

Model PIC-6B

Portable Ion Chamber Technical Manual

SALES

Eberline *A subsidiary of*
Thermo Instrument
Systems Inc.

GENERAL INFORMATION

Instruments for repair or calibration should be packaged, marked, or otherwise prepared in accordance with good commercial practices and shipped F.O.B. destination freight prepaid to one of the Eberline facilities below.

Repair and Calibration Facilities

Eberline Instrument Corporation
504 Airport Road
Santa Fe, NM 87504-2108
Attn: Western Service Center
(505) 471-3232
1-800-274-4212

Eberline Instrument Corporation
312 Miami Street
West Columbia, SC 29169
Attn: Eastern Service Center
(803) 822-8843
1-800-234-4212

Normal turn-around time for repair (Eberline instruments) is fifteen working days.

Normal turn-around time for calibration (Eberline instruments) is seven working days.

Prices (Subject to change without notice)

Certified calibration (Eberline portable instruments)(2 points/range)	
Unit and one probe	\$90.00
Second probe	45.00
Third or fourth probe (Limited to 4 probes per instrument)	25.00
Certified calibration (other manufacturer's portable instruments)	90.00
ALPHA-3, ALPHA-5, AMS-3, HFM's, Portal Monitors, RM-22, SAM-2, WLM-1A, ESP-2 6112B, 6112D (certified calibration)	145.00
RGM-2 (certified calibration)	405.00
RGM-3 (certified calibration)	235.00
As found readings on any of the above, a charge of 50% of calibration rate shall be made.	
Calibrate "non-removeable" contaminated instruments	QUOTE
Services Contracts (Eberline equipment)	QUOTE
Technical Specification writing and Consultation	QUOTE
Service Engineer at Customers Site	\$880.00/day plus expenses at cost +10% adm.
-Over 8 hours or Saturday and Sunday	165.00/hr
-Eberline Holidays	220.00/hr
Consulting	925.00/day
Repair rate (plus calibration and parts at list price)	85.00/hr
Repair "non-removeable" contaminated instruments	95.00/hr
Expediting Fee	50.00/ instrument
Accredited secondary standards laboratory calibration (Cs ¹³⁷ and Co ⁶⁰ photon)	QUOTE

Note: Repair and Calibration time on non-Eberline instruments is subject to availability of parts and literature for the specific instrument.

Repair or Calibration Warranty

Eberline warrants to replace or repair, at its option, any repaired products or replaced parts thereof (excluding tubes, crystals, batteries and normal consumables) which are found defective in material or workmanship within ninety (90) days from date of repair or the balance of the new purchase warranty, whichever occurs later. Instruments calibrated by Eberline are warranted to be within specified limits at time of shipment. In the event of calibration error, Eberline will again calibrate the instrument without charge to the instrument owner. The aforesaid warranty does not cover life-end failure of components and will be voided if repair has been attempted by other than seller's authorized personnel. In no event shall Eberline be liable for consequential or special damages, transportation, installation, adjustment, work done by customer or other expenses which may arise in connection with such defective product or parts.

Exclusion of Warranties and Limitation of Liability

The foregoing warranty is expressly made in lieu of any and all other warranties express or implied including the warranties of merchantability and fitness for a particular purpose. Under no circumstances shall seller be liable for any indirect, special, incidental, or consequential damages to customer or to any third party.

Price List

Repair Calibration

EFFECTIVE January 1, 1991
Prices are F.O.B. Santa Fe, New Mexico
Subject to change without notice
Terms: ¾ of 1% 10, net 30 days
Minimum order \$40.00

The prices quoted herein do not include state, gross receipts, or local sales tax. The tax will be added as a separate item in the event that the transaction is determined to be taxable.

