HEWLETT PACKARD

COMPANY

OPERATING AND SERVICING MANUAL

MANUAL CHANGES

MODEL 434A

CALORIMETRIC POWER METER

Serial 251 and above:

(See attached schematic diagram of 434A Calibrator)

C33: Add capacitor, fixed, paper, .01uf ±20%, 400 vdcw; -hp- Stock No. 16-109, Mfr., CC

CR21: Change to diode, silicon; -hp- Stock No. G-29A-25, Mfr., HP

CR22: Add diode, silicon; -hp- Stock No. G-172J, Mfr, HP

Q5: Add transistor, 2N169A; -hp- Stock No. 213-34, Mfr., HP

R200: Change to resistor, fixed, composition, 18,000 ohms ±10%, 2 W; -hp- Stock No. 25-18K, Mfr., B

R201: Change to resistor, fixed, deposited carbon, 9,380 ohms ±1%, ½ W; -hp- Stock No. 33-9.38K, Mfr., NN

R202: Change to resistor, fixed, deposited carbon, 2,900 ohms ±1%, ½ W; -hp- Stock No. 33-2.9K, Mfr., NN

R203: Change to resistor, fixed, deposited carbon, 2,510 ohms ±1%, ½ W; -hp- Stock No. 33-2.51KR, Mfr., NN

R204: Change to resistor, fixed, deposited carbon, 1,800 ohms ±1%, ½ W; -hp- Stock No. 33-1.8K, Mfr., NN

R205: Delete

R208: Delete

R209: Change to resistor, fixed, deposited carbon, 3,300 ohms ±10%, ½ W; -hp- Stock No. 23-3.3K, Mfr., B

R210: Add resistor, fixed, composition, 18,000 ohms ±10%, 2 W; -hp- Stock No. 25-18K, Mfr., B

R211: Add resistor, fixed, composition, 2,400 ohms ±5%, ½ W; -hp- Stock No. 23-2.4K-5, Mfr., B

R212: Add resistor, fixed, deposited carbon, 20,000 ohms ±1%, ½ W; -hp- Stock No. 33-20K, Mfr., NN Optimum value selected at factory. Average value shown.

R213: Add resistor, fixed, composition, 15,000 ohms ±10%, ½ W; -hp- Stock No. 23-15K, Mfr., B

R214: Add resistor, fixed, deposited carbon, 540 ohms ±1%, ½ W; -hp- Stock No. 33-540, Mfr., NN

R215: Add resistor, fixed, deposited carbon, 3,000 ohms ±1%, ½ W; -hp- Stock No. 33-3K, Mfr., NN

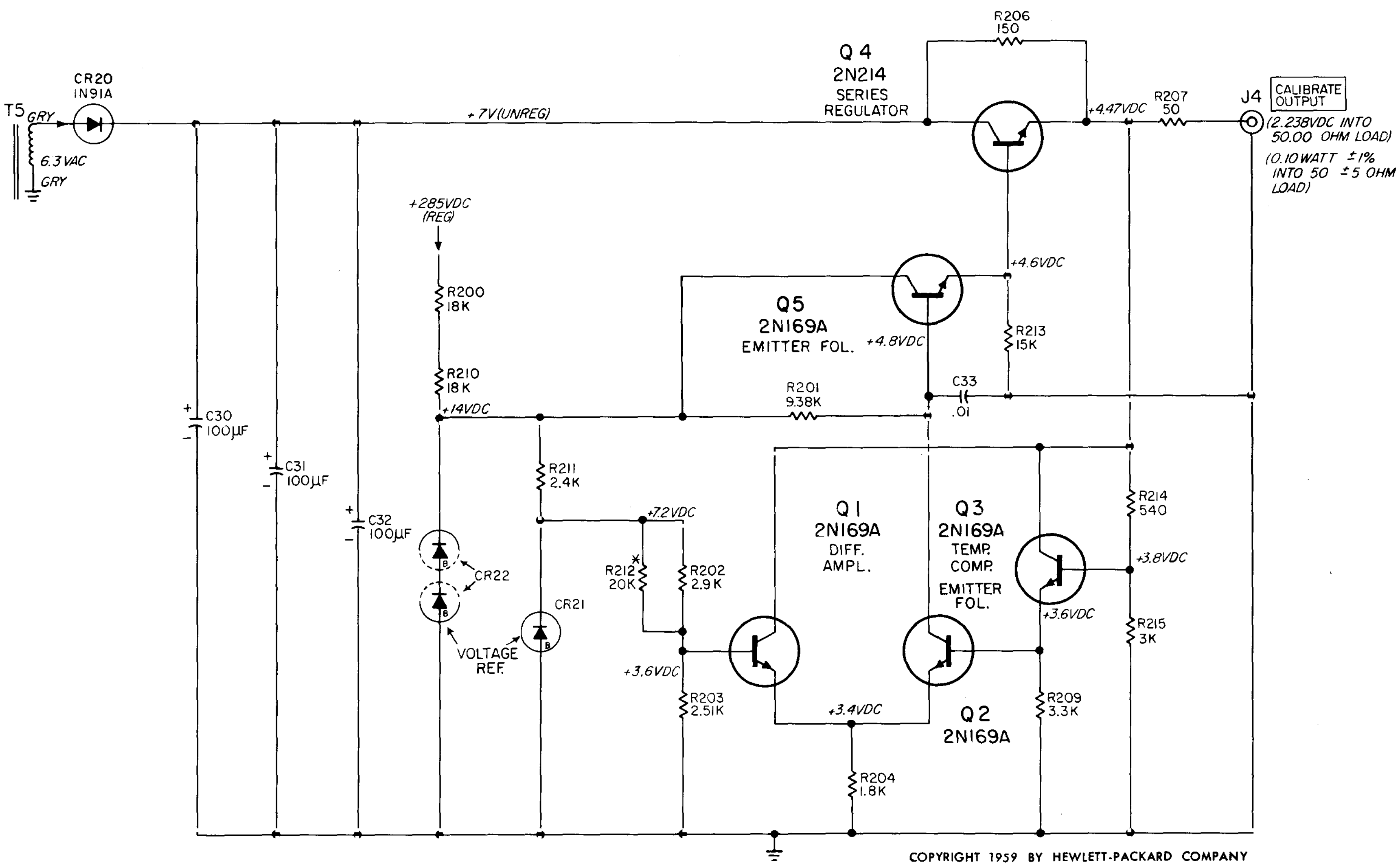
R41: Change to resistor, fixed, composition, 68,000 ohms ±10%, ½ W; -hp- Stock No. 23-68K, Mfr., B

R42: Change to resistor, fixed, composition, 150,000 ohms ±10%, ½ W; -hp- Stock No. 23-150K, Mfr., B

R91: Add resistor, fixed, composition, 15,000 ohms ±10%, ½ W; -hp- Stock No. 23-15K, Mfr., B (connected between R42 and ground)

C11: Should be connected between pin 6 of V3 and ground.

CR6 thru CR9: Change to diode, crystal; -hp- Stock No. 212-G11A, Mfr., HP

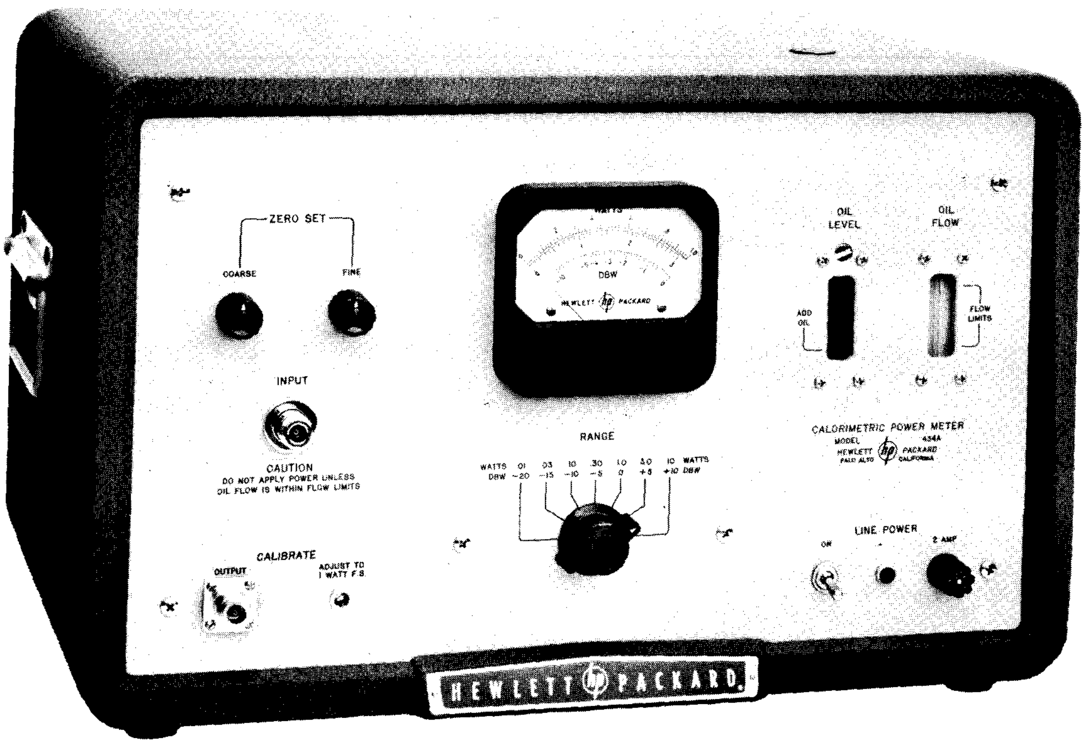

T5
GRY
6.3 VAC
GRY
CR20
IN91A
+7V(UNREG)
Q4
2N214
SERIES
REGULATOR
R206
150
+4.47VDC
R207
50
J4
CALIBRATE
OUTPUT
(2.238VDC INTO
50.00 OHM LOAD)
(0.10 WATT ±1%
INTO 50 ±5 OHM
LOAD)
C30
100µF
C31
100µF
C32
100µF
+285VDC
(REG)
R200
18K
R210
18K
+14VDC
Q5
2N169A
EMITTER FOL.
+4.8VDC
+4.6VDC
R213
15K
C33
.01
R201
9.38K
R211
2.4K
+7.2VDC
R212
20K
R202
2.9K
+3.6VDC
R203
2.51K
CR22
VOLTAGE
REF.
CR21
Q1
2N169A
DIFF.
AMPL.
+3.4VDC
R204
1.8K
Q3
2N169A
TEMP.
COMP.
EMITTER
FOL.
Q2
2N169A
+3.6VDC
R209
3.3K
R214
540
+3.8VDC
R215
3K

 434A - CAL. - 251

OPERATING AND SERVICING MANUAL

MODEL 434A
CALORIMETRIC POWER METER

SERIAL 151 AND ABOVE



275 PAGE MILL ROAD, PALC ALTO, CALIFORNIA, U.S.A.

434A001-1/9-59

CONTENTS

SECTION I
GENERAL DESCRIPTION

1-1 INTRODUCTION

Model 434A is a power meter which bridges the gap between bolometric methods and conventional calorimetric methods while retaining the advantages of both. Bolometric methods of power measurement using the self-balancing principle are fast, but the upper limit of power measurement is quite low (10 to 100 mw). On the other hand, conventional calorimetric methods are slow, and are not suitable at powers less than about 1 watt.

By combining the self-balancing principle with a calorimetric device, fast response has been obtained over the range from 1 milliwatt to 10 watts.

