HEATHKIT® MANUAL

for the

HF DUAL WATTMETER

Model HM-2140

595-2056-02

HEATH COMPANY · BENTON HARBOR, MICHIGAN

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595-2068-02

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BENTON HARBOR, MICHIGAN 49022

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INTRODUCTION

The HF Dual Wattmeter Model HM-2140 measures forward and reflected power in transmission lines for frequencies between 1.8 and 30 MHz.

This Wattmeter was designed primarily for the Amateur Radio bands within the high-frequency ranges on the 160, 80, 40, 20, 15, and 10 meter bands, and for other services which may lie in between the amateur bands. The Wattmeter will measure transmissions up to 200 and 2000 watts peak-envelope-power in the forward direction and up to 500 watts reflected.

You can power the Wattmeter with a battery for complete portability, or with the optional Heathkit Converter Model GRA-43-1 where AC power is available. No additional plug-in modules are required to cover the power or frequency ranges. The Wattmeter is housed in a small, attractive, readily portable cabinet.

A special switching circuit permits you to observe the battery condition at any time. The remote sensor can be mounted into the cabinet or up to four feet away from the metering cabinet and nearer to the transmitter's output cables.

If you use only the 9-volt battery to power the Wattmeter, you must purchase it separately. See Page 11 for additional details.

PARTS LIST

Unpack the kit and check each part against the following list. Any part that is packed in an individual envelope with the part number on it should be placed back in the envelope after you identify it until all parts are accounted for.

The key numbers correspond to the numbers on the "Parts Pictorial" in the separate "Illustration Booklet" on Page 1.

Each circuit part in this kit has its own "Circuit Component Number" (R1, C2, D101, etc.). This is a specific number for only that one part. The purpose of these numbers is to help you identify the same part in each section of the Manual.

These numbers will appear:

— In the Parts List.

— At the beginning of each step where a component is installed.

— In some illustrations.

— In the sections at the rear of the Manual.

To order a replacement part: Always include the PART NUMBER. Use the Parts Order Form furnished with the kit. If one is not available, see "Replacement Parts" inside the rear cover of the Manual. Your Warranty is located inside the front cover. For prices, refer to the separate "Heath Parts Price List."

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

RESISTORS

NOTE: The following resistors are 1/4-watt, 5% tolerance unless otherwise noted.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

Resistors (cont'd.)

A1	6-561-12	4	560 Ω (green-blue-brown)	R2, R4, R8, R9
A1	6-102-12	2	1000 Ω (brown-black-red)	R18, R22

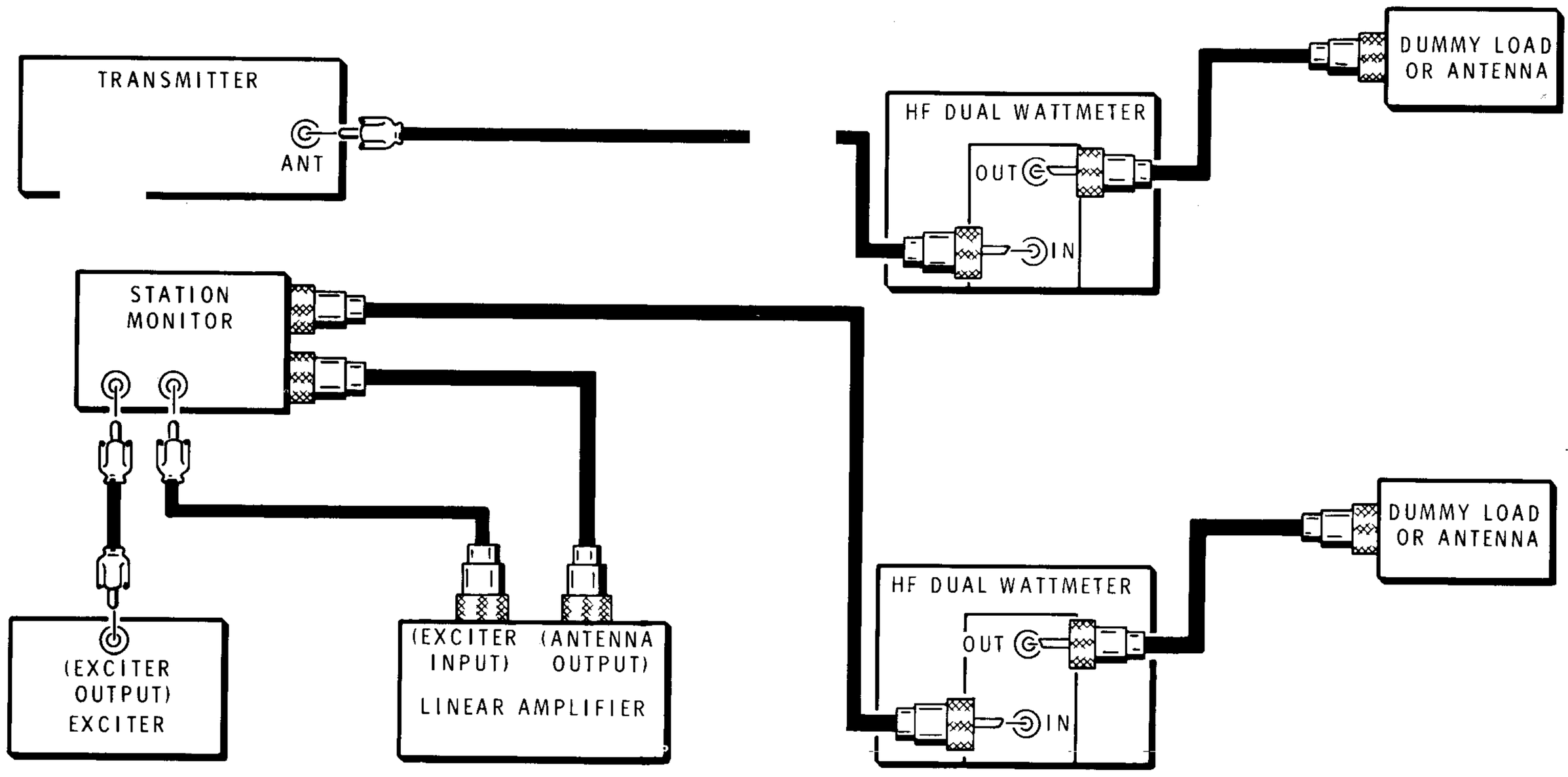
KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
Resistors (cont'd.)				
A1	6-103-12	2	10 kΩ (brown-black-orange)	R7, R11
A1	6-153-12	2	15 kΩ (brown-green-orange)	R19, R21
A1	6-473-12	2	47 kΩ (yellow-violet-orange)	R12, R16
A1	6-563-12	1	56 kΩ (green-blue-orange)	R6
A1	6-334-12	2	330 kΩ (orange-orange-yellow)	R15, R17
Precision Resistors, 1% Tolerance				
A2	6-1652-12	1	16.5 kΩ (brown-blue-green-red)	R24
A2	6-4022-12	1	40.2 kΩ (yellow-black-red-red)	R23
CAPACITORS				
B1	21-140	6	.001 μF ceramic	C1, C2, C3, C4, C7, C8
B1	21-176	7	.01 μF ceramic	C9, C11, C12, C13, C14, C15, C16
Capacitors (cont'd.)				
B2	25-885	2	100 μF electrolytic	C5, C6
B3	27-136	1	.015 μF Mylar*	C17
B3	27-137	1	.02 μF Mylar*	C18
DIODES-INTEGRATED CIRCUIT (IC)				
CI	56-56	2	1N4149 diode	D1, D2

NOTE: Integrated circuits may be marked for identification in any of th following four ways:

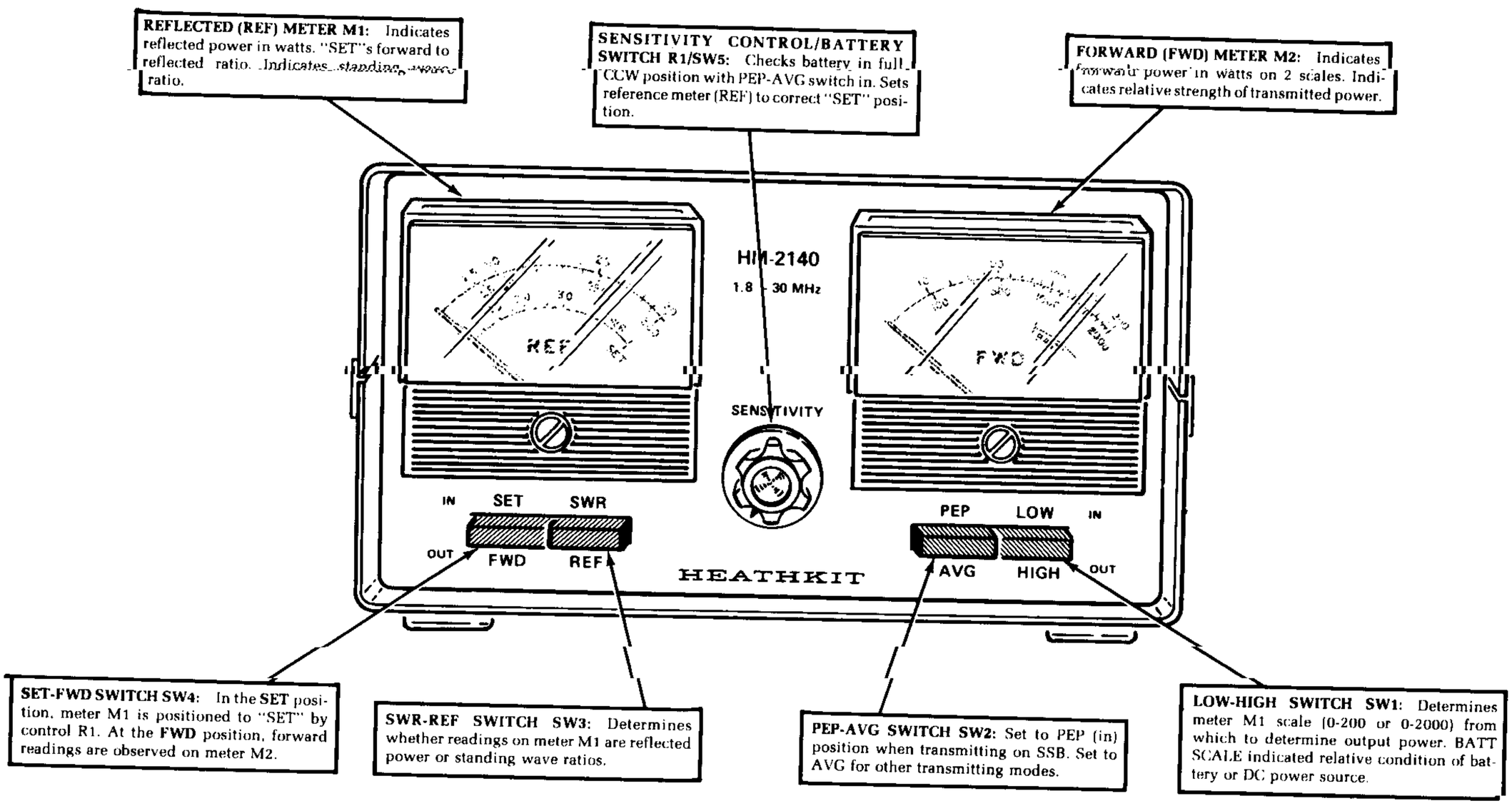
1. Part number.
2. Type number. (This refers only to the numbers; the letters may b different or missing.)
3. Part number and type number.
4. Part number with a type number other than the one listed.

