the burst generator signal in the comparison mixer.

4.4.2 THE COMPARISON IF CIRCUITS

Coupling capacitors C-311 through C-315 are used to insure substantially constant amplitude from the burst oscillator to the comparison mixer Q-306. The output of the spectrum generator and a signal from the high-frequency oscillator are coupled to-



SPECTRUM GENERATOR OUTPUT
MEASURED AT JUNCTION OF C345 AND C346

SPECTRUM GENERATOR, OUTPUT WAVEFORM

FIGURE 24

gether at the base of Q-306, which functions as a conventional transistor mixer. The double-tuned transformer T-301 in the collector circuit of the comparison mixer provides selectivity and gain. A neutralizing section of the primary winding provides transistor neutralization through capacitor C-351. A secondary tap on the transformer matches the base impedance of Q-307, the first 4.75-MHz amplifier,

Neutralization is provided through capacitor C-360. The secondary of T-303 is a balanced center-tapped winding providing two 4.75-MHz outputs with a 180° phase difference for the phase detector.

4.4.3 THE PHASE DETECTOR

The diodes CR-301A and CR-301B (a matched pair) are fed with the balanced output from T-303. This output is approximately 4 volts peak-to-peak in amplitude. An independent 4.75-MHz signal is derived from the 4.75-MHz oscillator Q-309. The crystal X-301 operating at 4.75 MHz serves as a collector load for transistor Q-309. The oscillator is operated in a grounded-base configuration with feedback from collector-to-emitter through capacitors C-363 and C-364. A 4-volt oscillator signal is applied in parallel to the phase detector diodes through capacitors C-368 and C-369. This gating signal in conjunction with the signals from the comparison IF will cause one of the diodes to conduct more heavily than the other, resulting in either a positive or a negative output at the junction of R-343 and R-344. Actually, the DC amplifier is so constructed that negative signals will take it beyond cutoff. Therefore, phase lock will always be obtained with a positive output sense from the phase detector. In normal operation, phase lock control will normally be obtained for phase detector voltages between +0.3 and +0.8 volts.

4.4.4 DC AMPLIFIER AND VARACTOR CONTROL

The positive DC output from the phase detector is filtered by the low-pass section made up of L-322 and C-371. In addition, resistor R-342 and capicitor C-370 adjust the gain-frequency characteristic to insure phase-lock stability. The output of the phase detector is coupled directly to the base of Q-310, the DC amplifier. Resistor R-345 in the collector circuit serves as the collector load. The amplified signal occurring at the collector of the DC amplifier will normally fall in the range between +3 and +8 volts when the synthesizer is properly op-

A DC clamping voltage is provided by resistor R-350 and R-351 and is applied to the DC amplifier output bus through clamping diode CR-300. When the DC amplifier output is below +3 volts, the diode will be forward-biased and will prevent further operation of the DC amplifier. This prevents control of the varactor in very low voltage regions to prevent excessive frequency control and improper synthesizer unlocking when tuning from one 500-kHz segment to another.

4.4.5 THE HIGH-FREQUENCY OSCILLATOR

The high-frequency oscillator is operated in a grounded-base mode with a tuned circuit functioning as the collector load. Feedback is obtained through capacitors C-335 and C-337. The inductors L-308, L-309, and L-310 are bandswitched and padded to insure proper frequency range and synthesizer dial calibration. The synthesizer tuning capacitor C-332A is controlled by the SYNTHESIZER TUNE control. The inductor L-308 is used commonly between Bands 1, 2, and 5. Additional padding adjustments C-328 and C-329 provide for range set on Bands 1 and 2.

An output from the emitter is coupled through C-336 to the base of Q-304, the tuned buffer amplifier. The coils L-315, L-316, and L-317 serve as collector loads for the buffer and are tuned by the syn-

trol circuit to insure stable phase loop operation. In the event that there is no IF output, there will be no output from the phase detector and the DC amplifier Q-310 will be cut off. Under these conditions, capacitor C-374 will charge towards the 10-volt supply potential through resistors R-345, R-346, and R-349, causing a ramp or sawtooth voltage to exist on the varactor control lead. During this time, the emitter of Q-311 has a very high impedance and does not affect the external circuit. When the firing potential of the unijunction transistor Q-311 is reached, the emitter-to-base 1 characteristic will rapidly become a very low impedance causing capacitor C-374 to be rapidly discharged to chassis. As the potential on capacitor C-374 approaches zero, there will no longer be sufficient energy to maintain the discharge condition of the unijunction transistor and the emitter-to-base 1 characteristic will rapidly revert to a high impedance. Capacitor C-374 will again charge towards the supply potential and a repetitive sawtooth will be created. This sawtooth will swing the varactor through a considerable capacity range and cause a wide and rapid frequency scanning of the high-frequency oscillator until such time as a 4.75-MHz IF signal results. At this time, a DC output will be obtained from the phase detector. Collector current will flow in the DC amplifier, causing a voltage drop in R-345 such that capacitor C-374 can no longer charge to the breakdown potential of the unijunction transistor. At this time, phase lock control has been resumed and the saw-

The negative signal available at the collector of Q-18 is also coupled through R-87 to the base of Q-16, the muting diode. This negative signal will cause the muting diode, Q-16, to conduct heavily, resulting in a potential of less than +11 volts on the emitter of Q-14, which will cut off the third 230-kHz IF amplifier of the receiver.

resistor R-82 to the bi-stable trigger circuit. Application of a positive voltage, such as +12 volts available from the power supply output, will cause the receiver to mute and the PHASE LOCK warming lamp to be illuminated. An additional input is provided from J-14, pin 12, directly to the base of the muting diode and collector of the bi-stable trigger Q-18. Grounding this input lead at J-14 will also result in muting of the receiver and illumination of the PHASE LOCK indicator lamp.

4.5 THE POWER SUPPLY: BASIC DESCRIPTION

A block diagram of the power supply is included as part of figure 19. The 117 volt, 50-60 hertz AC supply is fed to the power transformer. The secondary is connected to the power supply rectifiers and, in turn, to a series electronic regulator. The output of this regulator is approximately 12 volts positive DC. A transfer switch provides for connection of the power supply filters and zener diodes to the output of the electronic regulator when the HRO-500 is operated on the 117V AC line or directly to the 11-16V DC input when the HRO-500 is operated from a DC source. The +12-volt output is additionally filtered with taps provided for +11 and +10 volts in the filter circuits. The +10 volts is applied to a zener diode which provides a +7.5 volt regulated output. The 7.5 volt regulated output is

A balanced secondary winding on the power transformer T-18 is coupled to the rectifiers CR-11 and CR-12. This winding is designed to develop a 24-volt DC output after rectification. The ground return of the power supply circuit is arranged through the regulator transistor, Q-25, in such a way that +12 volts is developed at the output of the power supply rectifiers and −12 volts is developed at the

connected from the +12-volt power supply output to the base of the regulator transistor serves as a voltage reference and transfers any power supply output fluctuation directly to the base of the regulator transistor, thereby varying the impedance between the collector and grounded emitter of the regulator transistor, Q-25, in such a manner that any variation in power supply output is effectively cancelled by a variation in the resistance of the power supply center-tap return. All variations due to fluctuating load or line voltages will occur in the negative leg of the power supply and there will be no change in the +12-volt output. A third pole on the 117V AC/12V DC transfer switch is used to select the output of the 117V AC supply or to directly select the 11-16V DC input. A reverse polarity protection diode, CR-14, is wired directly in series with the 11-16V DC input to prevent damage to the HRO-500 in the event of reverse-polarity application.

The +12-volt output is directly used in some stages. Additional filtering is obtained through resistor R-119 and capacitor C-135C. The voltage drop occurring in R-119 provides a +11-volt output from the power supply. This output is again filtered by resistor R-118 and capacitor C-135B to provide a +10-volt output from the power supply. The 10-volt supply is then dropped through resistor R-117 to the zener diode CR-10 to provide a highly regulated

	+24 VOLTS		
Q-25	Power Supply Regulator		

	RECEIVER		SYNTHESIZER
	+12 VOLTS		
Q-1	RF amplifier	Q-302	Burst generator
Q-14	Third 230 kHz IF amplifier	Q-16	Muting circuit

	+11 VOLTS		
Q-4	26 MHz buffer	Q-306	4.75 MHz mixer
Q-3	First conversion mixer	Q-307	First 4.75 MHz IF amplifier
Q-22	Audio driver	Q-308	Second 4.75 MHz IF amplifier
Q-24	S-meter detector	Q-19	Indicator emitter follower
Q-11	AGC emitter follower	Q-310	DC amplifier
Q-23	S-meter bridge amplifier		

SECTION 5

HRO-500 TEST AND ALIGNMENT

5.1 GENERAL:

HRO-500 TEST AND ALIGNMENT PROCEDURES SHOULD BE PERFORMED ONLY BY QUALIFIED PERSONNEL.

Any one of the laboratory adjustment or test procedures may be performed individually, provided that the proper test setup and preliminary adjustments are made. All warnings, cautions, and notes applicable to a particular procedure should be strictly heeded. If an abnormal indication is obtained during the performance of these procedures, troubleshooting and repair of the circuit under test is indicated. For general troubleshooting procedures, refer to paragraph 5.6. To assure satisfactory receiver performance after repairs have been made, repeat the alignment or test procedure applicable to the circuit in which the repair was made.

5.2 EQUIPMENT REQUIRED:

Vacuum tube voltmeter (VTVM) or AC/DC volt-ohm-milliammeter (VOM) with sensitivity of 20,000 ohms per volt or better

Signal generator covering the range from 50 kHz to 50 MHz with properly terminated and calibrated output

Frequency counter, crystal calibrator, or other means of accurate signal generator frequency calibration

High-frequency oscilloscope covering the range from DC to 30 MHz with a sensitivity of 50 mv

Standard audio output meter

Audio oscillator covering the range from 10 hertz to 100 kHz

Suitable alignment tools for adjustment of coils and capacitors

HRO-500TS matching speaker

5.3 INITIAL CONTROL SETTINGS:

FRONT PANEL

FUNCTION switch	OFF
BANDSWITCH	4.0-10 MHz
RF GAIN	Full cw (clockwise)
AUDIO GAIN	Full ccw (counterclockwise)
SYNTHESIZER TUNE	9.5 MHz
PRESELECTOR TUNE	10.0 MHz
MAIN TUNING	500 kHz
REJECTION TUNE	OFF
PASSBAND TUNE	Narrow white rectangle centered at zero
AGC THRESHOLD	OFF
DIAL lamp switch	To right: ON
BANDWIDTH switch	8 kHz

REAR PANEL

NOTCH DEPTH	As received, or set to mid-range

5.4 POWER SUPPLY VOLTAGE TEST:

Check that all HRO-500 controls are set to the positions indicated in paragraph 5.3. Apply 117V AC, 50-60 hertz power to the rear panel 117V AC connector J-8. Set the front panel FUNCTION switch to the CAL position. Using either the VTVM or VOM, measure the power supply voltages at the accessory connector J-14 on the rear panel. The power supply output voltages should be as shown in the table below.