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MODEL PIC-6B

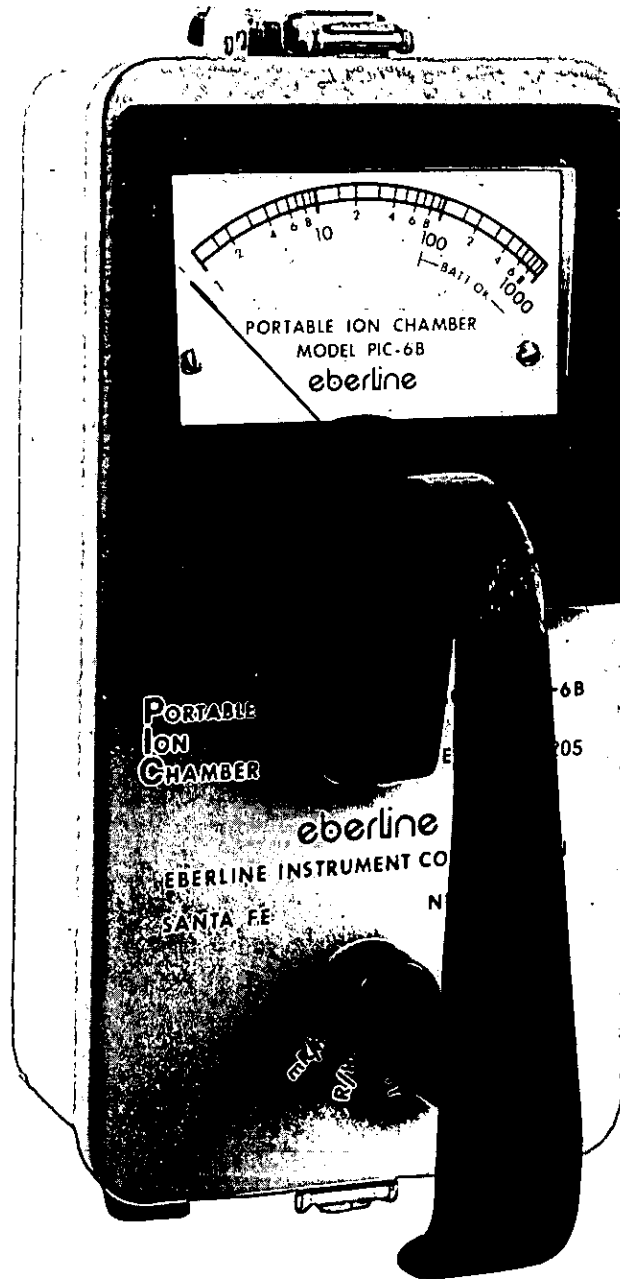


Figure 1-1. Portable Ion Chamber, Model PIC-6B

SECTION I GENERAL

A. PURPOSE AND DESCRIPTION

The PIC-6B is a small, lightweight portable instrument which measures the dose rate from gamma radiation. The detecting element is a gas filled ionization chamber operating in the proportional (gas multiplication) region. Six decades of dose rate, from 1 mR/h to 1000 R/h, are measured in two ranges of three decades each. A single rotary switch turns the instrument *OFF*, provides a *BATT* (battery) check, and selects the range. A beta window in the bottom of the instrument provides for the detection of energetic beta particles.

B. SPECIFICATIONS

1. Detector

- a. Wall: 30 mg/cm² stainless steel.
- b. Active Volume: 0.46 inches i.d. x 4.0 inches length = 0.66 in³ (11 cm³).
- c. Gas Filling: Pure grade propane to approximately 60 cm Hg pressure.
- d. Sensitivity: Chamber current through the linear operating region is approximately given by the equation:

$$\left(\frac{V - 1100}{300} \right)$$

$$I = R \times 10 \quad \times 10^{-12}$$

where:

- I = Current (amps)
 R = Dose Rate (R/h)
 V = High Voltage Applied (volts)

- e. Photon energy Response: Nominal ± 10 percent from 60 keV to 1.3 MeV. See Figure 1-2.
- f. Fast Neutron Response: Reads approximately 10 percent in mR/h of neutron field in mrem/h.

2. Indicator

- a. Scale Length: 2.8 inches.

- b. Scale Markings: Three decades numbered *1*, *10*, *100* and *1000* with 10 increments per decade.

- c. Range: Switch selected *mR/h* or *R/h*, yielding continuous coverage from 1 mR/h to 1000 R/h.

- d. Response Time: R/h range, essentially instantaneous; mR/h range - approximately 2 seconds for increasing reading, approximately 3 seconds per decade for decreasing reading.

- e. Linearity: Within ± 20 percent of reading.

- f. Battery Dependence: Calibration shifts less than 20 percent of reading with battery voltage change from 9 to 6.5 V (new battery to end point).

3. Power

- a. Battery Complement: Two each miniature NEDA type 1604 battery with voltage between 6.5 and 9 V. C-Zn, mercury or alkaline types may be used. Will operate satisfactorily from one battery, however, the life will be less than one half that from two batteries.

- b. Battery Life: Depends on battery type, age and temperature. Nominal life with new batteries near room temperature is:

C-Zn	55 hours
Alkaline	55 hours
Mercury	115 hours

4. Environmental

- a. Temperature: The instrument is operational from -10 °F to +140 °F (-23 °C to 60 °C). Typically the reading shift is less than 0.5 percent of reading per °F (0.9 percent per °C).

- b. RF Sensitivity: Reading unaffected by radar fields up to 20 mW/cm².

5. Mechanical

- a. Size
 Height: 5 $\frac{5}{8}$ inches (14.3 cm) including handle.
 Length: 8 $\frac{3}{8}$ inches (21.3 cm).
 Width: 4 inches (10.2 cm).

- b. Weight: 3 $\frac{1}{4}$ pounds (1.47 kg), with mercury batteries.

