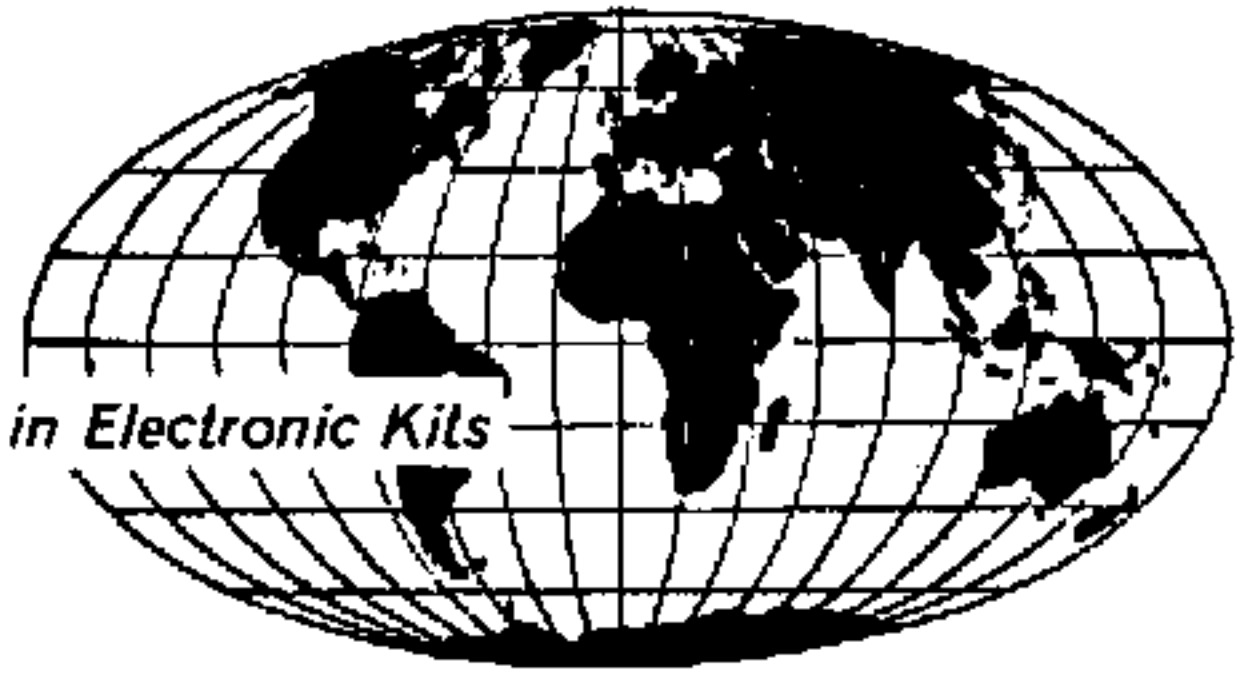


# specifications

FOR THE



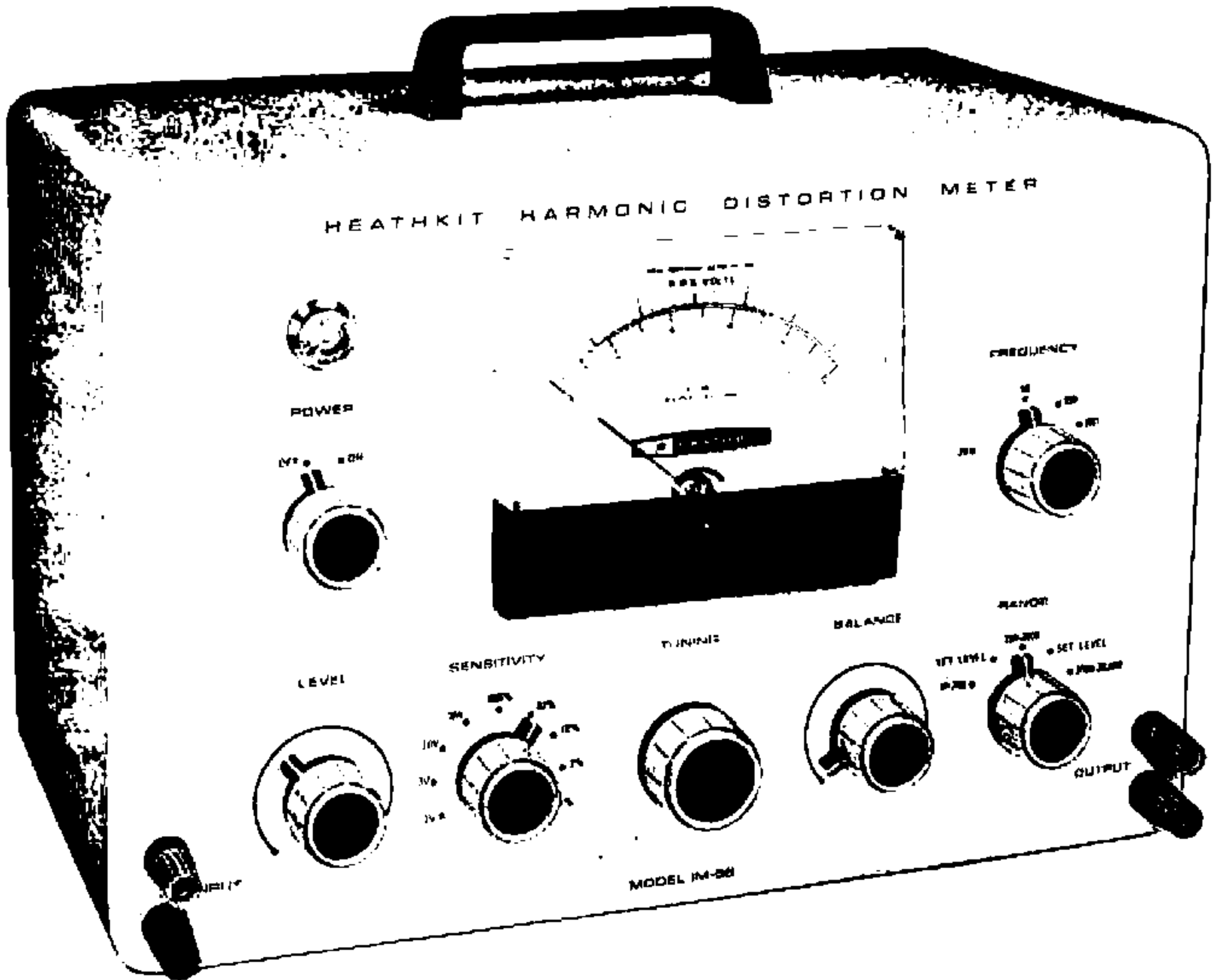
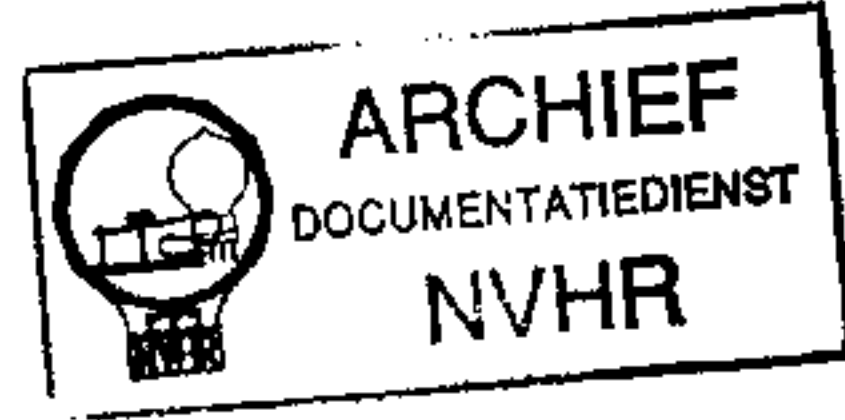
Pioneer And World-Leader in Electronic Kits



## HARMONIC DISTORTION METER

MODEL IM-58

Ned. Ver. v. Historie v/d Radio



All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time.