J-14 POWER SUPPLY OUTPUT VOLTAGES
Chassis or Pin 3 Ground Reference

Pin No.	Volts, DC	Tolerance
4	+12 V	±10%
5	+11 V	±10%
6	+10 V	±10%
7	+7.5 V	±10%
8	+5 V	±10%
9	+1.5 V	±½ V
10	+8.5 V	±10%

5.5 ALIGNMENT:

5.5.1 AUDIO TESTS

Check that all HRO-500 controls are set to the positions indicated in paragraph 5.3. Connect the audio output meter to the receiver audio output through either the front panel PHONES jack J-7 or to the rear panel 3.2-ohm and GND terminals of J-10. Connect the speaker leads and the oscilloscope input leads across the audio output meter terminals. Set the audio output meter impedance to 3.2 ohms and the power multiplier to 5 watts full scale. Turn the FUNCTION switch from OFF to either SSB, AM, or CAL. Apply a 0.06-volt, 400-hertz signal from the audio oscillator output leads between pin 18 of J-14 (detector output) and ground. Turn up the AUDIO GAIN control and listen to be sure that there is audio output.

Disconnect the speaker and rotate the AUDIO GAIN control slowly cw until the audio output meter indicates 2 watts. The oscilloscope display should show no distortion at the 2-watt output level. Advance the audio oscillator output level for a maximum indication on the audio output meter. The meter should indicate more than 3 watts of power output. The oscilloscope display will show definite clipping.

Decrease the audio oscillator output level until the audio output meter indicates 2 watts. Rotate the AUDIO GAIN control slowly ccw until the audio ouput meter indicates approximately 10 mw. Connect the speaker across the audio output meter terminals and listen to the 400-hertz tone. There should be no evidence of distortion.

Frequency response may be checked by observing the audio output meter as the audio oscillator frequency is varied. To maintain a constant input to the audio amplifier while checking the frequency response, the audio oscillator output should be monitored with the AC scale of the VTVM or VOM. The frequencies at which the audio output meter indications have dropped by 6-db should not be lower than 5.5 kHz and not higher than 100 hertz.

After completing the audio tests, remove all test equipment leads connected to the HRO-500 receiver.

5.5.2 PRELIMINARY S-METER ADJUSTMENT

With the FUNCTION switch in the AM position, the S-meter should indicate 0 on the S-UNITS scale. If it does not, adjust the rear panel S-METER ZERO control R-108 until the S-meter reads 0 S-units.

5.5.3 BFO AND PRODUCT DETECTOR ALIGNMENT

Check that all HRO-500 controls are set to the positions indicated in paragraph 5.3. Remove the muting transistor, Q-16, and turn the FUNCTION switch to the SSB position. Connect the signal generator through a 0.01-µf capacitor to the base of the third IF transistor Q-14. Set the signal generator frequency to exactly 230 kHz by comparison to the frequency counter or other calibrating means, and set the output to approximately 0.1 volt without modulation. Connect the HRO-500TS speaker to the 3.2-ohm and GND terminals of J-10.

Advance the AUDIO GAIN control in a cw direction until a beat note is heard. Connect the oscilloscope input leads to the BFO output jack, J-6, to monitor the BFO output level. Adjust the tuning core of L-24 for zero beat. As L-24 is adjusted, the BFO output as displayed on the oscilloscope should not be less than 70 per cent of the maximum level obtainable.

Connect the audio output meter to the receiver audio output through either the front panel PHONES jack J-7 or the 3.2-ohm and GND terminals on the rear panel terminal strip J-10. Tune the signal generator until a beat note of approximately 400 hertz is obtained at the audio output terminals. Peak the product detector transformer, T-14, by adjusting the tuning core for maximum audio output. Note the maximum output meter indication.

After completing the BFO and product detector alignment procedure, remove all test equipment leads connected to the HRO-500 receiver and insert the muting transistor, Q-16, into its socket.

— CAUTION —

TO PREVENT OVERLOADING AND IMPROPER TUNING IN THE IF SYSTEM, THE SIGNAL GENERATOR OUTPUT SHOULD BE REDUCED AS REQUIRED TO MAINTAIN MID-SCALE S-METER INDICATIONS DURING ALIGNMENT. MAKE SURE THAT THE TUNING CORES IN ALL TWO-WINDING TRANSFORMERS ARE SET TO THE OUTSIDE END OF THE WINDINGS. TUNING CORES WHICH ARE IMPROPERLY SET BETWEEN WIND-

5.5.7 5-kHz FILTER ADJUSTMENT

Turn the PASSBAND TUNE control knob fully ccw. The center of the narrow white band

Turn the PASSBAND TUNE control fully ccw (lowest frequency). Readjust the signal generator dial for maximum response and peak the six trimmer capacitors carefully, noting whether each trimmer capacitor requires more or less capacity. If less trimmer capacity is rquired to obtain a peak or maximum S-meter indication, the tuning range for that particular trimmer capacitor and coil combination is too broad. Conversely, if more trimmer capacity is required to obtain a peak, the tuning range is too narrow.

Return each capacitor which was not properly peaked to its original setting and continue turning it considerably beyond that point to a new trial position. Then repeak the associated coil only by adjusting its tuning core for maximum output or S-meter indication. Repeat this procedure for each trimmer capacitor.

When new trial settings have been made on all the trimmers and inductors which were not peaked properly, return the PASSBAND TUNE control to its full cw (highest frequency) position and repeat the tracking procedure. Only a few trial settings of the trimmer capacitors and inductors should be necessary to attain satisfactory filter tracking. This condition is achieved when none of the six trimmer capacitors needs to be adjusted after checking the peaks with the PASSBAND TUNE control in the full ccw (lowest frequency) position.

5.5.8.2 2.5-kHz FILTER ADJUSTMENT AND TEST

return the BANDWIDTH switch to the 2.5 kHz position. Observe the filter response as the PASSBAND TUNE control is rotated slowly from its full cw (highest frequency) position towards the mid-range point and onward to its full ccw (lowest frequency) position. The trace should resemble figure 29, which is a composite of several sweeps.

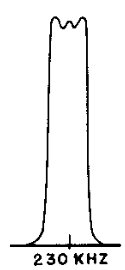


FIG. 26

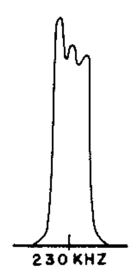


FIG. 27

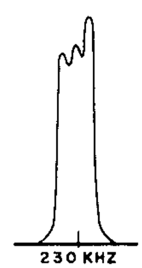
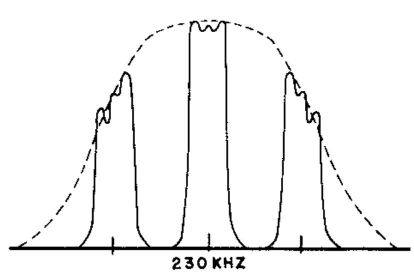


FIG. 28



COMPOSITE FILTER CURVES

5.5.9 TUNABLE IF AND PRELIMINARY VFO ALIGNMENT

Check that all HRO-500 controls are set to the positions indicated in paragraph 5.3. Remove the muting transistor, Q-16. Connect the signal generator to the base of the first mixer transistor, Q-3, through a 0.01-μf capacitor. Connect the HRO-500TS speaker and audio output meter to the 3.2-ohm and GND terminals of J-10. Turn the FUNCTION switch to the AM position and the BANDWIDTH switch to the 5.0 kHz position.

Turn the MAIN TUNING control until the dial indicates 500. Observe the capacitor rotor plates. They should be approximately 8° from their fully meshed position. To check the 8°, clamp the DIAL LOCK by rotating 90° cw. Then turn the MAIN TUNING dial to 475. Lock the DIAL LOCK. Rotate the MAIN TUNING dial back to 500. Unlock the DIAL LOCK.

Set the signal generator for 400 hertz, 30 per cent AM modulation. Align the VFO and tunable IF section of the receiver according to the directions given in figure 30.

Repeat Steps 1 through 4 as required to achieve proper alignment of each adjustment at both band ends. After completing the VFO and tunable IF alignment, remove the test equipment connections to the HRO-500 and replace the muting transistor, Q-16.

5.5.10 SYNTHESIZER 4.75-MHz COMPARISON

Turn the FUNCTION switch to the SSB or AM position. Tune the signal generator to exactly 4.75 MHz without modulation by comparison to the frequency counter or other calibrating means. Remove the 4.75-MHz crystal X-301. Connect either the VTVM or oscilloscope to the junction of CR-301A, C-368, and R-343.

Advance the signal generator output control until the output is visibly displayed on the oscilloscope or VTVM. Be careful not to saturate the synthesizer IF amplifier. Then adjust the top and bottom tuning cores of transformers T-303, T-302, and T-301 for maximum output in the order given.

Advance the signal generator output control until the output indication reaches a maximum level which indicates saturation of the IF output stage. This saturation output level should be greater than 3 volts P-P or 1.5 volts DC when the signal generator output is set for less than 30,000 microvolts

ternal 5-volt bias circuit which is shown in figure 31 to the junction of R-346, R-349, CR-300, and L-311. Connect the signal generator through a 10 pf capacitor to the junction of C-345 and C-346 at the synthesizer IF input. Connect the VTVM or oscilloscope to the junction of CR-301A, C-368, and R-343. Set the unmodulated signal generator output for approximately 100,000 microvolts.

Align the synthesizer high-frequency oscillator and the tuned buffer amplifier according to the chart in figure 32. In each step, the signal generator frequency should be accurately set by comparison to the frequency counter or other calibrating means.

— CAUTION —

STEPS 1 AND 2 AND ALL CHECKS ON BAND 5 MUST BE COMPLETED. BEFORE STEPS 3 AND 4, 5 AND 6 ARE ATTEMPTED. THIS IS NECESSARY BECAUSE THE BAND 5

After completing the synthesizer IF alignment, remove the signal generator and oscilloscope connections to the HRO-500 receiver. Replace the synthesizer IF cover, the 4.75-MHz crystal X-301, and transistors Q-302 and Q304.

