U.S. DEPARTMENT OF ENERGY

OCRWM

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YUCCA MOUNTAIN PROJECT

ENVIRONMENTAL RADIOLOGICAL MONITORING TECHNICAL PROCEDURE MANUAL

VOLUME IV

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Technical & Management Support Services

SAIC™

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

9007120239 PART 6

MODEL HD-28A

CONSTANT FLOW AIR SAMPLER

INSTRUCTION MANUAL

SCIENCE APPLICATIONS, INC.

NNA.871007.0054

MODEL HD-28A
CONSTANT FLOW AIR SAMPLER

INSTRUCTION MANUAL

February 1981

SAI RADECO
4060 Sorrento Valley Blvd.
San Diego, CA 92121

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ATTACHMENTS

I. GENERAL

The HD-28A Air Sampler is designed to maintain a constant flow of air through a sample holder for a reasonable sampling period. It can be equipped with any required sample holder and the constant flow controller will maintain preset sample air flow within the range of .5 to 3 CFM while automatically compensating for collector loading (see Figure 1 for constant flow range curve).

II. SIZE/WEIGHT

18" long (45.7 cm), 11" wide (27.9 cm), 9" high (22.9 cm), 35 lbs. (16 Kg).

III. POWER REQUIREMENTS

8A - 115V - 60Hz - 1Ø; Integral 6 feet, 3-wire power cord with Nema Type 5-15P Connector provided. (See Figure 2 for wiring diagram.)

IV. SAMPLE HOLDERS

Sample holder attachment is by a 3/8" female disconnect hose fitting on the front panel. RADeCO offers the below listed sample holders compatible with this fitting.

Model Number	Description
2500-04	• 2" diameter filter, open face
2500-42	• 47mm diameter filter, open face
2500-21	• 2" diameter filter with SAI radioiodine cartridge, open face
2500-46	• 47mm diameter filter with SAI radioiodine cartridge, open face
2500-45	• 2" diameter filter with SAI radioiodine cartridge, in-line
2500-44	• 47mm diameter filter with SAI radioiodine cartridge, in-line

V. PREPARATION FOR USE

Remove the HD-28A from the shipping carton. A suitable level installation area must be selected to ensure accurate rotameter readings. Plug the power cord into a suitable power source.

VI. OPERATION

Push the "Elapsed Sample Time" reset button prior to starting any sampling period.

Determine sample flow rate and obtain fresh sample holder of configuration desired.

Turn on power, increase or decrease flow rate to desired setting utilizing "Flow Adjust" knob (clockwise/decrease; counterclockwise/increase).

Observe rotameter flow stabilized, ΔP pressure approximately "0", and "Pump Head" pressure corresponds to indicated air flow. (See Figure 1.)

Install the sample holder. A slight rise in flow may be indicated by the rotameter due to the effect of air density change as the inlet pressure drop increases. For this reason, the rotameter should only be used to set the flow at the beginning of each sampling period without a sample holder installed. The constant flow range may be computed from the difference between the "Pump Head" reading and the "ΔP Paper" reading. When these two pressures are equal, the regulator is wide open and any further increase in pressure drop across the sample holder (collector loading) will result in a decrease in flow. Only under heavy dust atmospheric conditions will these two gauges equalize during a normal sampling period.

VII. MAINTENANCE

The HD-28A is designed to be maintenance-free, however, carbon vane pumps do wear. This can be detected by observing carbon buildup in the muffler and also by abnormally high pump head pressure readings at a particular flow rate. (10% above those shown in Figure 1.) Refer to Appendix A for recommended pump maintenance and vane replacement.

In high dust conditions the cooling fan may become fouled with dirt until it ceases to operate. To keep the equipment on line it is recommended that a replacement fan be installed and the dirty fan cleaned and re-greased at a maintenance facility. Step by step removal, installation and cleaning procedures are outlined in Appendix D.

VIII. SYSTEM DESCRIPTION

A. Vacuum Pump: Carbon rotary vane, continuous duty, capable of 4 CFM free air delivery and 26" Hg max vacuum; manufacturers recommended operating/maintenance instructions and parts list are reprinted in Appendix A as a customer convenience.

B. Operator Controls and Visual Indicators:

1. Power on/off switch and fuse holder located on the lower right of the front panel.

2. A resettable "Elapsed Sample Time" indicator which records only when the pump is running.

3. Vacuum guage; "ΔP Paper," measures the pressure drop from atmospheric across the sample holder.

4. Vacuum guage; "Pump Head," measures the pump inlet vacuum pressure.

5. Constant flow controller; "Flow Adjust" knob on the front panel adjusts the sample air flow rate set point. Clockwise decreases set point, and counterclockwise increases it.

6. Rotameter; combined with internal in-line venturi to give free air flow measurements. Calibrated from .5 to 3 SCFM in .5 CFM increments; certified to ± 5% accuracy. An NBS traceable air flow calibrator (RADeCO Model C-812) was used as a factory calibration standard.

C. Calibration: The HD-23A may be re-calibrated with any suitable flow system that is capable of measuring 0.5 to 3.0 SCFM with better than ± 5% accuracy. RADeCO offers a portable calibrator, Model C-812, that is fitting compatible with this air sampler, and provides more than adequate accuracy. Care should be taken to convert flow measurements to SCFM to ensure proper collected sample evaluation. The C-812 calibrator instruction manual provides pressure and temperature correction data to accomplish this. It is important that calibration points be picked that are within the range of the flow controller (ΔP Paper > 1" Hg). Check each index mark on the rotameter by varying the "Flow Adjust" knob until the rotameter ball aligns with the index. Record actual flow (ACFM), correct for temperature and pressure to SCFM and verify or re-define index marks. Do not adjust needle value on the top of the rotameter as this will change calibration indices values at SCFM.

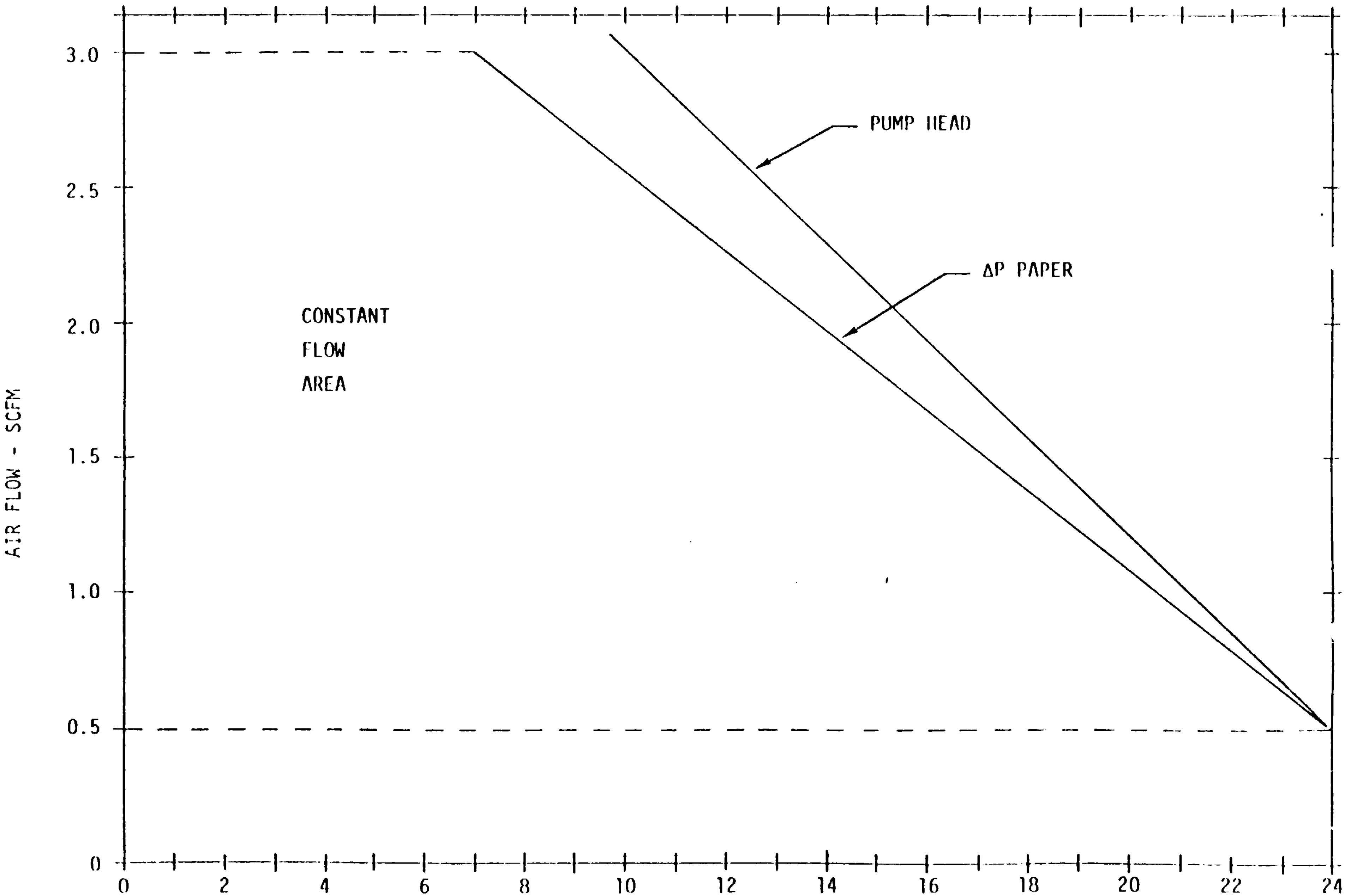


FIGURE 1
VACUUM PRESSURE - "Hg
CONSTANT FLOW RANGE AND PUMP HEAD CURVES

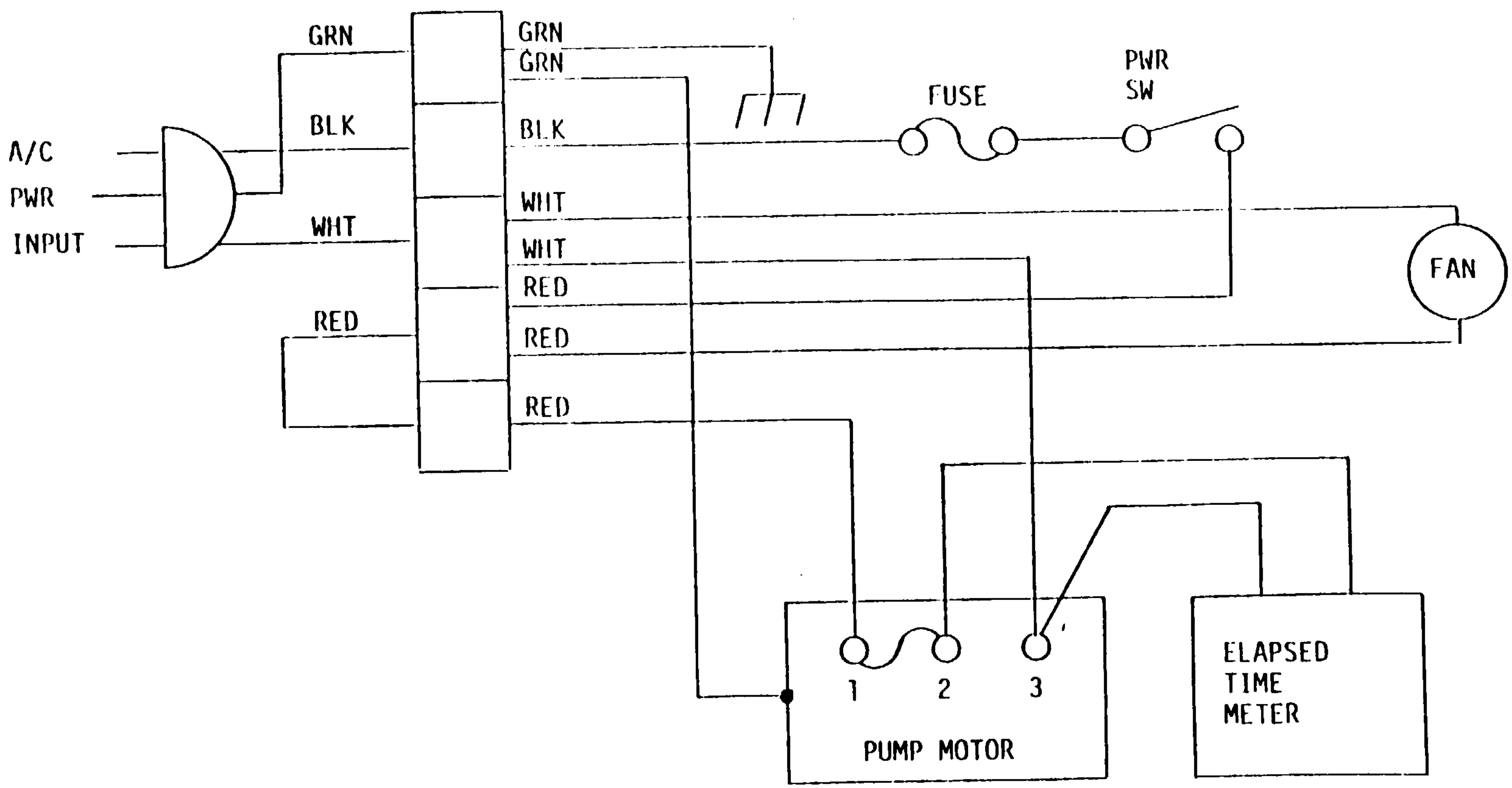


FIGURE 2

WIRING DIAGRAM

HD-28A/B

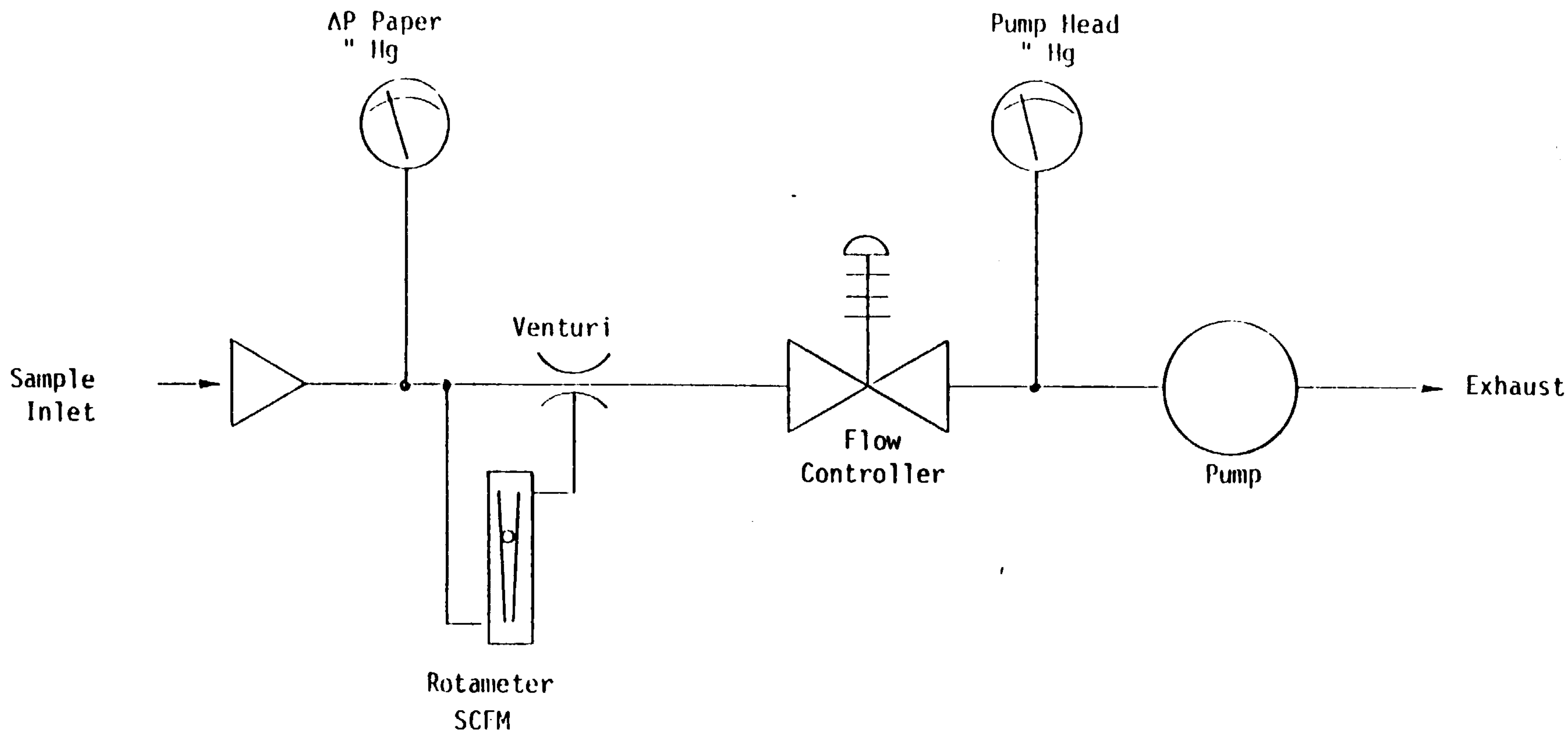


FIGURE 3

FLOW DIAGRAM

HD-28A/B

70-270
10-77

GAST MANUFACTURING CORPORATION
P. O. BOX 97, BENTON HARBOR, MICHIGAN 49022
PHONE 616-926-6171

PARTS LIST and OPERATING and MAINTENANCE INSTRUCTIONS FOR MODELS 0322-P102, 0522-P102 0322-V103, 0522-V103

CAUTION: NEVER LUBRICATE THIS DRY "OIL-LESS" AIR PUMP. The carbon vanes and grease packed motor bearings require no oil.

CONSTRUCTION: The outer end plate, body, rotor and mounting bracket are all cast iron. Consequently any moisture that accumulates in the pump will tend to corrode the interior when pump stands idle. The vanes are made of hard carbon and are precision ground. They should last 5,000 to 10m000 hours depending upon the degree of vacuum or pressure at which the pump is run.

STARTING: If the motor fails to start or hums, pull the plug and check the current rating shown on the motor nameplate. Examine the plug and switch also. Some motors (upon specification) are equipped with overloads that turn the current off automatically when the motor heats up due to mechanical or electrical overload. If the pump is extremely cold, bring to room temperature before starting. If anything appears to be wrong with the motor return the complete pump and motor assembly to the factory.

FLUSHING: Should excessive dirt, foreign particles, moisture or oil be permitted to enter the pump, the vanes will act sluggish or even break. Flushing of the pump should take care of these situations. In order to flush a pump, remove the filter and muffler assemblies and introduce several teaspoons full of solvent* into the pump through the intake WHILE THE PUMP IS RUNNING. Repeat the flushing procedure and if it does not remedy the situation, remove the end plate for further examination. Periodic flushing is recommended.

FILTERS: Dirty filters restrict air flow and if not corrected could lead to possible motor overloading and early pump failure. Check filters periodically and clean when necessary by removing felts from the filter and washing in a solvent*. Dry with compressed air and replace.

DISASSEMBLY: If flushing does not eliminate the problem, remove the six bolts holding the endplate and the four vanes (DO NOT REMOVE THE ROTOR OR LOOSEN ANY MOTOR "THRU-BOLTS"). If the pump fails to produce the proper vacuum or pressure, the vanes could be worn or the top clearance between the rotor and body may have increased to greater than .0015". A metallic clanging could mean the rotor and body are touching. The top clearance may be adjusted by "LIGHTLY" tapping on the pump body (either top or bottom depending upon whether clearance is too large or small). The rotor should be turned while setting clearance to assure that all points on the rotor clear the body. Total end clearance for both sides of the rotor will vary from .0035" to .0045".

*Recommended Solvents: Loctite Safety Solvent, Inhibisol Safety Solvent and Dow Chemical Chlorothane. DO NOT USE KEROSENE.

DANGER: To prevent explosive hazard, do not pump combustible liquids or vapors with these units.

It is usually quickest and least expensive to send the unit in for reqair. Authorized service facilities are located at:

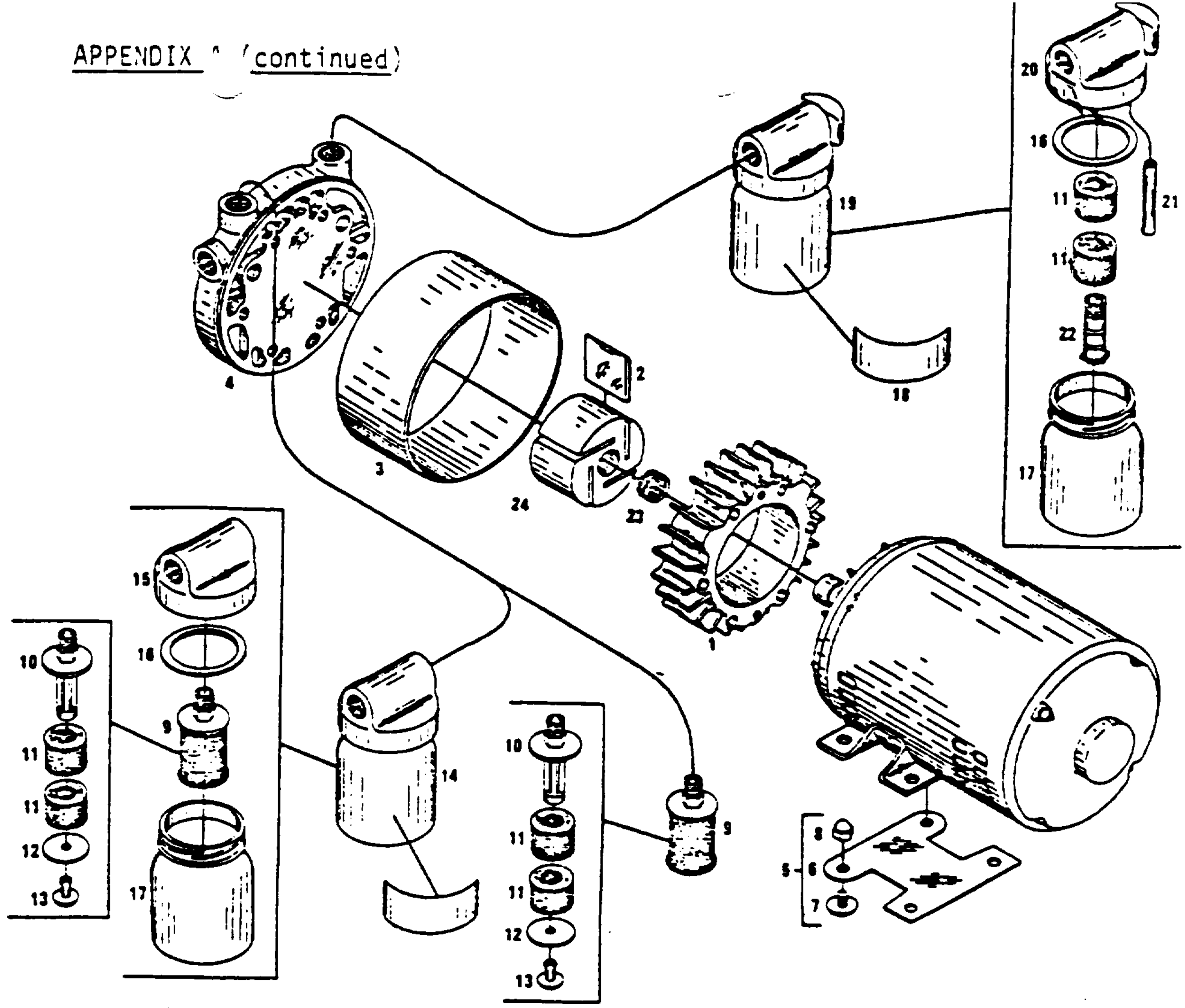
Brenner-Fiedler and Associates
16210 Gundry Avenue
Paramount, CA 90723
213/636-3206

Gast Manufacturing Corporation
515 Washington Avenue
Carlstadt, NJ 07072
201/933-8484

Gast Manufacturing Corporation
2550 Meadowbrook Rd.
Benton Harbor, MI 49022
616/926-6171

Wainbee, Ltd.
121 City View Dr.
Toronto, Ontario
Canada
216/248-5621

Wainbee, Ltd.
215 Brunswick Blvd.
Pointe Claire, Montreal, Quebec
Canada
514/697-8810



REF. NO.	DESCRIPTION	PART NO.	VACUUM PUMP 0322 - V103	VACUUM PUMP 0522 - V103	COMPRESSOR 0322 - P102	COMPRESSOR 0522 - P102
1	BODY	AF107	1		1	
1	BODY	AF108		1		1
• 2	VANE	AF109B	4	4	4	4
3	SHROUD	AF111	1	1	1	1
4	END PLATE	AF112	1	1	1	1
5	FOOT SUPPORT ASSEMBLY	AC136	1	1	1	1
6	FOOT SUPPORT	AC135	1	1	1	1
7	RUBBER FOOT	AA48	4	4	4	4
8	FOOT NUT	AA49B	4	4	4	4
9	INTAKE FILTER ASSEMBLY	B343B			1	1
10	BODY	B347			1	1
• 11	FILTER FELT	B344A			2	2
12	END CAP	AA730			1	1
13	RIVET STUD	B378			1	1
14	INTAKE FILTER	V400G	1	1		
15	COVER	AV402C	1	1		
• 16	COVER GASKET	B62A	1	1		
17	JAR	AA125A	1	1		
18	INSTRUCTION LABEL	AB678	1	1		
19	MUFFLER	V425L	1	1		
20	COVER & ELBOW ASSEMBLY	AV430	1	1		
21	TUBE	B346A	1	1		
22	FELT SUPPORT	B345A	1	1		
23*	TOLERANCE RING	AF105	1	1	1	1
24*	ROTOR	AF106B	1	1	1	1

•Denotes parts included in Service Kit K247 for both 0322 and 0522 oil-less models.
*Under most circumstances rotor and tolerance ring should not be replaced in the field.

