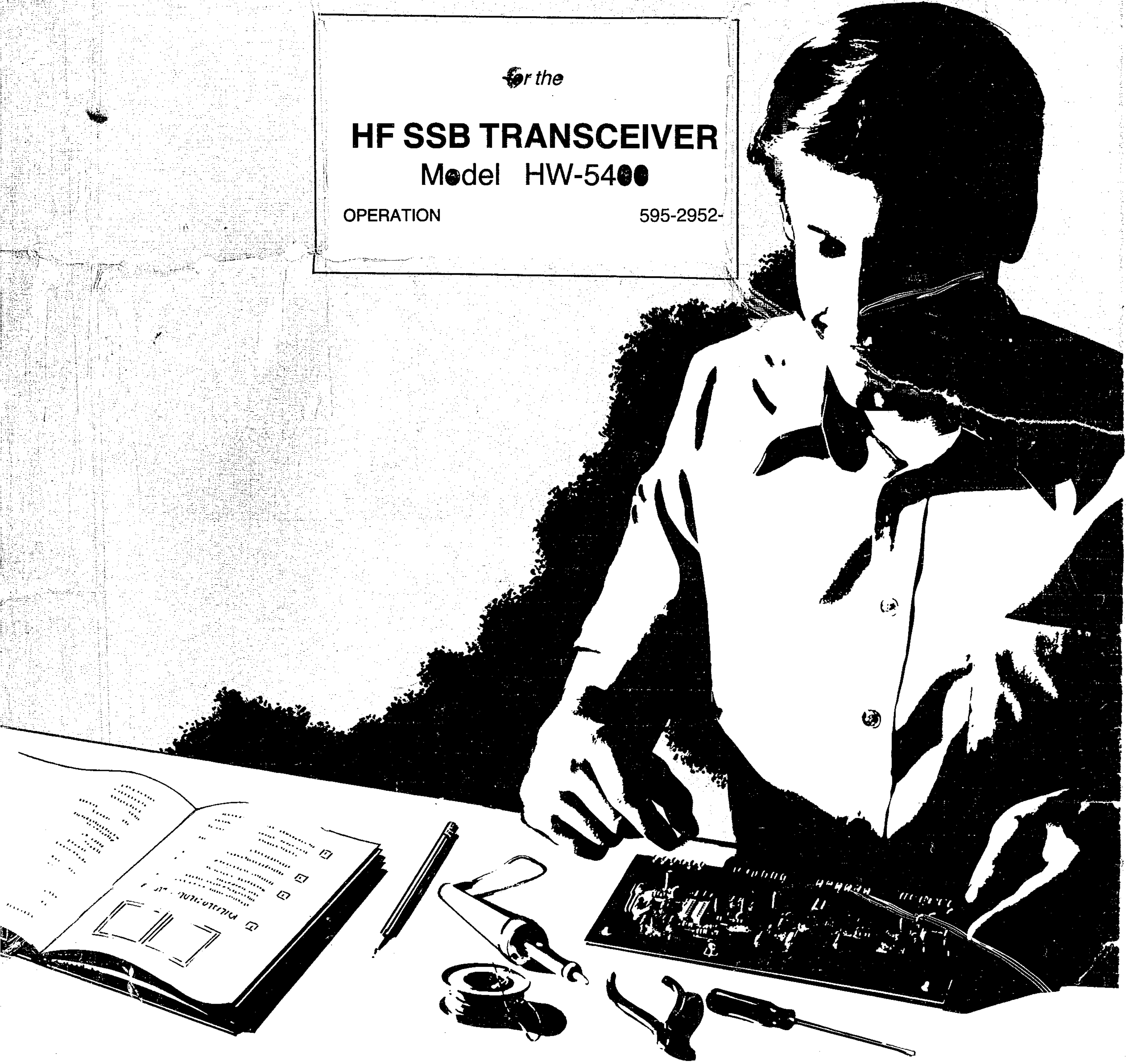
HEATHKIT® MANUAL

for the

HF SSB TRANSCEIVER

Model HW-5400

OPERATION 595-2952-



HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATH COMPANY PHONE DIRECTORY

The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information	(616) 982-3411
Credit	(616) 982-3561
Replacement Parts	(616) 982-3571

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HEATH

YOUR HEATHKIT 90-DAY LIMITED WARRANTY

Consumer Protection Plan for Heathkit Consumer Products

Welcome to the Heath family. We believe you will enjoy assembling your kit and will be pleased with its performance. Please read this Consumer Protection Plan carefully. It is a "LIMITED WARRANTY" as defined in the U.S. Consumer Product Warranty and Federal Trade Commission Improvement Act. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Heath's Responsibility

PARTS — Replacements for factory defective parts will be supplied free for 90 days from date of purchase. Replacement parts are warranted for the remaining portion of the original warranty period. You can obtain warranty parts direct from Heath Company by writing or telephoning us at (616) 982-3571. And we will pay shipping charges to get those parts to you . . . anywhere in the world.

SERVICE LABOR — For a period of 90 days from the date of purchase, any malfunction caused by defective parts or error in design will be corrected at no charge to you. You must deliver the unit at your expense to the Heath factory, any Heathkit Electronic Center (units of Veritechnology Electronics Corporation), or any of our authorized overseas distributors.

TECHNICAL CONSULTATION — You will receive free consultation on any problem you might encounter in the assembly or use of your Heathkit product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

NOT COVERED — The correction of assembly errors, adjustments, calibration, and damage due to misuse, abuse, or negligence are not covered by the warranty. Use of corrosive solder and/or the unauthorized modification of the product or of any furnished component will void this warranty in its entirety. This warranty does not include reimbursement for inconvenience, loss of use, customer assembly, set-up time, or unauthorized service.

This warranty covers only Heath products and is not extended to other equipment or components that a customer uses in conjunction with our products.

SUCH REPAIR AND REPLACEMENT SHALL BE THE SOLE REMEDY OF THE CUSTOMER AND THERE SHALL BE NO LIABILITY ON THE PART OF HEATH FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO ANY LOSS OF BUSINESS OR PROFITS, WHETHER OR NOT FORSEEABLE.

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

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EFFECTIVE WARRANTY DATE — Warranty begins on the date of first consumer purchase. You must supply a copy of your proof of purchase when you request warranty service or parts.

ASSEMBLY — Before seeking warranty service, you should complete the assembly by carefully following the manual instructions. Heathkit service agencies cannot complete assembly and adjustments that are customer's responsibility.

ACCESSORY EQUIPMENT — Performance malfunctions involving other non-Heath accessory equipment, (antennas, audio components, computer peripherals and software, etc.) are not covered by this warranty and are the owner's responsibility.

SHIPPING UNITS — Follow the packing instructions published in the assembly manuals. Damage due to inadequate packing cannot be repaired under warranty.

If you are not satisfied with our service (warranty or otherwise) or our products, write directly to our Director of Customer Service, Heath Company, Benton Harbor MI 49022. He will make certain your problems receive immediate, personal attention.

Heathkit® Manual

for the

HF SSB TRANSCEIVER

Model HW-5400

8.83140 -005

OPERATION 595-2952-02

8.82860 .005

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

TABLE OF CONTENTS

INSTALLATION

Pictorial 18-1 (Illustration Booklet, Page 1) shows you how to connect your Transceiver to some of your other station equipment. We recommend that you use shielded cable for all equipment interconnections.

LOCATION

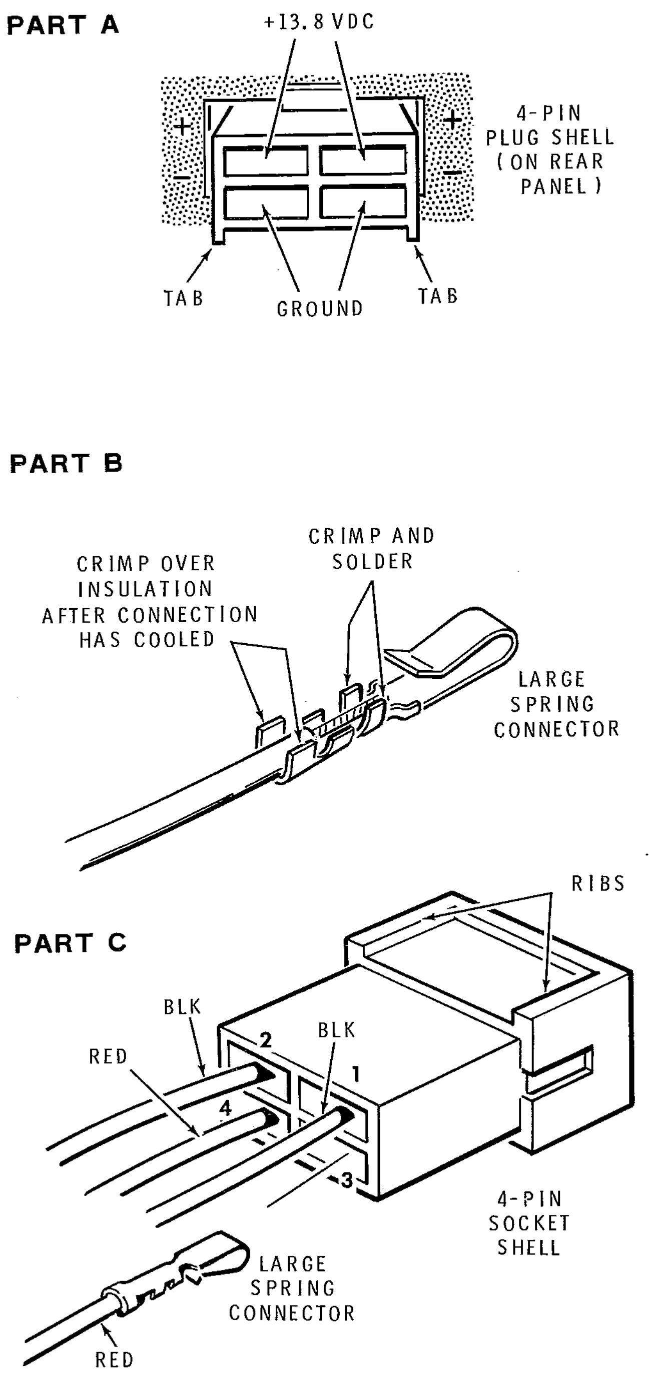
Carefully choose an operating location for the Transceiver so air can circulate freely around and through the cabinet. Do not place any books, magazines, or equipment under or on top of the cabinet. This could impede the free flow of air.

The location should also be dry and cool, and away from direct sunlight. Avoid extremes of heat and humidity.

POWER REQUIREMENTS

This Transceiver was designed to be used with the Heathkit Model HWA-5400-1 AC Power Supply/Speaker/Digital Clock. If you use any other power supply to power your Transceiver, be sure it can supply 13.8 VDC at 20 amperes. Be sure to use an acceptable fuse (not supplied) in the power cable.

NOTE: The following steps show you how to install the large spring connectors and the 4-pin socket shell on the free ends of the main power wires coming from the Model HWA-5400-1 Power Supply/Speaker/Digital Clock. If you use some other source of power, the wire colors called out may not match the colors of your wires.



Detail 18-1A

Detail 18-1A Part A shows the pinouts for the main power connector on the back of the Transceiver. NOTE: Due to the large amount of current drawn by the Transceiver while it is transmitting, two pins are provided for +13.8 VDC and two pins for ground.

Refer to Detail 18-1A and use the following procedure to install large spring connectors and a 4-pin socket shell on the free ends of the main power wires, coming from your Power Supply.

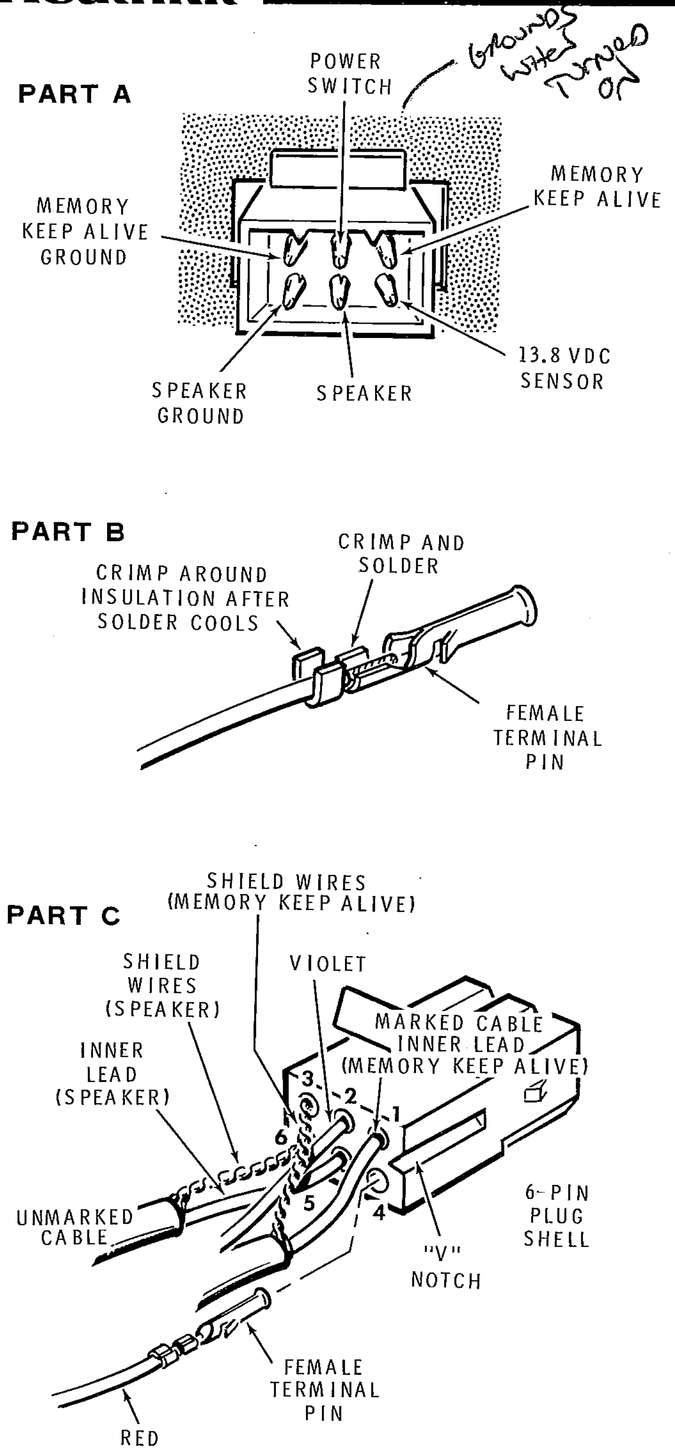
1. Cut off the ends of the red and black wires as necessary so they are all the same length. Then remove 1/4" of insulation from the end of each wire and prepare the ends.

2. Refer to Part B of the Detail and install a large spring connector on the end of each wire.

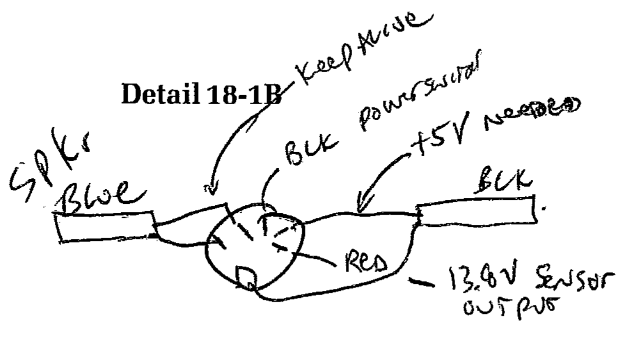
3. Position the 4-pin socket shell and the spring connector on the free end of one of the red wires (+13.8 VDC) as shown in Part C of the Detail (note the locations of the ribs). Then push the spring connector into hole 3 of the socket shell until it locks in place.

4. Similarly, push the spring connector on the free end of the remaining red wire (+13.8 VDC) into hole 4 of the socket shell.

5. Similarly, push the spring connectors on the free ends of the black wires (ground) into holes 1 and 2 of the socket shell.



Detail 18-1B



ACCESSORY SOCKET

The accessory socket contains connections for a speaker, power supply sense voltage, and a memory keep-alive supply.

NOTE: The following steps show you how to install female terminal pins and the 6-pin plug shell on the free ends of the 6-wire cable coming from the Model HWA-5400-1 Power Supply/Speaker/Digital Clock. If you use a different power source, the wire colors called out may not match the colors of your wires.

Detail 18-1B Part A shows the pinouts for the accessory socket on the back of the Transceiver.

Refer to Detail 18-1B and use the following procedure to install female terminal pins and a 6-pin plug shell on the free ends of the wires coming from your Power Supply:

1. Refer to Part B of the Detail and install a female terminal pin on the end of each wire.

2. Position the 6-pin plug shell as shown in Part C of the Detail (note the location of the "V" notch in the side of the shell). Then push the female terminal pin on the free end of the red wire (+13.8 VDC sensor) into hole 4 of the shell until it locks in place.

3. Push the female terminal pins on the unmarked shielded cable (speaker) into the holes in the 6-pin plug shell as follows:

   Inner lead into hole 5.
   Shield wires into hole 6.

4. Push the female terminal pins on the remaining shielded cable (memory keep alive) and wire into the 6-pin lug shell as follows:

   Inner lead of the marked shielded cable (memory keep alive) into hole 1.
   Violet wire (power switch) into hole 2.
   Shielded wires of the shielded cable (memory keep alive ground) into hole 3.

ANTENNA

Although your Transceiver cannot be damaged by an improper load at the antenna connector, under normal conditions, you should use a proper antenna for best results. Use an antenna and feed line that presents a 50 Ω load with a standing wave ratio (SWR) of less than 2:1 for the best efficiency. NOTE: As the SWR goes up, the protective circuitry in the Transceiver will automatically reduce the power output.

Antennas are available commercially from the Heath Company, and from other sources, or you can construct your own. A discussion of antennas is beyond the scope of this Manual. Refer to one of the several good handbooks on the subject, available from many electronic equipment dealers.

GROUNDING

Connect a good earth ground rod or water pipe ground to the ground post on the rear of the Transceiver. Use the heaviest and shortest connection available.

Before you use a water pipe ground, inspect the connections around your water meter and make sure there are no plastic or rubber hose connections that would interrupt electrical continuity to the water supply line. Install a jumper around any insulating water connections you find. Use heavy copper wire and pipe clamps. It is best to ground all of your equipment to one point at the operating position, and then to ground this point as described above.

KEY CONNECTIONS

In the CW mode, a positive voltage is present at the KEY jack on the rear panel of the Transceiver. If you use a keyer that has specific polarity requirements, be sure to connect the keyer to this jack properly.

MICROPHONE CONNECTIONS

Use a high-impedance microphone equipped with a push-to-talk switch (such as the Heathkit Model HDP-242) with this Transceiver so you can use either PTT or VOX to turn on the transmitter. A 4-pin connector (#432-1100) is available from the Heath Company for this purpose. Refer to Detail 18-1C (Illustration Booklet, Page 2) to install this connector on your microphone cable. If you use a microphone other than the one listed above, and you wish to use VOX, be sure the microphone element is not switched by the PTT switch.

SPEAKER CONNECTIONS

The Heathkit Model HWA-5400-1 AC Power Supply/Speaker/Digital Clock includes a cable to connect to the Accessory connector on the rear of the Transceiver. If you use a different speaker, be sure it has an impedance of 3.2 or 4 ohms.

LINEAR AMPLIFIER CONNECTIONS

Pictorial 18-1 shows the connections for a typical amplifier.

ALC

If your amplifier has an ALC (automatic level control) output provision (negative voltage), connect a cable between the ALC jack on the rear of the Transceiver and the linear amplifier. The ALC bias voltage from the amplifier helps prevent transmitter overloading and "splatter".

Although protective circuitry of this nature is a valuable circuit element, it is not a substitute for proper adjustment of the exciter and its drive level to the amplifier. Be sure to refer to the "Operation" section of this Manual for the proper tune-up procedure.

Antenna Relay

Many amplifiers have an internal transmit-receive relay which is activated when the relay coil circuit is grounded. Heath amplifiers are of this type. This Transceiver has an internal relay to operate the transmit-receive relay in a linear amplifier. You can use a shielded cable, connected between the Relay jack on the rear of the Transceiver and the linear amplifier, for this grounding connection.

NOTE: Be sure the Relay On/Off switch on the rear panel of the Transceiver is at On.

This completes the "Installation" of your Transceiver. Proceed to the "Operation" section of this Manual.

OPERATION

NOTE: You must have an amateur radio operator's license and a station license before you place the transmitter section of this Transceiver on the air. You can obtain information about licensing and amateur frequencies from the Federal Communicationss Commisssion as well as from many other sources.

Operation of this Transceiver has been simplified as much as possible so you can make rapid adjustments. Once you make the initial adjustments, it should not be necessary to readjust many of the controls. Read the following information carefully. Good operating techniques will provide good clean signals and long trouble-free life from this Transceiver.

FRONT PANEL CONTROLS AND CONNECTORS

Refer to Pictorial 19-1 (Illustration Booklet, Page 3) for the locations of the following front panel controls and connectors.

KEYPAD PUSHBUTTONS (accessory)

Allow you to directly access a frequency within a particular band. Refer to "Using the Keypad Accessory" (see Page 18) for more information.

DISPLAY

Displays the operating frequency to the nearest 50 Hz. Also indicates USB, LSB, CW, and split operation. During split operation, the display shows the operating frequencies of the transmitter and the receiver. The display also indicates when you have the **transmitter** set to a frequency that is outside the amateur band.

SYMBOLS:

←	Out-of-band transmit frequency indicator.
_	Split operation indicator.
M	Split-memory access.
U	Upper sideband mode indicator.
L	Lower sideband mode indicator.
C	CW mode indicator (either wide or narrow).
–	Transmit indicator.

METER

In the receive mode, the meter always indicates the strength of the incoming signal in S units.

In the transmit mode, the meter always indicates ALC.

VOX GAIN*

Adjusts the input level at which the voice-controlled relay circuits will operate. NOTE: VOX is defeated when the PTT/VOX pushbutton is in its released position.

ANTI VOX*

Adjusts the VOX circuits so a received signal from the speaker will not feed back into the microphone and key the transmitter.

VOX DELAY*

Sets the hold-in time of the transmit cycle in the VOX or CW modes.

SIDE TONE*

Controls the loudness of the sidetone signal when you are transmitting CW (or when the REC/TUNE pushbutton is depressed).

D→M

Copies the frequency shown on the display into memory. Any frequency that may already be in memory is lost.

D⇆M

Exchanges the frequency shown on the display with the frequency stored in memory. NOTE: After a power interruption, pressing this pushbutton causes the frequency to alternate between the upper and lower edges of the band that you have selected.

SPLIT

Allows you to transmit and receive on different frequencies. Refer to "Using Split-Frequency Operation" on Page 17 for more information.

REC/TUNE

Locks the Transceiver in the tune (CW) mode. You will hear a CW sidetone (if you have it turned up so you can hear it). Release this pushbutton to its out position to return to the receive mode. NOTE: This pushbutton has no effect when the Mode switch is at NORM or REV.

PTT/VOX

Selects either PTT (push-to-talk) or VOX control of the transmitter when you are using an SSB mode of operation.

When this pushbutton is in its released (or out) position, you must use the push-to-talk switch on the microphone to key the transmitter. When this pushbutton is in its depressed (or in) position, you can key the transmitter by simply speaking into the microphone, or by using the PTT switch.

*These controls are located under a small access door in the upper right-hand corner of the front panel. Push in on the top edge of the door to open it.

FAST/SLOW AGC

Selects fast or slow AGC action.

When this pushbutton is in its released (or out) position, fast AGC is activated. When this pushbutton is in its depressed (or in) position, slow AGC is activated.

PHONE

Allows you to use low-impedance headphones for private listening. Automatically disconnects the speaker.

MIC

Allows you to connect a high-impedance microphone. The mating connector (#432-1100) is available from the Heath Company. Refer to the "Installation" section of this Manual for the proper connections.

MODE

Selects the mode of operation.

CW-N: Same as CW-W, except it selects narrow CW (which uses a narrow CW active filter).

CW-W: Selects wide CW, USB mode, and uses the regular SSB filter. The CW sidetone oscillator is enabled, but the microphone input is inhibited. You can only turn the transmitter on by connecting a key to the KEY jack on the rear panel or by pressing the TUNE pushbutton. NOTE: If you press the microphone PTT switch in this mode, the Transceiver will change to transmit but you will have to close the CW key to obtain any output. (This disables the break-in feature and allows you to keep the Transceiver in the transmit mode when you use CW.)

NORM: Selects single sideband operation and uses the regular SSB filter. Microphone audio input is active and CW operation is inhibited. NOTE: When you use this mode, lower sideband is automatically selected for 80 and 40 meters; upper sideband is automatically selected for the other six bands.

REV: Same as NORM, except that it selects the opposite sideband on each band.

MIC/CW GAIN

Sets the output level of the transmitter.

The small knob adjusts the audio drive to the transmitter in the NORM or REV modes (this control is disabled in the CW modes).

The large knob adjusts the transmitter output to the desired level in the CW modes (this control is disabled in the SSB modes). Full clockwise is maximum power output (100 watts nominal).