1-2 SPECIFICATIONS

INPUT POWER RANGE:
Seven meter ranges. Full-scale readings of .01, .03, .1, .3, 1.0, 3.0 and 10 watts. Meter scale also calibrated from -10 to 0 DBW, providing continuous readings from -30 to +10 DBW. Power range can be extended upward with attenuators or directional couplers.

PEAK INPUT POWER: 1 kilowatt, maximum.

FREQUENCY RANGE: DC to 12.4 kmc.

DC INPUT IMPEDANCE:
50 ohms ±5 ohms at type N input jack.

INPUT SWR:

DC to 5 kmc:	less than 1.3:1
5 to 10 kmc:	less than 1.5:1
10 to 12.4 kmc:	less than 1.7:1

METER RESPONSE TIME:
Less than 5 seconds for full scale deflection.

ACCURACY:
Within ±5% of full scale. Includes dc calibration and rf loss. Greater accuracy can be achieved through appropriate techniques.

ESTIMATED ATTAINABLE ACCURACY:

	Upper Ranges	Two Lowest Ranges
DC	1/2%	2%
0 to 1 kmc	" 1%	" 3%
1 to 4 kmc	" 2%	" 4%
4 to 10 kmc	" 3%	" 5%
10 to 12.4 kmc	" 4%	" 5%

POWER SUPPLY:
115/230 volts ±10%, 50/60 cycles, approximately 155 watts with no input, 175 watts with 10 watts input.

DIMENSIONS:

Cabinet Mount:	20-3/4" wide, 12-3/4" high, 14" deep.
Rack Mount:	19" wide, 10-1/2" high, 13-3/8" deep behind panel.

WEIGHT:

Cabinet Mount:	Net 49 lbs, Shipping 71 lbs.
Rack Mount:	Net 44 lbs, Shipping 66 lbs.

1-3 DAMAGE IN TRANSIT

This instrument has been thoroughly tested and is ready for use when received. If any damage is apparent, please refer to the Warranty sheet.

1-4 INSTALLATION

To connect for operation from 230 volts, 50-60 cps, see paragraph 4-4.

Before using this instrument, check the oil level. Add silicone oil as described in paragraph 2-4. Also, since inverting the instrument may wash the oil from the lower motor bearing, lubricate it with several drops of light machine oil.

To assure adequate cooling do not obstruct the ventilating holes in the bottom of the cabinet or the air outlet at the rear of the cabinet.

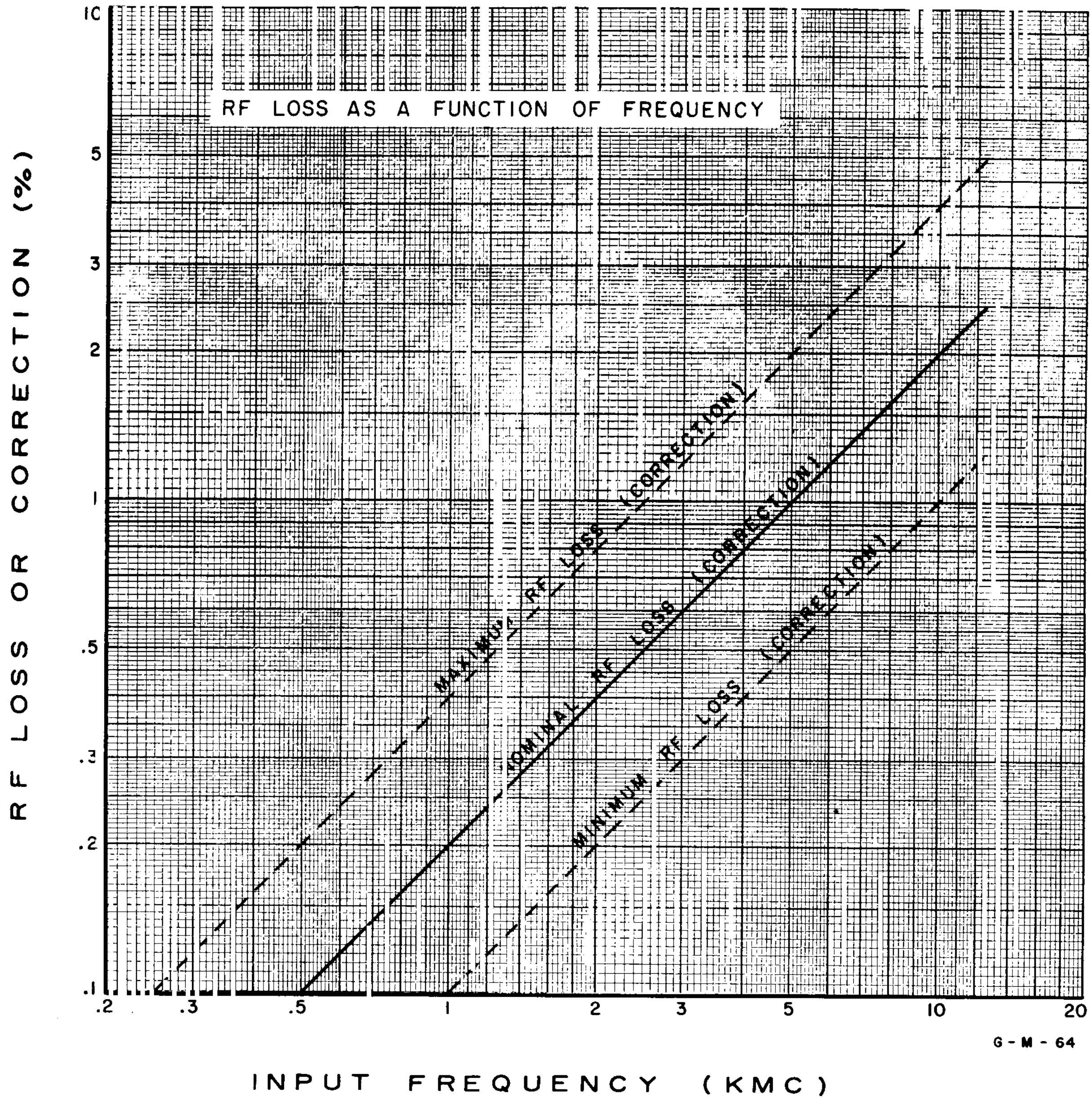


Figure 2-1. RF Loss Showing Probable Limits of Error

ADDITIONAL OPERATING INSTRUCTIONS

ELIMINATING EXCESSIVE NOISE

Air in the oil system may cause excessive noise on the most sensitive range (0.01 watts). This problem can be eliminated by allowing the instrument to operate for approximately 30 minutes before making measurements on the most sensitive range. If the instrument has been shipped or subjected to vibration, it may take as long as 10 hours of operation to remove the air from the oil system.

INTERNAL CALIBRATOR

A stable transistorized calibrator is included in the instrument. The calibrator produces a fixed dc voltage which develops 100 milliwatts (±1%) into a nominal 50 ohm load. The calibrator is useful for checking the dc calibration of the Power Meter.

Operating Procedure:

1. Turn instrument ON. For maximum stability, allow approximately 30 minutes to warm up.
2. Set RANGE switch to .10 watt.
3. Adjust ZERO SET controls to zero meter.
4. Connect the INPUT to the CALIBRATE OUTPUT. Meter should indicate .10 watt.
5. If necessary, adjust the CALIBRATE control (R79) on the panel for an indication of .10 watt.

Calibrator Maintenance:

The calibrator consists of a stable transistorized regulated dc power supply. Each calibrator is factory adjusted for optimum calibration with the particular instrument. No maintenance should be required.

Do not attempt to change any parts or values unless you have laboratory standards for establishing the output voltage to an accuracy of better than ±0.1%.

If precision tests indicate the calibrator needs adjustment, we recommend you return the instrument to the factory.

SECTION II
OPERATING INSTRUCTIONS

2-1 INTRODUCTION

This section contains the operating procedures for this instrument and in addition tells how to add oil and adjust oil flow.

2-2 CONTROLS AND TERMINALS

Controls and terminals are described in Figure 2-2.

2-3 OPERATING PRECAUTIONS

1) Check oil level and oil flow rate each time the Model 434A is turned on.

2) Apply power to INPUT only when the oil flow and level are within the prescribed limits.

3) NEVER APPLY POWER TO THE INPUT CONNECTOR WHEN THE 434A IS TURNED OFF, OR THE INPUT LOAD MAY BE DAMAGED.

2-4 FILLING THE RESERVOIR

1) Remove the oil filler plug; see Figure 2-2.

2) Fill syringe with silicone oil provided and insert nozzle into the oil filler hole.

3) Squeeze bulb gently so that air is not mixed with the oil. Air in the oil may cause noisy readings temporarily, but will work itself out in about 15 minutes.

4) Replace filler plug.

2-5 OPERATING PROCEDURE

See Figure 2-3.

2-6 ATTAINABLE ACCURACY

Over-all accuracy of the 434A is specified as within 5% of full scale. This is an over-all figure which includes rf loss and dc calibration error.

Accuracy of the 434A can be increased (see Estimated Attainable accuracy in paragraph 1-2) by the procedures outlined below.

1) Calibrate the 434A with an accurately-known dc power of the appropriate level by adjusting R79 in the Meter Circuit for an exact reading at the desired power level. See paragraph 4-14 for general calibration procedure. With adequate dc instrumentation the dc error can be reduced to about $\pm 1/2\%$.

2) Eliminate mismatch loss with a good low-loss tuner. For greatest accuracy, the loss in the tuner must be evaluated. Tuner loss equals percent loss times meter reading.

3) Find rf loss from Figure 2-1 (meter reading in watts x % loss). Figure 2-1 gives a nominal correction to be applied, with the probable limits of error.

4) Add tuner loss and rf loss to the meter reading.