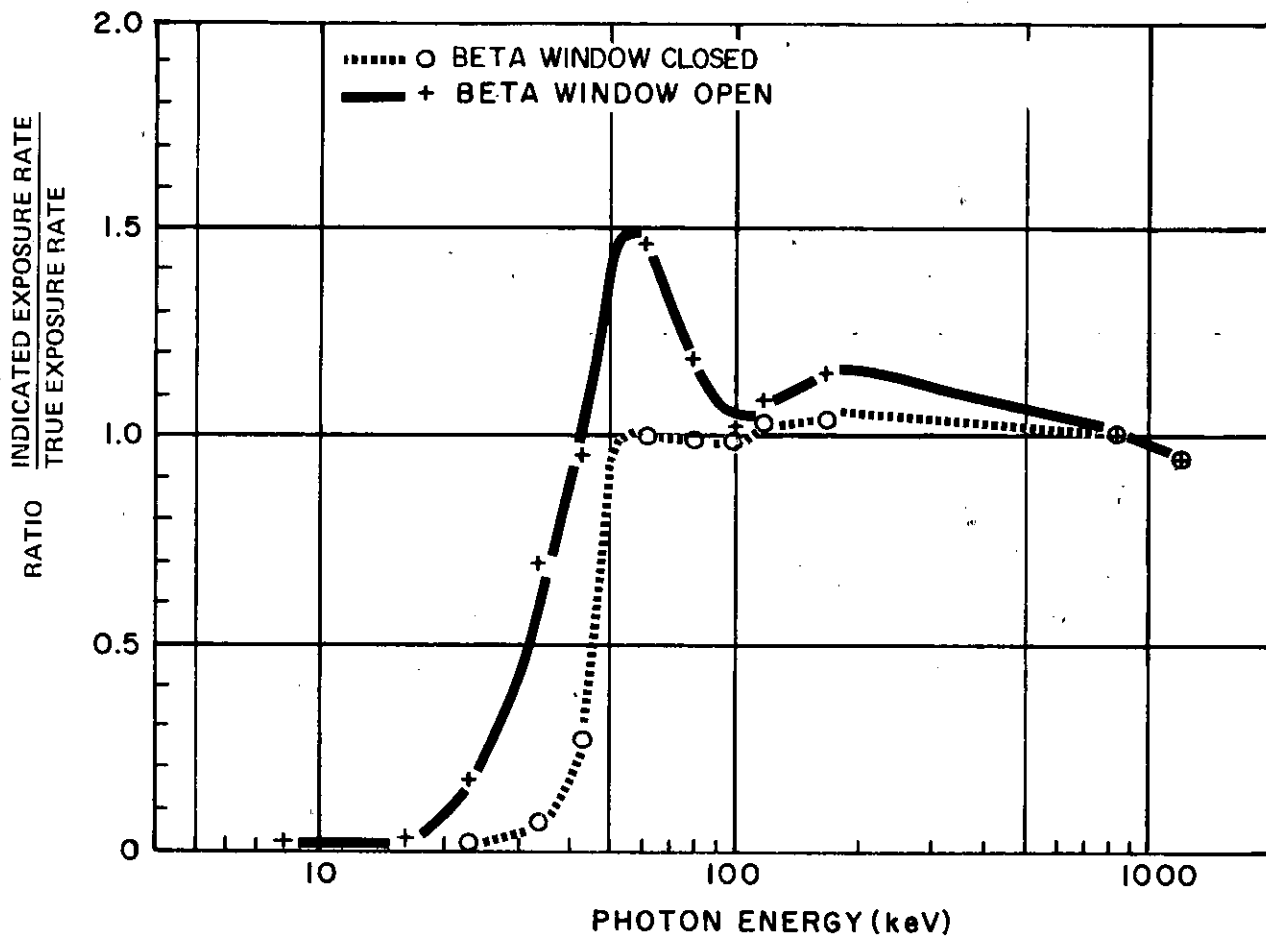


Figure 1-2. Typical Photon Energy Response of the Model PIC-6B

SECTION II OPERATION

A. DESCRIPTION OF CONTROLS

1. External

There is only one external control, this being the combined *OFF*, *BATT* check, and range selector switch. With this switch on *mR/h* the readout range is from 1 to 1000 mR/h and on *R/h* it is from 1 to 1000 R/h.

2. Internal

a. *HV LIMIT*: This control adjusts the maximum high voltage when the instrument is in a radiation field less than the lowest readable.

b. Calibration Controls: Four controls total, for *ZERO* and *SPAN* adjustments of each of the ranges.

B. USING THE INSTRUMENT

1. Starting

Turn the switch to the *BATT* check position. The meter should indicate above the *BATT* cutoff line.