MAIN TUNING

Manually adjusts the frequency up or down in 50 Hz steps (approximately 1.25 kHz per revolution). Use the metal insert to change the frequency in 1 kHz increments (approximately 25 kHz per revolution). NOTE: When you use the metal insert, the last two digits of the display will blank and will not change (when you remove your finger, the last two digits will be the same as they were before you touched the insert).

AF/RF GAIN

Adjusts the audio and RF gain of the receiver.

The small knob turns on the power to the Transceiver and controls the audio level of the received signal. The volume increases with clockwise rotation of this control.

The large knob sets the RF attenuation of the RF signal at the front end of the receiver. Clockwise rotation increases the receiver sensitivity. Full clockwise is the normal setting for this control. Turn the control counterclockwise to reduce sensitivity when exceptionally strong signals are present, or reduce adjacent-channel interference.

RIT/SHIFT

Allows you to vary the receiver frequency and the IF center frequency to reduce interference.

The small knob provides receiver incremental tuning. Set the knob to its center (detent) position for no receiver frequency offset. Counterclockwise rotation reduces the frequency while clockwise rotation increases the frequency.

The large knob provides IF shift. Set the knob to its center (detent) position for no IF offset. Counterclockwise rotation lowers the center frequency of the IF filter, while clockwise rotation raises the center frequency.

BAND

Selects the desired amateur band. NOTE: WWV (National Bureau of Standards) at 10 MHz is available on the 30 meter band. The markings on the front panel indicate the amateur band in meters.

REAR PANEL CONTROLS AND CONNECTORS

Refer to Pictorial 19-2 (Illustration Booklet, Page 4) for the locations of the following rear panel controls and connectors.

ANTENNA

Provides a connection for your station antenna.

GND

Provides a station ground connection for the Transceiver.

ALC

Accepts ALC input (negative-going voltage) from a linear amplifier.

RELAY

Allows you to key the relay in a linear amplifier (goes to ground in the transmit mode).

ACCESSORY

Provides a connection for your power supply and speaker.

ON/OFF:	Allows you to turn on your power supply from the front of the Transceiver. This pin goes to ground when the switch is in the On position.
GND:	Provides a ground connection for a memory keep-alive voltage source.
MEMORY:	Allows you to connect a continuous external (5 volt) voltage source to keep the memory contents intact when the Transceiver is turned off.
SPKR GND:	Provides a ground connection for an external speaker.
SPKR:	Provides a connection for your station speaker (4 ohms).
13.8 VDC SENSOR:	Provides a sensor connection for your power supply regulator circuits (for automatic voltage correction at the Transceiver under varying loads).

RELAY ON/OFF

Allows you to disable the linear relay inside the Transceiver for quieter operation when you are not using a linear amplifier.

KEY

Allows you to use a telegraph key or electronic keyer for the CW mode of operation (ground this jack to key the transmitter). NOTE: This is a positive key line.

13.8 VDC

Provides a connection for your 13.8-volt DC power supply (has two positive (+) and two negative (−) terminals).

INTERNAL CONTROLS

Refer to Pictorial 19-3 (Illustration Booklet, Page 4) for the locations of the following internal controls.

NOTE: Only those controls that you may wish to readjust during the normal operation of this Transceiver are explained here. Refer to the "Realignment" section of this Manual for the other internal controls.

ZERO

Allows you to set the S-meter to zero when no signal is being received.

SENS

Allows you to set the S-meter sensitivity.

SPECIAL SYMBOLS

Allows you to set the intensity of the special symbols on the left side of the display to high, medium, or off.

HI: Same intensity as the frequency display.

MED: Less intensity than the frequency display.

OFF: No special symbols.

INITIAL ACTIONS

NOTE: Once you adjust your Transceiver controls for either SSB or CW operation, all that is necessary to place your Transceiver on the air is to turn the Transceiver on. Other than selecting your frequency, no other action is required.

Before you attempt to use your Transceiver, check to make sure you have made all of the following connections:

1. An antenna for the band you intend to use should be connected to the Antenna jack on the rear panel.
2. A 3.2-ohm or 4-ohm speaker should be connected to the SPKR pins on the Accessory socket on the rear panel, or headphones should be plugged into the Phone jack on the front panel.
3. The Model HWA-5400-1 Power Supply or equivalent should be connected to the 13.8 VDC socket on the rear panel.
4. For best results, the Transceiver GND post should be connected to a good earth ground.

5. If you are using a linear amplifier:

   A. You should connect the ALC output of the amplifier to the ALC jack on the rear panel of the Transceiver.

   B. If the amplifier's transmit/receive relay is the type that is activated by grounding the relay coil, connect the amplifier's relay coil connection to the RELAY jack on the rear panel of the Transceiver.

   C. Make sure the RELAY ON/OFF switch is at ON.

6. Preset the front panel controls and switches as follows (CW means fully clockwise, CCW means fully counterclockwise):

   MODE—NORM.

   MIC GAIN—CCW.

   CW GAIN—CCW.

   REC/TUNE—Released (out).

   PTT/VOX—PTT.

   AF GAIN—CCW to OFF.

   RF GAIN—CW.

   RIT—Center of rotation (detent).

   IF SHIFT—Center of rotation (detent).

   BAND—Desired band.

NOTE: The settings of the other controls and switches are not important at this time.

RECEIVING

The receiver in this Transceiver is broad banded and requires no preselector tuning. Use an antenna designed for a 50 ohm impedance, or use an antenna coupler for matching the antenna's impedance to 50 ohms.

1. Check the connections in "Initial Actions" on Page 14.

2. Turn the power supply on, if this has not already been done. Then use the AF GAIN control to turn on the Transceiver. Adjust this control for the desired audio output.

3. If you intend to use VOX operation, depress the PTT/VOX pushbutton. Set your station microphone in the position it will occupy during normal operation, and tune in a strong station. The receiver may cycle on and off with voice peaks of a strong station. Turn the ANTI VOX control (refer to Pictorial 19-1) clockwise until the cycling action ceases. Do not advance the control beyond this point.

4. You may adjust the AGC switch to a different setting, but many SSB operators prefer SLOW. CW operators may prefer FAST.

5. If you desire, use the RIT control to fine tune a station.

TRANSMITTING

The power amplifier in this Transceiver is designed for service in any mode. For best performance, you must keep the vents on the top and bottom of the Transceiver free of restrictions.

SSB TRANSMISSION

1. Check the connections in "Initial Actions" on Page 14.
2. Turn the MODE switch to NORM (if you intend to use the conventional sideband for the band you select) or to REV (if you intend to use the opposite sideband). The display will indicate the sideband.
3. Turn the BAND switch to the desired band.
4. For PTT (push-to-talk), use the switch on the microphone to operate the transmit/receive switch.
5. For VOX operation, advance the VOX GAIN control until the transmitter keys with normal speech.
6. For VOX operation, advance the VOX DELAY control further until the transmitter holds in for the desired length of time after you cease talking.
7. Speak into the microphone and advance the MIC GAIN control until the meter kicks up into the ALC scale on voice peaks. CAUTION: Do not advance the control beyond this point because it will not increase power output, and may overdrive the power amplifier, which will result in clipping of voice peaks and cause sideband "splatter".
8. This completes the SSB tune-up procedure; you can now transmit.

CW TRANSMISSION

1. Preset the controls as in "Initial Actions" on Page 14.
2. Turn the MODE switch to the desired CW mode (wide or narrow).
3. Be sure a key is connected to the KEY jack on the rear panel.
4. Adjust the VOX DELAY control (see Pictorial 19-1) for the desired hold-in time.
5. Adjust the SIDE TONE control (see Pictorial 19-1) for the desired volume with keying (or Tune).
6. Adjust the CW GAIN control for the desired output (between 40 and 60 on the meter).
7. This completes the CW tune-up procedure.

LINEAR AMPLIFIER

If you use an amplifier with this Transceiver, DO NOT advance the Transceiver's gain beyond the point where amplifier output ceases to increase with rotation of the CW GAIN control.

USING SPLIT-FREQUENCY OPERATION

1. Use the MAIN TUNING knob to select the desired transmitter frequency. Do not push the SPLIT pushbutton yet when you do this.

2. Push the D→M pushbutton to copy the display (transmitter) frequency into memory.

3. Use the MAIN TUNING knob to select the desired receiver frequency. DO NOT push the D→M pushbutton after you do this.

4. Push the SPLIT pushbutton. NOTE: Whenever the Transceiver is in the split mode of operation, an indicator (short dash) will light on the left side of the display (unless the special symbols jumper is set to OFF).

After you perform the above steps, the display will indicate the receiver frequency in the receive mode and the transmitter frequency in the transmit mode. NOTE: In the split mode, you can still use the MAIN TUNING to vary the receiver frequency, but the transmitter frequency will remain unchanged.

Now, assume you wish to change the transmitter frequency without affecting the receiver frequency (due to QRM on your frequency). Use the following procedure to change the transmitter frequency while listening to the station you are communicating with. NOTE: DO NOT push the SPLIT pushbutton again.

1. Push the D⇆M pushbutton. The "M" (memory) indicator on the left side of the display will light. NOTE: The display will change to the current transmitter frequency, but the actual receiver frequency will not change (allowing you to continue listening to the other station).

2. Use the MAIN TUNING to vary the displayed frequency to the desired transmitter frequency.

3. Push the D⇆M pushbutton to exchange the display frequency with the frequency now in memory (the actual receiver frequency).

After you perform the above steps, the display will indicate the receiver frequency (unchanged) in the receive mode, and the new transmitter frequency in the transmit mode. NOTE: You can now use the MAIN TUNING to vary the receiver frequency as described earlier.

USING THE KEYPAD ACCESSORY

Use the following method to select a frequency with the keypad (if you have the Keypad Accessory installed in your Transceiver):

1. Press the ENT (Enter) pushbutton. The most significant digit (next to the mode display) will disappear and a cursor (–) will appear at the bottom segment of this digit.

2. Press a digit pushbutton. Each digit pushbutton will enter that digit into the display at the location of the cursor, which will then move one position to the right.

When the least significant digit is entered, the cursor will disappear and the Transceiver will access the new frequency, if it is within the allowed band limits. If it is not, the band-edge frequency that is nearest to the entered frequency will be accessed instead. If you press the ENT pushbutton instead of a digit pushbutton, the cursor will advance over that digit and leave it unchanged.

IN CASE OF DIFFICULTY

Begin your search for any trouble that occurs after assembly by carefully following the steps listed below under "Visual Tests." After you complete the "Visual Tests," refer to the Troubleshooting Charts. Start with the chart labeled "General Problems" and locate your problem in the left column of this chart. The right column of the chart shows you which components could be at fault and may give you typical voltage indications on a specific component. This chart may also direct you to another chart that deals with a specific circuit board. Refer to the "Circuit Board X-Ray Views" (Illustration Booklet, Pages 8 thru 13) for the physical locations of parts on the circuit boards.

VISUAL TESTS

1. Recheck the wiring. Trace each lead with a colored pencil on the Pictorial as you check it. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something that you have consistently overlooked.

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering. Therefore, you can eliminate many troubles by reheating all of your connections to make sure they are soldered as described on Page 13 of the Assembly Manual. Be sure there are no solder "bridges" between circuit board foils.

3. Check to be sure all transistors and diodes are in their proper locations. Make sure each lead is connected to the proper point. Make sure that each diode band is positioned above the band printed on the circuit board or as directed in its step.

4. Check electrolytic and tantalum capacitors to be sure their positive (+) or negative (−) mark is at the correct location.

5. Check to be sure that each IC is properly installed, and that the pins are not bent out or under the IC. Also be sure the ICs are installed in their correct locations.

6. Check the values of the parts. Be sure in each step that you wired the correct part into the circuit, as shown in the Pictorial. It would be easy, for example, to install a 22 kΩ (red-red-orange) resistor where a 2200 Ω (red-red-red) resistor should have been installed.

7. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

8. Look between each circuit board and the chassis to be sure all leads were cut off short.

9. A review of the "Circuit Description" may also help determine where the trouble is.

If you have still not located the trouble after you complete the "Visual Tests," and a voltmeter is available, check voltage readings against those shown on the Schematic Diagram. Read "Precautions for Troubleshooting" before you make any measurements. NOTE: All voltage readings were taken with a high input impedance voltmeter. DC voltages and resistances may vary as much as ± 20%.

PRECAUTIONS FOR TROUBLESHOOTING

Be sure you do not short any terminals to ground when you make voltage measurements. If the probe should slip, for example, and short across components or voltage sources, it is very likely to cause damage to one or more components.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Customer Service" information inside the rear cover of this Manual. Your Warranty is located inside the front cover.

TROUBLESHOOTING CHARTS

The following charts list the condition and the possible causes of several malfunctions. If a particular part is mentioned as a possible cause, check that part to see if it was correctly installed. Also check the parts connected to it for poor connections. It is also possible, on rare occasions, for a part to be faulty and require replacement.

GENERAL PROBLEMS

CONDITION	POSSIBLE CAUSE OR TEST
Transceiver does not turn on.	A. On-Off switch SW3 or wiring. B. See "Filter Circuit Board Problems." C. Relay K1 or wiring. D. Check for less than 16 VDC at red wires on plug P1 (main power plug). If you have more than 16 VDC, check your power supply. E. Check for 13.8 VDC at pin 6 of socket S2 (Accessory socket).
Main relay clicks but Transceiver does not stay on.	A. Check for correct voltage from your power supply. B. See "Filter Circuit Board Problems" (overvoltage protection circuits).
No display.	A. See "Display Circuit Board Problems."
Display indicates "PLL".	A. See "Synthesizer Problems."
Mode switch does not operate.	A. See "Controller Circuit Board Problems."

RECEIVER PROBLEMS

CONDITION	POSSIBLE CAUSE OR TEST
Display is normal, but no sound from receiver.	A. See "Audio Circuit Board" chart. B. Accessory plug connections or wiring. C. Phone jack J3 or wiring.
Sound okay, but no meter movement.	A. See "IF Circuit Board" chart. B. Check meter and wiring. C. Check for 9 VDC on display circuit board plug P201 pin 2. D. Check for 3.2 VDC on display circuit board plug P201 pin 1 (in receive).
Sound is okay, meter indicates, but no receiver signals.	A. See "Audio Circuit Board" chart. B. See "BFO Circuit Board" chart. C. See "RF Circuit Board" chart. D. See "Filter Circuit Board" chart. E. Check Band switch installation (and alignment). F. See "ALC Circuit Board" chart.
RF Gain control does not operate.	A. RF Gain control R2A or wiring. B. See "RF Circuit Board" chart.
IF Shift control does not operate.	A. IF Shift control R3A or wiring. B. See "BFO Circuit Board" chart.
RIT control does not operate.	A. RIT control R3B or wiring. B. See "IF Circuit Board" chart. C. See "Controller Circuit Board" chart.
Fast/Slow AGC switch does not operate	A. AGC switch SW3 or wiring. B. See "IF Circuit Board" chart.
No audio with Mode switch at CW-N.	A. See "Audio Circuit Board" chart.

TRANSMITTER PROBLEMS

CONDITION	POSSIBLE CAUSE OR TEST
Receiver okay, but no transmitter carrier.	A. See "Audio Circuit Board" chart (balanced modulator). B. See "RF Circuit Board" chart. C. See "Power Amplifier Assembly" chart. D. See "IF Circuit Board" chart.
Transmitter carrier okay, but low output.	A. See "ALC Circuit Board" chart (L651). B. See "IF Circuit Board" chart (U1101). C. See "Audio Circuit Board" chart (balanced modulator).
Transmitter carrier okay, but high output.	A. See "ALC Circuit Board" chart (Q651). B. See "IF Circuit Board" chart (U1101).
Transmitter and receiver do not operate.	A. Refer to "Receiver Problems" chart and troubleshoot receiver first.
VOX does not operate.	A. Microphone socket J2 or wiring. B. Microphone wiring. C. See "Audio Circuit Board" chart. D. VOX control R209 or wiring on the display circuit board.
PTT does not operate.	A. Microphone socket J2 or wiring. B. Microphone wiring. C. See "Audio Circuit Board" chart (T/R circuit).
No Sidetone.	A. See "Audio Circuit Board" chart. B. Sidetone control R213 or wiring on the display circuit board. C. REC/Tune switch SW5 or wiring.
No transmitter audio.	A. Microphone socket J2 or wiring. B. Microphone wiring. C. See "Audio Circuit Board" chart. D. Mic Gain control R4B or wiring.
CW Gain control does not operate.	A. CW Gain control R4A or wiring. B. See "Audio Circuit Board" chart.
Transmitter does not operate relay in linear amplifier.	A. Slide switch SW2 or wiring. B. See "ALC Circuit Board" chart (P651). C. See "Filter Circuit Board" chart.

AUDIO CIRCUIT BOARD

CONDITION (Receive Mode)	POSSIBLE CAUSE OR TEST
No sound.	A. Touch either lead of resistor R1038 with a screwdriver. If you do not hear a hum, check U905. B. Touch either lead of resistor R1004 with a screwdriver. If you do not hear a hum, check U906, D912, Q922 through Q928, or AF Gain control R2B. C. Check U903. D. Wrong value resistor at R1043.
Audio hiss, but no signals.	A. Check U904. B. Use RF probe to check for .1 volt RMS at plug P905 pin 5. If not, see "BFO Circuit Board" chart. C. If voltage at P905 pin 5 is okay, see "IF Circuit Board" chart.
No sound with Mode switch at CW-N.	A. Check for 5 VDC at plug P914 pin 6. If not, see "BFO Circuit Board" chart. B. Check Q926, Q927, or Q928.
No receiver R12 voltage.	A. Check for 0 volts at base of Q917. B. Check for 12.5 volts at base of Q918. C. Check for 12.5 volts at emitter of Q919. D. See "No Transmit T12 Voltage" below.

CONDITION (Transmit Mode)	POSSIBLE CAUSE OR TEST
No transmit audio.	A. Check U901C. B. Check P915 or P908. C. Check Mic Gain control R4B. D. Check P917. E. Check Q902, Q903, or Q901. F. Check for 9 volts at plug P908 pin 3.
VOX does not operate.	A. Check D905, D906, Q909, Q911, or Q912. B. Check microphone connector J2 or wiring. C. Check microphone wiring. D. Check PTT/VOX switch SW4 or wiring. E. Check for 0 volts at plug P913 pin 1. F. Check for 9 volts at plug P914 pin 5. G. Check VOX Gain control R209 or wiring on the display circuit board.
No Sidetone.	A. Check Key jack J1 or wiring. B. Check D911, D912, or Q907. C. Check U901D or U901A. D. Check Side Tone control R213 or wiring on the display circuit board.
Anti-VOX does not operate.	A. Check Anti-VOX control R211 or wiring on the display circuit board. B. Check Q908, D908, or D907.
No transmit T12 voltage.	A. Check Q913 or D909. B. Check for 0 volts at base of Q914. C. Check for 12.5 volts at base of Q915. D. Check for 12.5 volts at emitter of Q916.

AUDIO CIRCUIT BOARD (Cont'd.)

CONDITION (Transmit Mode Cont'd.)	POSSIBLE CAUSE OR TEST (Cont'd.)
VOX delay does not operate.	A. Check Q909 or Q911. B. Check C948 or C947. C. Check VOX Delay control R214 or wiring on the display circuit board.
PTT does not operate.	A. Check microphone connector J2 or wiring. B. Check Q912.
CW Gain control does not operate (CW transmit mode).	A. Check D904 or D903. B. CW Gain control R4A or wiring. C. Check for .2 volt at collector of Q906.
No carrier.	A. Check Q905. B. Check for .1 volt RMS at U902 pin 9. C. Check for .1 volt RMS at emitter of Q904.
No carrier null.	A. Check U902. B. Check Q905.

CONDITION (Miscellaneous)	POSSIBLE CAUSE OR TEST
No +9 volts DC.	A. Check U903. B. Check L904. C. Check D913.
No +12.5 volts DC.	A. Check Q921. B. Check P914 pins 1 and 2.

BFO CIRCUIT BOARD

CONDITION (General)	POSSIBLE CAUSE OR TEST
No signals in the USB or LSB mode.	A. Check for 5 volts RMS at the base of Q804. If voltage is not correct, check items B through H. B. Check L806 or L803. C. Check D808 or D811. D. Check Y801 or Y802. E. Check for 8.5 volts at the collector of Q804 (in LSB mode). F. Check for 8.5 volts at the collector of Q802 (in USB mode). G. Check Q801 or Q803. H. Check for 5 volts at plug P805 pins 1 and 2. If not correct, see "Controller Circuit Board" chart.
No BFO signal.	A. Check for .8 volt RMS at the emitter of Q814 or Q813. B. Check L807 or L802. C. Check for .1 to .2 volt RMS at plug P801 pin 2 or P802 pin 2.

BFO CIRCUIT BOARD (Cont'd.)

CONDITION (Receive mode)	POSSIBLE CAUSE OR TEST
IF Shift does not operate.	A. Check D812. B. Check IF Shift control R3A or wiring. C. Check P804 pin 2.
No +9 volts in a CW mode.	A. Check Q809 or Q811. B. Check D806, D807, or P805. C. Check for 5 volts at plug P805 pin 3 or 4. If voltage is not correct, see "Controller Circuit Board" chart.
No +9 volts in an SSB mode.	A. Check Q805, Q807, or Q806. B. Check D803, D801, or D802. C. See the above condition.
No +9T volts in an SSB mode.	A. Check Q808. B. Check D813 or D804. C. See "No +9 Volts in an SSB Mode".
Cannot center frequency in an SSB mode.	A. Check D812. B. Check control R834. C. See the condition above.
Cannot center frequency in a CW mode.	A. Check D814 or D805. B. Check control R837. C. Check Q812. D. See the condition "No +9 volts in a CW Mode."

IF CIRCUIT BOARD

CONDITION (Receive mode)	POSSIBLE CAUSE OR TEST
AGC does not operate.	A. Check Q1106. B. Check D1101 or D1102. C. Check U1101 D. Check for 3.2 volts DC at U1101 pin 1.
No ALC on the S meter.	A. Check Q1107. B. Check U1101. C. Check P1101. D. See "Display Circuit Board" chart.
RIT control does not operate.	A. Check Q1108 through Q1112. B. Check P1107. C. Check RIT control R3B or wiring.
No IF signal.	A. Check Q1101, Q1103, Q1104, or Q1105. B. Check for .6 volt at base of Q1102. C. Check T1101 through T1104. D. Check P1103 or P1104. E. See "No AGC" above.

IF CIRCUIT BOARD (Cont'd.)

CONDITION (Transmit mode)	POSSIBLE CAUSE OR TEST
No transmitter signal.	A. Check Q1103. B. Check T1102 or 1107. C. Check for less than .1 volt RMS at plug P1103. D. Check for .3 volt RMS at plug P1104. E. Check for .1 volt RMS at gate of Q1103. F. Check for 6 volts RMS at drain of Q1103. G. Check U1101. H. See "ALC Circuit Board" chart.
RIT does not center in the transmit mode.	A. Check Q1108 or Q1111. B. Check RIT control R3B or wiring.

RF CIRCUIT BOARD

CONDITION (Receive mode)	POSSIBLE CAUSE OR TEST
No receiver signals.	A. Check P401 or P407. B. Check Band switch alignment (wafers SW401A, SW401B, and SW401C. C. Check T401. D. Check D401, D402, D403, D407, or D408. E. Check L401, L408, L438, or L439. F. Check for .4 volt RMS at plug P406. If the voltage is not correct, see "Synthesizer Circuit Board" chart. G. Check Q404 or Q405. H. Check RF Gain control R2A or wiring. I. Check D409 or D411. J. Check L441, L442, or L444. K. Check for 3.2 volts at plug P405 pin 2. If voltage is not correct, see "IF Circuit Board" chart (AGC problem). L. Check U401. M. Check D412 or L445. N. Check Q411.
No receiver signal on only one band.	A. Check Band switch and its corresponding filters. B. Check bandpass filter alignment. C. See "Controller Circuit Board" chart. D. Check for .4 volt RMS at plug P406. If voltage is not correct, see "Synthesizer Circuit Board" chart. E. See "Filter Circuit Board" chart.
IF trap does not work.	A. Check C407, C406, or C405. B. Check L404 or L405.

RF CIRCUIT BOARD

CONDITION (Transmit mode)	POSSIBLE CAUSE OR TEST
No transmit signal.	A. Troubleshoot receiver first. B. Check U402. C. Check for .3 volt RMS at plug P408 pin 5. D. Check for .4 volt RMS on T403. E. Check for .25 volt RMS at base of Q402. F. Check for .3 volt RMS at emitter of Q401. G. Check L438 or L406. H. Check D404 or D408. I. Check for 1.5 volt DC at base of Q403 (transmitter keyed). J. Check Q412, D405, or D406. K. Check for 4 volts RMS or greater at plug P402 pin 1. L. Check T402 or wiring.
Cannot key transmitter in a CW mode.	A. Check Q402, Q406, or Q407. B. See "Controller Circuit Board" chart. C. Check D405. D. Check L445.
Cannot key the transmitter in an SSB mode.	A. Check Q409. B. Check D427 or D405. C. Check Q412.