C2	442-602	1	LM324N IC	U1

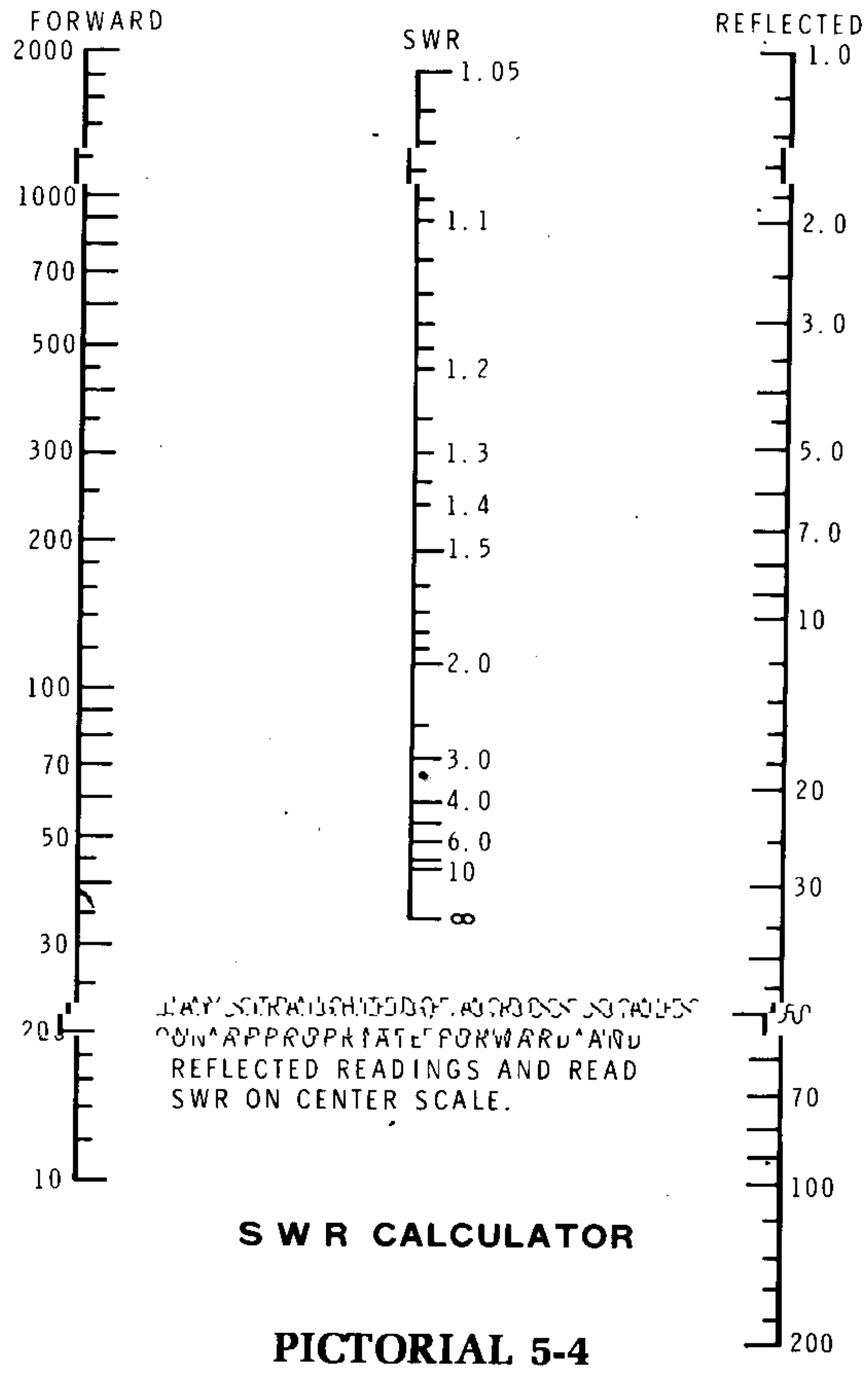
*Du Pont Registered Trademark



PICTORIAL 5-1



PICTORIAL 5-2



S W R CALCULATOR

PICTORIAL 5-4

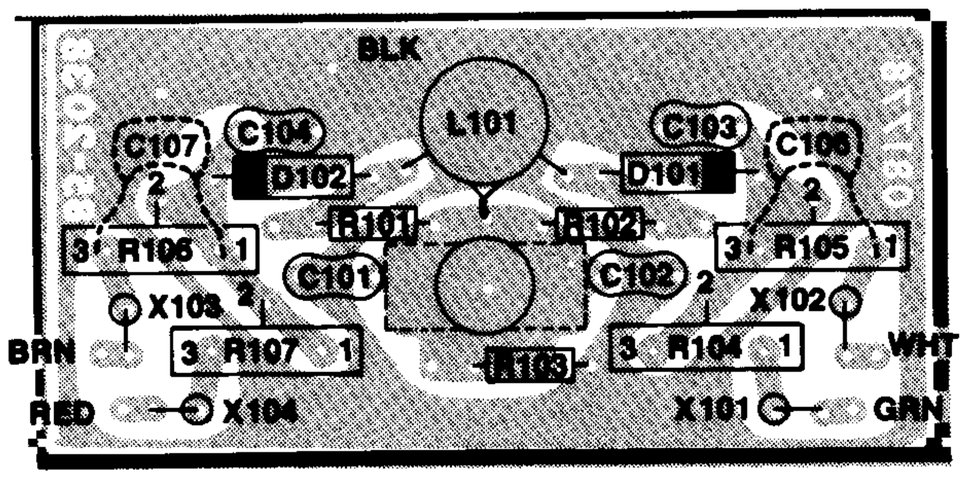
CIRCUIT BOARD X-RAY VIEWS

NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

A. Find the circuit component number (R7, C3, etc.) on the "Circuit Board X-Ray View."

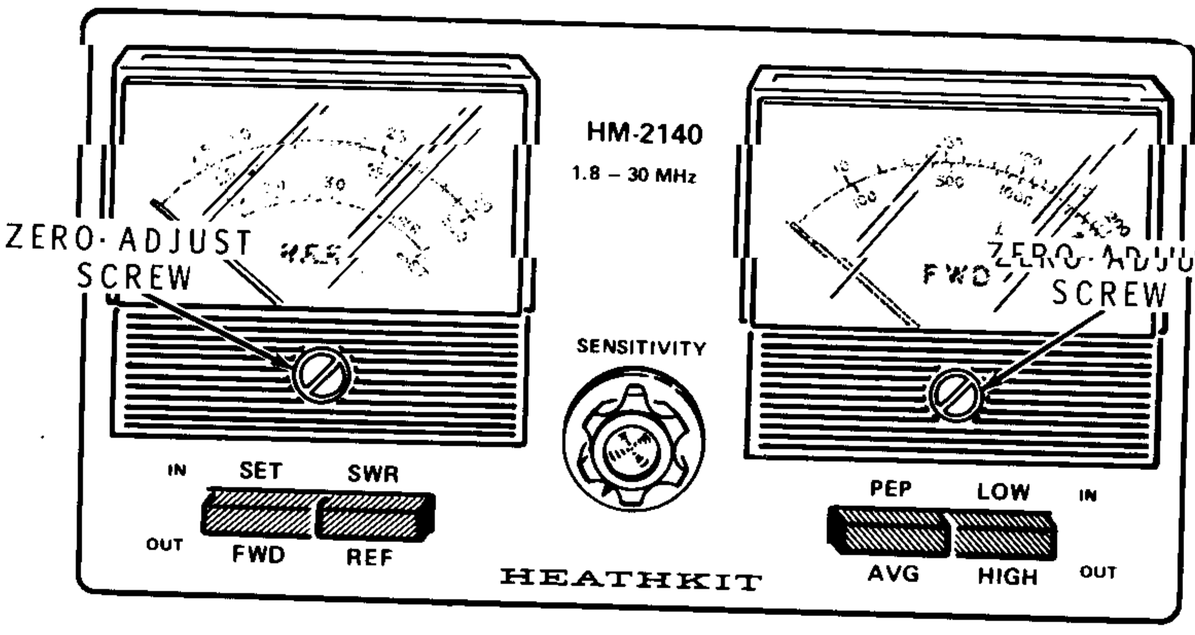
B. Locate this same number in the "Circuit Component Number" column of the "Parts List."