OPERATING CONTROLS

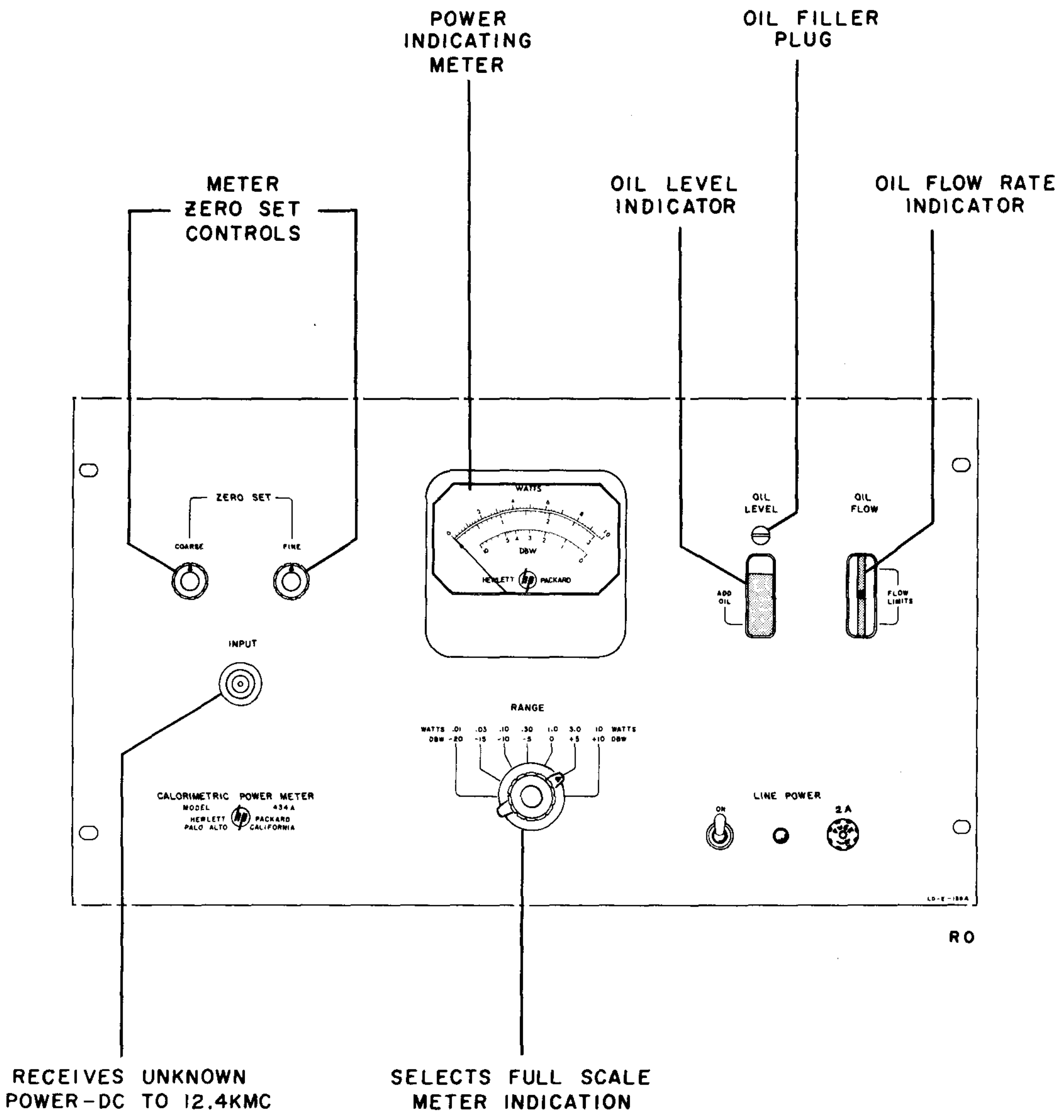
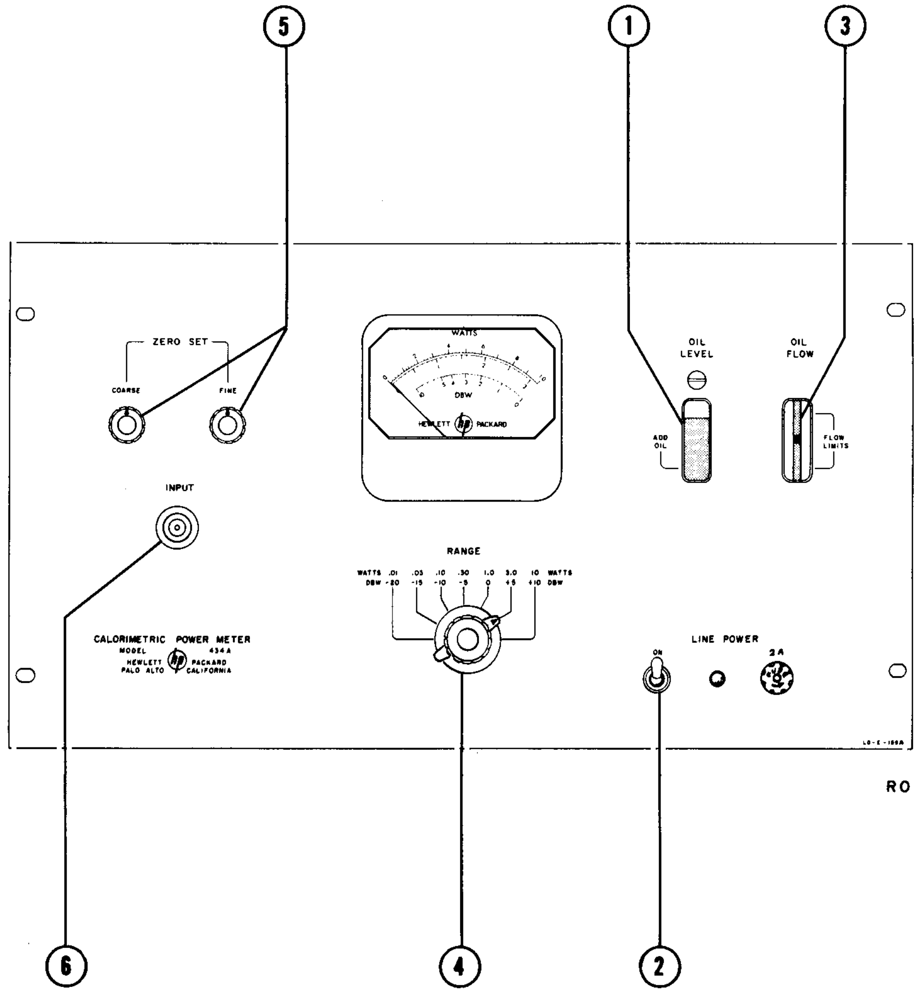


Figure 2-2

OPERATING PROCEDURE



1. Check oil level.
2. Turn ON.
3. Check flow rate.
4. Select range.
5. Adjust to zero meter.
6. Apply power.

Figure 2-3

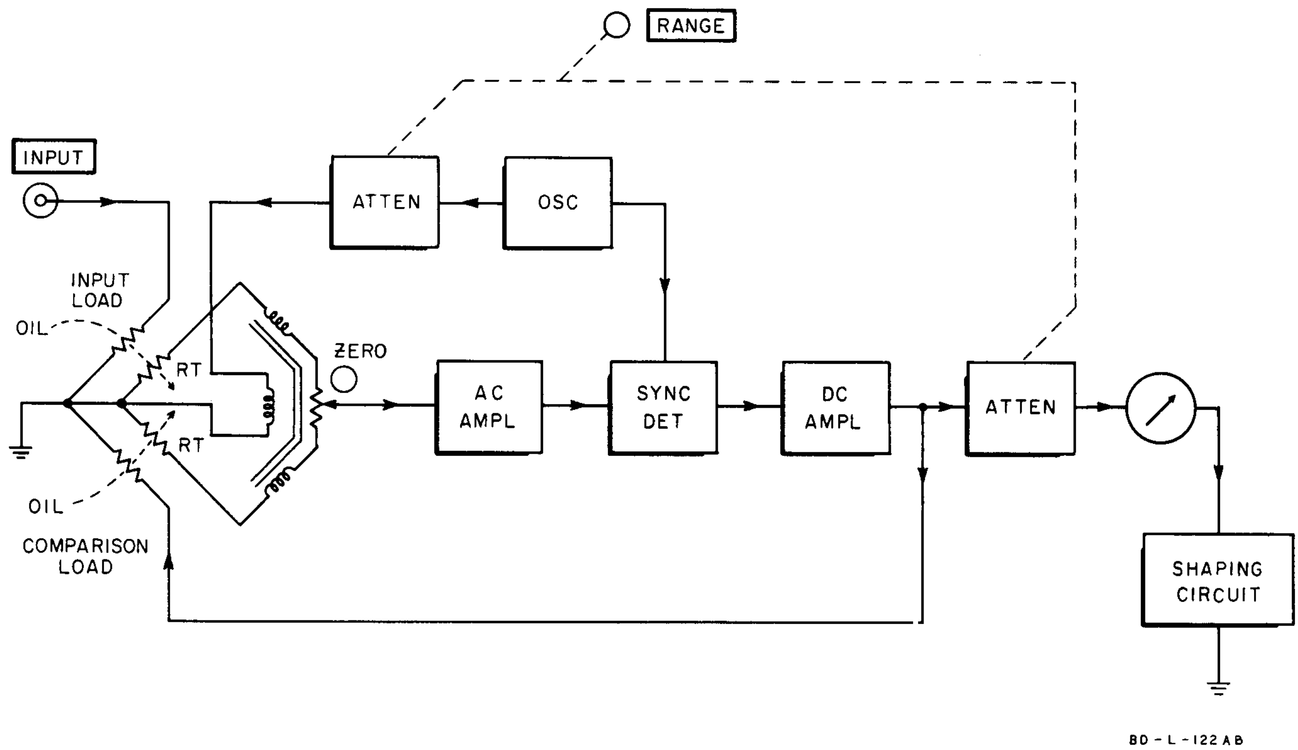


Figure 3-1. Block Diagram

SECTION III
THEORY OF OPERATION

3-1 INTRODUCTION

This section describes the circuit operation of the 434A Calorimetric Power Meter through the use of the Block Diagram, Figure 3-1, and the Schematic Diagram, Figure 4-2. Each major circuit is taken in turn and discussed.

3-2 OVER-ALL OPERATION

Power connected to the INPUT of the ⓗ Model 434A is dissipated as heat in the input load resistor, R1. Silicone oil flows over R1, is heated, and flows downstream to a temperature-sensitive resistance-wire gage which is one leg of the bridge. This load, oil stream, and gage form the input head of the bridge. A similar comparison head contains another load resistor, R2, and a gage which is a second leg of the bridge. The other two legs of the bridge are the secondary windings of transformer T1 driven by an oscillator. With no power to the input head the bridge is balanced with the ZERO SET controls. When power is applied to the input head, the oil stream transfers the heat from the input load to the gage, increasing its resistance and developing a signal at the output of the bridge. This signal is amplified and fed back to the comparison load resistor, heating its oil stream and gage and bringing the bridge back towards balance. The meter monitors feedback voltage and is calibrated directly in input power.

The signal output of each gage in volts is proportional to the power input in watts, so that each head constitutes a square-law element. This does not matter in the case of the input head, but the comparison head is located inside the feedback loop. As a result, the loop gain varies with power level and the ratio of feedback power to input power also varies with level. In changing ranges, the loop gain is adjusted by means of switch S1A so that the gain is the same for each range at any point on the meter scale. Thus, gain is always such that on any range the difference between input and feedback powers is, for example, 2% at full scale, 6% at one-tenth scale, etc. The actual difference between input and feedback power is calibrated out in the meter circuit so that the meter indication is in terms of the input power.

Since the comparison head is a square-law element ($R \propto E^2$), the resistance change of the gage is independent of the phase of the feedback voltage. Consequently, reversing the phase of the bridge output causes positive feedback, and the system runs away. This condition obtains when the ZERO SET controls move the meter pointer below zero. A small amount of positive feedback is necessary so the meter pointer can be brought below zero. Otherwise, zero setting the pointer would be difficult. The synchronous detector restores phase sensitivity to the system so the positive feedback can be controlled.

DC output polarity of the synchronous detector depends on the relative phase of the two ac voltages applied. Output is positive for the normal phase signal from the bridge; negative if the phase reverses. The dc output of the Synchronous Detector is applied through a two-stage amplifier to a tube biased near cut-off, whose cathode resistor is the comparison load. Thus, only positive voltages from the synchronous detector result in feedback.

3-3 INPUT BRIDGE

The Input Bridge circuit includes the input and comparison load resistors, their gages, the bridge transformer, a Phase Balance control and the zero-set circuit. The Phase Balance control is used to balance out the stray lead inductance and the transformer leakage inductance. The Bridge Balance control is a very coarse zero-set used to adjust for gross unbalance in the bridge so that the COARSE and FINE controls can be set to midpoint in normal operation.

