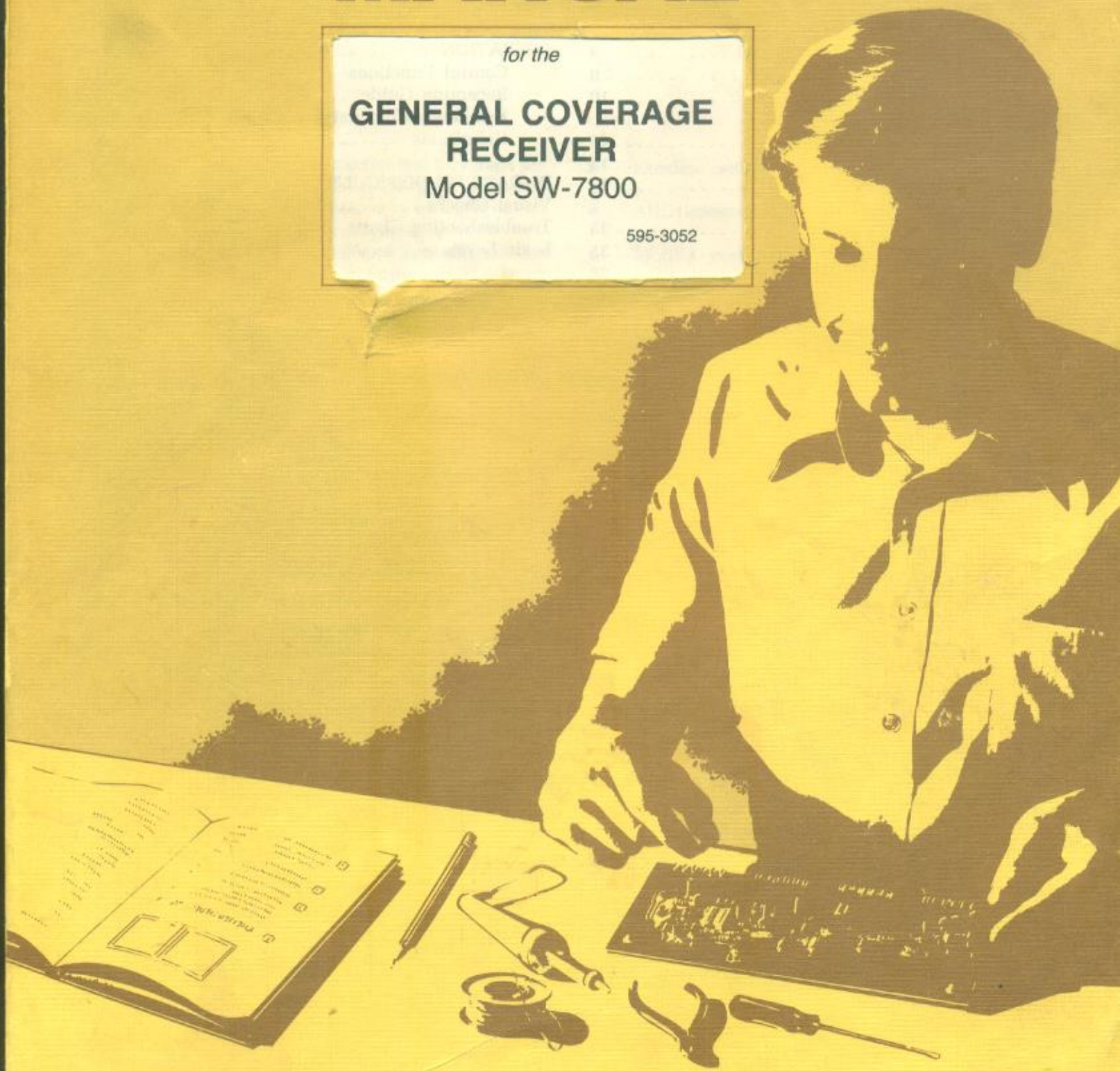
HEATHKIT®
MANUAL

for the

GENERAL COVERAGE RECEIVER
Model SW-7800

595-3052



HEATH COMPANY • BENTON HARBOR, MICHIGAN

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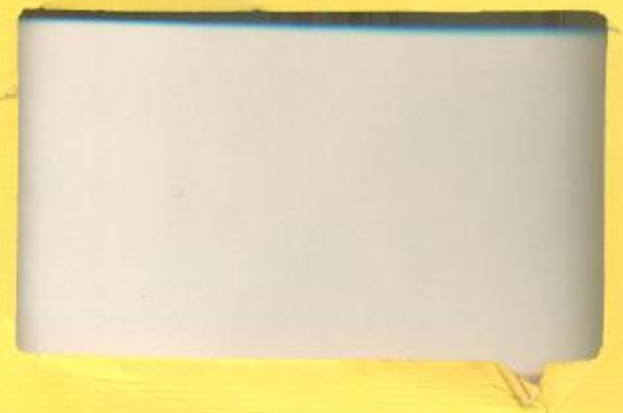

YOUR HEATHKIT 90-DAY LIMITED WARRANTY

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.

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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.

Owner's Responsibility

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

GENERAL COVERAGE RECEIVER

Model SW-7800

595-3052

WARNING: TO PREVENT FIRE OR SHOCK HAZARD, DO NOT EXPOSE THIS RECEIVER TO RAIN OR MOISTURE.

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

TABLE OF CONTENTS

INTRODUCTION

The Heathkit Model SW-7800 General Coverage Receiver is a synthesized receiver designed primarily with the avid shortwave listener in mind. It covers 150 kHz through 30 MHz continuously in 30 overlapping, 1 MHz bands. Broadband front-end circuits eliminate the need to tune circuits within a band. Just turn the band switch and select the desired frequency.

The design of the wide-band front-end stages eliminate the need for the customary RF amplifier. This results in a receiver that can properly handle incoming signals within a wide dynamic range. An up-converting, double-conversion mixing scheme is used to provide excellent image rejection.

You may operate this Receiver with its built-in power supply or, if you wish to operate mobile, use any 11 to 15-volt DC source (capable of supplying at least 3/4 amperes).

The following features are also included in your Receiver:

- Five-digit LED display providing 1 kHz frequency resolution.
- Lower sideband (LSB), continuous wave-upper sideband (CW-USB), amplitude modulation (AM) — wide and narrow.
- Excellent sensitivity and selectivity.
- AGC time-constant switch.
- Muting provision allows operation with a transmitter.
- Local/DX switch to protect against overload from very strong local stations.
- Front panel jack to allow tape recordings of received material – unaffected by the setting of the Volume control.
- Portable capability and low power consumption.
- Telescoping whip antenna included for local reception and portable operation.
- Comprehensive circuit description and servicing details aid in solving problems.

NOTE: To align this Receiver, you should have a high-input impedance multimeter.

INITIAL TESTS

In this section of the Manual, you will perform certain tests to verify that your Receiver operates properly. If you do not obtain the correct results in any of the following tests, refer to the "Possible Cause of Trouble" column, or the "In Case of Difficulty" section on Page 111, and correct the problem before you continue.

PRIMARY WIRING TESTS

CAUTION: Do NOT connect the line cord plug of your Receiver to an AC outlet until you are instructed to do so.

IMPORTANT: A wiring error in the primary wiring circuit (line cord, power switch, etc.) of your kit could cause you to receive a severe electrical shock. These "Primary Wiring Tests" will help you eliminate such wiring errors that may exist.

Refer to Pictorial 6-1 (Illustration Booklet, Page 35) for the locations of the "test points" called out in the following steps.

( ) Be sure the line cord plug is not connected to an AC outlet.

( ) Be sure the Power switch (on the VOLUME control) is off (turned fully counterclockwise).

NOTES:

1. If you do not have an ohmmeter, carefully check the line cord, switch SW3, and transformer wiring against the wiring shown in Pictorial 2-7 (Illustration Booklet, Page 8). Make sure there are no fine strands of wire or solder globs touching adjacent terminals on the chassis.

2. If you have an ohmmeter, perform the following resistance measurements. You will be instructed to connect one of the ohmmeter leads to ground. You may use the GROUND post on the rear panel for this.

( ) Turn on your ohmmeter and allow it to warm up, if necessary.

( ) Set the ohmmeter to the R × 10 k range.

NOTES:

1. The resistance readings in the following steps were taken with a VTVM. Readings taken with other ohmmeters (because of different measuring voltages and currents) may be considerably different.

2. The internal wiring of most ohmmeters is such that the positive terminal of the battery is connected to the negative (black) or common test lead. In some ohmmeters, this wiring is interchanged, and erroneous readings may result. Interchange the ohmmeter leads if the measurements do not check out correctly the first time.

( ) Temporarily remove meter lamp PL1 from its socket.

METER CONNECTIONS		METER READING	POSSIBLE CAUSE OF TROUBLE
POSITIVE LEAD	COMMON LEAD		
( ) Either prong of the line cord plug.	Ground.	2 MΩ minimum with Power switch on or off.	A. Wiring of switch SW3. B. Wiring of transformer T1.
( ) Other prong of the line cord plug.	Ground.	2 MΩ minimum with Power switch on or off.	A. Wiring of switch SW3. B. Wiring of transformer T1.
( ) Set the ohmmeter to the R × 10 range.			
( ) Either prong of the line cord plug.	Other prong.	INFINITE with the Power switch off.	A. Wiring of switch SW3. B. Wiring of transformer T1.
( ) Either prong of the line cord plug.	Other prong.	Approx. 50 Ω to 100 Ω with the Power switch on.	A. Wiring of switch SW3. B. Wiring of transformer T1.
( ) + (plus) lead of capacitor C511 (see Pictorial 6-1).	Ground.	Approx. ~~150 to 180~~ Ω. 80 Ω To 180 Ω	A. Diodes D425 through D428. B. Resistors R509 or R511. C. Capacitors C508, C509, or C511.

( ) Reinstall meter lamp PL1 in its socket.

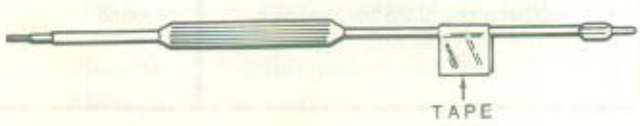
This completes the "Initial Tests." Proceed to "Alignment."

ALIGNMENT

An RF detector circuit is built into your Receiver to aid you in the alignment procedure. The only equipment you will need is a DMM (digital multimeter) or VTVM (vacuum-tube voltmeter).

CAUTION: When the line cord plug is connected to an AC outlet, the AC voltage will be present on the Receiver chassis, as shown in Pictorial 7-1 (Illustration Booklet, Page 35). Be careful that you do not contact this voltage because an electrical shock will result.

( ) Refer to Pictorial 7-2 and place a small tape "flag" near the center of the longer alignment tool as shown. This will help you count the number of turns of the tool during alignment.



PICTORIAL 7-2

INITIAL CONTROL SETTINGS

( ) Refer to Pictorial 7-3 (Illustration Booklet, Page 35) and set the Receiver controls and switches as follows:

DX/LOCAL (on rear panel) – DX

AGC – FAST

RF ATTEN – Fully clockwise

BAND – 16 (MHz)

VOLUME – Fully counterclockwise (power off).

MODE – AM WIDE

NOTES:

1. If you fail to obtain the desired readings in each of the following steps, immediately turn the power off (VOLUME control fully counterclockwise) and refer to the "In Case of Difficulty" section of this Manual.

2. Set your voltmeter to the proper DC voltage range to obtain meaningful readings in the following steps. Be sure to switch your voltmeter leads or voltmeter polarity switch to check for negative (–) voltages.