FILTER CIRCUIT BOARD

CONDITION	POSSIBLE CAUSE OR TEST
No receive or transmit signal.	A. Check Band switch and wiring. B. Check each low-pass filter. C. Check for 0 volts DC at plug P554 pin 3 (receive mode). D. Check K551. E. Check socket S1202 on the power amplifier circuit board.
No +10 volts DC at plug P553 pin 2.	A. Check Q555 or Q556. B. Check D555. C. Check plug P402 pin 1. D. Check for 13.8 volts DC at plug P553 pin 1.
Relay K1 does not close.	A. Check Q551 or Q552. B. Check D552. C. Check for 16 volts DC or less at plug P551 pin 2. D. Check relay K1 or wiring.
No power amplifier bias voltage.	A. Check Q554 or Q553. B. Check D554. C. Check for 12.5 volts DC at plug P553 pin 3 (transmit mode). D. Check feedthrough capacitor C1225 on the power amplifier assembly.
Cannot key the linear in the transmit mode.	A. Check slide switch SW2 or wiring. B. Check for 0 ohms at plug P551 pin 5 (transmit mode). C. Check K552. D. Check socket S653 on the ALC circuit board.

POWER AMPLIFIER ASSEMBLY

CONDITION	POSSIBLE CAUSE OR TEST
No power output.	A. Check for .68 volt DC on bases of Q1201 and Q1202. If this voltage is not correct, see "No Bias" below. B. Check T1201, T1202, T1203, or T1204. C. Check for .68 volt DC on bases of Q1203 and Q1204. If this voltage is not correct, see "No Bias" below. D. Check for .62 volt DC on bases of Q1206 and Q1207. If this voltage is not correct, see "No Bias" below. E. Check for 13.8 volts DC on the collectors of all transistors on the power amplifier circuit board. F. Check all diodes for correct installation.
Low power output on one or more bands.	A. Check causes A through F under "No Power Output" above. B. Check components on the bases of Q1201 through Q1207. C. See "RF Circuit Board" chart. D. See "ALC Circuit Board" chart.
No bias.	A. Check D1201 through D1204. B. Check Q1205. C. See "Filter Circuit Board" chart.

ALC CIRCUIT BOARD

CONDITION	POSSIBLE CAUSE OR TEST
Low power output.	A. Check L651. B. Check Q651, Q653, or Q654. C. Check D651 or D652. D. Check Q652 (high VSWR). E. Check for 3.2 volts DC at plug P651 pin 3 (in transmit mode). If this voltage is not correct, see "IF Circuit Board" chart.
Cannot key linear amplifier in the transmit mode.	A. Make sure socket S653 goes to ground (0 ohms) in the transmit mode. If it does not, see "Filter Circuit Board" chart. B. Check linear to be sure it is the grounded keying type.
No linear ALC.	A. Check linear to be sure it uses a negative-going ALC voltage. If not, consult its manufacturer. B. Check D653 or D654. C. See "Low Power Output" above.

DISPLAY PROBLEMS

CONDITION	POSSIBLE CAUSE OR TEST
Blank display.	A. Check for 20 volts at plug P201 pin 3. B. Check for 5 volts at plug P203 pin 6. C. Check D203. D. Check U202.
Dim display.	A. Check for 20 volts at plug P201 pin 3.
Tuning speed does not change.	A. Check adjustment of control R208. B. Check U203, U205, U206, or D204. C. Check the wire inside the Main Tuning knob to make sure it is making proper contact.
No comma display.	A. Check D201.
No decimal in display.	A. Check D202.
Cannot select a particular band.	A. Check diodes that are associated with the band. (Example: Check D223 and D224 for the 15-meter band.)
Display brightness not uniform from top to bottom.	A. Open filament in the display tube V201.
Mode switch changes mode on the display, but mode does not change.	A. Check U709 on the controller circuit board.
Same segment in each display digit does not light.	A. Exchange U201 and U202. If symptoms change, check U201.
Some digits do not light.	A. Exchange U201 and U202. If symptoms change, check U202. B. Check U203. C. Check U204.

SYNTHESIZER PROBLEMS

NOTE: Before you use the following troubleshooting information, be sure your display circuit board is operating correctly. If it is not operating properly, refer to "Display Problems" before you continue.

Loop 2 (PLL-2) is the easiest of the three phase-locked loops to troubleshoot. This loop is independent from the other loops and involves no frequency mixing. Once you have loop 2 operating, you should troubleshoot loop 1, as it requires a signal from loop 2.

After loops 1 and 2 are operating properly, you can troubleshoot loop 3. This loop requires outputs from VCO's 1 and 2, output from the BFO circuit board, and (on the 20- through 10-meter bands) the 10 MHz signal from the controller circuit board.

The following procedure provides you with some preliminary voltage checks and then leads you through loops 2, 1, and 3, respectively. Make the preliminary tests first, then skip over the parts of the procedure that are not required to troubleshoot your particular problem. If a measurement does not agree with the value specified, or a procedure does not produce the expected results, correct the problem. Then return to the "Realignment" section of this Manual. If a "Check" step asks you to make an adjustment to a coil or a trimmer capacitor that was adjusted previously, make sure that you follow the procedure in the corresponding part of the "Realignment" section of this Manual to make sure it is readjusted correctly.

NOTES:

1. Although it is possible to lock loop 1 while loop 2 is unlocked, and to lock loop 3 while loops 1 and 2 are unlocked, it is important to lock the loops in the order provided.

2. Use the RF probe provided and a VTVM with a high input impedance (10–11 megohms) to take the measurements in this procedure. Your measurements may vary ± 20%.

Preliminary Checks

CHECK	PROBLEM AREA
1. Check for 11 volts at pin 7 of U704, U707, or U713.	A. Inverter circuit board.
2. Check for 9 volts on the lead of the center feedthrough capacitor on the synthesizer circuit board shield.	A. Audio circuit board (U903 or D913).
3. Check for 11 volts at C314 on the 80-, 40-, and 30-meter bands; 0 volts on the other bands.	A. RF circuit board. B. Q118. C. Q119.
4. Check for 0 volts at C367 on the 80-, 40-, and 30-meter bands; 11 volts on the other.	A. RF circuit board. B. Q116. C. Q117.
5. Check for 9 volts at the following points. Be sure to select the band indicated. BAND — TEST POINT 80M — C317 40M — C316 20M — C372 17M — C371 15M — C369	A. RF circuit board.

The above procedure verified that the required DC source and switching voltages are present.

Loop 2 Troubleshooting

NOTE: Observe LED D705 on the controller circuit board to determine whether or not this loop is locked. If this LED stays lit when you adjust coil L102, the loop is not locked.

CHECK		PROBLEM AREA	
1.	Check for 4.5 volts (RF) at U712 pin 6.	A.	U703.
2.	Check for 1.8 volts (RF) at U712 pin 3.	A. B. C.	Q101. Q102. Q103.
3.	Check for a positive pulse at U712 pin 11 as the frequency steps when you turn the Main tuning knob. (Use a logic probe or an oscilloscope to check this.)	A. B. C. D.	U701. U702. U708. U711.
4.	Exchange U712 and U705. Then try to adjust L102 again for a lock (LED D705 extinguished).	A.	If the loop now locks, check IC now at U705.
5.	Exchange U713 and U707. Then try adjusting L102 again for a lock (LED D705 extinguished).	A.	If the loop now locks, check IC now at U707.
6.	If you still cannot lock this loop, recheck the controller and synthesizer circuit boards for proper assembly (no solder bridges, etc.). When loop 2 locks, proceed to the "Realignment" section.		

Loop 1 Troubleshooting

NOTE: Observe LED D703 on the controller circuit board to determine whether or not this loop is locked. If this LED stays lit when you adjust coil L105, the loop is not locked.

CHECK	PROBLEM AREA
1. Check for 1 volt (RF) at ungrounded end of R136.	A. Q104. B. Q105. C. Q106.
2. Check for some RF at the collector of Q707 (changes when you adjust T101 and T102).	A. U101.
3. Check for a positive pulse at U703 pin 11 as the frequency steps when you turn the Main Tuning knob. (Use a logic probe or an oscilloscope to check this.)	A. U701. B. U702. C. U708. D. U711
4. Exchange U703 and U705. Then try to adjust L105 again for a lock (LED D703 extinguished).	A. If the loop now locks, check IC now at U705.
5. Exchange U704 and U707. Then try adjusting L105 again for a lock (LED D703 extinguished).	A. If the loop now locks, check IC now at U707.
6. If you still cannot lock this loop, recheck the controller and synthesizer circuit boards for proper assembly (no solder bridges, etc.). When loop 1 locks, proceed to the "Realignment" section.	

Loop 3 Troubleshooting

NOTE: Observe LED D707 on the controller circuit board to determine whether or not this loop is locked. If this LED stays lit, the loop is not locked.

	CHECK	PROBLEM AREA
1.	Check for 4.5 volts (RF) at plug P107 pin 1.	A. Q718. B. Q719.
2.	Check for .2 volt (RF) at plug P102 pin 1.	A. BFO circuit board.
3.	Check for at least .5 volt (RF) at plug P104 pin 1 (be sure the Band switch is at 30).	A. Q303. B. Q304. C. Q305.
4.	Check for at least .5 volt (RF) at plug P104 pin 1 (be sure the Band switch is at 10).	A. Q354. B. Q355. C. Q356.
5.	Check for RF voltage at gate 1 of Q111 (be sure the Band switch is at 80). This voltage should change when you adjust T103 and T104. NOTE: The case of transistor Q109 should measure .6 volt.	A. Q109.
6.	Check for RF voltage at the drain of Q111 (be sure the Band switch is at 80). This voltage should change when you adjust T103 and T104. NOTE: The case of transistor Q111 should measure .6 volt.	A. Q111.
7.	Try to adjust C175 and C179 as described in the "Realignment" section.	A. Q115
8.	Check for RF voltage at gate 1 of Q112 on each band.	A. Corresponding bandpass is not being turned on. Check the diodes associated with the inoperative band.
9.	Check for RF voltage at the drain of Q112.	A. Q112.
10.	Check for 5 volts (RF) at collector of Q113.	A. Q113.
11.	Check for 5 volts (RF) at collector of Q708.	A. Q708.
12.	Check U706 pin 1 for the voltages shown below on each band. BAND — VOLTAGE 80M — 0 40M — 5 30M — 5 20M — 0 17M — 5 15M — 0 12M — 0 10M — 5	A. RF circuit board.
13.	Exchange U705 and U712.	A. If the loop still does not lock, check the IC now at U712.
14.	Exchange U707 and U713.	A. If the loop still does not lock, check the IC now at U713.
15.	If you still cannot lock this loop, recheck the controller and synthesizer circuit boards for proper assembly (no solder bridges, etc.).	

INVERTER ASSEMBLY PROBLEMS

CHECK	PROBLEM AREA
1. Check for 12 volts (RF) at U501 pin 3.	A. U501.
2. Check for 13 volts (RF) at collector of Q501.	A. Q501. B. Q502.
3. Check the voltages in the inverter assembly against those shown on the Schematic diagram.	A. Associated diode or capacitor.
4. Disconnect the wires from feedthrough capacitors C514 (20-volt supply) and C515 (12-volt supply) to remove the load from the supplies.	A. If 20-volt supply is still low, check U502. If 12-volt supply is still low, check U503 or L502.

CONTROLLER PROBLEMS

CONDITION	POSSIBLE CAUSE
Main Tuning does not operate..	A. U601. B. Q705. C. Q706.
Main Tuning operates in only one direction.	A. U602. B. Q703. C. Q704.
Loses memory when you turn the Transceiver off.	A. No +5-volt memory backup. B. Q716. C. Q717. D. D711.
One or more phase-locked are unlocked.	A. See "Synthesizer Problems."

REALIGNMENT

Although realignment of your Transceiver is not normally required, you may wish to check the adjustment of specific circuits. The only time you should have to do this is if you ever replace a part or parts in one of the circuits that require adjustment.

Since several of the circuit boards are involved in some of the alignment procedures, the Pictorial numbers will not be called out each time. The circuit boards will be referred to by name and correspond to the following Pictorials:

BFO circuit board	Pictorial 20-1
IF circuit board	Pictorial 20-2
Display circuit board	Pictorial 20-3
Synthesizer circuit board	Pictorial 20-4
Lo VCO assembly	Pictorial 20-5
High VCO assembly	Pictorial 20-6
Controller circuit board	Pictorial 20-7
RF circuit board	Pictorial 20-8
ALC circuit board	Pictorial 20-9

ALIGNMENT PREPARATION

1. Preset the front panel controls and switches as follows. Use this same initial setup for all of the adjustment, unless a step directs you to set a control differently.

   MODE—NORM
   MIC GAIN—Fully counterclockwise
   CW GAIN—Fully counterclockwise
   AF GAIN—Fully counterclockwise (until it clicks)
   RF GAIN—Fully clockwise
   RIT—0 (detent)
   IF SHIFT—0 (detent)
   BAND—80
   REC/TUNE button—Released (REC)
   PTT/VOX button—Released (PTT)
   AGC button—Released (FAST)

2. Connect your power supply and speaker to the connectors on the rear panel of the Transceiver.

BFO ALIGNMENT

1. On the BFO circuit board, set LEVEL control R823, SSB control R834, and CW control R837 to the centers of their rotations.

2. On the front panel, make sure the IF SHIFT control is set to the center (detent position) of its rotation.

3. Temporarily unplug the shielded cable from BFO circuit board plug P802.

4. Connect the probe of a frequency counter to plug P802 pin 2.

5. Set the MODE switch to NORM, if this has not already been done.

6. Turn the Transceiver on.

7. Adjust trimmer capacitor C816 until the frequency counter indicates 8.82255 MHz. 8.82850

8. Turn the MODE switch to REV.

9. Adjust trimmer capacitor C822 until the frequency counter indicates 8.83145 MHz. 8.83150

10. Connect a microphone to the MIC connector on the front panel. Then use the PTT button on the microphone to key the transmitter. Hold this button down until a step directs you to release it.

11. Adjust SSB control R834 until the frequency counter indicates 8.83145 MHz. Then release the microphone button.

12. Turn the MODE switch to CW(W).

13. Depress the TUNE pushbutton on the front panel.

14. Adjust CW control R837 until the frequency counter indicates 8.8307 MHz. Then release the TUNE pushbutton. 8.8309

15. Turn the Transceiver off.

16. Disconnect the frequency counter from the BFO circuit board and reconnect the shielded cable to plug P802. Be sure the shield wires in this socket are at plug pin 1.

IF ALIGNMENT

1. Set the MODE switch on the front panel to NORM, if this has not already been done.

2. Set the BAND switch to 80M, if this has not already been done.

3. Locate the shielded test cable that was assembled during the chassis assembly.

4. Unplug socket P802 from the BFO circuit board. Then push the socket on one end of the test cable onto plug P802. Be sure the shield wires in this socket are at plug pin 1.

5. Unplug socket P1102 from the IF circuit board. Then push the socket on the free end of the test cable onto plug P1102. Be sure the shield wires in this socket are at plug pin 1.

6. On the display circuit board, turn ZERO control R203 clockwise until the meter pointer starts to move upscale. Then turn the control counterclockwise until the meter pointer just indicates 0.

7. On the display circuit board, turn SENS control R201 fully counterclockwise.

8. On the BFO circuit board, turn LEVEL control R823 to the center of its rotation.

9. Connect the probe of a frequency counter to plug P802 pin 2. Then adjust trimmer capacitor C816 until the frequency counter indicates 8.83 MHz. 21.8

NOTE: As you perform the following adjustments, keep the meter pointer near mid-range. Adjust the display circuit board SENS control (R201) and the BFO circuit board LEVEL control (R823) as necessary to do this.

P553 pin 5 2.2 Filter Circuit in TUNE ... all Down 9.8-10.5

10. Adjust the following transformers in the order they are listed. Adjust each coil for a maximum indication on the front panel meter. NOTE: If necessary, to keep the meter pointer midrange, unplug the cable from BFO plug P802 and position the cable end near the plug.

    Transformer T1101

    Transformer T1102

    Transformer T1103

    Transformer T1104

11. Repeat step 10 until you notice no further improvement on the meter.

12. On the display circuit board, turn the SENS control fully counterclockwise.

13. Reconnect the test cable socket to P802 on the BFO circuit board, if you had to unplug it, and set control R823 to the center of its rotation.

14. On the display circuit board, turn the SENS control for a full-scale meter reading.

15. Unplug the shielded test cable from the BFO and IF circuit boards. Then reconnect the harness cables to these plugs. Be sure the shield wires in these sockets are at plug pins 1.

16. Adjust trimmer capacitor C816 until the frequency counter indicates [redacted] MHz.

17. Turn the Transceiver off.

RIT ADJUSTMENT

1. Be sure the RIT control on the front panel is at the center of its rotation (detent).

2. Set the MODE switch to NORM, if this has not already been done.

3. Set your voltmeter to read +8 volts DC.

4. Turn the Transceiver on.

5. Measure the voltage at IF circuit board plug P1106 pin 1. Remember this voltage.

6. Use your microphone PTT button to key the transmitter.

7. While the transmitter is keyed, adjust RIT CENTER control R1144, on the IF circuit board for the same voltage that you noted above in step 5 (at plug P1106 pin 1).

8. Release the microphone PTT switch.

9. Turn the Transceiver off and disconnect the voltmeter from the IF circuit board.

SYNTHESIZER AND VCO ALIGNMENT

1. Unplug the indicated jumper wire from the controller circuit board.

2. On the front panel, set all of the pushbutton switches to their out (released) positions.

3. Set the BAND switch to 80M, if this has not already been done.

4. Set the MODE switch to NORM, if this has not already been done.

5. Connect the common lead of your voltmeter to a convenient bare chassis ground.

6. Connect your voltmeter probe to test point PLL2 TUNE on the synthesizer circuit board.

7. Turn the MAIN TUNING knob on the front panel for an indication of 4.050.00 on the display.

8. Adjust trimmer capacitor C103 for a +9-volt DC reading. NOTE: If you cannot obtain +9 volts at any setting of trimmer capacitor C103, adjust coil L102 as necessary until you can.

9. Turn the MAIN TUNING knob for an indication of 3.459.95 on the display. Then adjust coil L102 for an indication of +3 to +4 VDC.

10. Repeat steps 7 through 9 until you obtain the correct voltages at each end of the band with no further adjustment. LED D705 on the controller circuit board should be off.

11. Connect the voltmeter probe to PLL1 TUNE.

12. Turn the MAIN TUNING knob for an indication of 4.050.00. Then adjust trimmer capacitor C128 for an indication of +9 VDC. NOTE: If you cannot obtain an indication of +9 volts at any setting of capacitor C128, adjust coil L105 as necessary until you can.

13. Turn the MAIN TUNING knob for an indication of 3.450.00. Then adjust coil L105 for an indication of +4 to +5 VDC.

14. Repeat steps 12 and 13 until you obtain the correct voltages with no further adjustment. LED D703 on the controller circuit board should be off.

15. Disconnect the voltmeter from PLL1 TUNE.

16. Connect a voltmeter RF probe to the collector (C) of transistor Q107.

17. Turn the MAIN TUNING knob for an indication of 3.459.95. Then adjust transformers T101 and T102 for a highest meter indication.

18. Turn the MAIN TUNING knob for an indication of 3.460.00. Then adjust trimmer capacitor C117 for a peak meter indication.

19. Repeat steps 17 and 18 several times until you notice no further improvement.

20. Connect the voltmeter RF probe to gate 1 (G1) of transistor Q112.

NOTE: When you adjust coils L107 and L108 in the following steps, be careful not to exert any downward pressure on the slugs. Also do not turn the slugs more than two turns clockwise. Too much pressure, or turning the slug too far clockwise, could dislodge the slug from the transformer.

21. Turn the MAIN TUNING knob for an indication of 3.500.00. Then adjust transformer T104 and coil L108 for a peak meter indication.

22. Turn the MAIN TUNING knob for an indication of 4.000.00. Then adjust transformer T103 and coil L107 for a peak meter indication.

23. Repeat steps 21 and 22 several times until you notice no further improvement.

24. Tune to the frequency (in steps 21 and 22) that produced the lowest meter reading. Then adjust the **opposite** transformer (T103 or T104) until the meter readings are as close as possible. For example, if 3500.00 produced the lowest meter reading, adjust **T103** until both frequencies produce meter readings that are as close as possible. Do not go back and readjust T104.

25. Connect the voltmeter RF probe to gate 2 (G2) of transistor Q111.

26. Turn the BAND switch to 12M. Then adjust trimmer capacitor C175 for a peak meter indication.

27. Turn the BAND switch to 17M. Then adjust trimmer capacitor C179 for a peak meter indication.

28. In steps 26 and 27, if trimmer C175 or C179 is at maximum capacitance, adjust transformer T105 slug 1/4 turn clockwise and repeat the two steps. If either trimmer is at minimum capacitance, turn the slug of the T105 1/4 turn counterclockwise and repeat steps 26 and 27.

29. Turn the BAND switch to 20M.

30. Connect the voltmeter RF probe to gate 1 (G1) of transistor Q112.

NOTE: When you adjust coils L109 and L111 in the following steps, be careful not to exert any downward pressure on the slugs. Also do not turn the slugs more than two turns clockwise. Too much pressure, or turning the slug too far clockwise, could dislodge the slug from the coil.

31. Turn the MAIN TUNING knob for an indication of 14.000.00. Then adjust coil **L111** for a peak meter indication.

32. Turn the MAIN TUNING knob for an indication of 14.350.00. Then adjust coil **L109** for a peak meter indication.

33. Repeat steps 31 and 32 several times until you notice no further improvement.

34. Turn the BAND switch to 10M.

35. Turn the MAIN TUNING knob for an indication of 28.000.00. Then adjust coil **L113** for a peak meter indication.

36. Turn the MAIN TUNING knob for an indication of 29.499.95. Then adjust coil **L112** for a peak meter indication.

37. Repeat steps 35 and 36 several times until you notice no further improvement.

38. Connect the positive voltmeter probe (not the RF probe) to test point PLL3 TUNE.

39. Turn the BAND switch to 30M and turn the MAIN TUNING knob for an indication of 10,000.00. Then adjust trimmer capacitor C309 (on the low band VCO) for +7 volts DC.

40. Turn the BAND switch to 40M and turn the MAIN TUNING knob for an indication of 6.950.00. Then adjust trimmer capacitor C302 (on the low band VCO) for +4 volts DC.

41. Turn the BAND switch to 80M and turn the MAIN TUNING knob for an indication of 3.450.00. Then adjust trimmer capacitor C305 (on the low band VCO) for +4 volts DC.

42. Turn the MAIN TUNING knob for an indication of 4.050.00 and check to make sure that LED D707 on the controller circuit board is not lit. The voltmeter should indicate less than +9 volts DC. NOTE: If the indicated voltage exceeds +9 volts, adjust coil L302 (on the low band VCO) clockwise 1/4 turn and repeat steps 39 through 41.

43. Adjust coil L352 (on the HI VCO) so the core is flush with the top of the coil form. Then turn the core two full turns counterclockwise.

44. Turn the BAND switch to 12M and turn the MAIN TUNING knob for an indication of 24.840.00. Then adjust trimmer capacitor C362 (on the high VCO) for +4 volts DC.

45. Turn the BAND switch to 10M and turn the MAIN TUNING knob for an indication of 29.750.00, and check to make sure that LED D707 on the controller circuit board is not lit. The voltmeter should indicate less than +9 volts DC. NOTE: If the indicated voltage exceeds +9 volts, adjust coil L352 (on the high VCO) 1/4 turn clockwise and repeat steps 44 and 45 again.

46. Turn the BAND switch to 15M and turn the MAIN TUNING knob for an indication of 20.950.00. Then adjust trimmer capacitor C352 (on the high VCO) for +4 volts DC.

47. Turn the BAND switch to 17M and turn the MAIN TUNING knob for an indication of 18.018.00. Then adjust trimmer capacitor C355 (on the high VCO) for +4 volts DC.

48. Turn the BAND switch to 20M and turn the MAIN TUNING knob for an indication of 13.950.00. Then adjust trimmer capacitor C358 (on the high VCO) for +4 volts DC.

49. Reinstall the jumper on the controller circuit board. Then check the display on the front of the Transceiver. It should still be displaying a frequency (not "PLL").

50. Turn the Transceiver off and disconnect the voltmeter.

CONTROLLER ADJUSTMENT

1. Be sure the RIT control is set to the center of its rotation (detent).

2. Connect a frequency counter to the collector (C) of transistor Q702 on the controller circuit board.

3. Turn the Transceiver on.

4. Adjust trimmer capacitor C702 until the frequency counter indicates 8.040000 MHz.

5. Connect the frequency counter to the collector (C) of transistor Q719. Then adjust trimmer capacitor C739 until the frequency counter indicates 10.000000 MHz.

6. Turn the Transceiver off and disconnect the frequency counter.

RF CIRCUIT BOARD ADJUSTMENT

1. Unplug socket P402 from the RF circuit board. Then rotate it and plug it back in so that only the orange wire is connected to its pin (pin 3).

2. Locate the 47 Ω resistor-socket assembly that you assembled during the chassis assembly. Then push this resistor-socket assembly onto circuit board plug P402 pins 1 and 2.

3. Connect the voltmeter RF probe to P402 pin 1.

4. Carefully remove the six screws from the RF circuit board coil shield. Then set the shield and the screws aside temporarily.

NOTE: In the following steps, you will align the bandpass filters on each of the eight bands. Except for the fact that the filters are different, the procedure for each band is the same.