3-4 AC AMPLIFIER, SYNCHRONOUS DETECTOR, AND FILTER

The signal from the bridge is amplified by a conventional ac-coupled amplifier and supplied to the Synchronous Detector. Output of the Synchronous Detector is positive when power is applied to the INPUT, and negative when the bridge is unbalanced in the wrong direction. The Filter is an rc network which shapes the gain characteristic of the feedback loop and smooths out the detector output, so that nearly pure dc is applied to the DC Amplifier. The time constant of the network is 5 seconds, giving a very low cutoff frequency to the loop. This is necessary because of the transit time of the oil between the comparison load and its gage. The transit time introduces into the feedback loop a phase shift which increases linearly with frequency.

When the meter pointer is moved below zero, a negative voltage is developed by the Synchronous Detector. Capacitor C9 (see schematic) tends to charge in the reverse direction. Since there is no feedback when meter pointer is set below zero, the feedback loop is open. In this case the discharge of C9 would cause a long delay between motion of the zero set controls and corresponding movement of the meter pointer upscale. Hence, the diode CR5 shunts C9 limiting its charge and speeding its discharge to assure fast response of the meter.

3-5 DC AMPLIFIER AND CLAMP

The DC Amplifier is composed of V3 and cathode follower V4 and has considerable negative feedback to make it linear. V4 is biased near cutoff when there is no signal from the Synchronous Detector. Thus, V4 supplies power to the comparison load when there is a positive output from the detector, but is driven into cutoff by a negative signal. When the meter is zeroed, a small current flows through V4 and through R35, R36, and R37, but the cathode is at ground potential and no power is dissipated in the comparison load (R2). When V4 is cutoff, its cathode goes below ground and a small current flows in reverse direction from ground through R2, R35, R36, and R37 to the negative supply. This current causes the meter pointer to move below zero. Without this movement there would be no way of telling when the zero-set controls had been moved too far. This is a condition of positive feedback, but the amount of "run-away" is limited by the clamping action of V5. Positive feedback power is never more than a few percent of full scale. The DC Zero control is used to set the meter to zero with no signal from the Synchronous Detector. Following the DC Amplifier is duodiode V5 which performs two clamping functions.

1) One section, (see schematic diagram) in conjunction with an attenuator operated by the range switch, limits the drive to the output cathode follower V4. This clamp prevents damage to the meter circuit if the RANGE switch is set to a sensitive range and applied power is large compared to full scale.

2) The other section of the clamp limits the reverse current in R2 when V4 is cutoff. Hence, the power in R2 (due to the reverse current) is kept to a small percentage of full scale power for each range, simplifying the zero set operation. The clamping action is reduced and then removed on the higher ranges.

3-6 RANGE SWITCH

The RANGE switch, S1, determines the sensitivity of the input bridge, attenuates the signal to the Meter Circuit, and sets the clamping levels of V5. S1A attenuates the drive to the bridge as the range is increased so that the loop gain varies in the same manner on each range as described in paragraph 3-2. S1B and S1C attenuate the signal to the meter so that the input to the Meter Circuit for full-scale deflection can be kept constant. S1D limits the output of V4 to prevent Meter Circuit damage should high power (compared to full scale) be applied to the INPUT. S1E controls the meter swing below zero.

3-7 METER CIRCUIT

Of major importance in the Meter Circuit is the Shaping Circuit. This network reduces the resistance in series with the meter as the voltage to the meter circuit increases to permit a meter scale that is nearly linear in power. The circuit contains four diodes which are biased by a voltage divider from a well-regulated source. As the voltage to the meter circuit increases, the diodes conduct in turn to reduce the resistance of the meter circuit. The difference between an exactly linear characteristic and the approximation actually obtained is calibrated out on the meter face. The calibration also includes the effect of variation in the difference between input and feedback power, as described in paragraph 3-2.

3-8 OSCILLATOR

The Oscillator is a conventional rc oscillator which operates at a fixed frequency of about 1200 cps. Amplitude is stabilized by a nonlinear resistance, RT1. Output voltages from the Oscillator are supplied to the Synchronous Detector and through a section of range switch to the Input Bridge.

3-9 POWER SUPPLY AND VOLTAGE REGULATOR

The Power Supply is a conventional full-wave rectifier and the Voltage Regulator is a series type which regulates for both line and load variations. There is also a half-wave rectifier which supplies -150 v, regulated by a glow discharge tube.

3-10 OIL SYSTEM

The oil-flow system is an important part of the 434A. It transfers the heat from the input load, R1, to its gage and from the comparison load, R2, to its gage. The complete oil flow system is shown in Figure 3-2.

Since the flow rate through the heads must be equal, the oil flows in a series path. The pump has more capacity than is required and an oil-flow regulator consisting of a spring-loaded by-pass valve maintains steady flow. Adjusting the valve sets the flow rate to any desired value. The flow indicator is a simple uncalibrated flow meter, used only to show that flow rate is within a range of about 30 to 50 cc per minute. If the flow rate gets too low, the system may oscillate because of excessive phase shift in the feedback loop as discussed in paragraph 3-4 while if flow rate is too high, the noise level of the system increases.

The parallel-flow heat exchanger decreases random variations of temperature along the streams and brings the streams to nearly the same temperature. Reducing temperature variations reduces noise in the system while bringing the stream temperatures together reduces the required zero-set range.

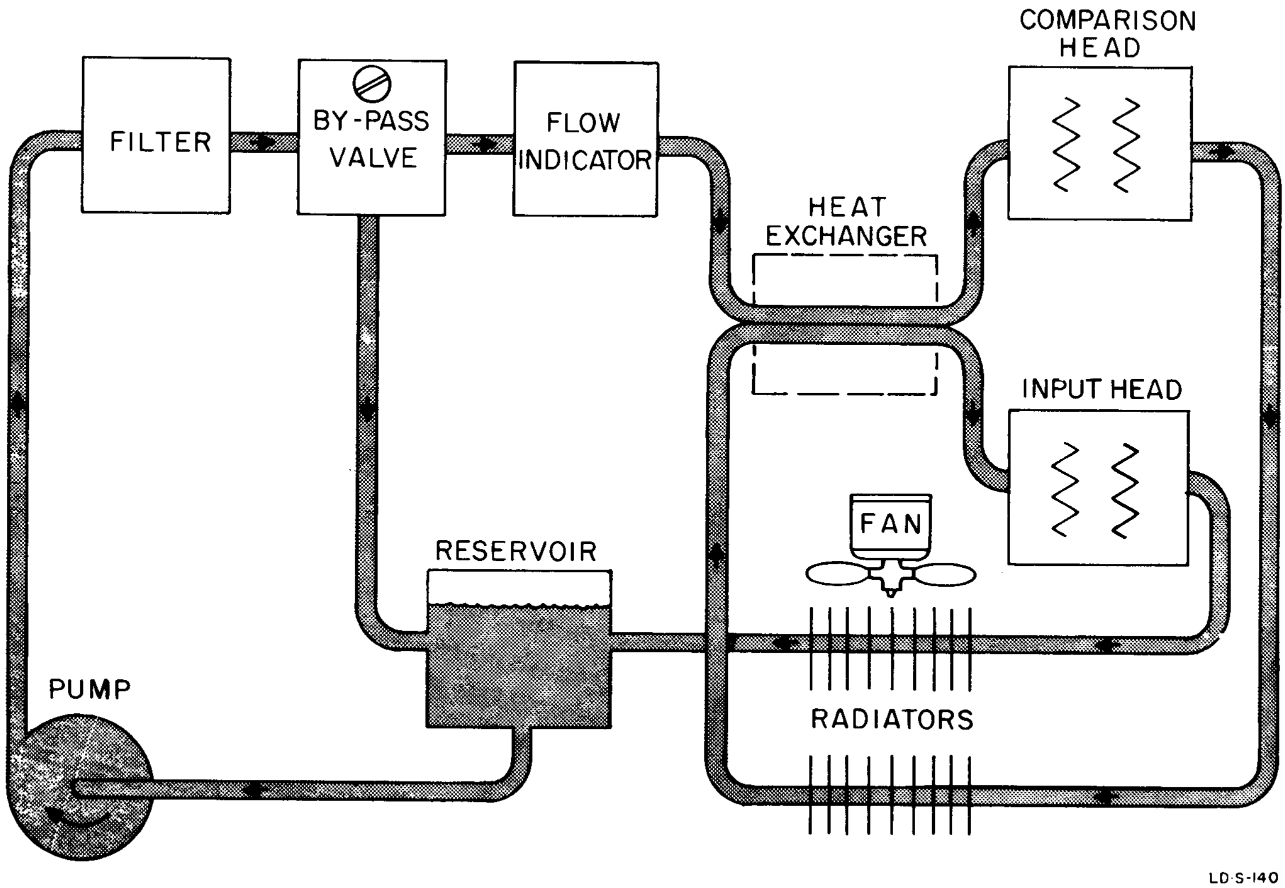


Figure 3-2. Oil Flow Diagram

SECTION IV
MAINTENANCE

4-1 INTRODUCTION

This section gives necessary maintenance information and also describes a simple check of overall performance.

4-2 CABINET REMOVAL

1) Remove the rear cover. Four screws hold it in place.

2) Turn the instrument on its back and unscrew the two recessed screws in the bottom of the bezel about 1/4 inch.

3) Lift the cabinet towards the top of the instrument and off.

4-3 PERIODIC MAINTENANCE

This instrument is equipped with a cooling fan and an air filter which should be inspected and cleaned periodically. Clean the filter by washing it thoroughly in warm water and detergent, dry it (blow it dry if clean air is available) and recoat it with a water-soluble oil such as Filter Coat #3, manufactured by Research Products Corporation, Madison 10, Wisconsin.

Every six months lubricate the lower motor bearing with several drops of light machine oil.

4-4 CONVERSION TO 230 VOLT OPERATION

1) Remove the two jumpers (see schematic) which connect the power transformer primary windings in parallel.

2) Connect the primary windings in series.

3) Change the line fuse to a 1 ampere slow-blow type.

4-5 TUBE REPLACEMENT CHART

The following chart, Table 4-1, lists the electron tubes used in the Model 434A and indicates which adjustments should be made when a tube is replaced.

TABLE 4-1. TUBE REPLACEMENT CHART

Tube	Check or Adjustment
V1	Adjust dc calibration. Par. 4-14
V2	Same as V1
V3	Compare accuracy of lower ranges with upper ranges. Reset DC Zero, R32. Par. 4-10
V4	Same as V3. Check accuracy with 10 watt input
V5	Check operation of the Clamp, Par. 4-13
V6	Check Oscillator output to bridge and Synchronous Detector Par. 4-8
V7-V13	Check regulation and ripple, Par. 4-7
V14	Adjust dc calibration, Par. 4-14
CR1-CR4	Check residual output of Synchronous Detector, Par. 4-9
CR5	Compare accuracy of lower ranges with upper ranges. Check Synchronous Detector performance, Par. 4-9. Check meter behavior below zero. Par. 3-4
CR6-CR9	Check meter tracking, Par. 4-14

4-6 CLEANING THE OIL FILTER

The oil filter removes particles from the oil stream which otherwise might plug the gage assemblies in the head box. Whenever sufficient flow rate cannot be obtained the oil filter should be removed, cleaned, and replaced. The oil filter is in a housing which looks like a hexagonal nut located under the off-set of the reservoir. To clean the oil filter:

1) Disconnect the oil line which connects to the oil filter housing. Be careful not to lose the small rubber O-ring.