3. Be sure to touch only the indicated circuit point. To do otherwise might short a connection and damage an integrated circuit (IC) or transistor, for example.

4. All voltages were taken with a vacuum-tube voltmeter (VTVM). The readings that you get should be within ±20% of those indicated in the steps.

SYNTHESIZER BOARD ALIGNMENT

Refer to Pictorial 7-4 (Illustration Booklet, Page 36) for the following steps.

( ) Turn on your voltmeter and allow it to warm up, if necessary.

( ) Position the chassis as shown in the Pictorial.

( ) Connect the line cord plug to a 120 VAC outlet. Then turn the VOLUME control on the Receiver clockwise until it clicks on. Meter lamp PL1 should light.

( ) Locate the 18" red test lead you prepared earlier. Then connect the alligator clip at one end of this wire to TP201 (270 Ω, red-viol-brn). Connect the other end of this wire to wire socket AF (on the controller circuit board).

( ) Connect the common (negative) lead of your DC voltmeter to the GROUND post on the rear panel of your Receiver.

( ) Touch the test probe of your DC voltmeter to wire socket AG.

( ) Using the longer alignment tool, adjust coils L202 and L203 for a maximum reading on your voltmeter. Repeat this step until you notice no further increase in the meter reading.

( ) Use the longer alignment tool and turn the slugs in coils L202 and L203 until the top of each slug is even with the top of the coil form.

( ) Disconnect the alligator clip from TP201. Instead, connect it to TP202 (390 Ω, org-wht-brn).

( ) Use the longer alignment tool to rotate the core in each of the following coils as necessary until the top of the core is flush with the top of the coil form. Then rotate the core in each coil clockwise as shown. Use the flag on the alignment tool to count the rotations of the tool.

L207 — 1-1/2 turns

L208 — 2-1/2 turns

( ) Touch the test probe of your DC voltmeter to wire socket AG; then adjust coils L207 and L208 for a peak (maximum) reading on your voltmeter. Repeat this step until you notice no further increase in the meter reading.

( ) Disconnect the 18" red test lead from the Receiver.

CONTROLLER BOARD ALIGNMENT

Refer to Pictorial 7-4 (Illustration Booklet, Page 36) for the following steps.

( ) Temporarily remove the small jumper wire connected between wire sockets D and E (on the synthesizer circuit board).

( ) Be sure the wire coming from synthesizer circuit board hole AA is plugged into wire socket K.

( ) Connect the alligator clip at one end of the 18" red test lead to TP302. Connect the other end of this wire to wire socket E (on the synthesizer circuit board).

( ) Turn the Receiver on.

( ) Turn the tuning knob until tuning capacitor C3 is half meshed (half closed) as shown in the inset drawing #2 on the Pictorial. Then, using the longer alignment tool, adjust coil L306 until the display reads between 6.035 and 6.055.

( ) Turn the Receiver off.

( ) Disconnect the red test lead from the controller and synthesizer circuit boards.

( ) Disconnect the wire installed in wire socket K (on the synthesizer circuit board).

( ) Reinstall the small jumper wire between wire sockets D and E (on the synthesizer circuit board).

( ) Unsolder and remove the cover from the controller circuit board shield, if it is installed.

( ) Turn the Receiver on.

NOTE: When a step directs you to set the BAND switch to a particular frequency, you can use the first (leftmost) digits of the display to determine when you have the switch set correctly.

( ) Set the BAND switch to 29 (MHz).

( ) Touch the test probe of your DC voltmeter to TP301. Then adjust coil L301 until your voltmeter reads 7.0 volts. Diode D201 (Unlock LED – on the synthesizer circuit board) should not be lit.

( ) Set the BAND switch to 8 (MHz). Then, with the test probe of your DC voltmeter touching TP301, adjust trimmer capacitor C316 until your voltmeter reads 1.5 volts.

( ) Set the BAND switch to 0 (MHz). Then adjust trimmer capacitor C314 until your voltmeter reads 1.5 volts.

( ) Turn the Receiver off.

( ) Disconnect the voltmeter test leads from your Receiver.

( ) Refer to inset drawing #1 on the Pictorial and install the cover on the controller circuit board shields. Push down on the shield before you solder the cover to the shields in the two places shown.

RECEIVER BOARD ALIGNMENT

( ) Refer to Pictorial 7-5 (Illustration Booklet, Page 37) for the following steps.

( ) Make sure no antenna is connected to your Receiver.

( ) Set the VOLUME control to the desired listening level. Then, using the shorter alignment tool, adjust transformer T402 for maximum hiss from the Receiver speaker.

( ) Adjust ZERO SET control (R496) to zero front panel meter M1.

( ) Set the MODE switch to AM NAR.

( ) Connect the spade lug on the free end of the blue wire, coming from a grommet in the rear panel, to the HI Z terminal.

( ) Set the BAND switch to a broadcast band (0 or 1 MHz), and tune in a weak broadcast station (indicating less than S-9 on the front panel meter).

( ) Adjust coils L424 and L425 for a maximum reading on front panel meter M1. Repeat this step until you notice no further increase in the meter reading.

NOTE: You may have to connect an external antenna to the Receiver so you can receive station WWV in the following steps.

( ) Set the BAND switch to 10 (MHz) and tune your Receiver to 10.000 MHz.

( ) Connect the alligator clip at one end of the red test lead to antenna terminal HI Z on the rear panel of your Receiver. Hold the free end of the test lead near integrated circuit U201 (on the synthesizer circuit board). Then adjust trimmer capacitor C203 to zero beat the 10 MHz oscillator with WWV. NOTE: zero beat is achieved when you cannot hear a difference tone between station WWV and the internal oscillator in the Receiver.

( ) Remove the red test lead from your Receiver.

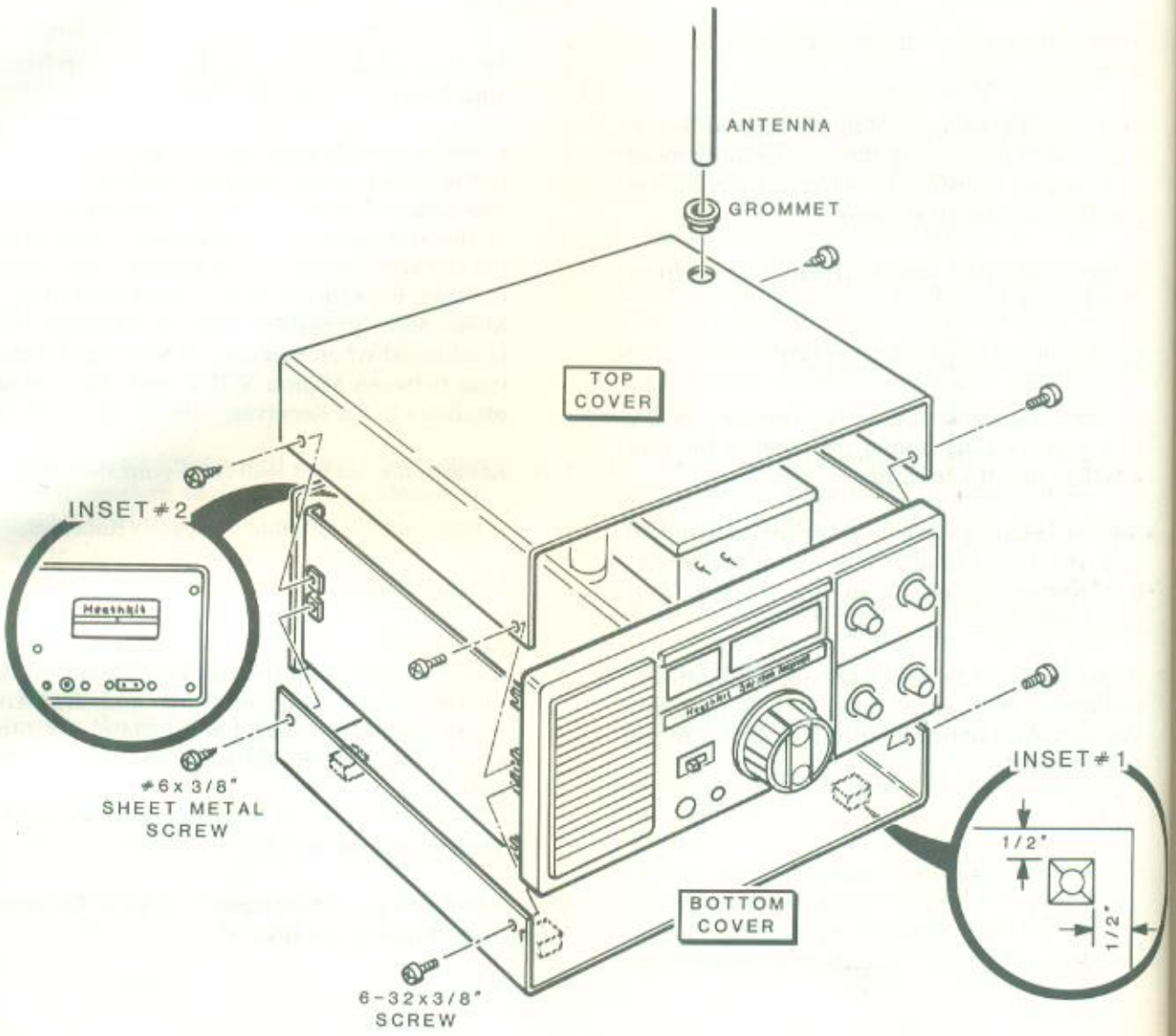
( ) Disconnect the antenna from your Receiver.

( ) Set the MODE switch to USB/CW.

( ) Adjust coil L426 until you hear a rushing sound coming from the speaker. Then turn the MODE switch between LSB and USB/CW while you adjust coil L426 to obtain about the same audio pitch for each position of the switch.

( ) Turn your Receiver off.

This completes the "Alignment" of your Receiver. Proceed to "Final Assembly.



PICTORIAL 8-1

FINAL ASSEMBLY

Refer to Pictorial 8-1 for the following steps.

( ) Locate the bottom cover (the cover without the 1/2" hole near one corner).

( ) Carefully peel the backing paper from one of the feet. Then refer to inset drawing #1 on the Pictorial and press the foot onto the bottom cover in the area shown.

( ) Similarly, press feet onto the bottom cover near the other three corners.

( ) Position the bottom cover on the Receiver as shown so the holes that are closer to the edges of the cover are toward the front panel. Then use two 6-32 × 3/8" screws to secure the front of the cover to the chassis. Use two #6 × 3/8" sheet metal screws to secure the rear of the cover to the chassis.

( ) Install a 1/2" rubber grommet in the 1/2" hole in the top cover.

( ) Position the top cover on the Receiver as shown. Then use two 6-32 × 3/8" screws and two #6 sheet metal screws to secure the cover to the chassis.

( ) Push the indicated end of the collapsable antenna into the rubber grommet in the top cover. Then turn the antenna onto the screw mounted on the chassis. Tighten the antenna only finger tight.

( ) Carefully peel the backing paper from the blue and white label. Then refer to inset drawing #2 on the Pictorial and press the label onto the rear panel in the area shown. Be sure to refer to the numbers on this label in any communications you may have with the Heath Company about your kit.

This completes the "Final Assembly." Proceed to "Installation."

INSTALLATION

To obtain satisfactory shortwave reception, your Receiver should have an outside antenna connected to it. (The built-in, telescoping antenna is for broadcast reception and portable operation). Also, a good ground system is required for good reception. The following paragraphs contain information about several types of antennas. Read this information so you can decide which type of antenna best suits your needs.

