HEWLETT PACKARD
COMPANY

MODEL 434A

SERIALS PREFIXED: 102 -

OPERATING AND SERVICING MANUAL

hp

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SERIALS PREFIXED: 102 -

CALORIMETRIC POWER METER

01024-1

Printed: APR 1961

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Table 1-1. 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 gc
DC INPUT IMPEDANCE:	50 ohms ±5 ohms at type N input jack
INPUT SWR:	DC to 5 gc: less than 1.3:1 5 to 12.4 gc: less than 1.5:1
METER RESPONSE TIME:	Less than 5 seconds for full scale deflection
INTERNAL CALIBRATOR:	100 mw dc ±1% into 45 to 55 ohms
ACCURACY:	Within ±5% of full scale. Includes dc calibration and rf termination efficiency but not mismatch loss. Greater accuracy can be achieved through appropriate techniques.

ESTIMATED ATTAINABLE ACCURACY:

	Upper Ranges	Two Lowest Ranges
DC	1/2%	2%
0 to 1 gc	1%	3%
1 to 4 gc	2%	4%
4 to 10 gc	3%	5%
10 to 12.4 gc	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 in. wide, 12-3/4 in. high, 14 in. deep. Rack Mount: 19 in. wide, 10-1/2 in. high, 13-3/8 in. deep behind panel.
WEIGHT:	Cabinet Mount: Net 49 lbs, shipping 71 lbs. Rack Mount: Net 44 lbs, shipping 66 lbs.

SECTION I
GENERAL DESCRIPTION

1-1. INTRODUCTION.

1-2. The Model 434A is a power meter which measures power over the range of 1 milliwatt to 10 watts, at any frequency from dc to 12.4 gc. It 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.

1-3. By combining the self-balancing principle with a calorimetric device, fast response has been obtained over the range from 1 milliwatt to 10 watts.

1-4. INSTRUMENT AIR COOLING.

1-5. The instrument is air cooled by a high velocity fan. The incoming air is filtered, sent through the oil system radiator, then circulated throughout the instrument. The filter used for this purpose must be inspected and cleaned frequently to ensure that it is not clogged with dirt (see paragraph 4-4, Periodic Maintenance).

1-6. THREE-CONDUCTOR POWER CABLE.

1-7. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The off-set pin on the power cable three-prong to two-prong connector is the ground wire.

1-8. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

1-9. 230-VOLT CONVERSION.

1-10. The 434A is usually shipped connected for 115-volt 50/60 cps operation but can easily be converted to operation from a nominal 230-volt, 50/60 cps source.

a. Remove the two jumpers (see figure 4-7) which connect the power transformer primary winding in parallel.

b. Connect primary winding in series.

c. Change the line fuse to a 1-ampere slow blow fuse.

1-11. DAMAGE IN TRANSIT.

1-12. This instrument has been thoroughly tested and is ready for use when received. If any damage is apparent, please refer to the warranty sheet.

1-13. RACK MOUNTING.

1-14. When mounting a rack model instrument, leave at least a 3-inch clearance behind the air intake to insure proper air circulation.

1-15. In addition, be certain that the air intake is not near another piece of equipment which is discharging hot air in the vicinity of the Model 434A air intake.

1-16. Slip 434AR into rack and secure.

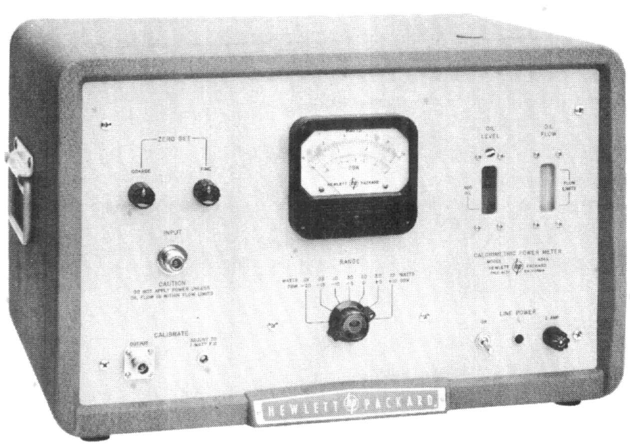


Figure 1-1. Model 434A Calorimetric Power Meter

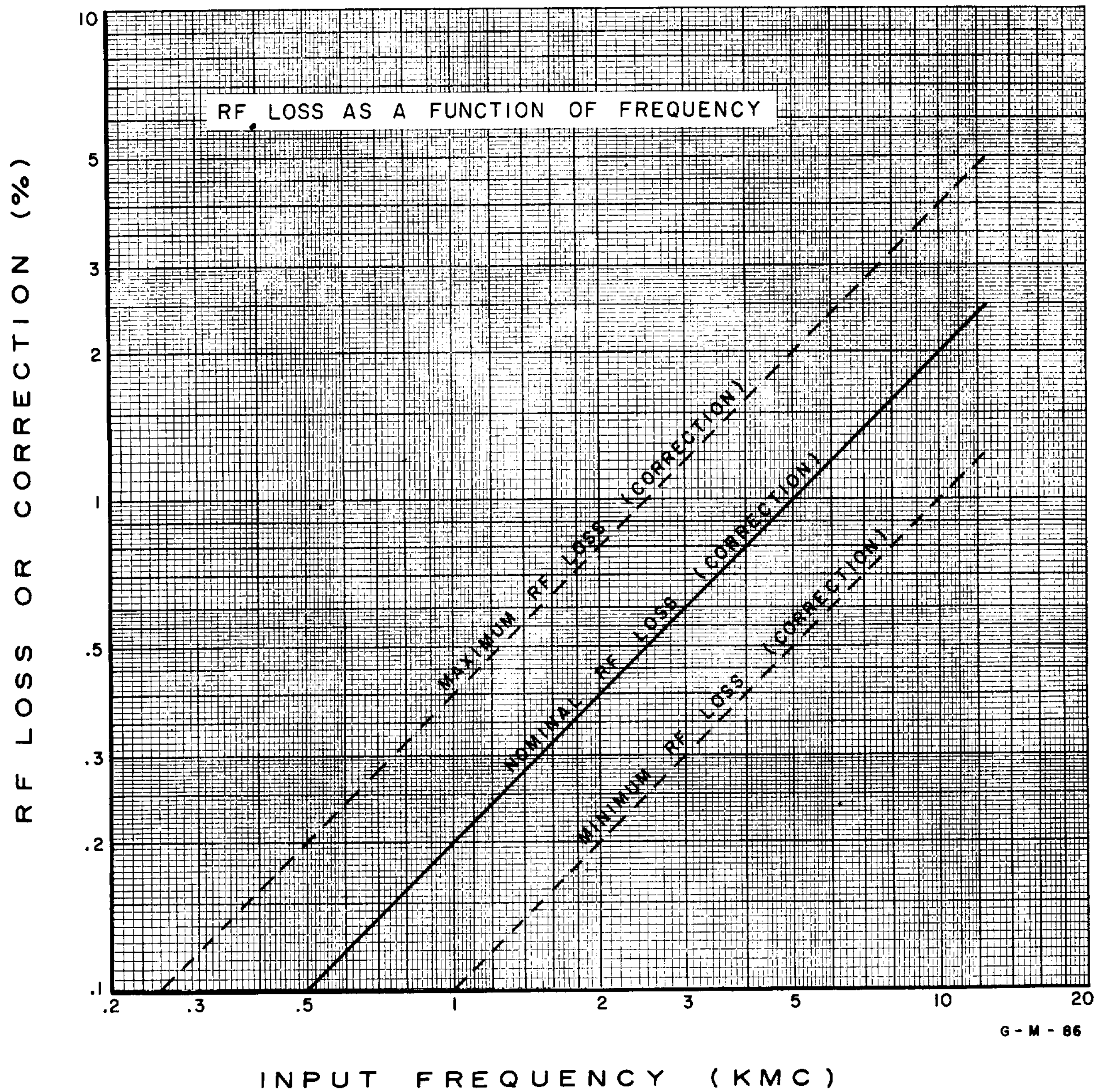


Figure 2-1. RF Loss Showing Probable Limits of Error

SECTION II
OPERATING INSTRUCTIONS

2-1. INTRODUCTION.

2-2. This section contains installation, operating procedures, and operating precautions; in addition, it gives instructions in regard to the adding of oil and oil flow adjustment.

2-3. INSTALLATION.

2-4. The Model 434A Calorimetric Wattmeter should be placed on a work bench or table with at least three inches of clearance at the rear to insure adequate air flow through the filter. To avoid seriously restricted air flow, be careful not to let loose pieces of paper, etc. remain in the rear area since they can be pulled against the air filter.

2-5. The power cable (paragraph 1-6) should be connected to a standard NEMA three-prong grounding receptacle.

2-6. Complete installation instructions for rack model instruments are given in paragraph 1-13.

2-7. Before using this instrument check the oil level. Add silicone oil (Dow Corning 200 fluid vis. at 25°C 1.0 cs) as described in paragraph 2-11.

2-8. CONTROLS AND TERMINALS.

2-9. Controls and terminals are described in figures 2-2 and 2-3.

2-10. OPERATING PRECAUTIONS.

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

b. Never tilt instrument to the point where OIL LEVEL goes below the ADD OIL marker.

c. If 434A has not been used for a period of time (one week) the oil pump leather seal must be lubricated (see paragraph 4-6).

WARNING

APPLY POWER TO INPUT ONLY WHEN THE OIL FLOW AND LEVEL ARE WITHIN THE PRESCRIBED LIMITS.

NEVER APPLY POWER TO THE INPUT CONNECTOR WHEN THE 434A IS TURNED OFF: THE INPUT LOAD MAY BE DAMAGED!

2-11. FILLING THE RESERVOIR.

a. Remove the oil filler plug; see figure 2-2.

b. Fill syringe with silicone oil provided, and insert nozzle into the oil filler hole.

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

d. Replace filler plug.

2-12. OPERATING PROCEDURE.

2-13. See figures 2-2 and 2-3.

2-14. ATTAINABLE ACCURACY.

2-15. Overall accuracy of the 434A is specified as within 5% of full scale. This 5% figure includes rf loss and dc calibration error.

2-16. Accuracy of the 434A can be increased (see Estimated Attainable Accuracy in table 1-1) by the procedures outlined below.

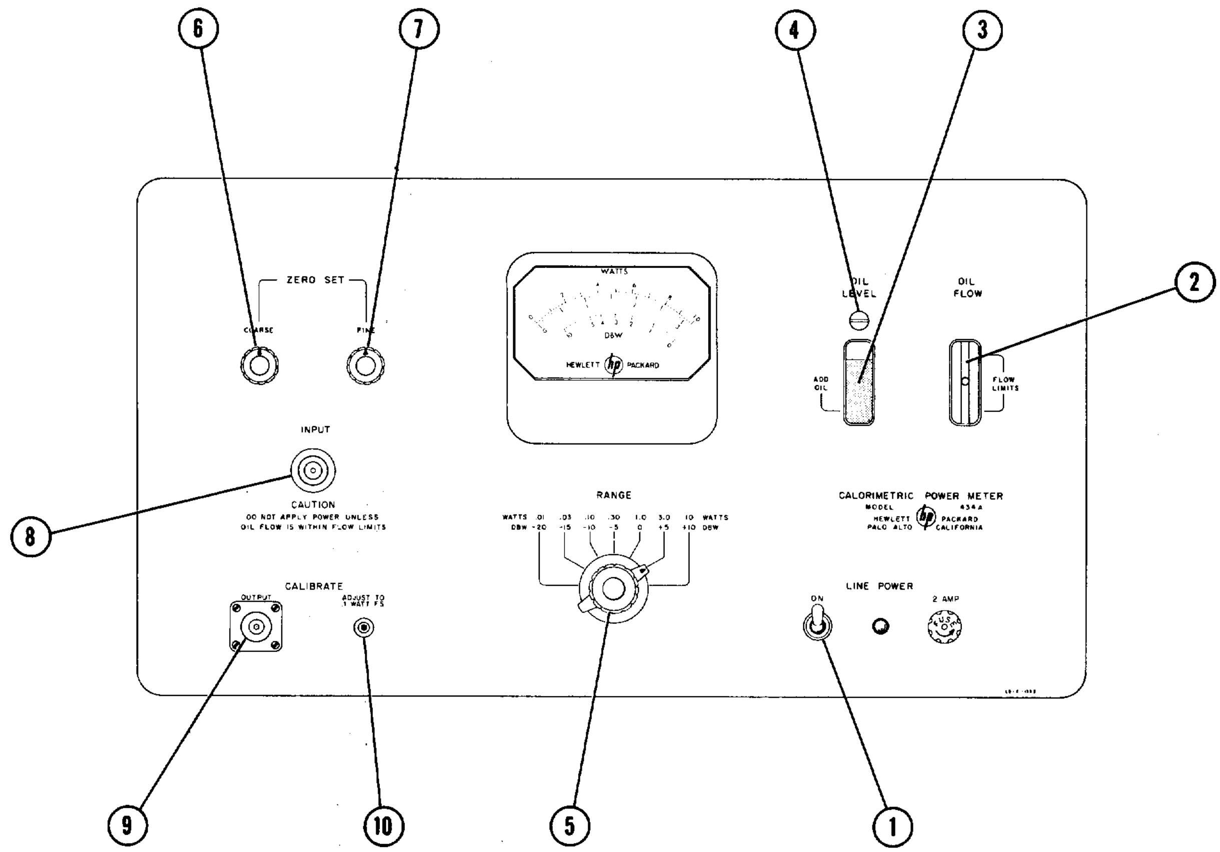
a. Calibrate the 434A with a dc power of known level by adjusting ADJUST TO .1 WATT F. S. (front panel adjustment) for a reading of exactly the level of the input power. With accurate dc instrumentation (K02-434A, see figure 4-5) dc error can be reduced to about ±1/2%.

b. Eliminate mismatch loss with a good low-loss tuner.

c. Add rf loss and tuner loss to the meter reading.