**HEATH COMPANY**  
BENTON HARBOR,  
MICHIGAN

# SPECIFICATIONS

Frequency. . . . .	20 cycles to 20,000 cycles in three ranges
Distortion. . . . .	0-1, -3, -10, -30, -100% full scale
Voltmeter. . . . .	0 - 1 - 3 - 10 - 30 volts full scale
Input Resistance. . . . .	300 K $\Omega$
Minimum Input Voltage for Distortion Measurement. . . . .	0.3 volts
Output Voltage for Monitoring. . . . .	2.5 volts at full-scale meter reading
Accuracy:	
Voltmeter. . . . .	$\pm 5\%$ of full scale
Distortion. . . . .	$\pm 5\%$ of full scale, +0.1%
Tube Complement. . . . .	0A2, 6X4, 5879, 12AT7, 12AX7, 12BY7
Power Requirements. . . . .	105-125 or 210-250 volts, 50/60 cycles, 30 watts
Dimensions. . . . .	13" wide x 8-1/2" high x 7" deep
Net Weight. . . . .	11 lbs

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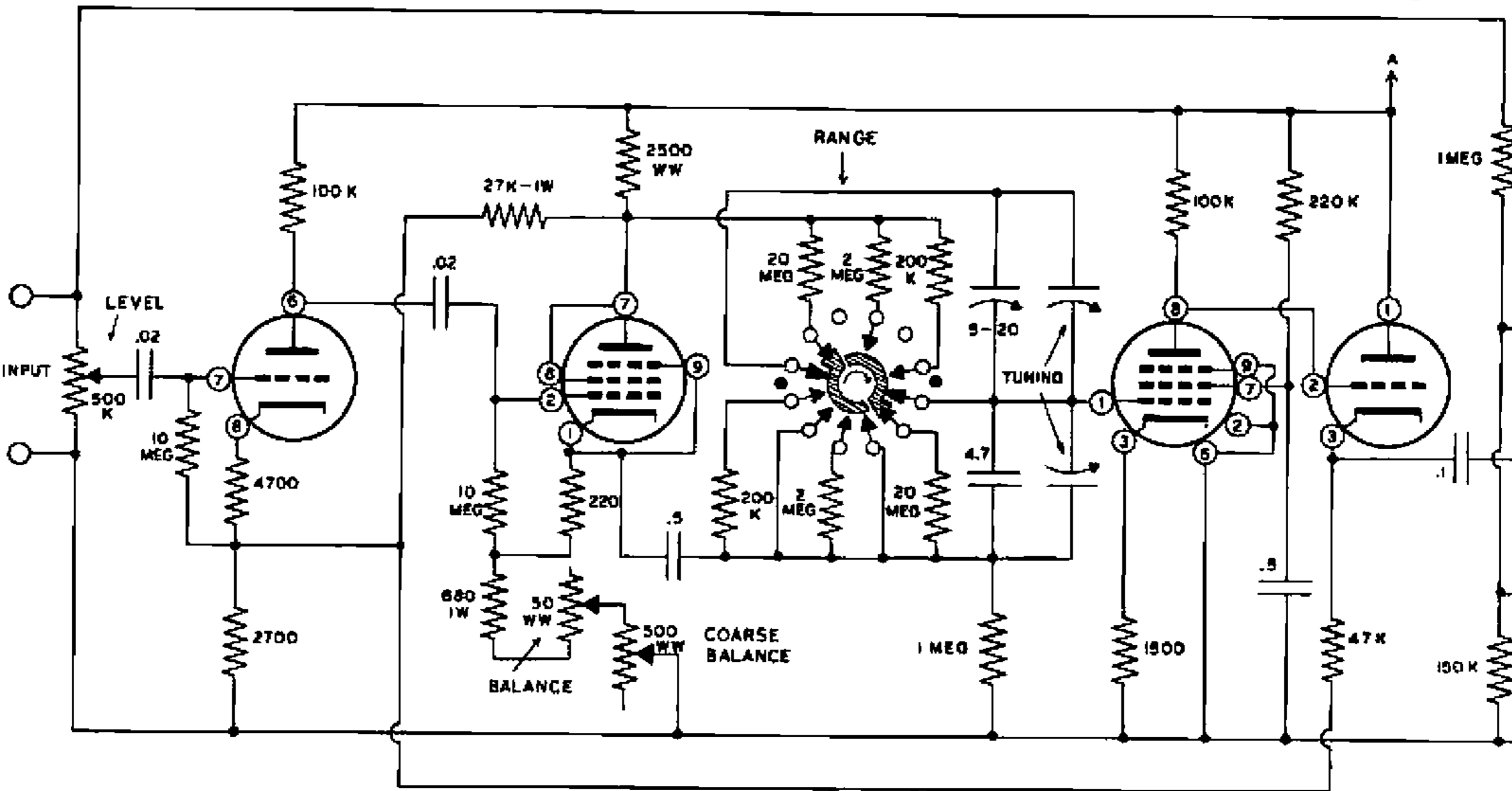
The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