CAUTION: Stay away from power lines when you install this, or any, antenna. Make sure the antenna cannot come into contact with power lines.

ANTENNA TYPES

The following information includes three types of antennas: random length wire, dipole, and inverted-V dipole antennas. Read the information concerning each antenna and then, after you have decided which one would be most suitable for you, build and install the appropriate antenna.

Random Length Wire – You can use a random length of wire for the antenna with a single wire lead-in coming from one end. If you have no favorite band, install as long an antenna as your facilities permit.

Dipole – This is a directional antenna designed for optimized shortwave reception. Since this type of antenna is directional, signals are received best when the antenna is turned broadside to the transmitting station (that is, when the ends of the antenna do NOT point toward the transmitting station). NOTE: This antenna is most effective over a narrow frequency range (about 2 MHz wide).

Inverted-V Dipole – This is a nondirectional antenn designed for optimized shortwave reception. Th nondirectional feature allows this antenna to receiv signals equally well from all directions. Therefor it is often possible to receive more stations with th antenna than you would with the straight dipole a tenna. NOTE: Like the straight dipole antenna, th antenna is most effective over a narrow frequen range (about 2 MHz).

The following sections show you how to constru the antennas described above.

Random Length Wire

You will need the following parts to install a rando length wire antenna. Similar parts are required t construct one of the dipole antennas.

Antenna – A length of bare antenna wire.

Lead-in – A length of insulated wire. Th length depends upon the height of your a tenna and the location of your Receiver.

Ground wire – Same type as the antenna wir The length depends upon the distance betwee your Receiver and the grounding surface.

Insulators – Three ceramic or glass type, ap proximately 2-1/2 inches long.

Ground rod – One 6- to 8-foot length, 3/8-inch diameter. NOTE: A ground rod is not needed if you use an alternate ground, such as the cold water pipe in your house.

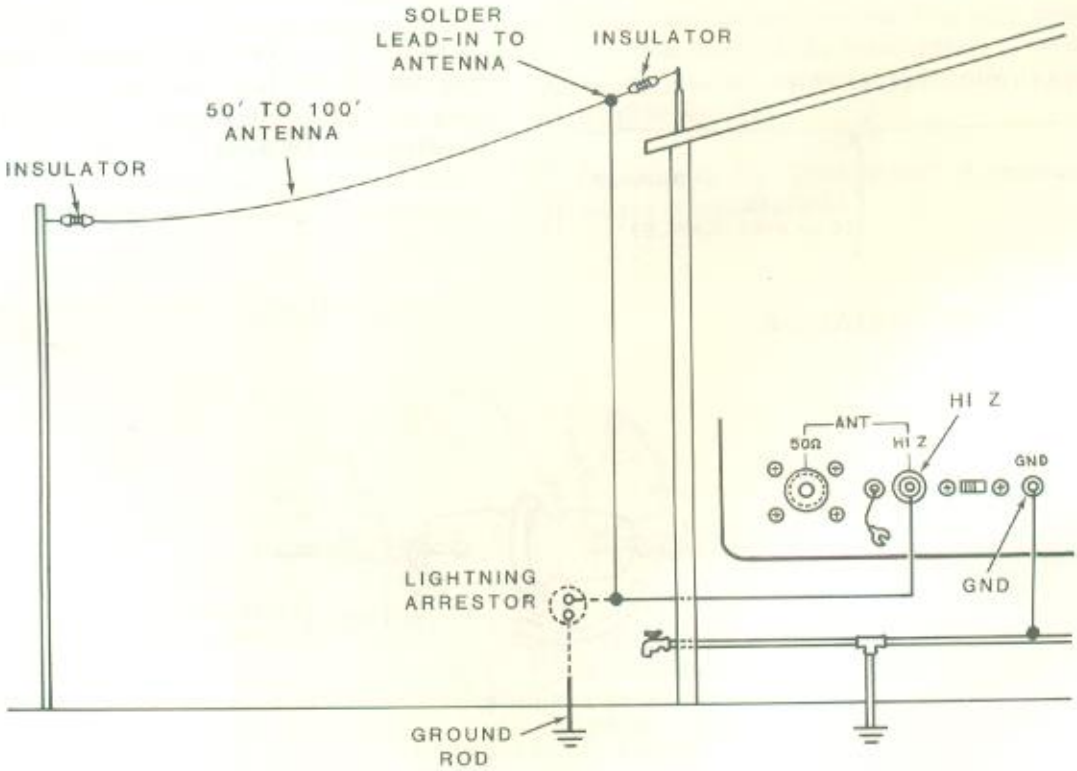
Clamp – One for the ground connection.

Lightning arrester – One for the lead-in cable.

For general broadcast and shortwave listening, we recommend you use an outside random-length wire antenna. Pictorial 9-1 shows a typical random-length wire antenna installation. The length of the wire may be from 50 to 100 feet. Attach and solder the lead-in to one end of the antenna. Connect the other end of the lead-in wire to the HI Z terminal on the rear panel of your Receiver.

Generally, the higher the antenna is off the ground, the better the reception. You may use a tree or a pole as one support and your house as the other support. Use insulators at each end of the antenna to separate the antenna wire from the support wire.

Connect a heavy wire from the GROUND terminal on the rear panel of your Receiver to a cold water pipe or to a 6- to 8-foot long ground rod driven into the earth.



PICTORIAL 9-1

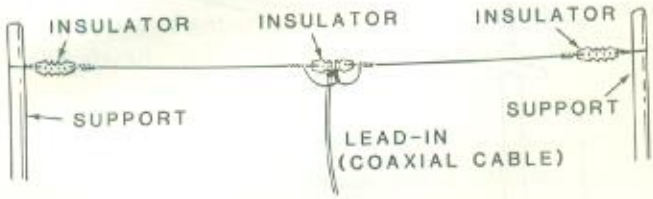
Dipole or Inverted-V Dipole

An antenna 100 feet long will provide good reception from 3 to 15 MHz, and provides the best reception near 5 MHz. Use the following formula to compute the length of an antenna that will have its best reception at a particular frequency.

$$\text{length (feet)} = \frac{468}{\text{frequency (MHz)}}$$

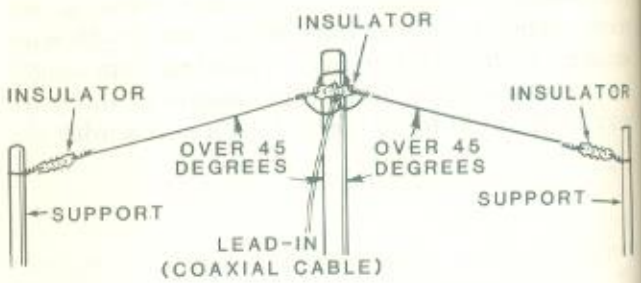
We suggest that you refer to an ARRL* Handbook or an Antenna Handbook for further information on these types of antennas.

To install a dipole antenna, locate two supports that are fairly high off the ground and 50-100 feet apart. One support could be your house and the other a pole. Pictorial 9-2 shows you how a dipole antenna can be supported between the two supports. Detail 9-2A shows you how to wire the center insulator.



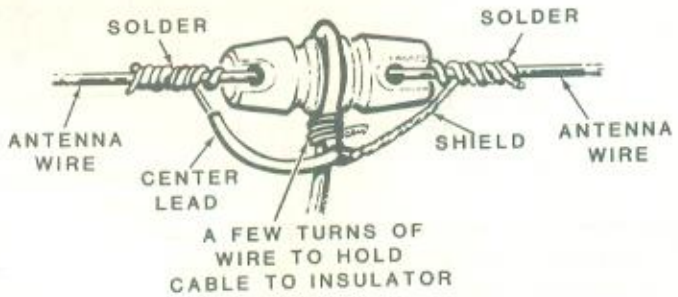
PICTORIAL 9-2

The center support for an inverted-V dipole antenna should be 20-100 feet from the ground and both end supports at least 10 feet from the ground. Note that the angle between the center support and the antenna wires should be greater than 45 degrees. Pictorial 9-3 shows you how you can suspend an inverted-V dipole antenna between the three supports.



PICTORIAL 9-3

Install a PL-259 coaxial plug (not supplied) on the free end of the lead-in. Then connect the coaxial plug to the antenna socket (50 Ω ANT) on the rear panel of your Receiver.



Detail 9-2A

* American Radio Relay League, Newington, Conn. 06111

EXTERNAL POWER SOURCE

Connector pins and a large 2-pin plug shell are provided so you can use an external DC power source (such as a battery) to power your Receiver. The power source you use must be capable of supplying 11 to 15-volts DC at 3/4-ampere.

To connect your Receiver to an external DC power source, refer to Pictorial 9-4 and perform the following steps:

( ) Locate the large 2-pin plug shell and the two female connector pins that were supplied with your kit. Then cut the ears from the connector shell as shown.

( ) Prepare a red wire and a black wire, at least 18 gauge (not supplied), long enough to reach from the Receiver to your power source. Remove 1/4" of insulation from one end of each wire and install a female connector pin on the end of each as shown.

( ) Position the 2-pin plug shell with its point as shown; then insert the pin on one end of the black wire into the hole at the pointed end. The pin is properly seated when it snaps into the shell.

( ) Similarly, insert the pin of the red wire into the other hole.

( ) Loosely twist the wires to form a 2-conductor cable. Then remove sufficient insulation from the end of each wire so you can connect your power source to this end.

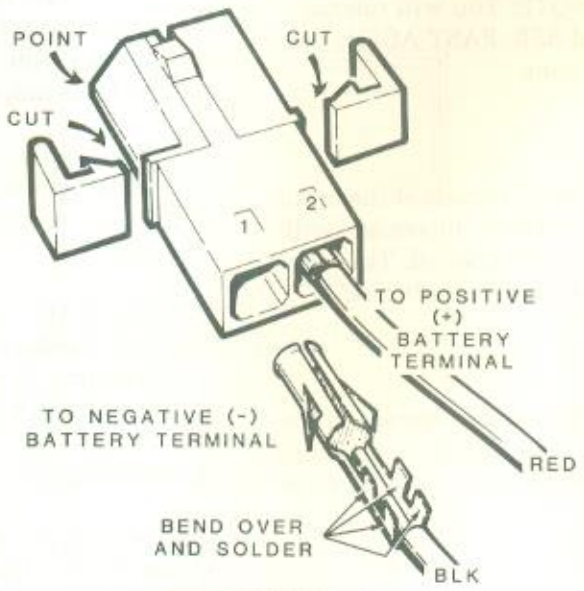
( ) Connect the black wire to the negative (−) source and the red wire to the positive (+) source.

CAUTION: Before you connect your power source to the Receiver, recheck the connections to be sure the negative (−) source is connected to the pointed end of the connector and the positive (+) source to the flat end. Reversed polarity could damage your Receiver.

( ) Plug the connector into the EXT. POWER socket on the back of your Receiver.

NOTE: If you use your Receiver in a boat or car, keep the power supply leads as short as possible to help reduce ignition noises. You may need to install a "hash filter" if the interference is severe. The ARRL Handbook contains valuable information about noise filtering.

This completes the "Installation" of your Receiver. Proceed to "Operation."



PICTORIAL 9-4

OPERATION

If you are not familiar with electronics, you may wish to refer to the "Definitions" on Page 109 before you refer to the other information in this section of the Manual. These definitions define some of the more frequently used terms.