C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION, which must be supplied when you order a replacement part.

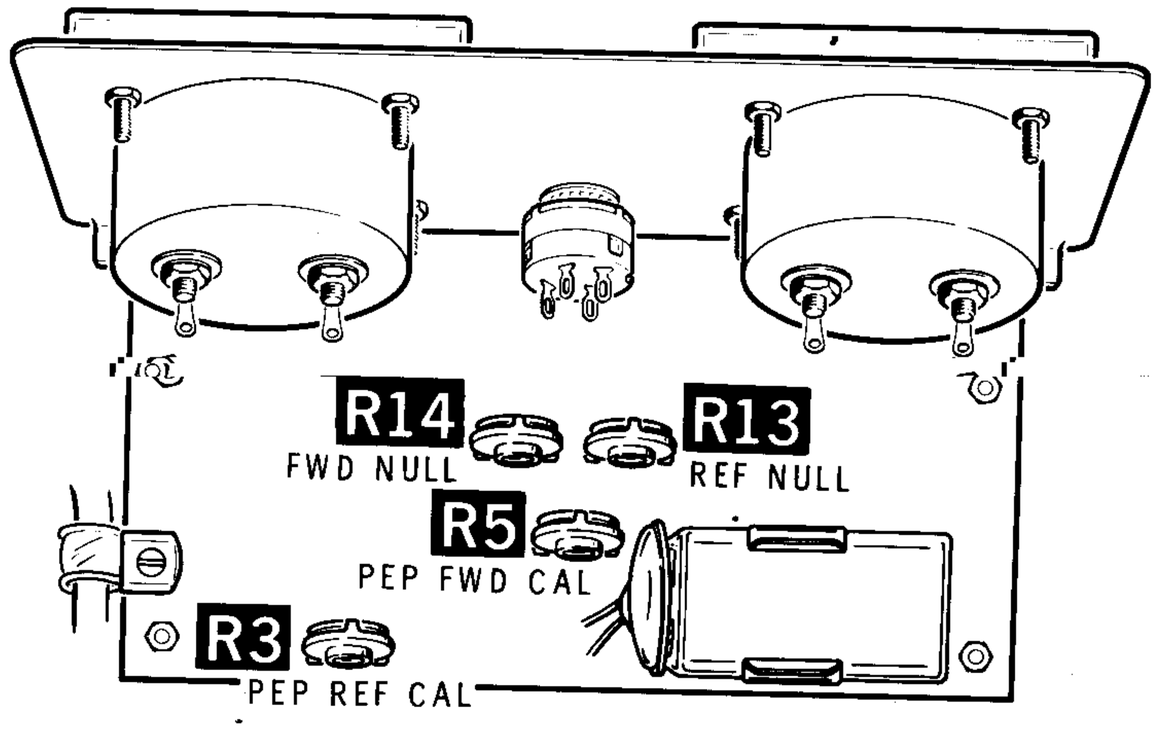


SENSOR CIRCUIT BOARD*
Shown from Component Side

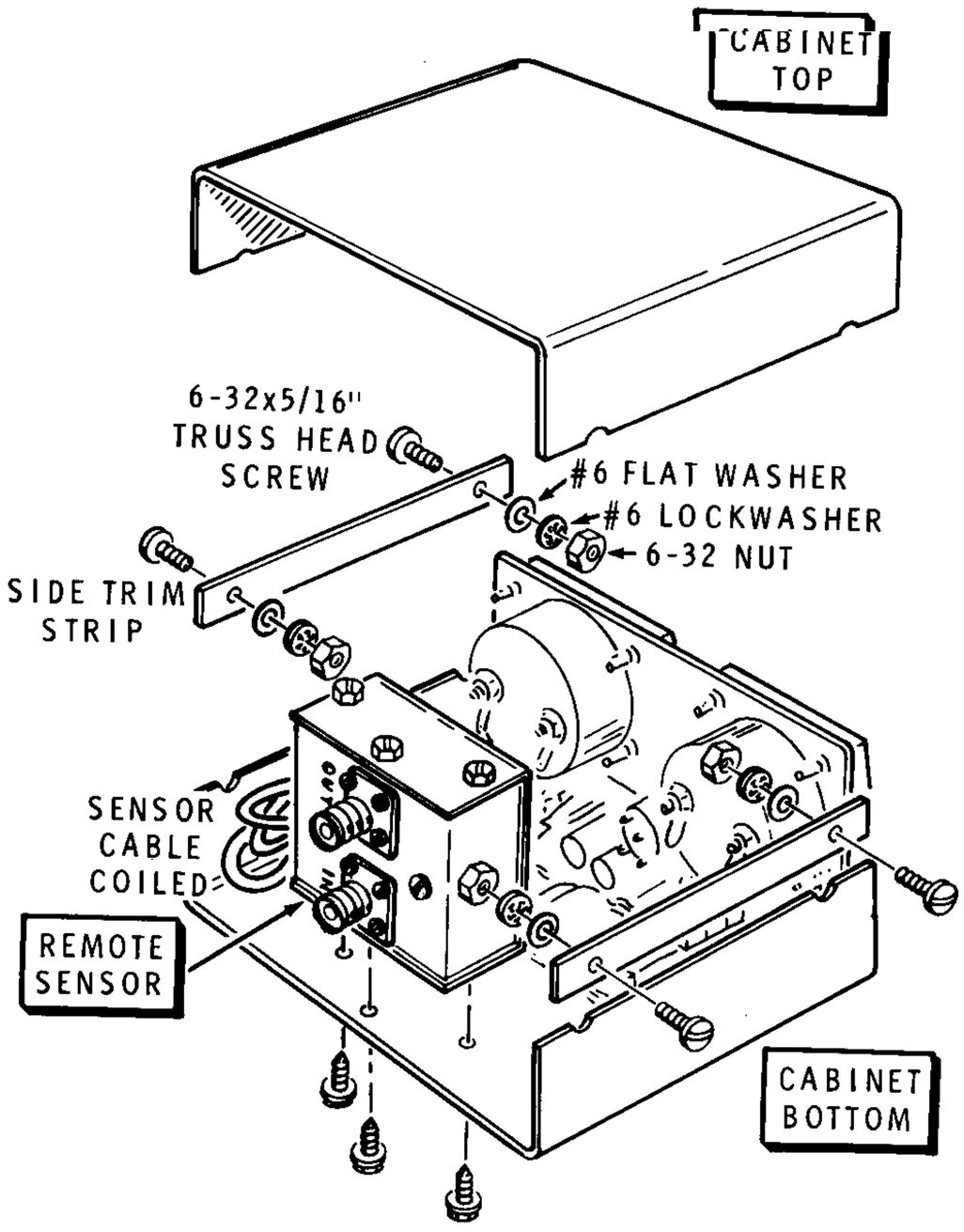
*NOTE: This circuit board is inside the sealed Remote Sensor assembly. To tamper with the assembly or circuit board may void the Warranty.