1/2 12AX7

12BY7

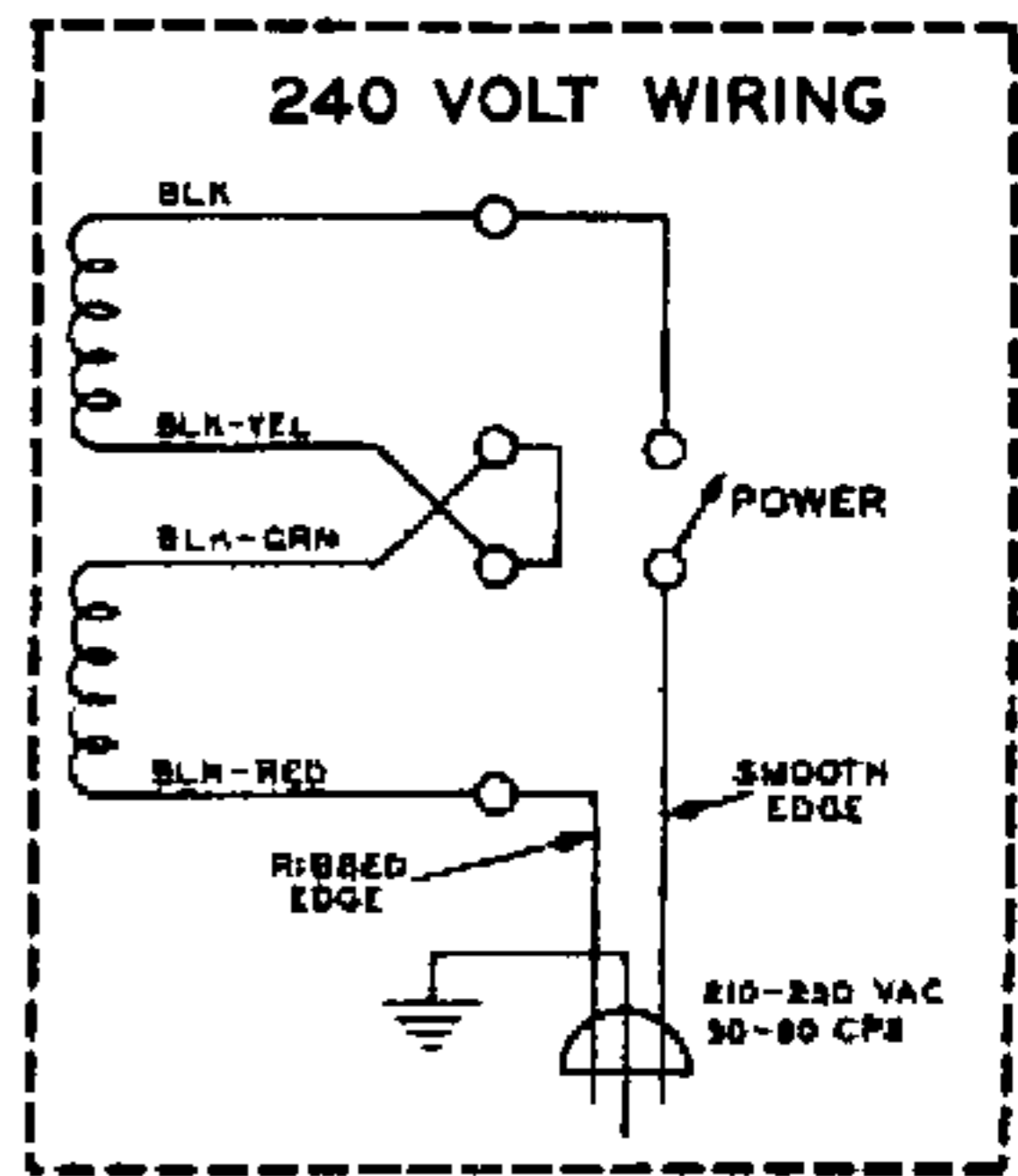
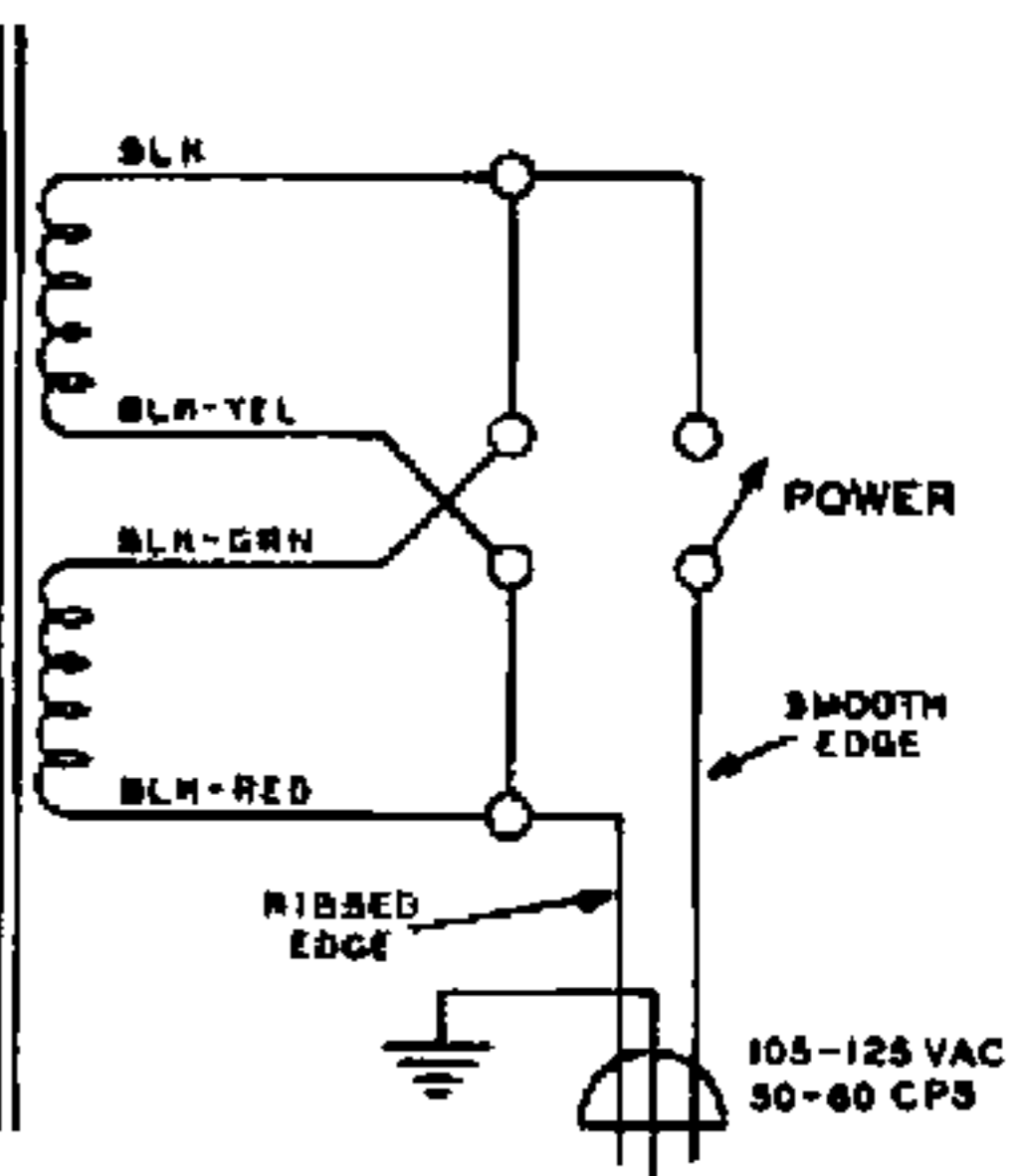
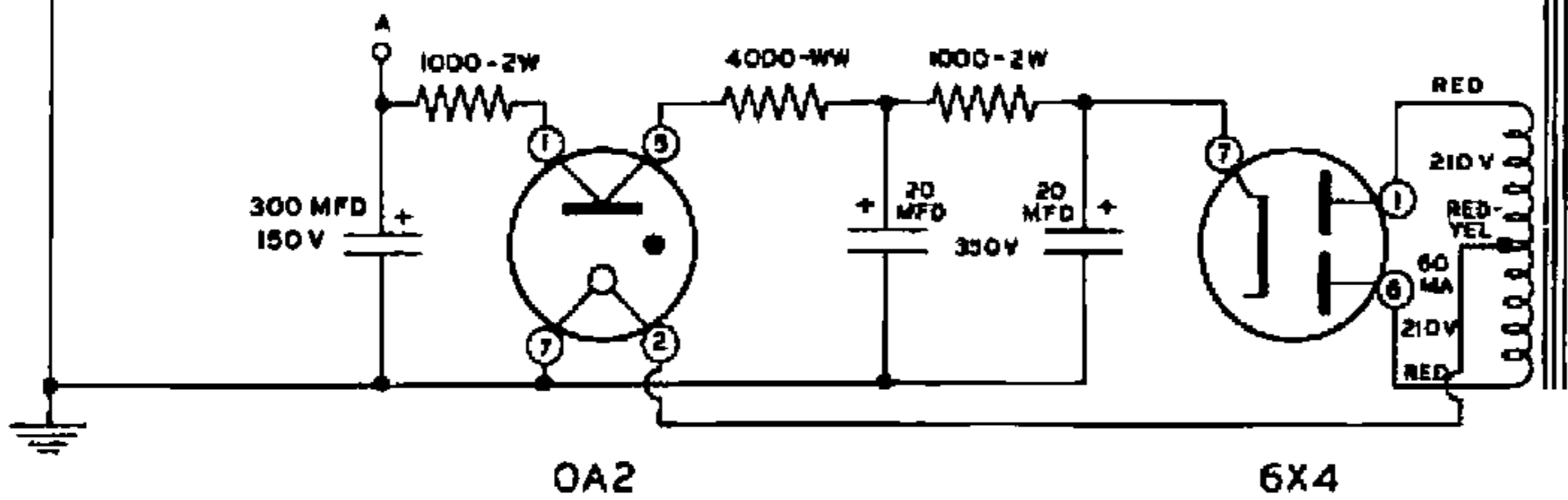
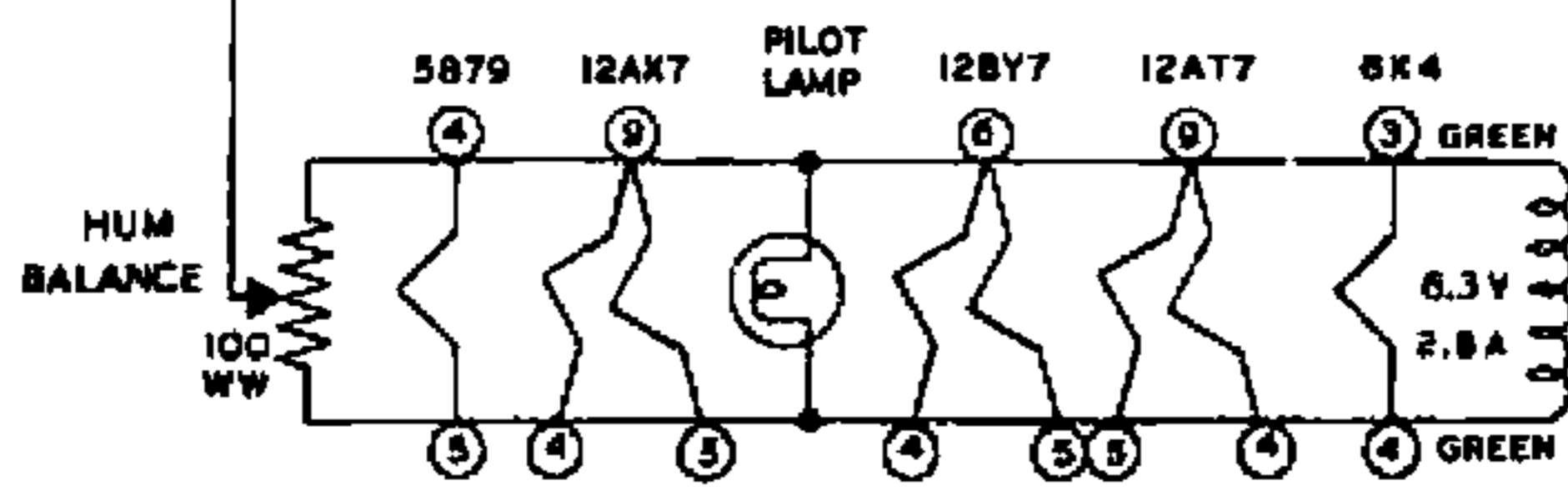
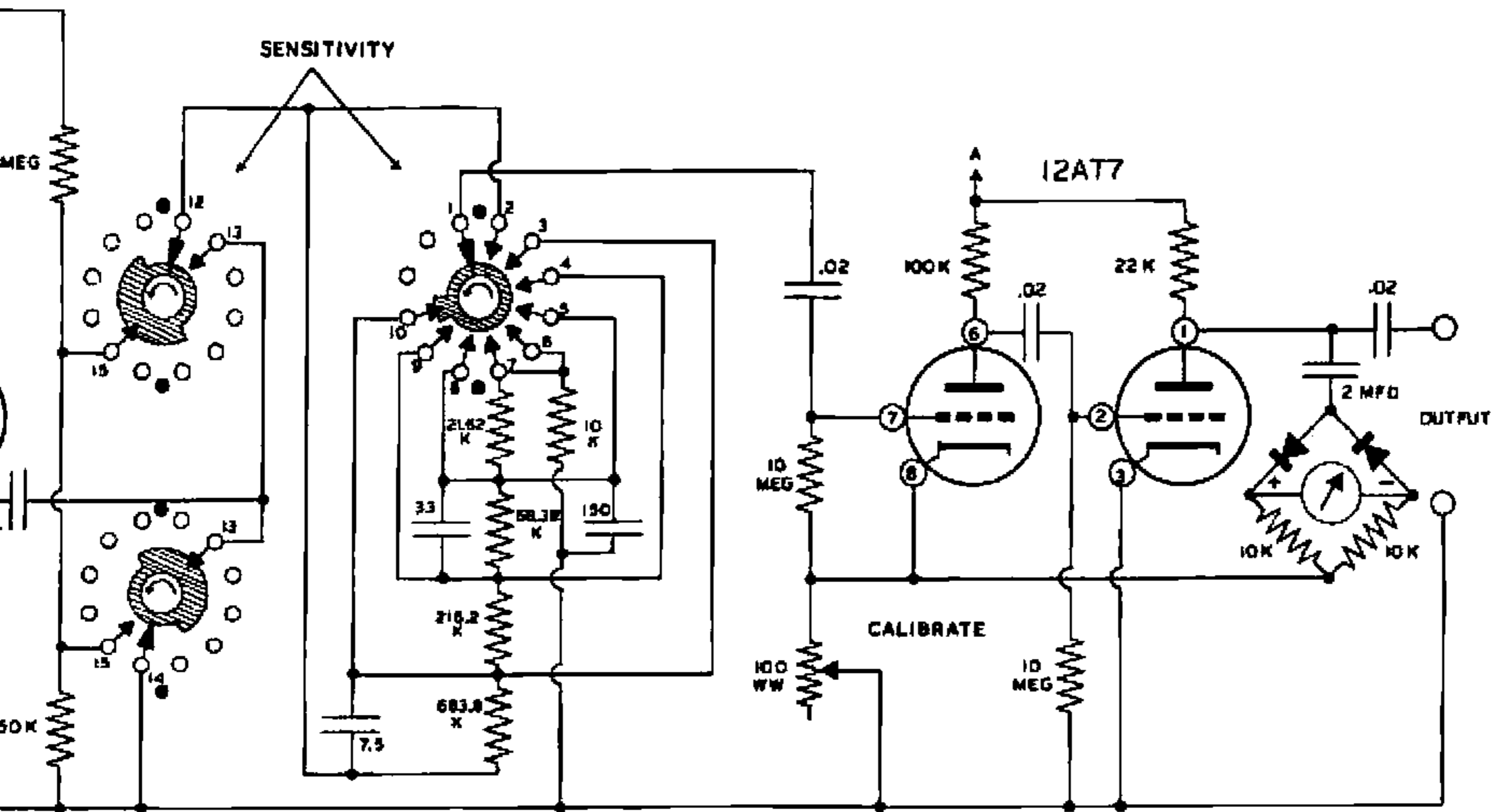
5879