CONTROL FUNCTIONS

Before you attempt to use your Receiver, carefully read the explanation of each control. Pictorial 10-1 (Illustration Booklet, Page 38) illustrates the front panel and describes the control functions.

AGC

Selects fast or slow AGC. NOTE: You will normally use SLOW AGC for CW and SSB. FAST AGC is useful on rapidly fading AM signals.

RF ATTEN

Adjusts the attenuation of the RF signals at the input of the Receiver. The attenuation increases with counterclockwise rotation of this control. This control is useful under very noisy band conditions.

BAND

Selects the desired 1 MHz frequency segment in the .15 MHz to 30 MHz range. The number markings on the front panel indicate the frequency band in MHz (Example: 5 = 5 MHz).

VOLUME

Applies power to the Receiver. Also controls th audio level of the received signal. The volume in creases with clockwise rotation of this control.

MODE

Selects the mode of operation:

LSB: Selects lower sideband. Generally used o frequencies below 10 MHz.

USB/CW: Selects upper sideband. Generall used on frequencies above 10 MHz. NOTE: Yo may wish to leave the MODE switch in th position for CW operation, regardless of the fre quency you are listening to in the .15 MHz t 30 MHz range.

AM WIDE: Selects amplitude modulation wide bandwidth. Use this mode when you ar listening to an interference-free AM transmis sion.

AM NAR: Selects amplitude modulation, nar row bandwidth. Use this mode when you ar listening to an AM transmission being inter fered with by strong, adjacent station(s).

MAIN TUNING

Manually adjusts the Receiver frequency up or dow within the 1 MHz segment selected by the BAN switch. Each band overlaps the adjacent band t

about .2 MHz (200 kHz). NOTE: When you have tuned an LSB signal correctly, the display will indicate a frequency that is about 1 to 2 kHz (.001 to .002 MHz) lower than the frequency of the transmitting station. On USB and CW, the display will indicate a frequency that is about 1 to 2 kHz higher. On AM WIDE or NAR(narrow), the readout will be the same as the transmitting station's frequency.

PHONES

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

REC

Provides you with an easy-access connection for a recorder to tape received material. The amplitude at this jack is unaffected by the setting of the VOLUME control.

Pictorial 10-2 (Illustration Booklet, Page 39) illustrates the rear panel and describes the control functions.

ANT

Connect the lead-in (50 Ω coaxial cable) from a dipole or inverted-V dipole antenna to the 50 Ω socket.

Connect the lead-in from a random length wire to the HI Z terminal.

Connect the spade lug at the end of the blue wire to the HI Z terminal when you wish to use the telescoping antenna. Do NOT connect this wire when you are using an external antenna with your Receiver.

LOCAL/DX

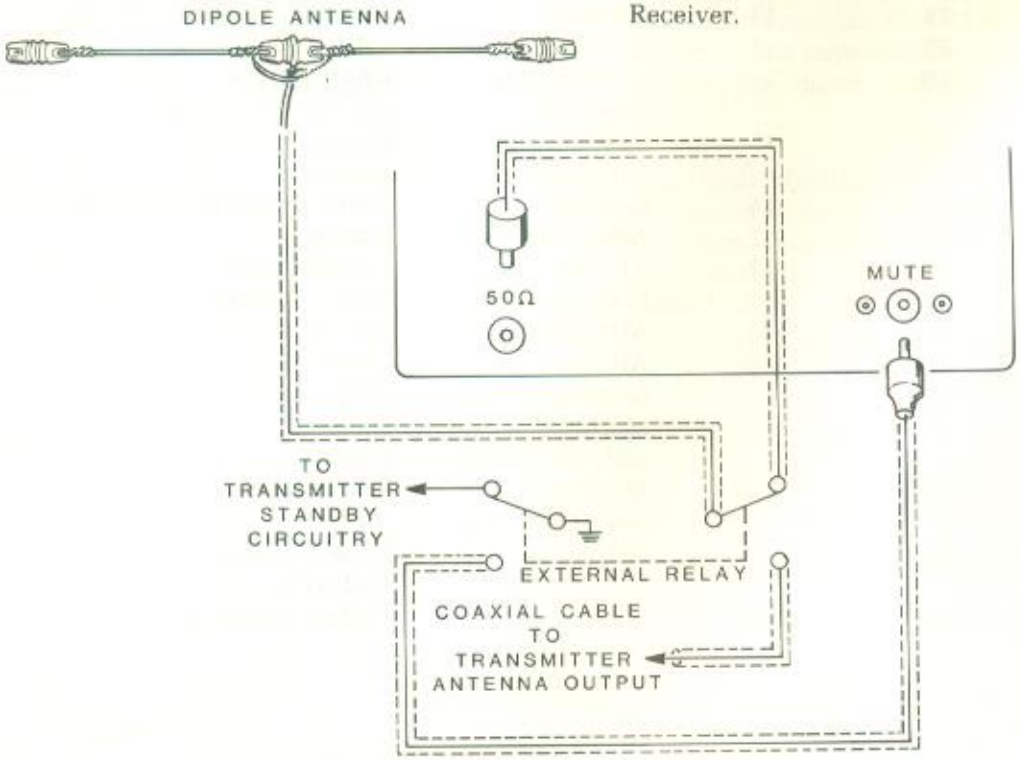
In the LOCAL position, this switch provides protection against overload from strong, local AM broadcast signals by attenuating them. NOTE: Due to the extreme sensitivity of this Receiver, you will normally place this switch in the LOCAL position when you receive signals below 2 MHz (and use an external antenna).

GROUND

Provides a ground connection for the Receiver.

MUTE

Allows you to mute your Receiver when it is used with an accompanying transmitter. This jack must be grounded in the transmit mode, and open in the receive mode. A remote set of contacts, connected as shown in Pictorial 10-3, can be used to mute your Receiver.



PICTORIAL 10-3

EXT POWER

Interconnect socket for an external 11 to 15 VDC source, such as an automobile battery, capable of supplying at least .75 ampere of current.

WWV

In the United States, National Bureau of Standards station WWV at Ft. Collins, Colorado, transmits on frequencies of 2.5, 5, 10, 15, and 20 MHz. This station transmits a variety of tones, often with a pulse (clock-like tone) each second, and is periodically identified by voice announcements.

RECEPTION GUIDE

This guide lists the reception conditions that prevail in the spring and fall of the year. These conditions are subject to varying atmospheric conditions, sunspot activities, and to some extent, weather conditions. In the winter, reception generally will be best on the lower frequency bands. In summer, reception will be better on the higher frequency bands.

BAND (meter)	FREQUENCY (MHz)	TIME	ZONE
80	3.5	Morning, evening	Local (Amateur)
49	6	Evening	Latin America and Europe
41	7	Evening	Europe
40	7	Morning	Unites States (Amateur)
40	7	Late afternoon, Evening	Europe
31	9	Morning	Asia and Australia
31	9	Afternoon	Europe and Africa
31	9	Evening	Europe and Latin America
25	11	Morning	Asia and Australia
25	11	Evening	Latin America
20	14	Late morning, afternoon	United States, Foreign, (Amateur)
19	15	Late morning, afternoon	Europe and North America
19	15	Evening	North and Latin America
16	17	Afternoon	Europe
16	17	All day	United States
16	17	Evening	South America
13	20	Afternoon	Europe
13	20	All day	United States
13	20	Evening	South America
15	21	Morning, early afternoon	Distant (Amateur)
15	21.5	Morning, early afternoon	Worldwide
11	27	All day	Local (Citizens Radio Service)
10	28	All day	Distant (Amateur)

FREQUENCY CONVERSION

The display of your Receiver reads the frequency. However, some of the shortwave bands are referred to by the term "wave length" expressed in meters. The formulas for converting wave length into frequency or frequency into wavelength are shown below.

Converting Wavelength to Frequency:

$$\frac{300}{\lambda(\text{meters})} = \text{Frequency (in MHz)}$$

Example 1: Suppose you want to know the frequency of Radio Free Europe in Germany and you know it is on 50.25 meters.

$$\frac{300}{50.25} = 5.970 \text{ (MHz)}$$

Converting Frequency to Wavelength:

$$\frac{300}{\text{Frequency (in MHz)}} = \text{Wavelength (in meters)}$$

Example 2: Suppose you are listening to a station on 17.715 MHz on your Receiver and you want to know what shortwave band that corresponds to. The formula would then be used as follows:

$$\frac{300}{17.715} = 16.93 \text{ (meters)}$$

This station can now be identified as being in the 16-meter band.

DEFINITIONS

Modulating: This term refers to the process of combining two frequencies at the transmitter, with the result that two new frequencies are produced in addition to the two original frequencies. For example, if a 1,000 kHz radio frequency is modulated by a 3 kHz audio frequency, the following four frequencies will result:

A. 1,000 kHz (radio frequency carrier),

B. 3 kHz (audio-modulating frequency),

C. 1,003 kHz (radio carrier frequency plus the audio modulating frequency), and

D. 997 kHz (radio carrier frequency minus the audio modulating frequency).

In the example shown, the 1,003 kHz frequency is often called the sum frequency, and the 997 kHz is often called the difference frequency.

Heterodyning: This term refers to the process of combining the tuned-in radio frequency with the frequency produced by the oscillator within the receiver. This combining, or mixing, takes place in the mixer stage of the receiver, with the result that two new frequencies are produced in addition to the two original frequencies. One of these new frequencies, known as the intermediate frequency or IF, is then additionally tuned and amplified within the receiver.

Amplitude Modulation (AM): This is the process of combining an audio modulating signal with a higher radio frequency. The outputs are the sum, the difference, and the two original frequencies. When viewed on an oscilloscope, the output appears as a waveshape whose amplitude varies according to the amplitude of the modulating signal.

Sideband: The band of frequencies on each side of the transmitter carrier frequency is called a sideband. The upper sideband (USB) is the band of frequencies created by the SUM of the carrier and modulating frequencies. The lower sideband (LSB) is the band of frequencies created by the DIFFERENCE between the carrier and modulating frequencies.

Single Sideband (SSB): Single sideband is not new. Over 50 years ago, it was determined that a single sideband contains all the elements necessary to reproduce the original modulation signal (intelligence) at the receiver. At the present time, single sideband systems are generally accepted for long-range, point-to-point communications.

Continuous Wave (CW): This is a process of transmitting a radio frequency in Morse code, with no modulation. In this case, intelligence is produced by causing the radio frequency to be interrupted at discrete intervals to produce radiotelegraph code. These code signals are made audible by a heterodyning process within the receiver.

It is unlikely that these short explanations have adequately covered such complex terms. There are, however, many fine books that treat these subjects in greater detail. Several books and magazines are available for electronic hobbyists at most newsstands and libraries. The Radio Amateur's Handbook by the American Radio Relay League (ARRL) is written especially with the needs of the amateur in mind.

IN CASE OF DIFFICULTY

Begin your search for any trouble that occurs after assembly by carefully following the steps listed below under "Visual Checks." After you complete the "Visual Checks," 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" for the physical locations of parts on the circuit boards.

VISUAL CHECKS

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 11 of this 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 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-org) 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. Be sure all the component leads are cut close to the foil on each circuit board, so the leads do not short to the chassis after the circuit boards are installed.