PICTORIAL 3-1

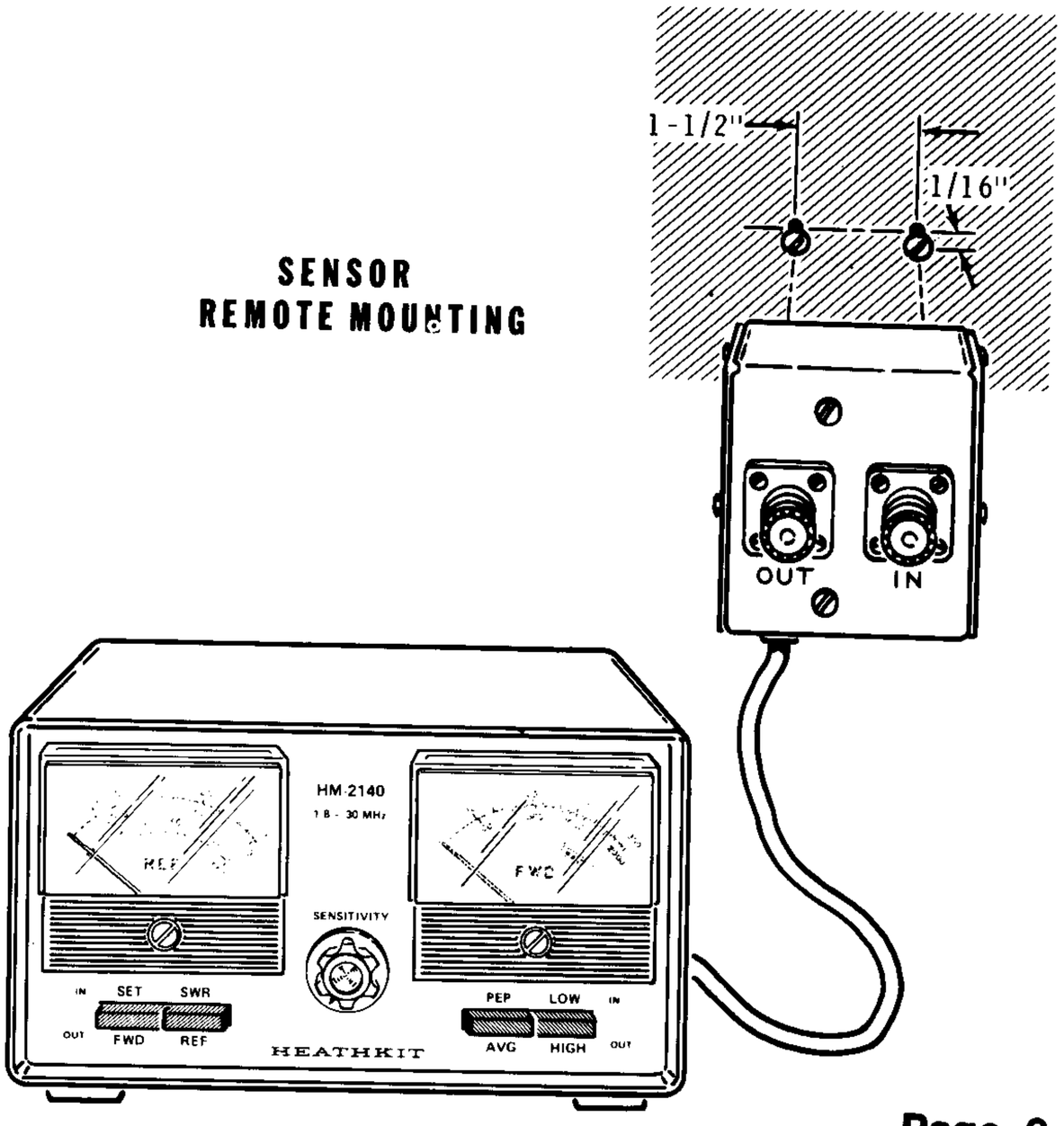


PICTORIAL 3-2



PICTORIAL 4-1

SENSOR REMOTE MOUNTING



PICTORIAL 4-2

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
GENERAL				
G1	10-390	4	20 kΩ control	R3, R5, R13, R14
G2	19-739	1	250 kΩ control with switch	R1/SW5
G3	64-32	1	2-section switch	SW3, SW4
G4	64-870	1	2-section switch	SW1, SW2
	85-2039-1	1	Switch circuit board	
G5	407-741	1	Forward power meter	M2
G5	407-742	1	Reflected power meter	M1
MISCELLANEOUS				
H1	205-778	1	Alignment tool blade	
H2	207-5	1	Cable clamp	
H3	208-42	1	Battery holder	
H4	432-798	1	Battery clip	
Miscellaneous (cont'd.)				
H5	436-49	1	Power jack	J1
H6	455-633	1	Knob bushing	
H7	462-932	1	Knob	
H8	490-5	1	Nut starter	
			Solder	
Printed Material				
		1	Blue and white label	
390-1524		1	"Operation" label	
597-260		1	Parts Order Form	
597-308		1	Kit Builders Guide	
		1	Assembly Manual (See title page for part number.)	

Remote Sensor Assembly (#100- 1749)

The Remote Sensor Assembly is a sealed unit which contains the following parts. This Assembly has been factory tested and aligned. CAUTION: Do not break the seal on the Remote Sensor Assembly; to do so may void the warranty.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
			RESISTORS, 1/4-WATT, 5%	
	6-470-12	2	47 Ω (yellow-violet-brown)	R101, R102
	6-332-12	1	3300 Ω (orange-orange-red)	R103
	6-223-12	1	22 kΩ (red-red-orange)	X102
	6-104-12	1	100 kΩ (brown-black-yellow)	X103
			CONTROLS	
	10-312	1	10 kΩ	R104
	10-390	1	20 kΩ	R107
	10-941	2	100 kΩ	R105, R106
			CAPACITORS	
	20-103	2	150 pF mica	C101, C102
	20-172	2	.001 μF (1000 pF) mica	C103, C104
	27-212	2	.0082 μF Mylar	C106, C107
	31-8	1	1-8 pF trimmer	C105
			HARDWARE	
	250-324	2	6-32 × 3/16″ screw	
	250-475	6	#6 × 3/8″ hex head screw	

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

Hardware (cont'd)

	253-1	1	#6 fiber flat washer
	254-1	12	#6 lockwasher
	257-12	1	#6 brass eyelet
	259-6	2	#6 solder lug
	256-5	8	Long rivet
	256-8	2	Short rivet

MISCELLANEOUS

	40-1970	1	Toroid coil
	56-20	2	1N295 diode

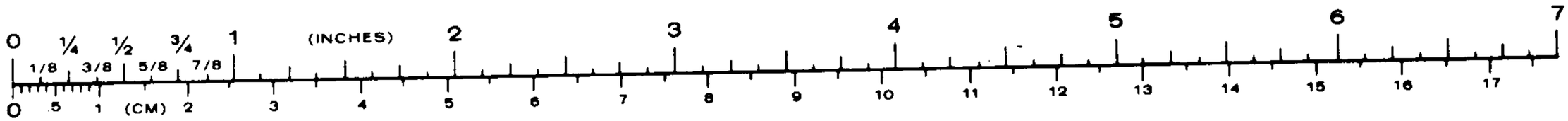
L101
D101, D102

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

Miscellaneous (cont'd.)

	75-30	1	Strain relief
	85-2038-1	1	Printed circuit board
	204-9	2	Angle bracket
	214-215	1	Cover
	214-216	1	Chassis
	340-3	6″	Bare wire
	346-21	6″	Sleeving
	347-39	60″	5-wire cable
	390-1505	1	Label seal
	436-5	2	Coaxial jack
	475-10	2	Ferrite bead

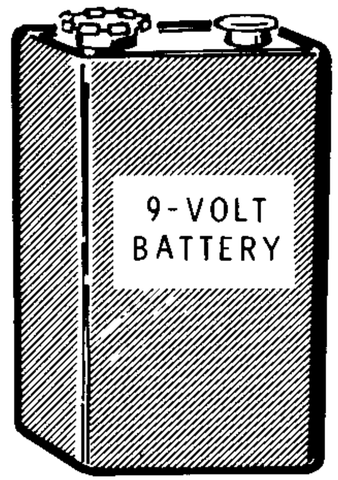
J101, J102
X101, X104



BATTERY

You should purchase the following battery at this time for use in your kit:

One 9-volt transistor battery, NEDA # 1604.



Representative manufacturers and their type numbers are:

Eveready #216 or # 1222
Mallory #M1604
Mallory #TR-146X (long life)
Burgess #2V6
RCA #VS323
Hellesens #410
Varta #438

The separate "Illustration Booklet" contains numbered illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. The step-by-step assembly instructions will direct you to the proper illustration in the Booklet. After you have completed the assembly of your kit, place the Illustration Booklet with the Manual and save them for future reference.

TESTS AND ADJUSTMENTS

Refer to Pictorials 3-1 and 3-2 (Illustration Booklet, Page 8) for the following steps.

INITIAL TESTS AND ADJUSTMENTS

( ) Refer to Pictorial 3-1 and, on the front panel of your Wattmeter, turn the SENSITIVITY control fully counterclockwise until it clicks.

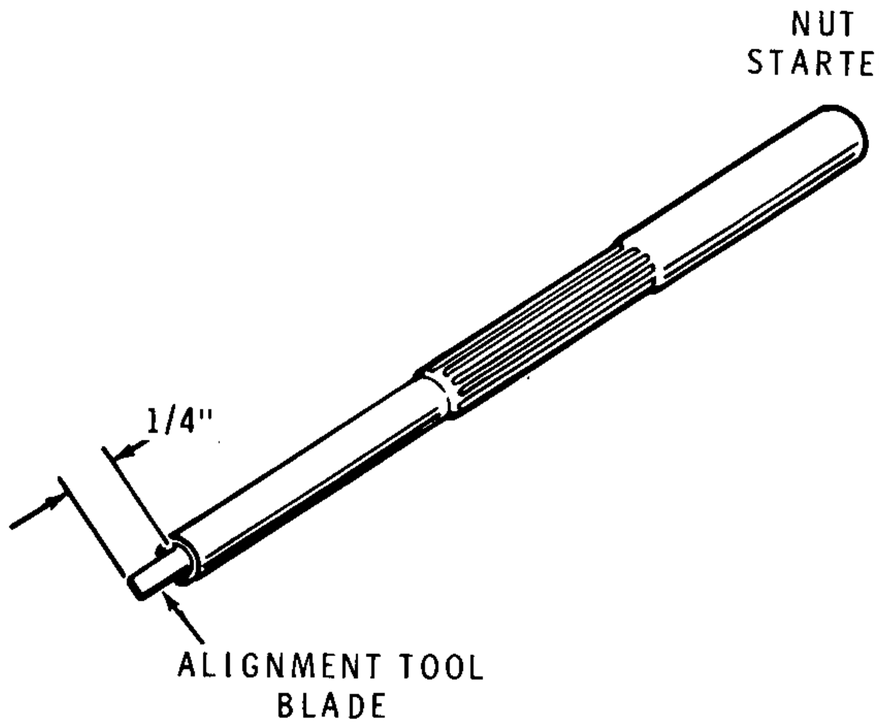
( ) Press the four pushbutton switches once or twice to be sure they are all in the "out" position.

( ) Set each of the circuit board controls to the mid-point of their rotation.

( ) Check the REF and FWD meters to make sure each meter pointer is exactly over the meter scale zero ("0"). If either one is not, adjust the zero-adjust screw on the front of the meter until the pointer is exactly at the "0" mark.

( ) Push the PEP-AVG switch in. Check the FWD meter to see that the pointer comes to rest in the segment labeled "BATT."

( ) Turn the SENSITIVITY control fully clockwise. Make sure the PEP-AVG switch is **in** – at the PEP position.



Detail 3-2A

( ) Refer to Detail 3-2A and push the thin alignment tool blade into the small end of the nut starter as shown. This is the tool you will use to adjust the circuit board controls in the following steps.

( ) As you observe the REF meter, turn REF NULL control R13 (on the circuit board) in either direction to exactly zero the pointer.

( ) As you observe the FWD meter, turn FWD NULL control R14 (on the circuit board) in either direction to exactly zero the pointer.

( ) Push the PEP-AVG switch to its AVG (out) position.