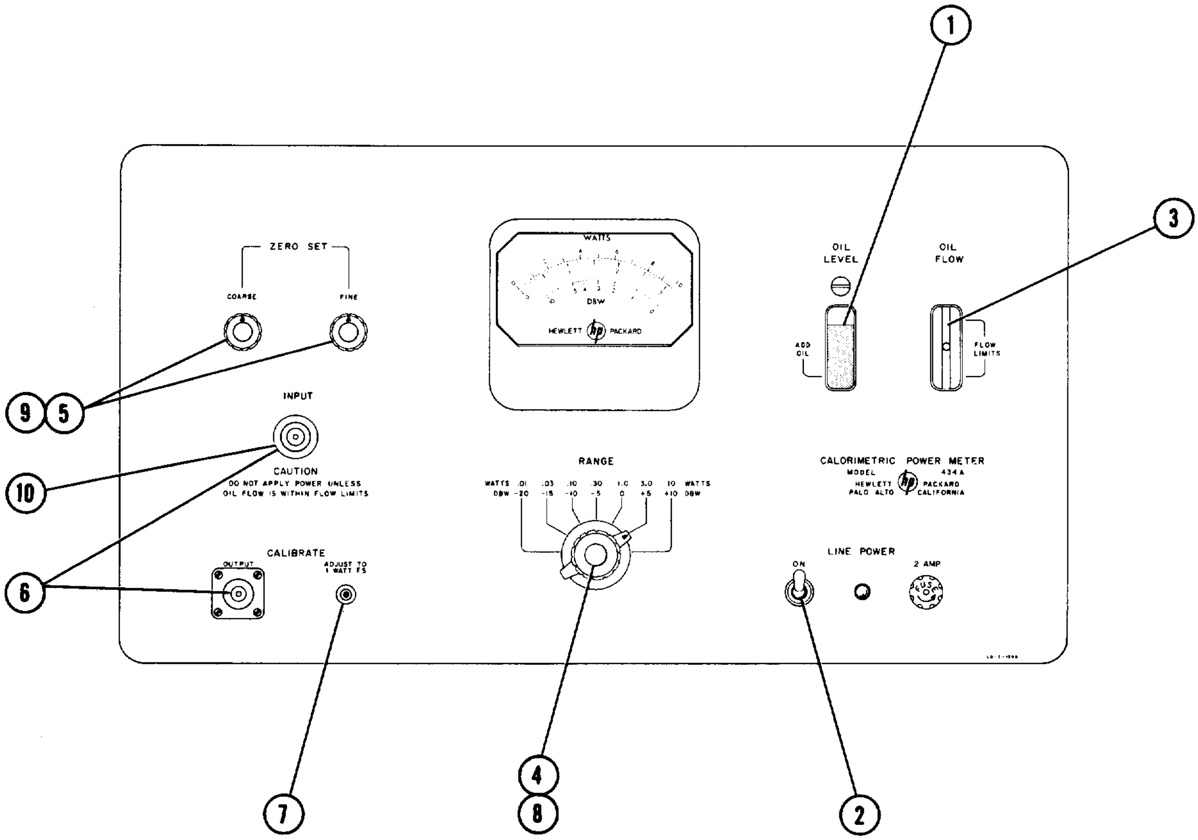
(1) Rf loss is meter reading in watts x % loss. Find % loss from figure 2-1, which gives the nominal correction factor and limits of possible error. For example, at 1 gc the nominal correction factor is 0.002, upper limit is 0.0035, and lower limit is 0.001.

(2) To find tuner loss, measure the insertion loss of the tuner at the setting which tunes out the mismatch.



1. LINE POWER switch.
2. OIL FLOW rate indicator: indicates the rate of oil flow, ball marker should not exceed FLOW LIMITS.
3. OIL LEVEL indicator: indicates the oil level in the reservoir.
4. Oil filler plug: allows filling the reservoir from the front panel.
5. RANGE switch: sets meter range from .01 to 10 watts (full scale) in 7 steps.
6. COARSE control: a coarse zero-set control.
7. FINE control: a fine zero-set control.
8. INPUT: apply power from .01 to 10 watts dc to 12.4 gc.
9. Calibrate OUTPUT supplies .10 watts ± 1% for routine calibration of the 434A.
10. ADJUST TO .1 WATT F. S.: adjusts position of meter pointer to read full scale on .1 WATT range.

Figure 2-2. Operating Controls



1. Check oil level.
2. Turn LINE POWER to ON.
3. Check flow rate.
4. Rotate RANGE switch to .10 WATT.
5. Adjust to zero meter.
6. Connect cable from CALIBRATE OUTPUT to 434A INPUT.
7. Adjust the ADJUST TO .1 WATT F.S. for .1 reading on 434A meter.
8. Select range desired.
9. Readjust to zero meter if necessary.
10. Apply power. (See paragraph 2-14 and figure 2-1 to obtain greatest accuracy from the 434A.)

    Note: If power is removed, the meter pointer will go below zero for a period of approximately 5 seconds, then return to zero reference.

Figure 2-3. Operating Procedure

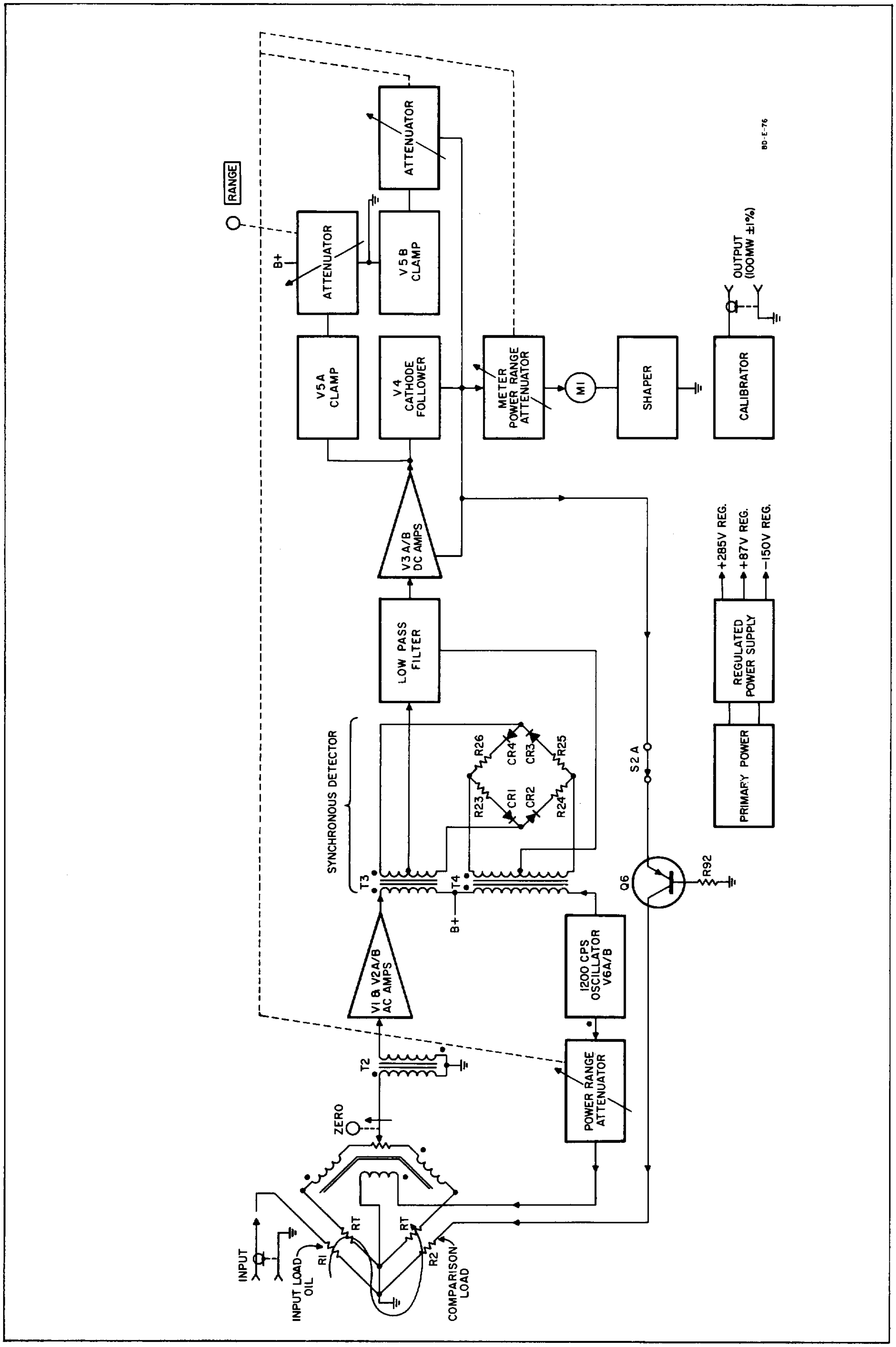


Figure 3-1. Block Diagram

SECTION III
THEORY OF OPERATION

3-1. INTRODUCTION.

3-2. This section describes the circuit operation of the Model 434A Calorimetric Power Meter through the use of the block diagram, figure 3-1, figures 3-2 through 3-5, and the schematic diagrams, figures 4-7 and 4-8. Each major circuit is discussed below.

3-3. The block diagram of the calorimetric power meter is shown in figure 3-1. The power (rf or dc) applied to the 434A INPUT changes the resistance of one leg of the input bridge. Within the 434A, power is applied to the bridge by a 1300 cps signal from the oscillator (V6A/B). The output from the bridge is an ac signal proportional to the power applied to the input connector. The signal from the input bridge is amplified and then detected and filtered at the synchronous detector. The output of the synchronous detector is a dc signal proportional to the power of the signal being measured. This dc signal is then amplified and applied to a meter. The signal to the meter is also fed back to the bridge input so that the comparison leg tracks the input leg. In following the circuit analysis, refer to figures 3-1 through 3-5 and the schematic diagrams, figures 4-7 and 4-8.

3-4. Power connected to the input of the instrument 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 gauge which is one leg of the bridge. The load resistor R1, oil stream, and gauge form the input head of the bridge. A similar comparison head contains another load resistor, R2, and a gauge 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 gauge, 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 gauge and bringing the bridge back towards balance. The meter monitors feedback voltage and is calibrated directly in input power.

3-5. The resistance of each gauge is proportional to the power input in watts, so that each head constitutes a square-law element. Since the comparison head is located inside the feedback loop (see figure 3-2). The loop gain varies with power level and the ratio of feedback power also varies with level. In order to maintain the same gain at any point on the meter scale and on any range, the oscillator drive to the bridge is varied in steps by section S1A of the range switch. Thus for any setting of the RANGE switch the difference between input and feedback powers is, for example, 2% at full scale, 6% at one-tenth scale, etc. This

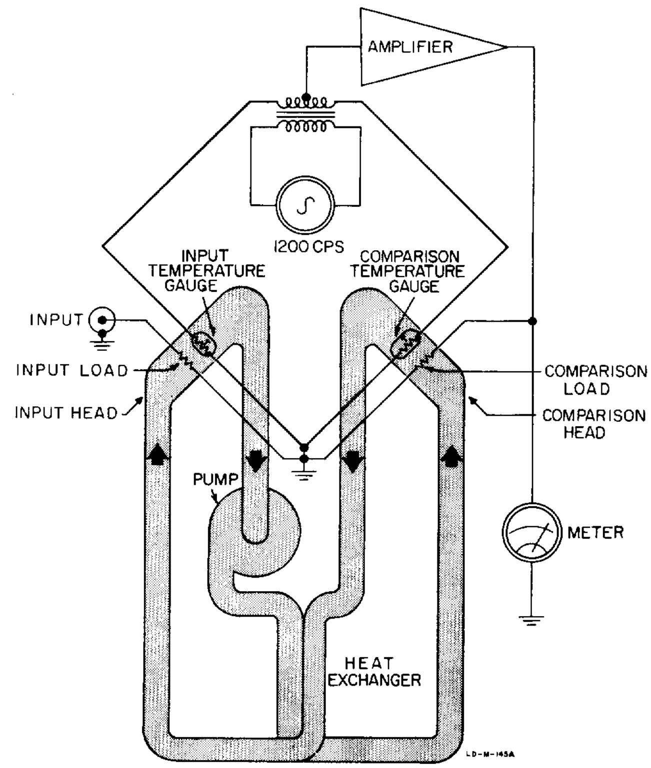


Figure 3-2. Head Box Block Diagram

difference between input and feedback power is calibrated out in the meter circuit to obtain a high degree of accuracy (see paragraph 3-21).

3-6. Since the comparison head is a square-law element ($R \propto E^2$), the resistance change of the gauge is independent of the phase of the feedback voltage. Consequently, reversing the phase of the bridge output causes positive feedback, and the system tends to run away. This condition occurs when the ZERO SET controls move the meter pointer below zero. Transistor Q6, functions as a switch, opening the feedback loop when the meter swings negatively, thereby preventing the runaway condition from occurring.