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

If you still have not located the trouble after you complete the "Visual Checks," and a voltmeter is available, check voltage readings against those shown on the Schematic. 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 the unusual event 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

CONDITION	POSSIBLE CAUSE
Receiver dead.	A. F1 (F401 if external DC power is used). B. SW3. C. T1. D. D425 through D428.
No sound from the speaker.	A. J2. B. SP1. C. U405. D. Shielded cables to R5 or SW2.
Audio hiss, but no signals.	A. Antenna. B. U401, U402, Q401. C. D401 through D413. D. See "Controller" and/or "Synthesizer" troubleshooting chart(s).
No signals in the AM-NAR, USB, or LSB modes. AM-WIDE is okay.	A. U404. B. SW2.

General (Cont'd.)

CONDITION	POSSIBLE CAUSE
No BFO signal.	A. Q406. B. L426. C. D429.
Signals sound identical in the USB and LSB modes.	A. Q405. B. D431. C. SW2.
RF attenuator does not function.	A. D414. B. R4.
Weak signal reception.	A. SW1.
No signals in the AM mode, SSB is okay.	A. Q402. B. SW2.
No signals in the SSB modes, AM is okay.	A. U406, Q403. B. Q406, L426, D429.
No + 11 volts on the receiver circuit board.	A. R511.
+ 13- and + 11-volts sources are low. Hum in the speaker.	A. C509, C511. B. D425 through D428.
No muting when the muting line is grounded.	A. Q404, D423.
Front-end overloads. No meter movement.	A. U407, D421, D422. B. U403. C. D418, D419.

CONTROLLER CIRCUIT BOARD

CONDITION	POSSIBLE CAUSE
+ 15-volt source missing or low (about 9 volts).	A. U304, U305. B. D308, D309. C. Q322, Q323. D. C325.
+ 12-volt source missing.	A. R509 (on the receiver circuit board).
*No VFO output.	A. Q324, Q325. B. L306. C. C3 (tuning capacitor) or shielded cables.
*No VCO output.	A. Q316 through Q318. B. L301. C. Output cable.
Incorrect input bandpass filter selected (on the receiver circuit board).	A. S101 and cable. B. S203 and cable. C. U301 through U304. D. Q301 through Q315.
Main tuning range less than 1 MHz.	A. Check for + 15 volts at P301 pin 3.

* You may use the RF detector on the Controller circuit board to verify that the oscillator is operating. Set the VTVM to the 1.5 VDC range; then connect the common test lead to chassis ground and the test probe to AG (on the RF detector). Connect a wire from AF to the oscillator output terminal. You should measure about .25 volt at the output terminal for both the VFO and VCO.

SYNTHESIZER CIRCUIT BOARD

CONDITION	POSSIBLE CAUSE
No RF voltage at TP201 or no 10 MHz oscillator injection. (You may check this by using the RF detector. See the chart for the Controller circuit board. Connect a wire from AF to the ungrounded end of R206. You should measure 2.5 volts on the VTVM.	A. U201. B. Q203, Q212, Q213. C. L202, L203. D. Y201.
No RF voltage at TP202.	A. No VFO injection. B. No VCO injection. C. Q221, U214. D. Q208, Q209, Q211.
LED D201 is lit, indicating an unlocked PLL condition, when band switch SW4 is set to a frequency higher than 25 MHz.	A. C272 through C276. B. L209, L211, L212.
Display indicates a frequency that is .455 MHz too high.	A. Ground jumper plugged in at K.
Display indicates .000, but Receiver receives okay.	A. Jumper wire between holes D and E is missing.
Receiver receives okay, but random frequencies appear in the display.	A. Q215 through Q219. B. U213. C. U202, U208 through U212.

LOGIC LEVELS

The following chart lists logic levels at various points in your Receiver for each position of the Band switch, if the Receiver is operating properly. A logic 0 indicates 0 volt, while a logic 1 indicates a voltage in the .6- to 15-volt range. NOTE: Refer to the Schematic for the location of each test point (they are not screened on the circuit boards).

BAND (MHz)	BAND SWITCH NLKJP	SYNTH. BOARD ABCDEF	CONTR. BOARD GHIJKL	CONTR. BOARD U V W X Y Z	CONTR. BOARD TP303	CONTR. BOARD TP304
0	00000	000111	101000	1 0 0 0 0 0	0	1
1	00001	001000	101000	0 1 0 0 0 0	0	1
2	00010	001001	101010	0 0 1 0 0 0	0	1
3	00011	001010	101001	0 0 1 0 0 0	0	1
4	00100	001011	101100	0 0 0 1 0 0	0	1
5	00101	001100	101100	0 0 0 1 0 0	0	1
6	00110	001101	101100	0 0 0 1 0 0	0	1
7	00111	001110	101100	0 0 0 1 0 0	0	1
8	01000	001111	010100	0 0 0 0 1 0	1	0
9	01001	010000	010100	0 0 0 0 1 0	1	0
10	01010	010001	010100	0 0 0 0 1 0	1	0
11	01011	010010	010100	0 0 0 0 1 0	1	0
12	01100	010011	010100	0 0 0 0 1 0	1	0
13	01101	010100	010100	0 0 0 0 1 0	1	0
14	01110	010101	010100	0 0 0 0 1 0	1	0
15	01111	010110	010100	0 0 0 0 1 0	1	0
16	10000	010111	011100	0 0 0 0 0 1	0	0
17	10001	011000	011100	0 0 0 0 0 1	0	0
18	10010	011001	011100	0 0 0 0 0 1	0	0
19	10011	011010	011100	0 0 0 0 0 1	0	0
20	10100	011011	011100	0 0 0 0 0 1	0	0
21	10101	011100	011100	0 0 0 0 0 1	0	0
22	10110	011101	011100	0 0 0 0 0 1	0	0
23	10111	011110	011100	0 0 0 0 0 1	0	0
24	11000	011111	011100	0 0 0 0 0 1	0	0
25	11001	100000	011100	0 0 0 0 0 1	0	0
26	11010	100001	011100	0 0 0 0 0 1	0	0
27	11011	100010	011100	0 0 0 0 0 1	0	0
28	11100	100011	011100	0 0 0 0 0 1	0	0
29	11101	100100	011100	0 0 0 0 0 1	0	0

SPECIFICATIONS

GENERAL

Frequency Coverage	150 kHz to 30 MHz in thirty 1 MHz ranges.
Frequency Readout	LEDs – 5 digits.
Readout Accuracy	To nearest 1 kHz.
Frequency Control	Synthesized (PLL and LC VFO).
Modes	CW/USB, LSB, and AM (wide or narrow).
Sensitivity:	
SSB/CW	Less than .35 μV for 10 dB, (S + N)/N.
AM	Less than 2.5 μV for 10 dB, (S + N)/N.
Selectivity:	
SSB/CW & AM Narrow	2.5 kHz minimum at 6 dB.
AM Wide	5.5 kHz minimum at 6 dB.
Selectivity Shape Factor	1.5 at 6/50 dB.
Image Rejection	55 dB minimum.

OTHER SPECIFICATIONS

Antenna	Built-in telescoping whip. Connections provided for 50 ohm, unbalanced, external antenna (SO239) and a high-impedance wire.
Audio Output	Internal speaker/phone jack for headphone or external speaker.
Muting	External mute jack for use with a transmitter.
Recorder Output	Miniature phone jack.
Power Requirements	120 VAC, internally. 11 to 15 VDC at 3/4-ampere, externally.
Overall Dimensions	11-1/2" W × 10-1/2" D × 4-5/8" H. (29.2 × 26.7 × 10.8 cm).
Net Weight	7 lbs. (3.2 kg).

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 Schematic (fold-in) and the Block Diagrams (Illustration Booklet, Pages 40-42) while you read the following information. 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 chassis.
101 – 199	Parts mounted on the front panel circuit boards.
201 – 299	Parts mounted on the synthesizer circuit board.
301 – 399	Parts mounted on the controller circuit board.
401 – 599	Parts mounted on the receiver circuit board.

GENERAL CIRCUIT DESCRIPTION

RECEIVER CIRCUIT BOARD

RF signals from either 50-ohm and high-impedance antennas, or the built-in collapsible antenna, are passed through the Local/DX switch to the receiver input filters. A DC voltage from the controller circuit board selects the proper filter for the band in use. The filtered signal then passes through an RF attenuator diode to the first mixer.

The first mixer mixes the received signal with a local oscillator signal (LO #1), which comes from the controller circuit board, to produce a difference frequency of 50.455 MHz. This first IF signal then passes through a crystal filter to the second mixer.

The second mixer mixes the first IF signal with a local oscillator signal (LO #2), which comes from the synthesizer circuit board, to produce a difference frequency of 455 kHz. This second IF signal then passes through a ceramic filter and buffer to the IF amplifier. The amplified signal now passes to the AM and product detector circuits.

The output from the AM detector drives the AGC amplifier, which controls the gain of the IF amplifier and drives the S meter. The output signal also passes through the audio preamp circuit where it is amplified and coupled to the Mode switch.

In the AM modes, the detected audio signal passes through an active filter circuit. In the AM Wide mode, the signal passes through only one of the stages. In the AM Narrow mode, however, the signal is processed by four filter stages. The resulting filtered signal then passes through the Volume control and the audio output amplifier to the speaker.

In the USB/CW or LSB modes, the amplified IF signal passes through a buffer to the product detector. The BFO (beat frequency oscillator) is activated in this mode and produces a signal that is also applied to the product detector. In the LSB mode, a switching transistor adds an extra capacitor to reduce the frequency of the BFO. After detection, the signal is processed like an AM narrow signal.

A mute circuit allows you to disable the IF amplifier and final section of the active filter so you can use the receiver with a transmitter.

AC power passes through the Power switch and a fuse to the primary of the power transformer. Rectifier diodes change the AC voltage at the secondary of the power transformer to DC, which is then filtered and applied to the other circuits in the Receiver. An external DC voltage passes through the Power switch and a polarity-protection diode to the output of the rectifiers.

CONTROLLER CIRCUIT BOARD

A binary-coded logic signal from the Band switch is applied to decoders on this circuit board, which select the proper input filter for the Receiver. These decoders also program the VCO for the correct frequency range, and the synthesizer dividers for proper synthesizer operation.

A DC voltage from the phase detector, on the synthesizer cicuit board, tunes the VCO. The decoders control two switching transistors that select the proper frequency range for the VCO. This VCO signal, which is referred to as the LO #1 signal, is applied to the first mixer on the receiver circuit board as described earlier.

The main tuning capacitor tunes the VFO circuit. The output of this circuit is applied to the synthesizer, where it mixed with the LO #2 signal to properly tune the receiver.

An inverter circuit on the controller circuit board converts the 12-volt DC supply to 15-volts DC for use by other synthesizer circuits.

An RF detector circuit is included on this circuit board to aid in alignment and troubleshooting. This circuit allows you to use a VOM or VTVM to measure RF signals.

SYNTHESIZER CIRCUIT BOARD

The synthesizer circuit board contains the VCO phase-locked loop, a display circuit, and a display driver/frequency counter/reference oscillator, which are contained in a single integrated circuit (U201).

The VCO loop is phase locked to the 10 MHz crystal oscillator reference. The 10 MHz reference signal is divided by 100 to produce a 100 kHz reference signal for the phase detector.

In addition, the 10 MHz reference signal is multiplied by 5 to produce a 50 MHz reference signal that is mixed with the VFO signal. The difference signal is then mixed with the VCO signal to produce a second difference signal. This signal is then divided by 10 and applied to the programmable dividers that are controlled by the Band switch.

The phase detector compares the signal coming from the programmable dividers with the 100 kHz reference. An error voltage from the phase detector tunes the VCO to keep it phase locked to the reference signal.

Whenever the VCO is not on the proper frequency, the detector produces a low level at one pin. This level turns on the on-board LED to indicate an out-of-lock condition.