When corresponding or ordering spare parts, please give complete model and serial number.

APPENDIX B

HD-28A REPLACEMENT PARTS LIST

DESCRIPTION	PART NO.
1/4" N.P.T. to 3/8" Hose Barb	0800-47
10-32 x 3/16 Hose Barb	0800-43
1/4" N.P.T. to 3/16" Hose Barb	0800-46
Venturi Tube, .5 CFM to 3 CFM (V-12)	6000-08
Power Cord, 18-3	8000-11
Fan, Cooling (110V, 60Hz)	0100-10
Fan, Cooling (220V, 50Hz)	0100-13
Control Valve Yoke Assy.	5000-02
Rotameter	1500-15
3/8" Pipe Nip 2" Long	0800-24
Regulator Mounting Bracket	1700-05
Regulator Knob	1850-01
Rotameter, Protection Bars	1500-18
Terminal Block	2800-01
1/8 N.P.T. x 3/16" 90° Hose Barb	0800-25
Pump - Vanes (Carbon)	6050-24
Pump Inlet Filter	0750-30
Muffler Filter	6050-21
Pump, 0522-V103-G18DX (110V, 60Hz)	0100-36
Pump, 0522-V103-G21DX (220V, 50Hz)	0100-37
Timer, Hour (110V, 60Hz)	2900-02
Timer, Hour (220V, 50Hz)	2900-06
Regulator Valve	5000-23
Instrument Case	0301-02
3/8" Quick Disconnect Socket	0800-16
2" Vacuum Gauge 30" Hg.	1100-01
Handle, Case	1300-05
Fuse Holder	0900-01
Fuse 3AG 8A-S/B	0900-09
Shock Mount	1800-01
Power Switch, SPST	2700-01
1/4" Pipe Nip 1½" Long	0800-02

(continued on next page)

APPENDIX B (Continued)

DESCRIPTION	PART NO.
1/4" Pipe Nip 3" Long	0800-05
1/4" N.P.T. Elbow	0800-07
1/4" N.P.T. 90^{o} Street L	0800-03
1/4" N.P.T. to 3/8" Elbow	0800-11

APPENDIX C

HD-28A TWO-YEAR SPARE PARTS LIST

DESCRIPTION	PART NO.	QUANTITY
Hour Timer (110V, 60Hz)	2900-02	1
Hour Timer (220V, 50Hz)	2900-06	1
Fuse 3AG 8A-S/B	0900-09	5
Plastic Tubing	4100-07	4 ft.
Power Switch	2700-01	1
Fan (110V, 60Hz)	0100-10	1
Fan (220V, 50Hz)	0100-13	1
Pump Vanes	6050-24	1 set
Pump Inlet Filter	0750-30	4 *
Pump Exhaust Filter	6050-21	2
Vacuum Gage	1100-01	2

* Should be replaced sooner than every 6 months in high ambient dust conditions.

APPENDIX D

HD-28A/B FAN MAINTENANCE

I. Removal/Installation

A. Turn instrument off and unplug power from A/C source.

B. Remove Cover (6 screws).

C. Unplug (2) power wires from fan.

D. Remove (4) fan attachment screws.

E. Lift fan out.

F. Install in reverse order.

II. Fan Dis-Assembly Cleaning, Greasing and Re-Assembly

A. Dis-Assembly

1. Unsnap power connector.
2. Remove decal from hub.
3. Remove (2) screws from hub.
4. Separate shroud from fan/motor assy.
5. Remove "C" clip from mounting end of motor shaft.

CAUTION: Observe location and type of spacers and plastic washers installed below the mounting hub.

6. Remove the rotor from the stator.
7. Thoroughly clean and de-grease all parts. (Alcohol or similiar solvent is suggested)
8. Apply a silicone grease to the upper and lower bronze bearings and the rotor shaft. (Dow Corning RTV-111 silicone compound is recommended)
9. Re-Assemble in reverse order.

AIR FLOW CALIBRATOR

INSTRUCTION MANUAL

SAIC

Science Applications International Corporation

NNA.871007.0056

AIR FLOW CALIBRATOR

INSTRUCTION MANUAL

SAIC - RADeCO
10373 Roselle St.
San Diego, CA 92121
(619) 458-3831
(619) 452-9983

REV 061786

GENERAL DESCRIPTION

The Air Flow Calibrator you have received is an accurate, low pressure drop, secondary level device for the calibration of all types of air samplers and monitors. It is especially useful for calibrating air samplers where the pressure drop across the calibrator must not interfere with the calibration of the sampler.

Your calibrator has been calibrated using Meriam air flow measuring instrumentation having traceability to the National Bureau of Standards. Each marking on the meter face has been corrected to 29.92" inches of mercury barometric pressure and an air temperature of 70°F and has a guaranteed accuracy of better than 5% under these conditions. During the calibration, the inlet of the calibrator is at atmospheric pressure.

Your calibrator is reasonably rugged and will withstand the rigors of routine handling. However, the continued accuracy will depend upon the cleanliness of the air in the calibration area. The unit should not be used in heavily dust ladened atmospheres because dust will foul the venturi tube throat, enter into the bellows of the Meriam gauge, or plug up the interconnecting hose fittings. The calibrator should never be openly exposed to oil vapors, fumes or airborne corrosive materials.

Breathing type low pressure air may be blown through the venturi tube to remove dust <u>only</u> after the interconnecting hoses to the Magnahelic gauge have been disconnected. Failure to disconnect the interconnecting hoses can cause permanent and irreparable damage to the Magnahelic gauge.

AIR SAMPLER INTERCONNECT

For SAI /RADēCO H-809 Series of samplers, the interconnect should be as shown in Diagram A.

1. The air inlet of the air flow calibrator must be open and exposed to the atmosphere.
2. The interconnect may be one of SAI /RADēCO's Calibrator Adaptor Kits or any other suitable leak-free mechanism.
3. The Sample Holder must contain the appropriate filter disc and/or cartridge that is to be used in the routine operation of the sampler.
4. The H-809 sampler should be run approximately five minutes prior to the final interconnect to the Air Flow Calibrator to assure temperature stabilization of the sampler.

For SAI /RADēCO samplers (K-Flows) which have a constant flow regulator (such as the AVS-28, AVS-28A, AVS-60, AVS-60A, HD-28A, HD-28B, HD-29, and HD-29A), the interconnect will be made through a male Quick Disconnect on the outlet of the calibrator. Since the constant flow regulator automatically corrects the air flow rate for most inlet pressure drops, no sample holder with filter paper and/or sampling cartridge should be used between the sampler and the calibrator. The male Quick Disconnect should be snapped directly into the female quick disconnect on the inlet of the sample.

CORRECTION FACTOR FOR VENTURI METER TYPE AIR FLOW CALIBRATORS USED AT OTHER THAN 29.92" (760mm) Hg and 70°F (21.1°C)

Bernoulli's equation for stream line flow in a non-viscous incompressable fluid is a statement of the conservation of energy and can be written for a pipe as

$$p + \tfrac{1}{2}\rho v^2 + \rho gh = \text{constant} \qquad (1)$$

where p is the pressure at a point in the pipe

ρ is the density of the fluid

v is the velocity of the fluid

g is the gravitational constant

and h is the elevation of the point

For a Venturi meter with the elevation of the pipe and throat equal, this equation can be written as

$$p_1 + \tfrac{1}{2}\rho v_1^2 = p_2 + \tfrac{1}{2}\rho v_2^2 \qquad (2)$$

where the subscript 1 denotes the position in the pipe and 2 the position in the throat. The volume flow Q is related to the cross sectional area of the pipe and the velocities

$$Q = A_1 v_1 = A_2 v_2$$

Equation 2 can be rewritten as

$$p_1 + \tfrac{1}{2}\rho \frac{Q^2}{A_1^2} = p_2 + \tfrac{1}{2}\rho \frac{Q^2}{A_2^2}$$

or (3)

$$Q = A_1 A_2 \left[\frac{2(p_1 - p_2)}{\rho(A_1^2 - A_2^2)}\right]^{\frac{1}{2}}$$

which relates the volume flow Q to the pressure $p_1 - p_2$ differential measured across the Venturi meter.

For a perfect gas the density is related to the pressure and temperature through the equation

$$\rho = \frac{P}{kT} \qquad (4)$$

where the pressure is absolute and T is the absolute temperature. Substituting this density back into equation 3 yields

$$Q\left(\frac{cc}{sec}\right) = A_1 A_2 \left[\frac{2\,(P_1 - P_2)kT}{P_1\,(A_1^2 - A_2^2)}\right]^{1/2} \qquad (5)$$

If an instrument is calibrated at a pressure and temperature P_c and T_c, the calibrated flow (Q_c) will be

$$Q_c\left(\frac{cc}{sec}\right) = A_1 A_2 \left[\frac{2\Delta P\; k\; T_c}{P_c\;(A_1^2 - A_2^2)}\right]^{1/2} \qquad (6)$$

Since the output of the meter is only dependent on ΔP, the pressure differential readings made at pressures and temperatures other than P_c and T_c will be in error and need a correction term applied to them. For the same ΔP (corresponding to the same meter reading) the ratio of Q to Q_c is given by

$$\frac{Q}{Q_c} = \left[\frac{T\,P_c}{P\,T_c}\right]^{1/2} \qquad (7)$$

where T and P correspond to the barometric pressure and absolute temperature at which the unit is operated. The true volume air flow is related to the air flow indicated by the instrument through the equation

$$Q = Q_c\left[\frac{T\,P_c}{P\,T_c}\right]^{1/2} \qquad (8)$$

The above derivation neglects two factors for gases: compressability and viscosity. Correct treatment of these parameters is beyond the scope of this presentation).

USE OF THE AIR FLOW CALIBRATOR

There is one basic method of using the air flow calibrator. This is to correct the air flow calibrator reading for atmospheric conditions other than NPT (29.92" or 760 mm Hg and 70^{o}F or 21.111^{o}C) and compare the corrected air flow through the calibrator with the air flow indicator on the air sampler.

Using Equation 8 from the derivation:

$$Q = Q_c \left[\frac{T\,P_c}{P\,T_c}\right]^{\frac{1}{2}}$$

or

$$Q = Q_c\ (C.F.)$$

where Q_c = Calibration Flow

C.F. = Correction Factor from Table

Q = Air Flow - Calculated

Barometric pressure reading devices often require the application of various correction factors to give the real barometric pressure. Please study the manual for your particular device and apply the appropriate factors before using the attached tables to look up the air flow correction factor you are to use.

To utilize the attached tables, it is suggested that you choose the block of numbers which is most appropriate to the existing conditions at your facility and extrapolate between the numbers to give a more precise set of correction factors. This is a fine tuning of the numbers for your particular application.

On examining the correction factor equation, you will readily see that the inlet pressure is the major controlling factor. Constrictions of any type on the inlet to the calibrator will have a deleterious effect on the accuracy of the calibrator.

CAUTION

It is directed to your special attention and to the attention of your Quality Assurance Department that when the Air Flow Calibrator is used with devices which blow or push air through the venturi tube of the calibrator, the calibration of the Air Flow Calibrator will no longer be accurate and the certification of the calibration of the Air Flow Calibrator is voided.

CORRECTED BAROMETRIC PRESSURE

mm Hg

°C	500	525	550	575	600	625	650	675	700	725	750	775	800
0	1.188	1.159	1.133	1.108	1.084	1.062	1.042	1.022	1.004	0.986	0.970	0.954	0.939
1	1.190	1.161	1.135	1.110	1.056	1.064	1.044	1.024	1.006	0.988	0.972	0.956	0.941
2	1.192	1.163	1.137	1.112	1.088	1.066	1.046	1.026	1.008	0.990	0.973	0.958	0.942
3	1.194	1.166	1.139	1.114	1.090	1.068	1.048	1.028	1.009	0.992	0.975	0.959	0.944
4	1.196	1.168	1.141	1.116	1.092	1.070	1.049	1.030	1.011	0.994	0.977	0.961	0.946
5	1.199	1.170	1.143	1.118	1.094	1.072	1.051	1.032	1.013	0.995	0.979	0.963	0.948
6	1.201	1.172	1.145	1.120	1.096	1.074	1.053	1.033	1.015	0.997	0.980	0.965	0.949
7	1.203	1.174	1.147	1.122	1.098	1.076	1.055	1.035	1.017	0.999	0.932	0.966	0.951
8	1.205	1.176	1.149	1.124	1.100	1.078	1.057	1.037	1.018	1.001	0.984	0.968	0.953
9	1.207	1.178	1.151	1.126	1.102	1.080	1.059	1.039	1.020	1.003	0.986	0.970	0.954
10	1.209	1.180	1.153	1.128	1.104	1.082	1.061	1.041	1.022	1.004	0.987	0.971	0.956
11	1.212	1.182	1.155	1.130	1.106	1.084	1.063	1.043	1.024	1.006	0.989	0.973	0.955
12	1.214	1.184	1.157	1.132	1.108	1.086	1.064	1.045	1.026	1.008	0.991	0.975	0.959
13	1.216	1.186	1.159	1.134	1.110	1.087	1.066	1.046	1.028	1.010	0.993	0.977	0.961
14	1.218	1.189	1.161	1.136	1.112	1.089	1.068	1.046	1.029	1.011	0.994	0.978	0.963
15	1.220	1.191	1.163	1.138	1.114	1.091	1.070	1.050	1.031	1.013	0.996	0.980	0.964
16	1.222	1.193	1.165	1.140	1.116	1.093	1.072	1.052	1.033	1.015	0.998	0.982	0.966
17	1.224	1.195	1.167	1.142	1.118	1.095	1.074	1.054	1.035	1.017	1.000	0.983	0.968
18	1.226	1.197	1.169	1.144	1.119	1.097	1.076	1.055	1.036	1.018	1.001	0.985	0.969
19	1.228	1.199	1.171	1.146	1.121	1.099	1.077	1.057	1.038	1.020	1.003	0.987	0.971
20	1.231	1.201	1.173	1.147	1.123	1.101	1.079	1.059	1.040	1.022	1.005	0.988	0.973
21	1.233	1.203	1.175	1.149	1.125	1.102	1.081	1.061	1.042	1.024	1.006	0.990	0.974
22	1.235	1.205	1.177	1.151	1.127	1.104	1.083	1.063	1.044	1.025	1.008	0.992	0.976
23	1.237	1.207	1.179	1.153	1.129	1.106	1.085	1.064	1.045	1.027	1.010	0.993	0.978
24	1.239	1.209	1.181	1.155	1.131	1.108	1.087	1.066	1.047	1.029	1.012	0.995	0.979
25	1.241	1.211	1.183	1.157	1.133	1.110	1.088	1.068	1.049	1.031	1.013	0.997	0.981
26	1.243	1.213	1.185	1.159	1.135	1.112	1.090	1.070	1.051	1.032	1.015	0.998	0.983
27	1.245	1.215	1.187	1.161	1.137	1.114	1.092	1.072	1.052	1.034	1.017	1.000	0.984
28	1.247	1.217	1.189	1.163	1.139	1.116	1.094	1.073	1.054	1.036	1.018	1.002	0.986
29	1.249	1.219	1.191	1.165	1.140	1.117	1.096	1.075	1.056	1.037	1.020	1.003	0.988
30	1.251	1.221	1.193	1.167	1.142	1.119	1.097	1.077	1.058	1.039	1.022	1.005	0.989
31	1.253	1.223	1.195	1.169	1.144	1.121	1.099	1.079	1.059	1.041	1.023	1.007	0.991
32	1.255	1.225	1.197	1.171	1.146	1.123	1.101	1.081	1.061	1.043	1.025	1.008	0.993
33	1.258	1.227	1.199	1.173	1.148	1.125	1.103	1.082	1.063	1.044	1.027	1.010	0.994
34	1.260	1.229	1.201	1.175	1.150	1.127	1.105	1.084	1.065	1.046	1.028	1.012	0.996
35	1.262	1.231	1.203	1.176	1.152	1.128	1.106	1.086	1.066	1.048	1.030	1.013	0.997
36	1.264	1.233	1.205	1.178	1.154	1.130	1.108	1.088	1.068	1.049	1.032	1.015	0.999

CORRECTED BAROMETRIC PRESSURE

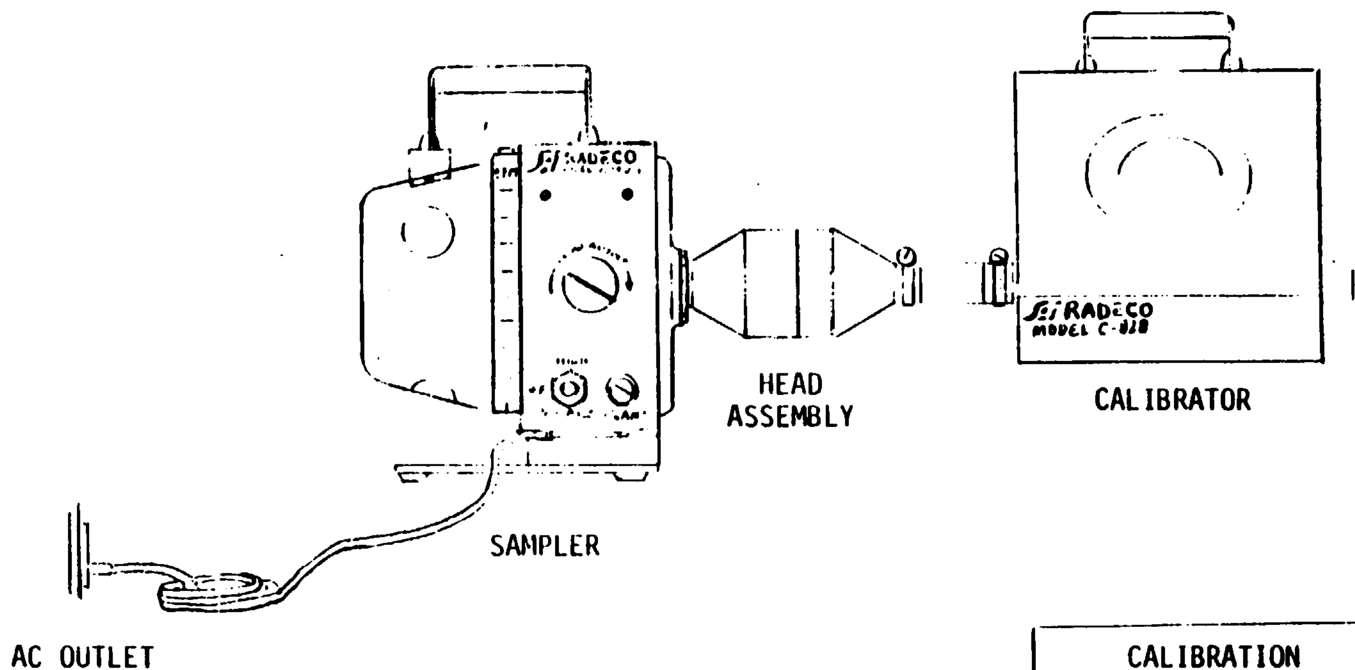
Inches Hg

°F	20	21	22	23	24	25	26	27	28	29	30	31
30	1.176	1.148	1.121	1.097	1.074	1.052	1.031	1.012	0.994	0.977	0.960	0.945
32	1.178	1.150	1.124	1.099	1.076	1.054	1.034	1.014	0.996	0.979	0.962	0.947
34	1.181	1.152	1.126	1.101	1.078	1.056	1.036	1.016	0.998	0.981	0.964	0.948
36	1.183	1.155	1.128	1.103	1.080	1.058	1.038	1.018	1.000	0.983	0.966	0.950
38	1.186	1.157	1.130	1.106	1.082	1.060	1.040	1.020	1.002	0.985	0.968	0.952
40	1.188	1.159	1.133	1.108	1.084	1.063	1.042	1.022	1.004	0.987	0.970	0.954
42	1.190	1.162	1.135	1.110	1.087	1.065	1.044	1.025	1.006	0.989	0.972	0.956
44	1.193	1.164	1.137	1.112	1.089	1.067	1.046	1.027	1.008	0.991	0.974	0.958
46	1.195	1.166	1.139	1.114	1.091	1.069	1.048	1.029	1.010	0.992	0.976	0.960
48	1.197	1.169	1.142	1.117	1.093	1.071	1.050	1.031	1.012	0.994	0.978	0.962
50	1.200	1.171	1.144	1.119	1.095	1.073	1.052	1.033	1.014	0.996	0.980	0.964
52	1.202	1.173	1.146	1.121	1.097	1.075	1.054	1.035	1.016	0.998	0.982	0.966
54	1.205	1.175	1.148	1.123	1.100	1.077	1.056	1.037	1.018	1.000	0.983	0.967
56	1.207	1.178	1.151	1.125	1.102	1.079	1.058	1.039	1.020	1.002	0.985	0.969
58	1.209	1.180	1.153	1.128	1.104	1.082	1.061	1.041	1.022	1.004	0.987	0.971
60	1.212	1.182	1.155	1.130	1.106	1.084	1.063	1.043	1.024	1.006	0.989	0.973
62	1.214	1.185	1.157	1.132	1.108	1.086	1.065	1.045	1.026	1.008	0.991	0.975
64	1.216	1.187	1.160	1.134	1.110	1.088	1.067	1.047	1.028	1.010	0.993	0.977
66	1.218	1.189	1.162	1.136	1.112	1.090	1.069	1.049	1.030	1.012	0.995	0.979
68	1.221	1.191	1.164	1.138	1.114	1.092	1.071	1.051	1.032	1.014	0.997	0.981
70	1.223	1.194	1.166	1.141	1.117	1.094	1.073	1.053	1.034	1.016	0.999	0.982
72	1.225	1.196	1.168	1.143	1.119	1.096	1.075	1.055	1.036	1.018	1.001	0.984
74	1.228	1.198	1.171	1.145	1.121	1.098	1.077	1.057	1.038	1.020	1.002	0.986
76	1.230	1.200	1.173	1.147	1.123	1.100	1.079	1.059	1.040	1.021	1.004	0.988
78	1.232	1.203	1.175	1.149	1.125	1.102	1.081	1.061	1.041	1.023	1.006	0.990
80	1.235	1.205	1.177	1.151	1.127	1.104	1.083	1.063	1.043	1.025	1.008	0.992
82	1.237	1.207	1.179	1.153	1.129	1.106	1.085	1.065	1.045	1.027	1.010	0.993
84	1.239	1.209	1.181	1.156	1.131	1.108	1.087	1.066	1.047	1.029	1.012	0.995
86	1.241	1.212	1.184	1.158	1.133	1.110	1.089	1.068	1.049	1.031	1.014	0.997
88	1.244	1.214	1.186	1.160	1.135	1.112	1.091	1.070	1.051	1.033	1.015	0.999
90	1.246	1.216	1.188	1.162	1.137	1.114	1.093	1.072	1.053	1.035	1.017	1.001