1/2 12AX7



ALL SWITCHES SHOWN IN COUNTER CLOCKWISE POSITION  
 FRACTIONAL CAPACITIES ARE IN MFD.  
 OTHER CAPACITIES ARE IN MMF, UNLESS NOTED  
 K=1000  
 MEG.= 1000,000  
 WW = WIREWOUND

**SCHEMATIC OF THE  
 HEATHKIT®  
 HARMONIC DISTORTION METER  
 MODEL IM-58**





## TESTS AND CALIBRATION

Set the voltmeter calibration control H (nearest the meter) and the coarse balance control G (by the power switch) at approximately the middle position of their rotation. Set the hum balancing control F fully counterclockwise. Set the RANGE switch to SET LEVEL position. Set the SENSITIVITY switch to 100%. Set the level control fully counterclockwise. Connect the line cord to the proper voltage outlet. **DO NOT PLUG INTO A DC OUTLET.** Like all transformer operated devices, this instrument will not operate on DC and the transformer will be damaged if connected to a DC source.

Turn the power switch on and see if the pilot light and tube heaters light up. The OA2 should show a faint purple glow inside the tube elements after about 30 seconds.

### VOLTMETER CALIBRATION

Set the sensitivity switch to 30 volts. Connect a piece of wire between the "hot" input binding post and touch it to one of the pilot light terminals. Try both terminals and use the one that gives an indication on the meter. Set the sensitivity switch to 10 volts. Observe that the meter reading increases. Adjust the voltmeter calibration control to show a 6.3 volt reading on the 0-10 volt scale. NOTE: If a standard meter of known accuracy is available, it may be used to provide a more exact calibration.

### BALANCE ADJUSTMENT

Connect the output from an audio generator to the input terminals of the instrument. Set the sensitivity switch to 100%. Set the range switch to one of the SET LEVEL positions. Set the audio generator to 2000 cycles with at least 0.5 volt output. Advance the level control to give a full scale meter reading. Turn the range switch to the 2000-20,000 position. Set the balance control at the middle position of its rotation. (1) Turn the tuning control for a minimum meter indication. (2) Adjust the coarse balance control with a screwdriver for minimum indication. Repeat these two steps until no further improvement is obtained.

NOTE: It may be necessary to turn the sensitivity switch to lower percentage values to show the minimum more clearly.

With the sensitivity switch at 100%, turn the range switch to 200-2000. (1) Turn the tuning control for a minimum meter indication. (2) Adjust the trimmer condenser (through the hole in the top shield) with an insulated screwdriver (alignment tool) for a minimum indication. Repeat these two steps until no further improvement is obtained.

NOTE: It may be necessary to turn the sensitivity switch to lower percentage values to show the minimum more clearly.

Now double check the setting of the coarse balance control by returning to the 2000-20,000 range as before. Finally, recheck the setting of the trimmer condenser by going back to the 200-2000 range again.

If the frequency pointer is more than 10 degrees off, readjust it by using a frequency of known accuracy. Connect this signal to the input terminals and obtain a null as before. Then loosen the setscrew of the insulated coupling (Figure 10, Page 13) and adjust the knob pointer to indicate the correct frequency. Make sure the insulated coupling does not turn. Retighten the setscrew before continuing.

### HUM BALANCE ADJUSTMENT

Install the instrument in its case with two #6 sheet metal screws through the rear of the cabinet. With no connections made to the input terminal, set the range switch to 20-200, the tuning control to show about 60 on the frequency dial and the sensitivity switch to 1%. Turn the hum balancing control with a screwdriver to give a minimum indication on the meter.

This minimum reading may be expected to fall around 1/10 of full scale and usually depends on the 5879 tube heater to cathode leakage. Readings above 1/10 full scale may drop below that value after a few hours of continuous operation.

This completes the test and calibration. The instrument is ready for use.

## IN CASE OF DIFFICULTY

If any difficulty is experienced during test and calibration, proceed as follows:

1. Read the circuit description to understand the principles of operation.
2. Recheck the specific instructions for the test and calibration procedure.
3. Check the operating voltages against the voltage chart. Any large discrepancies may give a clue to the source of the difficulty and further investigation in the particular part of the circuit, both visually and with a volt-

meter, may reveal improper construction or faulty components.

4. Frequently much time may be saved by having a friend check the wiring with you. Surprisingly often a simple mistake becomes invisible to the constructor but is clearly evident to another, even unskilled, person.

**NOTE:** In an extreme case where you are unable to resolve a difficulty, refer to the Service and Warranty sections of the "Kit Builders Guide", and to the "Factory Repair Service" information on Page 28 of this Manual.

### TABLE OF TYPICAL SOCKET VOLTAGES

TUBE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
5879	0	0	1.7	H	H	0	60	33	0
12AX7	125	33	34	H		103	5.5	12.5	H
12BY7	9	2	/	H		H	96	96	9
12AT7	85	-0.7	0	H		56	-0.6	0	H
OA2	145	0	/	/	145	/	0		
6X4	220 AC	/	H	H	/	220 AC	260		

Heater voltage between pins H is 6-7 volts AC. All DC voltages measured between pin and chassis using a VTVM with 11 megohm input resistance.