The display circuitry provides the 50 MHz reference signal for the second receiver mixer (LO #2) and the VCO loop, and mixes it with the VCO signal. The difference signal is then divided by 10 before it is applied to the counter circuit for the display.

DETAILED CIRCUIT DESCRIPTION

This section describes in detail how each circuit operates. Refer to the Schematic and the Block Diagrams as you read about the following circuits.

RECEIVER CIRCUIT

Receiver Input

RF signals from an external antenna or the built-in collapsible antenna are applied through the Local/DX switch to the receiver input filters. When the switch is in the Local position, resistors R1 and R3 form a 20 dB pad to attenuate strong signals coming from a 50-ohm, coaxial-cable-fed antenna. Resistor R2 serves the same function for a HI Z antenna. When the switch in the DX position, each pad is bypassed and full-strength signals are applied to plug P407 on the receiver circuit board.

Signals from the 50-ohm antenna are applied to T401, an impedance-matching transformer. Components C404, L401, and C405 form a low-pass filter to remove unwanted signals above 30 MHz. Capacitor C401 directly couples signals present at the HI Z connector to the low-pass filters. The RF signal then passes through one of six bandpass filters, which is selected by the bandswitch decoders and filter-select transistors on the controller circuit board.

Each bandpass filter is designed to cover a single-octave range. These filters cover 150 kHz to 1 MHz, 1 to 2 MHz, 2 to 4 MHz, 4 to 8 MHz, 8 to 16 MHz, and 16 to 30 MHz.

The appropriate switching transistor activates the proper bandpass filter by applying voltage to the input and output diodes for the filter. This allows the RF signal to pass through the filter to attenuator diode D414.

A DC bias from RF attenuator control R4 regulates the conduction of PIN diode D414. This diode acts like a variable resistor which shunts more of the signal to ground as the bias increases. The RF signal is then applied to first mixer U401.

Mixer and Filter

Integrated circuit U401 mixes the RF signal with the VCO signal, local oscillator #1 (LO #1), coming from the controller circuit board. This VCO signal ranges from 50.605 to 80.455 MHz. The difference frequency of 50.455 MHz is then passed through crystal filter FL401 to second mixer U402. Coils L423 and L424 match the impedance at the input of the filter, while L425, C444, and C445 match the output of the filter to U402.

Second mixer U402 mixes the IF signal with the 50 MHz local oscillator #2 (LO #2) signal coming from the synthesizer circuit board. The 455 kHz difference signal passes through ceramic filter FL402, buffer transistor Q401, and IF amplifier U403.

AM Detector and AGC

Transformer T402 couples the amplified IF signal coming from U403 to the AM detector formed by D415, D416, R444, and C464. Capacitor C463 also couples this signal to buffer transistor Q403 and on to the product detector circuit.

In the AM modes, the audio signal from the AM detector is passed to audio preamplifier Q402 and on to Mode switch SW2. In all modes, resistor R466 also couples this signal to AGC amplifier U407. U407 amplifies the detected AM signal before it is rectified by D421. Resistor R493 couples the positive DC voltage coming from D421 to the S meter. As the signal strength increases, the AGC voltage increases. This reduces the gain of U403 while the meter indication increases.

To control the decay time of the AGC voltage, C498 is switched in or out of the circuit. Switch SW5 grounds the negative lead of C498 when AGC Slow is selected, while the connection is opened for AGC Fast.

Active Filter, Audio Amplifier, and Mute

The AM audio signal coming from preamplifier transistor Q402 is applied to mode switch SW2. When the switch is in the AM Narrow position, the signal is passed to the active filter stages of U404. In the AM Wide position, the audio is passed only to switching stage U404D.

Sections A, B, and C of U404 form a three-stage, active, low-pass filter. This filter is designed for unity gain and has a roll-off frequency of 2700 Hz at 6 dB. The narrowed audio bandwidth helps prevent stations on nearby frequencies from interfering with the desired station. U404D forms an electronic switch which either selects an input from the filter stages or from audio preamplifier Q402 (through Mode switch SW2). U404D is connected as an inverting amplifier so it can be cut off by a decrease in voltage produced by the mute circuit.

Capacitor C473 couples the audio signals coming from U404D to Volume control R5 and to Recorder output jack J1. The voltage at J1 is unaffected by the setting of the Volume control, so a constant level is present at the jack for recording purposes.

The audio signal from R5 passes through audio amplifier U405, which increases the available audio signal to a power level of approximately one watt for an 8-ohm load. The output is then coupled through Phones (headphones) jack J2 to the external speaker.

Transistor Q404 performs a muting function. When the mute line is shorted to ground, Q404 turns on and places 11 volts on the AGC line, which cuts off U403. The grounded mute line also drops the voltage at U404D pin 2 through D423, R473, and R472. This turns off the amplifier to prevent audio from reaching the Volume control. D422 prevents the higher AGC line from driving the S meter to full scale so it can indicate zero during muting periods.

Product Detector, BFO, and BFO Switch

In the USB/CW or LSB modes, the amplified IF signal coming from U403 is coupled through C463 to buffer amplifier Q403. The output of this buffer is then coupled to the product detector where it is mixed with the BFO signal. Capacitor C495 couples the resulting audio signal to the active filter, where it is treated the same as an AM narrow signal.

A section of the Mode switch activates BFO Q406, BFO switch Q405, and product detector U406. In the USB/CW mode, B+ is applied through SW2 to each circuit. Coil L426 and capacitors C503 through C506 determine the frequency of the BFO. When LSB is selected, B+ is also applied to the base of Q405, which turns the transistor on and switches C502 in parallel with L426. This additional capacitor causes the frequency of the BFO to decrease. Diode D431 prevents Q405 from switching whenever USB is selected. In the AM modes, the same section switches B+ to audio preamplifier Q403.

Power Supply

AC power passes through power switch SW3, which is part of the Volume control, and fuse F1 to the primary of power transformer T1. Capacitors C1 and C2 remove any RF that may be present on the AC line. Resistor R1 allows any static charge on the chassis or antenna to drain off in the event the Receiver is not connected to an earth ground. The AC voltage at the secondary of T1 is changed to DC by a bridge rectifier formed by D425, D426, D427, and D428. Capacitor C511 filters the DC, while resistors R509 and R511 reduce the voltage to 12- and 11-volts DC respectively. Capacitor C509 further filters the 11-volt line, while C508 filters the 12-volt line.

A second set of contacts on switch SW3 allows power switching of an external DC source. Fuse F401 protects the external DC supply and diode D424 provides reverse-polarity protection for the Receiver.

SYNTHESIZER CIRCUIT

The synthesizer circuit consists of the display circuitry, and the VCO phase-locked loop. The heart of the display circuits is U201, which is a multifunction device. It also supplies the time base for the phase-locked loop.

LED Displays and Display Driver

Integrated circuit U201 contains a 10 MHz crystal oscillator, a decade time-base counter, an 8-decade data counter with latches, a 7-segment decoder, digit multiplexers, and 8-segment and 8-digit drivers for the LED display. The output of the frequency counter is coupled directly to the display drivers to provide an all-in-one counter package.

U201 pins 4 through 6, 8, and 9 select the digit, while pins 15 through 17 and 19 through 22 select the segment to be displayed. Pin 23 drives the decimal point. Input to the frequency counter is applied to pin 28 and a logic low measurement-in-progress signal is available at pin 2.

Programmable features of U201 include decimal point location, which is set by R201. R202 programs a constant decimal point display at digit 4 (digit 0 is for 100 Hz resolution, which is not used in this Receiver). R203 programs the internal time-base counter for a 100 millisecond sample gate time.

The display circuit board is driven directly by U201. Each digit is multiplexed at a 500 Hz rate through internal circuitry. Built-in blanking between digits is also provided to eliminate any ghosting of the display. U201 turns on each digit of the display and selects the proper segments.

The displays are common-cathode LEDs, and each display segment is connected in parallel with the same segment on all other displays. U201 supplies a 0-volt pulse to the cathode lead to turn each digit on, after it applies 5 volts to the anode segments to select the appropriate segments.

Display Circuit

The 10 MHz time-base signal coming from U201 is coupled through buffer transistor Q203 to quintupler Q212, and to amplifier Q204 for the phase detector. Components C228, L202, C224, L203, C231, and C232 select the fifth harmonic of the time-base signal. This 50 MHz signal is buffered by Q213 and Q214 and is then applied to mixer Q221 for the VCO loop. The signal coming from Q214 is also applied to Q215, where it is mixed with the VCO signal coming from Q222.

The 605 Hz to 30.455 MHz difference frequency is coupled through a low-pass filter, consisting of L204, L205, L206, C244, C245, and C246, to four amplifiers. Q216 through Q219 boost the signal to TTL levels for divider U213. U213 divides the signal by 10 before it is applied to pin 12 of U202A, the input gate for U201. The signal at this point is 455 kHz above the actual received frequency. With the counter sample gate at 100 milliseconds (.1 second) and the division by 10 of U213, this means 4550 (instead of 455,000) must be subtracted from the signal before you can obtain the correct readout. The output from U213 is also coupled to an up-counter, formed by U208, U209, U211, and U212, where this correction is made.

Normally, U202 pin 11 is low and allows the output of U213 to reach the counter input of U201. When a count period begins, U201 pin 2 goes low to indicate that a measurement is in progress. U202C inverts this low, which is differentiated by C207 and R208. The resulting pulse is applied to U202 pin 6, where it sets RS flip-flop U202D. This disables U202A and prevents any further signal from reaching the input of U201.

The positive pulse coming from U202C also causes a binary up-counter, formed by U208, U209, U211, and U212, to load a preset value of EE38 hex (60984 decimal) and begin to count. After 4551 counts, the up-counter reaches terminal value and resets to 0000 hex. At this point, a positive (carry) pulse is sent from U212 pin 15 to U202 pin 2. This resets the RS flip-flop and allows the output of U213 to pass through U202A to the counter. This effectively subtracts 455, since it prevents U201 from seeing the first 455 Hz. U201 then counts and displays the correct received frequency.

A special troubleshooting feature of the circuit allows it to be used as a straight frequency counter. By connecting jumper wire AA to point K, U202 pin 11 is grounded. This keeps the input gate enabled and allows U201 to receive any input from the loop. The frequency of a signal connected to point E, at Q219, will be displayed on the front panel display. The signal must pass through U213, due to the .1-second sample gate period of U201, or the indication will be high by a factor of 10.

The display circuit, when it is used as a frequency counter, will indicate frequencies up to 40 MHz with less than 30 millivolts input at point E.

VCO Phase-Locked Loop

Capacitor C237 couples the 50 MHz reference signal coming from the display circuit to point R for use as LO #2 by the second mixer. C258 also couples the signal to mixer transistor Q221. In addition, C257 couples the VFO signal coming from the controller circuit board to mixer transistor Q221. This results in a difference frequency between 43.455 and 44.455 MHz, which passes through a bandpass filter formed by C262, L207, C263, C264, C265, and L208

(to remove any unwanted mixing products). The filtered signal is then applied to U214 pin 1.

Transistor Q222 buffers the VCO signal (referred to as LO #1) before capacitor C267 couples it to mixer IC U214. C239 also couples the VCO signal to display mixer Q215. U214 mixes the VCO frequency with the signal at the output of Q221 to produce a difference frequency between 7 and 36 MHz. This difference signal passes through a low-pass filter, formed by C272, C273, C274, C275, L209, L211, and L212, before it is applied to the amplifiers described next.