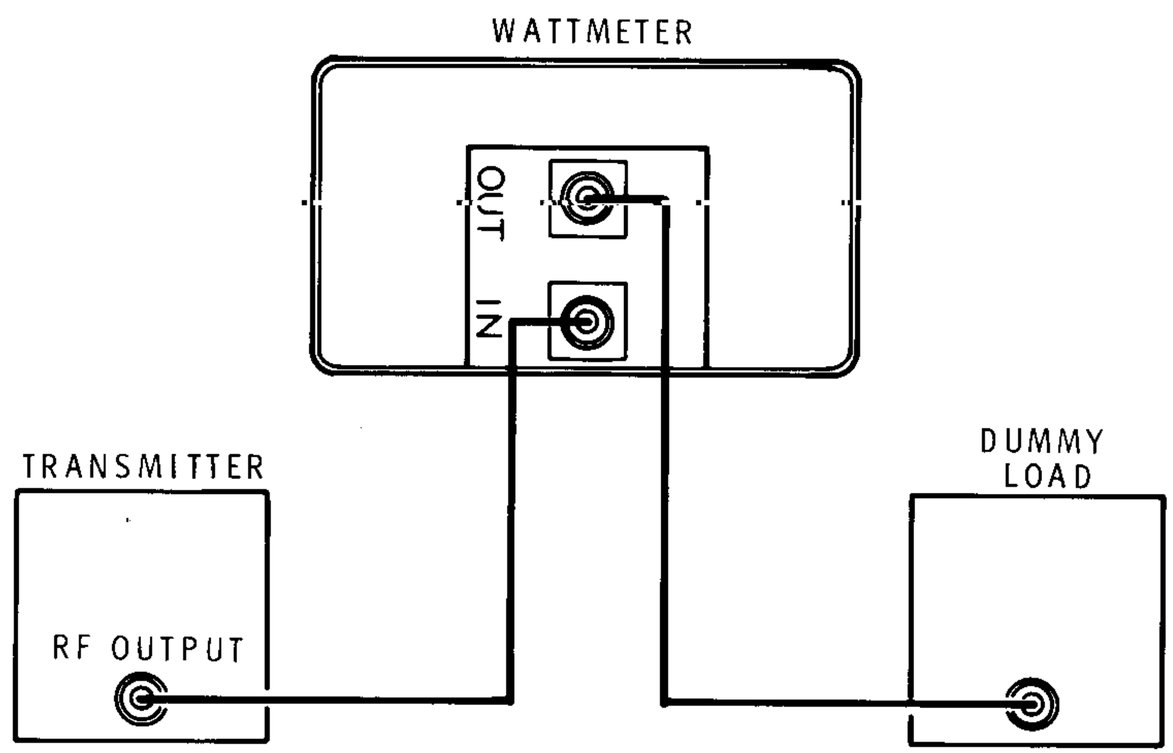
ADJUSTMENTS

NOTE: In the following steps that call for adjustments using transmitter power, your transmitter should ideally put out a CW level of at least 100-watts.

( ) Refer to Pictorial 3-3 and connect the output of your transmitter to the IN coaxial jack on the remote sensor and a 50-ohm dummy load to the OUT coaxial jack on the sensor as shown. NOTE: You may also use an antenna in place of the dummy load, but remember to properly identify your station because you will be radiating a signal.

( ) Tune the transmitter for a CW signal.

( ) Set the LOW-HIGH switch to the position that produces the highest-on-scale reading.



PICTORIAL 3-3

( ) Transmit a CW signal; note the reading on the FWD meter.

( ) Push the PEP-AVG switch to its PEP (in) position and allow the PEP reading a short time to settle. Note the reading on the FWD meter; it should be the same as the first reading. If it is not, refer to Pictorial 3-2 and adjust PEP FWD CAL control R5 until you get the same reading as in the previous step.

( ) Operate the PEP-AVG switch in and out as you perform the preceding two steps until the meter indication is the same for both switch positions.

( ) Turn off the transmitter.

( ) On the remote sensor assembly, connect the transmitter output to the OUT coaxial jack and the dummy load cable to the IN coaxial jack.

( ) Set the PEP-AVG switch to AVG (out).

( ) Tune the transmitter to produce a high-scale REF meter reading. Note the reading on the REF meter. Reduce the transmitter power if necessary.

( ) Push the PEP-AVG switch to the PEP (in) position. If the REF meter does not indicate the same reading as in the previous step, adjust circuit board PEP REF CAL control R3 until the reading is the same.

( ) Operate the PEP-AVG switch in and out as you perform the previous two steps until the meter indication is the same for both switch positions. Leave the switch in the AVG position.

( ) Turn off the transmitter and disconnect the cables from the remote sensor.

This completes the "Tests and Adjustments" of your HF Dual Wattmeter. Proceed to "Final Assembly."

FINAL ASSEMBLY

Refer to Pictorial 4-1 (Illustration Booklet, Page 9) for the following steps.

NOTE: Perform the next step only if you are **not** going to mount the remote sensor assembly away from the meter assembly.

( ) Position the remote sensor as shown in the Pictorial. Remove the three bottom housing screws from the sensor assembly. Position the remote sensor into the cabinet as shown and secure it with the three hex head sheet metal screws you just removed.

( ) Prepare the two side trim strips as follows: Place two 6-32 × 5/16" truss head screws through each side trim strip. Then place a #6 flat washer and a #6 lockwasher on the screw. Just start a 6-32 nut onto the end of each screw.

( ) Position each side strip down onto the top side edges of the cabinet bottom "brushed side" out as shown in the Pictorial, making sure the flat washers are inside the cabinet.

( ) Lower the cabinet top down behind the side trim strips. Make sure the front and rear edges of the two cabinet halves are aligned; then tighten the four side trim strip mounting screws.

( ) Coil the sensor cable and push it into the cabinet at the side of the sensor assembly.

REMOTE SENSOR MOUNTING

Refer to Pictorial 4-2 (Illustration Booklet, Page 9) for the following steps.

NOTE: Disregard the following steps if you have installed the remote sensor into the Wattmeter Cabinet.

Refer to Pictorial 4-2 for the following steps.

( ) Draw a horizontal line on the mounting surface for the remote sensor assembly.

( ) On the horizontal line, draw two short intersecting lines to the dimensions as shown in the Pictorial.

( ) At the intersecting lines, start two small holes for the mounting screws.

( ) Start each of the #6 × 1" sheet metal screws into the mounting surface and turn them down until they are about 1/16" from the wall or panel. Place the remote sensor onto the mounting screws.

This completes the assembly of your HF Dual Wattmeter. Proceed to "Operation and Installation."

OPERATION AND INSTALLATION

Refer to Pictorial 5-1 (Illustration Booklet, Page 10) for the following information.

The HF Dual Wattmeter was designed for amateur radio use, in the frequency spectrum between 1.8 and 30 MHz. The meter will help you:

- Tune your transmitter for its optimum output power.
- Adjust your antenna and antenna tuner for minimum standing wave ratios (VSWR).
- Provide you with an accurate power measurement when you use a good 50-ohm dummy load or a 1:1.1 (or less) VSWR antenna.

The wattmeter can be installed at any point in your transmission line and it will indicate the VSWR at that point. It is usually convenient to install the remote sensor assembly in the "ham shack" to measure the VSWR your transmitter will "see." Pictorial 5-1 (Illustration Booklet, Page 10) illustrates several examples of amateur stations which incorporate Wattmeters.

You can obtain the best results with readings that are greater than midrange of your Meter. Although you can use the Wattmeter with low-powered transmitters, you will get the best results when you use it with transmitters that produce 25 watts or more output since its accuracy is specified in percent of full scale.

CONTROL AND SWITCH FUNCTIONS

Refer to Pictorial 5-2 (Illustration Booklet, Page 11) for the following information.

LOW-HIGH switch — This pushbutton switch should be set to LOW (in) for all transmitters (or amplifiers) which produce an output of less than 200 watts (PEP) or 100 watts (AVG). Set the switch to HIGH (out) for output power from 200 to 2000 watts output (PEP) or 1000 watts (AVG).

PEP-AVG switch — Set this pushbutton switch to PEP (in) for single sideband operation. For all other transmitting modes, set the switch to AVC (out). IMPORTANT: When the Meter is not in use, set this switch to the AVG position; this disconnects the battery circuit.

SWR-REF switch – Set this pushbutton switch to REF (out) to read the amount of reflected power (in watts) directly from the REF meter. Set the switch to SWR (in) to take standing-wave readings from the REF meter. NOTE: This procedure will be described in "SWR Measurements" which follows.

SET-FWD switch – Set this pushbutton switch to FWD (out) as you perform tuning adjustments or at any time you wish to observe the forward output power (in watts) of the transmitted signal on the FWD meter. The SET (in) switch position allows you to adjust the SENSITIVITY control to the "SET" mark on the FWD meter (see "SWR Measurements").

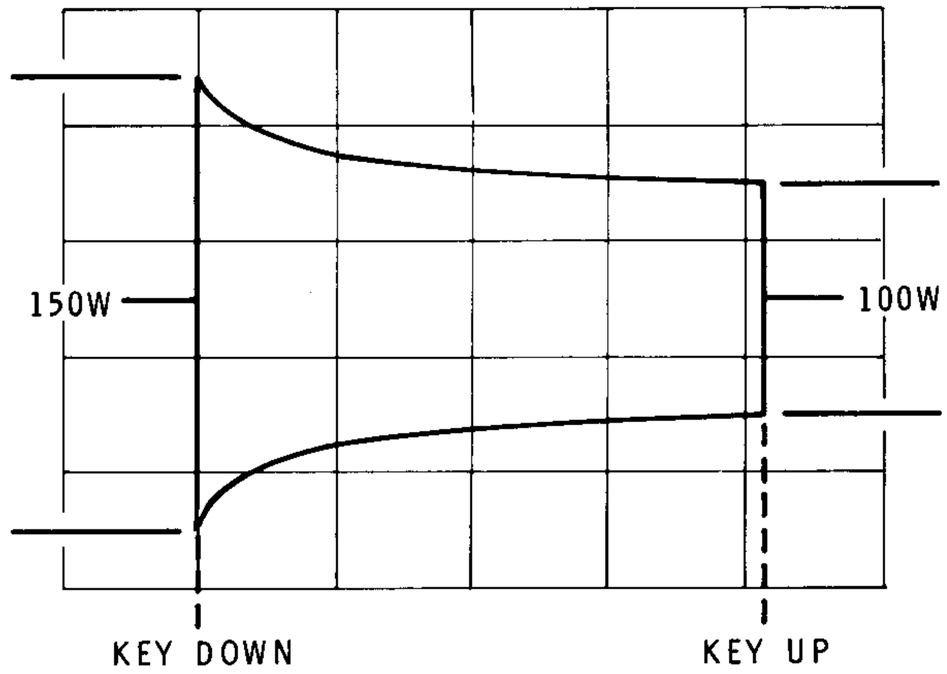
SENSITIVITY control (and Battery Switch) — When you wish to check the condition of the Wattmeter battery (if used - see "Wattmeter Power" in the following text), turn the SENSITIVITY control fully counterclockwise until it clicks, and set the PEP-AVG switch to PEP (in). Then make sure the FWD meter pointer comes to rest inside the "BATT" scale on the meter. If it does not, replace the battery before you use the Wattmeter. The control function is used when you "Set" the meter to read SWR (see "SWR Measurements").