CORRECTED BAROMETRIC PRESSURE

mm Hg

°C	500	525	550	575	600	625	650	675	700	725	750	775	800
37	1.266	1.235	1.207	1.180	1.155	1.132	1.110	1.089	1.070	1.051	1.033	1.017	1.001
38	1.268	1.237	1.209	1.182	1.157	1.134	1.112	1.091	1.071	1.053	1.035	1.018	1.002
39	1.270	1.239	1.211	1.184	1.159	1.136	1.114	1.093	1.073	1.054	1.037	1.020	1.004
40	1.272	1.241	1.213	1.186	1.161	1.138	1.115	1.095	1.075	1.056	1.038	1.022	1.005
41	1.274	1.243	1.215	1.188	1.163	1.139	1.117	1.096	1.077	1.058	1.040	1.023	1.007
42	1.276	1.245	1.216	1.190	1.165	1.141	1.119	1.098	1.078	1.060	1.042	1.025	1.009
43	1.278	1.247	1.218	1.192	1.167	1.143	1.121	1.100	1.080	1.061	1.043	1.026	1.010
44	1.280	1.249	1.220	1.193	1.168	1.145	1.123	1.102	1.082	1.063	1.045	1.028	1.012
45	1.282	1.251	1.222	1.195	1.170	1.147	1.124	1.103	1.083	1.065	1.047	1.030	1.013
46	1.284	1.253	1.224	1.197	1.172	1.148	1.126	1.105	1.085	1.066	1.048	1.031	1.015
47	1.286	1.255	1.226	1.199	1.174	1.150	1.128	1.107	1.087	1.068	1.050	1.033	1.017
48	1.288	1.257	1.228	1.201	1.176	1.152	1.130	1.108	1.088	1.070	1.052	1.034	1.018
49	1.290	1.259	1.230	1.203	1.178	1.154	1.131	1.110	1.090	1.071	1.053	1.036	1.020
50	1.292	1.261	1.232	1.205	1.179	1.156	1.133	1.112	1.092	1.073	1.055	1.038	1.021



CALIBRATION

SET-UP

DIAGRAM A

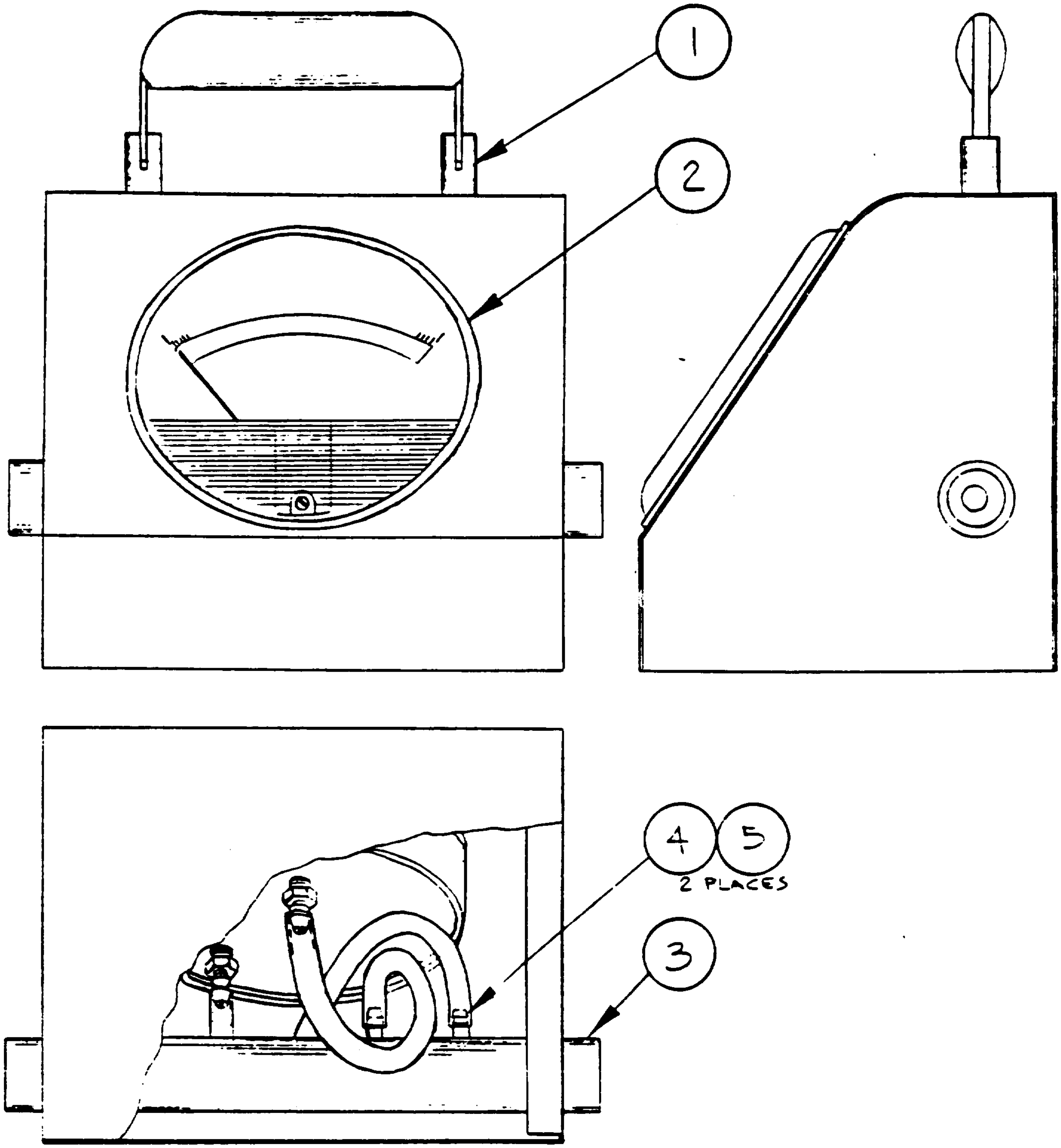
AIR FLOW CALIBRATOR ADAPTORS

MODEL NO.	DESCRIPTION
2500-43	Adapts C8528 to H-809VII Sample Head 2500-25
2500-54	Adapts C8528 to Staplex 4" Sample Head
2500-55	Adapts C828 to H-809VI Sample Heads 2500-34, 2500-39
2500-56	Adapts C828 to H-809VI Sample Heads 2500-19, 2500-27
2500-57	Adapts C828 to H-809VI Sample Head 2500-33
2500-58	Adapts C828 to H-809VI Sample Head 2500-23
2500-59	Adapts C812 to Intake of 442A
2500-79	Adapts C812 to Sample Heads 2500-35, 2500-46
2500-80	Adapts C812 to Sample Heads 2500-05, 2500-21
2500-81	Adapts C812 to Sample Head 2500-42
2500-82	Adapts C812 to 2500-04

Adaptors include interconnecting hose and hose clamps.

MODEL EFFECT	REVISION			
	LTR	DESCRIPTION	DATE	APPROVED

Notes:



ITEM NO	PART NO	NEXT ASSY	USED ON
		APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE
DECIMALS .X ± .XX ± .XXX ± ANGLES ±
MATERIAL
FINISH

CONTRACT NUMBER
PREPARED [illegible] DATE [illegible]30-86
CHECKED
APPROVED
APPROVED
QA
REL

SAIC RADECO

TITLE AIR FLOW CALIBRATOR

SIZE A | CODE IDENT NO | DWG NO FIGURE 1 | REV
SCALE | SHEET OF
PROJECT

91919
SAIC-RDCO-85-03-0202

LEGEND - FIGURE 1

AIR FLOW CALIBRATOR

Item No. (From Drawing)	Description
1	Handle
2	Magnehelic Gage
3	Venturi
4	Hose Barb
5	Washer, Fibre

Model ESP-1

Eberline Smart Portable Technical Manual

Eberline
A DIVISION OF Thermo Electron CORPORATION

A DIVISION OF

Eberline Thermo Electron CORPORATION

Service Centers

CERTIFIED CALIBRATION REPAIR

Eberline Instrument Certified Calibration .... Call Service Center for prices
Other Manufacturer Instrument Certified Calibration .... $100.00 each
Repair Rate above Calibration plus Parts at List Price $60.00/hour
Contractual rates are available on periodic repair and/or calibration. Contact Service Center for prices.

THREE-YEAR (3) EXTENDED WARRANTY

This includes Certified Calibration plus Parts

1. Eberline Instruments, FOB Eberline Instrument Repair and Calibration Facility .... $70.00 each/quarter

MISCELLANEOUS

1. Turn Around Time:
   Calibration: Five (5) working days on Eberline instruments.
   Repair: Twelve (12) working days on Eberline instruments unless parts have to be ordered.
2. FOB Santa Fe, New Mexico, or West Columbia, South Carolina
3. Instruments for warranty repair, repair, or calibration must be sent to:

   Instrument Repair and Calibration
   Eberline Instrument Corporation
   P.O. Box 2108, Airport Road
   Santa Fe, New Mexico 87504-2108
   Telephone: (505) 471-3232

   Instrument Repair and Calibration
   Eberline Instrument Corporation
   312 Miami Street
   West Columbia, South Carolina 29169
   Telephone: (803) 796-3604
4. In addition, the following Customer Service Centers are available for customers outside the United States.

   Thermo Electron, Ltd.
   Woolborough Lane
   Crawley, West Sussex
   England, RH10 2AQ
   Telephone: (44) 293-544811

   Safety Supply Canada
   214 King Street E
   Toronto, Ontario
   Canada M5A 1J8
   Telephone: (416) 364-3234

Prices at these locations will vary from U.S. prices. Please contact the facilities for current price and delivery information.

February 1986

EBERLINE INSTRUMENTS STANDARD WARRANTY

One-Year Warranty: Seller warrants to replace or repair, at its option, any products or parts thereof (excluding tubes, crystals and batteries [tubes and crystals 90 days]) which are found defective in material or workmanship within one year from date of shipment. Seller's obligation with regard to such products or parts shall be limited to replacement or repair, FOB seller's factory or authorized repair station, at seller's option. The aforesaid warranty will be voided if repair has been attempted by other than seller's authorized personnel. In no event shall seller 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.**

A DIVISION OF
Eberline Thermo Electron
CORPORATION
P.O. Box 2108
Santa Fe, New Mexico 87504-2108
(505) 471-3232 TWX: 910-985-0678

LIST OF EFFECTIVE PAGES

TOTAL NUMBER OF PAGES IN THIS MANUAL IS 67, CONSISTING OF THE FOLLOWING:

Page	Change In Effect	Latest Publication Date
Title	Change 1	March 13, 1986
A	Change 1	March 13, 1986
i	Change 1	March 13, 1986
ii	Change 1	March 13, 1986
iii	Change 1	March 13, 1986
1-62	Change 1	March 13, 1986

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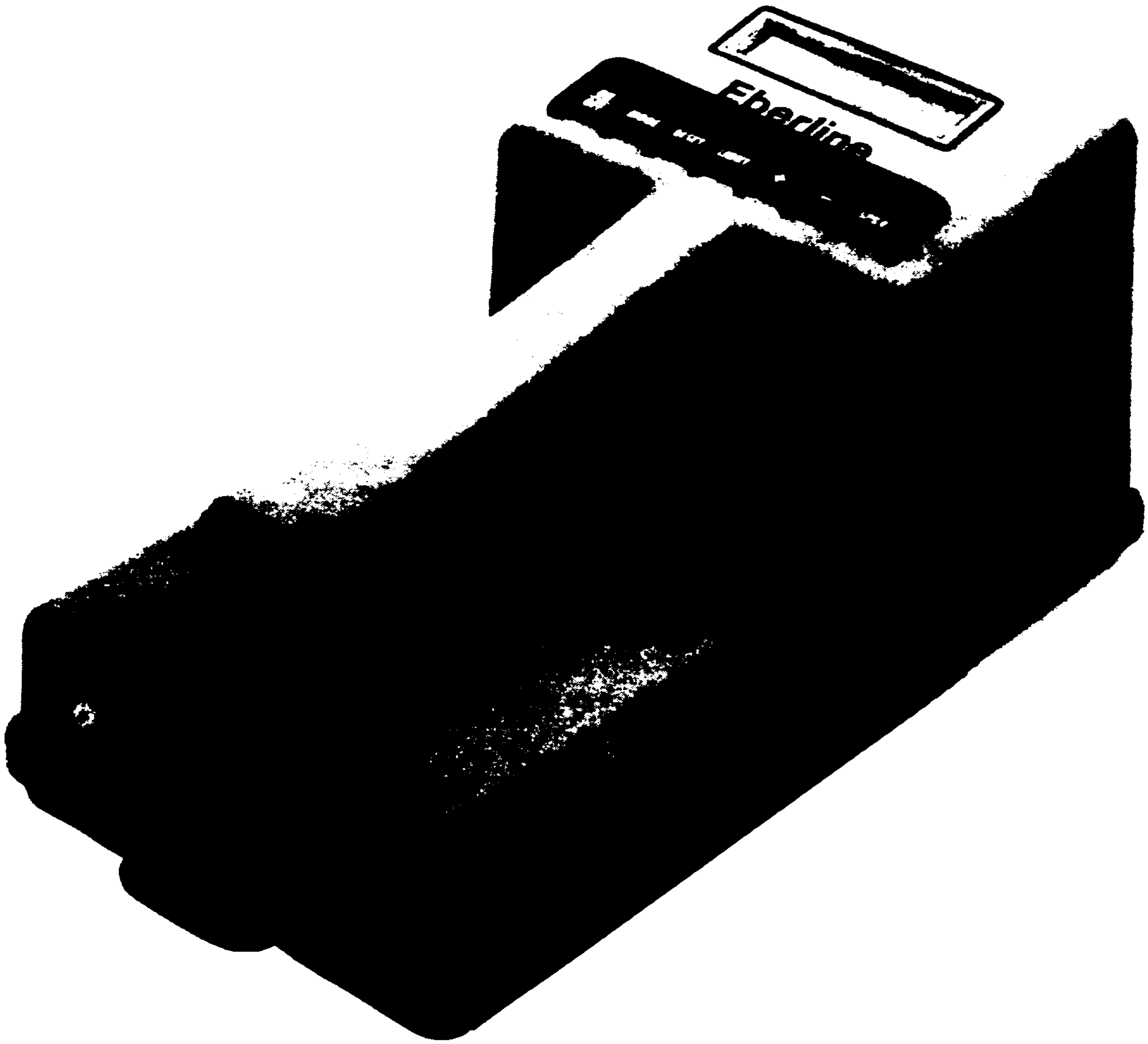


Figure 1-1. Model ESP-1

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The Eberline Smart Portable (ESP-1) is a microcomputer-based portable radiation survey instrument designed to operate with most Eberline radiation detectors. The ESP-1 can display the data from these detectors in radiation units as selected and calibrated by the user. In addition, the ESP-1 has a built-in speaker, with earphone output capability, available for use by the operator.

The external controls used to operate the ESP-1 are located on the face of the instrument in a single row of seven square pushbutton switches. Two are "push on-push off" switches and the remaining five are "push on-normally off." Internal controls, accessible through a door on the right side of the instrument, enable the user to adjust and select other functions that are available to the operator. The internal controls consist of four potentiometers and four switches.

The ESP-1 readout is a liquid crystal display (LCD) located on the face of the instrument.

The power supply for the ESP-1 is fully self-contained and consists of six "C" cells.

Several Eberline probes and detectors are available for use with the ESP-1. The Eberline detectors recommended for use with the ESP-1 are included in a catalog at the end of the manual.

The ESP-1 has three operating modes, Rate Meter, Scaler, and Inquiry/Calibration. The detector signal is input to the computer and converted to count rate. The basic unit is counts per second. The ***Rate Meter Mode*** provides the operator with a dual representation of count rate. Count rate is displayed as an analog bar graph, the length of which is proportional to the activity at the detector, and as a numerical value expressed in the applicable radiation units. An audio alarm feature alerts the operator when an alarm setting has been exceeded. To enhance accuracy, the ESP-1 provides both a slow and a fast range of time response, each of which varies automatically with count rate.

The ***Scaler Mode*** allows the operator to select a "countting period" over which the computer integrates the detector signal. On the first line of the LCD, the instrument displays the time remaining in the counting period. The second line shows cumulative "events" (the basic unit) or cumulative radiation units, e.g., "R." At the end of the counting period, the instrument displays the length of the counting period and the total number of events or radiation units counted. The scaler mode may be disabled by an internal switch.

An *Inquiry/Calibration Mode* is also available. This mode is used to enter and adjust various parameters as necessary to permit optimum operation of the instrument with several types of probes. In the Inquiry/Calibration Mode, the ESP-1 is actually measuring in the Rate Meter Mode, with the bar graph and the alarm suppressed and with the slow response time selected to enhance accuracy. This mode may also be disabled by an internal switch.

B. SPECIFICATIONS

1. Mechanical (with batteries, excluding probe)

a. Overall Dimensions (including all protrusions): 10.25 inches × 5.0 inches × 5.0 inches (26.0 cm × 12.7 cm × 12.7 cm).

b. Weight: Approximately 3.8 pounds (1.75 kg).

2. Operating Temperatures: −20 °C to +50 °C (-4 °F to +122 °F)

3. Voltages

a. Low Voltage: 5 Vdc.

b. High Voltage (detector bias voltage): 350 to 2300 Vdc, set by the person calibrating the instrument to the bias voltage required for the detector being used.

4. Detectors

Most Eberline GM, proportional, or scintillation detectors for alpha, beta, gamma, or neutron activity may be used on the ESP-1. The detectors recommended are described at the end of this manual. The detectors connect to the ESP-1 via an MHV-series coaxial connector located on the front of the instrument.

5. Readout

a. Two lines of 16 alphanumeric characters presented on liquid crystal display (LCD).

b. Character size: H = 0.175 inch (4.45 mm); W = 0.124 inch (3.15 mm).

c. Bar graph resolution: 1 in 48 (2.1 percent).

6. Alarm: A 2000-Hz audio tone from the speaker.

7. External Controls

A single row of seven 3/8-inch-square pushbutton switches on 1/2-inch centers across the face of the instrument. From left to right, they are:

a. *ON/OFF*: Press on - press off

b. *MODE*: Press on - normally off

c. *RESET*: Press on - normally off

d. *LIGHT*: Press on - normally off

e. +: Press on - normally off

f. −: Press on - normally off

g. *SPKR*: Press on - press off

8. Internal Controls

The internal controls consist of four potentiometers and four switches accessible through the door on the right side of the instrument. They are:

a. *LV* (Low Voltage): Potentiometer

b. *DISCR* (discriminator): Potentiometer

c. *HV* (High Voltage): Potentiometer

d. *VO* (viewing angle): Potentiometer

e. *SPKR* (speaker): One switch (three positions)

f. *MASK*: Two SPST switches

g. *TEST*: Switch

9. Power Supply

The ESP-1 uses six "C" cell batteries. In the ESP-1, the end-of-life (EOL) voltage per cell is 0.9 Vdc using carbon-zinc cells. Six carbon-zinc batteries provide approximately 250 hours of continuous use (excluding display lighting). The ESP-1 senses the low battery condition at 0.95 Vdc/cell and signals the user by blinking the first character on the display. This indicates that at least 4 hours of operation remain before the end of battery life. The ESP-1 is programmed to turn itself off after it has operated for 2 hours under the "low-voltage" condition (first character blinking). The instrument can be turned on by the operator and will operate for another 2 hours after which it will turn itself off again.

The ESP-1 computer always has a supply of power to the memory so that data will be retained when the power switch is off. The typical battery drain with power off is less than 10 μA; therefore, the batteries should be changed at least once a year. To allow battery change without loss of memory, the ESP-1 uses a 0.047-F capacitor to supply power to the computer. **This allows about 20 minutes to change batteries.**

SECTION II
SIMPLIFIED OPERATING INSTRUCTIONS

A. INTRODUCTION

1. General

This section is intended to provide the first time user with a quick guide to what the ESP-1 does and how to operate it. Much of the information included here occurs in later sections of this manual in more detail.

The ESP-1 is simple and straightforward in its operation. The basic principle of operation is that the signal from an attached detector is input into the computer in the ESP-1 instrument, and this signal is converted to count rate. The ESP-1 can be used either as a rate meter or as a scaler, and a variety of units can be selected for display of the data.

The ESP-1 has three modes of operation:

a. The Rate Meter Mode:

- updates and displays selected units per time, such as counts per minute or mR/h;
- provides the operator with a dual representation of count rate; that is, it provides a moving analog bar graph representing count rate and also a digital value for count rate;
- alarms when a preset value is exceeded.

The Rate Meter Mode is generally used for routine surveys of surfaces, personnel, and clothing for either contamination or exposure rate measurements from a radioactive source.

b. The Scaler Mode:

- allows setting the time interval over which counts or events are to be measured;
- counting is started and ends after the selected time interval;
- registers the number of events or integrated exposure in the selected time interval;
- sounds audible alarm if the integrated counts in the selected time period exceeds the value set on the alarm.

The Scaler Mode is used for quantitive data accumulation over a longer period of time. Using the Scaler Mode, comparisons can be made of radioactivity in various samples or situtations with the result that increased accuracy in the data may be obtained by counting over longer periods of time. An example would be the determination of thyroid gland burden of radioiodine by counting the thyroid for a period of time, perhaps five minutes. This mode can be disabled by an internal switch; refer to section II.D.

c. Inquiry/Calibration Mode:

- enables the user to select the units which will be used in the Ratemeter Mode;
- enables the user to set the alarm point;
- enables the user to set two constants, the calibration constant (CC) and the dead time (DT) for the particular detector being used;
- enables the user to monitor the high voltage which is applied to the detector.

This mode can be disabled by an internal switch; refer to section II.E.

2. User Calibration

a. User Calibration of the ESP-1 with a Detector Purchased with the Instrument:

The ESP-1 is calibrated at the manufacturing facility. If the instrument was purchased with a detector, the correct calibration factors for that detector are already entered at the factory and the instrument is ready for immediate use. You should verify that these parameters are the same as those supplied on the calibration certificate supplied with the detector. Refer to section II.E. for directions on viewing the parameters.

b. User Calibration of ESP-1 with Various Detectors:

If a radiation detector was not purchased with the ESP-1 from the factory, the ESP-1 was calibrated generically at the factory rather than for a specific detector. In that case, calibration factors for the detector of choice will have to be entered into the ESP-1 before it is ready for use.