2. Operation Check

Place a check source in a repeatable position against the bottom of the can and move the switch to the *mR/h* range. Note that the reading is sensitive to the position of the source. The reading may be recorded for future reference. Remove the source and the reading should fall to the background reading, normally below that readable. Switch to the *R/h* range. The reading should be below the marked scale.

3. Interpretation of Indications

The meter reading is a direct readout of the radiation intensity in either mR/h or R/h, depending on the range. Fluctuation of the meter is normal and is caused by the random nature of radioactive decay.

If measuring radiation below 100 keV, the most accurate reading is obtained with the bottom of the instrument pointed at the source.

SECTION III THEORY OF OPERATION

A. GENERAL (See Figure 3-1)

The high voltage applied to the detector is varied by the control amplifier to whatever value is required to hold a constant current flow through the detector. With a constant current, the detector characteristically results in a high voltage that is proportional to the log of the reciprocal of radiation intensity. The readout amplifier drives the meter proportional to the high voltage, which reads out in radiation units on a log scale.

The voltage reference circuit provides a regulated voltage for the control amplifier and the calibration controls.

B. FUNCTIONAL THEORY (See Figures 3-1 and 6-1)

1. Detector

The detector is a sealed, gas filled ionization chamber which operates in the gas multiplication region. The gain, due to the gas multiplication, is controlled by the high voltage applied to the detector. The output current is the result of the rate of ion generation (radiation intensity) times the gain. Thus a low radiation intensity and a high voltage can produce the same current as a higher radiation intensity and a lower voltage. The relation between these parameters provides the logarithmic response of the instrument. The chamber anode insulator has a guard ring to reduce the effects of surface leakage.

2. Control Amplifier

The input stage, Q5, is an extremely low leakage field effect transistor (FET) which provides a high input impedance. The voltage on the input is the product of detector current and resistance to ground, R17 and R18.

The output of Q5 is diode coupled to one input of a differential amplifier, Q6 and Q7. The other input is biased from the voltage reference circuit. Any unbalance between these two inputs changes the output of this circuit.

Q8 and Q9 are current gain stages. The collector current of Q9 controls the high voltage power supply. A voltage proportional to this current is fed back from Q9 emitter to the input to provide stabilization.

3. High Voltage Supply

The oscillator transistor, Q3, drives the transformer primary and gets its feedback from the red-orange winding. The voltage is stepped up by the transformer secondary, rectified and increased further by a voltage quadrupler circuit and then filtered. The output voltage is controlled by the biasing current drawn from the orange transformer lead.

4. Readout Amplifier

This circuit consists of a set of matched resistors, R14 and R15, which divide the high voltage, and a field effect transistor, Q4, which drives the meter. The output of Q4 is a voltage which is proportional to the high voltage.

A second variable output is taken from this circuit and is diode-coupled into the control amplifier. This signal limits the maximum high voltage that will be generated when the radiation intensity is below that readable on the meter.

5. Voltage Reference

This voltage is regulated by a Zener diode, CR3. The current taken by the Zener is regulated by transistors Q1 and Q2. This current regulation improves the Zener regulation and extends battery life.

6. Calibration Controls

Two controls are used for each scale. One is an adjustable fraction of the reference voltage which is set to yield zero current through the meter with a radiation field equal to the low end meter reading (*ZERO*). The other is adjustable series resistance which is set to yield a meter deflection equal to the radiation field when in higher field (*SPAN*).

7. Downscale Interrupt

Since the meter scale and internal circuits are logarithmic, a low radiation field would normally cause the needle to read in a negative direction and rest against the low scale mechanical stop. The interrupt circuit is designed to keep the needle away from the stop to avoid the possibility of sticking. The circuit prevents that from happening by sensing the polarity of the voltage applied to the meter. When a negative polarity is detected, the meter drive is removed and the meter is shorted with a low impedance.

One comparator in A1, a quad comparator, is used to sense the meter polarity. When the meter circuit has reverse polarity, the output at A1, pin 2, goes low, which pulls all three control inputs of A2 low. A2 is a three-section analog switch and when the control inputs go low, the commons are connected to the "x" outputs. Circuits B and C in A2 break the normal meter current path and circuit A shorts out the meter. When the meter circuit polarity is positive, the reverse occurs, which restores the meter into the circuit.