5.5.10.1 SYNTHESIZER IF ALIGNMENT (ALTERNATE PROCEDURE)

... it may be assumed that the

COIL IS ALSO USED ON BANDS 1 AND 2. ADJUSTMENT OF L-308 WILL HAVE A MAJOR EFFECT ON BANDS 1 AND 2, AS WELL AS ON BAND 5.

Repeat each pair of steps as required to insure proper alignment at each end of the band in use.

If difficulty is encountered during the synthesizer high-frequency oscillator alignment, the alternate

Step	Bandswitch	Synthesizer Tune	High-Frequency Oscillator	Signal Generator	Adjust	Indications and Remarks
1	Band 5 20 MHz-30 MHz	20 MHz	23.25 MHz	28.0 MHz	L-308 bottom	Adjust to place 28.0 MHz in IF passband as indicated by maximum output.
					L-315 bottom	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.
2	Band 5 20 MHz-30 MHz	29.5 MHz	32.75 MHz	37.5 MHz	C-323	Adjust to place 37.5-MHz in IF passband as indicated by maximum output.
					C-375	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.
3	Band 1 0-1.5 MHz	1.0 MHz	30.25 MHz	35.0 MHz	C-327	Adjust to place 35.0 MHz in IF passband as indicated by maximum output.
					C-382	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.
4	Band 1 0-1.5 MHz	0.0 MHz	29.25 MHz	34.0 MHz	C-328	Adjust to place 34.0 MHz in IF passband as indicated by maximum output.
5	Band 2 1.5-4.0 MHz	3.5 MHz	32.75 MHz	37.5 MHz	C-326	Adjust to place 37.5 MHz in IF passband as indicated by maximum output.
					C-380	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.
6	Band 2 1.5-4.0 MHz	1.5 MHz	30.75 MHz	35.5 MHz	C-329	Adjust to place 35.5 MHz in IF passband as indicated by maximum output.
7	Band 4 10 MHz-20 MHz	10 MHz	13.25 MHz	18 MHz	L-309	Adjust to place 18 MHz in IF passband as indicated by maximum output.
					L-316	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.
8	Band 4 10 MHz-20 MHz	19.5 MHz	22.75 MHz	27.5 MHz	C-324	Adjust to place 27.5 MHz in IF passband as indicated by maximum output.
					C-377	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.
9	Band 3 4.0-10 MHz	4 MHz	7.25 MHz	12 MHz	L-310	Adjust to place 12 MHz in IF passband as indicated by maximum output.
					L-317	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.
10	Band 3 4.0-10 MHz	9.5 MHz	2.75 MHz	17.5 MHz	C-325	Adjust to place 17.5 MHz in IF passband as indicated by maximum output.
					C-379	Adjust for maximum output. Reduce signal generator output as required to avoid IF saturation.

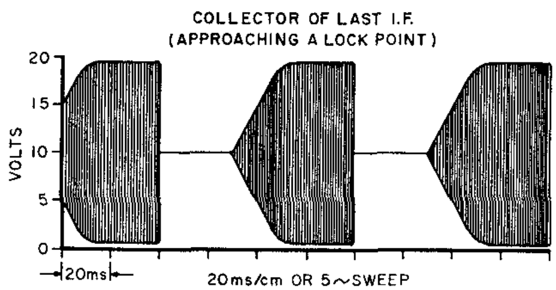
SYNTHESIZER AND TUNED BUFFER ALIGNMENT

FIGURE 32

A calibrated general coverage receiver or other detector (such as a grid dip oscillator) covering 7-33 MHz should be lightly coupled to the collector of the tuned buffer transistor, Q-304. Use less than 2 pf of coupling capacity to minimize loading effects. Proceed according to the instructions in figure 32. In each step, tune the detector to the high-frequency oscillator frequency. Then adjust as indicated to place the high-frequency oscillator signal in the external detector passband. Adjust the buffer alignment for maximum amplitude as indicated on the external detector. Disconnect all test equipment and replace synthesizer IF cover, crystal X-301, and transistors Q-301, Q-302, and Q-311.

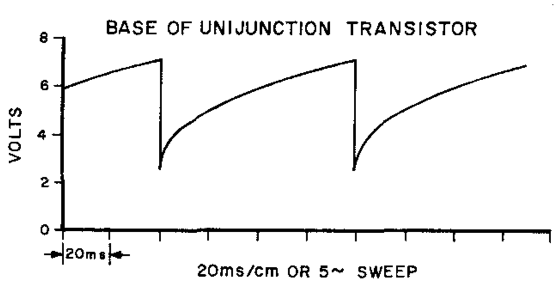
5.5.12 SYNTHESIZER LOCK CHECKS

Set the FUNCTION switch to the SSB or AM position. Set the BANDSWITCH and SYNTHESIZER TUNE control to the conditions given in Step 1 of figure 32. When these conditions are set up, the synthesizer should lock, as evidenced by the extinguishing of the PHASE LOCK indicator lamp. If the synthesizer does not lock, turn the SYNTHESIZER TUNE control to either side about the indicated dial setting. If the synthesizer still does not lock, refer to the synthesizer spectrum generator test in paragraph 5.5.13 and trouble shoot as required. The waveforms of figures 33 and 34 illustrate typical sweep conditions at the synthesizer 4.75-MHz comparison IF output.



SWEEP WAVEFORM AT COLLECTOR OF LAST IF

FIGURE 33



SWEEP WAVEFORM AT BASE OF UNIJUNCTION TRANSISTOR

FIGURE 34

When the synthesizer can be made to lock under the conditions given in Step 1 of the table, check the position of the number in the SYNTHESIZER TUNE dial window as the SYNTHESIZER TUNE control is turned to its unlocked conditions on either side of the proper locked position. Some readjustment of the high-frequency oscillator coil and trimmers may be required to properly center the number in the SYNTHESIZER TUNE window. Be sure to check that the proper HF oscillator frequency has been obtained by checking the frequency of the signal at the high-frequency oscillator frequency given in figure 32. This check may be made by following the instructions of paragraph 5.5.11.1.

Check for locked conditions at the detector frequency given in Step 2 of figure 32. Then check for locked conditions at all synthesizer frequencies between the frequencies given in Steps 1 and 2 by turning the SYNTHESIZER TUNE control to each number in succession. The PHASE LOCK indicator lamp should flash between each lock point and remain extinguished as each number is properly positioned in the SYNTHESIZER TUNE dial window.

Repeat the lock checks as given above for Steps 3 and 4, 5 and 6, 7 and 8, 9 and 10. When each band is set at both ends, check for a locked condition at each frequency within the band. When all lock checks are satisfactory, the synthesizer alignment is complete.

5.5.13 SYNTHESIZER SPECTRUM GENERATOR TEST

The synthesizer spectrum generator section has been carefully aligned and tested at the factory and normally needs no alignment. To insure that the spectrum generator is functioning properly, observe the waveforms by setting the FUNCTION switch to AM or SSB, removing the spectrum generator cover, and connecting the oscilloscope input leads to the test points specified for each waveform shown in figures 21, 22, 23, and 24.

If suitable lock points are not obtained as discussed in paragraph 5.5.12, the free-running frequency of the burst generator should be checked. This may be done by several methods. A general coverage receiver or spectrum analyzer may be coupled lightly to the coaxial output lead from the spectrum generator bandswitch section S301-1R. A signal will be heard at every 500-kHz point on the external receiver or analyzer. The signal of greatest amplitude should occur at or near the required spectrum generator frequency, depending on the setting of the BANDSWITCH and SYNTHESIZER TUNE control. See figure 32 for proper spectrum generator frequencies.

A different check may be made without external equipment by choosing a SYNTHESIZER TUNE frequency near the center of the BANDSWITCH range in use. Loosen the setscrews on the pulley of the spectrum generator tuning capacitor, C-373. Slowly rotate the spectrum generator tuning capacitor in either direction from the point at which it was set and observe whether a lock is obtained. If the synthesizer is already locked, the synthesizer should fall out of lock as the capacitor is rotated to either side of the set point. This check may be repeated at all band centers and band ends to check spectrum generator tracking.

This check may be made with greater accuracy by removing the synthesizer IF cover according to the directions in paragraph 5.5.10. Connect the VTVM or oscilloscope to the junction of CR-301A, C-368, and R-343. Note the IF output amplitude indicated by the VTVM or oscilloscope before loosening the setscrews on the pulley of the spectrum generator tuning capacitor. Then rotate the capacitor in either direction from the point at which it was set. Maximum synthesizer IF output should be obtained at or near the set point.

Rotate the SYNTHESIZER TUNE control to its full ccw travel. Observe that the synthesizer tuning capacitor, C-332, is fully meshed. Fully mesh the spectrum generator tuning capacitor, C-373, and tighten all setscrews. Remove the test equipment and replace all covers.

5.5.14 26-MHz OSCILLATOR CHECK

Check that all HRO-500 controls are set to the positions indicated in paragraph 5.3. Turn the FUNCTION switch to the SSB or AM position and the BANDSWITCH to the 0-1.5 MHz position (Band 1). Connect the oscilloscope to the 26-MHz buffer output at the junction of L-7, C-31, C-32, and C-44. Adjust the tuning core of the 26-MHz oscillator coil L-19 for maximum output. Turn the FUNCTION switch to OFF, then back to the AM position. Check for reliable starting of the oscillator. Finally, adjust C-44 for maximum output from the buffer.

5.5.15 UP-CONVERTER PASSBAND ALIGNMENT

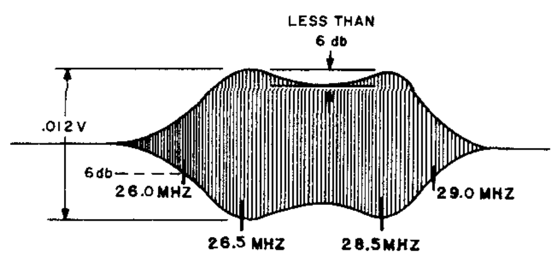
Set all HRO-500 controls to the positions indicated in paragraph 5.3. Set the FUNCTION switch

between 26 MHz and 30 MHz and the output to 100,000 microvolts without modulation.

Connect the sweep signal from the sweep generator to the oscilloscope horizontal amplifier and obtain an oscilloscope presentation of the response of transformer T-6. Then adjust the top and bottom tuning cores of T-6 for an oscilloscope waveform as shown in figure 35. Check the critical points of the response curve with the signal generator marker.