A. Set the CW GAIN control on the front panel fully clockwise.

B. Start with your voltmeter on its lowest range. Then, as necessary, set the voltmeter to successively higher ranges.

C. Set the MODE switch to CW(W).

D. Adjust the three stated coils for the given band.

E. Adjust the band edge voltage levels until they are equal.

5. Turn the Transceiver off, if this has not already been done. Then unplug the 6-pin accessory socket from the rear panel of the Transceiver. Wait at least 30 seconds; then reconnect the socket. This automatically resets the memory in the Transceiver to each band edge.

6. Turn the Transceiver on.

7. Turn the BAND switch to 80M.

8. Set the Transceiver to 3.500.00 MHz.

9. Depress the TUNE pushbutton.

10. Adjust coils L412 and L413 for the highest voltmeter indication.

11. Release the TUNE pushbutton.

12. Set the Transceiver to 4.000.00 MHz.

13. Depress the TUNE pushbutton.

14. Adjust coil L414 for the maximum voltage indication.

15. Release the TUNE pushbutton.

16. Alternate the frequency between 3.500.00 and 4.000.00 and note which frequency produces the lowest indication on the voltmeter. Then set the Transceiver to the frequency that produced the lowest indication.

17. Adjust coil L413 so you obtain the same voltmeter indication at each band edge. NOTE: You may have to very slightly readjust coils L412 and L414 to arrive at equal voltages. Check the voltages once again to make sure they are equal.

18. Repeat steps 8 through 17 until you obtain equal voltages at both ends of the band.

NOTES:

1. You should have an indication of at least 2.5 volts RF at each end of the band in the above steps and in the following steps.

2. When you adjust the 40 through 12-meter bands in the following steps, be careful not to exert any downward pressure on the slugs. Also do not turn the slugs more than two turns clockwise. Too much pressure, or turning the slug too far clockwise, could dislodge the slug from the coil.

19. Turn the BAND switch to 40M. Then, in the same manner as outlined in the previous steps, adjust 40-meter bandpass coils L415, L416, and L417.

20. Turn the BAND switch to 30M. Then, in the same manner, adjust 30-meter bandpass coils L418, L419, and L421.

21. Turn the BAND switch to 20M. Then, in the same manner, adjust 20-meter bandpass coils L422, L423, and L424.

22. Turn the BAND switch to 17M. Then, in the same manner, adjust 17-meter bandpass coils L425 and L427 (only two coils for this band).

23. Turn the BAND switch to 15M. Then, in the same manner, adjust 15-meter bandpass coils L428, L429, and L431.

24. Turn the BAND switch to 12M. Then, in the same manner, adjust 12-meter bandpass coils L432 and L434 (only two coils for this band).

25. Turn the BAND switch to 10M. Then, in the same manner, adjust 10-meter bandpass coils L435, L436, and L437.

26. Turn the Transceiver off.

27. Unplug the 47 Ω resistor-socket assembly and the RF probe from RF circuit board plug P402. Then reconnect socket P402 in its normal position on plug P402.

IF TRAP ADJUSTMENT

1. Unplug socket P802 from the BFO circuit board. Then connect the socket on one end of your shielded test cable onto plug P802. Be sure the shield wires in this socket are at plug pin 1.

2. Unplug socket P401 from the RF circuit board. Then turn this socket around so that only the two violet wires are making contact with their circuit board pins. NOTE: These two pins are connected together on the circuit board.

3. Plug the socket at the free end of the shielded test cable, coming from the BFO circuit board, onto plug P401 pins 4 and 5. Be sure the inner lead of the shielded cable in this socket is at plug pin 5.

4. Turn the Transceiver on.

5. Set the BAND switch to 40M and set the Transceiver to 7.300.00 MHz.

6. Connect the probe of a frequency counter to plug P802 pin 2. Then adjust trimmer capacitor C816 until the frequency counter indicates 8.83 MHz.

7. Adjust trimmer capacitor C406 and coil L405, on the RF circuit board, for the best null on the front panel meter.

8. Turn the Transceiver off.

9. Unplug the shielded test cable from the BFO and RF circuit boards. Then reconnect sockets P802 and P401 to their corresponding circuit board plugs. Be sure the shield wires in socket P802 are at plug pin 1 and the violet wires in socket P401 are at plug pins 1 and 2.

10. Adjust trimmer capacitor C816 until the frequency counter indicates 8.82855 MHz.

POWER AND ALC ADJUSTMENT

1. Turn the Transceiver on.

2. Turn the CW GAIN control on the front panel fully counterclockwise.

3. Depress the TUNE pushbutton on the front panel.

4. On the audio circuit board, adjust BIAS control R971 for an indication of exactly zero (0) on the front panel meter.

5. Release the TUNE pushbutton and turn the Transceiver off.

6. Connect the output of the Transceiver through a suitable wattmeter (100 watt capability) to a 50-ohm dummy load that can dissipate 100 watts of power.

7. Turn the Transceiver on. Be sure the front panel controls are at 80M and CW (W).

8. Turn the FWD control (R658) on the ALC circuit board fully clockwise.

9. Turn the BFO LEVEL control (R823) on the BFO circuit board to the center of its rotation.

10. Depress the TUNE pushbutton.

11. Turn the CW GAIN control clockwise for a maximum indication on the watt meter. NOTE: The output power should not exceed 100W. Also, the front panel meter should indicate full scale.

12. On the ALC circuit board, adjust FWD control R658 for 100 watts of output.

13. Watch the wattmeter and adjust BFO LEVEL control R823 counterclockwise until you obtain 95 watts of output.

14. Adjust FWD control R658, on the ALC circuit board, counterclockwise until you obtain 100 watts of output.

15. Release the TUNE pushbutton.

16. Turn the Transceiver off.

CARRIER NULL ADJUSTMENT

1. Be sure the MODE switch is set to NORM.

2. Connect a voltmeter RF probe to ALC circuit board socket S654.

3. Turn the Transceiver on.

4. Use the button on your microphone to key the transmitter.

5. On the audio circuit board, turn NULL control R931 for a dip or a null on the voltmeter.

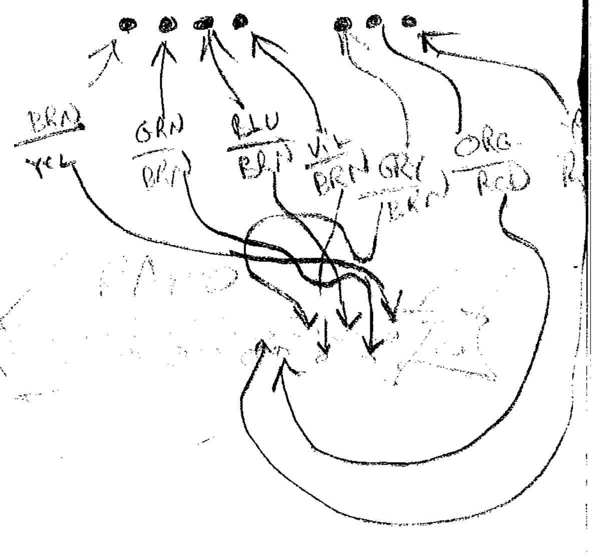
6. Set the MODE switch to REV.

7. Readjust control R931 for a null on the voltmeter.

8. Set the MODE switch to NORM.

9. Repeat steps 6 through 8 until you obtain the best possible null.

10. Turn the Transceiver off and disconnect the RF probe from the ALC circuit board.



SPECIFICATIONS

GENERAL

Overall Band Coverage	80 through 10 meters, and WWV at 10 MHz.
Frequency Coverage	3.450 — 4.050 MHz 6.950 — 7.350 MHz 10.000 — 10.200 MHz 13.950 — 14.400 MHz 18.018 — 18.218 MHz 20.950 — 21.500 MHz 24.840 — 25.040 MHz 28.000 — 29.750 MHz
Frequency Readout	7 digit display, vacuum fluorescent with special symbols.
Readout Symbols	— Split. ← Out of Band. M Memory. L,U,C Modes. — Transmit.
Readout Accuracy	To nearest 50 Hz.
Frequency Control	Synthesized.
Frequency Tuning (dual rate):	
Slow	50 Hz per step, 1.25 kHz per knob rotation.
Fast	1 kHz per step, 25 kHz per knob rotation.
Tuning Backlash	None
Split Frequency Operation	Transmit from memory frequency, receive from displayed frequency.
Memory	Stores 1 frequency per band. (The display frequency is also saved.)
Frequency Stability	Less than 50 PPM drift from turn on.
Modes	SSB Normal and Reverse; CW, Wide or Narrow.

RECEIVER

Sensitivity	Less than 0.35 μV for 10dB, S + N/N.
Selectivity (SSB):	
With standard filter	2.0 kHz min. at 6dB, 6 kHz max. at 60dB.
With HWA-5400-2 optional filter	1.8 kHz min. at 6dB.
CW audio active filter	250 Hz min. at 6dB, centered at 700 Hz.
Overall Gain	Less than 1 μV for 0.25 watt audio output.
Audio Output	2 watts min. into 4 ohms; less than 10% THD.
AGC	Selectable Fast and Slow AGC (no more than 8dB audio change for a 100 dB or greater input signal range).
Intermodulation Distortion	70dB min. at 25 kHz.
Image Rejection	80dB min.
IF Rejection	100dB min.
IF Shift Tuning	±600 Hz in Receive only.
Internally Generated Noise (spurious)	Generally below noise level; all below 1.0 μV.
Audio Hum and Noise	Greater than 40dB below max. output.
RIT	±350 Hz.

TRANSMITTER

RF Output:	
High SSB	100 watts PEP power min., except 10 meters = 80 watts.
CW	100 watts min., except 10 meters = 80 watts.
Duty Cycle	Continuous SSB (voice). 50% receive-transmit ratio on CW; 5 min. on, 5 min. off.
Load Impedance	At least 90% rated power with less than 2:1 SWR. Protected against high SWR.
Carrier Suppression	−50dB min., referenced to 100-watt single-tone 1000 Hz.
Unwanted Sideband Suppression	−50dB min., referenced to 100-watt single-tone 1000 Hz.
Harmonic Radiation	−50dB min., referenced to 100-watt output.
Spurious Radiation	−60dB min., referenced to 100-watt output.
Third Order Distortion	−30dB min., referenced to 100-watt PEP two-tone output.
Transmit-Receive Operation:	
SSB	PTT or VOX.
CW	Full break-in (simplex only).
CW Sidetone	700 Hz tone to speaker or headphones.
Microphone Input	High impedance (approx. 25k ohms) rated −55dB. Approx. 10 mV.

OTHER SPECIFICATIONS

Operation With External Linear Amplifier	Linear relay and linear ALC rear panel connections.
Front Panel Meter	S-Units in Receive, ALC in Transmit.
Operating Temperature Range	0 to 40 degrees C.
Power Requirements*	11 to 16 volts DC; 120/240 VAC with optional AC power supply.
Dimensions Overall	11-1/2" W × 14" D × 5" H. (29.2 × 35.6 × 12.7 cm).
Net Weight	24 lbs (10.9 kg).
Optional Accessories	HWA-5400-1 AC Power Supply with clock and speaker.
	HWA-5400-2 2.0 kHz SSB Filter.
	HWA-5400-3 Frequency Entry Key Pad.

*All specifications are referenced to 13.8 volts DC at 25° C.

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

CIRCUIT DESCRIPTION

Refer to the Block Diagram and the Schematic while you read this "Circuit Description". The component numbers are arranged in the following groups to help you locate specific parts on the Schematic, circuit boards, and chassis.

1-99	Parts mounted on the RF probe and the chassis.
101-199	Parts mounted on the synthesizer circuit board.
201-299	Parts mounted on the display circuit board.
301-349	Parts mounted on the low VCO assembly.
351-399	Parts mounted on the high VCO assembly.
401-499	Parts mounted on the RF circuit board.
501-549	Parts mounted on the inverter assembly.
551-599	Parts mounted on the filter circuit board.
601-649	Parts mounted on the shaft encoder circuit board.
651-699	Parts mounted on the ALC circuit board.
701-799	Parts mounted on the controller circuit board.
801-899	Parts mounted on the BFO circuit board.
901-999 1001-1099	Parts mounted on the audio circuit board.
1101-1199	Parts mounted on the IF circuit board.
1201-1299	Parts mounted on the power amplifier (PA) assembly.

RECEIVER SIGNAL FLOW

During the receive mode of operation, the incoming signals that are present at the antenna connector pass through the ALC circuit board and then through a low-pass filter circuit on the filter circuit board. The Band switch selects the required filter, which rolls off the high frequencies on each band. A T/R relay, also mounted on the filter circuit board, routes this filtered signal to the RF circuit board.

On the RF circuit board, the receiver signal first passes through a high-pass filter to roll off broadcast band signals and then through an 8.83 MHz IF trap. The resulting signal is further filtered by a bandpass filter circuit, amplified, and mixed with an injection signal from the VCO to produce an 8.83 MHz IF signal.

The 8.83 MHz IF signal from the RF circuit board is routed to the IF circuit board, where it either passes through a 4-pole, 8.83 MHz IF filter (optional) or directly to an IF amplifier stage. This signal then passes through a 6-pole IF filter and three stages of amplification before it is routed to the product detector on the audio circuit board. An AGC (automatic gain control) signal is produced on the IF circuit board to keep the IF and RF amplifiers operating at a constant level.

A product detector on the audio circuit board converts the 8.83 MHz IF signal to audio frequencies which then pass through either a wide or a narrow active filter. An audio frequency amplifier then amplifies this filtered signal so that it can drive a 4-ohm speaker.

TRANSMITTER SIGNAL FLOW

Although the transmitter signals flow in a direction that is opposite to the receiver signals, the stages are very similar.

Transmitter audio from the microphone passes through three stages of amplification on the audio circuit board and is then mixed, in a balanced modulator, with a signal from BFO circuit board to produce an 8.83 MHz transmitter IF signal. During CW operation, the signal from the BFO unbalances the balanced modulator so that the BFO can produce a carrier.

The IF circuit board amplifies and filters the 8.83 MHz transmitter IF signal in the same manner as the receiver signal. An ALC (automatic level control) voltage from the ALC circuit board is fed back to the circuits on the IF circuit board to control the RF output during the transmit mode.

On the RF circuit board, the filtered 8.83 MHz transmitter IF signal is mixed with an injection signal from one of the VCO's to produce the desired transmitter signal. This signal is then filtered by the same bandpass filters that are used during the receive mode before it is preamplified and applied to the power amplifier (PA) circuit board.

The power amplifier contains three push-pull amplifier stages to produce a 100-watt RF signal. This signal is filtered by the low-pass filters on the filter circuit board to reduce harmonic radiation before the signal is applied to the antenna.

As mentioned earlier, a pickup circuit on the ALC circuit board produces an ALC voltage that is applied to the IF circuit board to control the RF output under several conditions.

The following sections describe the operation of each circuit board and assembly in greater detail.

ALC CIRCUIT BOARD

The ALC circuit board controls the RF power output during the transmit mode.

Pickup coil L651 and capacitor C651 sense the forward RF current present on the antenna line and convert it to an RF voltage. Diode D651 rectifies this RF voltage to a DC voltage, which is filtered by capacitor C653. As the power increases to 100 watts, this DC voltage reaches a threshold level, which turns on transistor Q651 and pulls the ALC voltage toward ground. This turns off transistor Q1103 on the IF circuit board. Diode D652 and transistor Q652 operate in a similar manner with the reflected RF current.

Resistors R662 and R663 and capacitor C655 are used to bias transistors Q651 and Q652 and form a time constant for the ALC attack and release times. Transistor Q653 sets the output level in the CW mode while transistor Q654 sets the output level on 10 meters. Diodes D653 and D654 form a threshold level for the ALC control by an external linear amplifier to prevent flat-topping.

IF CIRCUIT BOARD

The IF circuit board amplifies both receiver and the transmitter signals and produces an AGC (automatic gain control) voltage for the receiver circuits.

Transistor Q1101 amplifies the receiver signal, coming from integrated circuit U401 on the RF circuit board, and then passes the signal through 6-pole filter Y1102 to transistor Q1103. Transformers T1101 and T1102 form the tuned circuits for transistors Q1101 and Q1103, respectively. Transistors Q1103, Q1104, and Q1105 provide amplification for the receiver IF signal so it can drive the product detector on the audio circuit board.

Transistor Q1106, an emitter-follower amplifier, drives AGC diodes D1101 and D1102 and produces a negative-going voltage. This voltage is applied to a gate (G2) of transistors Q1101, Q1103, and Q404 (on the RF circuit board) to control the gains of these stages. Transistor Q1107 is a DC amplifier, which drives the front panel meter for AGC and ALC indications.

During the transmit mode, transformer T1101 couples the transmitter IF signal coming from the audio circuit board into crystal filter Y1102. Transistor Q1103 amplifies this signal which is coupled to the RF circuit board through transformer T1102. The gain of transistor Q1103 is controlled by an ALC voltage that comes from the ALC circuit board.

FET switch U1101A passes the AGC signal to gate 2 (G2) of transistor Q1103 during the receive mode, while FET switch U1101C performs the same function with the ALC signal during the transmit mode. For slow AGC action, FET switch U1101B connects capacitor C1133 to change the time constant of the circuit.

The remaining transistors, Q1108, Q1109, Q1111, and Q1112, form the RIT circuit. Transistors Q1109 and Q1112 drive the RIT control during receive. During the transmit mode, transistor Q1108 pulls resistor R1144 to ground to effectively center the RIT control (no offset). Transistor Q1111 turns off transistor Q1108 during CW operation to produce the desired offset frequency.

FILTER CIRCUIT BOARD

The filter circuit board contains six low-pass filters which roll off the high frequencies during both transmit and receive modes. Each filter comprises two pi-sections.

Relay K551 opens during the transmit mode to prevent the RF from the power amplifier from entering the receiver front end (on the RF circuit board). Relay K552 is connected across the 12-volt supply and is used to operate the relay in an external linear amplifier.

Transistors Q551 and Q552 form an overvoltage protection circuit for the Transceiver. If the input voltage should happen to exceed 16 volts DC, diode D552 conducts and turns on transistor Q552. This turns off transistor Q551 which shuts down the Transceiver by de-energizing the master on-off relay (K1) located on the rear of the chassis.

A series-regulating circuit is formed by transistors Q555, Q556 and diode D555. Transistor Q556 senses the voltage at the emitter of transistor Q555 and adjusts the voltage drive level at the base of transistor Q555 as the load varies. Diode D555 forms the reference voltage for transistor Q556. Transistor Q553 supplies the drive for transistor Q554, which supplies the bias voltage to the power amplifier in the transmit mode.

BFO CIRCUIT BOARD

The BFO circuit board generates the LSB, USB, and CW signals for the product detector and the balanced modulator (located on the audio circuit board). The BFO circuit board also interfaces with the controller to generate several DC logic voltages that operate many stages throughout the Transceiver.

In the LSB mode, crystal Y801 is selected by diode D808 and connected to the series-tuned circuit formed by capacitor C819, coil L804, and diode D809. Transistor Q814 forms the BFO oscillator which has the required feedback provided by capacitors C811 and C812. Buffer transistor Q813 drives the low-pass filter that is formed by capacitors C805, C806, C807, and coil L801. This filter reduces any harmonic content in the signal produced by the BFO. Crystal Y802 is used during USB operation and operates in the same manner as the LSB circuit.

Varicap diode D809 varies the frequency of the BFO oscillator for proper IF shift and CW offset. Diode D812 allows the IF shift voltage to pass during the receive mode so diode can operate properly. Diode D813 and resistor R834 cause the SSB oscillator to return to center during the transmit mode. Diode D814 and resistor R837 produce the desired 700 Hz offset when the Transceiver is transmitting CW.

In the USB mode, the controller circuit turns on transistor Q801. Thus turns on transistor Q802, which produces an USB voltage that turns on crystal Y802. This also turns on diode D802 which turns on transistor Q807. Transistors Q803 and Q804 control the LSB voltage and operate in the same manner as transistors Q801 and Q802.

During the narrow CW (transmit) mode, the controller circuit turns on transistor Q811 via diode D807. In the wide CW (transmit) mode, the controller turns on transistor Q811 through diode D806. Transistor Q811 turns on transistor Q812 during the CW (transmit) mode, which feeds a DC voltage to CW offset control R837. Transistor Q811 also turns on transistor Q809, which provides a 9-volt source for other circuits in the Transceiver. Also during CW operation, transistor Q809 turns on transistor Q806 which keeps transistor Q807 off. Transistor Q807 is only turned on in the USB and LSB modes and turns on transistors Q805 and Q808. This generates a DC voltage in the transmit mode to operate the SSB centering and other stages.

POWER AMPLIFIER (PA) CIRCUIT BOARD

The power amplifier circuit board contains three stages of push-pull amplification which amplify the signal coming from the RF circuit board. Transformer T1201 matches the impedance of the signal coming from the RF circuit board to predriver transistors Q1201 and Q1202 on the power amplifier circuit board. Capacitor C1201 and resistor R1201 form a swamping circuit that matches the signal to the base of transistor Q1201 over the required frequency range. Resistor R1206 sets the amount of negative feedback to the base of transistors Q1201 and Q1202. This negative feedback limits the transistors from non-linear operation. Capacitor C1203 and resistor R1202 perform the same function for transistor Q1202 as capacitor C1201 and resistor R1201.

Transformer T1202 matches the push-pull collectors of transistors Q1201 and Q1202 to the push-pull base circuitry of transistors Q1203 and Q1204. Transformers T1203 and T1204 perform the same matching function for the final power transistors, Q1206 and Q1207. Capacitor C1214 and resistor R1216 supply negative feedback to the base of transistor Q1206, while capacitor C1217 and resistor R1219 supply negative feedback to the base of transistor Q1207.

Transistor Q1205 provides the proper bias for final transistors Q1206 and Q1207. Diodes D1203 and D1204 are mounted on top of the final transistors and provide thermal protection by sampling the transistor temperatures. As these diodes become warm, transistor Q1205 begins to turn off, which decreases the bias current to final transistors Q1206 and Q1207.

Diodes D1201 and D1202 are used as clamping diodes for transistors Q1201 through Q1204. These diodes sample the heat at transistors Q1201 and Q1203 and, as the temperatures increase, begin to clamp the bias current to prevent thermal runaway.

RF CIRCUIT BOARD

In the receive mode, the RF circuit board converts the incoming receiver signals into an IF frequency. During transmission, this circuit board mixes an IF signal to produce the desired frequency, and then amplifies this signal before it passes to the power amplifier.

The incoming receive signal first passes through a high-pass filter that is formed by capacitors C403 and C404 and coils L402 and L403. This filter rolls off broadcast band signals. Capacitors C405 through C407 and coils L404 and L405 form an 8.83 MHz IF trap which prevents this frequency (8.83 MHz) from being coupled to transformer T401. Transformer T401 matches the incoming signal to the input of the bandpass filters to be described next.

Diodes D403 and D407 route the incoming receive signal through the bandpass filter. Each band has its own bandpass filter that is selected by the Band switch. On the 80-meter band, the filter components are coils L412 through L414 and capacitors C427 and C482. The filters for the other bands are similar to the 80-meter filter.

After the signal passes through the proper bandpass filter, capacitor C459 couples it into RF amplifier transistor Q404. This amplifier is a broad-band amplifier that is controlled by an AGC voltage from the IF circuit board. The processed signal now passes through buffer transistor Q405 to double-balanced mixer U401, where it is mixed with a signal from one of the VCO's to produce an IF frequency of 8.83 MHz.

In the transmit mode, the signal passes through the RF circuit board in a similar, but opposite, manner. Double-balanced mixer U402 mixes the VCO signal with the 8.83 MHz IF signal (from the IF circuit board) to produce the desired transmitter frequency. Transformer T403 matches the output of mixer U402 to the input of the bandpass filter. Diodes D408 and D404 couple the transmitter signal through this filter.

Transistors Q402, Q401, and Q403 amplify the filtered RF signal to a level that is sufficient to drive the power amplifier. Transformer T402 matches the output of transistor Q403 to the input of the power amplifier.

CW keying is performed by transistor Q403 which is controlled by keying transistor Q412. Transistor Q412 sets the time constant for CW keying and supplies a muting voltage from the controller. This muting signal is a safety feature that turns off the transmitter if one of the phase-locked loops (to be described later) should become unlocked, or if a front panel control is tampered with during the transmit mode. DC driver transistors Q406 and Q407 also control the operation of transistor Q412 in the event the controller should happen to detect an abnormal control setting during the transmit mode.

Single sideband keying is provided by transistor Q409 while diodes D413 through D426 and transistor Q408 provide bandswitch information for the microprocessor (on the controller circuit board) so it can control the operation of the Transceiver.

AUDIO CIRCUIT BOARD

During the receive mode of operation, the audio circuit board converts the IF signal to an audio signal and amplifies it enough to drive a speaker. In the transmit mode, this circuit board amplifies the microphone audio and converts it to an IF signal. Other functions, such as VOX, anti-VOX, sidetone, and the transmit/receive voltage are also derived on this circuit board.

Product detector U904 converts the receiver IF signal into an audio frequency. This audio either passes through integrated circuits U905D and U905C in the wide CW mode, which roll off the high audio frequencies, or through integrated circuits U905A and U905B, which is a 250 Hz narrow CW active audio filter. Transistors Q922 and Q923 are the audio switches for the wide mode of operation, while transistors Q925 and Q924 are the switches for the narrow mode. These switches are controlled by switching transistors Q926, Q927, and Q928 which convert the controller circuit board logic to DC levels.