## CIRCUIT DESCRIPTION

The Heathkit Harmonic Distortion Meter indicates the remains of the signal under test, after the fundamental frequency is eliminated, as a percentage of the signal under test. The "indicated remains" include all frequencies in the audio range including hum, noise and harmonics from the generator, from the equipment under test and from the instrument itself.

Generally the remains are predominantly the harmonics (multiples of the fundamental test frequency) produced by the equipment under test. The hum, noise and distortion in the instrument are generally less than 0.1%

The circuit may be considered to have three parts: (a) The fundamental-suppression circuit, (b) The voltmeter circuit, (c) The power supply.

### FUNDAMENTAL-SUPPRESSION CIRCUIT

This section consists of a triode voltage amplifier (1/2 12AX7) driving a type of phase splitter using a triode connected pentode (12BY7). The phase splitter feeds the Wien Bridge null network to suppress the fundamental test frequency. The signal voltages that do not cancel in the null network are amplified by a pentode voltage amplifier (5879), which is directly coupled to a triode (1/2 12AX7) connected as a cathode follower.

The Wien Bridge requires two signal voltages of opposite phase at a 2:1 voltage ratio to produce a null. The plate and cathode signal voltages of the phase splitter are of opposite phase. The voltages are approximately 2:1 because of the values of the plate load and cathode load resistors.

The frequency determining elements of the Wien Bridge are the resistance-capacity series arm and the resistance-capacity parallel arm. The resistances are equal, as are the capacities. Minor variations within the tolerance of the precision resistors and variations due to mistracking of the two-gang tuning condenser are compensated by the balance control, which varies the 2:1 voltage ratio a small amount.

The natural response of a Wien Bridge null network is too broad for this instrument, for at twice the null frequency (where the second harmonic

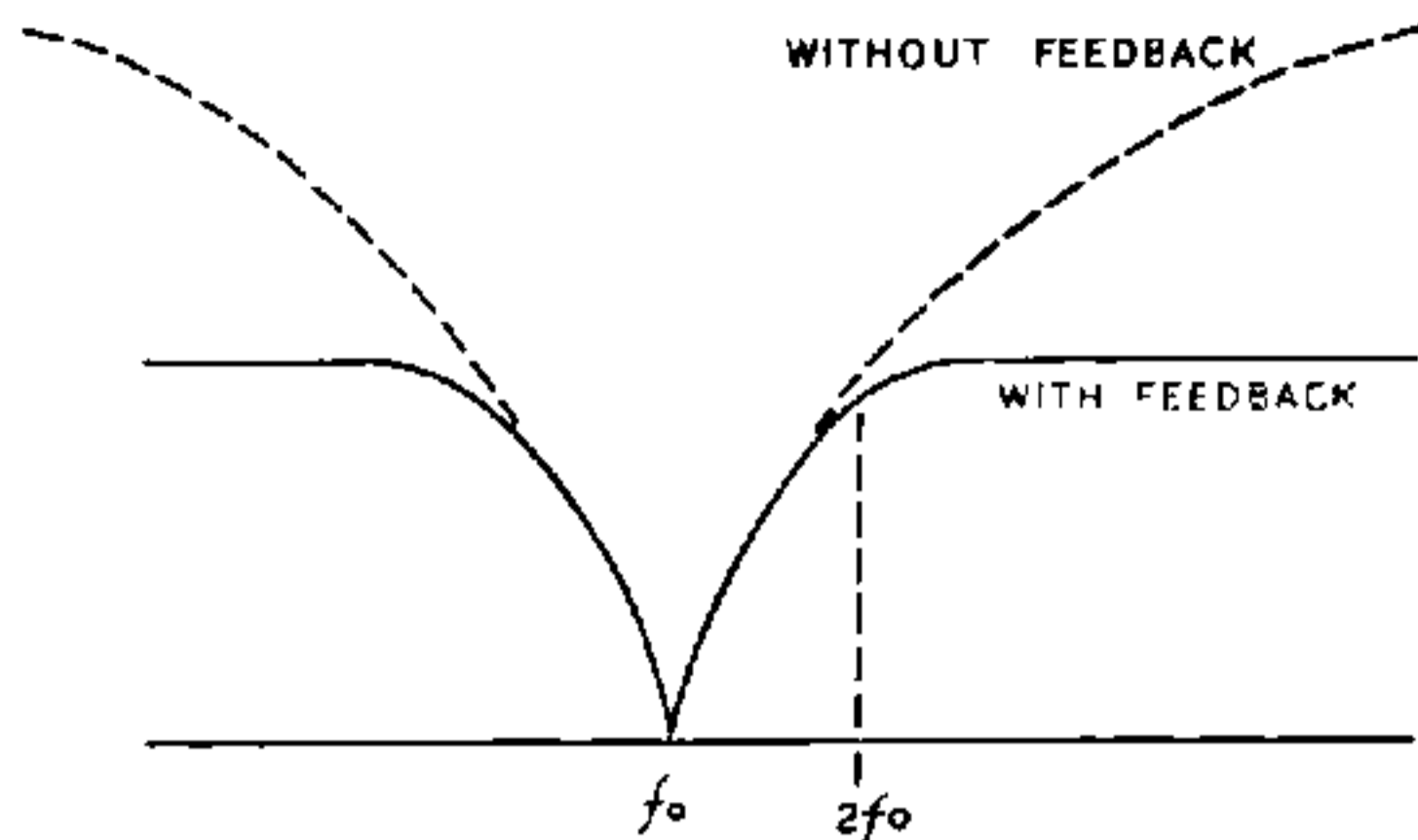


Figure 16

appears) the response is still considerably attenuated. Through use of negative feedback around the bridge, from the 1/2 12AX7 cathode follower to the input 1/2 12AX7 cathode, the bridge response is altered to a sharp notch at the null frequency with nearly flat response above twice the null frequency and below half the null frequency.

The range switch selects the resistance values in the Wien Bridge frequency determining arms. The two intermediate switch positions open one arm and short out the other arm. This permits the 12BY7 tube to function as a cathode follower only and drive the 5879 grid directly. Then this section acts as a normal amplifier having the same gain and frequency response but without the Wien Bridge null in the response characteristic.

In operation, the entire input signal is fed through this section to the voltmeter circuit. The operating level of this section is adjusted with the input level control to give a full scale reading on the meter.

Then the Wien Bridge is switched into the circuit and adjusted for elimination of the fundamental and the remaining voltage is read on the meter as distortion in percentage of full scale.

The physical construction of the Wien Bridge, such as the "hot" tuning condenser frame and the high impedance above chassis ground level (20 megohms on the 20-200 cycle range), tend to make the instrument subject to hum pickup. This inherent sensitivity is substantially reduced by

the feedback loop around the bridge. But during operation at or near line frequency, the null network opens the feedback loop and the hum reduction is thus ineffective. Therefore, shielding the tuning condenser, shielding the range switch, insulating the condenser shaft, balanced filament wiring and a wired ground circuit are used to reduce the residual hum level in the instrument.

## VOLTMETER CIRCUIT

This section consists of a two-stage amplifier, using a 12AT7 twin triode, driving a crystal diode half-bridge. Good linearity and frequency response are obtained by negative feedback from the half bridge to the input cathode. The calibration control permits adjustment of the feedback to give the desired sensitivity. The output voltage of this two-stage amplifier is also available at the output terminals, so the wave shapes of the voltages read on the meter may be visually monitored with an oscilloscope.

The input to the voltmeter is determined by the sensitivity switch which selects the fraction of

the voltage desired as well as the source. Full counterclockwise rotation connects the voltmeter to the input binding posts for observation of the signal level. Clockwise rotation reduces the meter reading in steps of 10 db.

In the fifth position, the voltmeter is connected to the cathode follower output of the Fundamental Suppression circuit. Clockwise rotation increases the meter reading in steps of 10 db. The frequency response at the various positions of the sensitivity switch are compensated with fixed condensers. At low sensitivity position, such compensation is not required.

## POWER SUPPLY

The power supply is transformer operated. It provides the filament current for all the tube heaters and the pilot light, as well as highly filtered, voltage regulated plate supply voltage for the instrument. A 6X4 rectifier and an OA2 regulator are used.

## APPLICATIONS

This instrument is used primarily in conjunction with audio frequency sine wave generators to determine the distortion characteristics of audio amplifiers and components used in audio amplifiers.

The distortion of a particular device under test generally varies with output level. Often other factors, such as test frequency, gain control setting and loading of the output may seriously affect the distortion readings obtained.