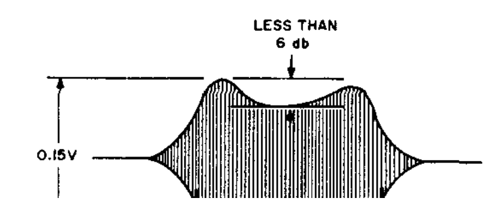
Turn the *BANDSWITCH* to the *1.5-4.0 MHz* position. Connect the sweep generator to the junction of C-33 and L-5. The other connections will remain as given above. Obtain an oscilloscope presentation of the response of transformer T-7. Adjust the top and bottom tuning cores of T-7 for a response curve as shown in figure 36. Check the critical points of the response curve with the marker generator.

Disconnect the marker generator, sweep generator, and oscilloscope leads: Insert the 26-MHz crystal X-1 into its socket and remove the short from the collector of the high-frequency oscillator transistor Q-302.



RESPONSE: BANDPASS TRANSFORMER T-6

FIGURE 35



5.5.15.1 UP-CONVERTER PASSBAND ALIGNMENT (ALTERNATE PROCEDURE)

If no sweep generator is available, the up-conversion bandpass transformers T-6 and T-7 may be aligned with only a signal generator and a general coverage receiver by performing the alternate alignment procedure described below.

To align the 0-1.5 MHz up-conversion bandpass transformer T-6, check to be sure that the FUNCTION switch is in the SSB or AM position and the BANDSWITCH is in the 0-1.5 MHz position. Remove the 26-MHz crystal X-1 and short the collector of the high-frequency oscillator Q-303 to ground. Connect the signal generator, tuned to 27 MHz, to the junction of R-10 and C-193. Connect a general coverage receiver, tuned to 27 MHz, through a coaxial cable to the junction of C-74 and bandswitch section S1-3R. All leads should be short and well shielded to minimize stray coupling effects around transformer T-6. Shunt the secondary of T-6 with a 100-ohm resistor across C-34. Peak the primary of T-6 (bottom tuning core) for maximum output on the receiver.

Remove the 100-ohm resistor from the secondary of T-6 and shunt the primary of T-6 with a 100-ohm resistor across C-35. Peak the secondary of T-6 (top tuning core) for maximum output. Disconnect the 100-ohm resistor.

To align the 1.5-4.0 MHz up-conversion bandpass transformer T-7, turn the BANDSWITCH to the 1.5-4.0 MHz position. Connect the signal generator tuned to 28.75 MHz, to the junction of C-33 and L-5. Tune the general coverage receiver to 28.75 MHz. Shunt the secondary of T-7 with the 100-ohm resistor across C-37. Peak the primary of T-7 (bottom

modulation at the frequencies indicated. Connect the HRO-500TS speaker and audio output meter to the 3.2-ohm and GND terminals of J-10. Then align the preselector according to figure 37.

After completion of preselector alignment, remove all test equipment from the HRO-500.

5.5.17 S-METER CALIBRATION AND AGC TEST

Set all HRO-500 controls to the positions indicated in paragraph 5.3. Turn the BANDWIDTH switch to the 1.5-4.0 MHz position. Set the SYNTHESIZER TUNE dial to 3.5 MHz. Turn the FUNCTION switch to SSB and the AGC THRESHOLD control to ON. Connect a properly terminated, unmodulated signal generator to the 50-ohm antenna connector J-1 on the rear apron of the receiver. Set the signal generator frequency to approximately 4 MHz and the output to 50 μv. Tune in the signal generator with the MAIN TUNING dial and carefully maximize the output with the PRESELECTOR TUNE control. Note the S-meter indication. If the S-meter does not indicate S-9 or 40 db, adjust the S-meter calibration control, C-156, for the correct indication.

To check the AGC release time, turn the AGC THRESHOLD control to OFF. The S-meter should indicate full scale. Turn the AGC THRESHOLD control to ON. The S-meter indication should return to S-9 in approximately 1 second. If the S-9 indication is obtained in less than 1 second, the AGC circuit requires troubleshooting.

Set the signal generator attenuator control for a 50,000 μv output. The S-meter should indicate

Band	*Synthesizer Tune*	*Main Tuning*	*Preselector Tuning*	*Signal Generator*	*Adjust*	*Indications and Remarks*
0.0-1.5 MHz Band 1	0.5 MHz	10	510 kHz	510 kHz	L-4 T-3 bottom T-3 top	Adjust for maximum output. Reduce signal generator input as required to avoid overload. The S-meter may be used as an overload - indicator. Maintain the S-meter at or below mid-scale. Repeat the adjustments at each end of a band as required to achieve proper tracking.
0.0-1.5 MHz Band 1	1.0 MHz	490	1490 kHz	1490 kHz	C-25 C-13 C-12	
1.5-4.0 MHz Band 2	1.5 MHz	250	1.75 MHz	1.75 MHz	L-5 T-4 bottom T-4 top	
1.5-4.0 MHz Band 2	3.5 MHz	250	3.75 MHz	3.75 MHz	C-26 C-15 C-14	
4.0-10 MHz Band 3	4.0 MHz	250	4.25 MHz	4.25 MHz	L-6 T-5 bottom T-5 top	
4.0-10 MHz Band 3	9.5 MHz	250	9.75 MHz	9.75 MHz	C-27 C-17 C-16	
10-20 MHz Band 4	10.0 MHz	250	10.25 MHz	10.25 MHz	L-2 T-1 bottom T-1 top	
10-20 MHz Band 4	19.5 MHz	250	19.75 MHz	19.75 MHz	C-23 C-9 C-8	
20-30 MHz Band 5	20.0 MHz	250	20.25 MHz	20.25 MHz	L-3 T-2 bottom T-2 top	
20-30 MHz Band 5	29.5 MHz	250	29.75 MHz	29.75 MHz	C-24 C-11 C-10	

PRESELECTOR ALIGNMENT
FIGURE 37

5.5.18.1 FINAL FREQUENCY CALIBRATION: SYNTHESIZER (ALTERNATE PROCEDURE)

Set the HRO-500 controls to the positions indicated in paragraph 5.3. Connect a suitable antenna or accurately known frequency standard to the 50-ohm antenna connector J-1. Connect the HRO-500TS speaker to the 3.2-ohm and GND terminals [illegible]

500-kHz crystal trimmer C-301 to bring this beat note to zero beat.

Tune the MAIN TUNING control to place the WWV carrier or frequency standard signal on one side of the IF passband to permit slope detection. Any images of the spectrum generator signal will show up as FM on the high-frequency oscillator DC control circuit. Correct adjustment of the [illegible]

5.5.19.1 50-kHz CALIBRATOR ADJUSTMENT (ALTERNATE PROCEDURE)

Check the synthesizer calibration as given in paragraph 5.5.18 above. The 50-kHz calibrator adjustment described as follows depends on an accurately calibrated synthesizer. Set all controls as indicated in paragraph 5.3 and connect the HRO-500TS speaker to the 3.2-ohm and GND terminals at J-10. Turn the FUNCTION switch to SSB and set the MAIN TUNING dial to zero beat a signal from WWV or a frequency standard signal against the BFO. Then turn the FUNCTION switch to the CAL position which activates the 50-kHz calibrator. Adjust the calibrator trimmer C-125 for zero beat with the WWV and BFO signals. This completes the 50-kHz calibrator adjustment. However, the MAIN TUNING dial may be accurately calibrated at this dial setting in the following manner: Turn the DIAL LOCK knob 90° cw to the locked position. Adjust the MAIN TUNING control for a MAIN TUNING dial indication of zero or 500, depending upon the synthesizer frequency chosen to receive the WWV or frequency standard signal. Then return the DIAL LOCK knob to its unlocked position by rotating it 90° ccw.

5.5.20 26-MHz OSCILLATOR CALIBRATION

Turn all controls to the positions given in paragraph 5.3. Turn the BANDSWITCH to the 0-1.5 MHz position. Set the FUNCTION switch to AM or SSB. Connect a counter capable of indicating frequencies up to 30 MHz to the 26-MHz oscillator output J-4 on the rear apron. Observe the counter frequency indication, and if necessary, adjust L-19 to obtain an indication of exactly 26.000 MHz. Remove the counter connections.

5.5.20.1 26-MHz OSCILLATOR CALIBRATION (ALTERNATE PROCEDURE

Check the synthesizer calibration as given in paragraph 5.5.18 above. Set all controls as indicated in paragraph 5.3. Connect the HRO-500TS speaker to the 3.2-ohm and GND terminals of J-10. Set the BANDSWITCH to the 0-1.5 MHz position. Turn the FUNCTION switch to the CAL position. Tune a signal from a frequency standard or a signal from

Turn all controls to the positions given in paragraph 5.3. Turn the FUNCTION switch to the SSB position. Connect the counter to the BFO output jack J-6 on the rear apron of the receiver. Observe the counter frequency indication. If necessary, adjust L-24 to obtain an indication of exactly 230 kHz. Remove the counter connections.

5.5.22 VFO FREQUENCY ADJUSTMENTS

Check that all HRO-500 controls are set to the positions indicated in paragraph 5.3. Connect the HRO-500TS speaker to the 3.2-ohm and GND connections of J-10. Set the main tuning clutch to mid-position following the procedure in paragraph 5.5.9. Turn the FUNCTION switch to the CAL position. Set the MAIN TUNING control to indicate 500 on the MAIN TUNING dial. Adjust the VFO inductance tuning core L-10 for zero beat with the 50-kHz calibrator signal.

Set the MAIN TUNING dial to zero. Adjust the VFO trimmer capacitor C-68 for zero beat. Repeat the above steps several times as required to insure that both end frequencies are correct.

5.5.23 VFO LINEARITY ADJUSTMENT

A special linearity adjustment (consisting of two segmented plates and a stator) is incorporated on the rear section of the HRO-500 main tuning capacitor. After adjustment of the VFO frequency at 2.98 MHz and 3.48 MHz as described in paragraph 5.5.22, it will be necessary to set the VFO linearity.

Set all controls as indicated in paragraph 5.3. Set the FUNCTION switch to CAL. Connect the HRO-500TS speaker to the 3.2-ohm and GND terminals of J-10. Turn the MAIN TUNING control to approximately 450. Zero beat with the 50-kHz calibrator signal should occur at exactly 450 to within ±¼ dial division (±250 hertz). If the dial indication is outside these limits, set the dial to exactly 450. Then carefully "knife" (bend) the proper frequency correction plate segment at the end of the main tuning capacitor to obtain zero beat. A long screwdriver may be used to knife these plates or a special alignment tool may be fashioned if desired.

checked against proper VFO dial indications to insure maximum dial calibration accuracy over the entire MAIN TUNING dial scale.