3-7. DC output polarity of the synchronous detector depends on the relative phase of the two ac voltages applied to the detector circuit. Output is positive for the normal phase signal (in phase condition) from the bridge when the input load is increased or when the ZERO SET controls are turned clockwise from the balanced setting. The synchronous detector output is negative when the phase is reversed (out of phase condition) by turning the ZERO SET controls counterclockwise from the balanced setting. The dc output of the synchronous detector is applied through a two-stage amplifier to a cathode follower V4, whose effective cathode resistor is R2.

3-8. INPUT BRIDGE.

3-9. The input bridge circuit includes the input and comparison load resistors (R1 and R2), their gauges, the bridge transformer (T1), a phase balance control (L1) and the zero-set circuit consisting of R7, R10 and R13. The phase balance control is used to balance out the stray lead inductance and the unbalance caused by transformer leakage inductance. The bridge balance adjustment (R7) 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.

3-10. The ac signal output of the bridge is of the normal phase when the bridge is unbalanced by an input signal to the input load. The phase reverses 180° when the ZERO SET controls unbalance the bridge in the opposite direction.

3-11. SYNCHRONOUS DETECTOR.

3-12. The signal from the input bridge is amplified by a conventional three-stage ac-coupled amplifier and applied to the synchronous detector (figure 3-3) transformer T3. Also applied to the synchronous detector is the oscillator output which is applied to transformer T4. The oscillator signal alternately opens and closes each half of the diode bridge consisting of diodes CR1 through CR4. During one-half cycle, diodes CR3 and CR4 conduct while diodes CR1 and CR2 are held cutoff. During the next half cycle, the situation reverses and diodes CR1 and CR2 conduct while diodes CR3 and CR4 are held cutoff. This action of the diode bridge results in closing a current path between center tap of transformer T3 and, alternately, top terminal (green wire) and bottom terminal (yellow wire) of T3. During the first half cycle, current flows between top terminal (green lead) and center tap of transformer T3. During the second half cycle, current flows between the center tap and the bottom terminal (yellow lead). The circulating circuit path for both halves of the signal from the input bridge pass through back biased diode, CR5.

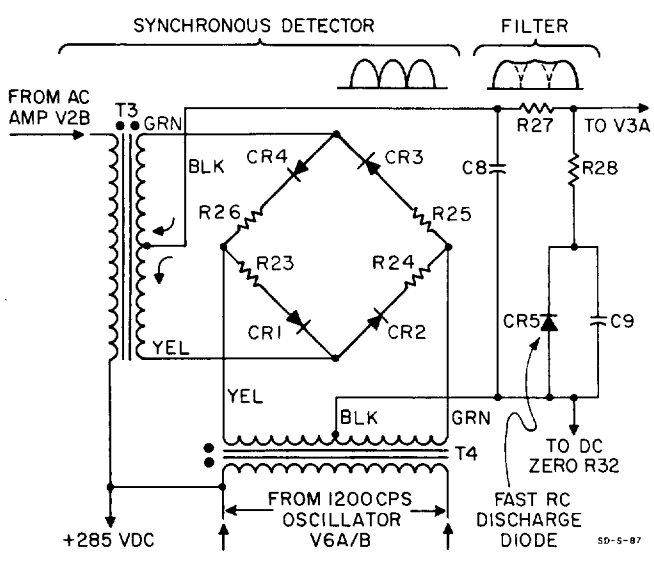


Figure 3-3. Synchronous Detector and Filter

This results in a rectified current to the filter section (figure 3-3). The polarity of this direct current depends upon the phase of the ac signal from the input bridge, and is positive when power is applied to the input load.

3-13. 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 about 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 gauge. The transit time introduces into the feedback loop a phase shift which increases linearly with loop fluxations.

3-14. When the meter pointer is moved below zero, a negative voltage is developed by the synchronous detector and capacitor C9 (see figure 4-8) tend to charge in the reverse direction. In this case the discharge of capacitor C9 would cause a long delay between rotation of the ZERO SET controls and the corresponding movement of the meter pointer upscale. Diode CR5 shunts capacitor C9 to limit its charge and speed its discharge. Thus assuring fast response of the meter.

3-15. DC AMPLIFIER.

3-16. The dc amplifier (figure 3-4) is composed of tube V3 and cathode follower tube V4. The dc amplifier V3A has negative feedback applied to its cathode to improve the linearity and to stabilize the gain. Output cathode follower V4, is biased near cutoff when there is no signal from the synchronous detector. Thus, the cathode follower 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 the cathode follower V4, and resistors R35, R36 and R37, but the cathode is at ground potential so no power is dissipated in the comparison load (R2). When the cathode follower is cut off, its cathode goes below ground and a small current flows in reverse direction from ground through 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 have been moved too far. Positive feedback is applied to the meter circuit, but is prevented from being applied to the comparison head R2 by V5B and switch Q6.

3-17. Following the dc amplifier is duodiode tube V5 which performs two clamping functions.

a. One section, V5A (see figure 3-4), in conjunction with an attenuator operated by section S1D of the RANGE switch limits the signal to the input cathode follower V4. Clamp V5A prevents damage to the meter circuit if the RANGE switch is set to too low a range.

b. The other section V5B, in conjunction with Q6, prevents the reverse current in resistor R2 when the cathode follower is cut off.

3-18. RANGE SWITCH.

3-19. 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 3-5. 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.

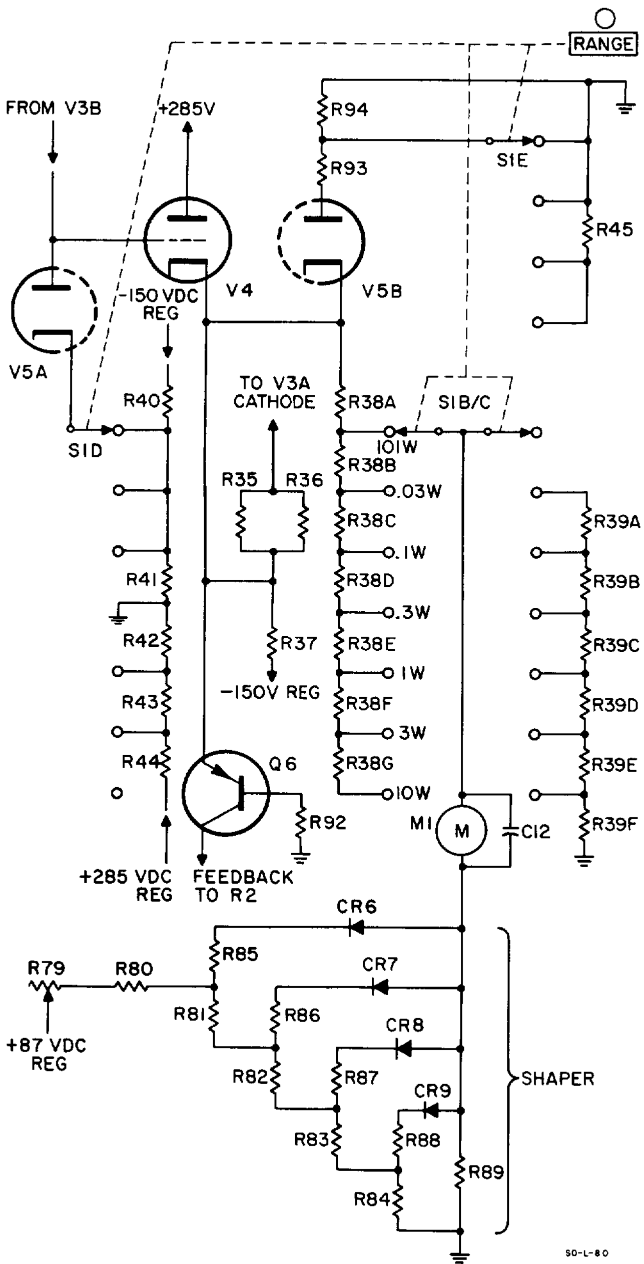


Figure 3-4. Cathode Follower V4, Clamp V5A/B and Shaper

3-20. METER CIRCUIT.

3-21. The portion of the output of the dc amplifier cathode follower which is fed to the meter, M1, is selected by sections S1B and S1C of the RANGE switch. The meter responds to voltage changes, consequently to make the meter read in power, a shaping circuit is included to approximate a square-law response. 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 includes four diodes which are biased by a voltage divider, powered from a well-regulated voltage source. As the voltage to the meter circuit increases, the diodes conduct in turn to reduce the resistance of the meter circuit (see figure 3-5). The difference between an exactly linear characteristic and the approximation actually obtained is calibrated out on the meter face. The calibration also includes the variations between input and feedback power, as described in paragraph 4-38.

3-22. OSCILLATOR.

3-23. The oscillator (see figure 4-8) is a conventional rc oscillator which operates at a fixed frequency of about 1300 cps. Positive feedback is developed at the plate (pin 1) of tube V6B and applied to the grid of the oscillator tube V6A through coupling capacitor C15. Capacitors C13 and C14 and resistors R47 and R48 are effectively a band-pass network, with regenerative feedback selective to a band centered at 1300 cps. Amplitude is stabilized by a non-linear resistance, lamp RT1. Output voltages from the oscillator are supplied to the synchronous detector and, through section S1A of the RANGE switch, to the input bridge.

3-24. OIL SYSTEM.

3-25. The oil-flow system transfers the heat from the input load, R1, to the oil stream which raises the temperature of the input gauge. The same oil-flow system transfers the heat from the comparison load, R2.

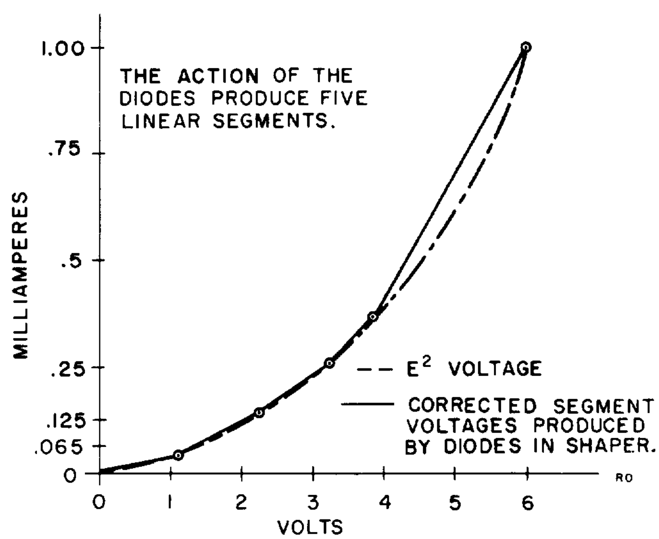


Figure 3-5. Compensating Segments Produced by Shaper Circuit

to the oil stream, raising the temperature of the comparison gauge. The complete oil flow system is shown in figure 3-6. Since the flow 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 the 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 cubic centimeters per minute. If the flow rate goes below its flow limits, the system may oscillate because of excessive phase shift in the feedback loop. If the flow rate goes above its flow limits, the noise level of the system increases.

3-26. The cooling radiators are directly in front of the intake air filter at the rear of the chassis. A blower circulates air through the radiator maintaining a cooling flow of air past the radiator fins.

3-27. 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 minimizing the difference in stream temperatures reduces the required zero-set range.

3-28. Figure 3-6 is a functional diagram of the signal flow and oil flow into the two head assemblies. The signal to be measured is coaxially coupled to a silver-coated glass rod which passes the energy to the 50-ohm resistance film coating on the end of the glass rod, heating the film. The input oil absorbs the heat from the film, then passes through the nickel-wire gauge. The gauge consists of about two feet of 1-mil nickel wire (approximately 100 ohms) wound on a metal bobbin. The nickel wire is heated by the oil stream and changes resistance. This is the input bridge input gauge. After flowing through a radiator assembly and the heat exchanger, the same oil passes around a precise 4000-ohm wirewound resistance which has been heated by the feedback comparison dc current. The heat absorbed by the oil stream raises the temperature of another nickel wire gauge, identical to the one in the input gauge. The latter is the input bridge comparison gauge. The series oil flow makes the bridge operation independent of changes in the oil flow rate (refer to figure 3-6).

3-29. POWER SUPPLY.

3-30. The power supply (see figure 4-8) includes a conventional full wave rectifier (tube V7) and a series-type voltage regulator (tubes V9, V10 and V11) which regulates for both line and load variations and provides regulated +285 vdc. Any change in the +285-volt output

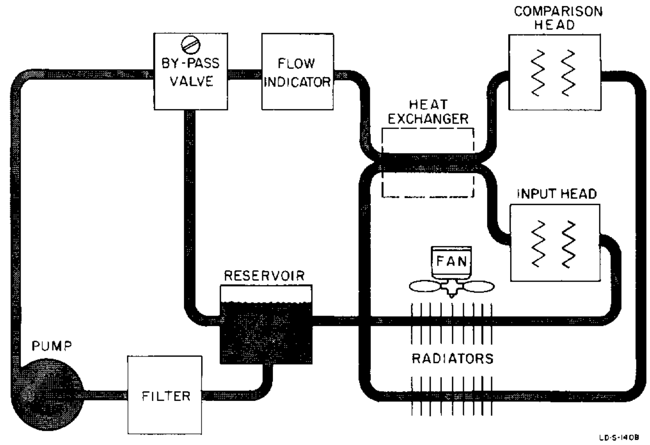


Figure 3-6. Oil Flow Diagram

is sampled at the junction of resistors R75 and R78 and applied to the grid of the control tube V12. The resulting change in the plate voltage of tube V12 changes the bias on V9, V10 and V11, and this changes the resistance in series with the output, restoring the voltage to normal. Sudden surges and ripple are ac-coupled through capacitor C24 to the grid of the control tube. Further ripple regulation is provided by the control tube V12 screen grid which is connected to the plates of the series regulator tubes V9 and V10 through voltage divider R66 and R67.