While frequently a single distortion figure is quoted for a specific test frequency, at a rated output level with a standard dummy load, operating at nominal line voltage, this rarely gives an

adequate picture to the design or test engineer, who is concerned with the capabilities under less favorable but realistic conditions. Thus not only a single distortion figure but families of distortion curves are desirable for proper evaluation of equipment under test.

The versatility of the Heathkit Harmonic Distortion Meter makes it possible to obtain adequate data for such curves conveniently and rapidly.

**NOTE:** Be sure that you only connect to one channel at a time when making measurements on stereo amplifiers. Also, if there is a speaker reversal switch, be sure it is in the "Normal" position.

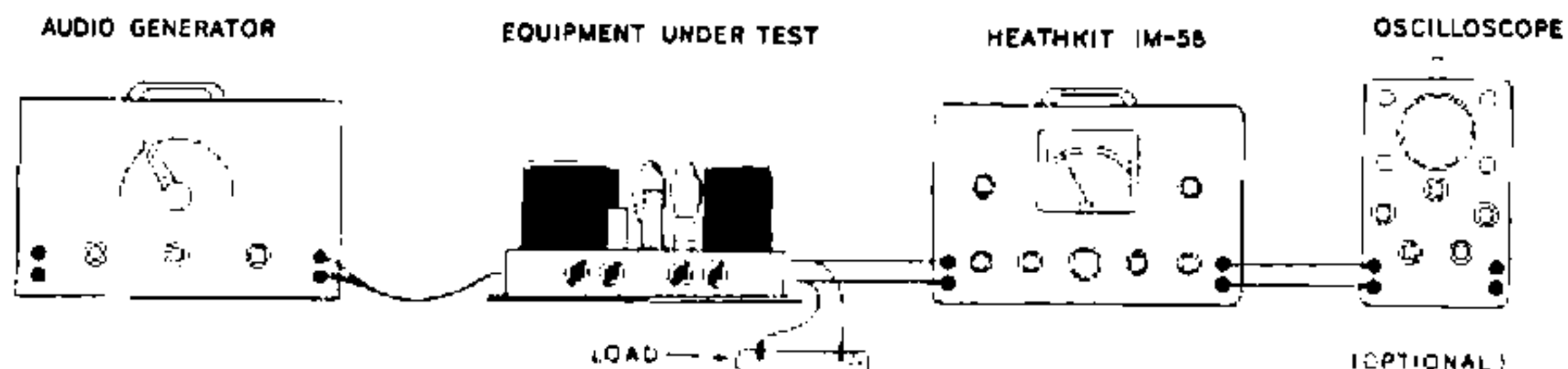


Figure 17



## EXAMPLE OF TEST PROCEDURE

Connect an audio generator with sine wave output to the input of the equipment under test. Connect the Harmonic Distortion Meter across the output load of this equipment. Set the range switch to SET LEVEL position. Set the sensitivity switch to 100%. Adjust the level control for full scale indication on the 0-10 scale.

Reset the range switch to the range appropriate for the generator frequency. Adjust the tuning control for a minimum reading. Adjust the balance control for a minimum reading. Reset the sensitivity switch clockwise to provide a more readable indication. Readjust tuning and balance controls for a minimum reading. Read the total harmonic distortion on the meter and sensitivity switch.

Rotate the sensitivity switch counterclockwise to a voltage position that gives a suitable meter reading to note the input level to the distortion meter. This voltage reading may be used to calculate the output power level of the equipment under test or the reading on the db scale may be used for comparative purposes.

While the majority of measurements will be made on complete amplifiers, often effective use may be made of this instrument to check portions of amplifiers during the development. The effect of changed operating voltages or circuit constants is readily observed and thus optimum operating conditions may be established. This instrument lends itself also to other applications such as measuring the distortion in receivers and transmission lines. With a high quality microphone and amplifier connected to the instrument, the distortion introduced by a speaker may be determined.

**CAUTION:** The circuit ground and the case of this instrument are both connected to the power line ground through the green wire of the line cord. Always connect the ground test lead of this device to the chassis, or ground, of the circuit being tested or measured.

When making harmonic distortion measurements, do not use any accessory instruments that have an earth ground connection (3-wire power plug). Such an earth ground connection can cause

ground loop currents that will make your distortion readings invalid. This applies particularly to solid state amplifiers, and all amplifiers that have current feedback through the speaker to the "common" output terminal.

With the range switch in the SET LEVEL position, the bridge amplifier may be used as a preamplifier for the voltmeter. The level control may be used to select a usable sensitivity. A simple way to set the level control for a convenient high value of sensitivity is as follows:

Connect a generator to the input of the instrument. Using the 1 volt scale, adjust the generator output to 0.3 volts. Switch to 100% and adjust level control for full scale. The instrument will now read:

0.3 volts full scale on 100% setting  
 0.1 volts full scale on 30% setting  
 0.03 volts full scale on 10% setting  
 0.01 volts full scale on 3% setting  
 0.003 volts full scale on 1% setting

If the signal source has an impedance of 600 ohms, the 0 db marks correspond to:

-10 dbm at 100%  
 -20 dbm at 30%  
 -30 dbm at 10%  
 -40 dbm at 3%  
 -50 dbm at 1%

The -10 db mark at the 1% scale corresponds to -60 dbm.

Noise levels are frequently expressed as a number of db below a certain output level. Thus an amplifier with a nominal output of 5.4 volts would read -3 db on the red scale, using the 10 volt position. Turning off the generator, the output level would drop. Assuming the level control on the instrument was adjusted as previously described, turning sensitivity switch to 100% makes the range 30 db less.

If a usable reading is found on the 3% scale of +1 db for instance, the noise level is then  $-3 + 60 - 1 = 56$  db. In this measurement, noise level is purely a ratio of signal voltage to noise voltage and is expressed as db, not dbm, and a statement of reference level is generally desirable: noise level 56 db below 3.6 watts (5.4 volts across 8 ohms).



## ACCURACY

**VOLTMETER:** The full scale accuracy of the voltmeter depends primarily on the exactness of the voltage divider resistors, which are within 1%, and the accuracy of calibration. The accuracy of meter indications of less than full scale is affected by linearity of the crystal diode bridge, the amplifiers and the meter. The overall accuracy should fall well within 5% of FULL SCALE.

**DISTORTION:** The accuracy of the distortion measurement depends primarily on the completeness of the null and the residual noise, distortion and hum generated within the instrument. The overall accuracy should fall well within 5% of FULL SCALE + 0.1% distortion.

The accuracy of the distortion measurement is independent of the accuracy of the calibration of the voltmeter, because the same meter sensitivity is used in the SET LEVEL position.

## REPLACEMENT PARTS PRICE LIST

To order parts, use the Parts Order Form furnished with this kit. If a Parts Order Form is

not available, refer to Replacement Parts in the Kit Builders Guide.

<u>PART No.</u>	<u>PRICE Each</u>	<u>DESCRIPTION</u>
<b>RESISTORS</b>		
1-45	.10	220 $\Omega$
1-11	.10	1500 $\Omega$
1-13	.10	2700 $\Omega$
1-16	.10	4700 $\Omega$
1-20	.10	10 K $\Omega$
1-22	.10	22 K $\Omega$
1-25	.10	47 K $\Omega$
1-26	.10	100 K $\Omega$
1-27	.10	150 K $\Omega$
1-29	.10	220 K $\Omega$
1-35	.10	1 megohm
1-40	.10	10 megohm
1-21-1	.10	680 $\Omega$ 1 watt
1-46-1	.10	27 K $\Omega$ 1 watt
1-15-2	.15	1000 $\Omega$ 2 watt
2-50	.20	10 K $\Omega$ precision
2-39	.20	21.62 K $\Omega$ precision
2-40	.20	68.38 K $\Omega$ precision
2-42	.20	216.2 K $\Omega$ precision
2-45	.20	683.8 K $\Omega$ precision
2-54	.20	200 K $\Omega$ precision
2-55	.25	2 megohm precision
2-26-1	1.20	20 megohm precision
3-1-5	.15	2500 $\Omega$ 5 watt
3-8-7	.15	4000 $\Omega$ 7 watt

<u>PART No.</u>	<u>PRICE Each</u>	<u>DESCRIPTION</u>
<b>CONDENSERS</b>		
21-29	.15	4.7 $\mu\text{mf}$ ceramic tubular
20-52	.35	7.5 $\mu\text{mf}$ mica
21-7	.10	33 $\mu\text{mf}$ ceramic disc
21-11	.10	150 $\mu\text{mf}$ ceramic disc
21-31	.10	.02 $\mu\text{fd}$ ceramic disc
23-28	.20	.1 $\mu\text{fd}$ paper tubular
23-56	.40	.5 $\mu\text{fd}$ paper tubular
23-17	1.40	2 $\mu\text{fd}$ metalite
25-30	1.00	20-20 $\mu\text{fd}$ 350 v. electrolytic
25-38	1.50	300 $\mu\text{fd}$ 150 v. electrolytic
26-9	2.20	Dual 420 $\mu\text{mf}$ tuning
31-6	1.20	5-20 $\mu\text{mf}$ trimmer

## CONTROLS-SWITCHES

10-255	.80	500 K $\Omega$ audio control
11-17	.70	100 $\Omega$ wire-wound control
11-102	1.25	50 $\Omega$ wire-wound control
11-22	1.00	500 $\Omega$ wire-wound control
63-506	2.25	5-position switch RANGE
63-507	2.40	9-position switch
<b>SENSITIVITY</b>		
63-505	1.30	On-off switch

April 17, 1973

**IMPORTANT NOTICE**

Please make the following changes in your Manual before you start to assemble your Harmonic Distortion Meter.