Transistors Q211, Q209, Q208, and Q207 amplify the 7—36 MHz signal to TTL levels before it is applied to U207, which divides it by 10. The resultant .7 to 3.6 MHz signal is then coupled to amplifier transistor Q206, where it is translated to a 15-volt logic level that is required by U204 (at pin 6). U204 is a binary, 4-bit, divide-by-N programmable counter.

U203 contains an independent, binary, 4-bit divide-by-N counter, a programmable divide-by-4, 16, 64, or 100 counter, and a phase comparator. The divide-by-N counter is used with U204 to form a binary 8-bit, divide-by-N counter that is programmed by the controller logic. Depending upon which band is selected, the logic will program the divider for division by a number between 7 and 36. When the VCO is on frequency, the results of this division is always 100 kHz. This signal is then applied to one input of the phase comparator.

Transistor Q204 amplifies the 10 MHz time-base signal coming from Q203 before it is applied to the input of the other divide-by counter in U203. Since pins 10 and 11 are connected to the 15-volt line, this counter is programmed to divide by 100. This provides a stable reference frequency of 100 kHz for use by the phase comparator. This reference frequency is internally connected to the second comparator input.

The phase comparator checks the leading edge of each signal to determine the phase relationship. If the signal at U203 pin 14 is leading the reference frequency, which indicates a decrease in the VCO frequency, the detector output at pin 13 will become more positive. Loop filter Q205 amplifies and filters this error voltage before it is applied to the VCO in an attempt to bring it back on frequency. An error voltage in the opposite direction develops when the frequency of the VCO increases.

When the phases of both signals match, pin 12 has narrow pulses riding on a logic high. This keeps Q202 turned on so its collector voltage remains at 0. When the two frequencies do not match, pin 12 drops to approximately one-half of Vcc, with an increase in the width of the pulses to nearly a 50% duty cycle. This pulse width causes Q207 to turn off long enough to charge C211. Diode D203 prevents C211 from discharging through Q202. The resulting voltage is applied to the base of switching transistor Q201, which turns it on and causes out-of-lock LED D201 to light.

U205 is a 5-volt regulator for Q207, U207, and LED D201. U206 supplies 5 volts to all other 5-volt circuits on the synthesizer circuit board.

CONTROLLER CIRCUIT

Bandswitch

Integrated circuits U301, U302, and U303 form the bandswitch decoder circuit. U303 is a dual 1-of-4 decoder which provides a switching voltage for bandpass filter select transistors Q307 through Q309 and Q311 through Q315. U301 and U302 are 4-bit binary adders that provide the proper logic for the programmable dividers on the synthesizer circuit board. These ICs also provide logic for band-select transistors Q303 through Q306. Q303 and Q306, in turn, switch the VCO to the proper tuning range.

NOTE: Refer to the Schematic and the logic chart as you read the following descriptions.

The bandswitch in this Receiver provides a 5-bit positive binary logic that corresponds to bands 0 through 29. The logic code ranges from 00000 to 11101, with the least significant bit on line 0 (circuit board location P).

Switch logic lines 1 and 0 provide inputs A (pin 14) and B (pin 13), respectively, for decoder U303B. The decoder selects the appropriate output line for bands 1 (pin 12, 0—1 MHz), 2 (pin 10, 1—2 MHz), or 3 (pins 9 and 11, 2—4 MHz). Pins 9 and 11 represent logic points L and K, respectively. These pins form a logical OR circuit to select filter 3. Diodes D301 and D302 form another wired OR gate that dis-

ables U303B whenever any other bands are selected. Their inputs are logic H, the carry output from adder U301, and bandswitch line 2.

U303A pin 7 selects band 4 (4—8 MHz). Inputs from bandswitch line 2, for input A (pin 2), and logic point G (U301 pin 13), for input B (pin 3), cause the decoder to select band 4 at the proper time. Logic point G represents the bit 4 sum of U301.

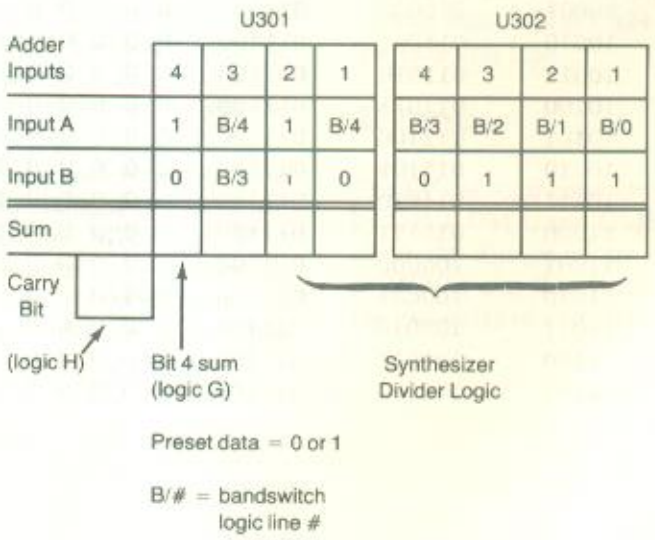
A logical NOR circuit, formed by R306, R307, and Q304, selects band 5. The inputs to the NOR are logic point G and bandswitch line 4. Band filter 5 is only selected when both lines are at a logic 0. Bandswitch line 4 selects band 6.

Integrated circuits U301 and U302 are 4-bit binary adders. For the synthesizer to properly tune the VCO, a binary 7 (0111) must be added to the bandswitch logic. U302 performs this addition, with its carry line connected to U301. This effectively makes U302 and U301 an 8-bit adder. A summary of the inputs to both adders is shown below.

Whenever the bandswitch value exceeds 7, switch line B3 or B4 becomes high, which causes an automatic carry to U301 bit 4 sum. This causes logic point G to go low and remain low for bands 0 through 7. This, in turn, insures that logic point H remains high for bands 8 through 29, since H is the carry line for U301.

As we mentioned earlier, the band 5 filter is only selected when bandswitch line 4 and point G are both low. Bandswitch line 4 is low for all bands above 7 (7 MHz). These logic levels are equal only in the 8—15 range, which is the tuning range of filter 5.

Point H controls the VCO range by turning Q303 off or on. A logic low must be present on the base of Q303 to turn it on and this only occurs on bands 0—7. As you will see later, the band select voltage from Q306, for band 5 (8—15 MHz), also changes the VCO tuning range.



A summary of the logic levels for each band and logic point is shown below.

Band (MHz)	Switch Logic Lines 43210	Divider Logic Output ABCDEF	Logic GHIJKL	Filter Select Points 1 2 3 4 5 6	VCO Range
0	00000	000111	101000	1 0 0 0 0 0	L
1	00001	001000	101000	0 1 0 0 0 0	L
2	00010	001001	101010	0 0 1 0 0 0	L
3	00011	001010	101001	0 0 1 0 0 0	L
4	00100	001011	101100	0 0 0 1 0 0	L
5	00101	001100	101100	0 0 0 1 0 0	L
6	00110	001101	101100	0 0 0 1 0 0	L
7	00111	001110	101100	0 0 0 1 0 0	L
8	01000	001111	010100	0 0 0 0 1 0	M
9	01001	010000	010100	0 0 0 0 1 0	M
10	01010	010001	010100	0 0 0 0 1 0	M
11	01011	010010	010100	0 0 0 0 1 0	M
12	01100	010011	010100	0 0 0 0 1 0	M
13	01101	010100	010100	0 0 0 0 1 0	M
14	01110	010101	010100	0 0 0 0 1 0	M
15	01111	010110	010100	0 0 0 0 1 0	M
16	10000	010111	011100	0 0 0 0 0 1	H
17	10001	011000	011100	0 0 0 0 0 1	H
18	10010	011001	011100	0 0 0 0 0 1	H
19	10011	011010	011100	0 0 0 0 0 1	H
20	10100	011011	011100	0 0 0 0 0 1	H
21	10101	011100	011100	0 0 0 0 0 1	H
22	10110	011101	011100	0 0 0 0 0 1	H
23	10111	011110	011100	0 0 0 0 0 1	H
24	11000	011111	011100	0 0 0 0 0 1	H
25	11001	100000	011100	0 0 0 0 0 1	H
26	11010	100001	011100	0 0 0 0 0 1	H
27	11011	100010	011100	0 0 0 0 0 1	H
28	11100	100011	011100	0 0 0 0 0 1	H
29	11101	100100	011100	0 0 0 0 0 1	H

Input Bandpass Filter Select

Each band filter except band 5 is selected by applying a high to the base of the first switch transistor. If band 1 is selected, for example, a high logic level is applied to the base of Q314. This turns the transistor on and causes its collector to go to ground. Q315 then has less than 12 volts applied to its base, which allows it to conduct and pass 12 volts to point U. This 12 volts forward biases the switching diodes for filter 1 on the receiver circuit board. Band 6 is selected directly from bandswitch line 4, while the other bands rely on logic functions to select them.

For band 5, a logic low is applied from logic point I, which is the result of the NOR function of logic G and bandswitch line 4. This low turns off Q304 and allows its collector to go high. This turns Q305 on and drops the base voltage of Q306 to allow 12 volts to appear at point Y.

VCO

The VCO consists of an FET hartley oscillator (Q316) and buffers Q317 and Q318. Switch transistors Q319 and Q321 add or remove additional trimmer capacitors C314 and C316, respectively, depending upon the tuning range that is selected. Varactor diodes D323 and D304 tune the VCO through the proper range by changing value as the phase detector output voltage, coming from the synthesizer, changes. Diode D305 reduces the harmonic content of the VCO signal.

As described in the decoder description, Q303 and Q306 perform the VCO range switching. When logic point H is low, Q303 conducts. This allows the base of Q319 to go high and turns it on. D306 also couples this high to the base of Q321 to turn it on. Since both transistors are on, C314 and C316 are effectively grounded. The added capacitance lowers the VCO frequency to its lowest range of 50.605 to 58.455 MHz.

When the bandswitch is above 7, Q303 is tuned off. Between bands 8 and 15, however, Q306 is on. This keeps Q321 turned on through D307, while D306 prevents Q319 from turning on. The result is to remove only C314 from the oscillator circuit so the VCO frequency range will increase to 58.455 to 65.455 MHz. When the bandswitch is above 15, both Q303 and Q306 are turned off, which removes both capacitors from the circuit and changes the VCO frequency range to 65.455 to 80.455 MHz. The VCO signal is used as LO #1 in the receiver to determine the first IF. It also mixes with the 50.0 MHz reference in the display circuitry to provide the proper frequency readout.

VFO

The VFO circuit consists of an FET colpitts oscillator (Q324) and buffer Q325. Main tuning capacitor C3 and coil L306 tune this oscillator. Diode D311 reduces the harmonic level of the VFO signal. The VFO is centered around 5.545 to 6.545 MHz, but will typically tune 5.4 to 6.7 MHz. This signal controls the VCO frequency within the desired tuning range.

Inverter Power Supply

An inverter circuit converts the 13.8-volt DC power supply voltage to 15-volts DC for use by the controller and synthesizer circuits. It consists of an oscillator, voltage amplifiers, a voltage doubler, and a voltage regulator.