2) Remove the filter housing.

3) Remove the larger O-ring which retains the oil filter.

4) The oil filter will drop out when the housing is turned upside down.

5) Wash the filter in nearly any clean hydro-carbon solvent (white gasoline, naphtha, benzene, carbon tetrachloride, acetone, etc.) or in the silicone oil. Use a toothbrush or other stiff bristled brush to remove embedded particles. Blow clean air, if available, through filter.

6) Reassemble and install.

4-7 POWER SUPPLY ADJUSTMENT

Potentiometer R76 is adjusted to provide +285 v dc ±5 v at the output of the series regulators. After adjusting R76, monitor the regulated output voltage while varying the line voltage from 103 to 128 volts. The dc voltage change should not be more than barely perceptible on the 300 volt range of a meter.

Connect an ac vtvm, such as an ⓗⓟ Model 400D, to the output of the power supply. Vary the line voltage as before. The rms ripple should remain below 10 mv with no power applied to the input jack.

At 115 volts line, measure the output of the negative supply. This voltage should be -150 v ±5 v. Vary the line voltage as before. Ripple voltage should be less than 15 mv.

4-8 OSCILLATOR

1) Set Range to .3W.

2) Measure the output voltage at pin 8 of V6. Adjust R49 for 4 v ±0.2 v rms.

3) The distortion at this point should be less than 2%. Use an ⓗⓟ Model 330B Distortion Analyzer (or equivalent).

4) Measure voltage at pin 1 of V6. Should be 40 v rms or more.

4-9 SYNCHRONOUS DETECTOR

The synchronous Detector has no adjustment. However, it is a critical circuit and its proper operation is imperative to over-all operation. To judge its operation both balance and gain must be measured.

To measure balance:

1) Ground grid (pin 2) of V2B.

2) Connect either a dc oscilloscope or ac and dc vtvm's across C8. The instruments should have a floating input or be isolated from ground.

CAUTION

During this measurement both input terminals of each meter will be about -150 volts from ground.

ⓗⓟ Oscilloscopes 120A, 122A, and 130A/B, ⓗⓟ 400 series ac Voltmeters, and ⓗⓟ 410A/B may be used if isolated from ground. ⓗⓟ Models 405A, 412A, and 425A dc vtvm's have a floating input. The combined shunting impedance of the instruments used in this measurement must not be less than 1 megohm.

3) The voltage at the center tap of T3 with respect to the center tap of T4 should be between 0 and +0.2 v dc. If the voltage is outside this range the bridge may be balanced by shunting one of the series resistors, R23, R24, R25, or R26. Shunting either of two of the resistors will change the dc voltage in the correct direction; shunting one of these two will cause a decrease in ac voltage as observed on the oscilloscope or the ac vtvm. Shunt this resistor with not less than 1 megohm. If 1 megohm or more will not balance the bridge, one or more of the crystal diodes must be replaced.

4) Remove ground at grid of V2B.

To measure gain:

Set the range switch to .3W. Connect an ac vtvm to monitor the voltage at pin 1 of V2B. Monitor the dc voltage across C8 with a dc vtvm.

CAUTION

The dc vtvm should have a floating input or be isolated from ground.

Get a 2 v rms reading on the ac meter by applying external power to the INPUT. The dc voltmeter should read at least +1.4 v. If the voltage is less, CR1-CR4 may be defective. The voltage at pin 2 of V3 should be the same as at the center tap of T3. If it is more than 1 or 2% less, CR5 or CR9 may be defective, V3 may need replacement, or the meter used to measure the voltage may be loading the circuit excessively. Check the ground leads.

4-10 ADJUST DC ZERO

1) Unplug P3.

2) Set RANGE to .01W.

3) Adjust R32, DC Zero, to zero the 434A meter.

4) Reconnect P3.

4-11 ADJUST PHASE BALANCE

1) AC couple the vertical input of an oscilloscope to V2B, pin 1.

2) AC couple the horizontal input of the oscilloscope to V6B, pin 8.

NOTE

The phase shift characteristics of the vertical and horizontal amplifiers of the oscilloscope must be similar. Check this by connecting the terminals of both amplifiers between ground and V6B, pin 8. The pattern on the oscilloscope should be a straight diagonal line.

----

3) Set RANGE to .03W.

4) Turn the ZERO SET to bring the meter pointer slightly above zero.

5) Adjust Phase Bal. L1, to close the pattern on the oscilloscope. L1 is on top of the head box assembly.

4-12 ADJUST BRIDGE BALANCE

This adjustment should be made after the Synchronous Detector has been balanced and the DC Zero adjusted.

To adjust Bridge Balance:

1) Set RANGE to .03W.

2) Center the ZERO SET controls.

3) Adjust Bridge Bal, R7 to zero the meter. R7 is on top of the head box assembly.

4-13 CLAMP OPERATION CHECK

The effectiveness of one-half the clamp is determined by measuring the dc voltage on V5, pin 2, when the diode should be clamping. If V5 does not clamp effectively, applying power in excess of the full-scale RANGE setting may damage the Meter Circuit. The following Table 4-2 gives the RANGE setting, input power and the permissible upper limit of plate voltage.

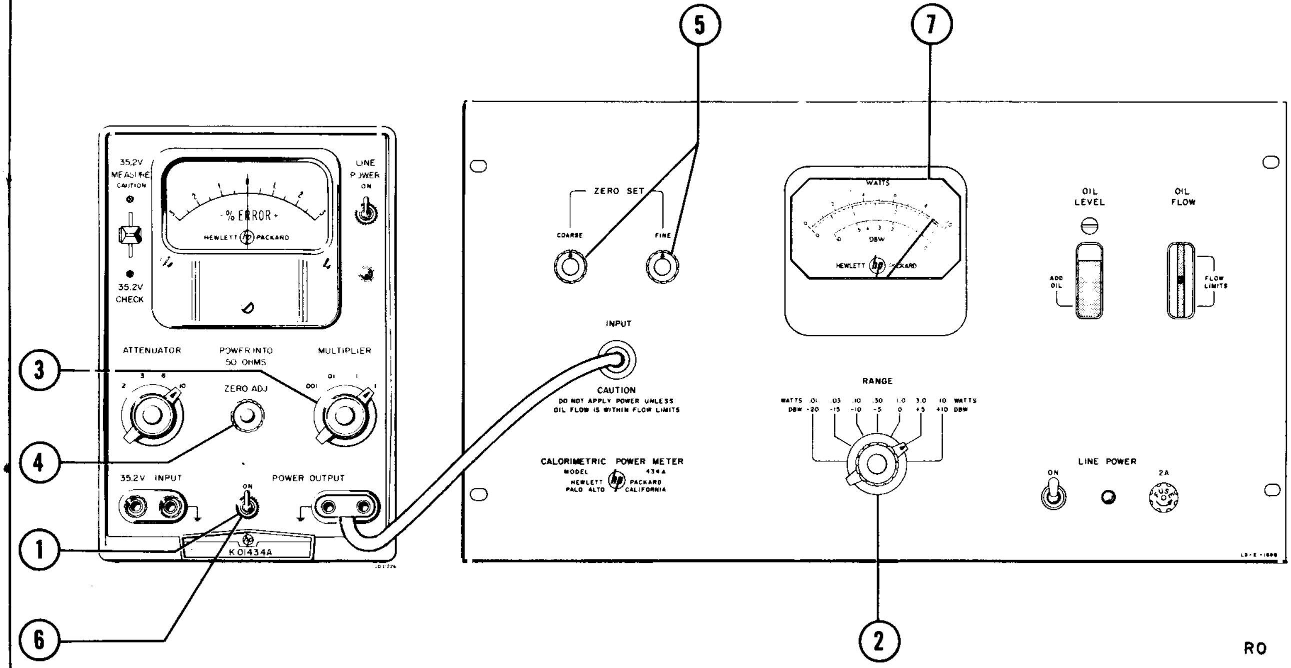
TABLE 4-2. CLAMP VOLTAGES

Range	Input Power	Maximum Plate Voltage on V5
10W	No clamp action	
3W	10 watts	+115 volts
1W	3 watts	+ 50 volts
.3W	1 watt	+ 5 volts
.1W	.3 watt	- 15 volts
.03W	.1 watt	- 20 volts
.01W	.03 watt	- 25 volts

The other half of the Clamp limits the power dissipated in R2 when V4 is cut off. Its action can be checked by turning the ZERO SET so that the meter pins below zero. Then, when the control is slowly turned to bring the pointer up towards zero, the pointer will jump up-scale. If the up-scale jump is less than 1/4 scale, clamp operation is satisfactory. Check on the four lowest ranges.

ADJUSTING DC CALIBRATION

Connect equipment as shown and allow the 434A 15 minutes to warm-up.



1. Turn off.
2. Set to .01 W.
3. Set to 434A RANGE setting.
4. Zero % ERROR meter.
5. Adjust.
6. Turn ON.
7. Read 434A and note error.
8. Repeat 1 through 7 for all ranges
   Also check meter tracking on bottom
   and top ranges.
9. Adjust V. M. Cal., R79 for best compromise.

Figure 4-1

4-14 OVER-ALL CHECK

Over-all accuracy of the 434A can be checked easily in two steps:

-- Compare indicated power with an accurately known dc power input.

-- Determine that the impedance of the input circuits within specifications.

If the 434A calibration is off, see paragraph 4-15. Two methods for checking dc calibration are given; Method A, shown in Figure 4-1, uses ⓗⓟ Specification K01 434A DC Test Set, an instrument specifically designed for testing and adjusting the 434A. Specification K01 434A supplies known powers to the 434A which are accurate within ±1/2%. In addition it can be used to determine how much error is calibrated out by V.M.Cal, R79. This procedure is described in paragraph 4-15. Method B replaces the Specification K01 434A with a dc power supply and any two of the following meters: a dc voltmeter, a dc ammeter, and a Wheatstone Bridge. These meters preferably should be accurate within 1/4% to measure input power within 1/2%. 60-cycle power may be used instead of dc if instruments of sufficient accuracy are available.

A. TO CHECK DC ACCURACY

Method A: See Figure 4-1.

Method B:

1) Use a dc power supply and two of the meters to measure input power to the 434A.

2) Compare the indicated power with input power for full scale deflection of each range. Set V.M. Cal, R79, for best compromise on all ranges. Indicated power should agree with calculated input power within ±2%. Check meter tracking on lowest and highest ranges.

B. TO MEASURE INPUT IMPEDANCE

Input impedance from dc to 12.4 kmc can be measured with conventional techniques and equipment.

4-15 MEASURING COMPENSATED ERROR

The compensated error is the difference between 98% of the indicated full-scale power and the feedback power supplied to the comparison load, R2. The 2% difference, which is inherent in the instrument, is a design factor and is compensated for by the Meter Circuit. Other errors should be kept to 6% or less. If compensated error is excessive, see paragraph 4-16. Two methods of measuring compensated error are described; Method A, which uses ⓗⓟ Specification K01 434A, and Method B, which uses conventional instruments.

To measure compensated error:

Method A

1) Check dc accuracy, paragraph 4-14.

2) Set RANGE to .3W.

3) Apply .3 watt from the K01 434A to the 434A INPUT.

4) Use the ZERO SET of the 434A to align the pointer to 1 on the 0 to 1 scale. This reading corresponds to meter full-scale or 0.316 watts.

5) Connect the 35.2V INPUT terminals between V4, pin 1 and chassis.