3-31. There is also a half-wave rectifier (tube V8) which supplies -150 vdc regulated by a glow discharge tube (V13). A portion of the +285-volt power is tapped and regulated by tube V14 to provide +87 vdc to the meter circuit.

3-32. CALIBRATOR.

3-33. The calibrator is a highly regulated transistorized power supply which supplies 100 milliwatts to the calibrator output into a 50.00 ohm load. It consists of a series regulator, Q4, an emitter follower Q5, a differential amplifier Q1 and Q2, and a temperature compensating emitter follower, Q3. Reference voltage for the differential amplifier is supplied by step regulator CR21 and CR22. Any tendency to vary at the calibrator output is applied to the differential amplifier, compared with the reference voltage, and sent as compensating voltage to series regulator, Q4.

3-34. The temperature compensating emitter follower Q3, is sensitive to variations and therefore used to compensate for the temperature drift of the reference source.

SECTION IV
MAINTENANCE

4-1. INTRODUCTION.

4-2. This section gives necessary maintenance information and also describes a simple check of overall performance.

4-3. CABINET REMOVAL.

a. Remove the rear cover. Four screws hold it in place.

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

c. Lift the cabinet towards the top of the instrument and off.

4-4. PERIODIC MAINTENANCE.

4-5. 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.

4-6. Every 3 months lubricate the lower motor bearing with several drops of light machine oil (see figures 4-2 and 4-4).

WARNING

The leather seal (see figs. 4-2 and 4-4) must be lubricated weekly with light machine oil.

4-7. TUBE REPLACEMENT CHART.

4-8. Table 4-1 lists the electron tubes used in the Model 434A and indicates which adjustments should be made when a tube is replaced.

4-9. CLEANING THE OIL FILTER.

4-10. The oil filter removes particles from the oil stream which otherwise might plug the gauge 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 held by a hexagonal nut housing located on top of the reservoir. To clean the oil filter:

a. Disconnect the oil line connected to the oil filter housing. Be careful not to lose the small rubber O-ring.

b. Remove the filter housing.

c. Remove the larger O-ring which retains the oil filter.

d. Remove the oil filter.

e. Wash the filter in 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.

f. Reinstall the filter.

4-11. EQUIPMENT NEEDED. (See table 4-2)

4-12. POWER SUPPLY ADJUSTMENT.

CAUTION

When the 434A is on and the pump motor is operating, never tilt the instrument beyond the OIL LEVEL-ADD OIL marker point. This condition causes air to be introduced into the oil system which will in turn cause unstable readings.

4-13. The series regulated power supply is referenced to a regulated -150 volt supply. Consequently it is necessary that -150 volt supply be checked before adjusting +285 volt supply.

Table 4-1. Tube Replacement Chart

Tube	Check or Adjustment
V1	Adjust dc calibration, Paragraph 4-30.
V2	Same as V1
V3	Compare accuracy of lower ranges with upper ranges. Reset DC Zero, R32. Paragraph 4-24.
V4	Same as V3. Check accuracy with 10 watt input.
V5	Check operation of the Clamp, Paragraph 4-28.
V6	Check Oscillator output to bridge and Synchronous Detector, Paragraph 4-16.
V7-V13	Check regulation and ripple, Paragraphs 4-14 and 4-15.
V14	Adjust dc calibration, Paragraph 4-30.
CR1-CR4	Check residual output of Synchronous Detector, Paragraph 4-22.
CR5	Compare accuracy of lower ranges with upper ranges. Check Synchronous Detector performance, Paragraph 4-20. Check meter behavior below zero, Paragraph 3-12.
CR6-CR9	Check meter tracking, Paragraph 4-30.

4-14. -150 VDC ADJUSTMENT.

a. Connect dc vtvm leads between pin 2 of V13 and ground.

b. Vary line voltage from 103 to 126 vac; variations in -150 volt supply must not vary more than ±2.5 VDC from high to low line.

c. If variations are excessive change V13.

d. Connect ac vtvm leads between pin 2 of V13 and ground.

e. Vary power line voltage from 103 to 126 vac. Ripple voltage should be less than 15 mv with RT1 removed.

4-15. +285 VDC ADJUSTMENT.

a. With power line voltage at 115 vac, connect dc vtvm leads between +285 VDC line and ground.

b. Adjust +285V Adj., R76 for a reading of +285 VDC on the dc vtvm.

c. Vary power line voltage from 103 to 126 vac. Variations must not exceed ±2.5 VDC.

d. Connect an ac vtvm from +285 VDC line to ground.

e. Vary line voltage from 103 to 126 VAC, ripple voltage should not exceed 15 mv with RT1 removed.

4-16. OSCILLATOR.

4-17. OSCILLATOR OUTPUT ADJUSTMENT.

a. Set 434A RANGE switch to .3 WATTS.

b. Attach an ac vtvm such as 400D from pin 8 of V6 to ground.

c. Adjust Oscillator Level Adj., R49 for 4 volts rms (±.2 volts).

d. Connect an ac vtvm to pin 1 of V6, the reading on the ac vtvm should be 40 to 50 volts rms.

4-18. FREQUENCY AND DISTORTION CHECK.

a. Connect 330B AF INPUT to pin 8 of V6.

b. 330B settings:
Function selector switch . . . . set LEVEL
Range switch 100%
Level control . . . . Adjust for 100%

c. Rotate function selector switch to DISTORTION.

d. Adjust frequency to minimum reading on 330B meter. (Distortion must be less than 2%.)

e. Read frequency on 330B (equal to oscillator frequency) which must be between 1200 to 1350 cps.

Table 4-2. Recommended Test Equipment

Equipment Type	Critical Characteristics	Use	Recommended Instruments
AC Voltmeter	Voltage Range: 10 to 15 millivolts Input Impedance: ≧ 3 megohms	Power supply adjustment Oscillator output adjustment	(hp) Model 400D Vacuum Tube Voltmeter (hp) Model 330B Distortion Analyzer
DC Voltmeter	Voltage Range: .5 to 500 volts Input Impedance: ≧ 10 megohms	Power supply adjustment	(hp) Model 412A DC Voltmeter
Oscilloscope	Bandwidth: dc to 1500 cps Sensitivity: 1 volt/cm	Oscillator phasing balance adjust	(hp) Model 130A/B Oscilloscope (hp) Model 150A Oscilloscope
Distortion Analyzer	Distortion Measurement Range: fundamental frequencies, 1000 to 1500 cps. Accuracy: distortion of 1% full scale	Synchronous gain check	(hp) Model 302A Wave Analyzer (hp) Model 330B Distortion Analyzer
Accurate DC Test Set	Voltage Range: .3 to 25 volts Accuracy: .25%	DC accuracy check Compensated error check	(hp) Model K02 434A DC Test Set (hp) Model 721 Power Supply * Fluke 801 *
Precision DC Voltmeter	Range: 2 volts Accuracy: .05%	Calibrator output adjust	Non-linear Systems, Inc. V34 or V35 Fluke 801

* The Fluke 801 and (hp) Model 721 Power Supply must be used together to obtain the readings required.

4-19. OSCILLATOR PHASING.

a. Using an oscilloscope such as the 130A/B or 150A, connect the positive vertical lead to the plate, pin 1 of V6B, the positive horizontal lead to the cathode pin 8 of V6B and the two common leads to ground. Note: The vertical and horizontal gain must be equal at the deflection plates of the oscilloscope.

b. There should be a straight diagonal line on the oscilloscope from the second to the fourth quadrant (see figure 4-1).

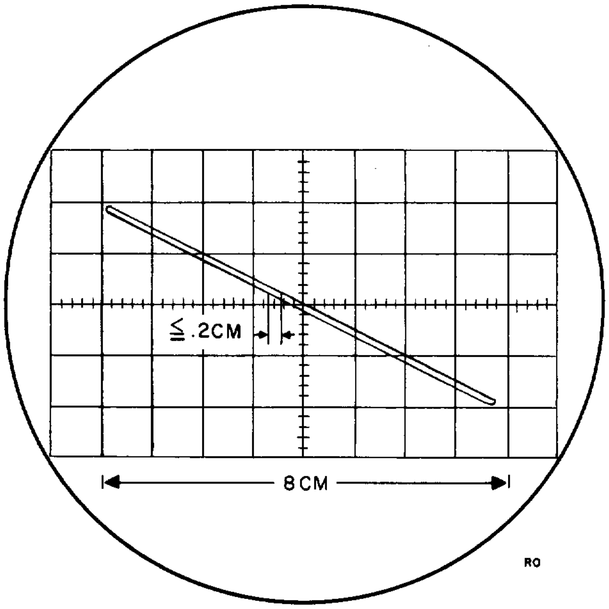


Figure 4-1. CRT Presentation of Oscillator Phasing

4-20. SYNCHRONOUS DETECTOR.

4-21. The synchronous detector has no adjustment. However, it is a critical circuit and its proper operation is imperative to overall operation. To judge its operation both balance and gain must be measured.

4-22. RESIDUAL DC.

a. Unplug P3.

b. Place dc vtvm common lead to center tap of R32.

c. Place dc vtvm positive lead to junction of C8 and R27.

d. Place an ac vtvm in parallel with dc vtvm.

CAUTION

Both points from which voltage is measured are at about -150 volts dc from ground. Special precautions in regard to isolation must be used if a vtvm referenced to power line ground is used.

e. Pad one or more resistors, R23 through R26, to obtain a voltage between 0 and .2 volts concurrent with the lowest obtainable residual ac voltage. No padding resistor should be less than 1 megohm.

f. Reconnect P3.

4-23. SYNCHRONOUS DETECTOR GAIN.

a. Connect ac meter on 330B to pin 1 of V2.

b. Rotate 434A RANGE switch to .3 WATTS and adjust COARSE (R10) front panel control for 2 volts rms at pin 1, V2.

c. With vtvm connected as directed in paragraph 4-22C, reading should be between 1.7 and 2 vdc. This corresponds to a gain of .85 to 1.0. The minimum allowable gain is .85.

4-24. DC ZERO ADJUST.

a. Unplug P3.

b. Set power line voltage to 130 vac.

c. Set 434A RANGE switch to 1.0 watts.

d. Adjust DC Zero Adj., R32 to zero the 434A meter reading.

e. Set power line voltage to 115 vac.

f. Reconnect P3.

4-25. PHASE BALANCE ADJUST.

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

b. 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. To check phase shift characteristics of the vertical and horizontal amplifiers of the oscilloscope connect the terminals of both amplifiers between ground and V6B, pin 8. The pattern on the oscilloscope should be a straight diagonal line.

c. Set RANGE to .03 WATTS.

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

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

4-26. ADJUST BRIDGE BALANCE.

4-27. This adjustment should be made after the synchronous detector has been balanced and the dc zero adjusted.

a. Set front panel ZERO SET controls mid-range.

b. Set RANGE switch to .3 WATTS.

c. Adjust Bridge Bal., R7 so meter pointer is resting between 0 and .1 watts on the .3 watt range, R7 is on top of the head box assembly.

4-28. V5 CLAMPING ACTION CHECK.

a. Connect a dc vtvm (+300 volt range) between pin 2, V5 and chassis ground.

b. Rotate 434A RANGE switch to 10 WATTS and apply power in excess of 3 watts into the 434A INPUT jack.

c. Place the 434A RANGE switch in the 3 WATT position. The dc vtvm reading should not be less than +115 vac.

d. With the same power input check the other ranges (see table 4-3).

Table 4-3. Clamp Voltages

RANGE switch	Maximum Plate Voltage Pin 2, V5
1. WATT	+50 VDC
.3 "	+ 5.5 "
.1 "	- 14 "
.03 "	- 14 "
.01 "	- 14 "

4-29. The clamping action checked here ensures that the meter is protected in the cases where power input at the 434A INPUT is in excess of full scale RANGE setting selected.

4-30. PERFORMANCE CHECK.

4-31. Overall accuracy of the 434A can be checked easily in two steps:

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

b. Determine that the impedance of the input circuit is within specifications.

4-32. If the 434A calibration is off, see paragraph 4-38. Two methods for checking dc calibration are given; method 1, shown in figure 4-5, uses ℗ specification K02 434A DC Test Set, an instrument specifically designed for testing and adjusting the 434A. Specification K02 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 ADJUST TO .1 WATT F. S., R79. This procedure is described in paragraph 4-40. Method 2 replaces the specification K02 434A with a dc power supply and a dc voltmeter (see table 4-2). These meters should be accurate within 1/4% (since power = E^2/R) to measure input power within 1/2%.

4-33. TO CHECK DC ACCURACY.

4-34. METHOD 1. See figure 4-5.

4-35. METHOD 2.

a. Use a dc power supply and two meters as specified above to measure input power to the 434A.

b. Compare the indicated power with input power for full scale deflection of each range. Set ADJUST TO .1 WATT F. S., R79, for best compromise on all ranges. Indicated power should agree with calculated input power within percentage accuracy of instrument involved. Check meter tracking on lowest and highest ranges.