CAUTION

Failure to enter the correct parameters for the detector being used may result in erroneous values being presented on the display of the ESP-1.

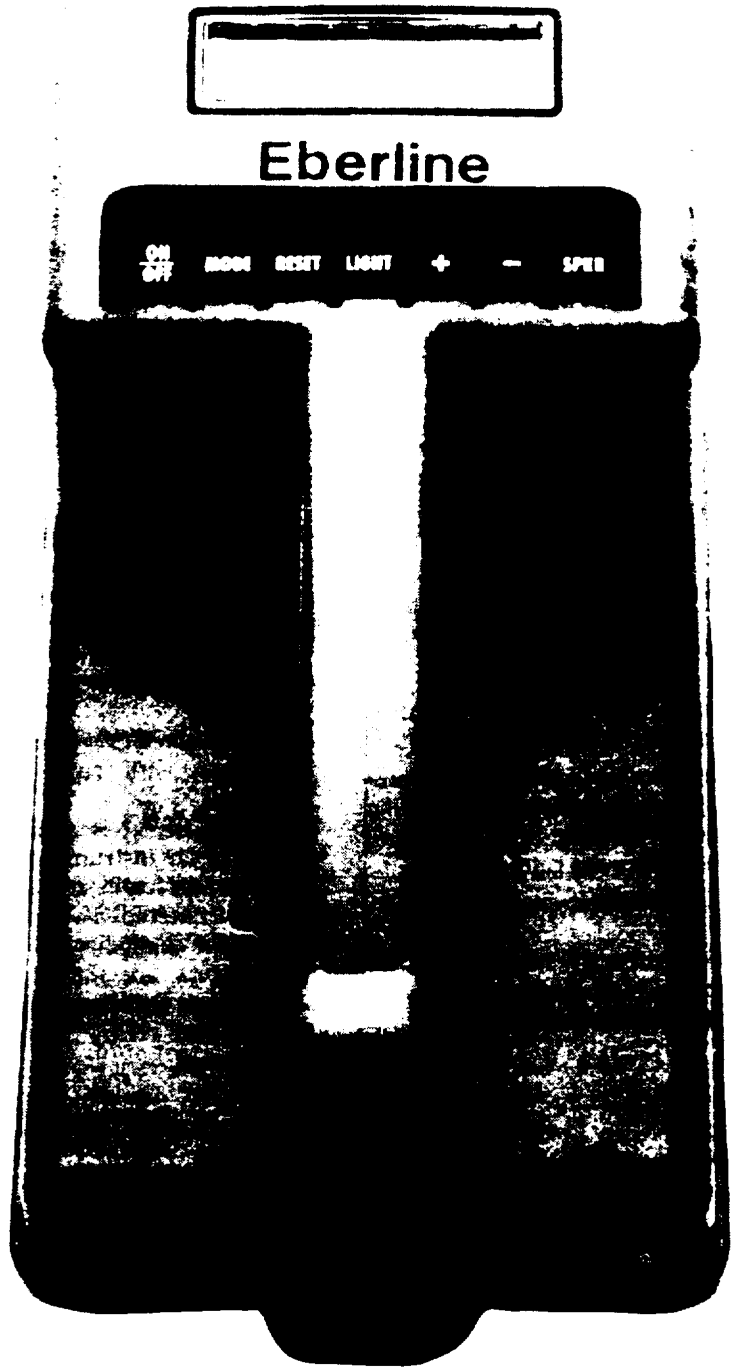


Figure 2-1. External Controls and Display

The parameters which require being set for a particular detector are:

	Section
1) Alarm Point	II.E.1.
2) Units	II.E.2.
3) Calibration Constant	II.E.3.
4) Detector Dead Time	II.E.4.
5) High Voltage	II.E.5.

The last four are preset at the factory for the detector which was purchased with the ESP-1. The alarm point is set at a high value at the factory and, thus, should be reset to a user determined value if it is desired to use this feature of the instrument.

Section II.E. provides simple instructions on how to reset (recalibrate) the items when changing detectors or recalibrating the instrument.

The high voltage should be checked or readjusted for a new detector, PRIOR to connecting the detector. Failure to do so may result in damage to the detector.

3. Calibrations Required by Regulatory Agencies

Regulatory agencies generally require routine laboratory calibration of radiation survey instruments by an approved facility at least once per year. To have your instrument recalibrated return the ESP-1 and detector to the factory in Santa Fe, to the Eberline repair facility in Columbia, South Carolina, or to another approved calibration facility. If your facility has been approved for such calibrations, this may be accomplished by using the procedures given in section V., "Calibration."

B. PRELIMINARY INSTRUCTIONS

Upon receiving the ESP-1 perform the following before proceeding.

1. Set Up the ESP-1 and Detector

The ESP-1 has an MHV connector on its front surface for connection to a radiation detector. This connector supplies high voltage to the detector and also transmits the detector signal to the ESP-1 for processing and display. If the ESP-1 is already connected to a detector then it is reasonable to assume that the high voltage has been previously set. If you are not sure that the high voltage has been properly adjusted, disconnect the detector from the instrument by rotating the cable connector counterclockwise. You can proceed through these instructions without the detector being connected.

CAUTION

Failure to disconnect the detector from the instrument before turning it on can damage the detector if the high voltage is not set properly for the particular detector. Instructions for checking and setting the high voltage can be found in section II.E.5.

When you are ready to connect the detector, verify that you have the proper cable. It should have a MHV connector on one end which mates to the ESP-1 and a connector on the other end to mate with the detector. Refer to the ESP-1 catalog sheet for the proper cable to use with the specific detector. The cable number is printed somewhere along the length of the cable. The MHV end of the cable connector typically has white insulation in the center which extends slightly beyond the end of the metal portion of the connector. In contrast, a BNC cable connector typically has the insulation flush with the connector end. To connect the cable, rotate the connector clockwise.

2. Turn the Instrument *ON* and *OFF*

Press the *ON/OFF* switch to turn the instrument on. The same switch will have to be pressed to turn the instrument off.

When the instrument is turned on, the display should indicate a numerical value on the lower line and a bar graph on the upper line. The bar graph may be off-scale, so press the *RESET* button to get it back on scale. The ESP-1 is in its Rate Meter Mode. Refer to section II.C. for more information on the displayed information.

If the instrument has been properly calibrated and is connected to a detector, it is ready to use. Refer to section II.E. for instructions on how to view and change the calibration parameters.

A quick check to determine that the instrument is functioning is to compare the numerical value being displayed to the background radiation level. If they are close, then the instrument is operating and ready to use. Remember that normal statistical fluctuations can cause relatively large changes in the displayed reading at low levels. Press the *SPKR* button and you should hear a click corresponding to each detector event. If this is not the case, the speaker rate switch could be in the wrong position. Refer to section III.A.2.

3. Determine Low Battery Condition and Battery Replacement

Examine the first character space in the display (upper left hand corner). If it is blinking, the batteries are low and need replacing. The ESP-1 uses six "C" cell batteries.

The instrument automatically turns itself off two hours after the low battery condition signal is given. The ESP-1 can be turned back on after it turns off, but will turn itself off again after two hours.

To change batteries, remove the large screw in the bottom of the case, and carefully remove the case bottom while being careful not to disconnect the grounding wire which is connected to the bottom of the case. Replace the batteries while being careful to orient the batteries according to the diagram printed on the bottom surface of the compartment which holds the batteries. (See figure 5-2.)

C. OPERATION IN THE RATE METER MODE

The ESP-1 is automatically placed in the Rate Meter Mode when the instrument is turned on. Examine the display. It will show:

1. Analog Bar Graph (at the top of the display)

The length of the moving analog bar graph is proportional to the detector count rate. One purpose of the moving bar graph is to permit more rapid recognition of a sudden increase or decrease in the radiation field being measured as compared to visual recognition from the changing numbers.

If the bar graph is off scale in either direction, it may be brought back on scale by pressing the *RESET* button. The full scale value of the bar depends on the level of radiation being measured. Pressing the *RESET* button always resets the value of the full scale of the bar graph to a point that is 33 percent of full scale. If the bar graph is displayed and is varying, the ESP-1 is working.

2. Numerical Value of Count Rate (at the bottom of the display)

The second line of the display is the numerical value of the count rate. The value is expressed as a number followed by a second positive or negative number. The second number corresponds to a power of 10. Example: 1.00 + 02 mR/h is $1 \times 10^2 = 100$ mR/h.

3. Alarm

The alarm point is a selected value which results in an audible alarm when the counting rate reaches that value. To silence the alarm, press *SPKR* key. The alarm will sound even if the speaker is off at the time the alarm is activated.

The alarm point can be viewed and set by pressing the *MODE* key. The display will contain either the "ALM AT" (Alarm Setting) display or will contain the "SCALER MODE?" prompt. If the latter is displayed, press the − key and you will see:

ALM AT (ALARM SETTING) RATE METER READING

The value of the alarm setting "ALM AT" can be increased or decreased as desired by simultaneously pressing *RESET* and + or *RESET* and −.

Note that the longer the *RESET* and + or − are held down, the faster the value changes. In this manner large changes in value can be made in a relatively short period of time. When the changing value approaches the desired value, release the keys and then press them down again to permit slow changes in the displayed numbers until the desired value is reached.

When the desired value of "ALM AT" is displayed, press the *MODE* key to return to the bar graph display.

CAUTION

While "ALM AT" is being displayed, the instrument will not provide an audible alarm even if the counting rate exceeds the alarm point. The audible alarm is only active in the Rate Meter Mode when the bar graph is displayed (regardless of whether the bar graph is on scale or not).

4. Overrange Indication

When the detector pulse rate exceeds the capability of the ESP-1 to maintain a linear relationship between radiation level and displayed reading, the words "OVERRANGE" will appear on the display in place of the analog bar graph. Numerical value will still be displayed but **should not be relied upon** as the useful range of the ESP-1 and detector has been exceeded. This is a latching condition, and once it occurs, the words "OVERRANGE" will be displayed in all three modes of operation. To clear the condition, the ESP-1 must be turned off and then back on. The overrange determination is based upon the detector pulse rate and the dead time (see section II.E.4.). This feature requires that the ESP-1 and detector be properly calibrated for it to function correctly.

D. OPERATION IN SCALER MODE

Start with the instrument in the Rate Meter Mode. Press the *MODE* switch. The display should read:

SCALER MODE + = USE/ – = NO

If the display does not indicate the above, the Scaler Mode has been disabled by an internal switch. To enable access to this mode, first open the door in the side of the instrument and locate the switch in the lower left corner marked *SCALER*. Refer to figure 3-1. Move this switch to the *ENABLE* position by sliding it to the left.

If the + key is pressed, the Scaler function will be selected. If the – switch is pressed, the instrument will again be placed in the Inquiry/Calibration Mode provided it has not been disabled by the internal switch. Press the + key. The display will read:

UNITS = EVENTS + = USE/ – = NO

or

UNITS = (UNITS SELECTED) + = USE/ – = NO

Units are either events or the selected rate meter units (e.g., mR, rem, CNT). To select units, press – until the desired unit is displayed. Then press + to accept the unit displayed. The units selected will utilize the same calibration constant as was used in the Rate Meter Mode. The display will change to:

UNITS = (AS SELECTED) ALM AT (ALARM SETTING)

The alarm indicated here is not the rate meter alarm, but is one that sounds if the set value of total (integrated) events or selected units is exceeded. Pressing *RESET* and + or – simultaneously will increase or decrease the total at which the alarm sounds. Press +. The display will read:

UNITS = (AS SELECTED) CNT FOR (COUNT PERIOD)

The count period can be set by the operator for any interval from 1 second to 4 hours. Pressing *RESET* and + or – simultaneously will increase or decrease the length of the counting period.

To obtain a total count over a set count period, press +. The display will read:

CNT FOR (X:XX:XX)(h:m:s) RESET TO START

Press *RESET*. After one second, the display will read:

(X:XX:XX) LEFT (h:m:s) (TOTAL COUNT SO FAR)

When the count period has expired, the display will read:

CNT FOR (X:XX:XX) (TOTAL COUNT)

For another total count, pressing *RESET* erases the previous count and starts a new counting interval. During the count period, the audio alarm will sound if the alarm limit is exceeded.

When operations or settings in the Scaler Mode have been completed, pressing *MODE* twice will shift the ESP-1 to the ratemeter mode. The display will read:

llll (BAR GRAPH) RATE METER READING

E. OPERATION IN INQUIRY/CALIBRATION MODE

1. Selecting of Inquiry/Calibration Mode and Setting the Alarm

After turning on the instrument it will be in the ratemeter mode. Press the *MODE* key and the display will read:

SCALER MODE
+ = USE/ − = NO

or

ALM AT (ALARM SETTING)
RATE METER READING

If the "SCALER MODE" prompt is displayed (the first possibility shown above) then press the − key to enter the Inquiry/Calibration Mode and obtain the "ALM AT" display (the second possible display shown above). Pressing the + key will place the instrument in the Scaler Mode; refer to section II.D.

The first entry in this mode is the alarm point viewing and setting. Refer to section II.C.3. where directions for this procedure have already been given in the discussion on the ratemeter mode. When the desired value of "ALM AT" is displayed, press the + key.

2. Changing Units

a. When the + key is pressed (step 1), the display should show:

UNITS = (UNITS SELECTED)
RATE METER READING

If the display does not indicate the above, the Inquiry/Calibration Mode has been disabled by an internal switch. To enable access to this mode, first open the door in the side of the instrument and locate the switch in the lower left corner marked *INQUIRY/CALIBRATION*. Refer to figure 3-1. Move this switch to the *ENABLE* position by sliding it to the left. This will permit adjusting of all the parameters that can be changed from the keypad on the top of the instrument. Likewise, after all the parameters have been adjusted, placing the switch in the *DISABLE* position will prevent changing of the parameters from the top of the instrument.

b. If the units currently displayed are acceptable, the next step (c.) may be bypassed by pressing +.

c. If units other than those displayed are desired, press *RESET*. The options for selection are the "BASE" unit, the "SUFFIX" on the unit, and the "PREFIX" on the unit. The first display will be the selection of the base unit as follows:

BASE (UNIT)
+ = USE/ − = NO

The selection of the "BASE" units is now possible.

The choices available for base radiation units are:

R	roentgen
cnt	counts
Gy	gray
Sv	sieverts
rem	roentgen equivalent man
dis	disintegrations
rad	radiation absorbed dose

Notice that the base unit is what is displayed; thus, if mR/h is desired on the display, select "R" as the base unit. The prefix (milli) and the suffix (h) will be added in the next steps.

In each case, press − to reject the displayed parameter, and another selection will be offered. When the display shows the desired base unit, press + to accept it.

CAUTION

Selection of a new base unit requires an appropriate change in the calibration constant (CC). Refer to section II.E.3. Changing the prefix or suffix **does not** affect calibration and so requires no change in the calibration constant.

Selection of "SUFFIX"

After the + is pressed (as discussed above) to accept the base unit, the display will then present the selection of suffix as follows:

SUFFIX (UNIT TIME)
+ = USE/ − = NO

The suffix is the unit of time used to calculate the displayed "RATE METER READING." Three are available:

s	second
min	minute
h	hour

Again, press the − switch to reject the suffix displayed and call the next choice to be displayed. When the desired suffix is displayed, press + to accept it.

Selection of "PREFIX"

After the + is pressed above to accept the suffix, the display will then present the selection of prefix as follows:

PREFIX (VALUE)
\+ = USE/ − = NO

The prefix is the value by which the base unit is multiplied to provide a more convenient unit of actual measurement. Four are available:

(NONE)	no prefix
μ	micro ($\times 10^{-6}$)
m	milli ($\times 10^{-3}$)
k	kilo ($\times 10^{+3}$)

If the prefix displayed is not the desired value, then press − to reject it and call the next choice to be displayed. When the desired prefix is displayed, press + to select it. The setting of radiation units to be measured would now be complete. An example of this would be:

PREFIX	BASE	SUFFIX
m	R	/ h
(milli)	(roentgen)	/ (hour)

The units may be selected in any combination of prefix/base/suffix. Press the + switch to select the prefix.

3. Setting the Calibration Constant (CC)

a. Definition of Calibration Constant:

The calibration constant (CC) is the number used to convert the counts from the detector to the previously displayed base unit. Specifically, the displayed rate meter reading is derived by dividing the counts per seconds (from the detector) by CC and then scaling the result based on the selected prefix and suffix.

b. Display of Calibration Constant (CC) Setting:

If the current value for the units was accepted by pressing + (step 2 above), the display will read:

CC = (NUMERICAL VALUE)
RATE METER READING

c. Selection of "CC" for Detectors Which Were Purchased with the ESP-1 from the Factory:

If a detector was purchased with the ESP-1 from the factory, the calibration constant will already be set at the factory for this detector and the following section may be bypassed until a different type of detector is to be used with the instrument or until time for routine recalibration of the instrument.

The calibration constant will have to be changed when switching detectors. When changing back from another detector to the detector which was purchased with the ESP-1, use the calibration constant which is given on the calibration sheet supplied with the combined ESP-1 and detector. Change values by pressing simultaneously either *RESET* and + or *RESET* and −.

d. Selection of Calibration Constant for Various Detectors:

(1) If the detector was not purchased with the ESP-1 and, thus, a calibration sheet is not available, use the nominal value for the particular Eberline detector which is given in section V, "Maintenance," table 2.

(2) To increase the value of CC, press *RESET* and + simultaneously. To decrease the value of CC, press *RESET* and − simultaneously.

(3) To calculate a calibration constant for detectors other than those listed in the table, the sensitivity of the detector must be known and is usually found in the list of specifications given on the catalog sheet. Calculations using a HP-270 detector as an example are given as follows:

$$\text{sensitivity} = 1200\ \text{c/min/mR/h}$$

Calibration =

$$\frac{1200\ \text{c/min}}{\text{mR/h}} \times 1000\ \text{mR/R} \times 60\ \text{m/h} = 7.2 \times 10^7\ \text{c/R}$$

4. Setting the Dead Time (DT)

a. Definition:

The dead-time correction constant is a derived number used to correct for counting losses due to in-ability of the detector to recover at high counting rates. This correction results in a more linear response to the radiation field being measured and extends the useful range of some detectors used with the ESP-1 by a factor of as much as ten times (which provides the equivalent of an extra range on a standard rate meter).

b. Selection of "DT" for Detectors which were Purchased from the Factory with the Instrument:

If the ESP-1 was purchased with a detector from the factory, the DT value will be correctly set at the factory and the next section may be bypassed until it is necessary to use a different detector or until time for routine calibration.

When changing back from another detector to the detector purchased with the ESP-1, use the DT given on the calibration sheet supplied with the combined ESP-1 and detector.

c. Selection of DT for Various Detectors:

(1) If the detector was not purchased with the ESP-1 and, thus, a combined calibration data sheet is not available, use the nominal value for the particular detector which is given in Section V, "Maintenance," table 2 (page 29).

(2) To increase the value of DT, simultaneously press *RESET* and +. To decrease the value of DT, simultaneously press *RESET* and −.

(3) For a detailed discussion of DT consult section V.A., "Calibration."

CAUTION

If you do change detectors, the calibration constant (CC) and the dead time (DT) must be changed. Use the procedures just described in section II.E., steps 3 and 4.

5. Setting the High Voltage for the Detector of Choice

CAUTION

Do not press any of the keys! The high voltage is **not** changed from the top of the instrument. Proceed as follows:

a. Selection of High Voltage for Detectors which were Purchased from the Factory with the Instrument:

If a detector was purchased from the factory with the instrument, the operating high voltage will already be set at the factory for this detector, and the following section may be bypassed until a different type of detector is to be used with the instrument.

b. Selection of High Voltage for Various Detectors:

(1) If the calibration data sheet supplied with the detector is available, use the recommended operating high voltage which is given there.

(2) If the calibration sheet supplied with the detector is **not** available, use the following general recommendations:

(a) Geiger-type detectors (HP-190, HP-260, HP-270): use 900 volts (exception: HP-290 requires 500 volts).

(b) Scintillation detectors: determine the plateau response of the detector according to the procedure described section V.A.3.c. and figure 5-1, and select as the operating voltage a value which is 75 volts above the beginning of the plateau.

c. Procedure for Determining the Present Setting for the High Voltage as Viewed on the Display:

After the desired value for DT is selected (as discussed above), press +. The display will then show the present value for the high voltage setting and will look like this:

HV = (NUMERICAL VALUE) RATEMETER READING

If this value is not the recommended high voltage for the detector which you plan to use with the instrument, change the value using the directions given in step d. (following).

CAUTION

Do not attempt to adjust the high voltage using the keys on top of the instrument. This adjustment is accomplished by an internal potentiometer.

d. Changing the High Voltage:

(1) Disconnect the detector from the instrument by rotating the MHV connector counterclockwise and then open the door on the side of the instrument.

(2) Refer to figure 3-1. Using a small screwdriver, adjust the potentiometer marked *HV* (the third potentiometer from the right) until the value seen on the display is the value desired for the operating high voltage.

The operating high voltage must be changed when switching to a different type of detector, such as switching from a Geiger-Mueller (G-M or ionization) type of detector (HP-210, HP-260, HP-190, HP-270, HP-290) to a scintillation type detector (LEG-1, SPA-3, SPA-6, etc.) or to the neutron detector (NRD-1). To accomplish this, remember that **high voltage can only be changed with a screwdriver at the side of the instrument** (inside the compartment at the right side) by adjusting the correct potentiometer (figure 2-3) and viewing the values on the display until the decided voltage is reached. **Do not attempt to change the values shown on the display for "HV" by pressing *RESET* and + or −.** This latter maneuver changes the calibration of the display itself, it does **not** change the high voltage. If this occurs, the meter will have to be recalibrated by returning the instrument to the factory or recalibrated by a competent electronic technician. If it is not recalibrated, then it is possible to operate the detector at the wrong high voltage and not realize it. This may result in damage to the detector or may result in erroneous values being presented on the display of the ESP-1.

Make sure that you have lowered the high voltage when changing from a scintillation detector to a Geiger-type detector, which requires lower high voltage, **before** you attach the detector to the ESP-1. This will protect your Geiger detectors from accidental exposure to voltage which is too high for the tube.

(3) The detector of choice may now be attached to the ESP-1 since there is now assurance that the correct high voltage will be applied by the instrument to the detector.

The next sequence on the display (after the "HV" display) goes back to the beginning of the sequence, which is the "ALM AT" parameter. Return to the Rate Meter Mode by pressing the *MODE* key.

F. SIMPLE TROUBLESHOOTING

Although detailed troubleshooting will be given in section V, two simple suggestions for troubleshooting will be given here.

1. Condition: Blinking character or letter on the display.

If the character in the upper left-hand corner of the display is blinking, the batteries are low and need replacing.

Remove the large screw in the bottom of the case, and carefully remove the case bottom while being careful not to disconnect the grounding wire which is connected to the bottom of the case. Replace the batteries while being careful to orient the batteries according to the diagram printed on the bottom surface of the compartment which holds the batteries; see figure 5-2.

2. Condition: Display prints erratic numbers or figures ("garbage").

If the display shows characters or letters which are not a part of the usual display mode (displays "garbage"), the program in the microprocessor has lost its initialization (has become "scrambled"). To correct this condition and reinitialize the microprocessor, perform one of the following procedures:

a. Take the batteries out of the instrument and wait about 20 minutes. This will give adequate time for a capacitor (C1) to discharge and allow the microprocessor to reinitialize itself when the batteries are replaced and the instrument turned on.

b. **Or**, if you cannot wait 20 minutes after removing the batteries, perform the following steps:

(1) Remove the side door to the instrument.