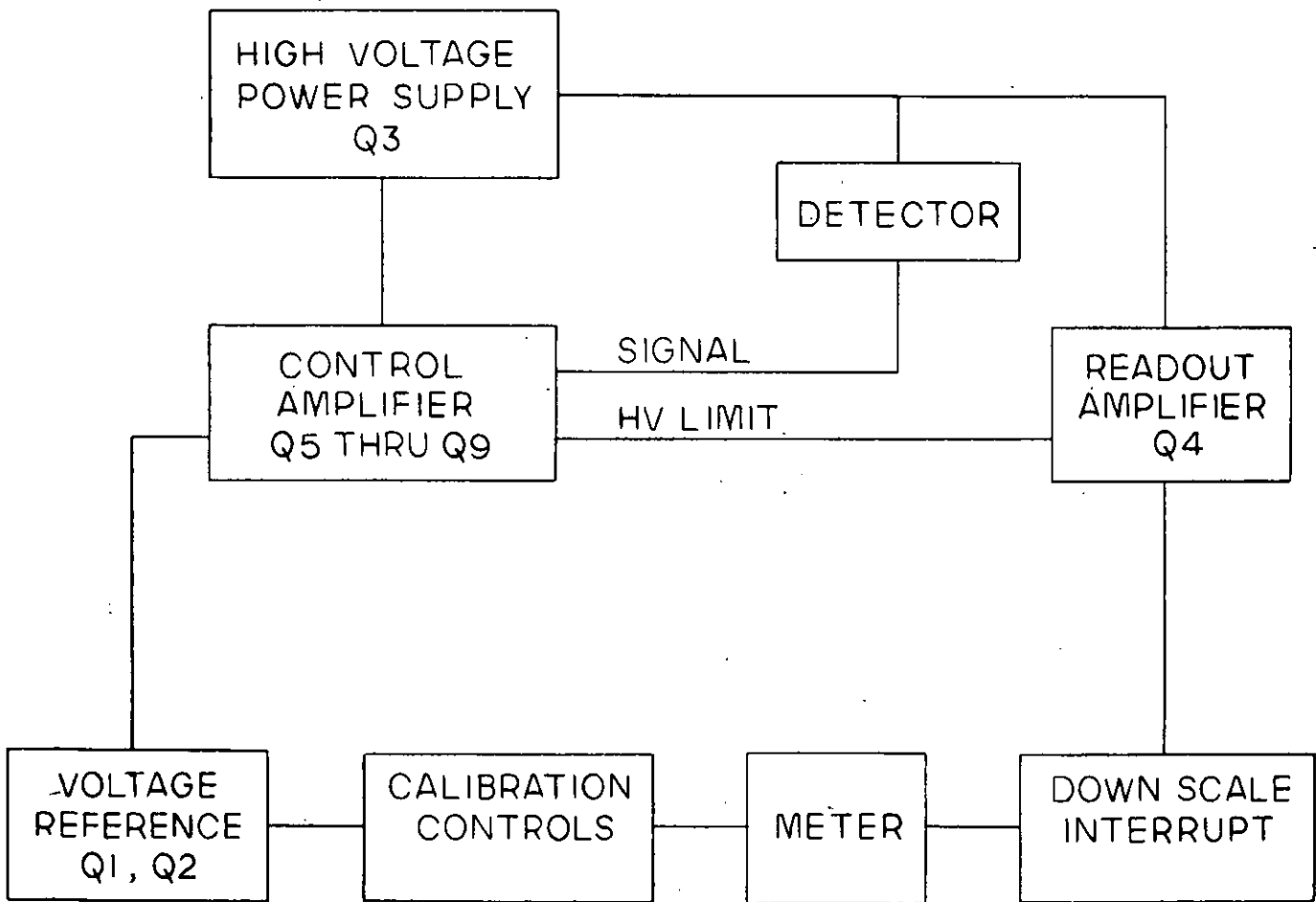


Figure 3-1. System Block Diagram (10540-B54)

SECTION IV MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. Batteries

Removal of the batteries is accomplished by pulling them from their holder, then unsnapping the connector. Replace in reverse order.

2. Etched Board

The etched board and cover may be separated for troubleshooting. Proceed as follows:

- a. Remove batteries to prevent electrical damage during disassembly.
- b. Remove the knob and mounting nut from the scale switch.
- c. Remove the two nuts from the meter studs.
- d. Separate the board and cover.
- e. For troubleshooting, place jumpers between meter studs and corresponding points on the board. Replace the battery.
- f. Reassemble in reverse order of disassembly.

B. PREVENTIVE MAINTENANCE

1. Keep the instrument clean and dry.
2. Replace batteries when their check reading falls below the cutoff.
3. Remove the batteries if the instrument is to be inactive for a long period of time.

C. CALIBRATION

For maximum accuracy the instrument should be calibrated under the same conditions as it will be used. Refer to Section I, B. for effects of gamma energy, battery voltage and temperature.

Before calibration, the *HV LIMIT* adjustment should be checked. Measure the high voltage output with an electrostatic voltmeter and adjust R16 for 3100 V out with the instrument in a low radiation field compared to the scale it is on.

CAUTION

DO NOT short the high voltage. Damaged transistors may result.