5.5.24 VFO TEMPERATURE COMPENSATION

The VFO temperature compensation capacitor C-200 has been carefully set at the factory and normally needs no readjustment. If VFO components have been replaced, it may be necessary to readjust the temperature compensation capacitor. The VFO frequency and linearity adjustment procedures should be performed prior to this procedure. Connect a suitable antenna or accurate frequency standard to the receiver antenna connector J-1. Connect the HRO-500TS speaker to the 3.2-ohm and GND connections of J-10. Tune to WWV or the frequency standard harmonic with the FUNCTION switch set to SSB. Carefully zero beat this signal against the BFO. Then raise or lower the ambient temperature around the receiver approximately 30°F. After one half hour or longer, note the change in the beat note and the direction of tuning necessary to return to zero beat. If this direction is up-scale (toward zero), increase the setting of the temperature compensating trimmer (C-200) by turning it towards its maximum capacity setting. If the direction is down-scale (toward 500), decrease the setting of C-200. Reset the MAIN TUNING control to the correct MAIN TUNING dial indication and reset the VFO trimmer C-68 to zero beat to re-establish proper calibration.

Repeat the above procedure until the receiver is satisfactorily temperature compensated. If necessary, VFO end frequency adjustments and linearity adjustments should be repeated according to the instructions in paragraphs 5.5.21 and 5.5.22.

5.6 TROUBLESHOOTING:

This section contains general information about transistors and their basic characteristics to aid service personnel in isolating circuit malfunctions and repairing the receiver transistor circuits. Typical transistor characteristics, NPN and PNP transistor basic circuit connections, and base diagrams are included. Specific service information, including a transistor voltage chart, a power supply distribution table, and general troubleshooting procedures are also included.

5.6.1 GENERAL TROUBLESHOOTING PROCEDURE

1. Determine the malfunctioning section or stages in the receiver by observation, signal injection, or other well-known servicing techniques.

2. Check the transistor voltages in the malfunctioning stage area. Typical transistor voltages for PNP and NPN transistors are shown in the following chart. For detailed voltages see section 5.6.5.

3. Apply a signal to the malfunctioning area. Check its alignment and the individual stage outputs. This should localize the trouble to a few components. These components may be replaced to correct the malfunction.

PNP	
Typical emitter-to-supply voltage	1 V
Typical base-to-supply voltage	0.2 V above emitter-to-supply voltage
Typical collector-to-ground voltage	0 V
NPN	
Typical emitter-to-ground voltage	1 V
Typical base-to-ground voltage	0.3 V above emitter-to-ground voltage
Typical collector-to-ground voltage	approximately equal to supply

5.6.2 TYPICAL TRANSISTOR CHARACTERISTICS AND PARAMETERS

Symbols	*Characteristic*	*Small Signal Transistors*	*Power Transistors*
Z in (base)	Input impedance	500 Ω	100 Ω
Z out (collector)	Output impedance	100 K Ω	10 K Ω
Z load	Stable load impedance	5 K Ω	50 Ω
Power gain	Single-stage power gain	20-30 db	20-30 db
Beta	DC current gain (Beta)	30-150	60-100

5.6.3 BASE DIAGRAMS AND MISCELLANEOUS INFORMATION

Base diagrams of 3-terminal small signal transistors are illustrated in figure 38.

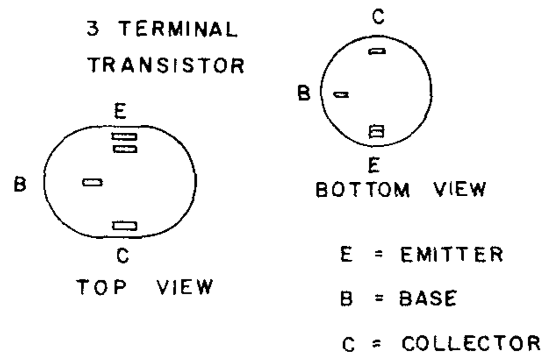
Base diagrams of 4-terminal small signal transistors are illustrated in figure 39.

Base diagrams of power transistors or TO-3 case are illustrated in figure 40.

The basic bias network for PNP transistors is shown in figure 41.

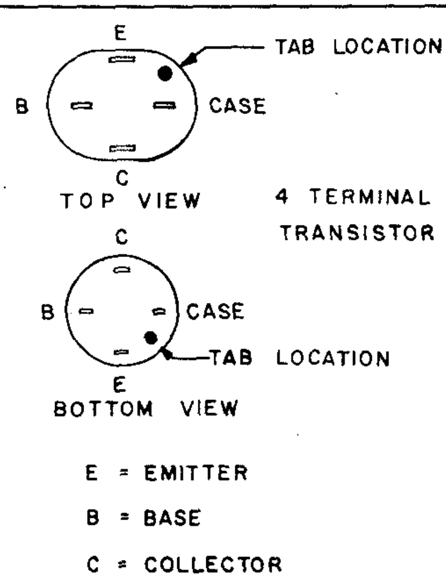
The basic network for NPN transistors is shown in figure 42.

Drive cord diagrams are shown in figures 43 and 44.



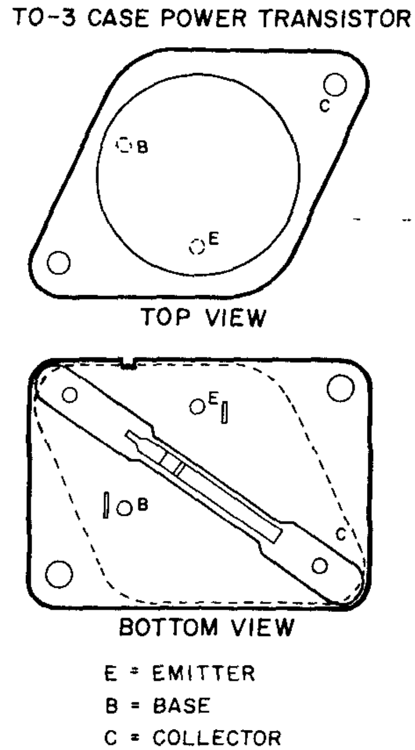
3-TERMINAL TRANSISTOR SOCKET (BOTTOM VIEW)

FIGURE 38



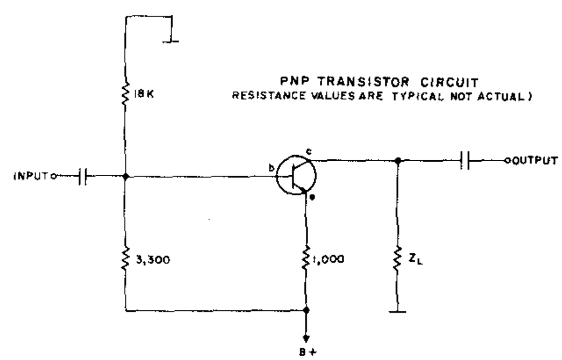
4-TERMINAL TRANSISTOR SOCKET (BOTTOM VIEW)

FIGURE 39



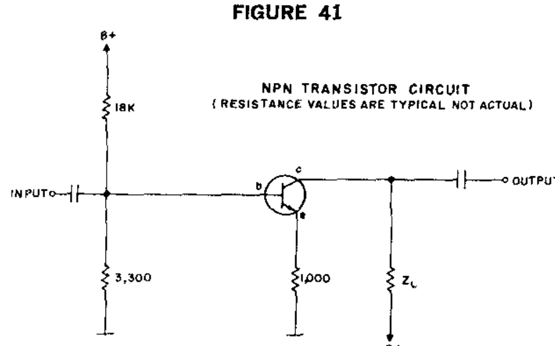
TO-3 CASE POWER TRANSISTOR SOCKET (BOTTOM VIEW)

FIGURE 40



PNP TRANSISTOR BIAS CIRCUIT

FIGURE 41



NPN TRANSISTOR BIAS CIRCUIT

FIGURE 42

5.6.4 RECEIVER POWER SUPPLY VOLTAGE DISTRIBUTION TABLE

The following DC voltage measurements are taken with a VTVM or a VOM with an input resistance of at least 20,000 ohms per volt. Receiver controls are set as follows:

SYNTHESIZER TUNE: 3.5 MHz
PRESELECTOR TUNE: 3.5 MHz
RF GAIN: Full cw (clockwise)
AF GAIN: Full ccw (counterclockwise)
BANDWIDTH switch: 8 kHz
AGC THRESHOLD: OFF
FUNCTION switch: CAL
DIAL lamp switch: ON
BANDWIDTH switch: 8 kHz
REJECTION TUNE: OFF

— CAUTION —

DO NOT ATTEMPT TO MEASURE CIRCUIT RESISTANCES WITH AN OHMMETER. SEVERAL COMMERCIAL OHM-METERS DEVELOP LARGE POTENTIALS ACROSS THE OHMMETER LEADS WHICH ARE CAPABLE OF DESTROYING TRANSISTORS. IT IS STRONGLY RECOMMENDED THAT ALL TROUBLESHOOTING BE BASED ONLY ON THE TRANSISTOR TERMINAL VOLTAGE CHART GIVEN BELOW.

		Voltage			
Transistor	*Function*	*Emitter*	*Base*	*Collector*	
Q-1	RF Amplifier	0.86	1.6	11.2	
Q-2	26-MHz Oscillator	6.1	5.9	0	
Q-3	First Conversion Mixer	0.42	0.9	7.5	
Q-4	26-MHz Buffer	8.8	8.7	0	
Q-5	Tunable IF	8.8		8.6	0
Q-6	Second Conversion Mixer	8.7	8.4	0	
Q-7	VFO	4.1	4.3	0.29	
Q-8	VFO Buffer	3.1	3.3	0.33	
Q-9	Filter Preamplifier	8.6	8.3	0	
Q-10	Crystal Calibrator	6.6	6.9	0	
Q-11	AGC Emitter Follower	6.3	6.0	1.4	
Q-12	First 230-kHz IF	8.5	8.3	1.8	
Q-13	Second 230-kHz IF	8.9	8.6	0	
Q-14	Third 230-kHz IF	8.9	8.7	0.84	
Q-15	BFO	7.0	6.8	0	
Q-16	Muting	9.8	11.8	GND	
Q-17	Bi-stable Trigger	12.0	11.9	0	
Q-18	Bi-stable Trigger	0	0	11.8	
Q-19	Emitter Follower	5.2	4.8	GND	
Q-20	Audio Output	11.8	11.7	0	
Q-21	Audio Output	11.8	11.7	0	
Q-22	Audio Driver	6.8	6.6	1.4	
Q-23	S-meter Bridge Amplifier	0.1	0.73	9.5	
Q-24	S-meter Detector	0.69	1.18	10.0	
Q-25	Regulator	GND	–0.15	–12.4	
Q-300	500-kHz Oscillator	4.25	4.5	0.6	
Q-301	Blocking Oscillator	GND	–0.68	8.6	
Q-302	Burst Generator	GND	–0.1	0.89	
Q-303	HFO	3.7	3.85	0.45	
Q-304	Tuned Buffer	6.4	6.2	0.52	
Q-305	Untuned Buffer	6.1	5.8	1.4	
Q-306	Mixer	8.9	8.7	0.12	
Q-307	4.75-MHz IF	8.4	8.2	0.11	
Q-308	4.75-MHz IF	9.0	8.8	1.3	
Q-309	4.75-MHz Oscillator	6.4	6.4	1.26	
Q-310	DC Amplifier	0.15	0.78	5.8	
Q-311	Unijunction Sweep	9.3	5.9	GND	

5.6.5 PILOT LIGHT REPLACEMENT

5.6.5.1 DRUM DIAL AND OR DIAL INDEX PILOT LIGHTS

To replace the drum dial and or dial index pilot lights, the mask and drum dial mechanically coupled to the SYNTHESIZER TUNE control must be removed.