The audio signal from the switching transistors passes through the front panel AF Gain control and then back to integrated circuit U906. This integrated circuit amplifies the audio enough to drive a 4-ohm speaker or headphones.

In the transmit mode, microphone audio is amplified by integrated circuit U901A and then passes through the Mic Gain control (on the front panel). Transistors Q902 and Q903 amplify the transmitter audio so it can drive the balanced modulator, integrated circuit U902. Transistor Q901 turns on transistor Q902 in a SSB mode and turns it off in the CW mode.

Balanced modulator U902 converts the transmitter audio to an 8.83 MHz IF signal and buffer transistor Q904 matches the output of the balanced modulator to the input of the IF circuit board. Since a carrier is required during CW operation, transistor Q905 performs this function by unbalancing the balanced modulator.

Part of the audio signal from microphone amplifier U901A is coupled to VOX amplifier U901B. The resulting audio now passes through the VOX Gain control on the front panel to integrated circuit U901C. This integrated circuit drives diodes D905 and D906, which rectify the positive part of the audio signal. Capacitor C936 and resistor R953 form an RC filter which filters the rectified positive DC voltage.

Anti-VOX is performed by transistor Q908, which amplifies the receiver audio coming from the Anti-VOX control on the front panel so it can drive diodes D907 and D908. These diodes rectify the negative part of the receiver audio and route it back to the output of the positive rectifier diodes. As long as the received audio is greater than the microphone level, the negative voltage keeps transistor Q909 off until the AF Gain decreases.

Transistor Q909 is a VOX delay driver which is keyed by the positive voltage from diode D906. Capacitor C947 and the VOX Delay control on the front panel set the amount of delay during VOX operation. The delay voltage turns on transistor Q911, which drives the transmit/receive switching circuit. Transistor Q912 allows you to key the transmitter via the push-to-talk pin on the microphone connector.

Either transistor Q911 or Q912 turns on transistor Q913 which turns off transistor Q914. Since the collector of transistor Q914 is now high, transistor Q915 conducts and drives many transmitter stages in the Transceiver. In the receive mode, the collector of transistor Q914 is low and causes the emitter of transistor Q916 to go low. This pulls the transmit line toward ground.Transistors Q917, Q918, and Q919 generate the receiver R12 switch voltage that operates similarly to the transmit switch.

Transistor Q907 keys sidetone oscillator U901D. This oscillator drives the VOX amplifier and receiver audio amplifier.

Capacitors C952 and C953 together with choke L904 remove any RF that may be present on the +13.8-volt DC source. Integrated circuit U903 regulates the +13.8-volt source down to 9 volts which operates several stages in the Transceiver. Capacitance amplifier transistor Q921 isolates the +13.8-volt source from the controller circuit board.

PIN diodes D903 and D904 control the level of the carrier during CW operation. The CW Gain control on the front panel varies the voltage that is applied to diode D903 (between 9 volts and ground). As you rotate the control clockwise, diode D903 stops conducting and diode D904 conducts. When diode D904 conducts, the BFO oscillator signal is coupled to the balanced modulator. During the receive mode, transistor Q906 turns off diode D904 to prevent the carrier from entering the balanced modulator.

INVERTER ASSEMBLY

The inverter converts the incoming +13.8 VDC supply into several voltages required by the Transceiver. It provides the +20 volts for the vacuum flourescent display and the +12 volts to operate the active loop filters on the controller circuit board, the high and low VCO assemblies, and to some circuits on the synthesizer circuit board.

A 555 astable multivibrator (U501) produces a square wave at a frequency of approximately 30 kHz. Complementary transistors Q501 and Q502 increase the drive capability of integrated circuit U501. This voltage now drives a voltage-multiplier string, which provides a voltage that is sufficient to drive +20-volt regulator U502 and keeps the brightness of the display relatively constant during changes in the main supply voltage. Integrated circuit U503 is connected to the midpoint of the voltage multiplier and provides a regulated +12 volts.

Choke L501 and capacitor C501 form a low-pass filter that keeps any noise created by the inverter off of the main supply line.

VCO ASSEMBLIES

Two separate voltage-controlled oscillator assemblies supply the injection frequencies to the Transceiver. Depending upon which band you have selected, only one of the VCO assemblies receives power. The low-band VCO operates on the 80-, 40-, and 30-meter bands, while the high-band VCO operates on the 20- through 10-meter bands. Since both VCO assemblies are similar, only the low-band VCO is described in the following paragraphs.

When you select the 30-meter band, the synthesizer circuit board supplies +12 volts to the low-band VCO. Pull-down resistors R313 and R314 hold the 40- and 80-meter band select inputs low. This allows resistors R303 and R305 to back-bias transistors Q301 and Q302 so that capacitors C302 through C306 are effectively disconnected from the circuit. With these components out of the circuit, the frequency of the Hartley oscillator (Q303) is determined by coil L302, capacitors C308 and C309, and varactor diode D301.

Transistors Q304 and Q305 form a buffer circuit for the oscillator before the signal is applied to the synthesizer circuit board. Transistor Q305 forms a Darlington pair with transistor Q313 on the synthesizer circuit board. The outputs and the inputs of the two VCO assemblies are connected in parallel, but since transistor Q356 in the high-band VCO is back-biased and the tune input has a high impedance, the selected VCO assembly is not affected by the other.

When you select the 40-meter band, 9 volts is applied to transistor Q301 via diode D302. This connects capacitors C302 and C303 across the oscillator tank circuit and lowers the frequency range of the oscillator. On the 80-meter band, transistor Q302 switches in capacitors C305 and C306. Since transistor Q301 is still held on by diode D303, the tuning range of the oscillator is lowered even further.

DISPLAY CIRCUIT BOARD

The display circuit board converts the logic information, coming from the controller circuit board, so it can be used by the fluorescent display. This circuit board also provides control and pushbutton information for many sections of the Transceiver.

Integrated circuit U207 decodes the BCD (binary-coded-decimal) information from the controller circuit board, which causes one of its ten outputs to go low. These outputs go low one at a time and select, in turn, each digit of the display. This integrated circuit also polls many of the front panel switches. The low output on the selected output of integrated circuit U207 is inverted by a section of either integrated circuit U203 or U204, to provide a high input to the corresponding display driver section. At the same time, the controller circuit board provides the appropriate segment information to segment driver U201 to refresh that particular digit.

The low output from integrated circuit U207 is also applied to the Band switch, the Mode switch, one of the three momentary pushbutton switches (Split, D⇆M, or D→M), the keypad pushbuttons (if you have this accessory installed), and the finger detection circuitry. Any of the diodes connected between the selected output of integrated circuit U207 and the four switch input lines to the controller circuit board will conduct, which allows the controller to determine the status of these front panel functions.

The finger-detect circuitry senses the presence of your finger in the metallic insert in the Main Tuning knob (which causes the tuning rate to increase from 50 Hz-per-step to 1 kHz-per-step). The following paragraph describes how this circuit operates.

One of the BCD scan inputs to integrated circuit U207 is buffered by integrated circuit U205A and is applied to both the D input and, after an adjustable delay, to the clock input to U206B. The delay provided by integrated circuits U205B and U203A, resistor R208, and capacitor C201 is adjusted so that, when the metallic finger insert (which is connected to the D input) is not being touched, the high level of each pulse arrives at the D input through resistor R207 just in time to be clocked to the Q output by the rising edge of the pulse at the clock input. Therefore, the Q output of integrated circuit U206B is normally high, which disables integrated circuit U205C and keeps diode D204 from conducting.

The Q output of U206B is normally low, which enables integrated circuits U204C and U204D so that the 100 Hz and 10 Hz digits in the display light. When you touch the metallic finger insert, your body capacitance is added between the D input of integrated circuit U206B and ground. This delays the input so that when the rising edge of the pulse arrives at the clock input, the D input is still low. This causes the Q and $\bar{Q}$ outputs to change state, which causes diode D204 to conduct when it is polled. This, in turn, causes the controller to increase the step size, and also disables integrated circuits U204C and U204D to blank the 100 Hz and 10 Hz display digits.

Display V201 also contains special characters which you may turn off, set at full brightness, or set at half brightness by means of a jumper wire. This operates by disabling, enabling or alternately enabling and disabling integrated circuits U204C and U204D by clocking them with a square wave that comes from integrated circuit U206A.

CONTROLLER CIRCUIT BOARD

The controller circuit board performs the following functions:

1. Refreshes the display.
2. Programs a synthesizer integrated circuit in each of the three phase-locked loops.
3. Receives inputs from the shaft encoder circuit board and keypad (if this accessory is installed) to alter the frequency.
4. Polls the front panel switches for the desired band, mode, etc.
5. Monitors the phase-locked loops for an unlocked condition.
6. Allows the Transceiver to go into the transmit mode when you request it to do so, but first ensures that the phase-locked loops are locked and the frequency you have selected is within certain limits.
7. Stores display and memory frequencies for each band even when the Transceiver is turned off (if the memory keep-alive voltage is present at the rear panel Accessory Socket).
8. Mutes the receiver when required.
9. Performs diagnostics on itself when the Transceiver is turned on (if backup power was lost).

The various circuits on the controller circuit board will now be described in detail.

SHAFT ENCODER

The shaft encoder consists of two slotted infrared switches (mounted on a separate circuit board) and a wheel that has alternating clear and opaque areas. This arrangement produces two pulse trains as the wheel rotates that are in quadrature (they are approximately 90 degrees out of phase) to produce four unique states. One of the shaft encoder outputs is applied to the external interrupt input of the microprocessor. This allows the microprocessor to determine the direction of rotation. When this input goes high, the microprocessor determines whether it should increase or decrease the frequency. It also determines whether or not you are using the fast-tune metallic finger insert in the Main Tuning knob. Schmitt trigger transistors Q703 though Q706 prevent false triggering due to vibration.

LOOP SELECT LOGIC

Three phase-locked loops are used in this Transceiver to ultimately produce a single injection frequency. Each of these loops uses a frequency synthesizer integrated circuit, which contains programmable divide-by-N and reference dividers and a digital phase detector with a lock-detection circuit. To program one of these IC's, each of the internal dividers is programmed by applying a 3-bit binary address code (to select one of the seven digit latches) along with a 4-bit binary digit code, and then the strobe input of the particular IC to be programmed is strobed. This process repeats for each of the seven latches within the IC.

Port 4 of the microprocessor supplies the required address/data for each latch and the strobe output of the microprocessor supplies the required strobe pulse. The address and data inputs for each of the three synthesizer IC's are connected in parallel across this port. Due to the loop select logic, only one of these latches receives the strobe pulse at a time.

Since only seven of the eight lines from port 4 are required, three for address and four for data, bit 7 is available to help select between the three ICs. One bit can only select between two ICs, however, so a trick must be used. Because there are only seven digit latches in each IC, the latches ignore a binary code of 111 (decimal 7). Integrated circuit U708A decodes this binary code and uses it to set or clear flip-flop U701B, depending upon the level of bit 7 at port 4. This provides four possible states when the latch address/data is strobed out on port 4. If integrated circuit U701B is in the cleared state, and bit 7 is low, integrated circuit U711A passes the stobe pulse to integrated circuit U703.

If integrated circuit U701B is in the cleared state and bit 7 is high, integrated circuit U711B passes the strobe pulse to integrated circuit U712. If integrated circuit U701B is in the set state, however, integrated circuit U711C passes the stobe pulse to integrated circuit U705 (regardless of the level on bit 7). Since interated circuits U703 and U712 must be reprogrammed each time you make a frequency change, integrated circuit U701B is normally kept in the cleared state. NOTE: Integrated circuit U705 is reprogrammed only when you make a band change (except for the 10-meter band, which is divided into four segments).

UNLOCK DETECTION

Lock detection logic within each synthesizer integrated circuit produces very narrow negative-going pulses on its output (pin 13) whenever it detects a phase-lock condition. If a large phase error occurs between the two inputs to the internal phase detector, the pulses increase in width. An external pulse width detection circuit senses this increase. NOTE: Since each lock detection circuit is identical, only the circuit associated with integrated circuit U703 is described in the next paragraph.

When the loop is locked, transistor Q711 is held on, which prevents diode D703 from conducting. If the loop unlocks, the wider pulses at the base of Q711 allow it to turn off long enough for capacitor C731 to charge through resistor R731 and diode D703. When the charge on this capacitor reaches 0.7 volt, transistor Q709 turns on. This applies a low to an input of integrated circuit U708C and takes its output high, which is inverted by integrated circuit U708B. If alignment jumper J is installed, the low on the output of U708B is applied to an input of microprocessor U710 and causes it to display a "PLL" message, force the Transceiver into the receive mode, and mute the receiver. Transistor Q709 lights LED D703 to indicate that this loop is unlocked.

CRYSTAL OSCILLATORS

Three crystal oscillators provide the frequency accuracy and stability of this Transceiver. Two of these are parallel-mode oscillators and are located on the controller circuit board. One of these oscillators operates at 8.04 MHz and is made up of transistor Q701, crystal Y701, and the associated components. The output of transistor Q701 drives transistor Q702 to TTL logic levels, which integrated circuit U701A divides by 2. This 4.02 MHz signal is used as a clock for microprocessor U710 and feeds the reference divider chain in integrated circuit U703. Integrated circuit U703 buffers this signal and also applies it to the reference divider chain in integrated circuit U712 (pin 16). Varactor diode D701 in this oscillator allows you to pull the oscillator frequency when you use the RIT (receiver incremental tuning) function.

The other oscillator on this circuit board, formed by transistor Q718, crystal Y702, and the associated components, operates at 10 MHz and operates very similarly to the 8.04 MHz oscillator. The output of buffer transistor Q719 drives the reference divider chain in integrated circuit U705.

LOOP FILTERS

Since the active loop filters for each of the phase-locked loops are similar, only the filter for loop 1 (PLL-1) is described below.

The double-ended outputs from the synthesizer IC's provide information about the relative frequency/phase differences between the outputs of the internal divide-by-N and the reference divider chains. If there is a frequency difference, one of the outputs remains high, while the other pulses low. If the frequencies match, both outputs pulse low and the widths of the individual pulses represents the phase difference between the two inputs. When the inputs are in phase, both outputs produce very narrow low-going pulses.

Loop filter U704 integrates the pulses at the outputs (pins 14 and 15) of the difference detector and produces a tune voltage. This voltage is used to tune a voltage-controlled oscillator (VCO), which provides an input to the divide-by-N input, and completes the loop. (In the case of loops 1 and 3, the output is first mixed with a signal from another source.) If the frequency of the VCO tries to rise or fall, the tune voltage from the loop filter changes in the direction required to return it to the correct frequency and attempts to keep the phase difference equal to zero. In loop 1, an additional low-pass filter follows the loop filter and reduces the reference frequency content on the tune voltage line.

MEMORY BACKUP

Microprocessor U710 has an internal memory that can be saved when you turn the Transceiver off. This is done by keeping +5 volts on the V_{SB} (standby) pin and causing the RST/RAMPRT (RAM protect) pin to go low before V_{CC} falls below its lower operating limit. Two frequencies are stored in this memory for each band. When the +13.8-volt source drops, capacitor C737 quickly discharges through diode D711. As this voltage reaches approximately 8 volts, transistor Q717 turns off and allows the back-up supply to turn transistor Q716 on. This causes the RST/RAMPRT line low before integrated circuit U714 goes out of regulation.

An additional safety factor is provided by filter capacitor C736. When you turn the Transceiver on, capacitor C737 charges through resistor R749, which allows the V_{CC} to stabilize before the RAM is enabled and the microprocessor resets.

MODE SELECTION

Pin 18 of microprocessor U710 changes state according to whether you select CW or SSB operation. Pin 19 changes state in both the CW and SSB modes depending upon whether you select wide or narrow CW, or upper or lower sideband. Integrated circuits U709 and U702B decode this information into the levels required by the various circuits in the Transceiver.

SYNTHESIZER CIRCUIT BOARD

The synthesizer circuit board works together with the controller circuit board and the VCO assemblies to affect changes in frequency.

The time it takes to make a step in frequency is inversely proportional to loop filter bandwidth. This filter must be narrow enough to attenuate reference frequency energy to an acceptable level, and yet wide enough to allow quick response. In a single-modulus, single-loop synthesizer, the minimum step size equals the reference frequency and these two considerations are always in conflict.

In this Transceiver, loop 2 (PLL-2) is the type of synthesizer described above, which has a reference frequency and step size of 10 kHz. In loop 1, the input to the divide-by-N chain is the difference between the output of the VCO in loop 2 (13.505 to 16.1 MHz) and the VCO output of loop 1 (approximately 5.45 to 6.05 MHz) and the reference frequency for this loop is 10.05 kHz. The bandwidth of these two loop filters, therefore, can be fairly wide to allow fast setting, and yet provide good attenuation of the reference frequency energy. When the VCO in loop 2 moves down in frequency by 10 kHz, the VCO in loop 1 moves up only 50 Hz to result in the required 10.05 MHz difference at the output of the mixer.

If the two loops had different slew rates, there would be an apparent overshoot in frequency, causing a chirping sound with each frequency step. To prevent this chirp, the microprocessor mutes the receiver for a few milliseconds during a frequency step.

The circuits for VCO 1 and VCO 2 are practically identical to the VCO's in loop 3 described earlier under "VCO Assemblies". The output of VCO 1 passes through a low-pass filter (formed by coil L106 and capacitors C134 through C136) to double-balanced mixer U101, where it is mixed with a signal from VCO 2. The difference between the two inputs is in the range of 8 to 10 MHz. This results in a signal that is bandpass filtered and amplified, and is then applied to the divide-by-N chain in loop 1 synthesizer integrated circuit U703 (on the controller circuit board).

Transistor Q109 now mixes the output of VCO 1, which changes in 50 Hz increments as described earlier, with a signal from the BFO circuit board. The sum of these two frequencies is in the range of about 14.28 to 14.88 MHz. This signal is now bandpass filtered and applied to transistor Q111, which acts as an amplifier on the 80-, 40-, and 30-meter bands. Transistor Q114 conducts on these three bands and effectively shorts out the tank circuit formed by transformer T105 and capacitor C175. On the 20- and 17-meter bands, transistor Q111 mixes the signal with 10 MHz (from the controller circuit board) to produce a 24.28 to 24.88 MHz output. Since capacitors C178 and C179 shunt this tank circuit on these two bands, due to transistor Q115 being turned on, the circuit resonates at 10 MHz. On the 15-, 12-, and 10-meter bands, transistors Q114 and Q115 are off, the tank circuit resonates at 20 MHz, and provides an output in the 34.28 to 34.88 MHz range.

The signal from the tank circuit is bandpass filtered and coupled to transistor Q112. The input to the other gate of transistor Q112 is the loop 3 VCO signal, which the Transceiver uses for the injection signal. As shown in the following table, the output of mixer transistor Q112 depends on the band and, on the 10-meter band, the frequency you have selected.

BAND	FREQUENCY RANGE	Q112 OUTPUT	÷N
80M	3.45—4.05 MHz	2.0 MHz	4
40M	6.95—7.35 MHz	1.5 MHz	3
30M	10.0—10.2 MHz	4.5 MHz	9
20M	13.95—14.4 MHz	1.5 MHz	3
17M	18.018—18.218 MHz	2.5 MHz	5
15M	20.95—21.5 MHz	4.5 MHz	9
12M	24.84—25.04 MHz	1.0 MHz	4
10M	28.0—28.49995 MHz	2.5 MHz	5
	28.5—28.99995 MHz	3.0 MHz	6
	29.0—29.49995 MHz	3.5 MHz	7
	29.5—29.7 MHz	4.0 MHz	8

The input to the reference divider in integrated circuit U705 (on the controller circuit board) is 10 MHz. This frequency is internally divided to produce a reference frequency of 500 kHz on all bands except 12 meters, which uses 250 kHz as the reference frequency. On four of the bands (80, 20, 15, and 12 meters), the VCO 3 input to transistor Q112 is below the input from transistor Q108 while on the other four bands, it is above. Integrated circuit U706, on the controller circuit board, is therefore used to reverse the two outputs of the phase detector in this circuit to provide a tune voltage that moves in the correct direction to obtain lock.

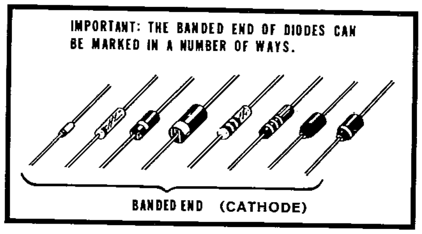
Transistors Q116 through Q121 select the required VCO for loop 3 and the injection to transistor Q108, depending upon the band you select.

In the receive mode, gate 2 (G2) of RF transistor Q404, on the RF circuit board, is partially muted between tuning steps, during band changes, and when a phase-locked loop is unlocked to force the receiver into a muted condition.

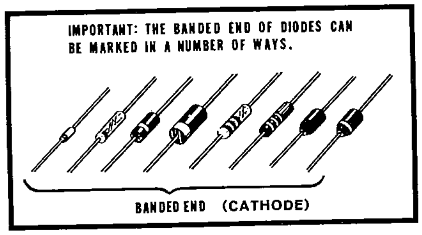
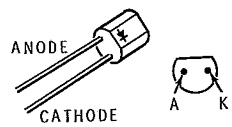
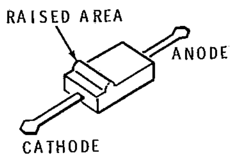
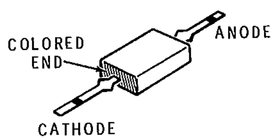
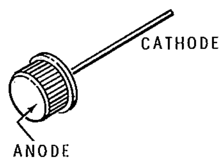
SEMICONDUCTOR IDENTIFICATION CHARTS

DIODES

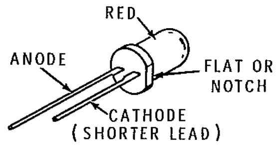
COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
D804	56-19	VR-9.1	
D651, D652	56-20	1N295A	
D105-D109, D111, D808, D811	56-24	1N458	
D552	56-25	1N4166A	
D1, D2, D102, D104, D204, D209, D211-D219, D221-D229, D231, D232, D905-D908	56-26	1N191	
D112, D113, D201, D202, D302-D304, D352-D357, D401-D405, D407-D414, D416, D418, D421-D426, D551, D553, D702, D704, D706, D708, D801-D803, D805-D807, D812-D814, D901, D911, D912	56-56	1N4149	



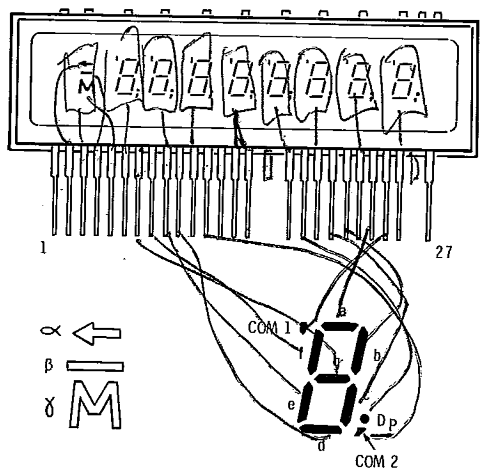
DIODES (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
D427, D555, D654, D902, D909	56-58	1N5234B	
D501-D504	56-93	FD333	
D554	56-616	1N5232B	
D406	56-621	VR-8.2	
D412	56-646	BA-244	
D203, D653, D1203, D1204	56-652	1N4448	
D103	56-666	MV2115	
D1201, D1202	57-27	1N2071	
D709, D913	57-65	1N4002	
D809	56-640	MV2110	
D101, D301, D351, D701	56-648	MV109	
D903, D904	56-656	BA-379	
D3	57-35	1N3491	

DIODES (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
D703, D705, D707	412-632	NLS5076A	

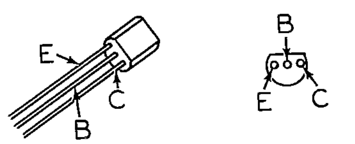
DISPLAY

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
V201	411-857		

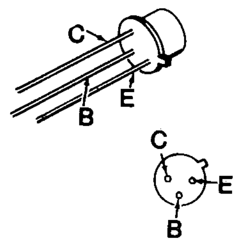
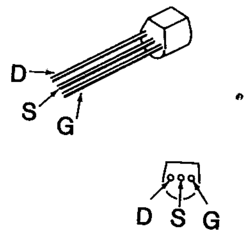
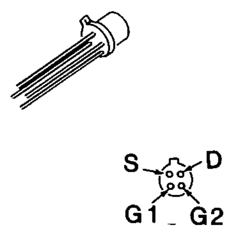
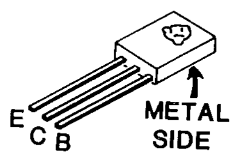
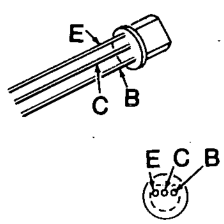
PIN	CONNECTION
1	FILAMENT
2	SEGMENT α (←)
3	G_9 (LEFT END)
4	SEGMENT β (−),
5	SEGMENT γ (M)
6	G_8
7	SEGMENT g
8	SEGMENT f
9	G_7
10	SEGMENT e
11	SEGMENT d
12	G_6
13	SEGMENT COM 2
14	NO CONNECTION

PIN	CONNECTION
15	G_5
16	NO PIN
17	G_4
18	SEGMENT Dp
19	G_3
20	SEGMENT c
21	SEGMENT b
22	G_2
23	SEGMENT a
24	SEGMENT COM 1
25	G_1 (RIGHT END)
26	NO PIN
27	FILAMENT

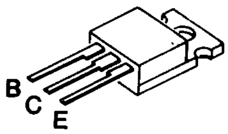
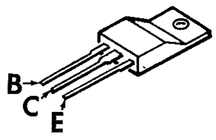
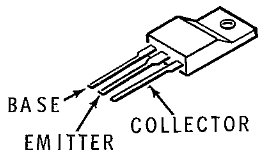
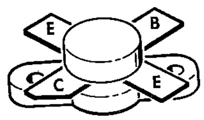
TRANSISTORS

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
Q1206, Q1207	117-16	(Matched pair; Replace with Heath part only.)	
Q114, Q115, Q301, Q302, Q351, Q352, Q353, Q411, Q813, Q904	417-134	MPS6520	
Q108, Q401, Q402, Q405, Q718, Q814, Q1104-Q1106	417-172	MPS6521	
Q116, Q118, Q119, Q406, Q408, Q409, Q703-Q709, Q711-Q717, Q801, Q803, Q806, Q807, Q811, Q901, Q905-Q907, Q926, Q928, Q1102, Q1108, Q1109, Q1111, Q1112	417-801	MPSA20	
Q552, Q553, Q556, Q651-Q654 Q902, Q903, Q908, Q909, Q913, Q914, Q917, Q922-Q925	417-864	MPSA05	
Q117, Q121, Q407, Q412, Q911, Q912, Q916, Q919	417-865	MPSA55	

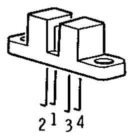
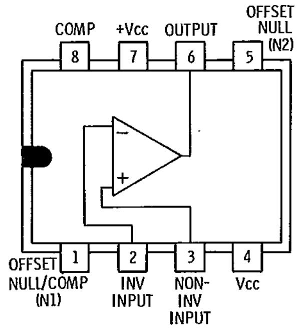
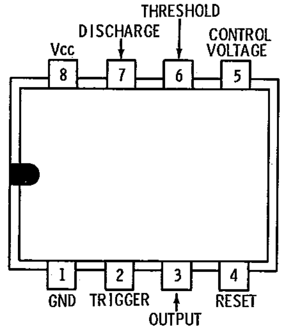
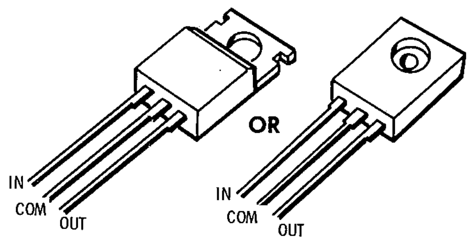
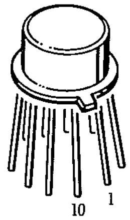
TRANSISTORS (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
Q103, Q106, Q107, Q113, Q305, Q356, Q701, Q702, Q719	417-154	2N2369	
Q403	417-205	2N3866	
Q101, Q104, Q303, Q354	417-169	MPF-105	
Q102, Q105, Q304, Q355, Q1107	417-241	EL131	
Q109, Q111, Q112, Q404, Q1101, Q1103	417-863	MFE131	
Q502, Q551, Q555, Q1205	417-818	MJE181	
Q501, Q554	417-819	MJE171	
Q802, Q804, Q805, Q808, Q809, Q812, Q927	417-201	X29A829 276-2023	

TRANSISTORS (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
Q915, Q918, Q921	417-852	TIP31	
Q1201, Q1202	417-971	(Replace with Heath part only.)	
Q1203, Q1204	417-972	(Replace with Heath part only.)	
Q1206, Q1207	417-973	(Replace with Heath part only.)	