(2) Refer to figure 3-1. While examining inside the instrument, locate capacitor C1. This capacitor is located on the top electronic board (in the top half of the area which is visible after the side door is removed). It is round in shape and is 5/8 inch in height and 5/8 inch in diameter and it is usually green or gray in color.

(3) Discharge this capacitor by touching the end of a small screwdriver across the two leads (wires at the bottom) of the capicator. A small discharge noise may be heard.

c. Replace the batteries in the instrument while being careful to orient them according to the diagram printed on the bottom surface of the compartment which holds the batteries.

d. Turn on the instrument and determine if the condition is corrected; that is, that the display presents letters and numbers which are a part of the usual display modes and are "reasonable."

e. If the display is still not functioning correctly, you may wish to consult detailed troubleshooting in section V or return your instrument to the factory for repair.

CAUTION

Reinitializing the microprocessor resets **all** parameters, including the high-voltage calibration. Complete recalibration must be performed before using the instrument.

SECTION III
DETAILED OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. Operator Controls - External (figure 2-1)

a. *ON/OFF*: Pressing this switch turns the instrument on or off.

b. *MODE*: Pressing the *MODE* switch changes the mode from that currently selected to one of the other modes (Rate Meter, Scaler, or Inquiry/Calibration.)

c. *RESET*: The functions of the *RESET* switch depend on the operating mode selected for the instrument.

(1) In the Rate Meter Mode the *RESET* switch is used to maintain the bar graph on the display.

(2) In the Scaler Mode the *RESET* switch resets the ESP-1 to a new count interval and starts the count. When used simultaneously with + or −, pressing the *RESET* will increase or decrease the selected parameter (count interval or alarm set point).

(3) In the Inquiry/Calibration Mode the *RESET* switch has two functions. Used alone, when units are displayed on the first line, it allows the operator to select or to change to another unit. When the operator is examining or setting parameters (calibration constant, dead time, or alarm), *RESET* used simultaneously with + or − will increase or decrease the value set for that parameter.

d. *LIGHT*: When the *LIGHT* switch is pressed, the display is illuminated.

e. + : The functions of the + switch depend on the operating mode.

(1) In Rate Meter Mode: The ESP-1 automatically varies response time with count rate to maintain a maximum +/−5 percent standard deviation above 2500 cpm. The normal (fast) response time ranges between 1.0 and 10.0 seconds. A slower response time, ranging from 1.8 to 29.0 seconds is available to maintain a maximum +/−3 percent standard deviation above 2500 cpm. The improved accuracy/slow response time is operative while the + switch is pressed and for 1.0 minute after it is released.

(2) In Scaler Mode: The + switch is used to set up the instrument to count events or basic units over a selected time interval. When used simultaneously with *RESET*, it increases the count interval or alarm set point.

(3) In Inquiry/Calibration Mode: The + switch has two functions. Used alone, it causes display of the next parameter in the list of parameters. Used simultaneously with *RESET*, + allows the operator to increase the value of the selected parameter.

CAUTION

External keypad controls allow monitoring and calibration of the high voltage display, but do not allow setting (or changing) the actual high voltage. Do not attempt to change the high voltage by pressing *RESET* + or *RESET* −. Refer to the "Operator Controls" section for a description of the internal potentiometer used to vary the actual high voltage.

f. − : The functions of the − switch depend on the operating mode.

(1) In Rate Meter Mode: If the slow response time is being used, pressing the − switch will override the 1.0-minute delay and will immediately place the ESP-1 back in the fast response time.

(2) In Scaler Mode: The − switch is used to provide the operator access to the list of parameters. When used simultaneously with *RESET*, − decreases the count interval or alarm set point.

(3) In Inquiry/Calibration Mode: The − switch has two functions. Used alone, − causes display of the preceding parameter in the list of parameters. Used simultaneously with *RESET*, − allows the operator to decrease the value of the selected parameter.

g. *SPKR*: Pressing the *SPKR* switch turns the speaker on or off. It also turns off the alarm when it sounds. When *SPKR* is used to silence the alarm, the speaker remains on until the operator presses *SPKR* again.

2. Operator Controls - Internal (figure 3-1)

Removing the right side door will provide access to the following:

a. *LV*: This potentiometer adjusts the operating voltage for the instrument. It is set for 5.00 V.

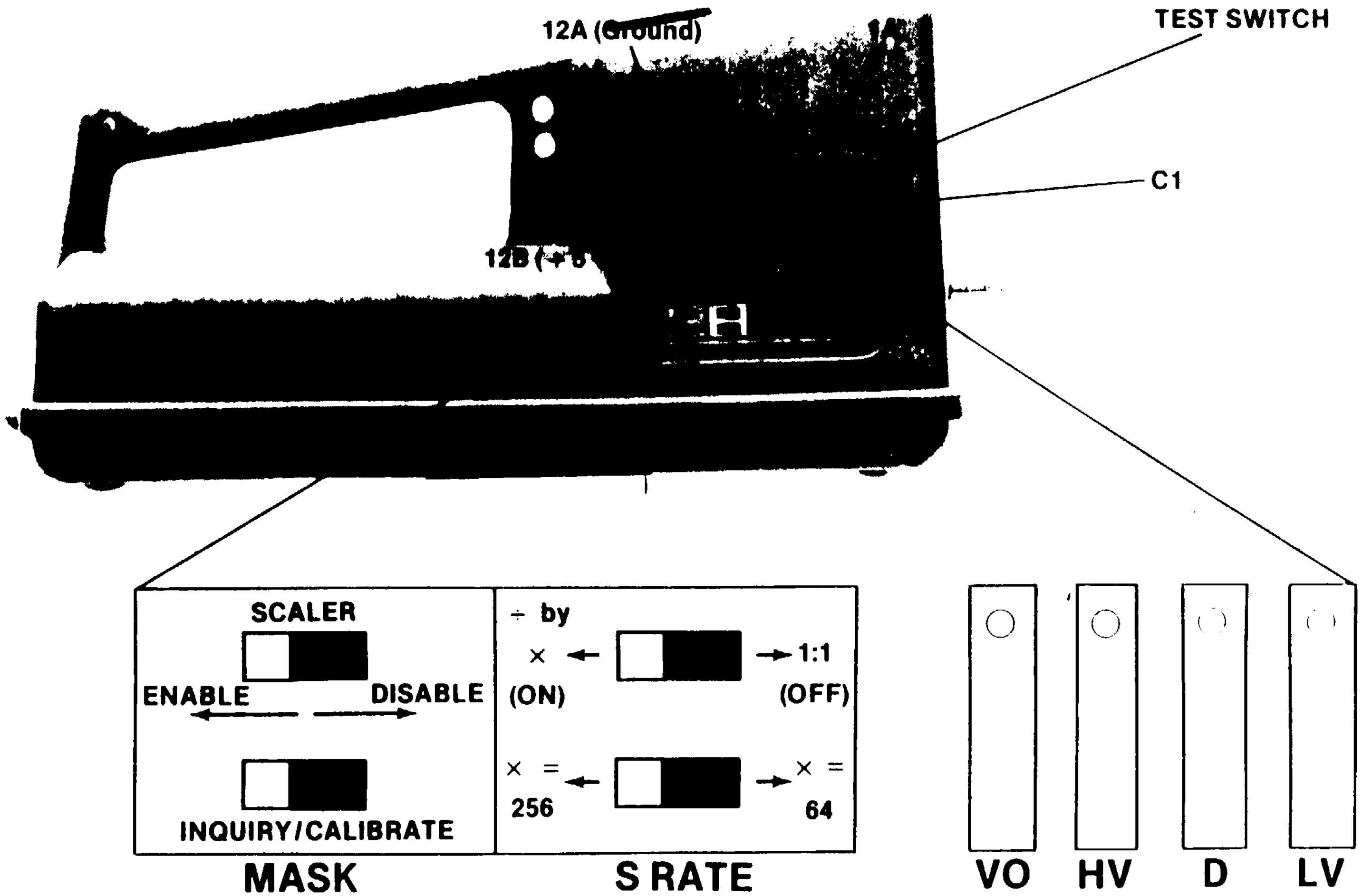


Figure 3-1. Internal Controls

b. *D*: This potentiometer is the discriminator adjustment. It is set to an optimum input sensitivity for the detector being used. (See section V.)

c. *HV*: This potentiometer adjusts the high voltage (detector bias). It is set to the optimum operating voltage for the detector being used (see section V). High voltage is continuously variable from 350 to 2300 V. Turn the potentiometer clockwise to increase the high voltage and counterclockwise to decrease it. The value of the high voltage being output to the detector is displayed as the "HV=" parameter in the Inquiry/Calibration Mode.

d. *VO*: This potentiometer adjusts the viewing angle of the display. It is set by the operator to optimize the readout to his manner of using the instrument.

e. *S RATE* (one switch, three positions): These switch positions select the rate heard from the speaker. They are used to scale down the count rate from a high count rate detector (e.g.; SPA-3) to a more usable rate from the speaker. The operator can set the rate heard from the speaker to be equal to the detector count rate or equal to the detector count rate divided by either 64 or 256. Figure 3-1 explains the switch settings.

f. *MASK* (two SPST switches): One switch disables the Scaler Mode. The other disables the Inquiry/Calibration Mode except for the Rate Meter "alarm setting." Either function or both may be disabled. Figure 3-1 explains the switches.

g. *TEST*: This switch is for use with automatic testing only and should always be set in the operate position (both poles up, toward PC board).

B. PREPARATION FOR USE AND OPERATIONAL CHECK

1. The instrument should be provided to the operator already calibrated and with the proper probe attached (section VIII).

2. The instrument should be checked for physical damage.

3. Insure that the instrument is operating by pressing the *ON/OFF* switch, energizing the instrument and causing the LCD readout to show the bar graph on the first line and a numerical value of count rate on the second line. If the first character of the display is steady, battery output is adequate. If the first character of the display is blinking, the operator should consider replacing the batteries before proceeding.

4. Press *RESET*. If the bar graph is displayed and is varying, the ESP-1 is working. Exposure to a radiation check source will confirm proper operation by causing the bar graph level and the digital value to increase.

5. Press and hold down the *LIGHT* switch. The display should be illuminated. If the outside light is too bright, shield the display so that the instrument light can be seen. Release the *LIGHT* switch.

6. Press the *SPKR* switch and listen for an audio indication that the instrument is detecting "events." This indication is a series of "click" sounds from the speaker. The presence of this indication confirms that the ESP-1 is operating, although its absence does not confirm that the instrument is not operating.

C. OPERATING THE INSTRUMENT

The ESP-1 is simple and straightforward in its operation. Turn the ESP-1 on by pressing the *ON/OFF* switch to obtain a display on the LCD.

1. **Rate Meter Mode** (refer to figure 3-2)

The instrument is always in Rate Meter Mode when it is first turned on. The display will read:

IIIIIIIIII [BAR GRAPH]
RATEMETER READING

Press *MODE*. If Scaler and Inquiry/Calibration Modes are disabled the display will look like:

ALM AT [ALARM SETTING]
RATEMETER READING

The setting of "ALM AT" establishes the count rate at which the alarm sounds in the Rate Meter Mode. If the level of activity exceeds this setting, the operator will be alerted by a 2000-Hz tone emitted by the speaker. This tone will sound even if the speaker is off at the time the alarm is activated. Pressing *SPKR* acknowledges the alarm, silencing it. The alarm will remain silent until the readout has dropped below the alarm setting and exceeded it again. The value of the alarm setting can be increased or decreased by pressing *RESET* and + or − simultaneously. When the desired value of "ALM AT" is displayed, press *MODE* to return to Rate Meter Mode.

NOTE

The longer *RESET* and + or − are depressed, the faster the value changes. This facilitates large value changes in a relatively short time. Releasing the switches and depressing again will return to slower value changes. This applies anytime *RESET* and + or − are used as described in the operations that follow.

When the ESP-1 is in the Rate Meter Mode, the operator may adjust the full scale of the bar graph and choose fast or slow ranges of response time.

The bar graph functions essentially as a graphic presentation of detector count rate. Pressing *RESET* will position the end of the bar graph at a point that is 33 percent of the total window width from the left side of the display. As an example, 100 mR/h is displayed as:

```
IIIIIIII
1.00 + 02 mR/h
```

When *RESET* is pressed, the end of the bar graph represents 100 mR/h. If the level drops, the end of the bar graph will move to the left. If the level increases, the end of the bar graph will move to the right. If the level increases more than a factor of 3 (above 300 mR/h in this example), the end of the bar graph will go off scale on the right. Pressing *RESET* will bring the end of the bar graph into view again and will set its value again.

2. Scaler Mode (refer to figure 3-3)

Begin in Rate Meter Mode and press *MODE*. If the Inquiry/Calibration Mode is disabled, the display will read:

```
SCALER MODE?
+ = USE/- = NO
```

Pressing − will call the "ALM AT" parameter as previously described. Press +. You are now in the Scaler Mode. The display will read:

```
UNITS = EVENTS
+ = USE/- = NO
```

or

```
UNITS = [UNITS SELECTED]
+ = USE/- = NO
```

"UNITS" are either events or the selected rate meter units (e.g., mR, REM, CNT). To select "UNITS," press − until the desired unit is displayed. Then press + to accept the unit displayed. The display will change to:

```
UNITS = [AS SELECTED]
ALM AT [ALARM SETTING]
```

The alarm indicated here is not the rate meter alarm, but is one that sounds if the set value of total (integrated) events or selected units is exceeded. Pressing *RESET* and + or − simultaneously will increase or decrease the total at which the alarm sounds. Press +. The display will read:

```
UNITS = [AS SELECTED]
CNT FOR [COUNT PERIOD]
```

The "COUNT PERIOD" can be set by the operator for any interval from 1 second to 4 hours. Pressing *RESET* and + or − simultaneously will increase or decrease the length of the counting period.

To obtain a total count over a set count period, press +. The display will read:

```
CNT FOR (X:XX:XX)(h:m:s)
"RESET" TO START
```

Press *RESET*. After one second, the display will read:

```
[X:XX:XX] LEFT (h:m:s)
[TOTAL COUNT SO FAR]
```

When the count period has expired, the display will read:

```
CNT FOR (X:XX:XX)
[TOTAL COUNT]
```

For another total count, pressing *RESET* erases the previous count and starts a new counting interval. During the count period, the audio alarm will sound if the alarm limit is exceeded.

When operations or settings in the Scaler Mode have been completed, pressing *MODE* twice will shift the ESP-1 to the Rate Meter Mode. The display will read:

IIIIII [BAR GRAPH]
RATE METER READING

3. Inquiry/Calibration Mode (all modes enabled, refer to figure 3-4).

Begin in the Rate Meter Mode. Press the *MODE* switch. The display will read:

SCALER MODE?
+ = USE / − = NO

Pressing − will place the instrument in the Inquiry/Calibration Mode. The display will read:

ALM AT [ALARM SETTING]
RATE METER READING

The value of alarm setting, "ALM AT," can be increased or decreased as desired, by pressing *RESET* and + or − simultaneously. This value of alarm setting is in the same units as shown on the bottom line of the display, (e.g. mR/h, REM/h, CNT/min). When the desired value of "ALM AT" is displayed, press +. The display will read:

UNITS = [UNITS SELECTED]
+ = USE / − = NO

If the units displayed are acceptable, press + to go on to setting parameters (CC). If the operator desires units other than those on the display, press *RESET*. The display will read:

BASE [UNIT]
+ = USE / − = NO

The selection of the "BASE" units is now possible. Press the − switch to reject the unit displayed and call for the next choice of units to be displayed. The available radiation units are:

R	roentgen
cnt	counts
Gy	gray
Sv	seiverts
rem	roentgen equivalent man
dis	disintegrations
rad	radiation absorbed dose

When the display shows the desired base unit, press + to accept it. The display will read:

SUFFIX [unit time]
+ = USE / − = NO

The "SUFFIX" is the unit of time over which the base units are counted. Three are available:

s	second
min	minute
h	hour

Again, press the − switch to reject the suffix displayed and call the next choice to be displayed. When the desired suffix is displayed, press + to accept it. The display will read:

PREFIX [value]
+ = USE / − = NO

The "PREFIX" is the value by which the base unit is multiplied to provide a more convenient unit of actual measurement. Four are available:

(NONE)	no prefix
u	micro ($\times 10^{-6}$)
m	milli ($\times 10^{-3}$)
k	kilo ($\times 10^{+3}$)

If the prefix displayed is not the desired value, then press − to reject it and call the next choice to be displayed. When the desired prefix is displayed, press + to select it. The setting of radiation units to be measured would now be complete. An example of this would be:

PREFIX	BASE	SUFFIX
m	R /	h
(milli)	(roentgen) /	(hour)

The units may be selected in any combination of prefix/base/suffix. Press the + switch to select the prefix and prepare the instrument for the setting of parameters, (i.e. calibration). Section V, "Maintenance," provides nominal values of the following parameters as they apply to the particular detector being used. The display will read:

CC = [numerical value] RATE METER READING

The calibration constant (CC) is the number used to convert the detector count rate to the displayed base unit previously selected. Specifically, the displayed rate meter reading arrived at by dividing the counts per second (from the detector) by CC and then scaling the result based on the selected prefix and suffix. To increase the value of CC, press *RESET* and + simultaneously. To decrease the value of CC press *RESET* and − simultaneously. Keep in mind that increasing or decreasing CC will have the inverse affect on the rate meter reading. With the rate meter reading always displayed on the bottom line, the changing value of CC and its affect on the reading is immediately noticeable. When the desired value of CC is displayed, press +. The display will read:

DT (SEC) [numerical value] RATE METER READING

This parameter is the dead time (DT) of the detector, in seconds. It is used to correct for coincidence loss from the detector, yielding a more linear response to the radiation field being measured. An extra decade of range is possible from most detectors due to the DT correction. Typical values of DT are in microseconds ($\times 10^{-6}$). To increase the value of DT, press *RESET* and + simultaneously. To decrease the value of DT, press *RESET* and − simultaneously.

NOTE

For a more detailed explanation on setting "CC" and "DT," as well as nominal values for various detectors, refer to section V.A.

When the desired value of DT is displayed, press +." The display will read:

HV = [numerical value] RATE METER READING

The "HV" value is the high voltage bias applied to the detector. Adjusting the actual high voltage is performed with the internal control potentiometer (labeled "HV"). The external controls, *RESET* and + or −, are to be used only when calibrating the displayed HV readout to match the actual high voltage (refer to section V). When properly calibrated, the HV parameter allows for high voltage monitoring on the top line of the display and the rate meter reading on the bottom. This is particularly useful when running detector plateaus. Pressing + will return the display to the "ALM AT" parameter. Pressing − repeatedly will step the instrument through the parameters in reverse order from that shown in the preceding paragraphs. Pressing the *MODE* switch anytime a parameter and rate meter reading are displayed, will revert the instrument to the Rate Meter Mode.

Summarizing, the ESP-1 provides the following to the operator.

a. In the Rate Meter Mode:

- Bar graph graphically displaying count rate.
- Count rate in selected units per unit time.
- Audible alarm if the rate exceeds the value set.

b. In Scaler Mode:

- Time remaining in the counting period which was set.
- Integrated value and selected units so far in the counting period.
- End of counting period, total time, and integrated value in selected units at the end of the counting period.
- Audible alarm if set limit on total count is exceeded during the set count period.

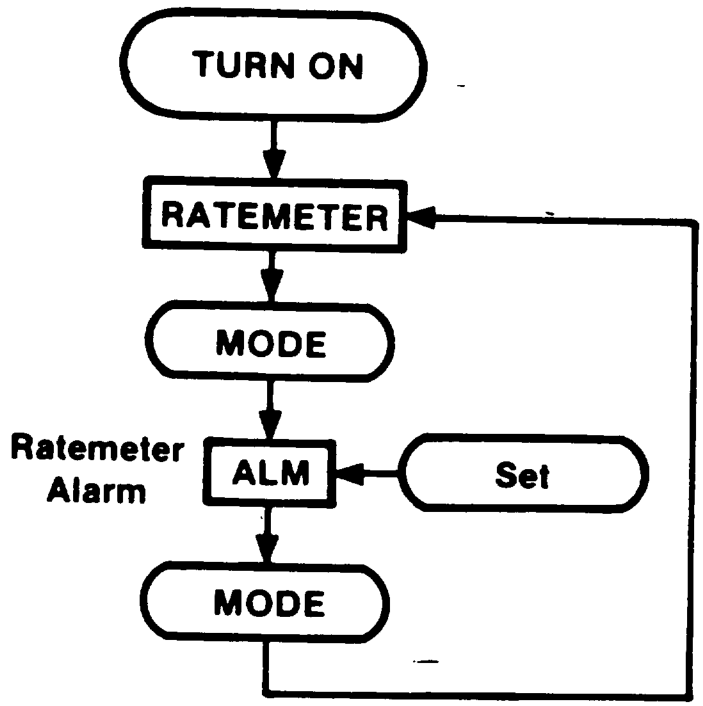
c. In the Inquiry/Calibration Mode

- Ability to set the rate meter alarm point.
- Enables the selection of units to be used in Rate Meter Mode.
- Ability to set the CC and DT (calibrate) to the detector being used.
- Monitor the high voltage applied to the detector. Set the high voltage readout to match the actual HV.

The current rate meter reading is displayed on the bottom line whenever the "ALM AT," "UNITS =," "CC =," "DT," or "HV =" parameters are displayed on the top line.