Each range is individually calibrated by a *ZERO* and a *SPAN* control. The general procedure for calibration of each scale is:

1. First place the instrument in a field corresponding to the lowest reading for the particular scale and adjust the *ZERO* control until the meter reading agrees with the field.
2. Next place the instrument in a field corresponding to the highest reading and adjust the *SPAN* control for meter agreement.
3. If a *SPAN* adjustment was necessary, the *ZERO* setting should be rechecked.

D. TROUBLESHOOTING

CAUTION

The high impedance field effect transistors are susceptible to damage from static charges. Always connect the ground end of test equipment first and use tools which are connected to instrument ground.

Troubleshooting a closed loop system requires more than average understanding of the operation of an instrument. It is recommended that Section III "Theory of Operation" be studied before attempting to locate a problem.

The high voltage applied to the detector is a good measure of instrument performance. The following table lists what this voltage should be vs radiation intensity on each scale. This voltage must be measured with an electrostatic voltmeter.

The high voltage supply may be evaluated independently by disconnecting the orange transformer lead and connecting it to a parallel 3.3 μ F and 25k variable resistor to ground. Adjustment of the variable resistor should allow the high voltage to easily exceed 3000 V.

Typical voltages are given on the schematic.

MODEL PIC-6B

SCALE	RADIATION	HIGH VOLTAGE ±100 VOLTS
mR/h	1 mR/h	2850
	10	2550
	100	2250
	1000	1950
R/h	1 R/h	2550
	10	2250
	100	1950
	1000	1650

Typical Operating Voltages

SECTION V PARTS LIST

The following table lists the electronic items incorporated in the PIC-6B and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number (PIC-6B), serial number, reference designation and value, or a word description if the part has no reference designation. Examples: R13, 470 ohm resistor, PIC-6B, S/N 115; or, Handle for PIC-6B, S/N 115, etc. Eberline will automatically substitute equivalent parts when the one called out by manufacturer's part number is not available.

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
1. Board Assembly				
A1	I.C.	Quad Comparator	LM 339	ICACA0339N(8)
A2	I.C.	Triple 2-Channel Multiplexer	CD4053BE	ICCCA4053B(9)
BT1, BT2	Battery		Mallory TR-146X or equivalent	BTHG3(5)
C1	Capacitor	120 μ F, 10 V, 20%	Kemet K121C10 or equivalent	CPTA121M3F(4)
C2	Capacitor	0.01 μ F, 100 V, 10%	CRL #CW30A104M	CPCE104P3P(5)
C3	Capacitor	0.0047 μ F, 200 V, 10%	Sprague 192P47292	CPPF472P3R(2)
C4	Capacitor	100 pF, 500 V, 5%	CDE No. CM-15-FD101JN3	CPMI101P3X(2)
C5	Capacitor	1.0 μ F, 15 V, 20%	CS13 B	CPTA105P3H(2)
C6	Capacitor	0.01 μ F, 200 V, 10%	Sprague 192P-10392	CPPF103P3R(3)
C7	Capacitor	0.01 μ F, 80 V	Sprague 192P1039R8	CPPF103P30(6)
CR1, CR2	Diode	Schottky	Motorola MBR130P	CRSCMBR130(2)
CR3	Zener Diode	5.3 V	Eberline 10416-A24	CRXX1(8)
CR4, CR5, CR6, CR7, CR8	Diode		1N4148	CRS11N4148(7)
Q1, Q2, Q8	Transistor		2N4126	TRSP2N4126(8)
Q3	Transistor		2N4234	TRSP2N4234(7)
Q4	Transistor		Siliconix 2N4220	TRJN2N4220(9)
Q5	Transistor		2N4118A	TRJN2N4118(4)
Q6, Q7, Q9	Transistor		2N4124	TRSN2N4124(2)
R1	Resistor	1.0k, 10%, 1/4 W		RECC102B22(4)
R2	Resistor	169k, 1%, 1/8 W		RECE164B12(4)
R3	Resistor	180, 10%, 1/4 W		RECC181B22(8)