INTEGRATED CIRCUITS (ICs)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U601, U602	150-74	Heath part only.	
U704, U707, U713	442-39	LM301AN	
U501	442-53	NE555	
U714, U715	442-54	UA7805	
U101, U902, U904	442-96	MC1496G	

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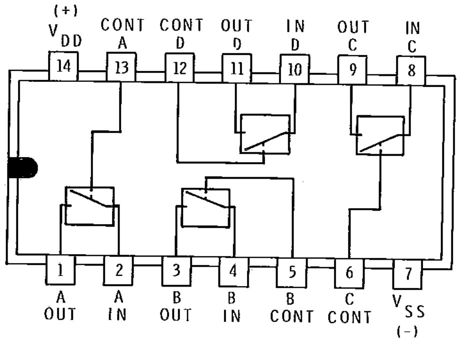
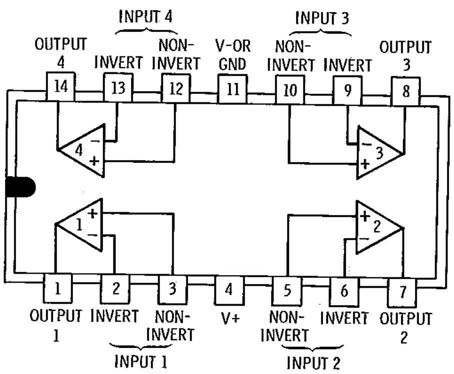
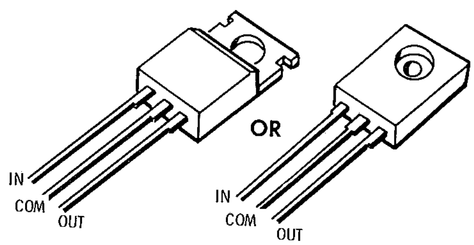
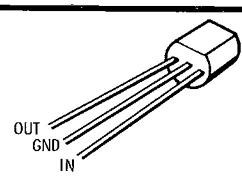
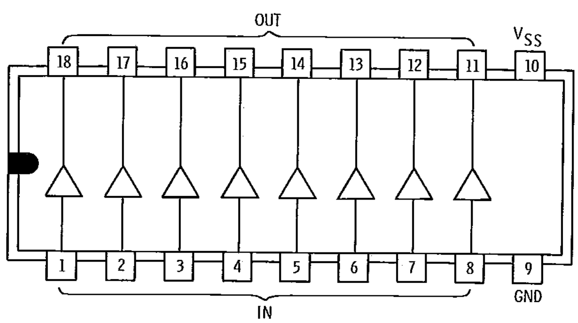
INTEGRATED CIRCUITS (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U1101	442-99	CD4016AE Analog sw itch	
U901, U905	442-602	LM324N	
U503	442-663	78M12	
U903	442-691	78M08	
U502	442-681	78L08	
U201, U202	442-682	UDN6118A	

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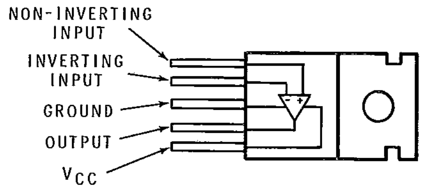
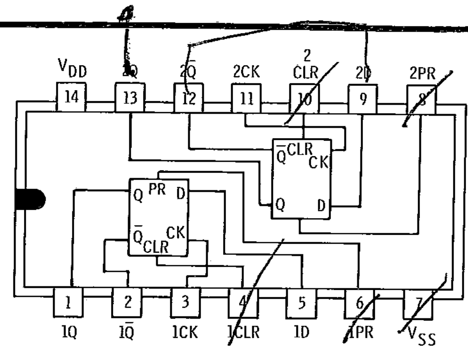
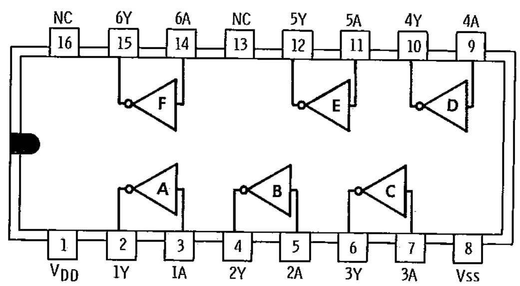
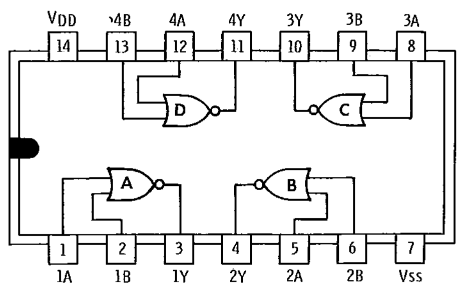
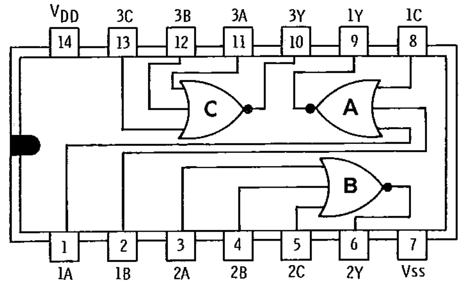
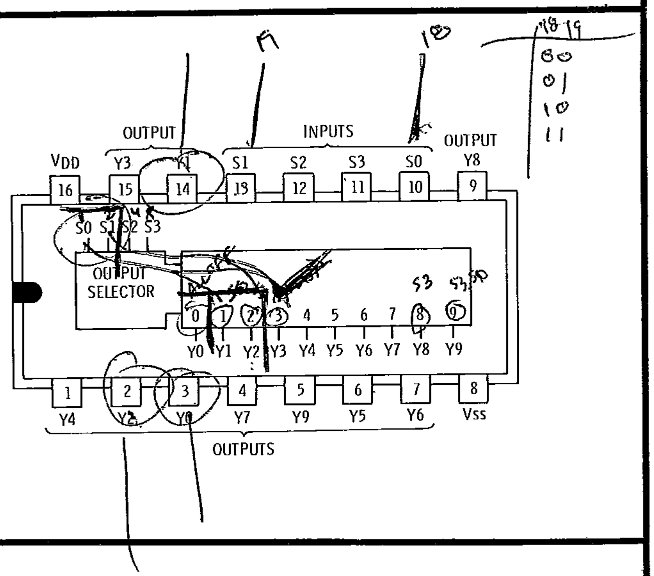
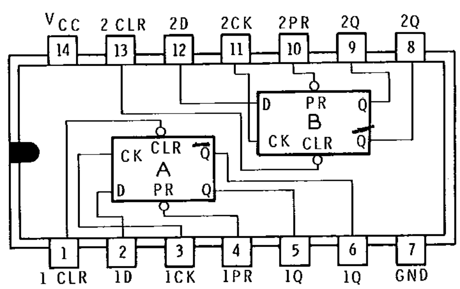
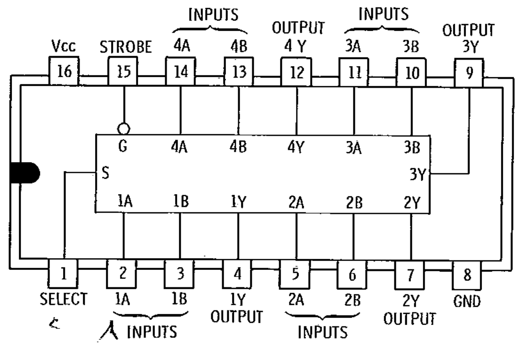
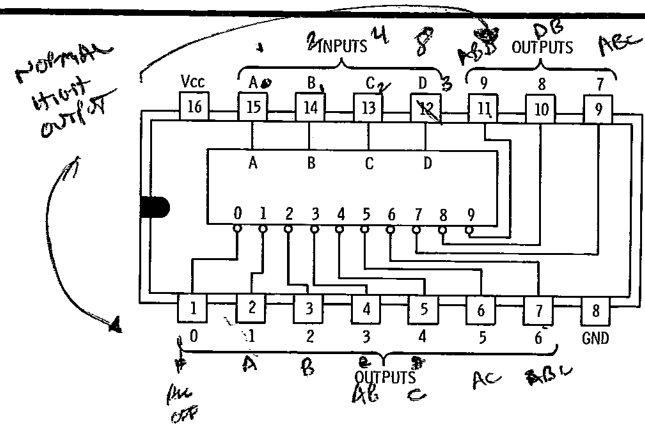
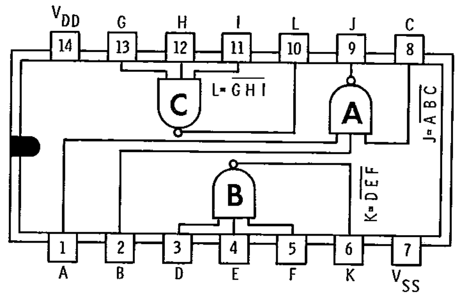
INTEGRATED CIRCUITS (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U906	442-713	LM383	
U206	443-607	MC14013A1 or CD4013BCN	
U203	443-701	MC14049CP or CD4049CN	
U204, U205, U702	443-703	MC14001CP or CD4001BCN	

INTEGRATED CIRCUITS (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U711	443-712	MC14025	
U709		MC14028 RCA 4028B	
U701	443-730	74LS74	

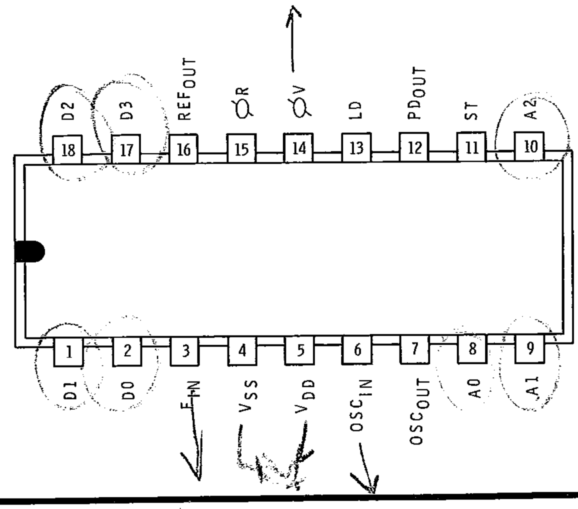
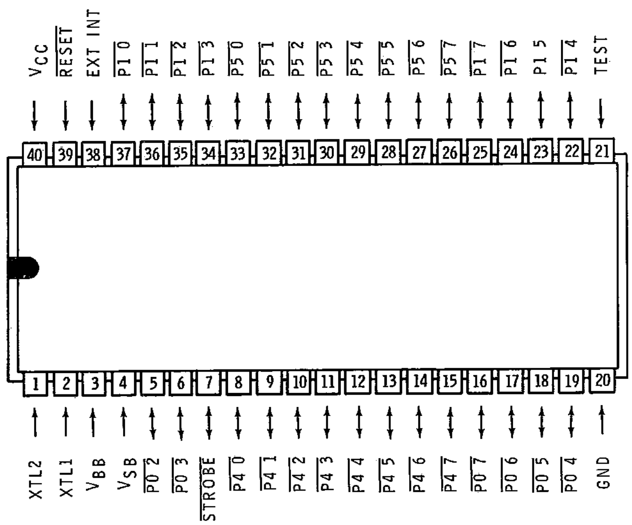
INTEGRATED CIRCUITS (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U706	443-799	74LS157	
U207	443-807	74LS42	
U708	443-887	4023	

AND

0 0	0 1
0 1	0 1
1 0	0 1
1 1	1 0

INTEGRATED CIRCUITS (Cont'd.)

<table>
<tr><th>COMPONENT NUMBER</th><th>HEATH PART NUMBER</th><th>MAY BE REPLACED WITH</th><th>IDENTIFICATION</th></tr>
<tr><td>U703, U705, U712</td><td>443-1030</td><td>MC145145</td><td>
</td></tr>
<tr><td>U710</td><td>444-94</td><td>MK3875</td><td>
</td></tr>
</table>

CUSTOMER SERVICE

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

TECHNICAL CONSULTATION

Need help with your kit? — Self-Service? — Construction? — Operation? — Call or write for assistance. you'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment. Do not include the kit Manual.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

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REPLACEMENT PARTS, Call 616-982-3571

HW-5400 TRANSCEIVER MODIFICATIONS COMPLETE LIST

Filter Circuit Board

1. Change D555 to 6.8V zener diode, part number 56-637.

Audio Circuit Board

1. Change R913 to 68k ohm, part number 6-683-12.
2. Change R994 and R995 to 1000 ohm, part number 6-102-12.
3. Change C929 to 330 pF, part number 21-722.
4. Remove C908 and replace with a jumper wire. —check this
5. Remove C915 and discard (4.7 uF).

High VCO Assembly

1. Change R367 to 33 ohm, part number 6-330-12.

BFO Circuit Board

1. Change C811 to 220 pF, part number 20-120.
2. Change C817 and C821 to 27 pF, part number 21-6.
3. Change C819 to .01 uF, part number 21-761.
4. Change L804 to 10 uH RF choke, part number 45-57.

Controller Circuit Board

1. Add diode D701B as shown on the attached sheet. —Check this
2. Change C703 and C704 to 220 pF, part number 20-120.
3. Change Q701 and Q702 to part number 417-154.
4. Note .... DO NOT change C702 .... it should be 3.2 - 18 pF trimmer (blue screw) part number 31-71.

IF Circuit Board

1. Change R1151 to 1500 ohm, part number 6-152-12.
2. Change R1145 to 2200 ohm, part number 6-222-12.

RF Circuit Board

1. Add the series resonant circuit as shown on the attached sheet, pa t number 45-631, 21-111, 6-470-12.
2. Add CW keying circuit as shown on the attached sheet, part number 6-122-12, 25-864, 25-922, 56-56. 1.2K
3. Add ferrite bead to base of Q401 and base of Q402, part number 475-16. check
4. Remove R419 and discard (100k ohm). —Check this

ALC Circuit Board

1. Change D654 to 30V diode, part number 56-64.

Power Amplifier Circuit Board

1. Add a .01 uF capacitor as shown on the attached sheet, part nu 21-176.

START

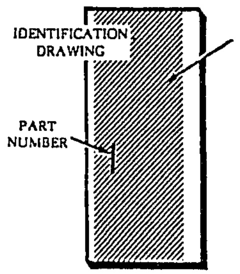
( ) Position the controller circuit board printed side up as shown. IMPORTANT: This circuit board has foil on both sides. DO NOT solder to the foil on the printed (component) side of the board.

NOTE: Only a portion of the circuit board is shown in some Pictorials. The small "Identification Drawing" at the top of the page shows the area of the board to be assembled.

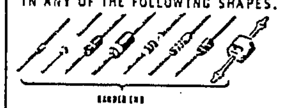
NOTE: When you install a diode, always align its banded end with the band on the board. See Detail 10-1A.

( ) D706: 1N4149 diode (#56-56).

STEP-BY-STEP ASSEMBLY



The steps performed in this Pictorial are in this area of the circuit board.



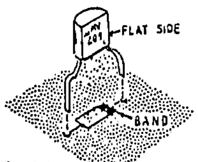
Detail 10-1A

#56-648 DIODE NO LONGER AVAILABLE

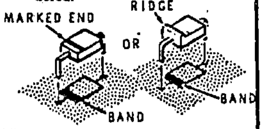
The MV109 varactor diodes at D101, D301, D351, D701, and D701B are changed:

From #56-648 to #56-674.

This new diode is an MV209 and has a different case style. Install it as shown at the right. Use this new diode when a replacement is needed.



( ) D701: MV109 diode (#56-648). Solder the leads to the foil when you install it. Check the leads to make sure they are well soldered.



( ) D701B: MV109 diode (#56-648). There is no outline for this diode. Be sure to position the marked end as shown.

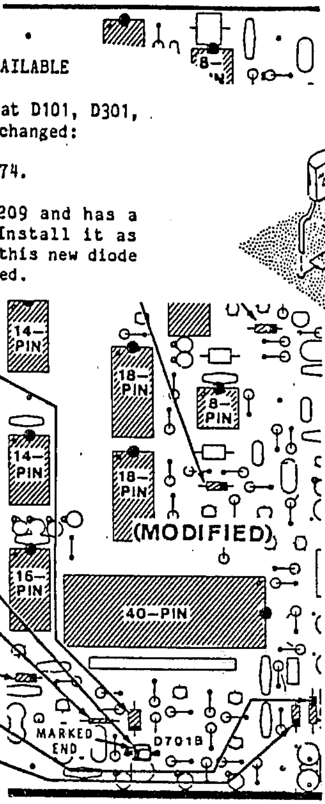
( ) L701: 100 µH choke (#45-604, brn-blk-brn).

( ) D702: 1N4149 diode (#56-56).

( ) D709: 1N4002 diode (#57-65).

( ) D711: 1N4149 diode (#56-56).

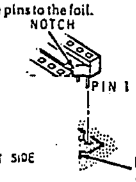
( ) Solder the leads to the foil and cut of the excess lead lengths.



PICTORIAL 10-1

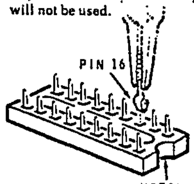
CONTINUE

NOTE: When you install an IC socket, be sure the index mark is still visible after the socket is installed. Then solder the pins to the foil.



...ets at U712 and

...8-pin socket as ... note the location ...hen grasp pin 16 with long-nose ...iers and pull the pin all the way out of the socket. The pin will not be used.



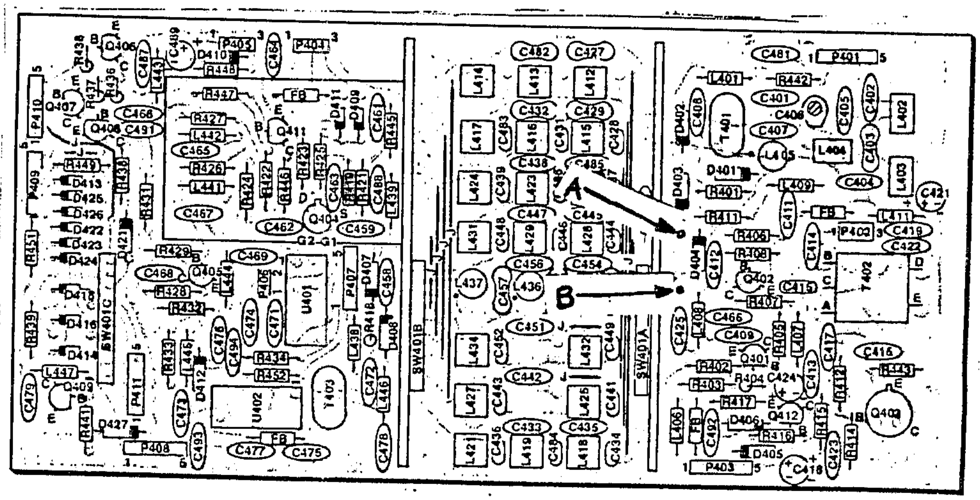
( ) Install the modified socket at U703. Be sure to match the notch on this socket with the index mark on the circuit board.

( ) 18-pin IC sockets at U706 and U709.

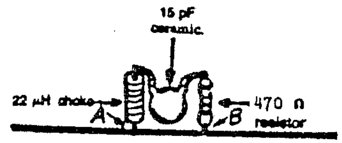
( ) 14-pin IC sockets at U711, U702, U708, and U701.

( ) 8-pin IC sockets at U713, U707, and U704.

( ) 40 pin IC socket at U710.



RF CIRCUIT BOARD
(Shown from the component side.)



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IMPROVING THE HEATHKIT HW-5400 TRANSCEIVER

◊ Ever since it was new, my Heathkit HW-5400 transceiver had an unusual "peaky" quality to the receive audio. On the air tests indicated that the transmitted audio also had a peaky frequency response, as well as some distortion. One fellow described it as sounding unnatural and harsh. After several hours of tests and measurements, I determined that the cause of the poor audio was excessive passband ripple in the crystal filters and distortion in the balanced modulator circuit.

IF-Board Modifications

The HW-5400 uses two crystal filters in its IF section. The standard filter is used on both transmit and receive while the optional filter is used only on receive (in conjunction with the standard filter). In-circuit measurement of these filters revealed some rather startling characteristics. I found the optional four-pole filter to have a peak-to-peak (P-P) ripple of almost 10 dB! The standard 6-pole filter's ripple was almost 8 dB P-P. Fortunately, the ripples did not add directly (to produce a possible maximum of 18 dB P-P) because their peaks and dips did not coincide.

Assuming filters of sound design, such ripple can be caused by terminating the filters with improper sources and loads. I replaced all the components that match the filters' inputs and outputs, but the problem was still there. Rather than live with the ripple, I decided to redesign the filter matching networks. The solution was much simpler than I had anticipated:

1. Change capacitor C1112 from 0.01 µF to 10 pF.
2. Remove and discard R1154, a 51-Ω resistor.
3. Change L1101 to 4.8 µH. I wound a new coil using 36 turns of #32 enameled wire on a T-30-6 toroidal core (you can modify the original toroid to achieve the required inductance by removing turns).
4. Add a 68-pF silver-mica capacitor across the input of filter Y1101.
5. Realign the HW-5400's IF board as described in the manual.

Balanced-Modulator Modifications (Audio Board)

The HW-5400 uses the popular MC1496 IC as its balanced modulator. Because I am familiar with this device, I was surprised at the amount of distortion it produced in my transceiver. Circuit analysis and studying the MC1496 data sheet suggested that several factors contributed to the distortion: insufficient BFO/carrier drive, excessive audio input, and a missing low-frequency bypass capacitor.