Block Diagram of ESP-1 Operation
(Scaler and Inquiry/Calibration Modes Disabled)

Rate Meter Mode Operating



NOTES FOR BLOCK DIAGRAMS

1.  or  = Control operation

2.  = Increase or decrease value

3.  = Representative display

Figure 3-2. Rate Meter Mode

Block Diagram of ESP-1 Operation
(Inquiry/Calibration Mode Disabled)

Scaler Mode Operating

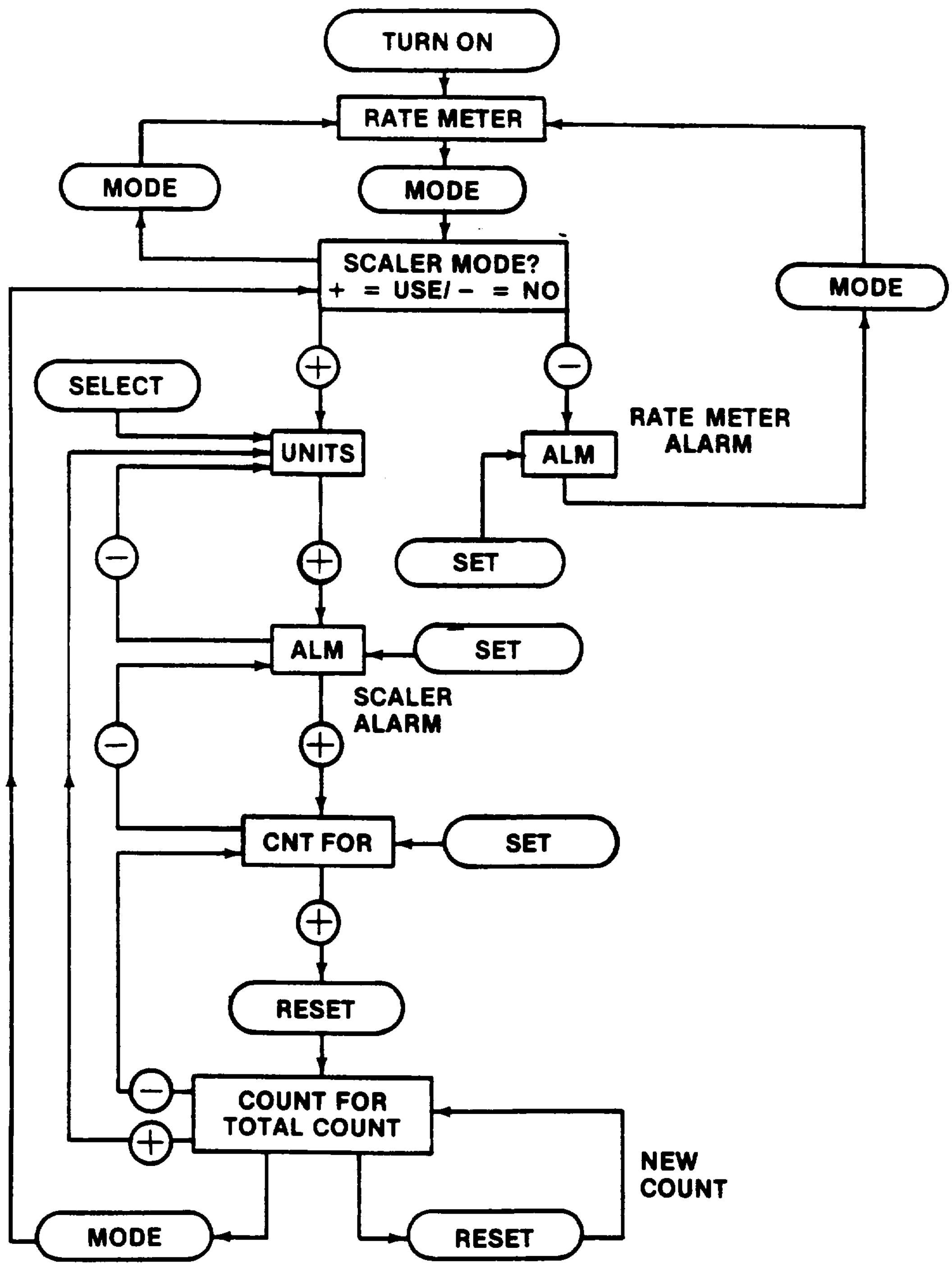


Figure 3-3. Scaler Mode

Block Diagram of ESP-1 Operation
Inquiry/Calibration Mode

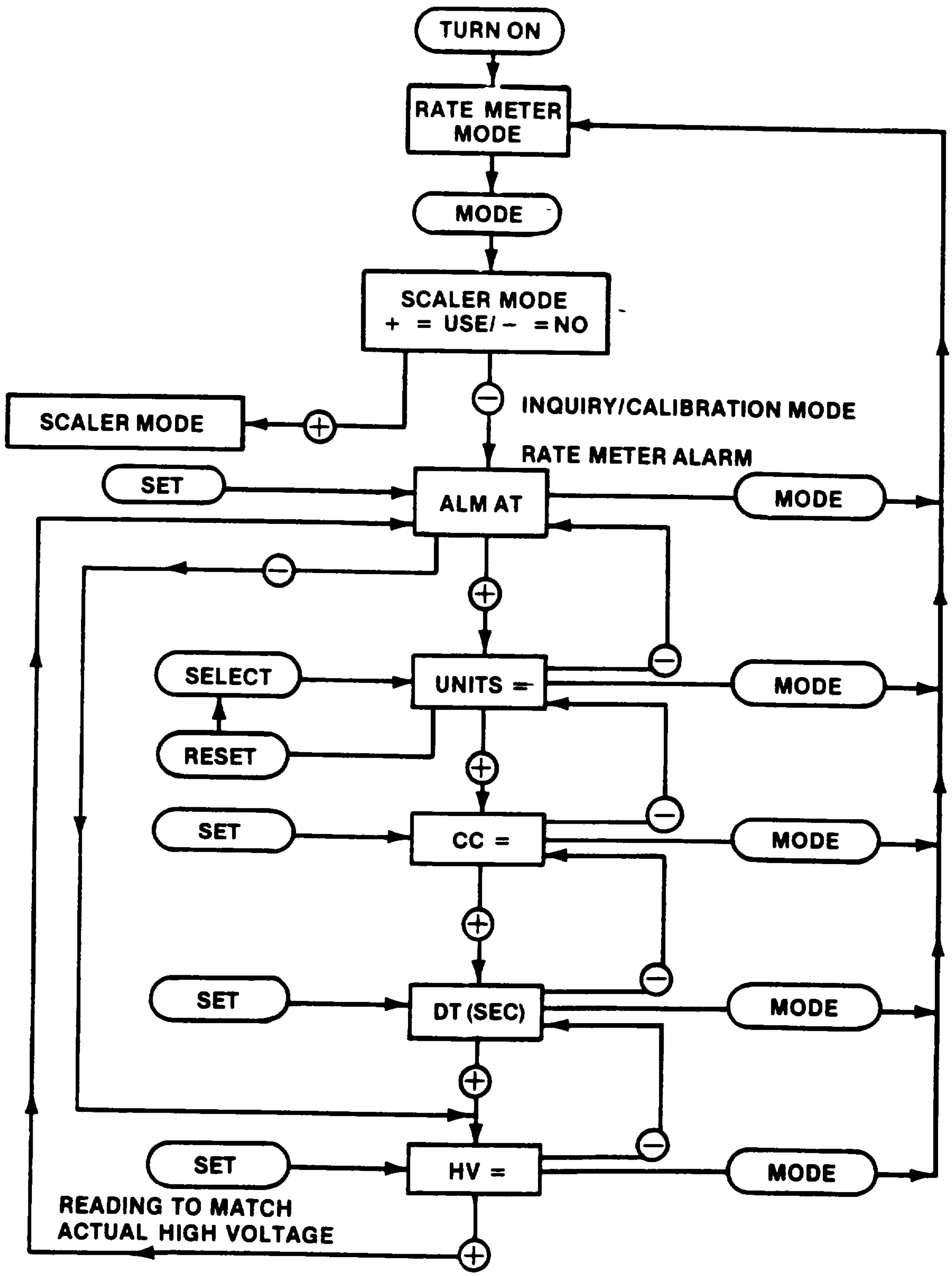


Figure 3-4. Inquiry/Calibration Mode

SECTION IV
THEORY OF OPERATION

A. GENERAL

The ESP-1 employs current technology to provide to the user a compact instrument that can be used to measure several kinds of radiation as detected by different detectors. In addition, the ESP-1 is portable and will operate for over 250 hours before battery replacement becomes necessary. The instrument's most important function is the delivery of accurate information to the operator efficiently and rapidly.

B. FUNCTIONAL THEORY

The ESP-1 consists of six functional sections as detailed below (see figures 7-1, 7-2, 7-3).

1. Detector

The detector connected to the ESP-1 is selected to optimize its output for the radiation of interest. It provides the pulse signal to the electronics for counting. The pulse rate from the detector is proportional to the radiation-field intensity at the detector.

2. High-Voltage Supply

The high-voltage supply provides the bias voltage to the detector as required for proper operation. The high voltage is adjustable to provide the correct operating voltages for a large selection of detectors and regulated to enhance operating stability.

3. Amplifier/Discriminator

The amplifier is a linear, fixed-gain, multistage design. It amplifies the signal from the probe to a usable level at the amplifier output. The discriminator provides a signal on its output only if the signal from the amplifier exceeds its adjustable threshold. This, in turn, provides a means for counting only the radiation signals and to reject any noise and/or unwanted signals.

4. Speaker/Alarm

The speaker/alarm section provides an audible "click rate" from the speaker, which is proportional to the output of the amplifier/discriminator. This rate can be scaled down to enhance the usefulness of the speaker when high-count rate (very sensitive) detectors are employed. When the alarm is activated, the speaker emits a continuous 2000-Hz tone.

5. Microcomputer

The microcomputer is an eight-bit device programmed to function as the interface between the ESP-1 operator and the information provided by the radiation detector (probe). Its program logic and speed of execution allow the ESP-1 to be extremely versatile by applying mathematical functions and logic to its input signals and displaying the results to the operator in an understandable format.

6. Low-Voltage Supply

The low-voltage supply regulates and provides the control point for the operating voltage for the ESP-1 electronics.

C. OPERATIONAL THEORY

For the discussion that follows, please refer to figures 7-1 through 7-12.

1. Low-Voltage Power Supply

Power is supplied to the ESP-1 electronics by six C-type dry-cell batteries and regulated to 5.0 volts with A101. The battery output limits are 9 volts for new batteries down to approximately 5.4 volts for "dead" batteries. The lower limit is set by the voltage differential between the input and output of A101 and enables A101 to maintain voltage regulation.

Computer voltage (Vc) is always applied to the computer to maintain its random-access memory (RAM). With the ESP-1 off, battery drain consists of the normal leakage current of CMOS, typically less than 50 microamperes. During battery changeout, capacitor C1 (0.047 F) provides power for RAM for about 20 minutes (instrument off). This power maintains all the operating parameters at the values entered during calibration.

Pressing the *ON/OFF* keypad causes the microcomputer to initialize the program at BEGIN (figure 7-8).

If the ESP-1 is operating when the keypad is pressed, it sets "PWR ON" to A1, HI (+5 V), turning off the low voltage (Q101, Q102, Q103) to all electronics except the microcomputer and its program access (A1, A2, A3).

If the ESP-1 is off when the *ON/OFF* keypad is pressed, it sets "PWR ON" low (0.0 volts) turning Q101 on. This supplies the operating voltage (+V) to the amplifier, high-voltage control, display, and speaker circuitry. It also switches on the battery voltage (V_{BB}) to the HV oscillator and battery sense via Q102 and Q103. (All circuits are now energized.)

Integrated circuit (IC) A11 converts +V to a negative voltage to provide a bias voltage (V_o) to the display (LCD). Adjustment of V_o allows the operator to optimize the viewing angle of the display.

Battery condition is monitored by one of the comparators in A103. Pin 15 is connected to the regulated reference (amplifier "bias"). When the voltage at pin 14 falls below this reference, the output (pin 16) goes low. This voltage transition is input to the microcomputer, causing it to initiate blinking of the first character on the LCD. The blinking indicates a low battery condition to the operator. This switch point occurs when the battery output is approximately 5.9 volts and allows the instrument to operate properly for about another four hours or until the battery voltage reaches its minimum.

Pressing the *LIGHT* keypad lights the LCD via Q1 and DS1 mounted on the keyboard. Diodes CR2 and CR3 set Q1 and R3 as a current source that maintains a constant drain on the batteries and prolongs lamp life.

2. High-Voltage Power Supply

High voltage is obtained by stepping up (T1) the voltage of the oscillator, (Q10), rectifying it (CR10) and filtering the output (C12, C13, R11). High voltage is regulated by feeding back the output to control the oscillator. At turn on, Q103 is on, causing Q10 to turn on. Current flow through T1 (pins 2, 3) feeds back via T1 (pins 4, 5), turning off (blocking) Q10. With Q10 off, blocking stops and Q10 turns on. This is a blocking oscillator, the frequency of which is limited by C16-R10, maintaining best efficiency of T1.

The high-voltage output is fed back via resistive divider R12 to a voltage follower (A102, pin 3). This stage, with a high input impedance, allows R12 to be large, presenting a minimal current load for the supply. The output of the voltage follower is then proportional to the high-voltage output. Because the input impedance to this stage is high, CR104, R113, and C114 provide filtering to reduce noise interference.

The filtered high voltage sample is input to a comparator (A102, pin 15) that is referenced to the high voltage adjusting potentiometer, R17. When the sample (pin 15) exceeds the reference (pin 14), the output at pin 16 goes low, turning off Q103, which turns off the oscillator, reducing high voltage. As the sample decreases to less than the reference, pin 16 goes high, turning Q103 on. The oscillator then runs to increase the high voltage. In this way, the high voltage is regulated to a value set by the *HV* adjusting potentiometer, R17.

The filtered output of the high voltage sample is also applied to pin 5 of A102. This stage is connected with Q104 to achieve a voltage-to-current conversion with current through R114 proportional to high voltage. Current-to-frequency conversion is performed by the voltage comparator A102, pins 11, 12, and 10. The output at pin 10 is a frequency (F_{HV}) that is proportional to high voltage. This frequency is input to the microcomputer, which can then convert F_{HV} to a digital value and display it as high voltage.

3. Amplifier/Discriminator

Transistor Q106 and the amplifier section of A103 form a dc-coupled linear amplifier. The gain of this amplifier is set by R126 and the output impedance of the preamplifier, Q106, along with R127-R128 and the gain of the preamplifier stage. Feedback via R141 provides dc stability. The dc bias is set by R131-R132 to half of +V (~2.5 volts) for a linear swing of signal on the amplifier outputs. Input protection is provided by CR103-R122, which gives a charge path for input capacitor C11 when high voltage is shorted.

The amplifier output signal is coupled to the discriminator (A103, pin 12) with capacitor C110. An output (A103, pin 10) occurs when the amplitude of the signal (pulse) exceeds the reference (A103, pin 11) set by the discriminator potentiometer, R16.

The discriminator output is divided down by 2, A105, yielding a binary input for the microcomputer. The microcomputer counts the binary transitions and calculates and displays the result as either rate or integrated value for the operator.

4. Speaker

Pulses that cause an output from the discriminator are input to the speaker control either directly or counted down for slower audible rate. In either case, the rate from the speaker is proportional to the radiation level at the detector (probe). The speaker is enabled or disabled by the microcomputer when the operator presses the *SPKR* keypad. The speaker is enabled when "SPKR" is low (0 volt).

One-half of A104 is interconnected as a monostable multivibrator (TRIGGER). The output pulse (TRIGGER) width is set by R136-C112 time constant. The other half of A104 is configured as an oscillator. It is running while the trigger output (pin 11) is low, driving the speaker via Q11 and Q12. The input signal to the trigger is differentiated by C111-R135 to prevent excessive trigger pulse widths.

The alarm is activated by "ALM" and "SPKR" set low (0 volts) by the microcomputer. This sets the trigger output low (pin 11), turning on the oscillator frequency to the speaker.

"ALM" low also activates the auxiliary alarm ("A") providing an active low output for external indication (250 mA, 20 Vdc maximum).

5. Keyboard

The switch poles are etched on the PC board. Contact between the poles is made by a conductive pad cast into each keypad. Pressing a keypad effectively short-circuits the poles.

The *ON/OFF* keypad pulls the "RST" (pin 9) of the microcomputer high. This causes the computer to reset itself and begin running its program at the program beginning (see figure 7-8). The *LIGHT* keypad causes DS1 to turn on via Q1, lighting the display.

All other keypads are inputs to the microcomputer via its input/output (I/O) port P1, which is configured as an input port under program control. These inputs are normally high. Pressing a keypad pulls the corresponding port input low.

The program running in the microcomputer performs the contact debounce, determines the switch(es) pressed, and logically performs the task(s) associated with the keyboard condition.

6. Microcomputer

Simply stated, a computer must have provisions for moving data in and out (I/O), a logical means of handling and saving data (memory), and logical elements to control I/O and memory (central processing unit, CPU). To perform any task, the CPU must execute a series of logical steps (program), which is contained in read-only memory (ROM). Memory used to save data written to or read from it is random-access memory (RAM). The RAM contains the parameters (variables), logic flags, data, scratch pads, etc., used by the program.

a. Inputs:

(1) Keyboard inputs are the operator's input to the computer. Under program control, the inputs cause the task associated with the keypad(s) to be performed (see section III).

(2) Mask (S11) switch inputs are used to signal (flag) the program to perform certain tasks differently or omit them completely (see section III).

(3) FHV is a frequency, the rate of which is proportional to the high voltage applied to the detector (probe). When the program is displaying high voltage (HV) to the user, it converts this frequency input to its HV equivalent.

(4) LO BATT (low battery) input (normally high) switches low when the low-battery condition is sensed (see "Low Voltage," section IV.4.C.1). This causes the program to blink the first character on the display at each display update (output), warning the operator of the low-battery condition.

(5) CNT (count) input is a signal the rate of which is proportional to the radiation intensity at the detector. The rate is calculated by the program (counts/time). The calibration constant (CC) and correction factor (CF [based on detector dead time]) result in a value in radiation units as calibrated. The length of the bar graph is also calculated. The results are then output to the display for the operator.

b. Outputs:

(1) "PWR ON" (power on, active low) is output under program control to turn the power to the instrument on or off (see "Low Voltage Supply," section IV.C.1).

(2) "SPKR" (speaker on, active low) is output under program control when the *SPKR* keypad is pressed. The output is complemented at each press of the keypad. This results in a push-on/push-off action of the *SPKR* keypad (see "Speaker," section IV.C.4).

(3) "ALM" (alarm output, active low) is output-activated when the program has sensed that the calculated reading has exceeded the value input by the operator for "ALM AT" (alarm setting). "SPKR" output is also activated to turn the speaker on (see "Speaker," section IV.C.4).

(4) The display is a liquid crystal (LCD) 5 × 7 dot matrix character, 2 lines of 16 characters per line. This allows the full alphanumeric ASCII character set as well as the special characters used to display the analog bar graph. The LCD is a "smart" display in that it is supported by its own microprocessor and program, thus relieving the computer of this processing load.

The computer outputs to the LCD command instructions and data to be displayed based on the tasks being performed. These data/commands are passed to the display via the 8-bit address-data bus (A1, port P0). A command (instruction) is differentiated from data (character-to-display) by address line 14 (A1, pin 27), high equals command. The command/data are accepted by the LCD when "WR" (A1, pin 16) is low simultaneously with address line 15 (A1, pin 28) being low. This yields an address of 8000H for data and 0C000H for commands.

The LCD requires its "E" (enable, pin 6) to be strobed 0.14 microseconds (minimum) after data and addresses are stable. The quad NOR gate, A4 and resistance-capicitance R-C time constants provided by R2-C6 and R1-C5 accomplish this delay.

The viewing angle of the display may be changed by varying the V_0 input (pin 3).

The display is not considered to be field repairable.

c. Memory and CPU:

All RAM registers and timers are contained within the microcomputer chip and are not available to be observed. Their functions are solely to control the program (i.e., program counter and stack pointer) or for use by the program to perform its tasks (RAM and ALU).

Port P0, A1, is the address-data bus. It is bidirectional (input and output). Port P2, A1, outputs the upper eight bits of the address. On a typical program step:

(1) The address (program counter) is output at P0 (low byte) and P2 (high byte).

(2) ALE (address latch enable) is asserted and latches the address low byte in A3.

(3) PSEN (program store enable) is asserted, enabling the addressed byte to be input to the computer via P0.

(4) The program step is executed.

The program is stored in A2.

SECTION V
MAINTENANCE

A. CALIBRATION

1. General

The ESP-1 is an extremely versatile instrument. It is useable with a wide variety of detectors and can be calibrated in a large variety of radiation units. The end result of the calibration process is the reading provided by the instrument. The accuracy of that reading depends on the accuracy achieved in the calibration process.

Properly set up and calibrated, the instrument is inherently linear and accurate because of its microcomputer-based design. The only real limitation is the detector and its application in a particular measurement. For detector application information, see section VIII.

The calibration procedure should include testing for instrument/detector quality (plateau) as well as adjusting the reading to the radiation field at the detector. A recommended procedure follows:

NOTE

> To change the parameters that calibrate the ESP-1, the inquiry/calibration mask switch must be on (enabled). (Lower "mask" switch to the left, figure 3-1).

2. High Voltage

High-voltage readout is via an analog-to-digital conversion (ref: "Theory of Operation," section IV). The readout must be calibrated to equal the actual high voltage. Connect a voltmeter to the detector connector. The input impedance of the voltmeter must be 1000 MΩ or greater. Adjust the *HV* control for 900 V. Select the "HV =" parameter using the keypads. Hold *RESET* and + or *RESET* and − until the readout is 9.00 + 02 (900 V).

3. Instrument/Detector Quality

The overall gain of the instrument is adjustable with the detector bias (high voltage) and the discriminator setting. The gain should be adjusted for the maximum detector efficiency that also provides the best stability for the measurement.

The discriminator setting (threshold input sensitivity) is set according to the detector type to be used (see table 1) and may be set by either of the following methods. The pulse generator method is preferred.

a. Pulse Generator (Eberline MP-1 or MP-2 recommended)

Connect a pulse generator with a calibrated pulse amplitude output to the ESP-1 detector connector. Set the ESP-1 input sensitivity as recommended in table 1, by adjusting the *D* (discriminator) control until the instrument is just reading the pulse generator (see figure 3-2).

b. Voltmeter (20k ohms/volt minimum)

Measure the voltage on *TEST* connector, pin 11A, (see figure 3-2). Adjust the *D* (discriminator) control for a voltmeter reading corresponding to the proper input sensitivity referenced in tables 1 and 2.

WARNING

> **The high voltage should be set to the "nominal operating voltage" or less (see table 1) before connecting the detector to the ESP-1, to prevent damage to the detector. Check the high voltage by selecting the "HV =" parameter on the display. Make sure high voltage calibration has been performed.**

Input Sensitivity (mV)	V_{thld}* (volts)
0.5	0.071
0.75	0.107
1.0	0.143
2.0	0.286
5.0	0.715
10.0	1.43
15.0	2.15

*Test connector, pin 11A (see figure 3-2).

Table 1. Input Sensitivity vs. V_{thld}

c. Connect the detector to the ESP-1. With the discriminator properly set, the plateau curve can be plotted. This is the only data that can truly verify that the detector and instrument are operating properly and, with the possible exception of G-M detectors, should be plotted anytime a detector is changed or repaired.

The bias (high voltage) operating point for a G-M detector is fixed by its physical properties (i.e., size, counting gas, anode size, and fill pressure). Therefore, a check of its sensitivity or efficiency may preclude the plateau. It should be within +/− 20 percent of specified sensitivity at the specified operating voltage (see section VIII).

To plot the plateau (figure 5-1):

(1) Select the "HV = " parameter on the display (inquiry/calibration mode). The second line of the display shows the current average rate from the detector.

(2.) Adjust the *HV* control for a low reading from the detector. Record the reading and the high voltage.

(3) Increase *HV* in steps of 50 volts, recording the high voltage reading at each step. Allow enough time at each step for the reading to stabilize.

(4) Select the operating high voltage and adjust the *HV* control accordingly.

4. Rate Meter Calibration

For clarity, a brief overview of the readout determination follows:

a. The average count rate is calculated each one-half second. This average is maintained in counts per second (cps) and is the basic unit for all readout displays. This average is also corrected for detector dead time (parameter DT).

b. The average (AVG) is divided by the calibration constant (parameter CC) (see table 3) and the proper factors, specified in the units, prefix, and suffix are applied, converting the cps to the radiation units selected. This is performed and displayed every 2.0 seconds.

The calibration is performed by adjusting the CC and DT values so that the rate meter reading agrees with the radiation intensity at the detector.

Note that the dead-time correction is applied to the average before CC. At lower count rates, this correction is insignificant.

Refer to table 1 for the following:

(1) Set the instrument to Inquiry/Calibration Mode (discussed in section III.C.).

(2) Set the high voltage and input sensitivity to suggested values for detector being calibrated.