6) Push the MEASURE-CHECK switch to CHECK. If the meter deflection is greater than one division, the compensated error is excessive. Refer to paragraph 4-16. If it is less than one division, push the switch to MEASURE. The meter reads the percent error in feedback voltage. Double the meter reading for percent feedback power error.

Method B

Method B replaces the K01 434A with a power supply and a dc meter. The meter preferably should be accurate to ±1/4%.

1) Check dc accuracy, paragraph 4-14.

2) Set RANGE to .3W.

3) Connect a source of power to the INPUT and adjust its output (about 4 volts rms or dc) to align the meter pointer with 1 on the 0 to 1 scale. This deflection corresponds to 0.316 watts. The ZERO SET control may be used to simplify setting the pointer to 1.

4) Measure the dc voltage at V4, pin 1. The 6% power error voltages are +34.1 v and +36.3 v.

4-16 TROUBLE LOCATION

The Table 4-3 lists symptoms, possible cause, and references.

TABLE 4-3. TROUBLE LOCATION

Symptom	Possible Cause	Reference
10W range reads low or has excessive response time	Low Gain Low Osc. Drive	Par. 4-17 Par. 4-8
.01W range reads low	DC Zero requires adjustment CR5 defective V3 defective	Par. 4-10 Par. 4-9 Par. 4-5
Excessive compensated error	Low Gain Low Osc. Drive R2 off value R3 or R4 defective	Par. 4-17 Par. 4-8 Par. 4-18 Par. 4-19

4-17 MEASURING GAIN

1) Remove RT1 to disable the oscillator.

2) Set the RANGE to 10 watts.

3) Connect a 1200 cps signal to the grid of a stage and measure the voltage on the plate. Table 4-4 lists the nominal gains for the AC amplifiers, less than 80% of the nominal gain indicates the tube should be replaced.

TABLE 4-4. GAIN MEASUREMENT

Tube	Nominal Gain	Input Voltage	Nominal Output Voltage
V1	63	0.1 v rms	6.3 v rms
V2A	46	0.1 v rms	4.6 v rms
V2B	23	0.1 v rms	2.3 v rms

4) Install RT1 and adjust ZERO SET (meter upscale) to obtain 2.0 v rms on V2B pin 1.

5) Voltage on V4 pin 1 should be +36 vdc. If this voltage is below 28.5 vdc try changing V3.

4-18 EXCESSIVE COMPENSATED ERROR

If compensated error appears to be greater than ±6%:

1) Measure the value of R2 as accurately as possible, preferably within 1/4%. If R2 is more than 0.5% off value, return the 434A to the Hewlett-Packard Company. (See warranty for shipping instructions) or replace the head box assembly, paragraph 4-19.

2) If R2 is within ±0.5% of 4000 ohms, check instrument for low gain, low oscillator voltage. If no other source of trouble can be located, replace head box assembly.

4-19 REMOVING HEAD BOX ASSEMBLY

The head box assembly contains the input and comparison loads, the parallel-flow heat exchanger, and the resistive temperature gages. The head box assembly is an intricate and precision assembly, and no attempt to repair it should be made in the field.

To remove the head box assembly:

1) Remove the cabinet; see paragraph 4-2.

2) Leave the instrument on its back and remove the two truss-head screws which anchor the assembly from the bottom. Unplug the coaxial cable (P2) at the head box.

3) Turn the instrument right side up and unplug J3.

4) Disconnect the four oil lines from the box.

5) Remove the three lengths of tubing at the rear of the box.

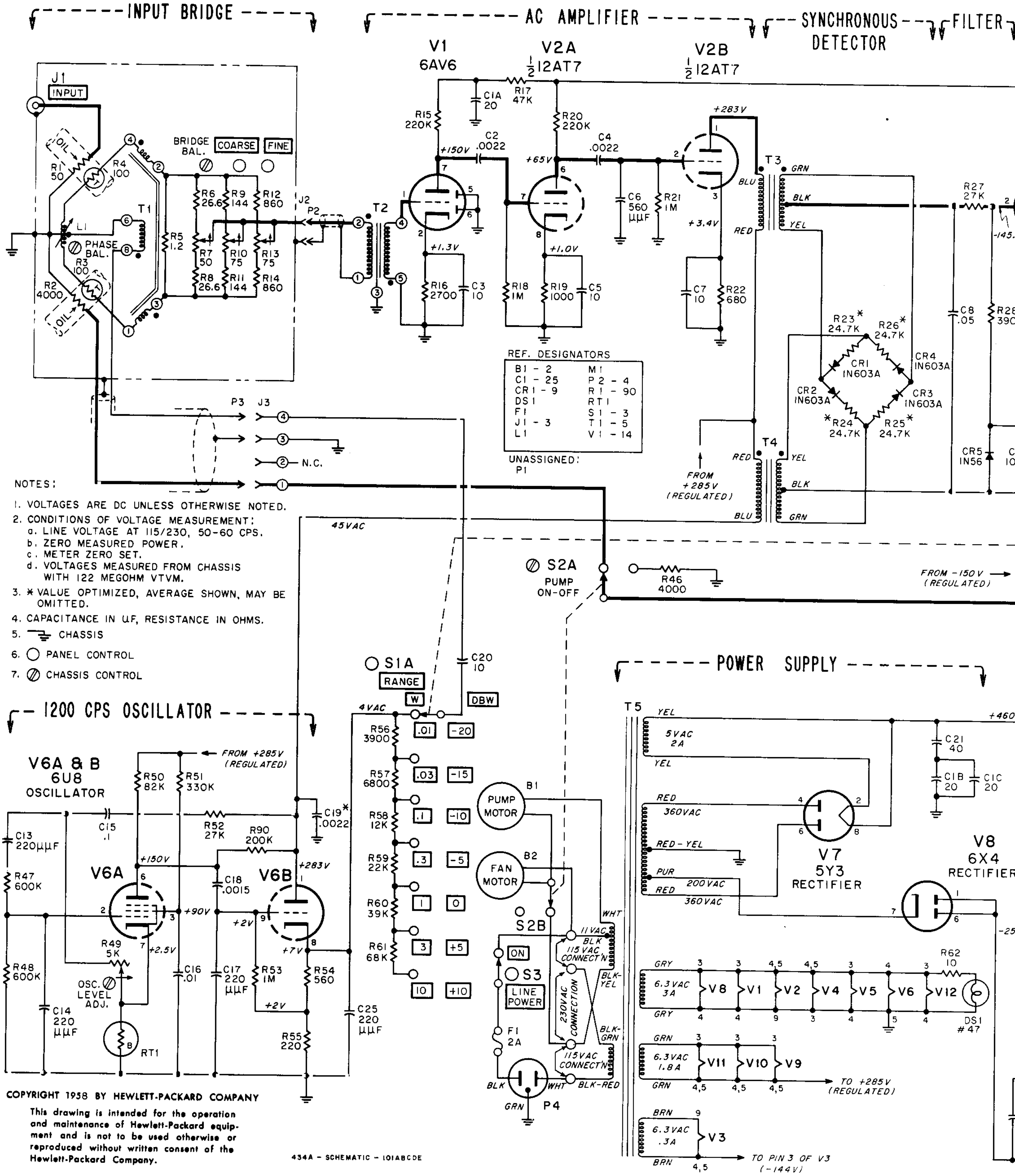
6) Remove the ZERO SET knobs and the knurled nut on the INPUT connector.

7) Move the head box assembly back and up. Be careful not to apply force to the two oil connectors at the rear of the box. These are part of the gage asemblies and may be damaged.

8) Place the three oil lines in a plastic bag and store them inside the instrument.

9) Pack the head box assembly in a strong, well-padded carton (see Warranty page) and return it to the Hewlett-Packard Company for repair.

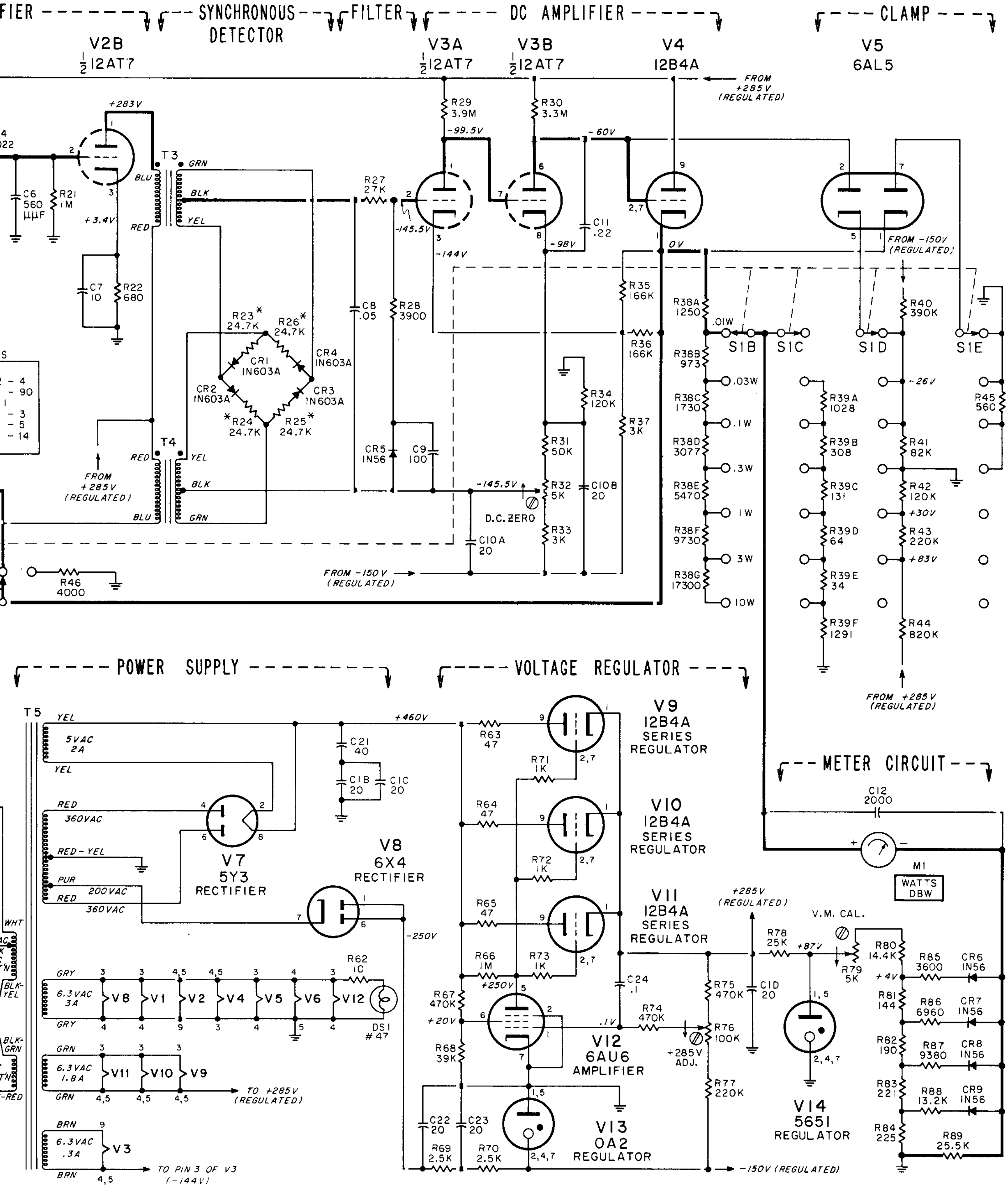
10) When replacing the head box in the instrument be sure all oil lines and fittings are clean.