Remove the mask by removing the screws which attach the mask to the hubs at each end of the mask. The mask may now be removed by lifting it out through the front panel slot.

Loosen the set screws which attach the mask hub and drum to the gear box and remove the two screws which attach the assembly to the notch tuning capacitor bracket. Now remove the drum dial by sliding it to the right and then lifting it out through the slot at the top of the panel. The dial index and drum pilot lights are now accessible.

Replace the defective pilot lamp. After replacing the dial index and or drum dial pilot lamps, replace the synthesizer drum dial, the drum support and pilot lamp holder assembly, and the mask.

After replacing, align the drum dial first by turning the SYNTHESIZER TUNE control ccw to its maximum capacity position with the BANDSWITCH in the 0-1.5 MHz position. Align the white horizontal line on the synthesizer drum dial with the center of the window. Then position the mask so that the white line appears through the rectangular opening in the mask which is nearest the gear box.

5.6.5.2 DIAL INDEX PILOT LAMP

To replace the pilot lamp in the front panel dial index, the mask and drum dial mechanically coupled to the SYNTHESIZER TUNE control must be removed. This may be accomplished by first removing the right side gusset, filter cover, S-meter, the synthesizer drum support, and pilot lamp assembly as described in paragraph 5.6.7.1 above, and then removing the mask and drum dial as follows.

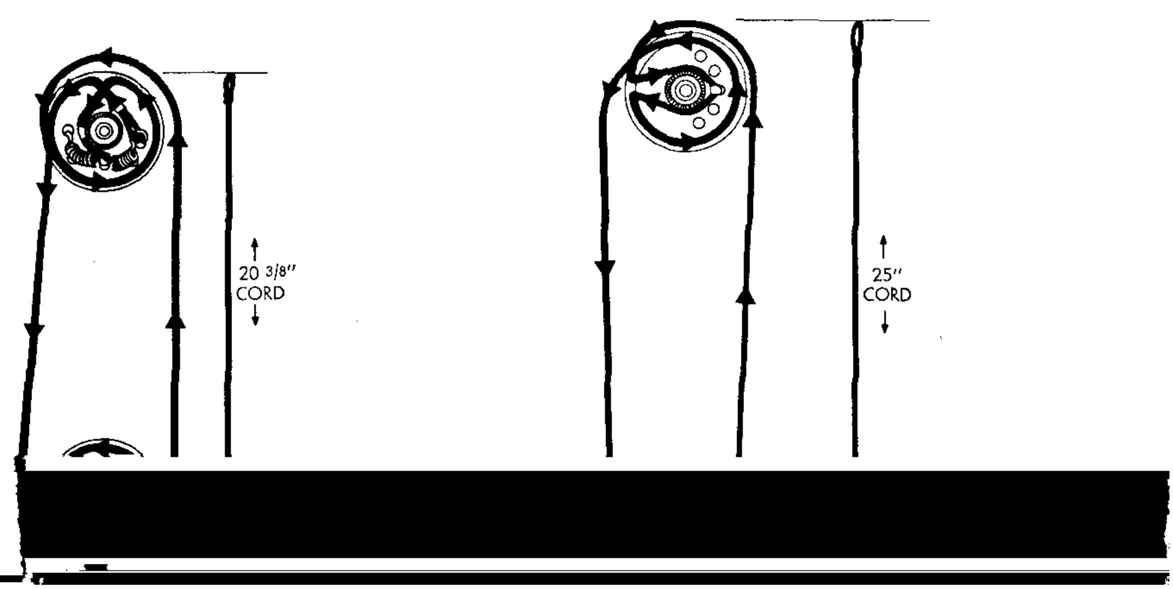
Remove the mask by removing the screws which attach the mask to the rectangular pivot blocks at each end of the mask. Loosen the setscrew on the left pivot block and rotate the mask to clear the drum. The mask may now be removed by lifting it out through the front panel slot.

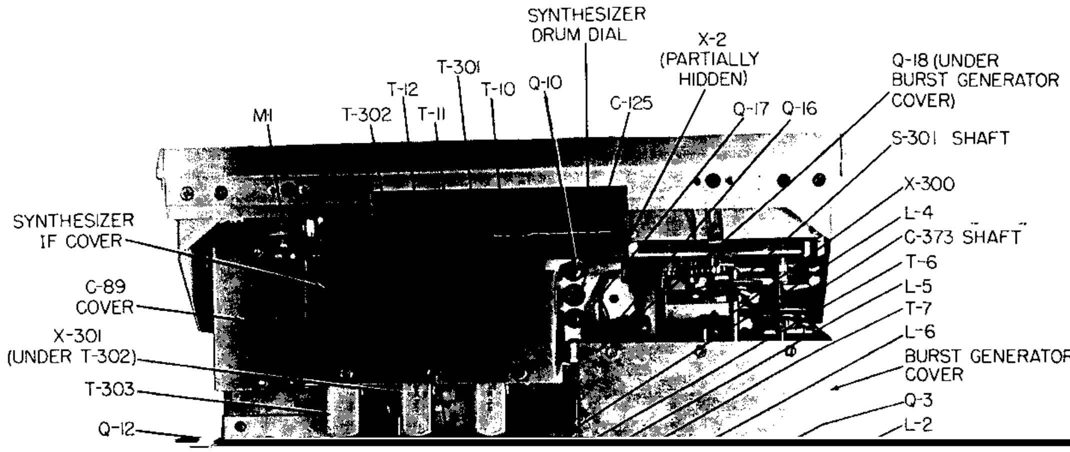
Remove the drum dial by loosening the setscrews which attach the drum to the gear box, sliding it to the right, and then lifting it out through the slot at the top edge of the front panel. The dial index pilot lamp holder is now accessible.

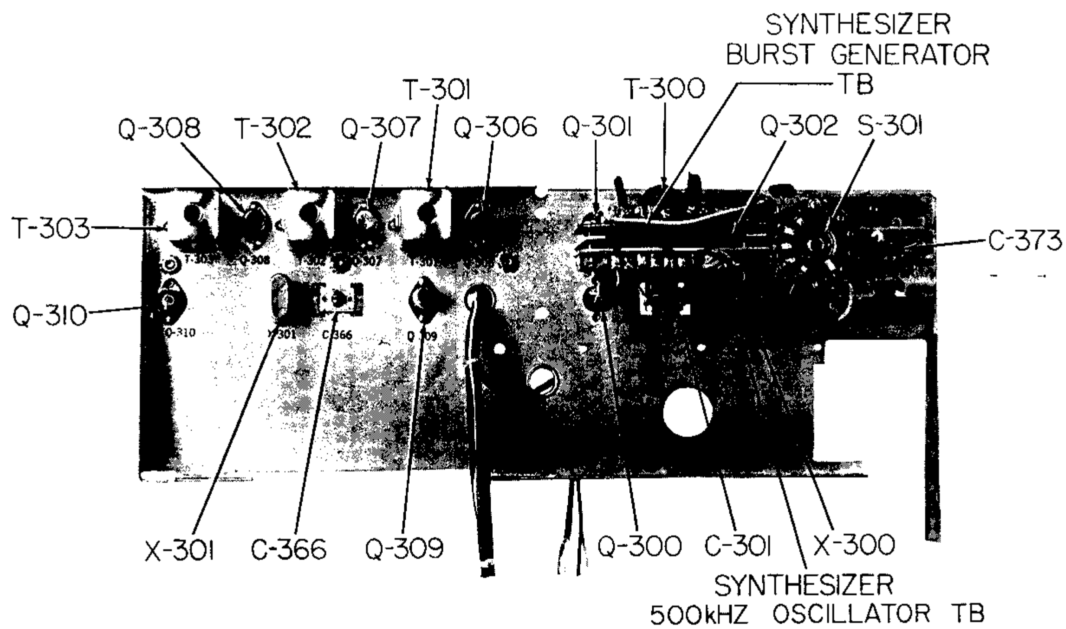
Replace the defective pilot lamp. After replacing the dial index pilot lamp, replace the synthesizer drum dial, the drum support and pilot lamp assembly and the mask.

After replacing, align the drum dial first by turning the SYNTHESIZER TUNE control ccw to its maximum capacity position with the BANDSWITCH in the 0-1.5 MHz position. Align the white horizontal line on the synthesizer drum dial with the center of the window. Then position the mask so that the white line appears through the rectangular opening in the mask which is nearest the gear box.

After aligning the drum dial and mask, replace the S-meter, filter cover and right side gusset.