Correcting these problems is relatively easy. While I was working on this board, I also modified the VOX circuit to provide a longer maximum delay time. Here are the changes:

1. Change R913 to 33 kΩ.
2. Change C906 to 300 pF. (Capacitors of this value may be hard to find. Use two 150-pF capacitors in parallel; or a 270-pF capacitor should be okay.)
3. Change R937 to 6.8 kΩ.
4. Change R938 to 3.3 kΩ.
5. Add a 22-µF, 16-V tantalum electrolytic capacitor from pin 4 of U902 to ground. (Connect the capacitor's positive lead to pin 4.)
6. Change C926 to 100 pF.
7. Change C929 to 0.01 µF.
8. Install a 15-Ω resistor between the collector of Q905 and the other circuitry as shown in Fig 1.
9. Change R927 and R993 to 100 Ω.
10. Change C921 and C932 to 1500 pF.
11. Change C947 to an 8.2-µF, 16-V tantalum electrolytic capacitor (10 µF will work well also).
12. Change C957 to 150 pF.
13. Change R987 to 8.2 kΩ.
14. With the rig in SSB mode and the mike connector's PTT contact shorted to ground, adjust R823 for a BFO level of 150 mV P-P at pin 8 of U902. If the BFO level is too low when R823 is turned all the way up, change R822 on the BFO board to 47 Ω. (This step requires an oscilloscope or RF voltmeter capable of giving readings of known accuracy at 8.83 MHz.)
15. Optional: Add a 2N2222 transistor, 0.0047-µF capacitor, 8.2-kΩ and 1-kΩ resistors, two 1N4148 diodes, and a 0.001-µF capacitor between pin 5 of U902 and the **R12** line as shown in Fig 2. These changes eliminate one side effect I noticed after modifying the balanced modulator (specifically, increasing the carrier/BFO injection level): a small amount of BFO feedthrough into the IF, noticeable with the IF shift control fully counterclockwise, when receiving in CW mode. The leakage path was through balanced modulator U902 and amplifier Q904. The added transistor shuts off U902 during receive, reducing the feedthrough by about 20 dB and making it inaudible. Finding room for these parts is rather difficult, so it may be wise not to make this change unless you need to.
16. Readjust the radio's carrier balance.

These changes smooth the HW-5400's peaky audio and eliminate transmit distortion during normal operation. (Overdriving the radio by using too much mike gain will still produce distortion, as with any other rig.) After you've made these changes, expect the radio's CW gain control to behave a bit differently than before. You'll need to turn the control farther counterclockwise than before to reduce carrier power. This is normal.

These changes made my HW-5400 seem like a different rig. Rematching the filters resulted in a passband ripple of less than 1.5 dB total for the two filters. The effect of this improvement was immediately evident on receive. The audio was much more pleasant. Because of the better filter matching, the radio's IF gain increased slightly, resulting in higher S-meter readings on all signals. Last, but certainly not least, on-the-air tests indicated that my transmitted audio had improved drastically. One old friend (Warren Ziegler Jr, NY2H) remarked that for the first time with this rig my audio sounded natural, with none of the usual harshness: "Wow, what a difference!"

If you want more information on these modifications, or would like to exchange tips on the HW-5400, please write to me. *—Paul Akimov, WA2RIA, 6418 Charnwood St, Springfield, VA 22152-1933*

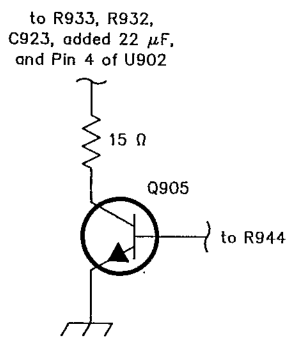


Fig 1—Adding a 15-Ω resistor between Q905 "and the other circuitry."

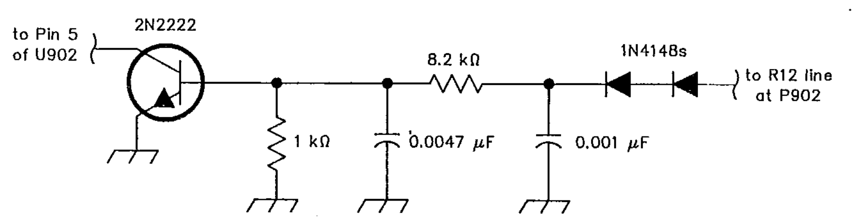


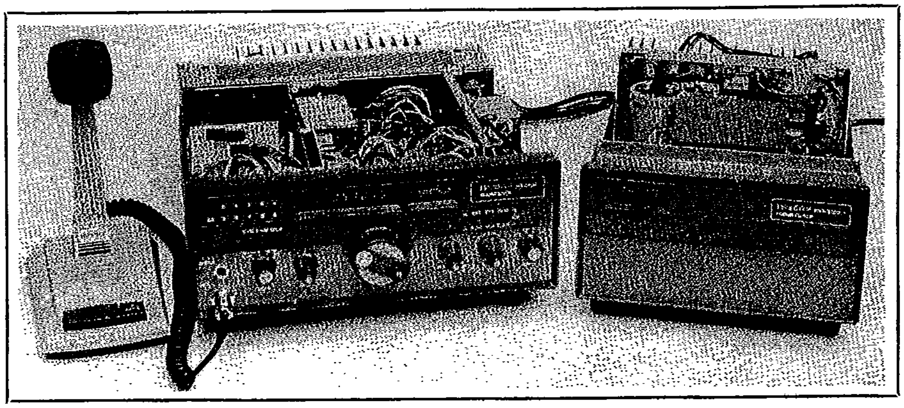
Fig 2—These optional components reduce BFO-to-IF-amplifier leakage during CW reception by turning off U902, the HW-5400's MC1496G balanced modulator IC.

Product Review

Conducted By Paul K. Pagel,* N1FB

June 1994 p76
July 1993 p48
Sep 1988 p42

Heath HW-5400 HF Transceiver



My excitement ran high that Christmas of 1967. I had recently passed my Novice exam, and my parents had bought me a Knight-Kit T-60 crystal-controlled AM and CW transmitter. I spent most of my Christmas vacation assembling the kit. I got a lot of soldering experience, I learned how the pieces of my transmitter fit together (so that later, when repairs were necessary, I was willing to dive right in and locate the faulty components), and my parents saved about 40% of the cost of an assembled, comparable rig.

There was a lot of excitement around my house for the Christmas of 1983, too. This time most of the excitement was generated by my three harmonics, but I also had a new radio kit to build. I had been asked to complete the construction and review the Heath HW-5400 transceiver. This rig has many features I wish I could add to my Tempo 2020, so I quickly accepted the challenge.

A former ARRL Hq. staffer had started the project in April 1983. Three boxes were returned to Headquarters by mid-December: one for the radio, one for the power supply, and the heaviest and smallest one of all for the power transformer. The review unit also included the optional SSB filter unit, the push-button frequency-entry keypad and the HDP-242 desk microphone.

Luckily, the original reviewer had followed the most important instruction of all when he began the project: *Do not remove any bag or parts from the shipping carton until it is called for in the instructions.* There are 14 circuit boards in this kit, and the components for each one are found in one or two small paper bags. Heath has even included a map to show you where each bag of components is located in the carton.

My first step was to transfer all of the corrections on the enclosed addendum into the construction manual (a large, three-ring notebook). One point of confusion here was that I had two sets of addendum sheets, and at one or two points they made different changes to the same assembly step! Which change is correct? A call to Heath helped me determine which sheet to follow in those cases.

Most of the small hook-up wires are supplied in a 30-inch length of 25-conductor ribbon cable.[1] One of the first steps is to cut this cable into various length strands and multi-conductor cables. I found that it is very easy to ruin this wire. If you try to cut the full length of the cable with a knife, you are sure to nick the insulation in many places. When you perform this operation, do not attempt to cut all the way along the length of cable. Use a very sharp knife to start the cut, then zip the wires apart by hand. I called Heath and explained why I needed a new length of ribbon cable and a few other parts that had not survived the change in hands for the project. In the meantime, I had all of this work to do, and a deadline for the review that was only about a month away.

That was when I decided to start on a fresh project — the power supply. Actually, I recommend that anyone building this kit start with the power supply. It is a small project that goes together quickly. My total assembly time, including circuit checkout and a minor modification (more on this later), was just over 13 hours. Besides, when you have completed the '5400 assembly, you will want to power it up right away, so it helps to have a power supply ready and waiting.

The HWA-5400-1 complements the transceiver nicely. It supplies 13.8 V at up to 20 A to power the rig. It also supplies a 13.8-V memory keep-alive voltage so the transceiver will remember the frequencies stored in memory and the last operating frequency even when the power is switched off. The main supply transformer is activated with the HW-5400 power ON/OFF switch. It features a remote voltage-sensing circuit for the regulator transistors. This circuit monitors the voltage being supplied at the rig, and feeds control information back to the transistors. The power supply includes a remote speaker, and it even has a digital-display clock! What more could you ask for?

A small transformer is used to power the clock and memory keep-alive circuit. This transformer is on as long as the supply is plugged in. The main power-transformer primary circuit is closed by means of a relay that is activated when the power switch is turned on.

At construction time, you must decide if you will use the supply on 117- or 234-V mains. There are separate steps in the procedure to guide you through the installation of the proper fuses and jumpers. I decided to wire my supply for use on 117-V circuits. Even though a 234-V supply is more efficient, it is easier to find a 117-V outlet to plug into! Heath provides a standard 117-V, 15-A plug on the line cord. If you decide to go with 234-V operation, you are instructed to cut the plug off the cord and install the proper one.

When you wire the clock circuit board, you must select 50- or 60-Hz operation, depending on the line frequency you have, and you also select 12- or 24-hour display format. I chose the 24-hour format.

The only problem I had while constructing the power supply occurred when I tinned a couple of the larger-diameter wires, as instructed. They would not fit through the circuit-board holes provided. Then I had to clip off the tinned end and use a clean end to solder the wire to the PC board. The wire lengths provided seem adequate in most cases, so making the wire ½-inch shorter did not present any problems. As expected, the instruction manual is detailed and well written.

After completing the power supply and checking the operation, I was shocked to realize that this beautiful station clock provided no way to synchronize the seconds with a WWV time signal! The only way to come close is to plug the power cord in right on the BEEP. I found I could get the clock within 5 or 6 seconds of the correct time this way. But wait! If the only radio I will have in my station to receive WWV signals is the '5400, and it needs the power supply to operate, how can I listen for the tone to plug my supply in? It just won't work! What a disappointment.

Inspection of the clock chip revealed it to be an MM53113N IC. Checking the specifications on this chip in the back of the instruction book proved that it is indeed a full-featured clock chip, capable of alarm functions and much more. Grounding pin 32 (by means of a switch) displays a single minute digit, along with seconds. Now the fast-set switch holds the seconds and the slow-set switch resets them to zero. It didn't take me more than a few minutes to drill a small hole on the bottom of the cabinet, near the front, and to epoxy a small toggle switch to the main chassis

[1]mm = in × 25.4; m = ft × 0.3048.
*Assistant Technical Editor

so the handle just fits through the hole. One word of caution here. Since Heath's warranty does not cover modified kits, I would recommend you build the radio and power supply without modification. After you are sure everything is operating as it should be, then go back and start making your modifications. You might even want to wait for the warranty to expire.

To set the clock, you must use some device to reach through a small hole in the front panel. A plastic tube about 1 inch long, which is a molded part of the front panel, guides the tool to the contact switch. Heath suggests use of a toothpick, but it did not work for me. A flat toothpick flares too much to fit all the way through the tube, and when I shaved one down so it would fit, it lacked the necessary strength. The perfect instrument proved to be a paper clip, with one end straightened. The remaining bends in the clip form a nice handle, the metal is thin enough to fit through the tube, and it has the required strength.

On with the Construction

The replacement parts arrived before I had completed assembling the power supply, so I was ready to get on with the radio by now! After I got into "virgin territory," things went smoothly with the kit assembly. The 259-page assembly manual is complete and detailed (so what else is new?). The instructions for each circuit board direct you the parts-box map to locate the correct bag and circuit board. Then you do a quick parts inventory for that section, and begin stuffing the board. Some of the boards are rather densely packed, but not so much that you can't work on them. The parts are installed in an orderly fashion, usually starting with the small resistors, diodes and capacitors, and then on to the larger components, such as electrolytic capacitors. You are instructed to move around the board, adding components section by section. A pair of small needle-nose pliers and a close-cut dikes are handy tools for this project.

Chuck Hutchinson, K8CH, showed me a nifty trick for installing the components. Even though the instructions are to mount the small components flush against the PC board, Chuck likes to mount them a little above it. His reasoning is that when a component burns or explodes, it is not as likely to char the PC-board markings. This can be important when you try to identify the part number and value to replace the damaged part. A piece of scrap PC-board material can be cut to a width about equal to the length of a ¼-W resistor body, and several inches long. This "spacer" can be held under the component being installed and the leads flared slightly to hold it in place while you solder them to the board. This provides a uniform spacing for the components above the board, and makes a very professional-looking job when the circuit board is done.

After each circuit board is completed, you are directed to make a series of visual checks on your work. It is much easier to double-check each component location and orientation at this time than after the boards are installed in the chassis! Also be sure to check every solder connection for cold-soldered joints or excess lead lengths that could short against another circuit trace or the chassis.

Most of the check-out procedures include a few resistance measurements. Heath recommends use of a high-input-impedance VOM. My meter has an input impedance of 20 kΩ/V. Heath also cautions that the negative ohmmeter lead must be connected to the ground foil unless you are told to do otherwise. Most hams will be aware that the red (+) lead on most VOMs is negative in the ohmmeter positions. Be sure to check your meter with a second voltmeter. You will get erroneous results on many of the measurements if the leads are reverse connected. My VOM gave results that did not agree with the expected measurements in a number of instances. I tried a VTVM from the ARRL lab to double-check those results. In most cases, the results were in the range of acceptable values when I used the VTVM. I would recommend the use of an FETVM or VTVM if at all possible.

Even with the VTVM, some measurements indicated problems with certain components. On the audio board, I found one troublesome measurement that indicated a faulty capacitor. When I tried to locate that part on the board, I discovered that it had been replaced with a jumper wire in the installation step! This illustrates the fact that a kit as complex as an HF transceiver is a dynamic project. The engineers at Heath are constantly working to improve the radio, but the documentation may not always keep up with the changes. (Of course, the same is also true for fully assembled rigs, but you would not be as aware of the changes. Many of the schematic diagrams supplied with those rigs do not match the actual circuitry inside the box.) There are markings and mounting holes on several boards for components no longer used. I used a felt-tip pen to mark off those areas, just so I wouldn't wonder if I had left out an important component later on.

There were a few other minor snags in doing these resistance checks. On the HI and LOW VCO boards you are instructed to check for shorts on the feedthrough capacitors, using your ohmmeter set to the ×1-kΩ range. The +12 V leads on both these boards have a 600-Ω resistor to ground on this capacitor, which looks like a dead short on the recommended range. It can be rather confusing until you start tracing the circuit wiring and schematic diagram.

On the controller circuit board, I installed a set of wires in holes I, G and O. A few steps later, I was again instructed to solder wires to holes I, G and O. That was when I discovered two sets of holes on the board with the same labels! Of course, I had seen the wrong set first. So I had to unsolder the wires and move them. Why label two sets of holes with the same letters on one board? Beats me!

Well, I finally had all of the boards built after spending about 70 hours working on the radio. Approximately another 10 hours of putting the circuit boards on the chassis, and I was ready to begin the alignment procedure. It has been very time-consuming, but fun. I am intimately familiar with every piece of my radio, and how it all fits together.

Then came the snag! While adjusting the USB oscillator on the BFO board, I found that I could not set the frequency to 8.83145 MHz. In fact, I could not adjust it higher than 8.827 MHz. Heath suggests a couple of diodes, an inductor or a transistor as possible culprits, so I lifted them off the board to check. All seemed normal. After many hours searching the circuit board for a bad solder joint and studying the schematic diagram for other possibilities, I came to realize that there was plenty of tuning adjustment, and everything was working. The trimmer capacitor was set to minimum value when the oscillator was tuned to the highest frequency possible. I just couldn't tune high enough — too much capacitance in the circuit! Then I noticed that the manual originally called for a 7.7-pF NP0 capacitor in the circuit, but that value had been changed to a 27-pF NP0 unit. I tried replacing the capacitor with the original one supplied with the kit. Now the frequency was too high, and would not adjust low enough! Well, try some values in between. After several hours of changing capacitors and checking the resonant frequency, I managed to hit on a combination that worked. Now I was able to adjust the frequency properly.

I spent some time on the phone with the Heath technicians on this one! They suggested a faulty capacitor or an incorrect inductor in the circuit. I received prompt, courteous service every time I called (even without identifying myself as an ARRL employee!), and within a few days I had some replacement parts to install. These did not seem to cure my problem, so I put my previous capacitor combination back into the circuit.

Toward the end of the alignment procedure, I hit another snag. To adjust the HI VCO circuit on 12 meters, you are instructed how to set the controls, and then directed to adjust a trimmer capacitor for a reading of +4 V at a test point. I found that by changing the trimmer setting, I could set the voltage to +1.6 or +11, but nothing in between! More calls to Heath. This is a complicated piece of equipment, and troubleshooting over the telephone is next to impossible, but the hams on the technical assistance line really know their stuff. The two or three gentlemen I talked to always had some suggestions or ideas about what could be causing my problems. We finally decided that I had a defective band-switch wafer, causing improper voltages to be switched to the HI VCO board. The band-switch wafers mount on the RF circuit board. A plastic shaft goes through three wafers on this PC board, and connects the front-panel knob and a wafer mounted to it with the sections mounted on the filter circuit board. There seems to be quite a bit of play in this system, and if one of the plastic-capsule wafers is a bit loose (as one of mine was), I don't see any way the whole thing can track properly. I replaced the band-switch wafers on the RF board and a few other components suggested by the Heath technicians. The problem just would not go away!

Heath Solves the Problem

I concluded that I was spending an unreasonable amount of time trying to solve this problem, while Heath could probably swap one or two circuit boards to locate the faulty one, and then it would be much easier to pinpoint the problem component. So I completed the final assembly without doing the rest of the alignment. Then I packed the radio up and shipped it back to Heath, along with a detailed letter explaining the problem I was having. The unit was sent out in early April, but by early June I still had not even received an acknowledgment that it had arrived at the service center! After several phone calls to the Advertising Manager, we did locate the radio. It appears to have had been repaired since early May, but it had been misplaced. I was promised that it would be returned that day, and a week later I had my '5400. I believe this is a case in which a regular customer would have received faster service. Apparently, there was some confusion about how to handle a repair for the ARRL!

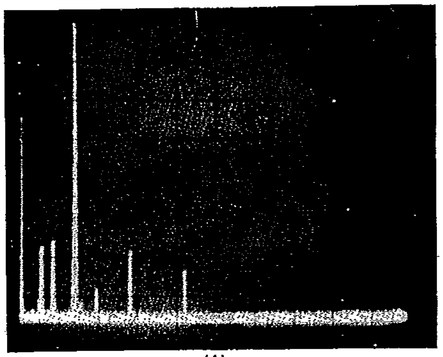
Heath returned a copy of the service technician's report and all of the components they replaced. One small coil on the HI VCO board was open. That apparently caused all of

Table 1
Heath HW-5400 HF Transceiver, Serial No. 01-47504

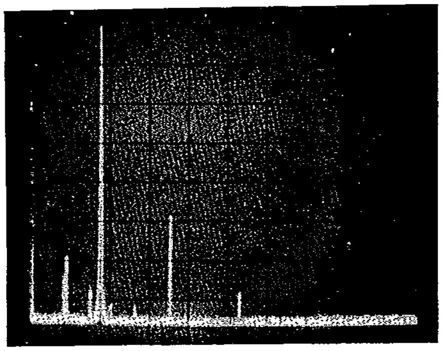
Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency Coverage: 3.450-4.050 MHz, 6.950-7.350 MHz, 10.000-10.200 MHz, 13.950-14.400 MHz, 18.018-18.218 MHz, 20.950-21.500 MHz, 24.840-25.040 MHz, 28.000-29.750 MHz.	As specified.
Modes of operation: CW-W, CW-N, LSB, USB.	As specified.
Tuning rate: 50 Hz/step, 1.25 kHz/turn 1 kHz/step, 25 kHz/turn with touch sensor.	As specified. Backlash nil.
Frequency display: 7 digit, vacuum-fluorescent green.	5/16-inch-high digits.
S-meter sensitivity (μV for S9): Not specified.	80 m: 46; 40 m: 43; 30 m: 85; 20 m: 65; 17 m: 82; 15 m: 160; 12 m: 180; 10 m: 94
Transmitter power input: 100 W minimum, except 80 W minimum on 10 m.	117 W maximum on 12 m, 94 W minimum on 10 m.
Harmonic suppression: −50 dB min., referenced to 100-W output.	−58 dB worst case, except −48 dB on 17 m.
Spurious suppression: −60 dB min., referenced to 100-W output.	See Fig. 1.
Third-order IMD: −30 dB min., referenced to 100-W output.	As specified.
Receiver sensitivity: less than 0.35 μV for 10 dB S+N/N.	Receiver dynamics measured with narrow (250-Hz) CW filter:

	80 m	*20 m*
Noise floor (MDS) dBm:	−135	−133
Blocking DR (dB):	110	112
Two-tone, 3rd-order IMD DR (dB):	82	90
Third-order intercept (dBm):	−12	+2

Receiver audio output at 10% THD: 2 W min. into 4 Ω.	2.2 W.
IF shift tuning: ±600 Hz (receive only).	Not measured.
RIT tuning: ±350 Hz.	+400, −700 Hz.
Operating temperature range: 0 to 40° C.	Not measured.
Size (HWD): 5 × 11½ × 14 in (12.7 × 29.2 × 35.6 cm).	5½ × 11½ × 15 in (14 × 29.2 × 38.1 cm), with raised front feet and clearance for heat sink and knobs.
Weight: 24 lb (10.9 kg).	



(A)



(B)

Fig. 1 — Worst-case spectral output of the HW-5400. At A, the rig was operated at 100 W on the 20-meter band. At B, the power output was 109 W on the 17-meter band. For both photos, the vertical scale is 10 dB/division and the horizontal scale is 10 MHz/division. The spectrum analyzer bandwidth was 100 kHz. The transceiver meets the manufacturer's specifications and current FCC spectral-purity requirements.

the difficulty I had with the alignment. I believe I did also have a defective band-switch wafer, but it is hard to be sure. Several other components had to be replaced as a result of improper voltages being applied, either as I had tried to set the band switch to track properly or because of the defective wafer. The technician had even replaced my two 7.7-pF parallel capacitors on the BFO board with the original 27-pf value, and the USB BFO circuit adjusts to the proper frequency now. All of the remaining alignment steps had been completed.

After testing the rig in the ARRL lab (see Figs. 1, 2 and 3 and Table 1), I was ready to take it home for some on-the-air operating. Field Day weekend was fast approaching, and I planned to to use that contest to really see how good the receiver is.

Circuit Description

The main signal flow follows the pattern of most modern transceivers. I will describe only those features that are unique or specific to the HW-5400. Two voltage-controlled oscillators (VCOs) provide the LO signals for the transceiver. One operates on 80, 40 and 30 meters, while the other functions on the higher-frequency bands. Incoming signals are converted to the 8.83-MHz IF before being routed to the audio circuit board. With the HWA-5400-2 2.1-kHz, four-pole SSB crystal filter installed, the signal is filtered before being amplified. After the first IF amplifier, the signal goes through a six-pole filter and three more stages of amplification before being passed to the audio board. The wide and narrow CW filters are active audio stages. The narrow CW filter has a 250-Hz bandwidth, centered on 700 Hz.

At the heart of this radio is a microprocessor. Some of the functions it performs are: refresh the frequency display line; receive input from the shaft encoder or the frequency-entry keypad; program the frequency synthesizer for the desired frequency; poll the front-panel switches for the desired band and modes of operation; ensure that the PLL circuits are locked and the frequency is within certain limits before allowing the transmitter to operate; store the display and memory frequencies for each band, even when the transceiver is turned off (provided the memory-keep-alive voltage is present); and perform diagnostics on the transceiver when it is first powered up.

This last feature can be helpful if some problems develop with your radio. The controller displays certain information to help you track down the problem. If you see PLL on the display when you turn the transceiver on, for example, you will know that one or more of the PLL circuits has not locked. The information is rather limited, but it could prove helpful.

BCD information from the CONTROLLER board is routed to the display circuit board to provide a frequency readout. The vacuum-fluorescent display includes seven digits, a comma, a decimal point and several special display symbols. A small U, L or C to the left of the digits indicates USB, LSB or CW operation. A one-segment bar above this letter indicates that the unit is in the transmit mode. If you tune above or below either amateur-segment band edge, a left-pointing arrow near the left edge of the display will warn you that you are out of band. When you select split-frequency

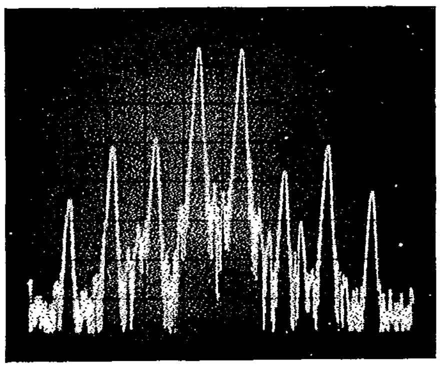


Fig. 2 — Results of the two-tone transmitter test. Third-order products are down approximately 30 dB. The transmitter was being operated at 100-W PEP output on the 20-meter band. The horizontal scale is 1 kHz/division, and the vertical scale is 10 dB/division. The spectrum analyzer bandwidth was 100 kHz.

operation, a bar will light under the arrow position; and if you choose to display the memory frequency (which is the transmit frequency during split-mode operation), a bright M will light.