REF meter — This is a direct readout meter that indicates either the power reflected back through the transmission line in watts or indicates the standing wave ratio on the transmission line. A "Set" index is used in conjunction with SWR measurements.

FWD meter — This meter indicates the direct power output (in watts) of your equipment at the point in the transmission line where you have installed the Wattmeter. The meter has two power scales — high and low — and a third scale labeled "BATT" so you may observe the condition of the battery at any time.

Special Note

Many transceivers do not provide the same output power in the CW mode when the peak power and the average power readings are taken. A typical waveform is shown in Pictorial 5-3.



PICTORIAL 5-3

This drop is usually attributed to inherent conditions in some power supplies, especially those in self-contained transceivers, that is, with all power being internal to the unit. This is a normal condition; neither the transceiver nor the Wattmeter are malfunctioning.

SWR MEASUREMENTS

To make standing wave ratio measurements:

A. Push the SWR-REF pushbutton to SWR (in).

B. Push the SET-FWD pushbutton to SET (in).

C. Transmit a CW signal. Turn the SENSITIVITY control and position the REF meter pointer to the "SET" index.

D. Push the SET-FWD pushbutton to FWD (out).

E. Read the standing wave ratio (SWR) on the REF meter.

If you wish to calculate an exact VSWR, refer to the "SWR Calculator" shown in Pictorial 5-4 (Illustration Booklet, Page 12). Follow the instructions on the scale and read the SWR directly from the center scale.

WATTMETER POWER

You may use either of two power sources in the Wattmeter, or you may use both. We recommend an **alkaline** power cell, NEDA Type #1604 for battery power, and you may purchase the optional 9-volt Heathkit Converter Model GRA-43-1 if you want to power the Wattmeter without a battery or if you wish to use both.

When you use the Wattmeter away from conventional AC power sources, you will need the battery for PEP operation. The battery is easy to install into the battery holder on the switch circuit board; merely loosen the four side-trim screws, lift the top cover from the Wattmeter, then plug in the battery and push the battery down into the battery holder. Replace the cabinet top cover and tighten the trim screws.

When you are close to a conventional source of 120-volt AC power, and if you have the Converter, merely plug it into a wall outlet and push the small plug into switch circuit board jack J1. NOTE: In the HF Dual Wattmeter, the Converter is used as a **Battery Eliminator**; it will **not** charge your battery, which is disconnected from the Wattmeter circuits when the Converter is connected to J1.

IN CASE OF DIFFICULTY

This section of the Manual is divided into two parts. This first part, titled "General," describes what to do about any difficulties that might occur right after the unit as assembled. The second part, titled "Troubleshooting Chart," lists a number of possible difficulties that could arise. It also lists the possible causes of these difficulties.

GENERAL

The following paragraphs deal with the types of difficulties that may show up right after the kit is assembled, before you can put it into operation. These difficulties are most likely to be caused by assembly errors or faulty soldering. The following checks will help you locate any error of this type.

NOTE: Refer to the "X-Ray Views" (Illustration Booklet, Pages 13 and 14) for the physical location of parts.

1. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something you consistently overlook.

2. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore you can eliminate many troubles by reheating all connections to make sure that they are soldered as described in the "Soldering" section parts. Be sure the proper part has been wired into the circuit at each location as shown in the Pictorials and as called out in the wiring instructions.

3. Check the values of the parts. Be sure the proper part has been wired into the circuit at each location as shown in the Pictorials and as called out in the wiring instructions.

4. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring or between the foils on the circuit board.

5. If, after careful checks, you still can not locate the trouble and a voltmeter is available, check voltage readings against those shown on the Schematic Diagram. NOTE: All voltage readings were taken with a high input impedance voltmeter. Voltages may vary as much as ±20%.

6. A review of the "Circuit Description" may also help you find the trouble.

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

Troubleshooting Chart

The following chart lists conditions and possible causes of several specific malfunctions. If a particular part is mentioned (R23 for example) as a possible cause, check that part and other components connected to that part to see that they are installed and/or wired correctly. Also check for solder bridges and poor connections in the surrounding area. It is also possible, on rare occasions, for a part to be faulty and require replacement.

PROBLEM	POSSIBLE CAUSE
Meters inoperative, PEP-AVG switch in AVG position.	1. Shorting wire still on meters. 2. Sensitivity control wiring. 3. No RF through remote sensor. 4. Sensor cable connections on the circuit board.
Meters inoperative, PEP-AVG switch in PEP position.	1. Battery dead. 2. Integrated circuit U1. 3. Solder bridge on circuit board foil.
Battery check produces no meter movement.	1. Battery dead. 2. Resistor R6. 3. Battery switch SW5. 4. PEP-AVG switch set to AVG (out).
Unable to calibrate PEP circuit.	1. Solder bridge on circuit board foil. 2. Battery weak or dead. 3. Check PEP circuit components for correct installation.

SPECIFICATIONS

Frequency Range	1.8 to 30 MHz.
Functions	Forward and reflected power (AVG and PEP), and SWR.
Meter Ranges	
Forward (2 scales)	Low, 0-200 watts PEP. High, 0-2000 watts PEP.
Reverse (3 scales)	Low, 0-50 watts PEP. High, 0-500 watts PEP. SWR, 1:1 to 3:1
Insertion SWR	Less than 1.05:1.
Accuracy (full scale)	
200 W and 2000 W (FWD), 500 W (REF)	±5% (AVG).
50 W (REF)	±7.5% (AVG).
Power	9-volts DC (Battery NEDA Type #1604, or optional Heathkit Converter).

Dimensions (overall)	7-1/2″ wide × 4-1/8″ high × 6-3/8″ deep. (19.05 × 10.48 × 16.19 cm).
Net Weight	4 lbs. (1.82 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 fold-in Schematic Diagram as you read the following circuit description.

REMOTE SENSOR

A bare wire connects input jack J101 to output jack J102 through toroid coil L101. L101 is a current pickup element for both the forward and reflected power which passes through the remote sensor. A transmitted signal passing through the sensor induces a voltage in the toroid coil which is directly proportional to the RF current. A voltage sampled directly from the transmission line is summed with the voltage at L101. The sum of the voltages is then rectified by diode D102 and is filtered by capacitor C104. The sensor is factory calibrated to within 5% accuracy by control R106 for the 0-2000-watt circuit and by control R107 for the 0-200-watt circuit.

The "out-of-phase" (reflected) current-induced voltage that was summed with the sampled voltage is rectified by diode D101 and filtered by capacitor C101. With a very good load, that is one with less than 1.05: 1 VSWR, the two voltages will be about equal and out of phase and no reflected voltage would appear in the reflected circuits. Reflected power is factory calibrated by control R104 for the 0-50-watt scale and by R105 for the 0-500-watt scale.

The calibrated voltages from the remote sensor are routed through a 5-wire cable to the input circuits of the switch circuit board.

IMPORTANT: The remote sensor is factory aligned, calibrated, and is sealed; unauthorized tampering with the remote sensor can void the Warranty on your Wattmeter.

SWITCHING CIRCUITS

NOTE: The forward and reflected circuits on the switch circuit board are virtually identical. In the following discussion, we will explain the operation of the forward circuits. Where differences exist between the basic operation of the two circuits, further details will be supplied.

The forward signal from the remote sensor is coupled to the switch circuit board and is routed through LOW-HIGH switch SW1. If the output of the transmitter is known to be less than 200 watts, switch SW1 should be set to the LOW (in) position. If the power is greater than 200 watts, switch SW1 should be set to HIGH (out).

Signals from SW1 are routed directly to SET-FWD switch SW4. When SW4 is in the SET (in) position, the forward (FWD) meter is temporarily disconnected from the circuit. The low-current input from the sensor is coupled directly through SW4, through Sensitivity control R1 to the contacts of SWR-REF switch SW3. The SET position of SW4 is used only in conjunction with SW3 when SW3 is in the SWR position. At that time, the REF (reflected) meter "Set" index is used to calibrate the meter for SWR readings.

When switch SW4 is in the FWD (out) position, the FWD meter is again enabled to indicate forward power, while SW3, in the SWR position, indicates the amount of standing wave apparent at the point the Wattmeter is inserted in the transmission line. When SW3 is at the REF (out) position, the power reflected through the transmission line from the antenna, dummy load, etc., is indicated on the REF meter in watts.

When switch SW4 is in the FWD position, the signals coupled from SW1 are routed to PEP-AVG switch SW2. If SW2 is set to the AVG (out) position, signals are direct-coupled to the FWD and REF meters. When SW2 is set to the PEP (in) position, the incoming signals are then routed to the meters through the PEP circuits, consisting mainly of four-section integrated circuit U1 with its associated components.