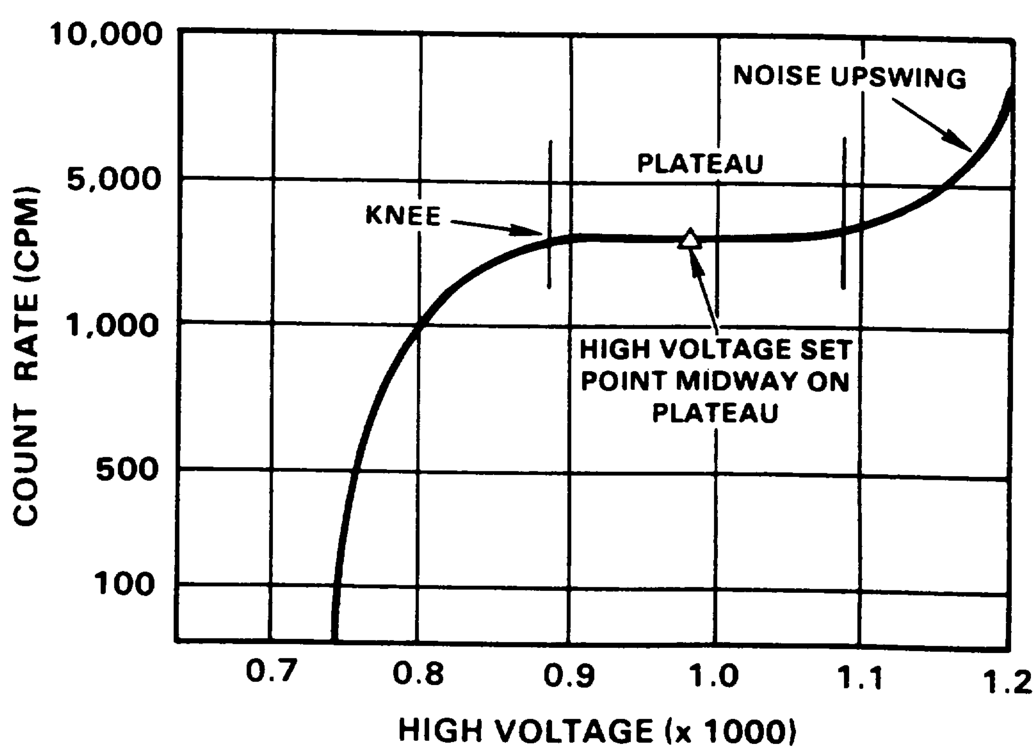


Figure 5-1. Typical Detector Plateau

DETECTOR MODEL	HIGH VOLTAGE	INPUT SENSITIVITY	UNITS	NOMINAL VALUES***** "CC="	"DT(SEC)"	CALIBRATION FIELDS SET "CC" AT:	SET "DT" AT:
HP-270	900V	10mV	mR/h	7.20+07	1.00-04	20 mR/h	1.0 R/h
HP-290	550V	10mV	R/h	5.00+06	2.00-05	500 mR/h	25 R/h
HP-210, 260	900V	10mV	cpm	1.00+00*	8.00-05	72K cpm (~20 mR/h)†	2700K cpm (~750 mR/h)†
HP-190A	900V	10mV	cpm	1.00+00*	2.00-04	5K cpm (~2 mR/h)†	500K cpm (~200 mR/h)†
HP-230A	900V	10mV	cpm	1.00+00*	1.20-04	60K cpm (~20 mR/h)†	1800K cpm (~600 mR/h)†
AC-3	1000V**	10mV	dpm	3.10-01***	1.20-05	50K cpm	3000K cpm
LEG-1	1000V**	2mV	cpm	1.00+00	1.40-05	50K cpm	3000K cpm
NRD	1800V****	2mV	mREM/h	3.00+06	1.00-05	27 mREM/h (~1200 cpm)	67 REM/h (~3000K cpm)
SPA-3	1000V**	10mV	cpm	1.00+00	1.40-05	700K cpm	3000K cpm
SPA-6	1000V**	10mV	cpm	1.00+00	1.00-05	50K cpm	3000K cpm

Table 2. Suggested Calibration Levels

* These are the values to be used when the instrument is set up to read in units of CPM. Other values must be used for 'CC' if you wish to set your instrument to read in 2π cpm or 4π dpm beta efficiency.

** Detector high voltage should be set after running detector plateau as previously discussed (see Instrument/Detector Quality, and Figure 5-1).

*** Set to the efficiency value determined from plateau (e.g., if 31 percent efficient, then CC = 3.10-01). If calibration is to true detector counts, "CC" should be set to 1.00, after "DT" adjustment has been performed.

**** HV setting depends on gamma rejection point. Determine by placing NRD in 10 R/h gamma field (or desired gamma field to be rejected) and adjust HV for approximately 50 cpm. Reduce HV by 50 V, and verify no counts in the 10 R/h field. The HV set point is now established, and should not exceed 2200 V.

*****The nominal values may be used to set up the ESP-1: (1) if the calibration sheet (which has the exact values) for the ESP-1 with the specific detector is not available; or (2) if the user wishes to use a detector which was not purchased with the ESP-1. Please note that the use of nominal values constitutes a generic rather than a specific calibration and, therefore, will be less accurate as compared to using values from the calibration sheet.

† Values in mr/hr are based on Cs-137 photons.

(3) Set "CC=" and "DT" equal to nominal values for detector being used. (Refer to detailed operation, section III.c. , if necessary.)

(4) Select the "CC=" parameter. The current rate meter reading is always displayed on the bottom line of the LCD (this applies to all parameters, DT, HV,etc.).

(5) Expose the detector to the radiation field indicated under "set CC at" (table 1), and adjust "CC=" until the "rate meter reading" matches the field strength. Note that increasing the value of "CC" will decrease the "rate meter reading" and decreasing "CC" will increase the "rate meter reading." See table 3.

(6) Select the "DT (SEC)" parameter. Expose the detector to the field indicated under "set DT at" (table 1), and adjust "DT" until the "rate meter reading" matches the field strength.

(7) Recheck the reading taken in step 5. If not in agreement, repeat steps 5 and 6 until both readings are correct without having to vary the "CC" and "DT" parameters.

(8) At this point no further adjustment is necessary. However, a few linearity readings at fields in between the "CC" and "DT" settings would be an added verification of correct detector/instrument operation. Increasing the radiation field above the "DT" set point, will eventually cause an over-range alarm. This is useful in determining the upper range limit of that particular detector and instrument combination.

NOTE

The instrument may be rough-calibrated by adjusting nominal values in table 1. For detectors which nominal values are not specified, the user may determine his own nominal values for ease and/or speed of the calibration process.

CC = counts/base unit.

Example:

a. HP-270 sensitivity is 1200 cpm/mR/h (nominal).

b. "Base" unit selected is "R."

CC = (1200 cpm/mR/h * 60 min/h)/1 × 10 − 3 R/mR

CC = 7.2 x 107 cnt/R

SPECIFIED PREFIX	PREFIX FACTOR (PF)	SPECIFIED SUFFIX	SUFFIX FACTOR (SF)
(none)	1	s (second)	1
μ (micro)	1×10^{-6}	min (minute)	60
m (milli)	1×10^{-3}	h (hour)	3600
k (kilo)	1×10^{3}		

(AVG/CC) * SF * PF = READOUT IN RADIATION UNITS AS SPECIFIED.

NOTE: PF and SF are applied automatically as defined by the "units" selected and do not affect CC.

Table 3. Calculating Calibration Constant

B. PREVENTIVE MAINTENANCE

1. Periodic Maintenance

Because of the simplicity of the ESP-1, periodic maintenance is neither time consuming nor overly frequent.

a. Install fresh batteries at least once per year.

b. Remove the bottom cover and the side access and blow out the inside with clean, dry, low-pressure air once a year.

c. Keep the outside of the case clean.

d. Open the bottom and side accesses only when calibration, maintenance, or battery change are necessary.

2. Battery Replacement

a. Turn the instrument off. If the ESP-1 is placed face down, exercise caution with the push buttons to prevent accidentally turning the instrument on. Approximately 20 minutes are available for battery change with the ESP-1 turned off.

b. Remove the large screw in the bottom cover.

c. Remove the bottom cover.

d. Dispose of the expended batteries.

e. Install six fresh "C" cell batteries, observing polarity as shown in the battery compartment (figure 5-2).

f. Reinstall the bottom cover and secure it with the screw.

3. Right-Side Access

a. To open, turn the fastener in the center of the access cover about one turn counterclockwise and pull straight out.

b. To close, press the cover into the opening and turn the fastener about one-half turn clockwise.

C. CORRECTIVE MAINTENANCE

1. Disassembly / Assembly

WARNING

When starting screws, exercise care. Use screwholders and other proper tools. Don't over tighten!

Use care to minimize the tension on the ribbon cables connecting the PC boards and the display. The cables are short and can be damaged.

a. Removal of PC Boards:

NOTE

For proper orientation, the front is the end with the MHV connector. The lower PC board is the board closest to the bottom cover and the upper PC board is closest to the keypad and display.

(1) Rest the ESP-1 on its top, exercise caution to prevent operation of the push-button switches.

(2) Remove the bottom cover and the batteries.

(3) Remove the nut and lockwasher that hold the coaxial connector at the front of the instrument.

(4) Remove the lower-board mounting screws (one at each corner, one in the center of the opposite end near speaker).

(5) Remove the screws on either side of the speaker (in the semicircular retainer).

(6) Lift the front edge of the lower PC board and simultaneously push the coaxial connector into the instrument case.

(7) Fold the lower PC board over the battery compartment.

(8) Remove the side access cover.

(9) Unscrew the two screws at the corners of the upper PC board.

(10) Lift the upper board and move it toward the battery compartment. The speaker will come up out of its mounting and the retainer/spacer will be freed from its position. Set the retainer/spacer aside.

(11) Step 10 pulls the upper and lower boards clear of the display assembly, which is secured by the four large screws at the corners. Loosen these screws completely.

(12) Carefully lift the PC board set. The display assembly will come out of its position. Take the screws out of the Lucite® mounting.

(13) The light heads extend from the button contact board to the Lucite® mounting. Be careful not to break these leads.

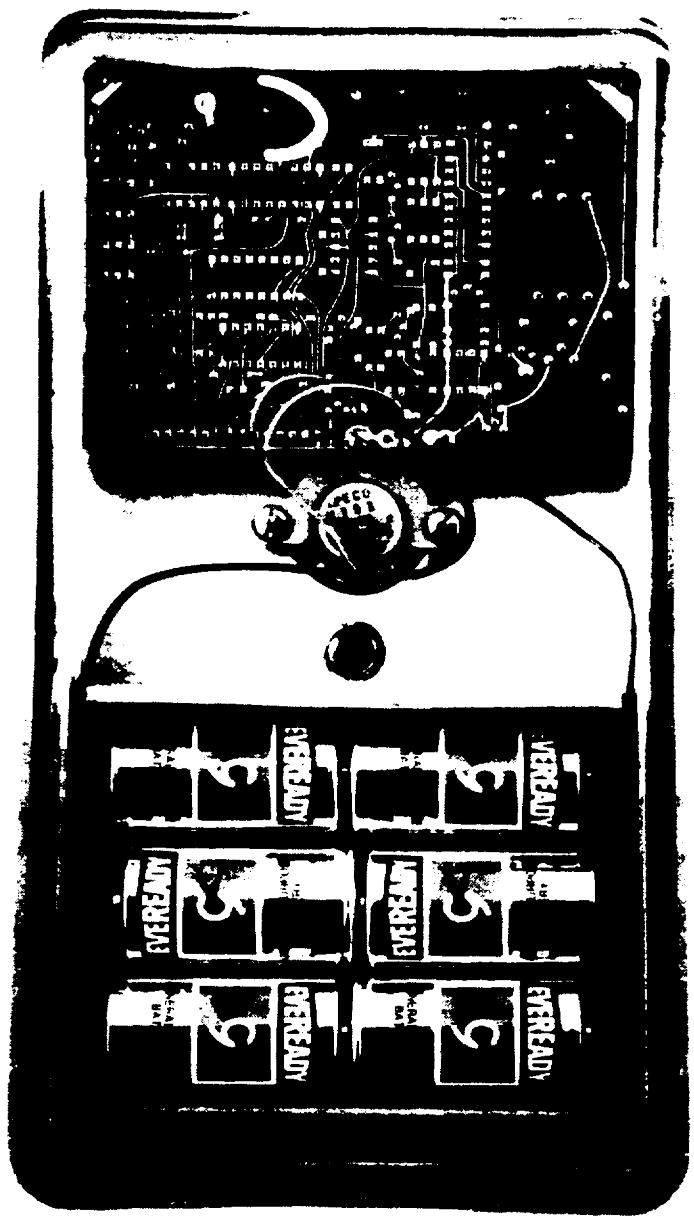


Figure 5-2. ESP-1 with Bottom Cover Removed

(14) To remove the board complex completely from the case, unsolder the battery leads from the lower board.

(15) To remove the speaker, unsolder the speaker leads from the lower board.

b. Reinstallation of PC boards:

(1) Insert the four screws into the corner holes of the Lucite® display mounting so that it holds the keypad board in place and so that the screws in the Lucite® line up with the threaded holes in the case. Tighten the screws.

(2) Position the upper PC board, component side up, so that the holes in the board line up with the threaded holes in the corners of the instrument case. Insert the screws and screw them down loosely.

(3) Holding up the lower board, position the speaker in its mounting.

(4) Pulling up carefully on the lower board, raise the forward edge of the upper board enough to allow the speaker retainer's channel-shaped support for the upper board to be positioned so that the board is in the channel. The holes in the speaker retainer should be lined up with the threaded holes in the case.

(5) Making sure that the speaker leads are not pinched under the retainer, screw the retainer in tight.

(6) Tighten the two screws on the upper board.

(7) Guide the coaxial-connector lead through the cutout at the rear of the lower board.

(8) Insert the coaxial connector through the opening in the front of the case and guide the lower board into position.

(9) The hole in the center (rear edge) of the lower board should line up with the threaded hole in the speaker retainer.

(10) Insert the screw and turn it down loosely.

(11) Insert the screws to hold each corner of the upper board.

(12) Tighten the mounting screws on the lower PC board.

(13) Install the lockwasher and nut on the coaxial connector and tighten nut.

(14) If the speaker was removed, solder the speaker leads to the points on either end of the label *SPK* on the lower circuit board.

(15) If the battery leads were unsoldered, solder the red lead to the + point and the black lead to the − point on the lower circuit board.

(16) Install the side access cover.

(17) Install the batteries noting polarity.

(18) Install the bottom cover.

2. Troubleshooting

The ESP-1 uses the latest state-of-the-art components and circuitry available at the time of its design. Eberline's experience using similar components has shown them to be very reliable and trouble free. Realizing that failures and problems will occur, this section is intended to assist the technician with the task of repair.

Eberline provides a repair and calibration service at two locations in the United States and one in England for the European market. Contact Eberline for details (see front of manual).

To hold downtime to the minimum possible, users might consider changing the entire printed-circuit-board set. By maintaining a spare board set and exchanging the board set when a failure occurs, downtime (including recalibration) can probably be limited to less than one hour. The inoperative board(s) can then be repaired in-house or by Eberline without taking the ESP-1 out of service for lengthy periods of time.

NOTE

Always recalibrate after repair.

a. General Procedure

A thorough understanding of the ESP-1 circuitry and program operation is necessary before any field repairs are attempted. For component problems, review section IV, "Theory of Operation" and the schematic and logic drawings, section V. For problems related to operation, review section III "Detailed Operation" and the logic flow charts, section VII.

The incorporation of a microcomputer in the ESP-1 does not change the general approach to troubleshooting and repair. In short, the problem must be defined, the trouble isolated, and the defect identified. Only then can effective repair be accomplished.

The circuitry used in the ESP-1 employs CMOS technology. These CMOS devices are sensitive to electrostatic discharge. To prevent damage, they should be properly grounded before and during handling.

Generally, problems can be defined in one of two categories. These would be a nonfunctioning microcomputer or a nonfunctioning counter.

NOTE

"Counter" refers to the pulse amplifier, low-voltage circuits, and high-voltage circuits.

A nonfunctioning microcomputer can be recognized by:

- No information on the display.
- Erratic display information.
- Unidentifiable/wrong characters on the display.

A nonfunctioning counter can be recognized by:

- Rate meter readout too low.
- Rate meter readout too high.
- Readout not statistical (erratic).

The first step in determining any problem should be the condition of the batteries. If battery life is shorter than specified, turn the ESP-1 *OFF* and check the drain on the batteries by inserting an ammeter in series with the + lead from the battery. The current should be less than 50 μA. With the ESP-1 turned *ON*, this drain should be less than 25 mA.

If the drain is too high in either condition, isolate the faulty component and replace it. Remember to look for leaky capacitors, but only as a last resort.

The second step is to check all voltages. Use table 4. The test connector (board edge) is reached through the side access door. Viewed through the access door, pin 1 is toward the board center, side A is on top of the board, and side B on the bottom (component side) of the board. (Refer to figure 3-1.)

TEST CONNECTOR (FIG. 3-1)	DESIGNATION	LIMITS	DESCRIPTION
10B	V_B	+6 to +10 V	Battery voltage
12B	V_C	+4.99 to +5.01 V	Regulated low voltage
9B	+V	+4.85 to +5.0 V	Switched V_C
11B	V_{BB}	+5.9 to +10 V	Switched V_B
9A	V_O	0 to −1.5 V	Display viewing angle bias
12A	GND	—	Reference

Table 4. Check Voltages

Any voltage not meeting the limits set establishes a reason for repair before proceeding. See "Repairing the Low-Voltage Supply," which follows.

b. Nonfunctioning Microcomputer

1) Check the *TEST* switch (S1). Both switch arms should be set toward the PC board. To reinitialize the computer:

(a) Remove the batteries (at least 1).

(b) Short C1 (0.047 F capacitor). This can be reached through the side access door. (See figure 3-1.) Allow 10 seconds.

(c) Reinstall batteries.

NOTE

Reinitializing the computer resets all parameters including high-voltage calibration. Complete recalibration should be performed before putting the instrument back into service.

(2) Remove batteries and lower (amplifier/HV) board to expose the microcomputer board. Check all the integrated circuits (ICs) for proper seating in their sockets. If a loose IC is found, replace the batteries and repeat step 1 above. If the problem persists, proceed to step 3.

3) This leaves the following possibilities:

(a) Shorted keypad switch or test connector.

(b) CR1 open.

(c) C2 shorted.

(d) A1 or X1 inoperative.

(e) A2 inoperative.

(f) A3 inoperative.

(g) A4 inoperative.

(h) Display not operating.

(i) Damaged PC board or ribbon cable(s).

c. Nonfunctioning Counter

A nonfunctioning counter usually results because either the counter has failed or the counter is noisy.

NOTE

> The instrument must be turned *OFF* and back *ON* to reset an "OVERRANGE" condition. An "OVERRANGE" indication could be caused by an incorrect "DT" setting for the detector in use.

In either case, first determine that the condition is not caused by the detector or cable. The best way to do this is to connect a known good detector and cable and then check the operation.

Next, remove the lower board so its components are exposed. Visually inspect for loose and/or poorly seated components, broken wires, broken components, etc.

If the counter has failed, check:

(1) High voltage at the detector connector. Use a voltmeter with 1000 MΩ or greater input impedance. The voltage should be set for the detector being used. If not correct, see "Repairing the High Voltage Supply," section V.C.2.d. below before proceeding.

(2) Amplifier output at pin 7 of A103 using an oscilloscope with an Eberline MP-2 (or MP-1) connected to the detector connector. Set the pulser to 15 mV and 40k counts per minute.

The positive pulse on the scope should be 2.0 volts or greater. If good, go to step 3 below.

If bad, the probable causes are:

(a) A103 inoperative.

(b) Q106 inoperative.

(c) CR103 shorted.

7d) C11 defective.

(3) Discriminator output at pin 10 of A103 using the scope (MP-2 still connected and set as in step 2 above). This should be a positive square pulse of 4.0 volts or greater. If good, go to step 4 below.

If bad, the probable causes are:

(a) A103 inoperative

(b) *DISCR* control (R16) defective.

(c) A105 inoperative.

(4) Binary output at pin 9 of A105 using the scope (MP-2 still connected and set as in step 2 above). This signal should change state at the rate of the MP-2 and switch between ground and 4.0 volts or greater.

If the signal is not present, A105 is bad. If the signal is present, move the scope to pin 14 of A1 (microcomputer chip). The signal should be as above. If it is, A1 is bad. If not, check for broken wire in the ribbon jumper between boards, for damaged PC board, or bad contact at A1, pin 14.

If the counter is noisy, the most common causes of counter noise are:

(a) High voltage too high.

(b) Loose or bad ground connections.

(c) High voltage breakdown.

(d) Input sensitivity (discriminator "D" set . sensitive).

(e) Noisy low voltage supply.

Loose or bad ground connections are best detected by visual inspection. Check for:

(f) Damaged PC board.

(g) Broken wire(s) in ribbon cables.

(h) T1 frame is jumpered to ground.

If the high voltage is too high, try readjusting it (*HV* control). If it will adjust and control, then check with the detector to prove the fix. If the high voltage does not adjust and/or control, go to "Repairing the High Voltage Supply," section V.C.2.d.

Breakdown or arcing of the high voltage is normally caused by a dirty PC board, damaged component, or dirty/bad detector connector.

Input sensitivity can easily be checked using an Eberline MP-2. Check it with reference to table 1 in section IV for the detector being used. If the input sensitivity is too high, reset it to the proper value and check instrument operation. If it is still noisy, proceed.

Check the low voltage (V_c, +V) using a scope. The ac component should be less than 10 mV. If not, the probable causes are:

(i) A101 inoperative (if noise is on Vc).

(j) A11 inoperative.

(k) Q101 defective.

(l) Leaky filter capacitors.

d. Repairing the High Voltage Supply

NOTE

All measurements of the high voltage require a voltmeter of 1000 MΩ or greater input impedance. Use an electrostatic voltmeter or a special high voltage arrangement such as a Fluke model 8020A with 80k-40 high voltage probe.

It is normal that the high voltage will fluctuate around the control point (+ / − 5 percent). Adjust the high voltage by using the internal *HV* control on the PC board.

(1) No high voltage. Probable causes:

(a) Q10 and/or T1 defective.

(b) Q103 defective.

(c) A102 inoperative.

(d) CR10 defective.

(e) C17 defective.

(f) *HV* control (R17) defective.

(2) High voltage too high. Probable causes:

(a) A102 inoperative.

(b) Q103 defective.

(c) C17 defective.

(d) R12 defective.

(3) No fHV output (computer does not display high voltage).

(a) A102 inoperative.

(b) Q104 defective.

(c) Q105 defective.

(d) Broken wire in ribbon cable.

(e) Damaged PC board.

(f) Bad connection A1 pin 12 to socket.

(g) A1 inoperative.

(4) Fluctuating high voltage (see note above). Probable causes:

(a) CR104 defective.

(b) A102 inoperative.

(c) R12 defective.

e. Repairing the Low-Voltage Supply

(1) V_c low

Check for excessive current drain. Isolate to faulty component by removing one IC at a time until fault is found.

Next, try to adjust for 5.00 volts. If the adjust is satisfactory, use. If adjustment fails, A101 is inoperative. Replace it and readjust V_c for 5.00 volts.

(2) V_c high.

Try to readjust for 5.00 volts. If the adjustment is satisfactory, use. If adjustment fails, replace A101 and readjust V_c for 5.00 volts.

(3) Error in +V. Probable causes:

(a) Q101 defective.

(b) PWR ON from computer > 0.4 volts.

(4) Error in V_{BB}. Probable causes:

(a) Q102 defective.

(b) Q13 defective. Also check Q10 and C10.

(5) Error in V_0. Probable causes:

(a) A11 inoperative.

(b) C15, C14 defective.

(c) V_0 adjust, (R18) defective.

f. Speaker nonfuctioning (Note: Check S-RATE [S10] for proper setting.) Probable causes:

(1) Speaker defective.

(2) Q11, Q12 defective.

(3) A104 inoperative.

(4) S10 defective.

(5) CR101 defective.

(6) *SPKR* from computer > 0.4 volt with speaker *ON*. Check ribbon cable, contact at pin 8 of A1, and board damage. If they are satisfactory, A1 or keypad switch is defective.

(7) A105 inoperative.

If speaker works but alarm does not:

(a) CR102 defective.

(b) ALM from computer > 0.4 volt when in alarm condition. Check contact at pin 7 of A1, ribbon cable, and board damage. If they are satisfactory, A1 is inoperative.