The main-tuning method is quite interesting. The knob contains a metal insert connected to a capacitive-touch circuit. If you place a finger into this indentation, the microprocessor changes from a 50-Hz tuning rate to a 1-kHz rate! Behind the front panel is a plastic disc that has alternate clear and black radial stripes. When you rotate the tuning knob, these stripes pass between two pair of optical encoders. Signals from these encoders enable the microprocessor to determine which way you are turning the knob, and then decide to increase or decrease the operating frequency. During alignment, I discovered that if a bright light shines on the encoder, the frequency will not change! This could lead to a simple "dial lock" modification for the radio!

Most modern transceivers use PLL frequency-synthesis circuits. One problem with these circuits is that the time required to make a frequency step is inversely proportional to the loop filter bandwidth. This filter must have a bandwidth that is narrow enough to attenuate the reference-frequency signal to an acceptable level, and yet wide enough to allow a fast response to frequency changes. For a single-loop synthesizer, the minimum step size is equal to the reference frequency. If the filter bandwidth is left wide enough to provide small frequency steps, then more reference-frequency-oscillator noise will get through to the audio stage, or appear in the transmitted output.

A dual PLL synthesizer is employed in the Heath HW-5400. Loop one has a 10.05-kHz reference frequency, while loop two has a 10-kHz reference. Thus, the loop filters can have a fairly wide bandwidth and still provide good attenuation of the reference frequency. Each loop uses a VCO, whose output varies depending on the band and operating frequency. The VCO signals are combined with the PLL reference oscillators through a divide-by-N counter on the synthesizer board to provide 50-Hz frequency steps. The output from this synthesizer does not suffer from severe phase-noise problems, as has been common with many synthesized rigs. Evidence of this is shown in Table 1. We were able to measure the blocking dynamic range. Many rigs have a "noise limited" entry in that position!

The power amplifier uses three push-pull amplifier stages to produce 100 W of RF output. The final-amplifier transistors are a matched pair of Motorola SRF3351P power transistors. These devices are thermally protected by a pair of diodes mounted in contact with them. As the diodes heat up, they turn off a bias transistor, reducing the bias on the finals. While the transmitter should only be operated into a 50-ohm load, this type of protection does prevent the transistors from being damaged by a mismatched condition. When rigs with transistor final amplifiers first came out, they were prone to destruction of the output transistors if the SWR on the feed line was allowed to go too high. Many hams still seem to believe that this is a problem, but protection schemes such as are employed in the Heath HW-5400, have virtually eliminated this effect.

An Uncluttered Front Panel Means Easy Operating

One of the first things I noticed about the '5400 was that the pictures show a minimum of control knobs on the front panel. Does that mean the radio lacks some of the features of the other manufacturers' newest offerings? You may have noticed that some manufacturers seem to be competing to see how many controls they can squeeze onto the front panel of their radios. Well the HW-5400 may not have *all* of the features, but it does seem to have the important ones!

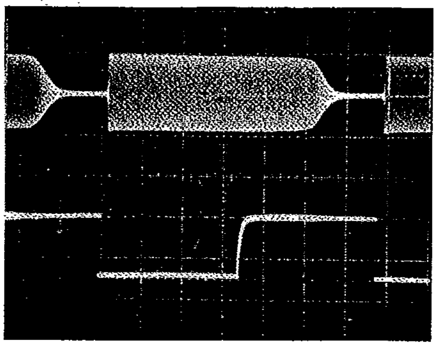


Fig. 3 — Display of the original keyed CW output waveform. The top trace is the RF output envelope, and the bottom trace is actual key closure and opening. Each horizontal scope division is 10 ms. Notice that it takes approximately 20 ms after the key contacts open before the output wave begins to decay. This delay appears to be independent of keying speed, and tends to eliminate the interelement spacing at speeds much above 20 WPM. This should be considered unacceptable for high-speed CW operation.

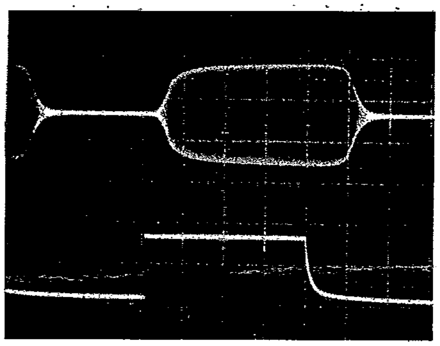


Fig. 4 — CW output waveform of the HW-5400 after I performed Heath's suggested modification. Each horizontal division is only 5 ms on this photo. The rise and fall times are much better, but most important, it only takes about 5 ms for the radio to begin to turn off the carrier after the key contacts are opened.

There is a grand total of six knobs on the front panel. Three of them are concentric, dual controls, however. Single knobs control the main tuning, and select the band and operating mode. The dual controls are for MIC/CW GAIN on transmit, AF/RF GAIN on receive and RIT/IF SHIFT. There are also six, small push-button switches to select other operating features, such as FAST or SLOW AGC action, PTT or VOX operation, TUNE, SPLIT transmit/receive operation, swapping memory and display frequencies or writing the display frequency to memory. With the optional frequency-entry keypad (for the price, I don't understand why anyone would choose to be without this), add 11 more buttons in the top-left corner. Hidden under the name label at the top right are the VOX controls and the sidetone-level adjustment. While you will need a small-bladed screwdriver to turn these controls, it sure beats hiding them under the top cover, where they end up being virtually inaccessible in many cases. Rounding out the front panel are the S meter, a PHONE jack and a MIC connector.

The rear panel is equally simple. A large heat sink for the power amplifier circuit board takes up most of the space. On one side of the heat sink is an SO-239 coaxial connector, a ground lug and phono jacks for a power amplifier ALC voltage and a set of relay contacts that close when the transmitter is activated. On the other side is a six-pin accessory connector, which provides a speaker output, memory-keep-alive voltage input and an output for the voltage-sensing circuitry of the HWA-5400-1 power supply. There is a phono jack for a positive CW keying line and a switch to turn the relay on or off. The largest connector on this side is for the four-conductor power-cord.

Operating Impressions

Lab testing of the receiver section showed it to be a fine performer. The characteristics listed in Table 1 will compare favorably with most receivers on the market today. The two-tone output spectrum and the CW keyed waveform gave me reason for concern about the transmitter portion of the radio, however. The two-tone output does meet Heath's specifications for the radio in terms of the third-order products, but normally we expect the fifth-order products to be reduced below that level. Fig. 2 indicates that the transmitted audio may be distorted somewhat. This is not a major problem, but something that could be improved. Actual operating experience brought no complaints of distorted audio.

My main concern was for the CW waveform. When you look at Fig. 3, you will notice a rather sharp turn-on characteristic, but the real problem is what happens when you let the key up. It takes 20 ms for the radio to realize it is supposed to turn off the carrier, and then about 6 ms more to accomplish this task. For the dot shown here, the transmitted dot length is almost twice the keyed dot length.

Notice what happens to the interelement spacing. For speeds much above 20 WPM, the space almost goes away completely. At Novice speeds, the rig will probably work fine, but for a high-speed CW operator, this waveform would be totally unacceptable. I called Heath for help with this problem. Their engineers looked at the waveform from a '5400 they had, and discovered that it was not what they had intended. I received a phone call a few days later, with a suggested modification to the keying circuit. I was assured that this simple change is being incorporated immediately. If you own an early version of the kit, contact Heath for the information. Any new kits purchased should include the changes on the RF board. Fig. 4 shows the keyed waveform after I made the changes. Quite an improvement!

I made a few contacts prior to the start of Field Day to become familiar with the operation of the rig. This radio is easy to operate, and the controls are placed so that large fingers can use them. The concentric controls have a full-sized knob next to the front panel, with a thin extension through the center. I do not feel like I must carefully reach around the center control to reach the rear one, as I do with many rigs that use this type of control.

I was anxious to try the IF SHIFT feature. I found several CW and SSB signals that had rather severe interference on them during Field Day. By turning this knob to the + or − side, I could usually find a setting that would allow copy of the original station. I find this feature to be very effective!

Since it was such a nice day, I decided to take the rig out to my picnic table for some Field Day fun. After about a half hour of sitting in the direct sunlight, I was getting warm, but not ready to quit yet. The '5400 felt differently about it, though. The brown cabinet and black heat sink were soaking up more heat than I was, and the radio decided to "go north" for a while! After I took it back inside and let it cool off a bit, everything was back to normal.

Switching between the memory and display frequency is an effective way to make a few more contest exchanges while listening to a particular station, waiting for a chance to work it. A single front-panel button makes this change quick and easy.

Fast break-in CW operation is achieved by setting the VOX DELAY to a minimum. It takes a little practice to get used to hearing the active receiver between code letters. But there is no better way to keep track of what is happening on your transmit frequency. More than once I completed a transmission with a non-QSK rig, only to find that the contact was broken because of a strong interfering signal. It is much easier to pick up the pieces when you are aware of the interference right away.

The HW-5400 selects the "normal" sideband on each amateur band. You have the option of choosing the reverse sideband if you have some reason to do so. There are two active audio filters that are selectable for CW operation. The narrow filter has a 250-Hz bandwidth. If you wish to operate other modes, you will have to adapt the radio to suit your needs. To get on RTTY, for example, you will have to wire an extra microphone connector to your modem for AFSK operation.

The S meter has the normal 0-to-9 signal-strength markings, plus marks for 20, 40 and 60 dB over S9. During transmit, the meter doubles as a relative power output meter. There is a block marked ALC on the meter face. It is important that you keep the needle within this block on voice peaks while transmitting SSB. Otherwise, you will overdrive the final amplifier, causing a distorted signal. Adjust the MIC GAIN control while talking into the microphone. For CW operation, you press the TUNE push button and adjust the CW GAIN control for the desired output.

I obtained an extra power cable from Heath so I could connect the transceiver in my car during the review period. The '5400 is small and lightweight, making it be a nice mobile rig. It may present some problems if you want to find space under the dash of a compact car, however. You will have to find some means for connecting a speaker for mobile operation. This could be through the front-panel PHONE jack or by means of a mating connector for the accessory jack. If you want the radio to remember your favorite frequencies between operating periods, you will also have to provide a battery connection to the memory-keep-alive pins.

What has been left out of the HW-5400? It has no noise-blanker circuit, no RF attenuator and no crystal-calibrator or marker-generator circuit. Neither is there any means to disable the AGC operation. There is no provision for auxiliary microphone input or audio output. These features would make it easier to connect an RTTY modem to the radio.

Tuning the receiver without an antenna connected revealed numerous weak "birdies" and other "growlies." The receiver has some odd-sounding noises on the 80-meter band. These seem to be coming from the controller circuit, because when I entered numbers on the keypad while tuned to some of these frequencies, the noise would change. The loudest birdies occur at 4.02112 MHz, 7.0362 MHz, 28.13850 MHz and 28.96365 MHz. These signals just barely move the S meter. I found one stronger signal by tuning to 10.000 MHz and then turning the RIT control as low in frequency as possible. When I also move the IF SHIFT control to the low-frequency side, the S meter moves nearly half an S unit. I did not find any of these spurious signals to be a problem during normal operation, even after I knew where to look for them.

Conclusions

At the beginning of this review I mentioned my first transmitter, a Knight-Kit T-60. There were many reasons for buying a kit then, the greatest of which was the fact that it was possible to save as much as 40% of the cost of a comparable rig. Other reasons were the claims that the builder would learn a lot about electronics in the process, gain knowledge of the radio itself and the sheer pleasure associated with being able to say, "I built it myself!" Were these claims valid then, and are they still valid today? Well, there are probably many different opinions about this.

I never did believe a person could learn electronics by building a kit. You certainly gain a lot of soldering experience, but there is more to electronics than being able to solder properly. There is a potential to learn some electronics, however, if you want to take the time to learn the function of each component as you install it. By tracing the schematic diagram as you go, you can certainly begin to understand the general flow of signals through the radio. While my T-60 was an excellent first-time kit for a high-school-aged Novice, I don't think I could recommend the HW-5400 as a first project under the same circumstances!

Dollar for dollar, can you get a better-performing rig today by building it from a kit than if you bought one already built? Probably not. The price of a fully equipped HW-5400 may be a little less than the price of a comparable transceiver already assembled, but you must be willing to spend on the order of 100 hours to complete this transceiver. Certainly not a weekend project!

So why buy a kit radio? Well, it is certainly true that you will be intimately familiar with the component layout. And I am sure that I will be better able to dig into my '5400 to correct any problems. Heath includes a detailed troubleshooting section with the manual. Complete realignment instructions are also included. To get similar information about another brand of transceiver, you would have to purchase a service manual. Even that may not contain as much material as Heath supplies.

All of this familiarity with the radio also leads to ease of modification. While I was building my kit I thought of several features I might add at some point. I like having a stereo phone jack for my headphones. I have purchased a pair of the lightweight headphones that go with the popular portable FM stereo radios. These 'phones are ideal for long hours of operating, because they are light and comfortable. Also, with a stereo jack, it is possible to insert the plug half way, and have audio in the speaker and the headphones. I've found this to be handy under a variety of circumstances. It might also be nice to have an auxiliary audio output and mic input for use with a radioteletype modem or phonepatch. These and many other modifications will be easy to add.

Finally, there is definitely a great satisfaction to be gained by operating a radio that you have built yourself. This sense of pride is all the greater when the result of your work is a nice-looking, functional transceiver like the HW-5400.

Yes, there are many valid reasons for building a project like this. I hope you'll enjoy it as much as I did. The HW-5400 and accessories are available from Heath Company, Benton Harbor, MI 49022, tel. 616-982-3411. Price classes: HW-5400, $500; HWA-5400-1 (power supply), $200; HWA-5400-2 (SSB crystal filter), $60; HWA-5400-3 (frequency-entry keypad), $60. — *Larry Wolfgang, WA3VIL, ARRL Hq.*

New Products

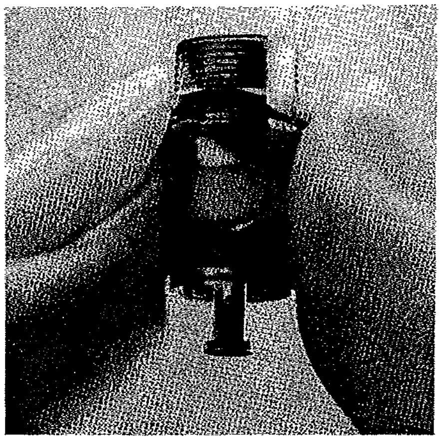
TRIM-TRONICS AIR-VARIABLE CAPACITORS

□ Trim-Tronics, Inc., offers a line of air-variable capacitors designed with a self-resonant frequency greater than 5 GHz. They are suitable for sensitive telecommunications applications such as satellite, microwave, two-way radio and test instrumentation, where very precise tolerances are required. Typical applications include uses with RF amplifiers and oscillators, and for crystal tuning, coupling, impedance matching and filter tuning.

A unique design produces a high-Q factor (greater than 5000 at 200 MHz), allowing the capacitor to operate at microwave frequencies. The vertical slotted rotor mechanism of the capacitor results in complete surface area contact, producing uniform torque and a contact resistance of less than 1 milliohm.

Available in several mounting styles, the Trim-Tronics air-variable capacitor has a temperature coefficient of ±15 parts per million over a wide temperature range. The capacitor has a voltage rating of 250-V dc.

Trim-Tronics manufactures air plate and tubular capacitor lines. The company is a member of the Trush Group, Inc., and is affiliated with Alfred Tronser GMBH of Germany. For more information concerning their capacitor lines, contact Mr. James E. Dowd, Trim-Tronics, Inc., 67 Albany St., Cazenovia, NY 13035; tel. 315-655-9528. — *Paul K. Pagel, N1FB*



which allows me to assign macros to the function keys. Defining one function key as Control-V Control-H (^V^H in *QMODEM* terminology) gives me a backspace key that works properly in PacTOR.—*Allan Schwartz, WA6EHA, San Jose, California*

CURING TRANSMIT AND RECEIVE DISTORTION IN THE HEATH HW-5400 TRANSCEIVER

◊ Ever since I built my HW-5400 in the spring of '86, it had shown high sensitivity to transmit distortion, and its receive audio seemed somewhat distorted when I listened to familiar voices. Only after several friends who know my voice well complained of the distortion did I decide to do something about it.

I investigated this problem by breadboarding the HW-5400's entire audio input circuit, up through the modulator and IF buffer (Q904), and investigating its performance with test equipment. The first stage, an op amp (U901A) behaved well, but both succeeding stages (Q902 and Q903) were prone to severe distortion and asymmetrical clipping. Changing feedback resistor R922 from 10 kΩ to 3.3 kΩ eliminated the problem while retaining adequate balanced-modulator drive.

The HW-5400's balanced modulator circuit uses a Motorola MC1496G (U902). According to Motorola data, the supply voltages at the IC's pins 6 and 9 are supposed to be equal, but are not in this application. I solved this by adding a 2.7-kΩ resistor between pin 6 of U902 and the supply rail.

Adjusting the BFO level according to the Heath manual set the modulator's SSB-mode carrier input well below the level recommended by Motorola. Increasing C921 to 0.1 µF brought the level up to approximately the value Motorola recommends for maximum carrier suppression.

The HW-5400's product detector also uses an MC1496G (U904), which also operated with unequal supply voltages in the unmodified Heath design. As in the balanced modulator, I equalized the voltages by adding a 2.7-kΩ resistor between pin 6 of U904 and the supply rail.

Testing now revealed that the HW-5400's transmit audio was acceptably distortion-free across the radio's transmit-audio passband, which measured 525 to 2650 Hz. Even audio inputs 25% greater than normal voice peaks produced no distortion. I made these tests at several power levels up to the HW-5400's maximum of 100 W. The radio's receive audio is now similarly free from distortion, and I enjoy listening to it.

Owners of HW-5400s with these distortion problems can easily correct them and be told, as I have been, "You sound great!"—*Ken Pierpont, KF4OW, Yorktown, Virginia*

HOW TO REMOVE CONNECTOR SEALANT FROM COAXIAL HARDWARE

◊ After several antenna experiments, I accumulated a pile of used coaxial hardware covered with connector sealant. The sticky black residue made reuse problematic, but I was reluctant to discard the connectors, especially since some were silver plated. Here's how I restore them to like-new condition.

First, use a pocketknife or similar tool to remove as much of the old sealant as you can. Then, place the connectors in a jar of turpentine and allow them to soak for about 10 minutes. This softens the sealant and allows you to remove the rest of it rather easily with a paper towel. (Take the appropriate handling precautions when working with turpentine.) If all of the material does not come off at once, repeat this process until satisfied. You can reclose the jar of used turpentine and keep it for future use. The dissolved sealant will settle out and fall to the bottom.

After the turpentine treatment, a quick bath in warm water and detergent should make your connectors sparkle like new if they were not badly weathered to begin with. You can then remove any cable remains with your soldering iron.—*Edgar Reihl, WA9ULU, Northbrook, Illinois*

MODIFIED GROUNDING CURES RF FEEDBACK IN A GM MOBILE

◊ In December 1991 and January 1992, *QST* carried a two-part article on mobile installations.[2] After sending for the GM bulletin mentioned in the article, I followed the instructions for a TS-440S in my 1989 Oldsmobile 98, using fuses in both positive and negative leads. I used RG-8 as the power cable[3] from the battery and routed it around the front of the vehicle on the driver's side and through the firewall. Contrary to the GM instructions, I found that passenger-compartment grounding in the passenger compartment was *necessary*. With my Hustler mobile antenna, the passenger's compartment was full of RF, and the TS-440S tended to oscillate, every time I spoke into the mike on 15 m. Grounding to the frame from the bolt and wing nut on the rear of the transceiver cured the problem.

I connected the power cable to the battery bolts using a small stainless-steel hose clamp rather than the Delco clamp GM recommends. It works fine.—*William A. Melanson, W1LID, Phoenix, Arizona*

LOWER MONITOR-MODE CURRENT DRAIN FOR THE CMOS SUPER KEYER II

◊ For me—I am a CW fan—the most important circuit in the 1992 *ARRL Handbook* was the CMOS Super Keyer II.[4] I have built a lot of "electronic bugs" since I was licensed in 1949 and, in my opinion, the Super Keyer II is not only up to date, it's the best development I can imagine. Its high current consumption (40 mA) in the Monitor mode disappointed me, however. Yes, I could switch off monitoring while transmitting and use my transmitter's sidetone instead, but the monitor is necessary when using the keyer's Function and Inquiry commands, and when changing memory contents in preparation for a new contest.

Speaker driver Q2 (2N2222) and the low-impedance speaker account for this high current drain. To reduce the current to only 9.8 mA (at 5 V), I use a 200-Ω telephone earpiece unit, which is small (47 mm) and cheap. I replaced the 2N2222 at Q2 with a BC517 Darlington transistor. (If you cannot find a BC517 in the States, you may use any other small-signal NPN Darlington transistor [an MPSA13 or MPSA14, for example].) The Darlington matches the 200-Ω speaker well, so the monitor volume is agreeable loud.

The modification reduces current drain in the Monitor mode to one-quarter of its original value, considerably extending the life of the keyer's batteries.

Last, but not least, my honest respect to KCØQ and NØII for their excellent CMOS Super Keyer II!—*Adolf Vogel, DL3SZ, Ansbach, Germany*

TIPS ON INSTALLING AND CONNECTING TO GROUND RODS

◊ Driving a ground rod 8 feet into the ground with a sledgehammer batters the rod end into an ugly flare. Some types of ground clamps can't open far enough to slip over the enlarged rod. Of course, you can file, grind or saw off the flared end, but doing all of these things at ground level can be difficult.

Alternatively, you could slip the clamp over the rod before driving it into the ground; or use a clamp that opens far enough to pass over the flare. In the case of ½-inch ground rods, however, clamps wide enough to pass the flare may not tighten adequately.

After considering these problems, I attached my shack ground wire to a ½-inch ground rod as follows. I drilled a tap-size hole, about ¾ inch deep, into the rod top. I tapped this hole for a ¼-inch, standard thread. Driving in a hex-head bolt permitted firm attachment of the wire to the rod end.

Although I did this by drilling only one hole, drilling a pilot hole—say, about ⅛ inch in diameter—*before* driving in the rod would assist. Doing so would allow you to put the rod in a vise for stability and accurate drilling. Your sledgehammer may obliterate this hole, but you should be able to relocate it by probing with a center punch.

In any such drilling and thread cutting, use a sharp drill and lubricate it and your tap often while cutting. One more tip: If you have a welder friend, consider having him or her weld a ¼-inch bolt to the ground-rod top—after you've driven it in—to provide a stud for connections.—*A. W. Edwards, K5CN, Corpus Christi, Texas*

[2] S. Ford, "Going Mobile," Part 1, *QST*, Dec 1991, pp 22-25; Part 2, Jan 1992, pp 53-55.

[3] Different "RG-8" cables vary considerably in center-conductor size—#9.5 to #16 in one listing I've seen. They therefore vary so widely in current-carrying capability that some "RG-8" cable may be unsuitable for powering a 12-V, 100-W transceiver without heating and/or significant voltage drop on power peaks. See cable catalogs and *The ARRL Handbook*'s copper wire table for more information.—*Ed.*

[4] J. Russell and B. Southard, "The CMOS Super Keyer II," *QST*, Nov 1990, pp 18-21.

Items **1** to **8** of **8**

Issue	Page	Title	Author
Oct 1984 QST	34	Heath HW-5400 HF Transceiver (Product Review) **Article:** http://www.arrl.org/members-only/prodrev/pdf/pr8410.pdf (941,752 bytes)	Wolfgang, Larry, WA3VIL
Jun 1994 QST	76	Curing Transmit and Receive Distortion in the Heath HW-5400 Transceiver (Hints and Kinks) **Keywords:** HEATHKIT MODIFICATION HW 5400	Pierpont, Ken, KF4OW
Jul 1993 QST	48	Improving the Heathkit HW-5400 Transceiver (Hints and Kinks) **Keywords:** MODIFICATION HEATHKIT HW-5400 TRANSCEIVER	Akimov, Paul, WA2RIA
Jul 1990 QST	37	Battery Backup for the HW-5400 Transceiver (Hints and Kinks) **Keywords:** MODIFICATION BATTERY HEATH HW5400	Smardon, Al, VE3OX
Apr 1989 Ham Radio	74	Improving Clock Setting for the HW-5400 (Ham Notebook)	King, Dexter, AB4DP
Sep 1988 QST	42	Improving RIT and Split-Frequency Operation in the Heath HW-5400 Transceiver (Hints and Kinks) **Keywords:** MODIFICATION HEATH HW-5400	Audiss, Gary, N6SI
Sep 1988 QST	43	HW-5400 Speedy Tune (Hints and Kinks) **Keywords:** MODIFICATION HEATH HW-5400	King, Dexter, AB4DP
Feb 1984 Ham Radio	96	Heath: HW-5400 HF Transceiver (Product Review)	