NOTES:

1. VOLTAGES ARE DC UNLESS OTHERWISE NOTED.
2. CONDITIONS OF VOLTAGE MEASUREMENT:
   a. LINE VOLTAGE AT 115/230, 50-60 CPS.
   b. ZERO MEASURED POWER.
   c. METER ZERO SET.
   d. VOLTAGES MEASURED FROM CHASSIS WITH 122 MEGOHM VTVM.
3. * VALUE OPTIMIZED, AVERAGE SHOWN, MAY BE OMITTED.
4. CAPACITANCE IN µF, RESISTANCE IN OHMS.
5. ⏚ CHASSIS
6. ○ PANEL CONTROL
7. ⊘ CHASSIS CONTROL

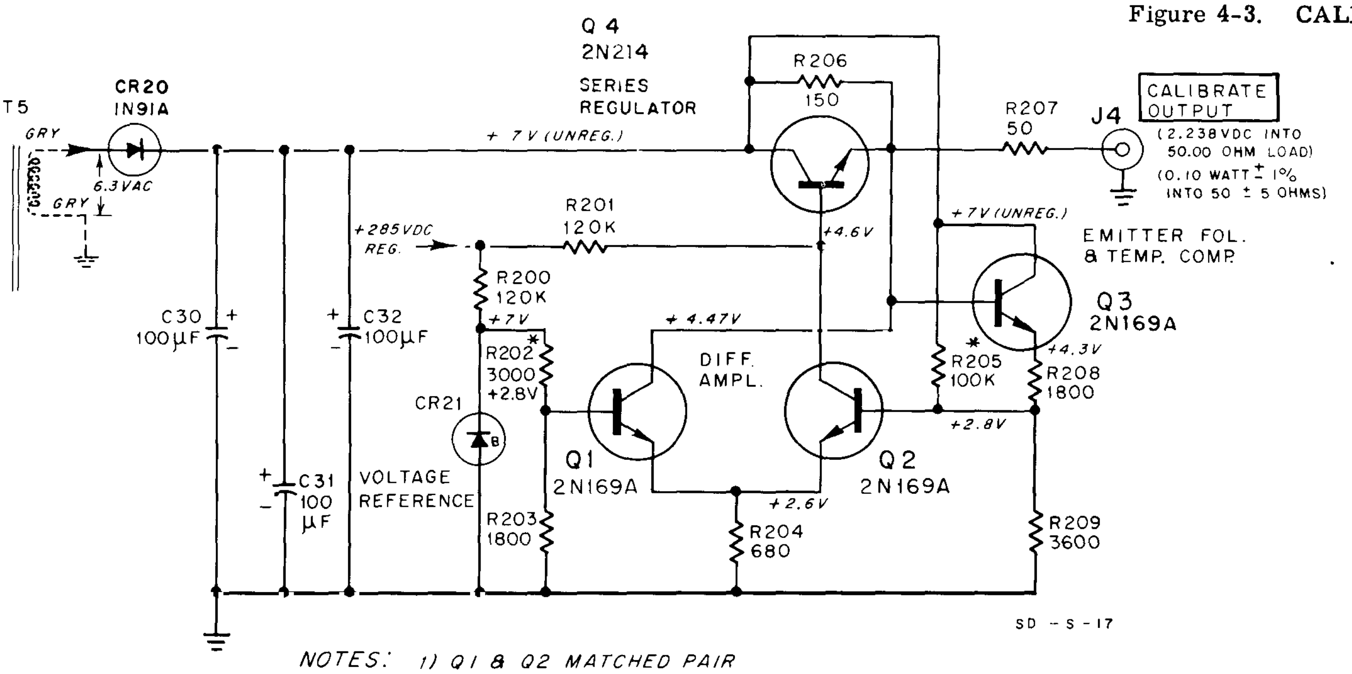
434A - SCHEMATIC - 101ABCDE



FIER
SYNCHRONOUS DETECTOR
FILTER
DC AMPLIFIER
CLAMP
V2B ½12AT7
V3A ½12AT7
V3B ½12AT7
V4 12B4A
V5 6AL5
FROM +285V (REGULATED)
+283V
R29 3.9M
R30 3.3M
-99.5V
-60V
C6 560 μμF
R21 1M
+3.4V
C7 10
R22 680
T3
T4
GRN
BLK
YEL
RED
BLU
R27 27K
-145.5V
-144V
-98V
C11 .22
0V
FROM -150V (REGULATED)
R23* 24.7K
R26* 24.7K
CR1 1N603A
CR2 1N603A
CR3 1N603A
CR4 1N603A
*R24 24.7K
R25* 24.7K
C8 .05
R28 3900
CR5 1N56
C9 100
R31 50K
R32 5K
D.C. ZERO
R33 3K
R34 120K
C10B 20
C10A 20
R35 166K
R36 166K
R37 3K
R38A 1250
R38B 973
R38C 1730
R38D 3077
R38E 5470
R38F 9730
R38G 17300
.01W
.03W
.1W
.3W
1W
3W
10W
S1B
S1C
S1D
S1E
R39A 1028
R39B 308
R39C 131
R39D 64
R39E 34
R39F 1291
R40 390K
-26V
R41 82K
R42 120K
+30V
R43 220K
+83V
R44 820K
FROM +285V (REGULATED)
R45 560
R46 4000
FROM +285V (REGULATED)
POWER SUPPLY
VOLTAGE REGULATOR
T5
YEL
5VAC 2A
RED
360VAC
RED-YEL
PUR
200VAC
360VAC
WHT
C21 40
C1B 20
C1C 20
+460V
V7 5Y3 RECTIFIER
V8 6X4 RECTIFIER
-250V
R62 10
DS1 #47
GRY
6.3VAC 3A
V8 V1 V2 V4 V5 V6 V12
GRN
6.3VAC 1.8A
V11 V10 V9
TO +285V (REGULATED)
BRN
6.3VAC .3A
V3
TO PIN 3 OF V3 (-144V)
R63 47
R64 47
R65 47
R66 1M
R71 1K
R72 1K
R73 1K
V9 12B4A SERIES REGULATOR
V10 12B4A SERIES REGULATOR
V11 12B4A SERIES REGULATOR
+250V
R67 470K
+20V
R68 39K
V12 6AU6 AMPLIFIER
.1V
R74 470K
C24 .1
R75 470K
R76 100K
+285V ADJ.
R77 220K
C1D 20
C22 20
C23 20
R69 2.5K
R70 2.5K
V13 OA2 REGULATOR
-150V (REGULATED)
+285V (REGULATED)
R78 25K
+87V
V.M. CAL.
R79 5K
V14 5651 REGULATOR
METER CIRCUIT
C12 2000
M1
WATTS DBW
R80 14.4K
+4V
R81 144
R82 190
R83 221
R84 225
R85 3600
R86 6960
R87 9380
R88 13.2K
R89 25.5K
CR6 1N56
CR7 1N56
CR8 1N56
CR9 1N56

FIGURE 4-2
SCHEMATIC DIAGRAM

Figure 4-3. **CALIBRATOR**



NOTES: 1) *Q1 & Q2 MATCHED PAIR*
2) *R202 FACTORY ADJUSTED FOR CORRECT OUTPUT VOLTAGE.*
3) *R205 FACTORY ADJUSTED FOR BEST REGULATION WITH CHANGE IN LINE VOLTAGE.*
4) *VOLTAGES MEASURED ON A TYPICAL INSTRUMENT WITH LINE VOLTAGE ADJUSTED TO 115 VAC.*

Calibrator Parts List

C30 thru C32:	Capacitor: fixed, electrolytic, 100 µf, 12 vdcw; ⓗⓟ Stock No. 18-60, Mfr., CC
CR20:	Rectifier, silicon: 100 v PIV, 500 ma; ⓗⓟ Stock No. 212-148, Mfr. BV
CR21:	Diode, silicon; ⓗⓟ Stock No. G-29C-74, Mfr. HP
R200, 201:	Resistor: fixed, composition, 120,000 ohms ±10%, 1 W; ⓗⓟ Stock No. 24-120K, Mfr. B
R202:	Resistor: fixed, deposited carbon, 3000 ohms ±1%, 1/2 W; ⓗⓟ Stock No. 33-3000, Mfr. NN Electrical value adjusted at the factory.
R203:	Resistor: fixed, deposited carbon, 1800 ohms ±1%, 1/2 W; ⓗⓟ Stock No. 33-1800, Mfr. NN
R204:	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W; ⓗⓟ Stock No. 23-680, Mfr. B
R205:	Resistor: fixed, composition, 100,000 ohms ±5%, 1/2 W; ⓗⓟ Stock No. 23-100K-5, Mfr. B Electrical value adjusted at the factory.
R206:	Resistor: fixed, composition, 150 ohms ±10%, 1/2 W; ⓗⓟ Stock No. 23-150, Mfr. B
R207:	Resistor: fixed, deposited carbon, 50 ohms ±1%, 1/2 W; ⓗⓟ Stock No. 33-50, Mfr. NN
R208:	Resistor: fixed, deposited carbon, 1800 ohms ±1%, 1/2 W; ⓗⓟ Stock No. 33-1800, Mfr. NN
R209:	Resistor: fixed, deposited carbon, 3600 ohms ±1%, 1/2 W; ⓗⓟ Stock No. 33-3600, Mfr. NN
Q1, 2:	Matched pair of 2N169A transistors, ⓗⓟ Stock No. 213-34, Mfr. HP
Q3:	Transistor, type 2N169A, ⓗⓟ Stock No. 213-33, Mfr. ZZ
Q4:	Transistor, type 2N214, ⓗⓟ Stock No. 213-35, Mfr. ZZ

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Readily available standard-components have been used in this instrument, whenever possible. However, special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. ⓗⓟ Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed give complete description, function, and location of part.