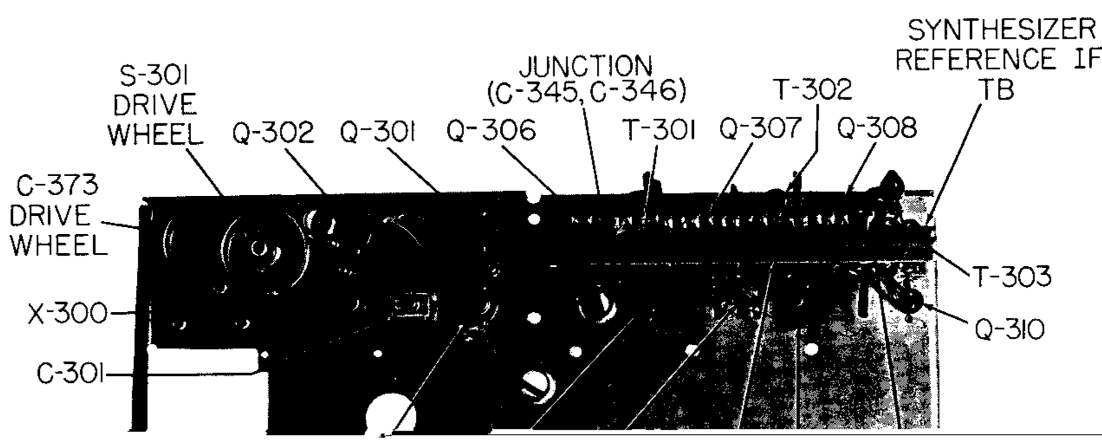


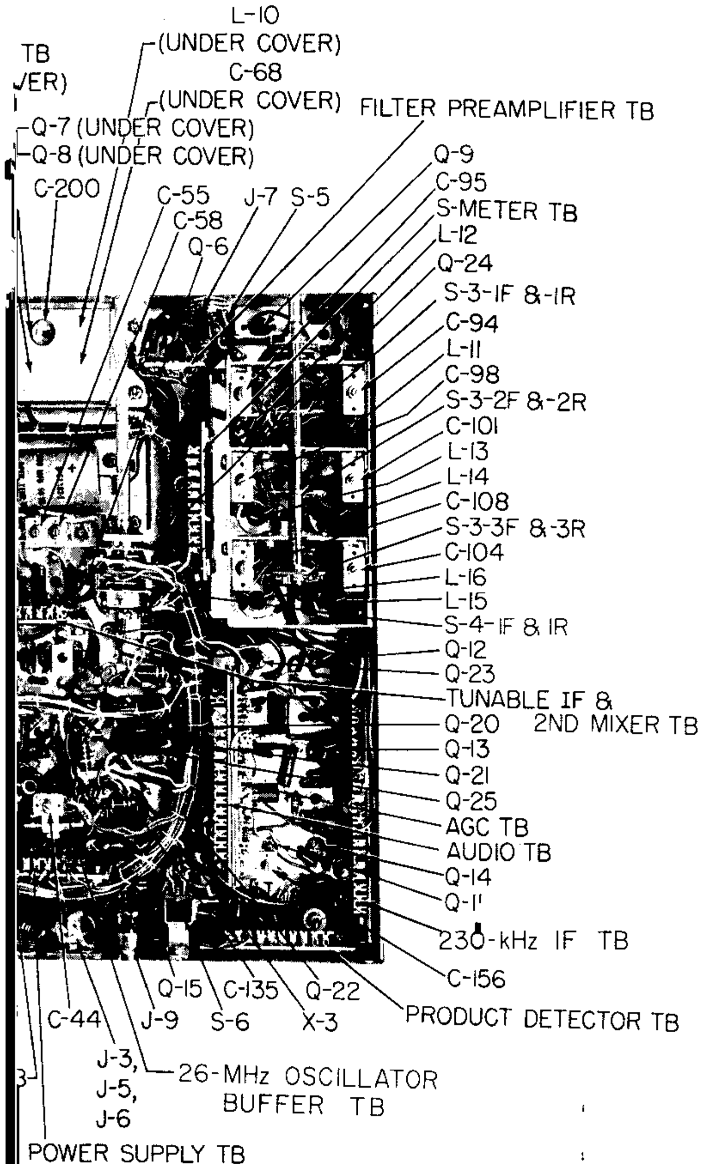

SYNTHESIZER DRUM DIAL
X-2 (PARTIALLY HIDDEN)
Q-18 (UNDER BURST GENERATOR COVER)
T-301
T-12
T-10
Q-10
C-125
Q-17
Q-16
MI
T-302
T-11
S-301 SHAFT
X-300
SYNTHESIZER IF COVER
L-4
C-373 SHAFT
T-6
C-89 COVER
L-5
T-7
X-301 (UNDER T-302)
L-6
BURST GENERATOR COVER
T-303
Q-3
Q-12
L-2



SYNTHESIZER CHASSIS, REAR VIEW

FIGURE 47





SIS, BOTTOM VIEW

SPECIFICATIONS

HRO-500 SPECIFICATIONS

FREQUENCY RANGE: Five kilohertz to 30 MHz in sixty 500 kHz bands, continuous coverage.
MODES: Selectable upper or lower sideband, MCW, FSK, AM, CW.
POWER REQUIREMENTS:
A. Pilot lamp switched off
   1. 117/234 V.A.C. 50-60 hertz; 10 watts at 50 mw audio output, 15 watts at 1.5 watts audio output.
   2. 12.6 V.D.C.; 2.5 watts (200 ma.) at 50 mw audio output, 6.5 watts (525 ma.) at 1.5 watts audio output.
B. Pilot lamps switched on.
   1. 117/234 V.A.C. requires additional 7 watts
   2. 12.6 V.D.C. requires additional 590 ma.
CALIBRATION ACCURACY: Within one kHz per 500 kHz band.
SYNTHESIZER ACCURACY: Within 250 hertz over entire tuning range when zeroed at 10 MHz.
RESET ACCURACY (Including Visual Error): Within 250 hertz.
TUNING DIAL BACKLASH: Less than 50 hertz.
TUNABILITY: Within 2 hertz.
MAIN TUNING RATIO: Two-speed; 50 kHz/revolution (flywheel) or 10 kHz/revolution.
MAIN TUNING BANDSPREAD: ¼" per kilohertz; 12 feet per 500 kHz band.
CALIBRATOR: 50 kHz crystal controlled.
FREQUENCY STABILITY:
A. In room ambients: 300 hertz per hour from point of turn-on to two hours after turn-on; better than 100 hertz per day thereafter.
B. With respect to temperature: 50 hertz per °C.
C. With respect to A.C. supply variation: essentially none for ±27% change.
R.F. INPUT IMPEDANCE: 50 ohm unbalanced (nominal); also separate high impedance unbalanced input for use with random antennas.
SENSITIVITY (500 kHz-30 MHz):
A. AM (Nominal): Better than 2.0 uv for 10 db S/N.
B. SSB/CW (Nominal): Better than 1.0 uv for 10 db S/N.
SENSITIVITY (Five kHz-500 kHz): 25-200 uv for 10 db S/N without LF-10 preselector; equal to HF sensitivity when LF-10 preselector is used.
SELECTIVITY:
A. 6 db bandwidths available; 500 hertz; 2.5 kHz, 5.0 kHz; 8.0 kHz.
B. Filter Design: six-pole LC type operating at 230 kHz; tunable through 6 kHz range in 500 hertz and 2.5 kHz bandwidths.
C. Filter shape factor (Nominal): 2.5:1 (6-60 db) in 2.5 kHz bandwidth.
D. Audio filtering provisions incorporated in LF-10 preselector.
HETERODYNE REJECTION FACILITIES: 230 kHz bi-filar notch (REJECTION TUNE control) with ±10 kHz range around IF passband; minimum rejection capability of 50 db. Also. PASSBAND TUNE control (of tunable six-pole filter) permits rejection of adjacent channel interference without change in frequency of desired signal.
IMAGE REJECTION (500 kHz-30 MHz.): Averages 80 db; minimum 50 db.
SPURIOUS RESPONSES TO OFF-TUNE EXTERNAL SIGNALS: Minimum 50 db rejection.
INTERNALLY GENERATED SPURIOUS SIGNALS: All less than 2.0 uv equivalent signals (between 500 kHz and 30 MHz.) except for two discrete responses at 2.75 MHz and 3.0 MHz.
AGC: Time constant; 60 millisecond attack, 3 sec. delay. AGC merit; average 5 db output change for input increase from 10 to 100,000 uv.
AUDIO FREQUENCY RESPONSE: 100 hertz-5500 hertz within 6 db.
AUDIO OUTPUT DISTORTION (Nominal): 0.5 watts, 3.2%; 1.0 watts, 4.4%; 2.0 watts, less than 10%.
AUDIO HUM: Better than 60 db below maximum output.
AUDIO OUTPUTS: 3.2 ohms to rear panel and front panel headphone jack; 600 ohms balanced with center tap (ground reference or floating) to rear panel.
REMOTE CONTROL PROVISIONS: R.F. Gain; A.F. Gain; Receiver Mute; BFO On-Off; Power On-Off.
METERING: Front panel meter calibrated in db above 1.0 uv and from 0 to S-9 between no-signal and 40 db above 1.0 uv.
AGC THRESHOLD CONTROL: R.F. input attenuator; 0-30 db in nominal 10 db steps.
FRONT PANEL CONTROLS: SYNTHESIZER TUNE (MHz); PRESELECTOR TUNE; PASSBAND TUNE; REJECTION TUNE; MAIN TUNING (kHz); R.F. GAIN; A.F. GAIN; BANDSWITCH; AGC On-Off-Threshold Control (to 30 db); FUNCTION Off-Standby-SSB-AM-Calibrate; DIAL LAMPS On-Off; BANDWIDTH 500 hertz-2.5 kHz-5.0 kHz-8.0 kHz; DIAL LOCK; PHASE LOCK Warning.
REAR PANEL CONTROLS: S Meter Zero; Rejection Tune Balance; 117/234 V.A.C. 12.6

SECTION 7

PARTS LIST

SOCKETS, JACKS, AND PLUGS

J-1	Coaxial Connector, Antenna	A51479
J-2, J-4, J-300	Jack, HI-Z Antenna, 26 MHz and HFO Out	A51084
J-3, J-5, J-6	Jack, LO-Freq In, VFO, and BFO	A51084
J-7	Jack, Phones	A50793-3
J-8	Socket, 117V AC Power	A51081
J-9	Socket, 12V DC, Jones, 2-T, Male Chassis Mounted	A51267
P-9	Plug, Jones, 2-T, Female	A51268
J-10	Terminal Board, Speaker	A51080-5
J-11, J-12, J-13	Jack, IF, Spare and Spare	A51084
J-14	Socket, Jones, 18-T, Female Chassis Mount	A51083
P-14	Plug, Jones, 18-T, Male	B51265
	Socket, Transistor, 3-Terminal	A50981
	Socket, Transistor 4-Terminal	A51725
	Socket, Power Transistor	B51068
	Socket, Crystal	A50799
	Socket, Indicator Lamp	A51246
	Socket, Panel Lamp Assembly (3 Sockets)	B51601
	Socket, Panel Lamp (Drum) (2 Sockets)	B51184

POTENTIOMETERS

R-54, R-98	Potentiometer, RF Gain and Audio Gain	B51272
R-68	Potentiometer, Depth	B50088
R-108	Potentiometer, S-meter, Zero	B51282-1