4-36. TO MEASURE INPUT IMPEDANCE.

4-37. Input impedance from dc to 12.4 gc can be measured with conventional techniques and equipment.

4-38. MEASURING COMPENSATED ERROR.

4-39. There exists a 2% difference between the power applied at the input load and the feedback power applied to the comparison load. Thus if 10 watts were applied at the input, 9.8 watts would be fed back to the comparison load. This 2% error is compensated for at the meter with the ADJUST TO .1 WATT F. S. (front panel). Other errors should be kept to 6% or less. Two methods of measuring compensated error are described; method 1, which uses the ℗ specification K02 434A, and method 2, which uses conventional precision instrument. If after measuring the compensated error it is found that the error is greater than 2%, see paragraph 4-45.

4-40. METHOD 1. See figure 4-6.

4-41. METHOD 2. This approach replaces the K02 434A with a power supply and a dc meter. The meter preferably should be accurate to ±1/4%.

a. Check dc accuracy, paragraph 4-30.

b. Set RANGE to .3 WATTS.

c. Connect a source of power to the INPUT and adjust its output (about 4 volts rms or dc) to align the meter pointer to 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 10.

d. Measure the dc voltage at V4, pin 1. The 6% power error voltages are +34.1 volts and +36.3 volts (35.2 volts = zero error, full scale).

4-42. TROUBLE LOCATION.

4-43. Table 4-4 lists symptoms, possible causes, and paragraph references.

Table 4-4. Trouble Location

Symptom	Possible Cause	Paragraph Reference
10 watt range reads low or has excessive response time	Low gain Low osc. drive	4-44 4-16
.01 watt range reads low	DC zero requires adjustment CR5 defective V3 defective	4-24 4-20 4-13
Excessive compensated error	Low gain Low osc. drive R2 off value R3 or R4 defective	4-44 4-16 4-45 4-47

4-44. MEASURING GAIN.

a. Remove RT1 to disable the oscillator.

b. Set the RANGE to 10 watts.

c. Connect a 1300-cps signal to the grid of a stage and measure the voltage on the plate. Table 4-5 lists the nominal gains for the ac amplifiers, less than 80% of the nominal gain indicates the tube should be replaced.

Table 4-5. 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

d. Turn pump off, set RANGE switch to 1.0 WATT.

e. Install RT1 and adjust ZERO SET (meter upscale) to obtain 2.0 volts rms on V2B, pin 1.

f. Voltage on V4, pin 1 should be +36 vdc or more. If this voltage is below 28.5 vdc try changing V3.

4-45. EXCESSIVE COMPENSATED ERROR.

4-46. If compensated error appears to be greater than ± 6%:

a. 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 4-47.

b. 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.

4-47. HEAD BOX REPLACEMENT.

4-48. Repair of the head-box assembly, Hewlett-Packard stock number 434A-96J, in your Model 434A Calorimetric Power Meter is best accomplished by replacement of the complete head-box assembly. Fast factory exchange service will provide you with a replacement head box to assure maximum continuous use of your power meter.

4-49. If the head box in your instrument is suspected to be defective, a new one should be ordered, and be on hand before the defective box is removed. On receipt of the exchange head box, complete the procedure below under paragraph 4-50. Return the defective head box to the factory. Full credit will be allowed less normal repair costs. Note: Save the exchange head-box shipping carton for packaging defective unit.

4-50. HEAD BOX REPLACEMENT PROCEDURE.

4-51. The head box assembly contains the input and comparison loads, parallel-flow heat exchanger, and resistive temperature gauges. The head box assembly is an intricate and precision assembly. No attempt to repair it should be made in the field.

4-52. To remove head box assembly:

a. Remove the cabinet (refer to paragraph 4-3).

b. Refer to figure 4-3, bottom view. Leave instrument on its back and remove the two truss-head screws which anchor head box assembly from bottom. Unplug coaxial cable, P2, at the head box.

c. Turn instrument right side up and unplug P3 (see figure 4-2).

d. Pad oil line connection area with cleaning tissue to absorb oil drip. Disconnect the four oil lines from the head box (see note, paragraph 4-49). Save neoprene "O" rings on oil line connectors.

e. Remove the three lengths of tubing at rear of head box.

f. Remove ZERO SET knobs and knurled nut on INPUT connector.

g. Move head box assembly back and up. Be careful not to apply force to the two oil line connectors at rear of box. These are part of the gauge assemblies and may be damaged.

h. Lift out defective head box.

4-53. INSTALLATION OF REPLACEMENT HEAD BOX.

a. Mount replacement head box and bolt to chassis with truss-head screws.

b. Replace knurled nut on INPUT connector.

c. Set COARSE and FINE, ZERO SET controls to their mechanical midranges. Install knobs with arrows pointing "up".

d. Remove oil line connector caps from head box. Install these caps on defective head box immediately.

e. Install the three rear oil line sections. Connect all four oil lines to head box.

f. Plug in connector P3.

g. Turn instrument bottom side up and connect P2.

Note: Cleanliness is vital. Do not break oil lines until replacement head box is on hand. Oil lines must not be left open and exposed to dust contamination. Transfer oil line caps from exchange unit to defective head box.

4-54. ADJUSTMENT PROCEDURE.

a. Turn instrument ON. PUMP switch (near V4) must be ON.

b. Observe oil flow rate. Adjust to center of flow limits.

c. Add oil to reservoir if necessary (Dow Corning 200 Fluid, vis. at 25°C 1.0 cs).

d. Allow instrument to run for 15 minutes to stabilize and to clear air from oil lines.

e. Refer to paragraphs directed below and complete the calibration procedures under:

(1) Paragraph 4-12 to 4-15, Power Supply Adjustment.

(2) Paragraph 4-16 to 4-19, Oscillator.

(3) Paragraph 4-20 to 4-23, Synchronous Detector.

(4) Paragraph 4-24, Adjust DC Zero.

(5) Paragraph 4-25, Adjust Phase Balance.

(6) Paragraph 4-26, Adjust Bridge Balance.

(7) Paragraph 4-28, Clamp Operation Check.

(8) Paragraph 4-33, To Check DC Accuracy.

4-55. HEAD BOX SHIPMENT.

a. Be sure oil line connector caps are in place.

b. Pack head box assembly in carton in which exchange head box assembly was received or in a strong well-padded container.

c. Ship to: CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

4-56. CALIBRATOR ADJUSTMENT.

a. Connect a precision dc vtvm (see table 4-2) between ground and the CALIBRATOR OUTPUT.

b. If voltage at CALIBRATOR OUTPUT is not 2.238 volts ±.5%, parallel R212 with a resistor (1/2 watt) to bring within specifications.