If there are any corrections for the Table of Replaceable Parts they will be listed on an Instruction Manual Change sheet at the front of this manual.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
B1	Pump Motor, see Pump and Motor Assembly (Misc.) HP*	- - -	1			
B2	Motor General Industrial Co.	314-43	1			
C1	Capacitor: fixed, electrolytic, 4 sections, 20 μf/sect., 450 vdcw CC*	18-42HP	1			
C2	Capacitor: fixed, paper, .0022 μf ±10%, 600 vdcw CC*	16-22	3			
C3	Capacitor: fixed, electrolytic, 10 μf, 10 vdcw CC*	18-52	4			
C4	Same as C2					
C5	Same as C3					
C6	Capacitor: fixed, mica, 560 $\mu\mu$f ±10%, 500 vdcw Z*	14-81	1			
C7	Same as C3					
C8	Capacitor: fixed, paper, .051 μf ±10%, 200 vdcw Z*	16-84	1			
C9	Capacitor: fixed, electrolytic, 100 μf, 12 vdcw CC*	18-60	1			
C10	Capacitor: fixed, electrolytic, 2 sections, 20 μf/sec., 450 vdcw CC*	18-22HP	1			
C11	Capacitor: fixed, paper, .22 μf ±10%, 400 vdcw CC*	16-48	1			
C12	Capacitor: fixed, electrolytic, 2000 μf, 6 vdcw J*	18-6	1			
C13, 14	Capacitor: fixed, silver mica, 220 $\mu\mu$f ±5%, 500 vdcw V*	15-76	3			
C15	Capacitor: fixed, electrolytic, 8 μf, 350 vdcw CC*	18-69HP	1			
C16	Capacitor: fixed, paper, .01 μf ±10%, 600 vdcw CC*	16-11	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	#			
C17	Same as C13					
C18	Capacitor: fixed, paper, .0015 μf ±10%, 600 vdcw CC*	16-32	1			
C19	Same as C2 Electrical value adjusted at factory					
C20	Same as C2					
C21	Capacitor: fixed, electrolytic, 4 sections, 40 μf/sect., 450 vdcw CC*	18-40HP	1			
C22, 23	Capacitor: fixed, electrolytic, 20 μf, 450 vdcw CC*	18-20HP	2			
C24	Capacitor: fixed, paper, 0.1 μf ±10%, 400 vdcw CC*	16-35	1			
C25	Capacitor: fixed, silver mica, 220 μμf ±5%, 500 vdcw Z*	15-32	1			
CR1, 2, 3, 4	Rectifier, silicon, Type 1N603A BV*	212-140	4			
CR5, 6, 7, 8, 9	Rectifier, crystal, Type 1N56A BN*	212-G12	5			
DS1	Lamp, incandescent: 6-8V, .15 amp, #47 N*	211-47	1			
F1	Fuse, cartridge: 2 amp, 125V E*	211-16	1			
J1	Connector, R.F. , part of Head Box Assembly					
J2	Connector, phone jack, part of Head Box Assembly					
J3	Connector, female: 4 contact H*	125-11	1			
L1	Coil, part of Head Box Assembly					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
M1	Meter	BF*	112-81	1			
P1	This circuit reference not assigned						
P2	Connector, pin	H*	125-99	1			
P3	Connector, male: 4 contact	H*	125-10	1			
R1	Resistor: 50 ohms, part of Head Box Assembly						
R2	Resistor: 4000 ohms, part of Head Box Assembly						
R3, 4	Resistance gage, part of Head Box Assembly						
R5	Resistor: part of Head Box Assembly 1.2 ohms.						
R6	Resistor: part of Head Box Assembly 26.63 ohms						
R7	Resistor: part of Head Box Assembly 50 ohms						
R8	Same as R6						
R9	Resistor: part of Head Box Assembly 144 ohms						
R10	Resistor: part of Head Box Assembly 75 ohms						
R11	Same as R9						
R12	Resistor: part of Head Box Assembly 860 ohms						
R13	Same as R10						
R14	Same as R12						

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
R15	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W	B*	23-220K	4			
R16	Resistor: fixed, composition, 2700 ohms ±10%, 1/2 W	B*	23-2700	1			
R17	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W	B*	23-47K	1			
R18	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W	B*	23-1M	3			
R19	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	B*	23-1K	4			
R20	Same as R15						
R21	Same as R18						
R22	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W	B*	23-680	1			
R23, 24, 25, 26	Resistor: fixed, deposited carbon, 24,700 ohms ±1%, 1/2 W	NN*	33-24.7K	4			
R27	Resistor: fixed, composition, 27,000 ohms ±10%, 1/2 W	B*	23-27K	2			
R28	Resistor: fixed, composition, 3900 ohms ±10%, 1/2 W	B*	23-3.9K	2			
R29	Resistor: fixed, composition, 3.9 megohms ±10%, 1/2 W	B*	23-3.9M	1			
R30	Resistor: fixed, composition, 3.3 megohms ±10%, 1/2 W	B*	23-3.3M	1			
R31	Resistor: fixed, deposited carbon, 50,000 ohms ±1%, 1/2 W	NN*	33-50K	1			
R32	Resistor: variable, composition, linear taper, 5000 ohms	G*	210-15	3			
R33	Resistor: fixed, deposited carbon, 3000 ohms ±1%, 1/2 W	NN*	33-3K	2			
R34	Resistor: fixed, composition, 120,000 ohms ±10%, 1/2 W	B*	23-120K	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R35, 36	Resistor: fixed, deposited carbon, 166,000 ohms ±1%, 1W	NN*	31-166K	2			
R37	Same as R33						
R38	Resistor: wirewound	HP*	434A-26C	1			
R39	Resistor: wirewound	HP*	434A-26D	1			
R40	Resistor: fixed, composition, 390,000 ohms ±10%, 1/2 W	B*	23-390K	1			
R41	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W	B*	23-82K	2			
R42	Resistor: fixed, deposited carbon, 120,000 ohms ±1%, 1/2 W	NN*	33-120K	1			
R43	Same as R15						
R44	Resistor: fixed, composition, 820,000 ohms ±10%, 1/2 W	B*	23-820K	1			
R45	Resistor: fixed, composition, 560 ohms ±10%, 1/2 W	B*	23-560	2			
R46	Resistor: fixed, wirewound, 4000 ohms ±5%, 10 W	R*	26-38	1			
R47, 48	Resistor: fixed, deposited carbon, 600,000 ohms ±1%, 1/2 W	NN*	33-600K	2			
R49	Same as R32						
R50	Same as R41						
R51	Resistor: fixed, composition, 330,000 ohms ±10%, 1/2 W	B*	23-330K	1			
R52	Same as R27						
R53	Same as R18						
R54	Same as R45						

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
R55	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W B*	23-220	1			
R56	Same as R28					
R57	Resistor: fixed, composition, 6800 ohms ±10%, 1/2 W B*	23-6.8K	1			
R58	Resistor: fixed, composition, 12,000 ohms ±10%, 1/2 W B*	23-12K	1			
R59	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W B*	23-22K	1			
R60	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W B*	23-39K	2			
R61	Resistor: fixed, composition, 68,000 ohms ±10%, 1/2 W B*	23-68K	1			
R62	Resistor: fixed, composition, 10 ohms ±10%, 1W B*	24-10	1			
R63, 64, 65	Resistor: fixed, composition, 47 ohms ±10%, 1/2 W B*	23-47	3			
R66	Same as R18					
R67	Resistor: fixed, composition, 470,000 ohms ±10%, 1 W B*	24-470K	1			
R68	Same as R60					
R69, 70	Resistor: fixed, wirewound, 2500 ohms ±10%, 10 W S*	26-7	2			
R71, 72, 73	Same as R19					
R74, 75	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W B*	23-470K	2			
R76	Resistor: variable, composition, linear taper, 100,000 ohms BO*	210-82	1			
R77	Same as R15					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R78	Resistor: fixed, wirewound, 25,000 ohms ±10%, 10 W	S*	26-11	1			
R79	Same as R32						
R80	Resistor: fixed, deposited carbon, 14,400 ohms ±1%, 1 W	NN*	31-14.4K	1			
R81	Resistor: fixed, deposited carbon, 144 ohms ±1%, 1/2 W	NN*	33-144	1			
R82	Resistor: fixed, deposited carbon, 190 ohms ±1%, 1/2 W	NN*	33-190	1			
R83	Resistor: fixed, deposited carbon, 221 ohms ±1%, 1/2 W	NN*	33-221	1			
R84	Resistor: fixed, deposited carbon, 225 ohms ±1%, 1/2 W	NN*	33-225	1			
R85	Resistor: fixed, deposited carbon, 3600 ohms ±1%, 1/2 W	NN*	33-3600	1			
R86	Resistor: fixed, deposited carbon, 6960 ohms ±1%, 1/2 W	NN*	33-6960	1			
R87	Resistor: fixed, deposited carbon, 9380 ohms ±1%, 1/2 W	NN*	33-9380	1			
R88	Resistor: fixed, deposited carbon, 13,200 ohms ±1%, 1/2 W	NN*	33-13.2K	1			
R89	Resistor: fixed, deposited carbon, 25,500 ohms ±1%, 1/2 W	NN*	33-25.5K	1			
R90	Resistor: fixed, composition, 200,000 ohms ±5%, 1/2 W	B*	23-200K-5	1			
RT1	Lamp, incandescent: 3 W, 120 V	N*	211-4	1			
S1	Range Switch Assembly	HP*	434A-19W	1			
S2	Switch, toggle: DPDT	D*	310-54	1			
S3	Switch, toggle: SPST	D*	310-11	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
T1	Transformer, part of Head Box Assembly						
T2	Transformer, audio	Paeco	912-47	1			
T3, 4	Transformer, audio	Paeco	912-52	1			
T5	Transformer, power	Paeco	910-154	1			
V1	Tube, electron: 6AV6	ZZ*	212-6AV6	1			
V2, 3	Tube, electron: 12AT7	ZZ*	212-12AT7	2			
V4	Tube, electron: 12B4A	ZZ*	212-12B4A	4			
V5	Tube, electron: 6AL5	ZZ*	212-6AL5	1			
V6	Tube, electron: 6U8	ZZ*	212-6U8	1			
V7	Tube, electron: 5Y3	ZZ*	212-5Y3	1			
V8	Tube, electron: 6X4	ZZ*	212-6X4	1			
V9,10,11	Same as V4						
V12	Tube, electron: 6AU6	ZZ*	212-6AU6	1			
V13	Tube, electron: OA2	ZZ*	212-OA2	1			
V14	Tube, electron: 5651	ZZ*	212-5651	1			
	MISCELLANEOUS						
	Candelabra socket	AD*	145-15	1			
	Ear Syringe	Seamless Rubber Co.	432-68	1			
	Fuse holder	T*	140-16	1			
	Fan, blade	BD*	314-44	1			
	Face plate, reservoir	HP*	434A-96B-2	1			
	Flow Meter Assembly	HP*	434A-96K	1			
	Ball, glass		427-16	(1)			
	Block, flow meter		434A-96K-1	(1)			
	Fitting, flow meter		434A-96K-2	(2)			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	Gasket, reservoir	Cole Mfr. Co.	432-66	1			
	Head Box Assembly	HP*	434A-96J	1			
	Jewel	HP*	145-23A	1			
	Knob: ZERO SET	HP*	G-74D	2			
	Knob: RANGE	HP*	G-74N	1			
	Lampholder		145-23	1			
	Line Cord	Elec. Cords Co.	812-56	1			
	Nut, oil coupling	HP*	434A-96H-3	20			
	"O" ring: .101 x .070	Cole Mfr. Co.	432-60	20			
	Oil Coupling, male	HP*	434A-96H-2	20			
	Pump and Motor Assembly	HP*	434A-96A	1			
	Reservoir Assembly	HP*	434A-96B	1			
	Adjustment screw, by-pass		434A-96B-8	(1)			
	Filter		315-1	(1)			
	Gasket, rubber: .900 OD		432-45	(1)			
	O ring: 5/16 OD		432-61	(2)			
	O ring: 11/16 OD		432-83	(1)			
	Oil fitting		434A-96G	(5)			
	Plug, reservoir filler		434A-96B-3	(1)			
	Plug, filter		434A-96B-4	(1)			
	Plug, reservoir		434A-96B-5	(1)			
	Plug, by-pass		434A-96B-6	(1)			
	Reservoir		434A-96B-1	(1)			
	Spring		140-46	(1)			
	Radiator Assembly: right	HP*	434A-96E-2	1			
	Radiator Assembly: left	HP*	434A-96E-3	1			
	Silicone oil, Dow Corning 200 Fluid Dow Corning Corp. Midland, Michigan, U.S.A.		850-98				
	Tube socket: 9 pin	AE*	120-10	7			
	Tube socket: 7 pin	AE*	120-11	6			
	Tube socket: octal	AE*	120-27	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

275 PAGE MILL ROAD PALO ALTO. CALIF. U.S.A.

CABLE "HEWPACK"