DIODES

CR-1, CR-2	Diode, 1N541	1N541
CR-7, CR-8	Diode, 1N484	A51672
CR-3	Diode, Zener, 5 V, 1N761-2	1N761-2
CR-4 (2), CR-301 (2)	Diode, Matched Pair 1N541	1N542
CR-6, CR-9, CR-300	Diode, 1N60	1N60
CR-10	Diode, Zener, 7.5 V, 1N3017B	A51343-1
CR-11, CR-12	Diode, Columbus Electronics (CEC-105)	A51294-2
CR-13	Diode, Zener, 13V, ±5%	B52020-8
CR-15, CR-302, CR-303	Diode, 1N295X	1N295X
CR-14	Diode, Solitron 2A50 (1N1908) (1N4513)	A51707-4
C-402	Diode, Varactor, (Sylvania D6650)	A51875
C-390	Diode, Varactor, Pacific Semiconductor VC-47	A51307-9

COILS AND TRANSFORMERS

T-1	Transformer, Antenna 10 MHz to 20 MHz	B51023
T-2	Transformer, Antenna 20 MHz to 30 MHz	B51024
T-3	Transformer, Antenna .5 MHz to 1.5 MHz	B51705
T-4	Transformer, Antenna 1.5 MHz to 4 MHz	B51021
T-5	Transformer, Antenna 4 MHz to 10 MHz	B51022
T-6	Transformer, Bandpass 26.5 MHz to 27.5 MHz	B51030
T-7	Transformer, Bandpass 27.5 MHz to 30 MHz	B51031
T-8	Transformer, First Mixer Output	B51045
T-9	Transformer, Tunable IF 2.75 MHz to 3.25 MHz	B51049
T-10	Transformer, 230 kHz, 8-kHz Bandwidth	B51047
T-11, T-12	Transformer, 230 kHz, 5-kHz Bandwidth	B51048
T-13	Transformer, Second 230 kHz IF	B51054
T-14	Coil, Product Detector	B51335
T-16	Transformer, Audio Driver	B51649
T-17	Transformer, Audio Output	B51062
T-18	Transformer, Power (115-230V)	C51622
T-301, T-302	Transformer, IF 4.75 MHz Reference	B51380
T-303	Transformer, IF 4.75 MHz Output	B51379
T-300	Coil, Blocking Oscillator	B51085
L-2	Coil, RF Output 10 MHz to 20 MHz	B51028
L-3	Coil, RF Output 20 MHz to 30 MHz	B51029
L-4	Coil, RF Output .5 MHz to 1.5 MHz	B51025
L-5	Coil, RF Output 1.5 MHz to 4.0 MHz	B51026
L-6	Coil, RS Output 4 MHz to 10 MHz	B51027
L-10	Coil, VFO	B50992
L-11, L-12, L-13, L-14, L-15, L-16	Coil, Ferrite Filter	A51251
L-17	Coil, 230-kHz Filter, Preamplifier	B51051
L-18	Coil, Crystal Calibrator	B51264
L-19	Coil, 26-MHz Oscillator	B51032
L-20	Coil, First 230-kHz IF	B51053
L-21	Coil, Bifilar T	B51067
L-22	Coil, Bifilar Tuning	B51056
L-23	Coil, Third 230-kHz IF	B51052
L-24	Coil, BFO	B51334

L-315, L-317	Coil, HFO Buffer Bands 3 and 5	B50932
L-316	Coil, HFO Buffer Band 4	B50939
L-301	Coil, 500-kHz Oscillator Coil	B51264
L-305	Coil, Spectrum Generator Bands 1, 2, and 5	B51345
L-306	Coil, Spectrum Generator Band 4	B51346
L-307	Coil, Spectrum Generator Band 3	B51344

FIXED CAPACITORS

C-316, C-387	Capacitor, Mica, 18 pf ±2% 100V	NCS-15-180-G-1
C-386	Capacitor, Mica, 22 pf ±2% 100V	NCS-15-220-G-1
C-317	Capacitor, Mica, 24 pf ±2% 100V	NCS-15-240-G-1
C-311, C-312, C-315	Capacitor, Mica, 27 pf ±2% 100V	NCS-15-270-G-1

[redacted]

CHOKES

L-7	Coil, .68 uh	C50750-11

C-180, C-181, C-182, C-183	±2% 100V	470-G-1
C-114, C-120	Capacitor, Mica, 68 pf	NCS-15-

TRIMMERS

C-8, C-10	Capacitor, Trimmer Assembly (Antenna)	B50993-3
C-9, C-11	Capacitor, Trimmer Assembly (RF Base)	B50993-3
C-12, C-14, C-16	Capacitor, Trimmer Assembly (Antenna)	B50993-2
C-13, C-15, C-17	Capacitor, Trimmer Assembly (RF Base)	B50993-2
C-23, C-24	Capacitor, Trimmer Assembly (RF Collector)	B50993-3
C-25, C-26, C-27	Capacitor, Trimmer Assembly (RF Collector)	B50993-2
C-44	Capacitor, Trimmer (26-MHz Buffer)	A51383-2
C-49, C-53, C-55, C-58	Capacitor, Trimmer Assembly (Tunable IF)	B51304-4
C-68	Capacitor, Trimmer NPO (VFO Tuning)	B19783-2
C-94, C-95 C-98, C-101 C-104, C-108	Capacitor, Trimmer (Filter)	A50980
C-125	Capacitor, Trimmer NPO (50 kHz Oscillator)	B19783-2
C-156	Capacitor, Trimmer	A51383

Terminal Board, RF and 26-MHz Oscillator	B51043
Terminal Board, Tunable IF and Second Mixer	B51046
Terminal Board, 230-kHz IF	B51055
Terminal Board, AGC	B51060
Terminal Board, S-meter	B51258
Terminal Board, Filter Preamplifier	B51050
Terminal Board, 26-MHz Oscillator Buffer	B51341
Terminal Board, Indicator and Calibrator	B51289
Terminal Board, VFO Bias	B50991-2
Terminal Board, First Mixer	B51042
Terminal Board, Product Detector	B51058
Terminal Board, Audio	B51063
Terminal Board, Power Supply	B15064

TRANSISTORS

Q-1	Transistor, 2N3663 General Electric	
Q-2, Q-4,	Transistor, 2N2672	or 2N2188

GEAR BOX

Gear Box Housing	C51151-3
Shaft, Vertical, Mask Drive	A51158
Miter Gear, Mask Drive	A51152
Special Miter Gear, Mask Drive	A51153
Shaft, Transverse, Drum Drive	A51165
Helical Gear, Drum Drive	A51170-1
Hollow Shaft, Mask Drive	A51164
Special Miter Gear, Mask Drive	A51157
Pinch Shaft, Synthesizer Tuning Drive	A51162
Fly Wheel, Synthesizer Tuning Drive	A51392
Pinion Shaft, Synthesizer Tuning Drive	A51161
Disc, Drive, Synthesizer Tuning Drive	A51160-1
Hub, Synthesizer Tuning Drive	A51156-2
Worm Gear, Synthesizer Tuning Drive	B51170-2
Gear 115T, Synthesizer Tuning Drive	A51599-1
Shaft, Fiberglass, Preselector	A50818-5
Gear, Anti-Backlash, Preselector	A51154-2
Couplink, Preselector	B25000
Shaft, Preselector Dial	A51163
Dial, Preselector	A51617
Gear, Spur, Preselector Drive	B51155-1
Ball Vernier Assembly, Preselector	A51728

GEARS, SHAFTS, COUPLINGS, AND DRIVE TRAIN

Clamp, Dial Lock	A51173
Cam Shaft, Dial Lock	B51174
Clamp Guide, Dial Lock	B51286
Spring, Dial Lock	B234-1
Bandswitch Detent	B20662-2
Bandswitch Shaft Coupling	A12611
Bandswitch Pulley Assembly	A51276-1
Bandswitch Shaft	A50854
Bandswitch Miter Gear	A51152
Function Switch Shaft	A50818-4
Shaft, Coupling, Function Switch	B25000
Synthesizer Tune Pulley and Hub Assembly	A51276-1
Main Tuning Capacitor Worm Gear	C50982-2

COVERS

Cover, Rear Synthesizer	C51631-1
Cover, Front Synthesizer	C51631-2
Cover, Filter Tuning Capacitor	C51386
Cover, Preselector Tuning Capacitor	C51387
Cover, Filter	C50989
Cover, VFO	B51340
Cover, VFO Coil	A51987

MISCELLANEOUS PARTS

Gusset, Left	D51347-3
Gusset, Right	D51347-4
Bracket, Synthesizer Tuning Gang	A51071
VFO Extrusion Sub-Assembly	D50983
Shield Bracket, Filter	C50971
Mounting, Worm Gear (VFO)	A51339
Shield, Bandswitch Mounting	C50958
Stand Off Terminal	A51078-1
Indicator Lamp Cap (Red)	A51248-1
Mounting Plate, Indicator Lamp	A51287
Washer, Phones Jack	H-638-2
Nut, Phones Jack	A50363
Drum Stud and Holder Assembly	A51183
Dial Cylinder, Calibrated	B52133
Cylinder Mask	B52131
Window, Front Panel	B51076-1
Dial Cord Assembly, Bandswitch	B19347-12
Dial Cord Assembly, Synthesizer, Tune	B19347-13
Screws, Power Transistor Mounting	A50029-31
Mica Washer, Power Transistor	A51305
Index, Main Tuning	C51293
Function Switch Mounting Bracket	A51256
Panel Bushing, Function Switch	A50840
Palnut, Panel Bushing	B19322-8
Ground Strap, Synthesizer Capacitor	A51388
Connector, Male (Lamp Harness)	A51384-2
Connector, Female (Lamp Harness)	A51384-1
Clutch Assembly Main Tuning	A51729
Main Tuning Dial Assembly	A51731
Main Tuning Ball Vernier Assembly	A51730
Front Panel Complete	A51732
Cabinet	A51733
Insulator Block, Burst Tuning	B51266
Hub Mask — Left	A52130-1
Hub Mask — Right	A52130-2

MISCELLANEOUS ELECTRICAL

PL-6	Indicator Lamp Sylvania –6ESB	A51246-1
PL-1, PL-2	Panel Lamp #47	NPL47
PL-3, PL-4	Panel Lamp #53X	A51985
PL-5	Panel Lamp #1815	NPL1815
	Line Cord	B51077
M-1	S-meter	C51342
X-1	Crystal, 26 MHz	A51377
X-2	Crystal, 50 kHz	A51373
X-3	Crystal, 230 kHz	A51374
X-300	Crystal, 500 kHz	A51375
X-301	Crystal, 4.75 MHz	A51376