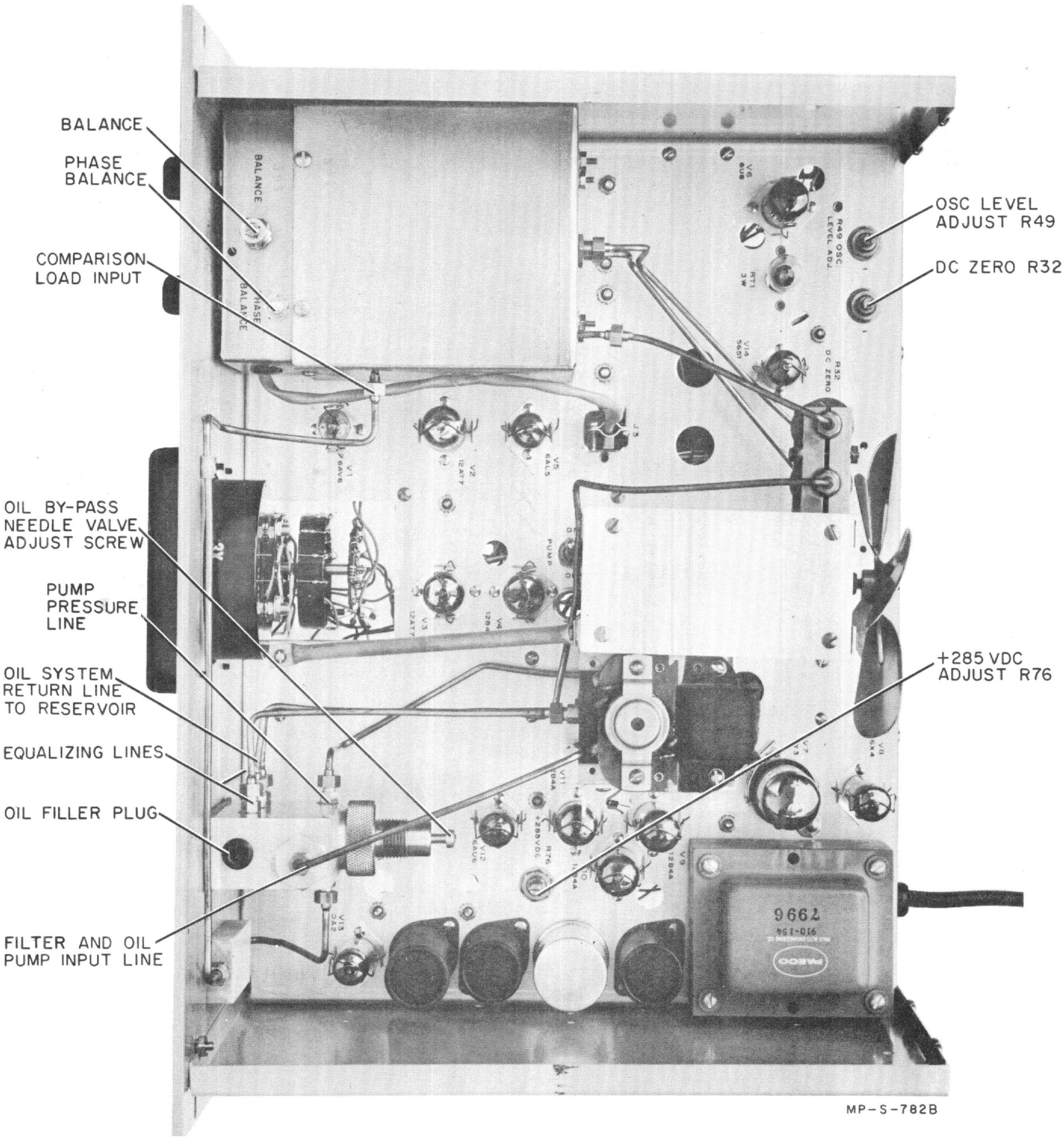


Figure 4-2. Top View of Model 434A

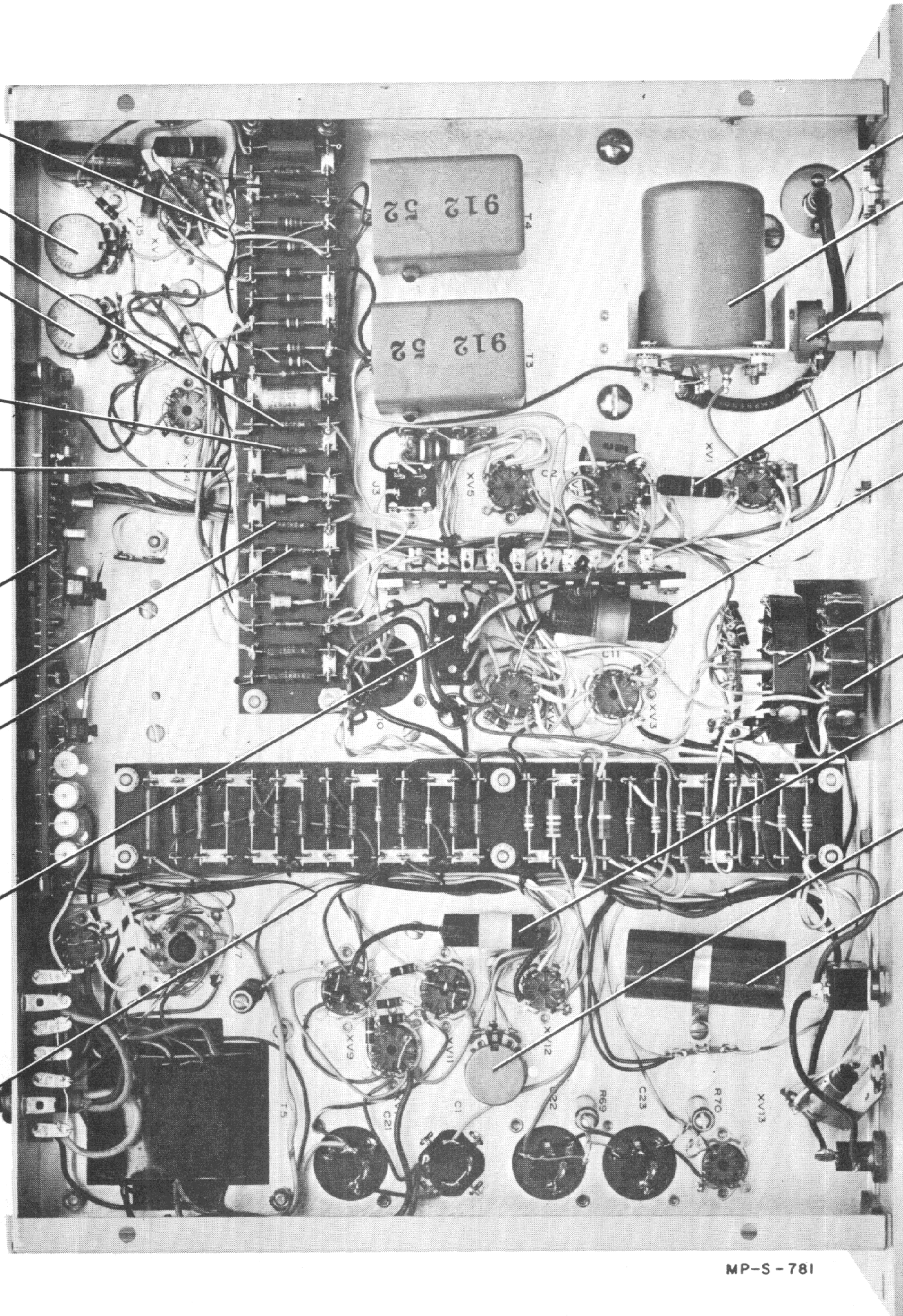


Figure 4-3. Bottom View of Model 434A

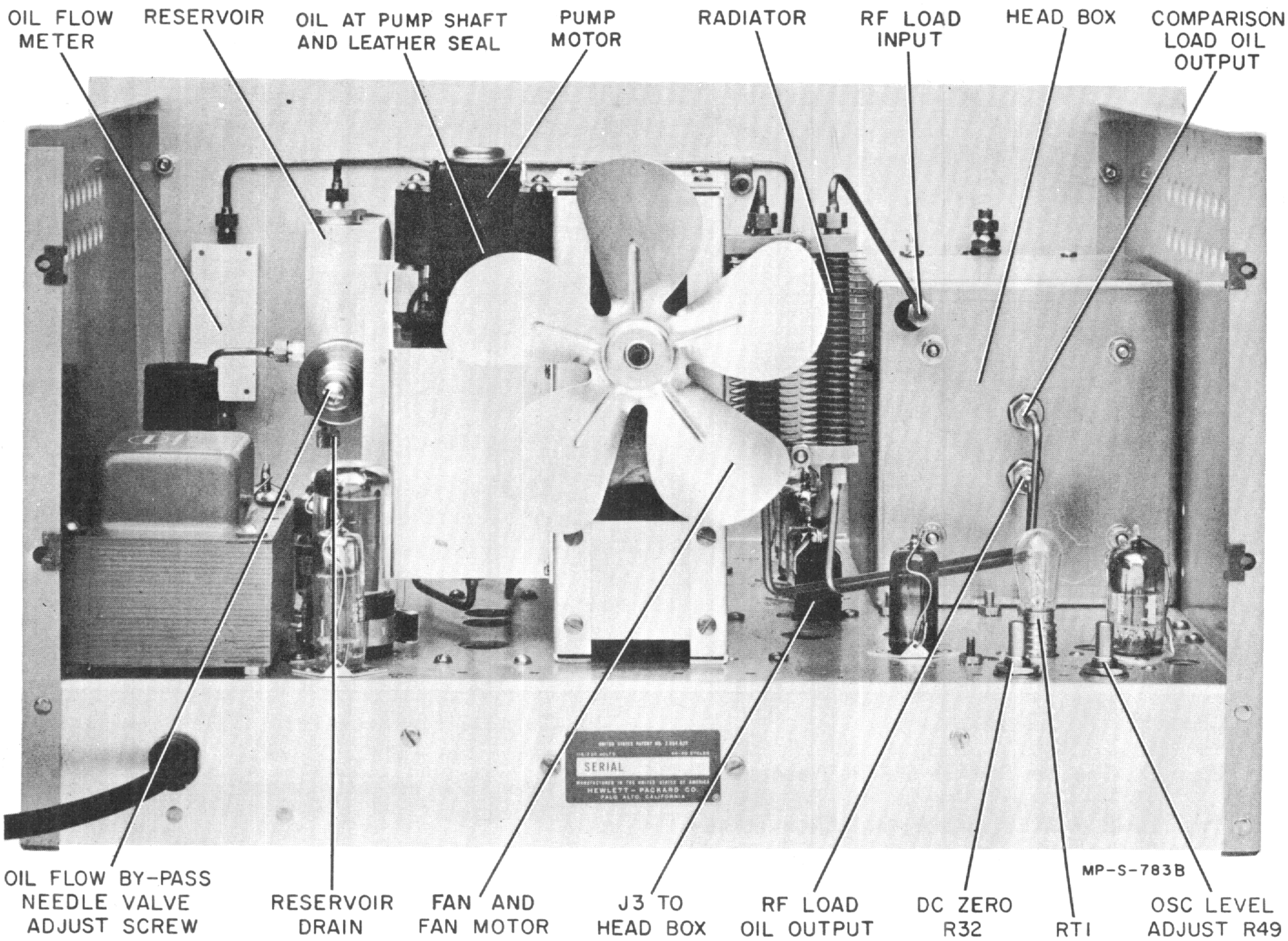
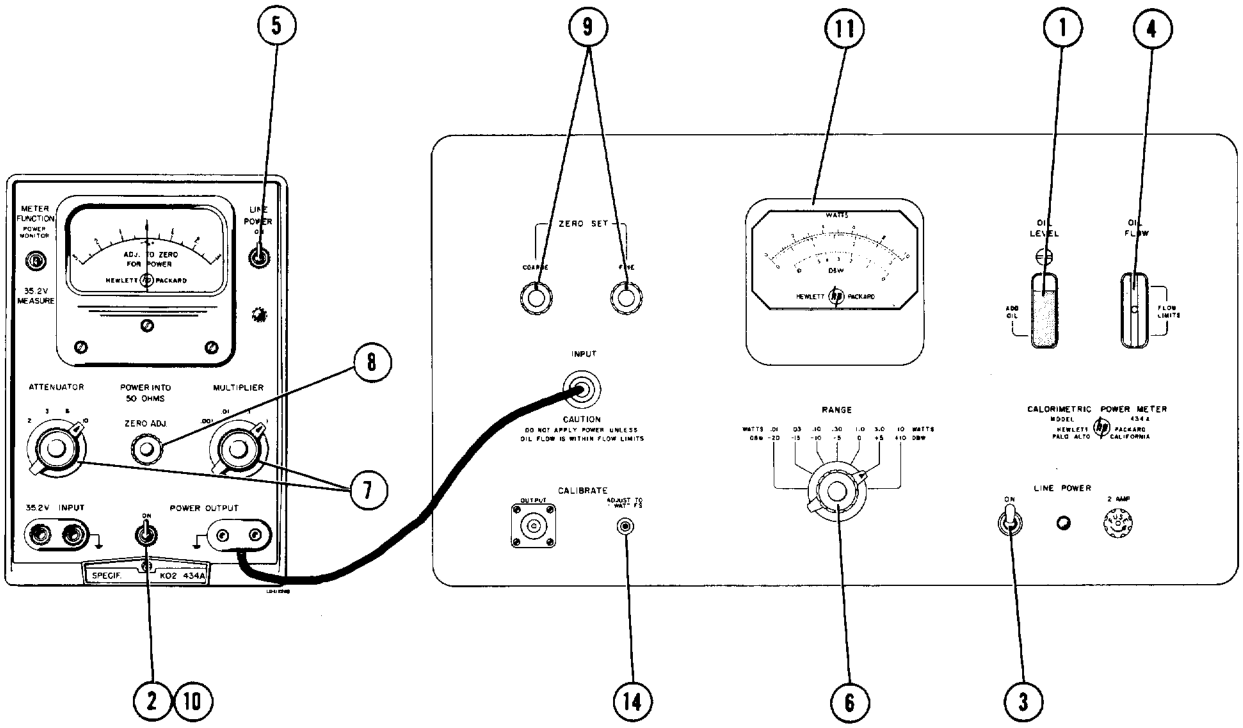


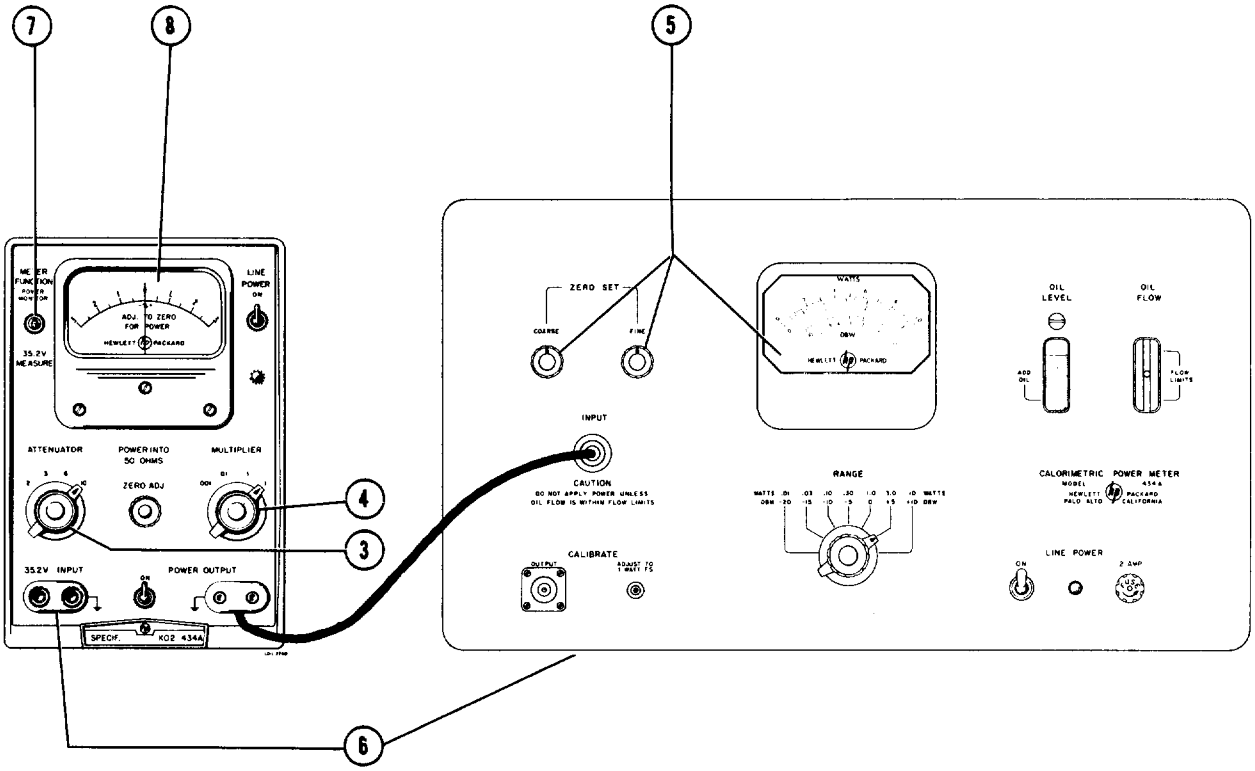
Figure 4-4 Rear View of Model 434A



1. Check the OIL LEVEL.
2. Turn DC Test Set POWER OUTPUT switch off.
3. Turn LINE POWER switch on. Allow 30 minutes for warmup.
4. Verify that the oil is within FLOW LIMITS.
5. Turn LINE POWER switch on. Allow 15 minutes for warmup.
6. Set RANGE switch to .01 watts.
7. Set switches to CPM range setting.
8. Zero-set % error meter with the ZERO-ADJ. control.
9. Zero-set the CPM meter using the ZERO-SET control.
10. Turn DC Test Set POWER OUTPUT switch on.
11. Read CPM and note deviation from full scale indication.
12. Repeat steps 6 through 11 for all ranges.
13. Check CPM meter tracking on .01 and 10 watt range. (On the 0 to 1 scale, track the meter with the Test Set ATTENUATOR set to 3, 6, and 10.)
14. Adjust front panel control (ADJUST TO .1 WATT F.S.) for best compromise in minimizing the distributed error noted in steps 11 and 13.

Note: The internal CALIBRATOR, 434A is used as a quick check and calibration of the Calorimetric Power Meter (see figure 2-3).

Figure 4-5. Checking DC Calibration of Calorimetric Power Meter (CPM)



1. Check dc calibration as described in figure 2-3.
2. Set to .3 watts.
3. Set to 3.
4. Set to .1.
5. Adjust CPM meter to read full scale on the 0 to 1 scale (0.316 watt).
6. Connect feedback line and chassis ground from the CPM to the 35.2V INPUT. (The feedback voltage is taken from pin 1 of V4 in the 434A).
7. Depress to 35.2V MEASURE.
8. Read % error in CPM feedback voltage. If compensated voltage error is greater than ± 3%, see paragraph 4-42, Trouble Location, in the Model 434A Operating and Servicing Manual.