MODEL PIC-6B

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
R4	Resistor	33k, 10%, 1/4 W		RECC333B22(5)
R5	Resistor	15k, 10%, 1/4 W		RECC153B22(7)
R6	Resistor	18k, 10%, 1/4 W		RECC183B22(4)
R7	Resistor	680, 10%, 1/4 W		RECC681B22(7)
R8	Resistor	2k, 1%, 1/4W	RN55D	RECE202B12(2)
R9, R10	Potentiometer	2 kΩ (Zero-Adjust)	Beckman Helitrim No. 62PA	PTCE202B03(7)
R11, R12	Potentiometer	20 kΩ (Span Adjust)	Beckman Helitrim No. 62PA	PTCE203B43(7)
R13	Resistor	470, 10%, 1/4 W		RECC471B22(3)
R14, R15	Resistor Pair	10 ³ and 10 ⁴ Ω, ± 5%, with TC match within ± 0.04%/°C	Welwyn Style F44D	REXX1(8)
R16	Potentiometer	5 kΩ (H.V. Limit)	Beckman Helitrim No. 62PA	PTCE502B03(0)
R17	Resistor	22M, ± 20%	IRC Type MVX-1	REHV226B45(9)
R18	Resistor	4 x 10 ³ Ω, ± 20%	IRC Type MVX-2	REHV408B45(3)
R19, R20	Resistor	100k, 10%, 1/4 W		RECC104B22(0)
R21, R25, R26	Resistor	10k, 10%, 1/4 W		RECC103B22(2)
R22	Resistor	5.6k, 10%, 1/4 W		RECC562B22(9)
R23	Resistor	390k, 10%, 1/4 W		RECC394B22(7)
R24	Resistor	4.7k, 10%, 1/4 W		RECC472B22(1)
R27	Resistor	56k, 5%, 1/4 W		RECC563B22(7)
S1	Switch Assembly		Eberline 10449-B01	SWRO28(8)
2. Cover				
M1	Meter	50 μA, Black Needle, Dual Stop	Eberline 10540-B17	ZP10540017(0)
3. Chamber				
	Ion Chamber		Eberline 10450-B26	TUIO1(0)
4. Transformer Assembly				
	Transformer Assembly		Eberline 10931-B05	YX10540052(7)

SECTION VI
DIAGRAMS

- NOTES:
 1. SWITCH VIEWED FROM REAR IN OFF POSITION.
 2. CAPACITOR VALUES ARE IN MICROFARADS.
 RESISTOR VALUES IN OHMS UNLESS OTHERWISE NOTED.