PEP CIRCUITS

The PEP circuits consist of two sections. The first is a peak detector with gain, and the second is a unity-gain buffer network with an offset adjustment.

The forward signal is coupled from switch SW1, through SW4 in the FWD position, through resistor R23 and the contacts of SW2 in the PEP position, and then into the PEP circuit. Resistors R9 and R4 form a 6 dB voltage divider while they maintain the equivalent resistance of meter M2 on the remote sensor. This preserves the calibration of the sensor. Amplifier IC U1C acts as a peak detector when combined with diode D2. There is a minimum voltage gain of 1.5 which is adjustable. This adjustment allows the gain to be varied so it will duplicate the voltage normally present at meter M1 in the AVG mode across capacitor C6 (with some small offset due to the effect from the operational amplifier).

The following stage is a unity-gain buffer into which an offset voltage has been summed from resistor R17. This permits any small voltages induced by the amplifiers to be balanced out. The result is an exact replica of the voltage from the remote sensor to appear at U1D pin 14, with one exception. The peak detector will catch and hold the peaks. Hence, on a CW signal the PEP reading is the same, but on vocal tones, there will be a great difference in readings. The time constant for the peak reading is a product of capacitor C6 and resistors R11 and R5. If a longer or shorter time constant is desired, the value of capacitor C6 may be changed. Use a good quality, low-leakage capacitor.

The output from the PEP circuit at IC U1D is routed to the FWD meter through switch SW2 and contacts 1, 2, and 3 of switch SW5.

POWER SUPPLY

The power for the Wattmeter is taken directly from either a 9-volt NEDA Type 1604 battery or from the Heathkit Converter Model GRA-43-1. When only the 9-volt battery is connected to the switch circuit board, the closed contacts of accessory jack J1 connect the positive and negative battery

voltages to the circuits of integrated circuit U1. If the Converter is plugged into jack J1, power is taken only from the Converter Charger, the battery, if installed, is disconnected from the circuit. NOTE: The Converter will **not** charge the battery in your Wattmeter even if you use a rechargeable battery. The Wattmeter may be powered at all times with the Converter; however, if you wish to operate the instrument away from an AC source, you must use a battery.

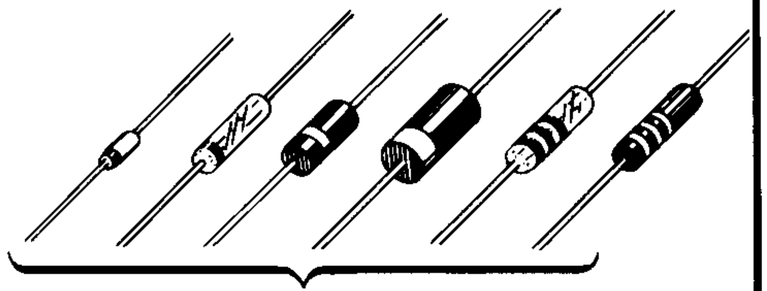
When the front panel Sensitivity control is rotated fully counterclockwise until the control clicks, the battery (or Converter) power, through contacts in the PEP-AVG switch (which must be in the AVG position), may be observed on the BATT portion of the FWD meter. NOTE: If you have turned the Sensitivity control to check the battery condition, be sure to once again "Set" the REF meter to measure SWR.

IMPORTANT: Always return the PEP-AVG switch to the AVG (out) position when your Meter is not in use; this disconnects the battery from the circuit.

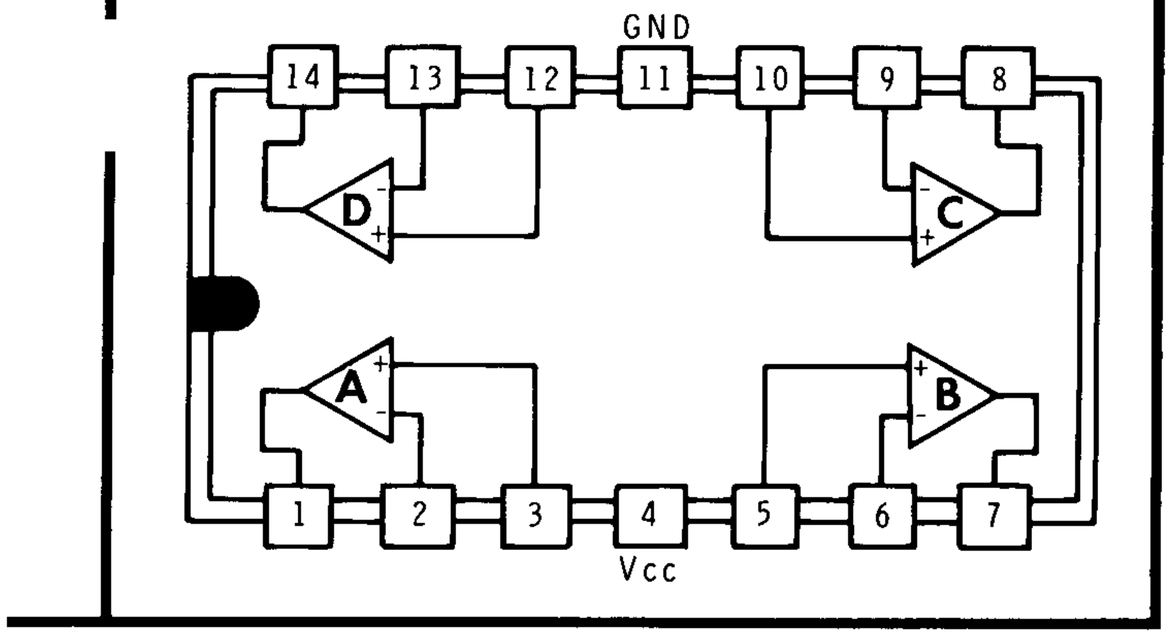
SEMICONDUCTOR CHART

COMPONENT	HEATH PART NO.	MANUFACTURER'S NUMBER	IDENTIFICATION
D1, D2	56-56	1N4149	
D101, D102	56-20	1N295	

IMPORTANT: THE BANDED END OF DIODES CAN BE MARKED IN A NUMBER OF WAYS.



BANDED END

COMPONENT	HEATH PART NO.	MANUFACTURER'S NUMBER	IDENTIFICATION
U1	442-602	LM324N	

SWITCH CIRCUIT BOARD

M1 REF

M2 FWD

C1 .001

C2 .001

BLK A B RED

BLK E

SW5 BATT 4 2,3 1

RED D C RED

R6 56K

R2 560

C3 .001

U1A -4.12

D1 56-56

R7 10K

C5 100 µF

R3 20K PEP REF CAL.

R8 560

R12 47K.

R13 20K REF NULL

R15 330K

C7 .001

U1B +4.14 -4.1

C9 .01

R22 1000

R19 15K

R18 1000

R16 47K

C17 .015

R23 49.2K 1%

GRN J

FWD (OUT) SET (IN) NC.

R1 250K SENSITIVITY

SW4

K BRN

REF (OUT) SWR (IN) N.C.

SW3

R24 16.5K 1%

C18 .02

R9 560

R4 560

C4 .001

U1C -4.1

D2 56-56

R11 10K

R5 20K PEP FWD CAL.

C6 100 µF

R14 20K FWD NULL

R17 330K

C8 .001

U1D

R21 15K

GRN J

HIGH (OUT)

C12 .01

SW1

BRN K

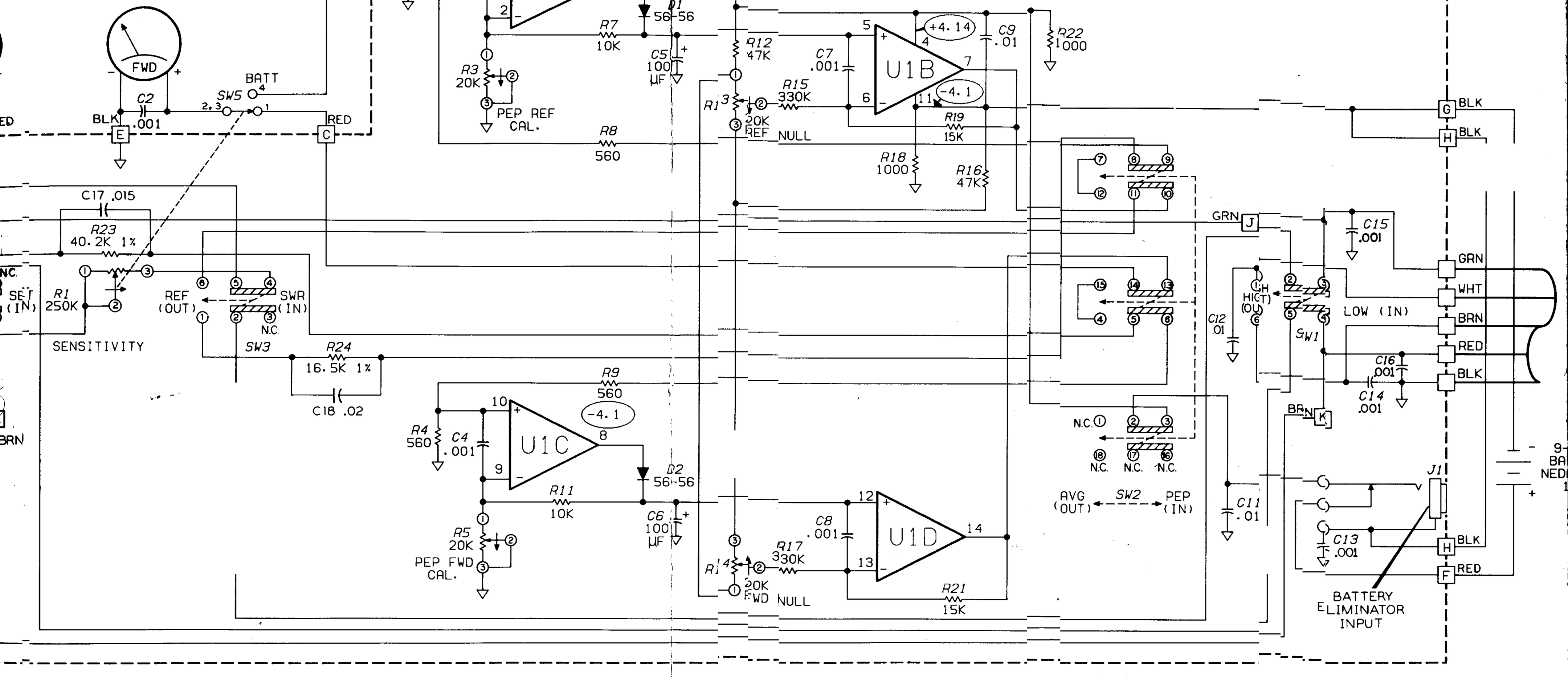
N.C. N.C. N.C. N.C.