Figure 4-6. Measuring Compensated Error in Calorimetric Power Meter (CPM)

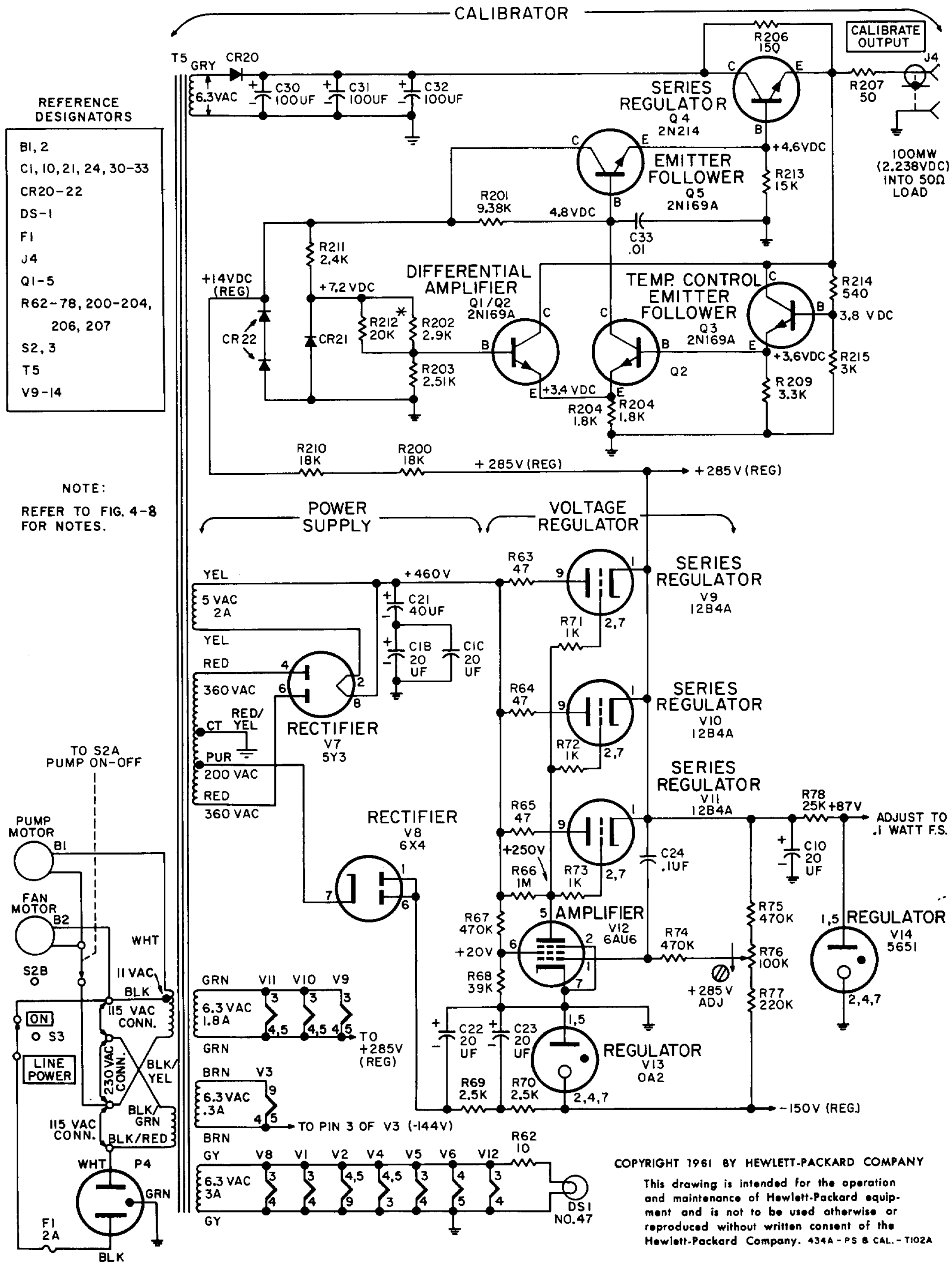
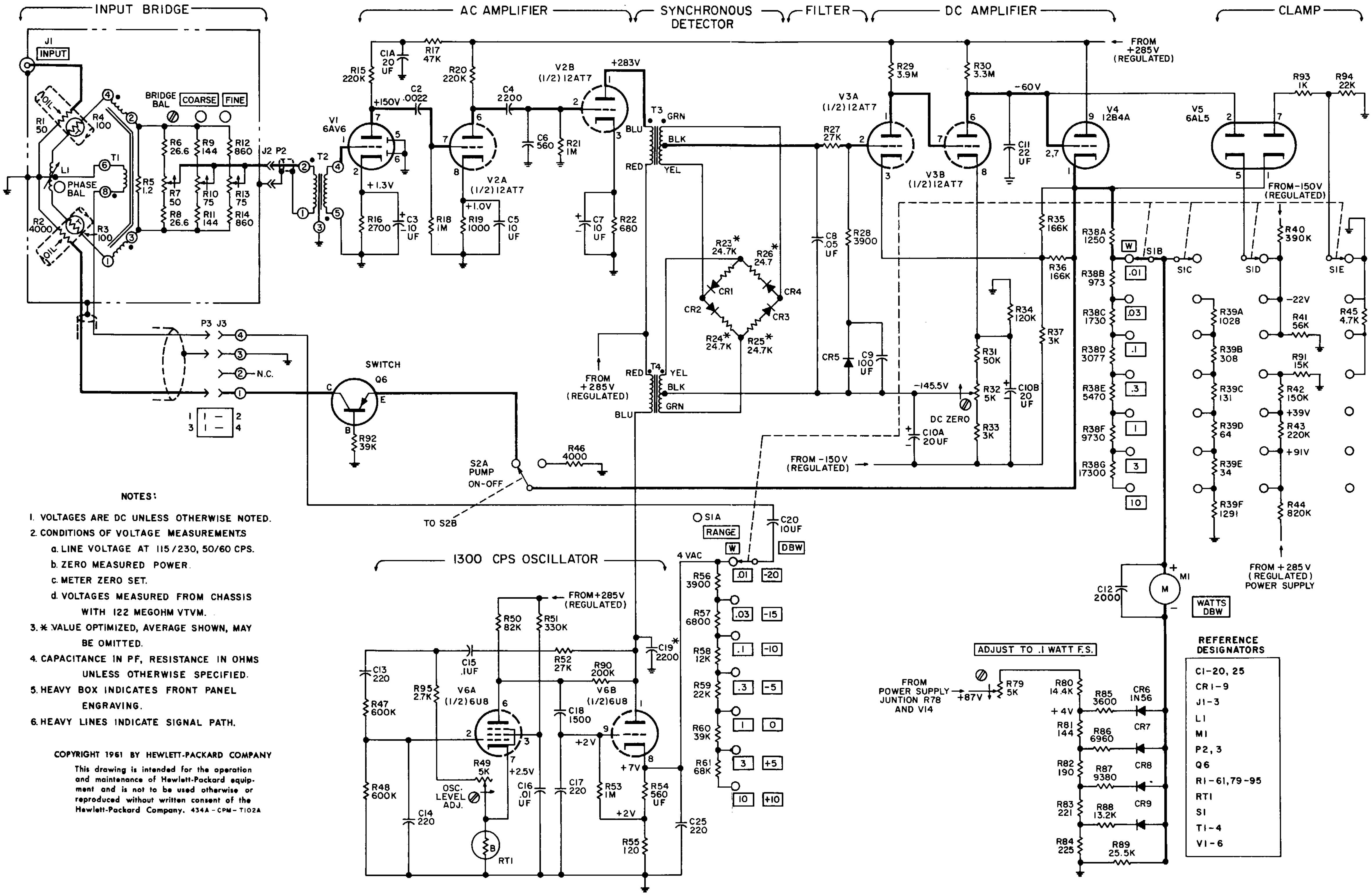


Figure 4-7. Power Supply and Calibrator



NOTES:

1. VOLTAGES ARE DC UNLESS OTHERWISE NOTED.
2. CONDITIONS OF VOLTAGE MEASUREMENTS
   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 PF, RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED.
5. HEAVY BOX INDICATES FRONT PANEL ENGRAVING.
6. HEAVY LINES INDICATE SIGNAL PATH.

 434A-CPM-T102A

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION.

5-2. This section contains information for ordering replacement parts for the 434A Calorimetric Power Meter.

5-3. Table 5-1 lists replaceable parts in alpha-numerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

a. Reference designator.

b. Full description of the part.

c. Manufacturer of the part in a five-digital code; see list of manufacturers in appendix.

d. Hewlett-Packard stock number.

e. Total quantity used in the instrument (TQ col).

f. Recommended spare quantity for complete maintenance during one year of isolated service (RS col).

5-4. ORDERING INFORMATION.

5-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales office or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland

5-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

5-7. To order a part not listed in table 5-1, give a complete description of the part and include its function and location.

Table 5-1. Replaceable Parts (Sheet 1 of 11)

Ckt Ref.	Description	Mfr *	hp Stock No.	TQ*	RS*		
B1	Pump Motor See Pump and Motor Assembly (Misc.)						
B2	Motor	73793	3140-0010	1	1		
C1	Capacitor: fixed, electrolytic, 4 sections, 20 μf/sect., 450 vdcw	56289	0180-0025	1	1		
C2	Capacitor: fixed, paper, 2200 pf $\pm 10\%$, 600 vdcw	56289	0160-0012	3	1		
C3	Capacitor: fixed, electrolytic, 10 μf, 10 vdcw	56289	0180-0032	4	1		
C4	Same as C2						
C5	Same as C3						

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 2 of 11)

Ckt Ref.	Description	Mfr *	hp Stock No.	TQ*	RS*		
C6	Capacitor: fixed, mica, 560 pf ±10%, 500 vdcw	00853	0140-0044	1	1		
C7	Same as C3						
C8	Capacitor: fixed, paper, .051 μf ±10%, 200 vdcw	00853	0170-0003	1	1		
C9	Capacitor: fixed, electrolytic, 100 μf, 12 vdcw	56289	0180-0039	4	1		
C10	Capacitor: fixed, electrolytic, 2 sections, 20 μf/sect., 450 vdcw	56289	0180-0012	1	1		
C11	Capacitor: fixed, paper, .22 μf ±10%, 400 vdcw	56289	0160-0018	1	1		
C12	Capacitor: fixed, electrolytic, 2000 μf, 6 vdcw	14655	0180-0002	1	1		
C13, 14	Capacitor: fixed, mica, 220 pf ±5%, 500 vdcw	76433	0140-0083	3	1		
C15	Capacitor: fixed, paper, .1 μf ±10%, 400 vdcw	56289	0160-0013	2	1		
C16	Capacitor: fixed, paper, .01 μf ±10%, 600 vdcw	56289	0160-0002	1	1		
C17	Same as C13						
C18	Capacitor: fixed, paper, 1500 pf ±10%, 600 vdcw	56289	0160-0012	1	1		
C19	Same as C2 Optimum value selected at factory. Average value shown.						
C20	Same as C3						
C21	Capacitor: fixed, electrolytic, 4 sections, 40 μf/sect., 450 vdcw	56289	0180-0024	1	1		
C22, 23	Capacitor: fixed, electrolytic, 20 μf, 450 vdcw	56289	0180-0011	2	1		
C24	Same as C15						
C25	Capacitor: fixed, mica, 220 pf ± 5%, 500 vdcw	00853	0140-0068	1	1		
C26 thru C29	Not assigned						
C30 thru C32	Same as C9						
C33	Capacitor: fixed, paper, .01 μf ±20%, 400 vdcw	56289	0160-0054	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 3 of 11)

Ckt Ref.	Description	Mfr *	hp Stock No.	TQ*	RS*		
CR1 thru CR4	Diode, silicon: 1N603A	81483	1901-0005	4	4		
CR5	Diode, germanium: 1N56A	08792	1910-0009	1	1		
CR6 thru CR9	Diode, germanium	73293	1910-0011	4	4		
CR10 thru CR19	Not assigned						
CR20	Diode, silicon: 100 PIV, 500 ma	81483	1901-0008	1	1		
CR21	Diode, silicon	28480	G-29A-25	1	1		
CR22	Diode, silicon	28480	G-172J	1	1		
DS1	Lamp, incandescent: 6-8V, .15 amp, #47	24455	2140-0009	1	1		
F1	Fuse, cartridge: 2 amp, 125V	71400	2110-0006	1	10		
J1	Connector, R.F., part of Head Box Assembly; not separately replaceable						
J2	Connector, phone jack part of Head Box Assembly; not separately replaceable						
J3	Connector, female: 4 contact	71785	1251-0011	1	1		
L1	Coil, part of Head Box Assembly not separately replaceable						
M1	Meter	65092	1120-0064	1	1		
P1	Power cable	70903	8120-0015	1	1		
P2	Connector, pin	71785	1251-0076	1	1		
P3	Connector, male: 4 pin	71785	1251-0010	1	1		
Q1 thru Q3	Transistor: selected 2N169A	28480	1851-0010	4	4		
Q4	Transistor: 2N214	93332	1851-0009	1	1		
Q5	Same as Q1						
Q6	Transistor: 2N650	04713	1850-0048	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 4 of 11)

Ckt Ref.	Description	Mfr *	hp Stock No.	TQ*	RS*		
R1	Resistor: 50 ohms, part of Head Box Assembly; not separately replaceable						
R2	Resistor: 4000 ohms, part of Head Box Assembly; not separately replaceable						
R3, 4	Resistance gauge, part of Head Box Assembly; not separately replaceable						
R5	Resistor: 1.2 ohms, part of Head Box Assembly; not separately replaceable						
R6	Resistor: 26.63 ohms, part of Head Box Assembly; not separately replaceable						
R7	Resistor: 50 ohms, part of Head Box Assembly; not separately replaceable						
R8	Same as R6						
R9	Resistor: 144 ohms, part of Head Box Assembly; not separately replaceable						
R10	Resistor: 75 ohms, part of Head Box Assembly; not separately replaceable						
R11	Same as R9						
R12	Resistor: 860 ohms, part of Head Box Assembly; not separately replaceable						
R13	Same as R10						
R14	Same as R12						
R15	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W	01121	0687-2241	4	1		
R16	Resistor: fixed, composition, 2,700 ohms ±10%, 1/2 W	01121	0687-2721	2	1		
R17	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W	01121	0687-4731	1	1		
R18	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W	01121	0687-1051	4	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 5 of 11)