Page 4 – Left column, under "Wire-Sleaving,"

Add: 346-29 1 Sleaving, clear

– Under "Terminal Strips,"

Delete: 431-11 1 5-lug terminal strip

Change: 431-55 1 6-lug terminal strip

To: 431-45 2 6-lug terminal strip

– Right column, under "Miscellaneous,"

Add: 421-17 1 Fuse 3/4 A

Add: 390-362 1 Fuse label

Page 5 – Right column. Change the first line to read:

( ) Install two 1-lug, one 2-lug and one 6-lug . .

Page 15 – Right column. Change the first two sentences of the eighth step to read:

( ) Form two 11" wires into a twisted pair. Push these wires through the grommet, and connect one wire to lug 1 (NS) and the other wire to lug 6 (S) on terminal strip A.

Cut the portions from Page 2 of this notice and tape them over the corresponding areas in your Manual.

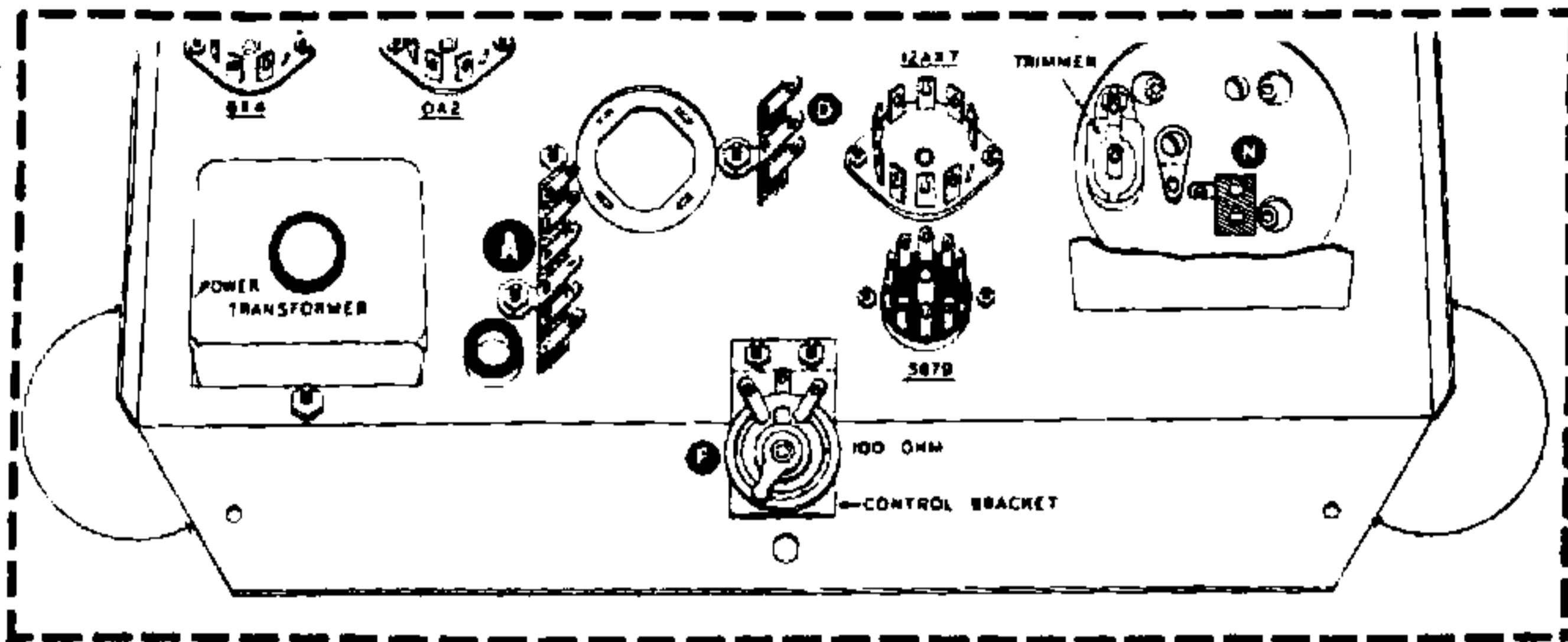
Similarly, tape the new Page 7 and 16, and the new Pictorial 2 (for the fold-out from Page 21) over the corresponding Pages in your Manual.

Thank you,

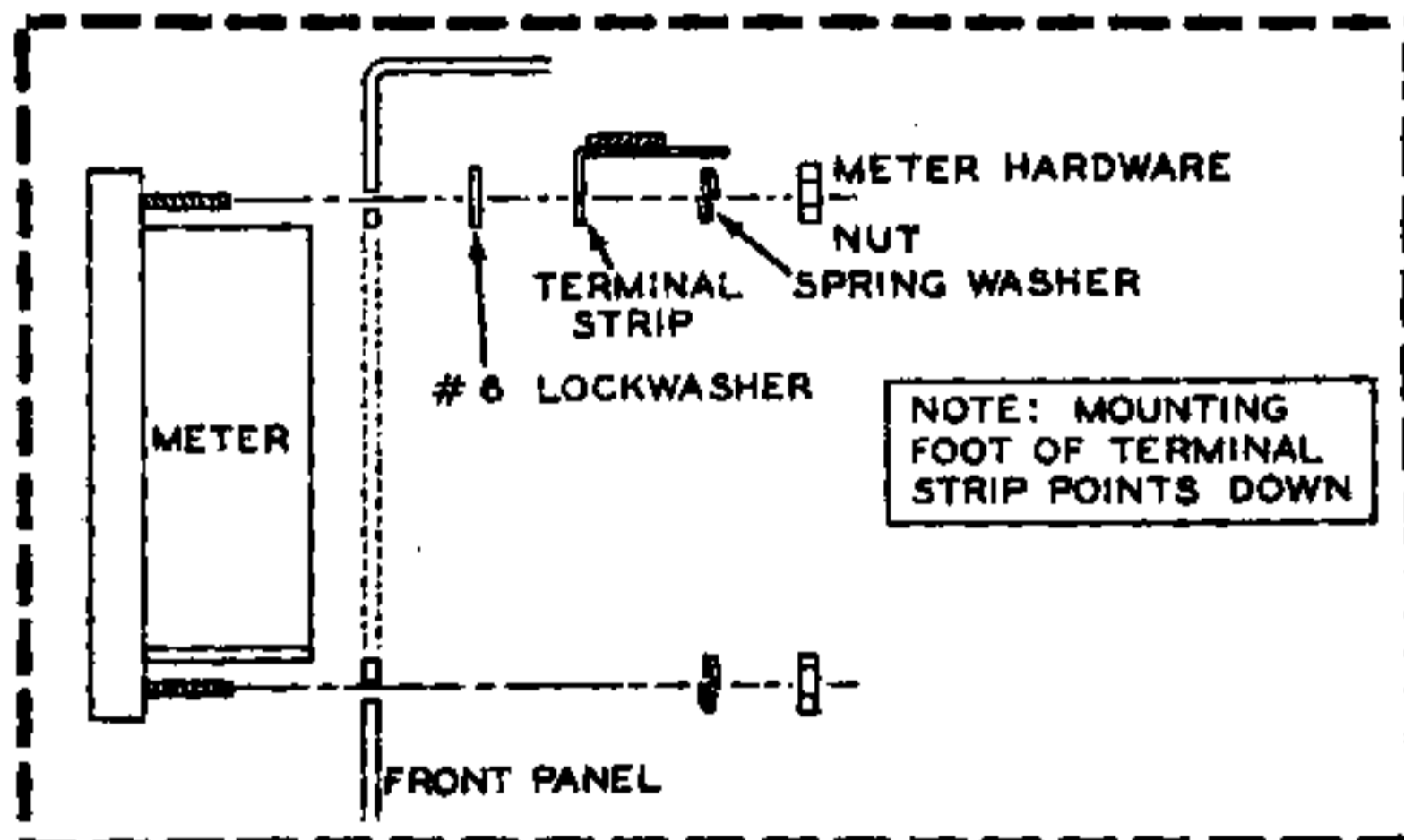
HEATH COMPANY

CUT OFF the outer dotted line. . .