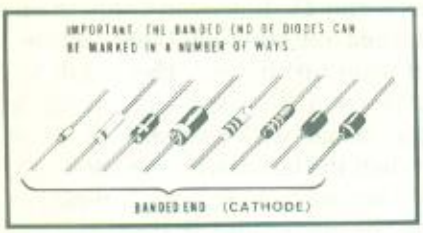
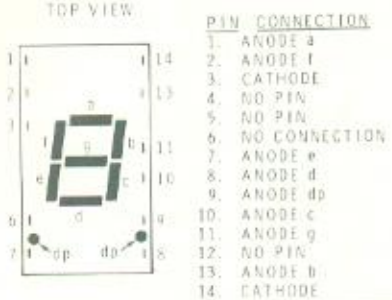
U304 is a timer, which forms an astable multivibrator. A 30 kHz square wave from U304 is fed to Q322 and Q323, amplified, and rectified by a voltage doubler. D308, D309, C325, and C326 form the doubler. U305 regulates the rectified DC to 15 volts. C328 and L304 filter any 30 kHz signal from the 15-volt line, while C324 and L303 do the same for the 13.8-volt line.

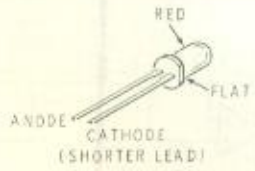
RF Detector

The RF detector consists of a voltage doubler formed by D313, D314, and C338. C337 couples an RF sample to the diodes where it is rectified. Any DC VOM or VTVM can then measure the RF signal without the necessity of a separate RF probe.

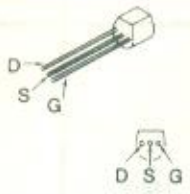
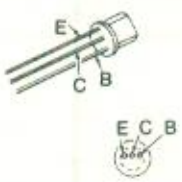
SEMICONDUCTOR IDENTIFICATION CHARTS

DIODES

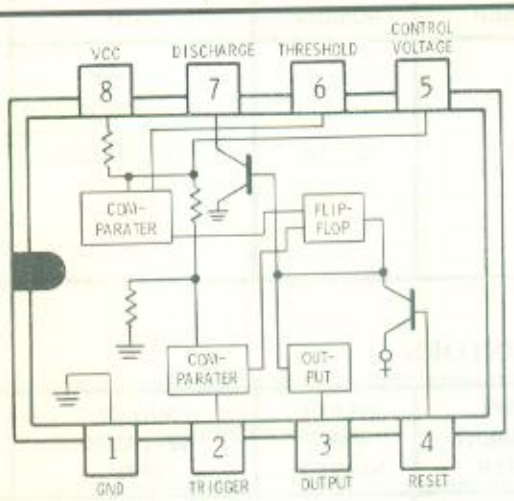
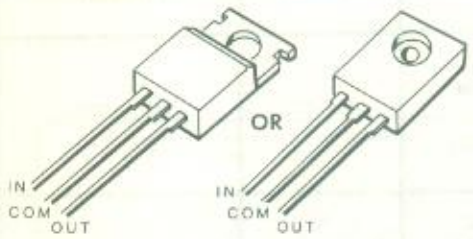
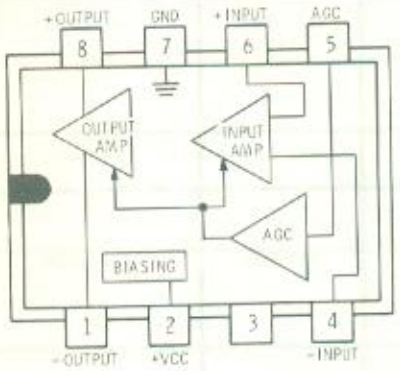
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
D313, D314, D415, D416, D418, D419, D422	56-26	1N191	
D202-D204, D301, D302, D305-D307, D311, D401-D409, D411-D413, D417, D421, D423, D431	56-56	1N4149	
D308, D309	56-93	FD-333	
D429	56-97	1N3071B	
D312	56-621	1N4738A	
D424-D428	57-65	1N4002	
D304, D323	56-674	MV209	
D414	56-675	MPN3404	
V101-V105	411-860		

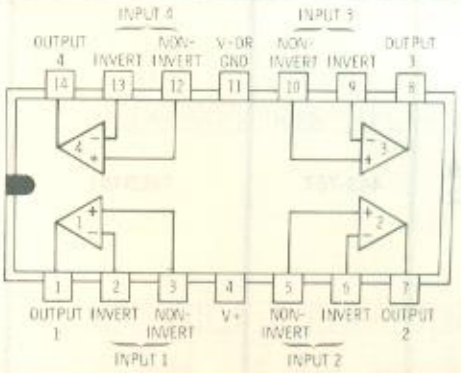
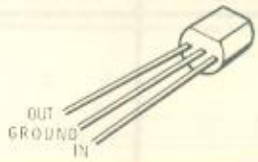
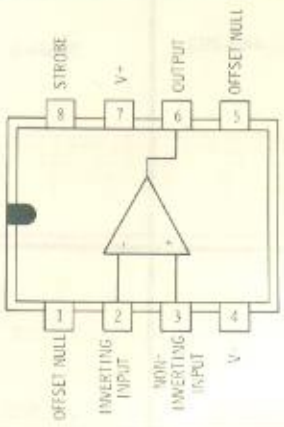
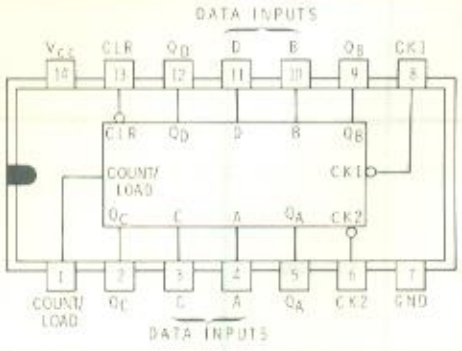
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
D201	412-79	TIL209 LED	

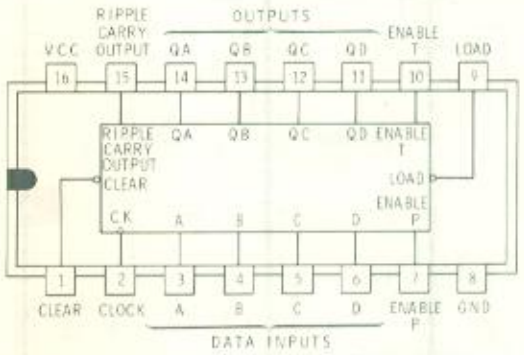
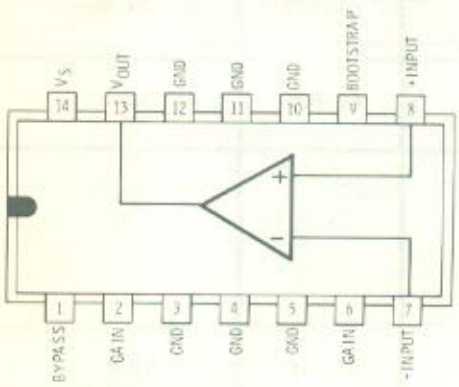
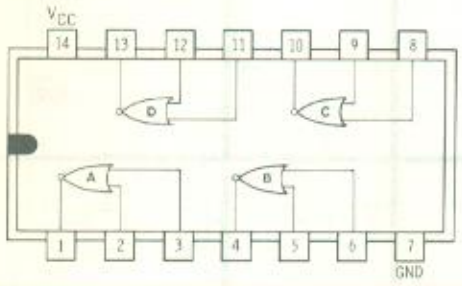
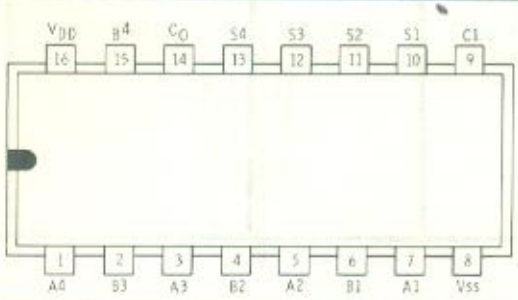
TRANSISTORS

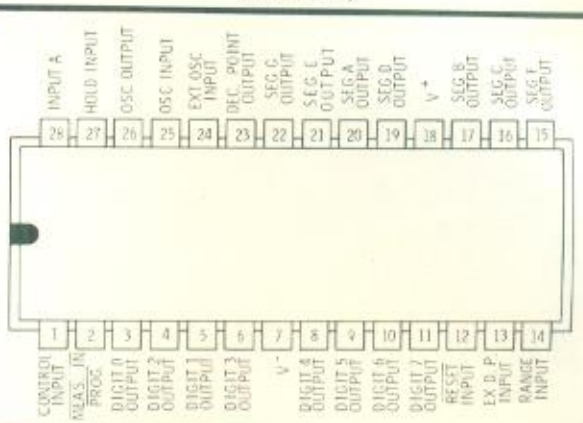
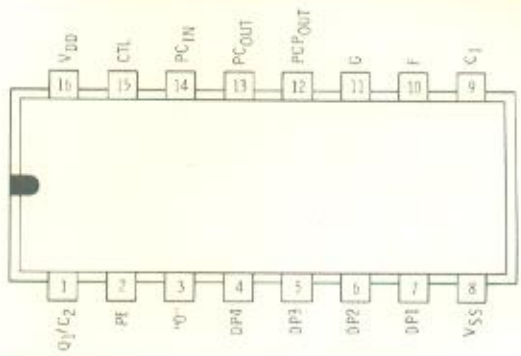
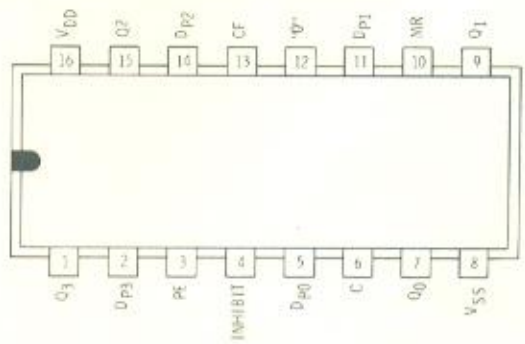
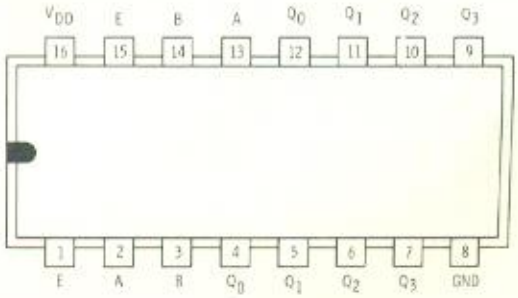
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
Q319, Q321, Q405	417-134	MPS6520	
Q203, Q204, Q206-Q209, Q211-Q219, Q221, Q222, Q318	417-172	MPS6521	
Q201, Q202, Q301, Q304, Q305, Q307, Q309, Q312, Q314, Q401-Q403, Q406	417-801	MPSA20	
Q323	417-864	MPSA05	
Q302, Q303, Q306, Q308, Q311, Q313, Q315, Q322, Q404	417-865	MPSA55	
Q316, Q317, Q324, Q325	417-169	MPF105	
Q205	417-222	2N5308	

INTEGRATED CIRCUITS (ICs)

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION (TOP VIEW)
U304	442-53	555	
U206	442-54	7805	
U403	442-55	1349	
U214, U401, U402, U406	442-96	1496	

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION (TOP VIEW)
U404	442-602	324	
U205	442-627	78L05	
U305	442-695	78L15	
U407	442-715	3130	
U207, U213	443-628	74196	

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION (TOP VIEW)
U208, U209, U211, U212	443-757	74LS161	
U405	442-763	388N-3	
U202	443-779	74LS02	
U301, U302	443-928	4008	

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION (TOP VIEW)
U201	443-938	7216	
U203	443-1146	14568	
U204	443-1147	14526	
U303	443-1151	14555	

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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