AVG (OUT) SW2 PEP (IN)

C11 .01

SCHEMATIC OF THE HEATHKIT® HF DUAL WATTMETER MODEL HM-2140

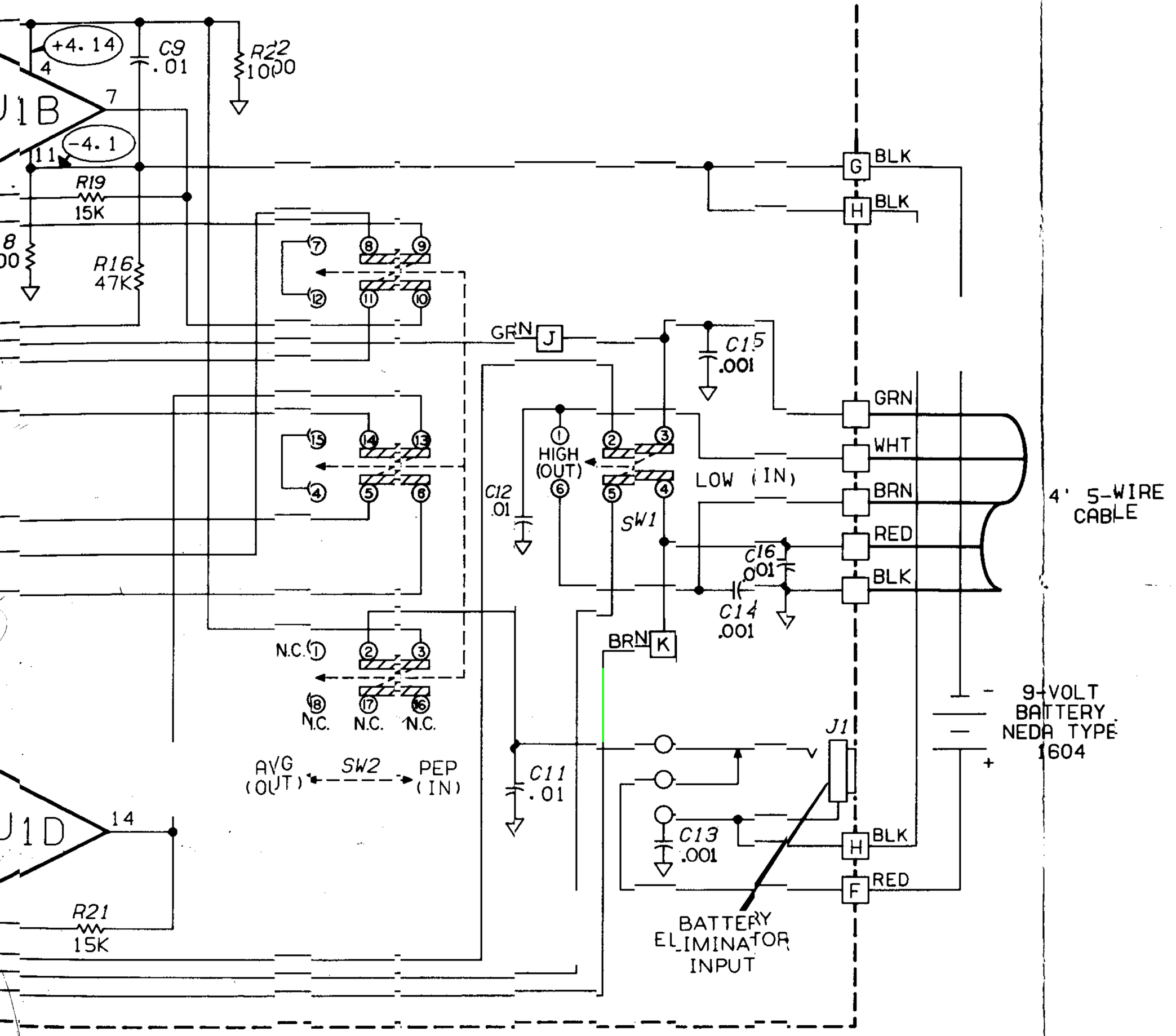
4. ⏚ THIS SYMBOL INDICATES A CHASSIS GROUND.



SCHEMATIC OF THE HEATHKIT® HF DUAL WATTMETER MODEL HM-2140

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS (Ω): (K = 1000).
2. ALL RESISTORS ARE 1/4-WATT, 5% TOLERANCE UNLESS OTHERWISE NOTED.
3. CAPACITOR VALUES LESS THAN 1 ARE IN µF (MICROFARADS). VALUES OF 1 OR GREATER ARE IN pF (PICOFARADS) UNLESS OTHERWISE MARKED.
4. ⏚ THIS SYMBOL INDICATES A CHASSIS GROUND.
5. ▽ THIS SYMBOL INDICATES A CIRCUIT BOARD GROUND.
6. □ THIS SYMBOL INDICATES A CIRCUIT BOARD WIRE CONNECTION.
7. THIS SYMBOL INDICATES THE CLOCKWISE ROTATION OF A CONTROL.
8. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE MEASURED FROM THE POINT INDICATED TO CIRCUIT BOARD GROUND.



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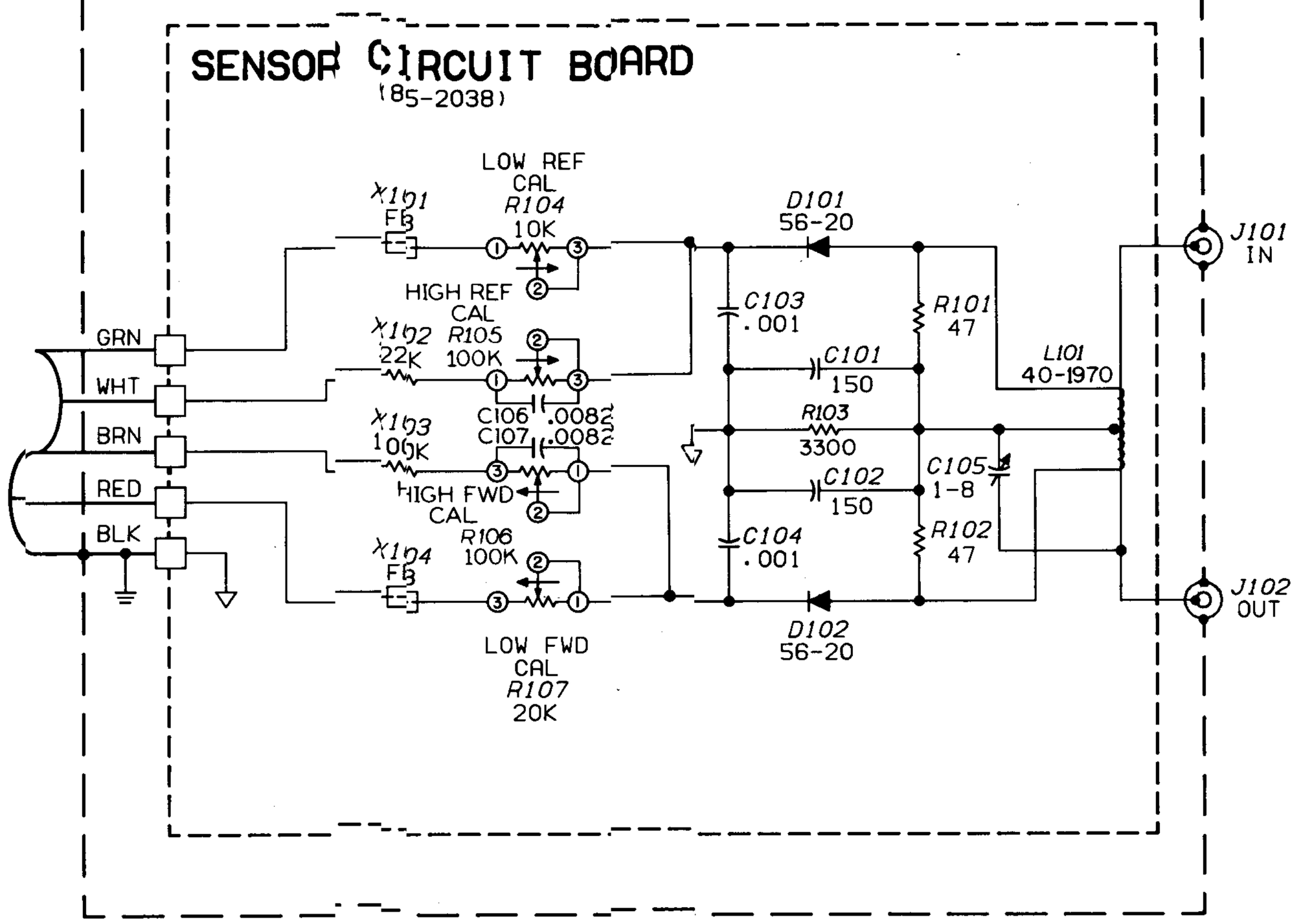

Part of 595-2056-02