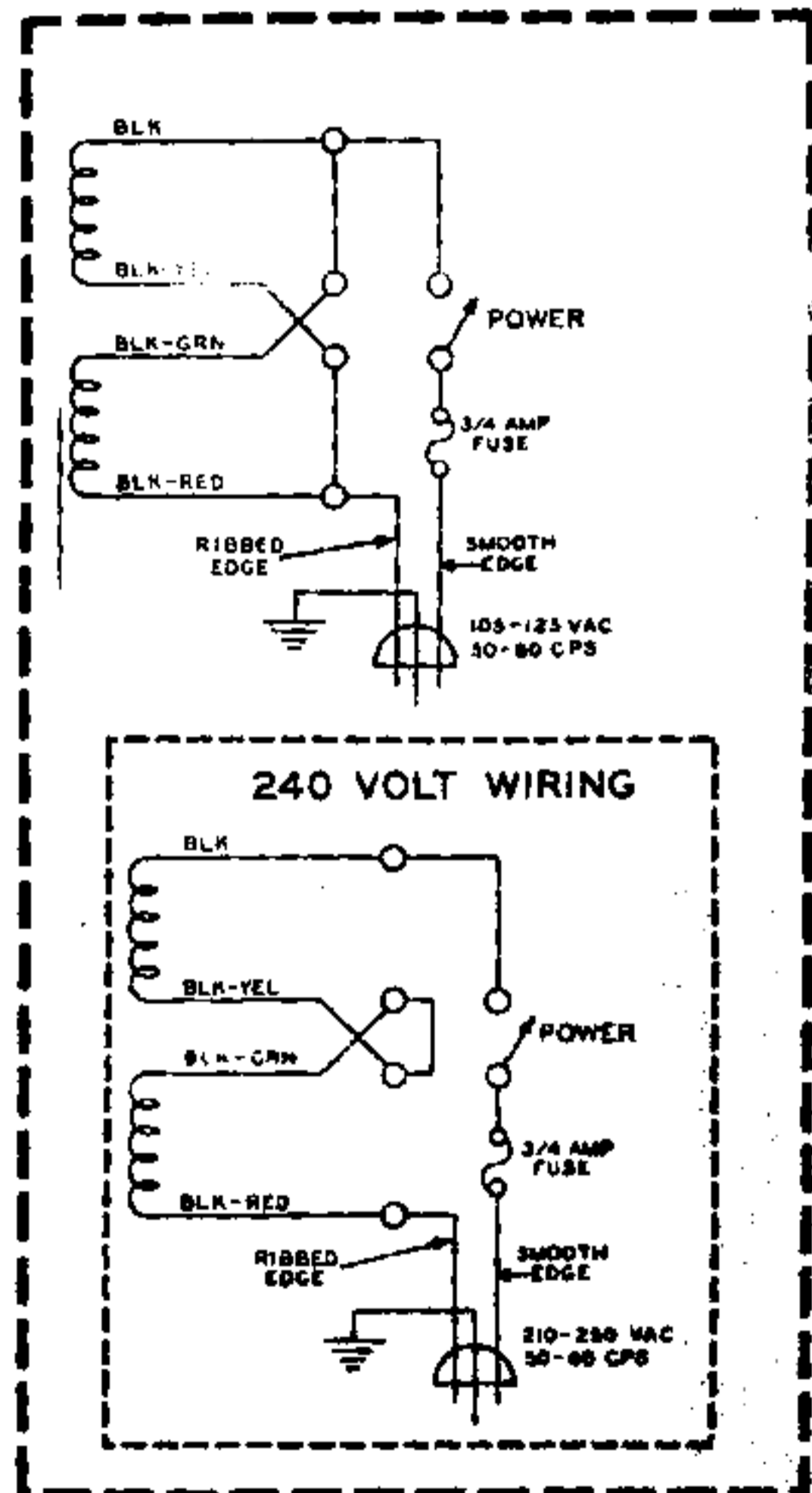
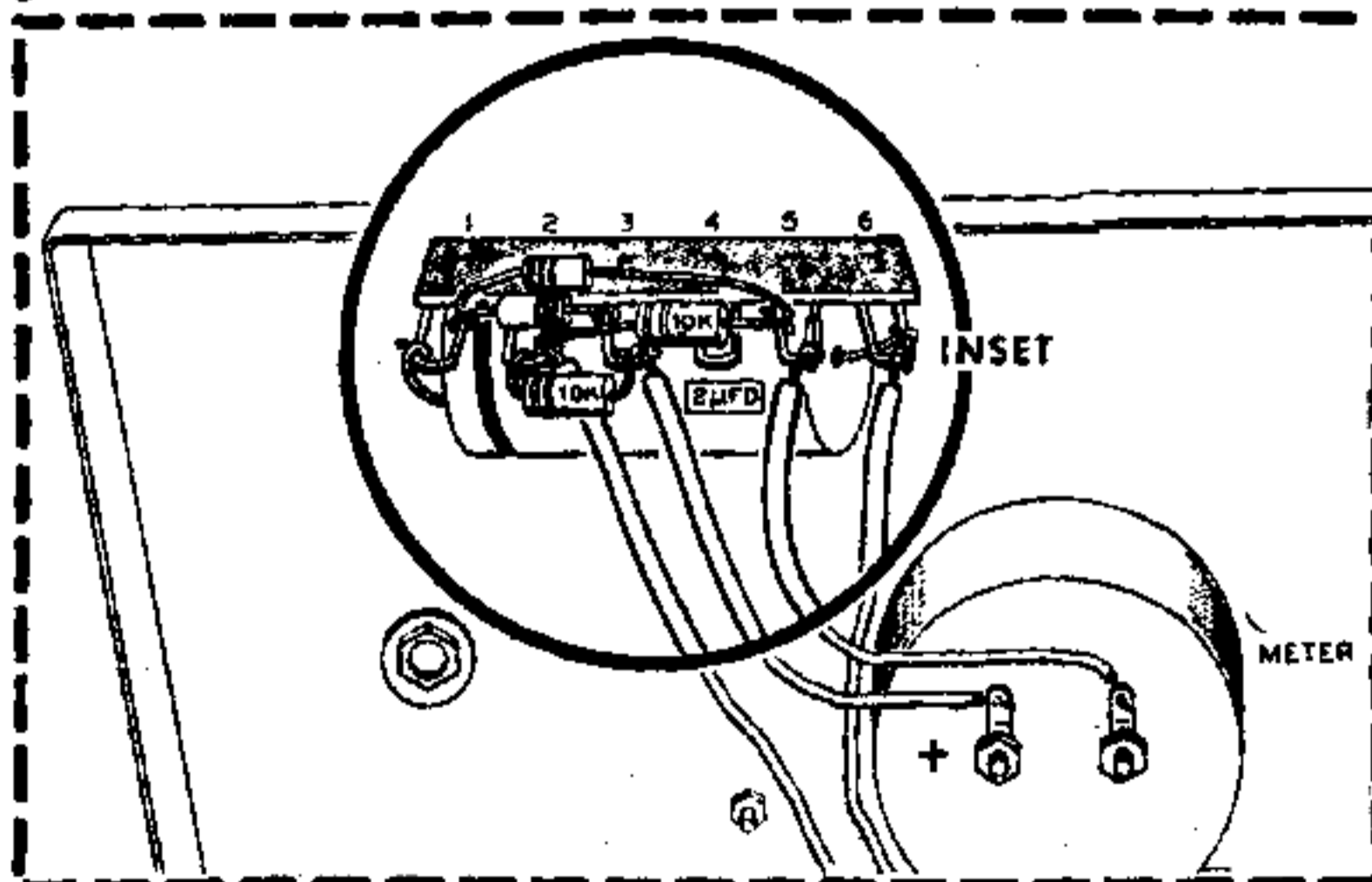
FOR PICTORIAL 1  
FOLD-OUT FROM  
PAGE 4.



REPLACES  
FIGURE 8  
on PAGE 10.



FOR TOP,  
LEFT-HAND  
CORNER OF  
PICTORIAL 3  
ON PAGE 11.



FOR BOTTOM RIGHT-HAND CORNER  
OF SCHEMATIC, FOLD-OUT FROM PAGE 22.