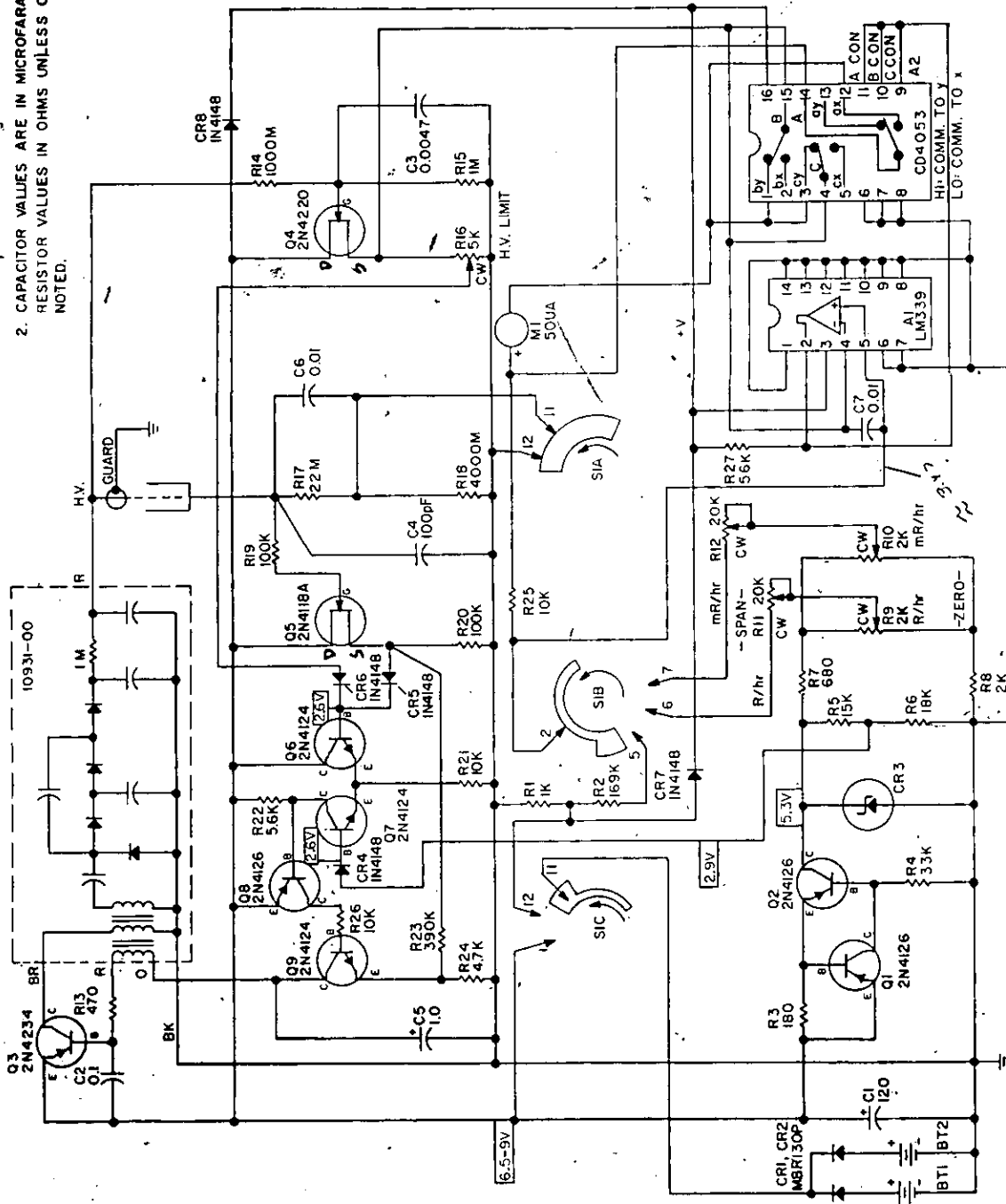


Figure 6-1. PIC-6B Schematic (10540-C50C)

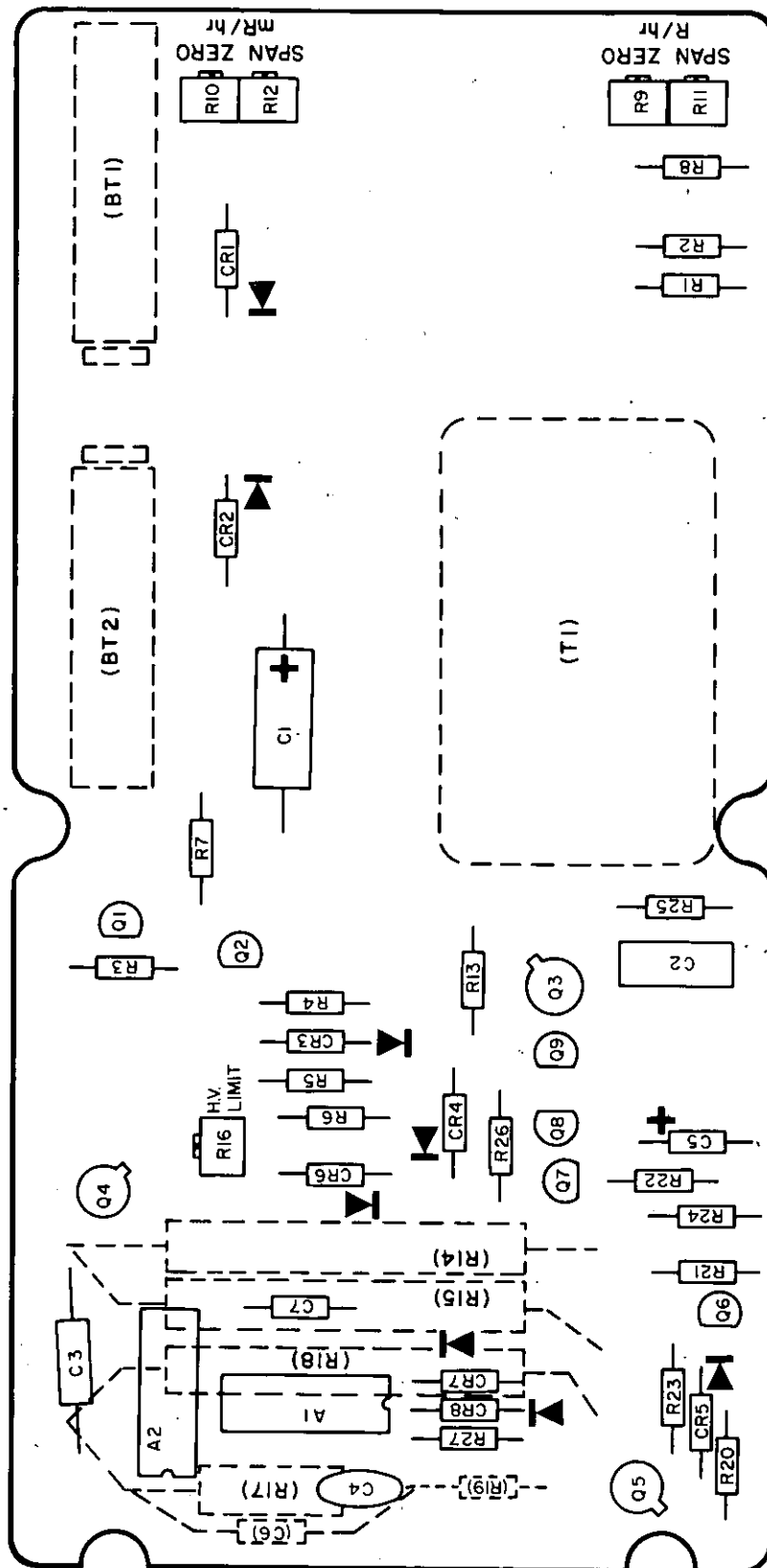


Figure 6-2. Board Assembly (10540-C55)