Ckt Ref.	Description	Mfr *	hp Stock No.	TQ*	RS*		
R19	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121	0687-1021	5	2		
R20	Same as R15						
R21	Same as R18						
R22	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W	01121	0687-6811	1	1		
R23 thru R26	Resistor: fixed, deposited carbon, 24,700 ohms ±1%, 1/2 W Optimum value selected at factory. Average value shown.	19701	0727-0178	4	1		
R27	Resistor: fixed, composition, 27,000 ohms ±10%, 1/2 W	01121	0687-2731	2	1		
R28	Resistor: fixed, composition, 3,900 ohms ±10%, 1/2 W	01121	0687-3921	2	1		
R29	Resistor: fixed, composition, 3.9 megohms ±10%, 1/2 W	01121	0687-3951	1	1		
R30	Resistor: fixed, composition, 3.3 megohms ±10%, 1/2 W	01121	0687-3351	1	1		
R31	Resistor: fixed, deposited carbon, 50,000 ohms ±1%, 1/2 W	19701	0727-0195	1	1		
R32	Resistor: variable, composition, linear taper, 5000 ohms	71590	2100-0011	3	1		
R33	Resistor: fixed, deposited carbon, 3,000 ohms ±1%, 1/2 W	19701	0727-0124	3	1		
R34	Resistor: fixed, composition, 120,000 ohms ±10%, 1/2 W	01121	0687-1241	1	1		
R35, 36	Resistor: fixed, deposited carbon, 166,000 ohms ±1%, 1W	19701	0730-0076	2	1		
R37	Same as R33						
R38A thru R38G	Resistor: fixed, wirewound, Part of Range Switch Assembly	28480	434A-26C	1	1		
R39A thru R39F	Resistor: fixed, wirewound, Part of Range Switch Assembly	28480	434A-26D	1	1		
R40	Resistor: fixed, composition, 390,000 ohms ±10%, 1/2 W	01121	0687-3941	1	1		
R41	Resistor: fixed, composition, 56,000 ohms ±10%, 1/2 W	01121	0687-5631	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 6 of 11)

Ckt Ref.	Description	Mfr *	ⓗⓟ Stock No.	TQ*	RS*		
R42	Resistor: fixed, composition, 150,000 ohms ±10%, 1/2 W	01121	0687-1541	1	1		
R43	Same as R15						
R44	Resistor: fixed, composition, 820,000 ohms ±10%, 1/2 W	01121	0687-8241	1	1		
R45	Resistor: fixed, composition, 4,700 ohms ±10%, 1/2 W	01121	0687-4721	1	1		
R46	Resistor: fixed, wirewound, 4,000 ohms ±5%, 10 W	75042	0815-0003	1	1		
R47, 48	Resistor: fixed, deposited carbon, 600,000 ohms ±1%, 1/2 W	19701	0727-0246	2	1		
R49	Same as R32						
R50	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W	01121	0687-8231	1	1		
R51	Resistor: fixed, composition, 330,000 ohms ±10%, 1/2 W	01121	0687-3341	1	1		
R52	Same as R27						
R53	Same as R18						
R54	Resistor: fixed, composition, 560 ohms ±10%, 1/2 W	01121	0687-5611	1	1		
R55	Resistor: fixed, composition, 120 ohms ±10%, 1/2 W	01121	0687-1211	1	1		
R56	Same as R28						
R57	Resistor: fixed, composition, 6800 ohms ±10%, 1/2 W	01121	0687-6821	1	1		
R58	Resistor: fixed, composition, 12,000 ohms ±10%, 1/2 W	01121	0687-1231	1	1		
R59	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121	0687-2231	2	1		
R60	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W	01121	0687-3931	2	1		
R61	Resistor: fixed, composition, 68,000 ohms ±10%, 1/2 W	01121	0687-6831	1	1		
R62	Resistor: fixed, composition, 10 ohms ±10%, 1 W	01121	0690-1001	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 7 of 11)

Ckt Ref.	Description	Mfr *	hp Stock No.	TQ*	RS*		
R63 thru R65	Resistor: fixed, composition, 47 ohms ±10%, 1/2 W	01121	0687-4701	3	1		
R66	Same as R18						
R67	Resistor: fixed, composition, 470,000 ohms ±10%, 1 W	01121	0690-4741	1	1		
R68	Same as R60						
R69, 70	Resistor: fixed, wirewound, 2500 ohms ±10%, 10 W	35434	0816-0005	2	1		
R71 thru R73	Same as R19						
R74, 75	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W	01121	0687-4741	2	1		
R76	Resistor: variable, composition, linear taper, 100,000 ohms	71450	2100-0063	1	1		
R77	Same as R15						
R78	Resistor: fixed, wirewound, 25,000 ohms ±10%, 10 W	35434	0816-0009	1	1		
R79	Same as R32						
R80	Resistor: fixed, deposited carbon, 14,400 ohms ±1%, 1 W	19701	0730-0034	1	1		
R81	Resistor: fixed, deposited carbon, 144 ohms ±1%, 1/2 W	19701	0727-0047	1	1		
R82	Resistor: fixed, deposited carbon, 190 ohms ±1%, 1/2 W	19701	0727-0052	1	1		
R83	Resistor: fixed, deposited carbon, 221 ohms ±1%, 1/2 W	19701	0727-0058	1	1		
R84	Resistor: fixed, deposited carbon, 225 ohms ±1%, 1/2 W	19701	0727-0060	1	1		
R85	Resistor: fixed, deposited carbon, 3600 ohms ±1%, 1/2 W	19701	0727-0128	1	1		
R86	Resistor: fixed, deposited carbon, 6960 ohms ±1%, 1/2 W	19701	0727-0145	1	1		
R87	Resistor: fixed, deposited carbon, 9380 ohms ±1%, 1/2 W	19701	0727-0154	3	1		
R88	Resistor: fixed, deposited carbon, 13,200 ohms ±1%, 1/2 W	19701	0727-0165	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 8 of 11)

Ckt Ref.	Description	Mfr *	ℏ Stock No.	TQ*	RS*		
R89	Resistor: fixed, deposited carbon, 25,500 ohms ±1%, 1/2 W	19701	0727-0180	1	1		
R90	Resistor: fixed, composition, 200,000 ohms ±5%, 1/2 W	01121	0686-2045	1	1		
R91	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W	01121	0687-1531	2	1		
R92	Resistor: fixed, composition, 39,000 ohms ±10%, 2 W	01121	0693-3931	1	1		
R93	Same as R19						
R94	Same as R59						
R95	Same as R16						
R96 thru R199	Not assigned						
R200	Resistor: fixed, composition 18,000 ohms ±10%, 2 W	01121	0693-1831	2	1		
R201	Same as R87						
R202	Resistor: fixed, deposited carbon, 2900 ohms ±1%, 1/2 W	19701	0727-0123	1	1		
R203	Resistor: fixed, deposited carbon, 2510 ohms ±1%, 1/2 W	19701	0727-0122	1	1		
R204	Resistor: fixed, deposited carbon, 1800 ohms ±1%, 1/2 W	19701	0727-0112	1	1		
R205	Not assigned						
R206	Resistor: fixed, composition, 150 ohms ±10%, 1/2 W	01121	0687-1511	1	1		
R207	Resistor: fixed, deposited carbon, 50 ohms ±1%, 1/2 W	19701	0727-0023	1	1		
R208	Not assigned						
R209	Resistor: fixed, composition, 3300 ohms ±10%, 1/2 W	01121	0687-3321	1	1		
R210	Same as R200						
R211	Resistor: fixed, composition, 2400 ohms ±5%, 1/2 W	01121	0686-2425	1	1		
R212	Resistor: fixed, deposited carbon, 20,000 ohms ±1%, 1/2 W Optimum value selected at factory Average value shown	19701	0727-0173	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 9 of 11)

Ckt Ref.	Description	Mfr *	ⓗ Stock No.	TQ*	RS*		
R213	Same as R91						
R214	Resistor: fixed, deposited carbon, 540 ohms ±1%, 1/2 W	19701	0727-0078	1	1		
R215	Same as R33						
RT1	Lamp, incandescent: 3 W, 120V	24455	2140-0001	1	1		
S1	Range Switch Assembly	28480	434A-19W	1	1		
S2	Switch, toggle: DPDT	04009	3101-0005	1	1		
S3	Switch, toggle: SPST	04009	3101-0001	1	1		
T1	Transformer, part of Head Box Assembly Not separately replaceable						
T2	Transformer, audio	28480	9120-0023	1	1		
T3, 4	Transformer, audio	28480	9120-0028	2	1		
T5	Transformer, power	28480	9100-0084	1	1		
V1	Tube, electron: 6AV6	80131	1939-0001	1	1		
V2, 3	Tube, electron: 12AT7	80131	1932-0027	2	2		
V4	Tube, electron: 12B4A	80131	1921-0010	4	4		
V5	Tube, electron: 6AL5	80131	1930-0013	1	1		
V6	Tube, electron: 6U8	80131	1933-0004	1	1		
V7	Tube, electron: 5Y3	80131	1930-0010	1	1		
V8	Tube, electron: 6X4	80131	1930-0016	1	1		
V9 thru V11	Same as V4						
V12	Tube, electron: 6AU6	80131	1923-0021	1	1		
V13	Tube, electron: OA2	80131	1940-0004	1	1		
V14	Tube, electron: 5651	80131	1940-0001	1	1		
	MISCELLANEOUS						
	Candelabra socket	72765	1450-0013	1	1		
	Ear Syringe	85911	4322-0006	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 10 of 11)

Ckt Ref.	Description	Mfr *	ⓗⓟ Stock No.	TQ*	RS*		
	Fuse holder	75915	1400-0084	1	1		
	Fan, blade	06812	3160-0011	1	1		
	Face plate, reservoir	28480	434A-96B-2	1	1		
	Filter, air: permanent	28480	3150-0004	1	1		
	Flow Meter Assembly Includes the following:	28480	434A-96K	1	1		
	Ball, glass		4330-0016	(1)	0		
	Block flow meter		434A-96K-1	(1)	0		
	Fitting, flow meter		434A-96K-2	(2)	0		
	Gasket, reservoir	02286	0905-0021	1	1		
	Head Box Assembly	28480	434A-96J	1	1		
	Jewel	72765	1450-0020	1	0		
	Knob: ZERO SET	28480	G-74D	2	0		
	Knob: RANGE	28480	G-74N	1	0		
	Lampholder	72765	1450-0019	1	0		
	Nut, oil coupling	28480	434A-96H-3	20	2		
	"O" ring: .101 x .070	02286	0900-0010	20	2		
	Oil coupling, male	28480	434A-96H-2	20	2		
	Oil, soluble: for permanent air filter	82866	3150-0002	1	0		
	Pump and Motor Assembly	28480	434A-96A	1	1		
	Reservoir Assembly Includes the following:	28480	434A-96B	1	1		
	Filter		3150-0011	(1)	0		
	Kit, By-Pass Assembly		1490-0026	(1)	0		
	"O" ring: 11/16 O.D.		0900-0015	(1)	0		
	"O" ring: 13/16 O.D.		0900-0003	(1)	0		
	Oil fitting		434A-96G	(5)	0		
	Plug, pipe		1490-0027	(1)	0		
	Plug, reservoir filler		434A-96B-3	(1)	0		
	Plug, filter		434A-96B-4	(1)	0		
	Plug, by-pass		434A-96B-6	(1)	0		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 11 of 11)

Ckt Ref.	Description	Mfr *	ⓗⓟ Stock No.	TQ*	RS*		
	Reservoir Assembly (cont'd)						
	Reservoir		434A-96B-10	(1)	0		
	Seat, spring		434A-96B-12	(1)	0		
	Spring		1460-0036	(1)	0		
	Spring, compression		1460-0080	(1)	0		
	Valve, needle		434A-96B-11	(1)	0		
	Radiator Assembly	28480	434A-96M	1	1		
	Silicone oil, Dow Corning 200 Fluid	71984	6040-0007				
	Tube, socket: 9 pin	91662	1200-0008	7	1		
	Tube, socket: 7 pin	91662	1200-0009	6	1		
	Tube, socket: octal	91662	1200-0020	1	1		

* See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04404	Dymec Inc.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
10646	Carborundum Co.	Niagara Falls, N.Y.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	Chicago Telephone Supply Co.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78790	Transformer Engineers	Pasadena, Calif.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80130	Times Facsimile Corp.	New York, N.Y.

00015-3
Revised: 2 March 1961

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated Oct. 1960

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Spencer Thermostat, Div. of Texas Instruments, Inc.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div.	Newton, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics, Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000A	Amp, Inc.	Hawthorne, Calif.
0000B	Chicago Telephone of Calif.	S. Pasadena, Calif.
0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000D	Connex Corp.	Oakland, Calif.
0000E	Fisher Switches, Inc.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000G	Microwave Engineering Co.	Palo Alto, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000J	Ti Tal, Inc.	Berkeley, Calif.
0000K	Transitron Electronic Sales Corp.	Wakefield, Mass.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000R	Metro Cap. Div., Metropolitan Telecommunications Corp.	Brooklyn, N.Y.

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated Oct. 1960

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

1501 PAGE MILL ROAD PALO ALTO. CALIF. U.S.A.

CABLE "HEWPACK"