SECTION VI
PARTS LIST

The following table lists the electronic items incorporated in the ESP-1 and should contain any part necessary for normal 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, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

Board Set (3 boards plus display) part no. SP10A

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
A1	Integrated Circuit	Microprocessor	Intel 80C31	ICCMA80C31
A2	Integrated Circuit	EPROM	National 27C32-45	ICCMA27C32
A3	Integrated Circuit	Octal Buffer	National 74HC373 or 54HC373J	ICHCA74373
A4	Integrated Circuit	NOR Gate	74HC02	ICHCA00002
A11	Integrated Circuit	Converter	Intersil ICL7660CPA	ICVC07660
A101	Integrated Circuit	Regulator	Intersil ICL7663CPA	ICAVA7663C
A102, A103	Integrated Circuit	Operational Amplifier	Motorola MC14575CP	ICAOA14575
A104	Integrated Circuit	Quad 2-input NOR Gate	RCA CD4001BE	ICCMA4001B
A105	Integrated Circuit	12-Bit Binary Counter	RCA CD4040BE or SGS HFC4040BE	ICCMA4040B
C1	Capacitor	0.047 F, 5 V	NEC FAOH473Z	CPSP473MXC
C2	Capacitor	1.0 μF, 10%, 35 V, tantalum	Sprague 196D105X9035HA1	CPXX11
C3	Capacitor	15.0 μF, 10%, 20 V, tantalum	Sprague 196D156X9020KA1	CPXX10
C4	Capacitor	33.0 μF, 10%, 10 V, tantalum	Sprague 196D336X9010KA1	CPXX12
C5, C6	Capacitor	100.0 pF, 50 V	AVX SP155A101KAA	CPCE101P3N
C8, C101	Capacitor	0.047 μF, 20%, 50 V	Sprague 1C25Z5U473M0508	CPCE473P4N
C10	Capacitor	220.0 μF, 20%, 10 V, tantalum	Sprague 150D227X9010S2	CPTA221M3F
C11	Capacitor	220.0 pF, 10%, 3 kV	Centralab DD30-221	CPCE221P3Y
C12, C13	Capacitor	0.01 μF, 20%, 3 kV	Sprague 30GA-S10 or Centralab DD30-103	CPCE103P4Y
C14, C15	Capacitor	10.0 μF, 20%, 16 V, tantalum	Sprague 199D106X0016CB1 or ITT TAP-B10K35	CPTA100M4X
C16	Capacitor	0.047 μF, 10%, 50 V	Mepco 711D1AA473PK500AX or Westlake 160/.047/K/250/C	CPPF473P3N

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
C17	Capacitor	3.3 μF, 20%, 35 V, tantalum	Sprague 199D335X0035CB1	CPTA335P4L
C7, C104, C107, C114	Capacitor	0.1 μF, 10%, 50 V	Centralab CW20C104K	CPCE104P3N
C106	Capacitor	0.01 μF, 20%, 50 V	SpragueSR155C103KAA	CPCE103P3N
C110	Capacitor	820.0 pF, 10%, 100 V	Erie CK12BX821K	CPCE821P3P
C111	Capacitor	22.0 pf, 10%, 200 V	Kemet C052C220K2X1CA	CPCE220P3R
C112	Capacitor	0.022 μF, 10%, 100 V	Kemet C062C223K1X1CA	CPCE223P3R
C113	Capacitor	1000.0 pF, 10%, 100 V	Centralab CN20A102K	CPCE102P3P
CR1, CR2, CR3, CR101, CR102, CR103, CR104	Diode	Silicon Switching	1N4148	CRSI1N4148
CR10	Diode	Silicon	Varo VA25	CRSIVA0025
DS1	Bulb	T-1 ¼, 6 V, 60 mA incandescent	Chicago Mini, CM2114D	LPBU17
Q1, Q11, Q12, Q21, Q103	Transistor	NPN, silicon	2N4401	TRSN2N4401
Q10	Transistor	PNP, silicon	Motorola 2N4234 or National 2N4234, 2N4236	TRSP2N4234
Q13, Q101	Transistor	PNP, silicon	2N4403	TRSP2N4403
Q20	Transistor	PNP, silicon	2N4126	TRSP2N4126
Q102, Q104, Q105	Transistor	NPN, silicon	2N4124	TRSN2N4124
Q106	Transistor	NPN, silicon	2N5088	TRSN2N5088
R1, R22, R23, R107	Resistor	10k, 5%, 1/8 W, carbon composition		RECC103B21
R2	Resistor	2.4k, 5%, 1/8 W, carbon composition		RECC242B21
R3, R101	Resistor	12 Ω, 5%, 1/8 W, carbon composition		RECC120B21
R4	Resistor	270 Ω, 5%, 1/8 W, carbon composition		RECC271B21
R20	Resistor	1k, 5%, 1/8 W, carbon composition		RECC102B21
R10	Resistor	270 Ω, 5%, 1/4 W, carbon composition		RECC271B22
R11	Resistor	10M, 5%, 1/4 W, carbon composition		RECC106B22
R12	Resistor	2500M/2.5M, 10%	TRW/IRC 76-99-00K-00-044-2507	REXX5
R13	Resistor	100k, 5%, 1/4 W, carbon composition		RECC104B22

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
R14	Resistor	22 Ω, 5%, 1/4 W, carbon composition		RECC220B22
R15	Potentiometer	500k	Spectrol 64X504	PTCE504B23
R16, R17	Potentiometer	50k	Spectrol64X503	PTCE503B33
R18	Potentiometer	25k	Spectrol 64X253	PTCE253B13
R21, R109, R113, R151	Resistor	47k, 5%, 1/4 W, carbon composition		RECC473B21
R102	Resistor	3.0M, 5%, 1/8 W, carbon composition		RECC305B21
R103	Resistor	910k, 5%, 1/8 W, carbon composition		RECC914B21
R104	Resistor	20k, 5%, 1/8 W, carbon composition		RECC203B21
R105, R136	Resistor	75k, 5%, 1/8 W, carbon composition		RECC753B21
R106	Resistor	18k, 5%, 1/8 W, carbon composition		RECC183B21
R108, R115	Resistor	200k, 5%, 1/8 W, carbon composition		RECC204B21
R110	Resistor	30k, 5%, 1/8 W, carbon composition		RECC303B21
R111, R120, R121, R127, R140	Resistor	22k, 5%, 1/8 W, carbon composition		RECC223B21
R112	Resistor	470 Ω, 5%, 1/8 W, carbon composition		RECC471B21
R114	Resistor	49.9k, 1%, 0.1 W	RN50	RECE493B11
R116	Resistor	390k, 5%, 1/8 W, carbon composition		RECC394B21
R117	Resistor	2.1k, 1%, 0.1 W	RN50	RECE212B11
R125	Resistor	2.2k, 5%, 1/8 W, carbon composition		RECC222B21
R118	Resistor	4.7k, 5%, 1/8 W, carbon composition		RECC472B21
R5, R119	Resistor	1M, 5%, 1/8 W, carbon composition		RECC105B21
R122	Resistor	2k, 5%, 1/8 W, carbon composition		RECC202B21
R123	Resistor	39k, 5%, 1/8 W, carbon composition		RECC393B21
R124	Resistor	68k, 5%, 1/8 W, carbon composition		RECC683B21
R126, R129, R141	Resistor	150k, 5%, 1/8 W, carbon composition		RECC154B21
R128, R135	Resistor	100k, 5%, 1/8 W, carbon composition		RECC104B21

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
R131, R132	Resistor	200k, 1%, 0.1 W	RN50	RECE204B11
R133	Resistor	130k, 1%, 0.1 W	RN50	RECE134B11
R134	Resistor	100k, 1%, 0.1 W	RN50	RECE104B11
R137	Resistor	510k, 5%, 1/8 W, carbon composition		RECC514B21
R138	Resistor	270k, 5%, 1/8 W, carbon composition		RECC274B21
R139	Resistor	3.3k, 5%, 1/8 W, carbon composition		RECC332B21
S1	Switch	Dip Toggle 2PST	Alco DTP-02	SWTO1
S10, S11	Switch SPDT	Dual Slide right angle	Alco TSD21DDG-RA	SWSL7
T1	Transformer	blocking oscillator	Microtran M8149	TFHV5
X1	Crystal	6.0 MHz, 0.015%	MP-060	CYOS9
	Speaker O-ring	Buna N2-021	ORBN2021	
	Speaker	1-inch-diameter × 0.6 deep, 8 Ω		ADSP4
	Display	2-line × 16-character (LCD)		OPDS16
	Keypad			ZP11292005
	Case	Upper, Lower		ZP11919011
	Screw	Lower-case retaining screw	3/8 - 16 × 1 flat-head, stainless-steel	SCFH3716
	Ribbon Cable	Keyboard/Computer Board Cable (9-conductor)		WRFC092601
	Ribbon Cable	Display/Computer Board Cable (14-conductor)		WRFC142602
Ribbon Cable	Computer Board/ Cable	Amp.—High Voltage Board (16-conductor)	WRFC162603	
	Access door			ZP11292012
	Access door latch			HDFA10
	Battery	1.5 V, "C" cell, carbon-zinc		BTCZ6
	Display lens			ZP11292013
	Speaker Retainer			ZX11292013

SECTION VII
DIAGRAMS

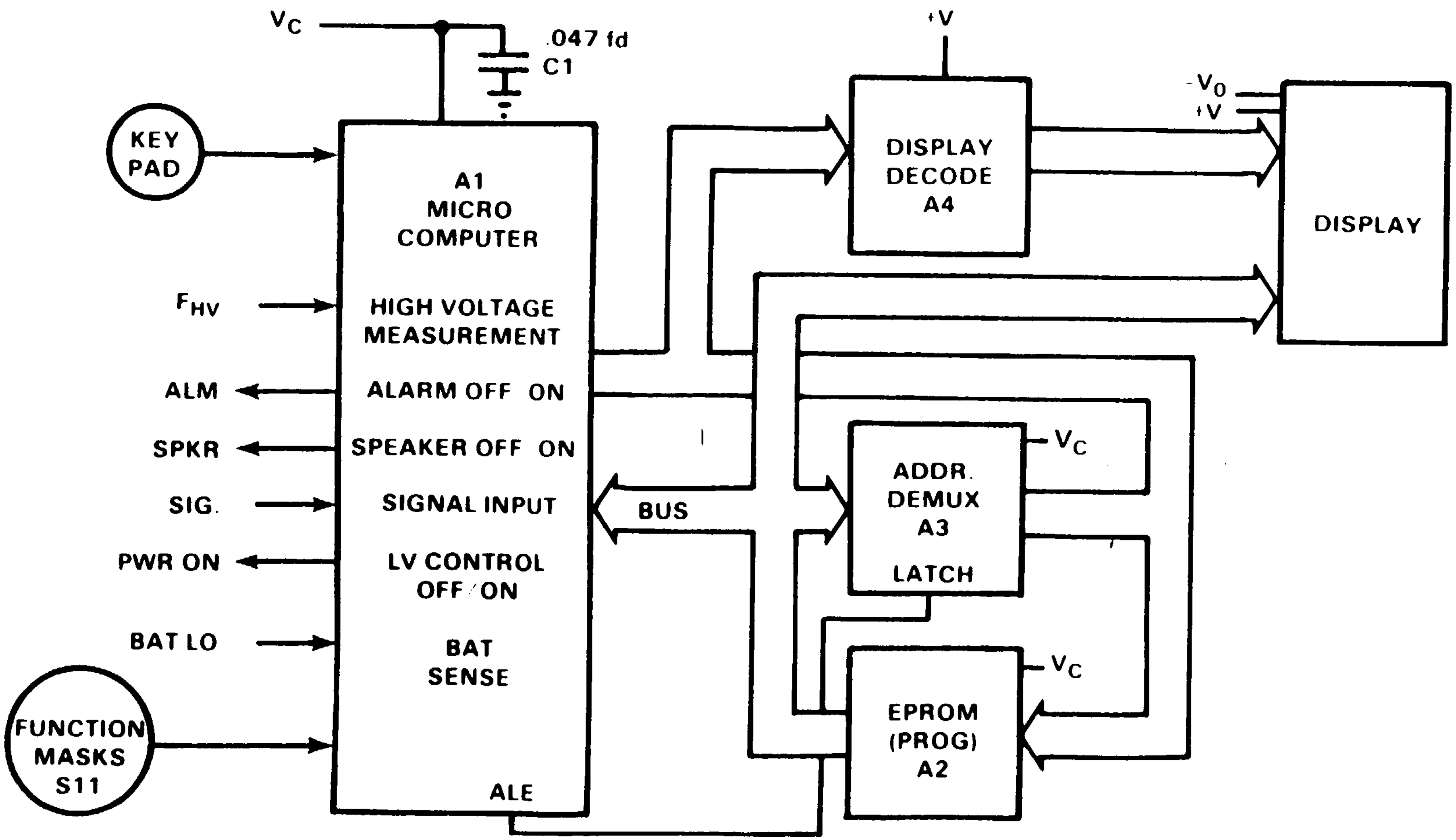


Figure 7-1. Microcomputer Functional Block Diagram

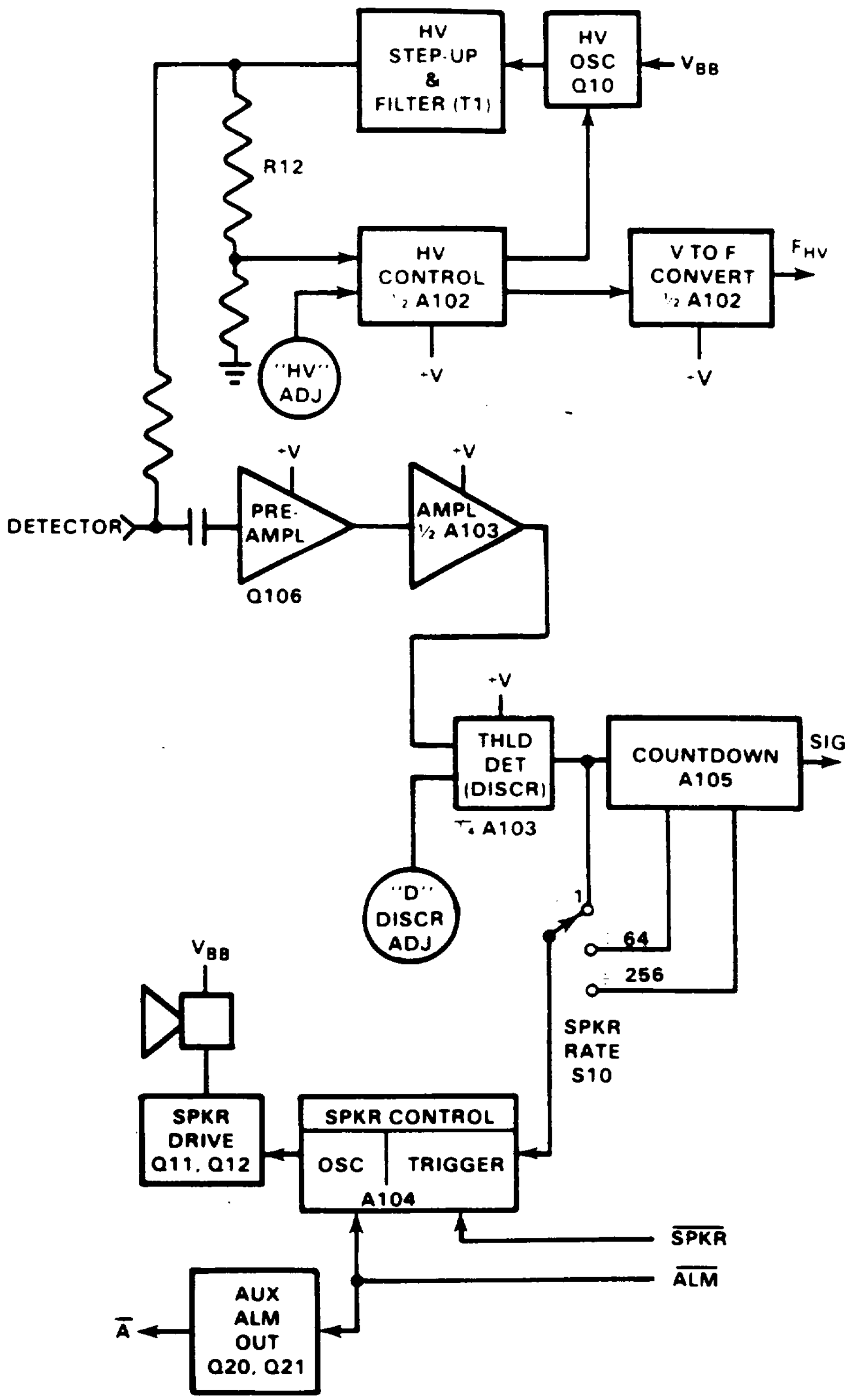


Figure 7-2. Functional Block Diagram for Amplifier, High Voltage and Speaker

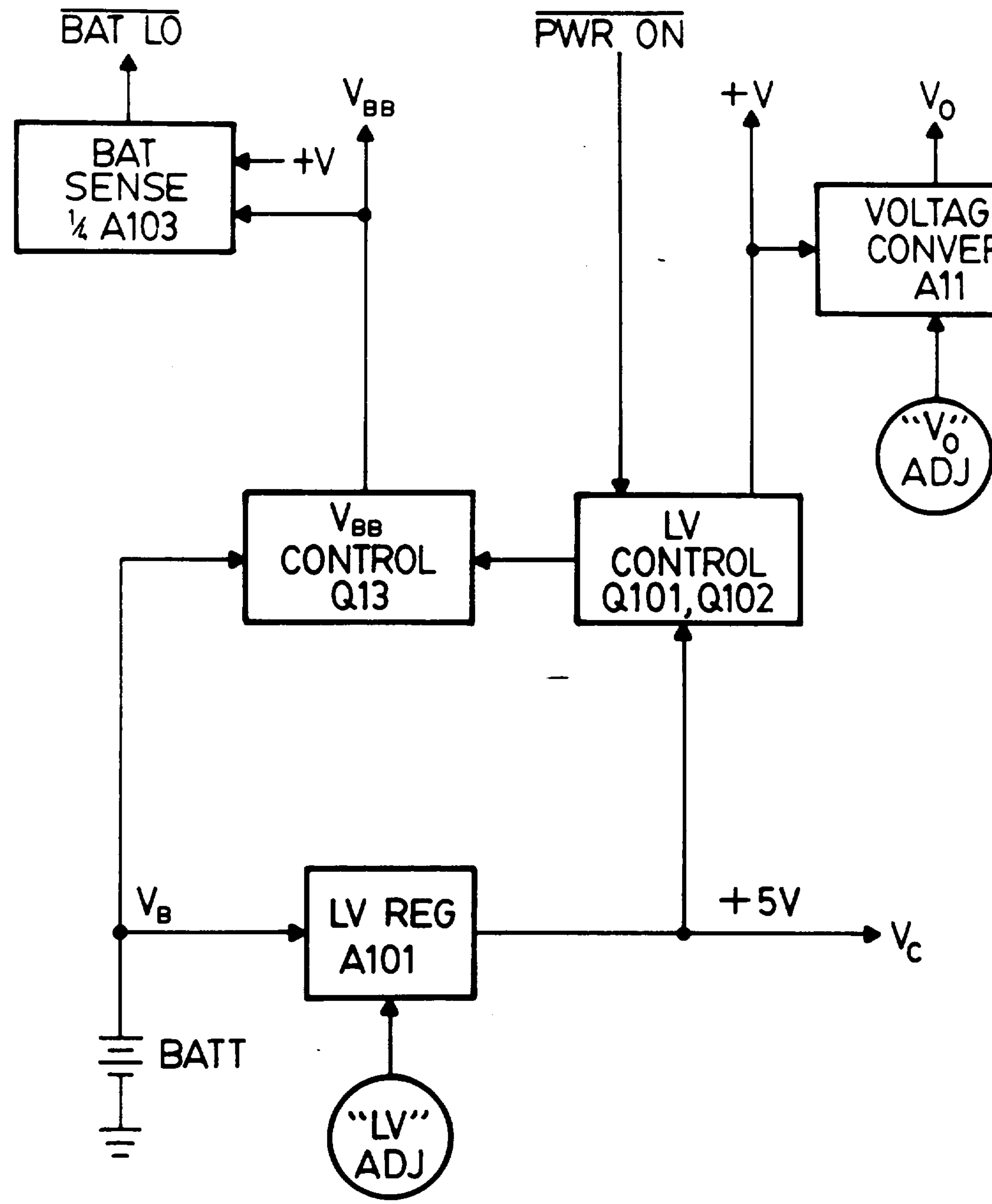


Figure 7-3. Low Voltage Functional Block Diagram

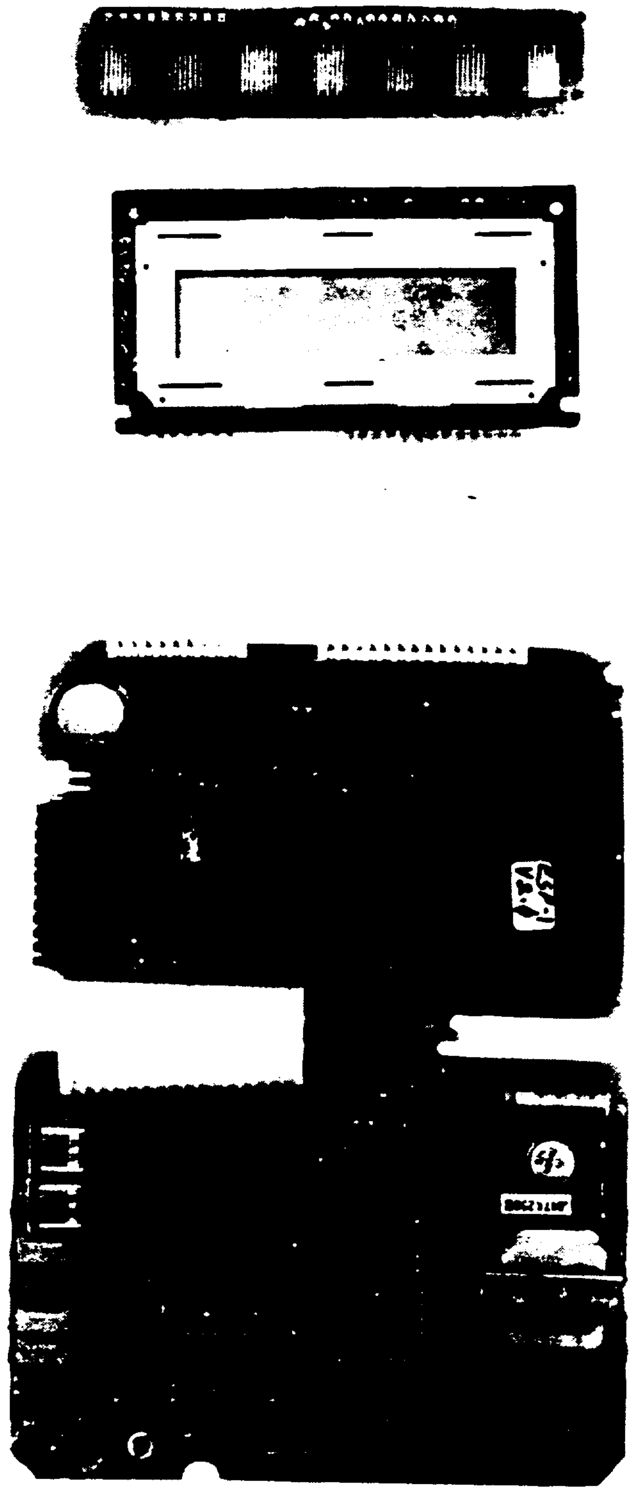


Figure 7-4. Printed Circuit Board Set

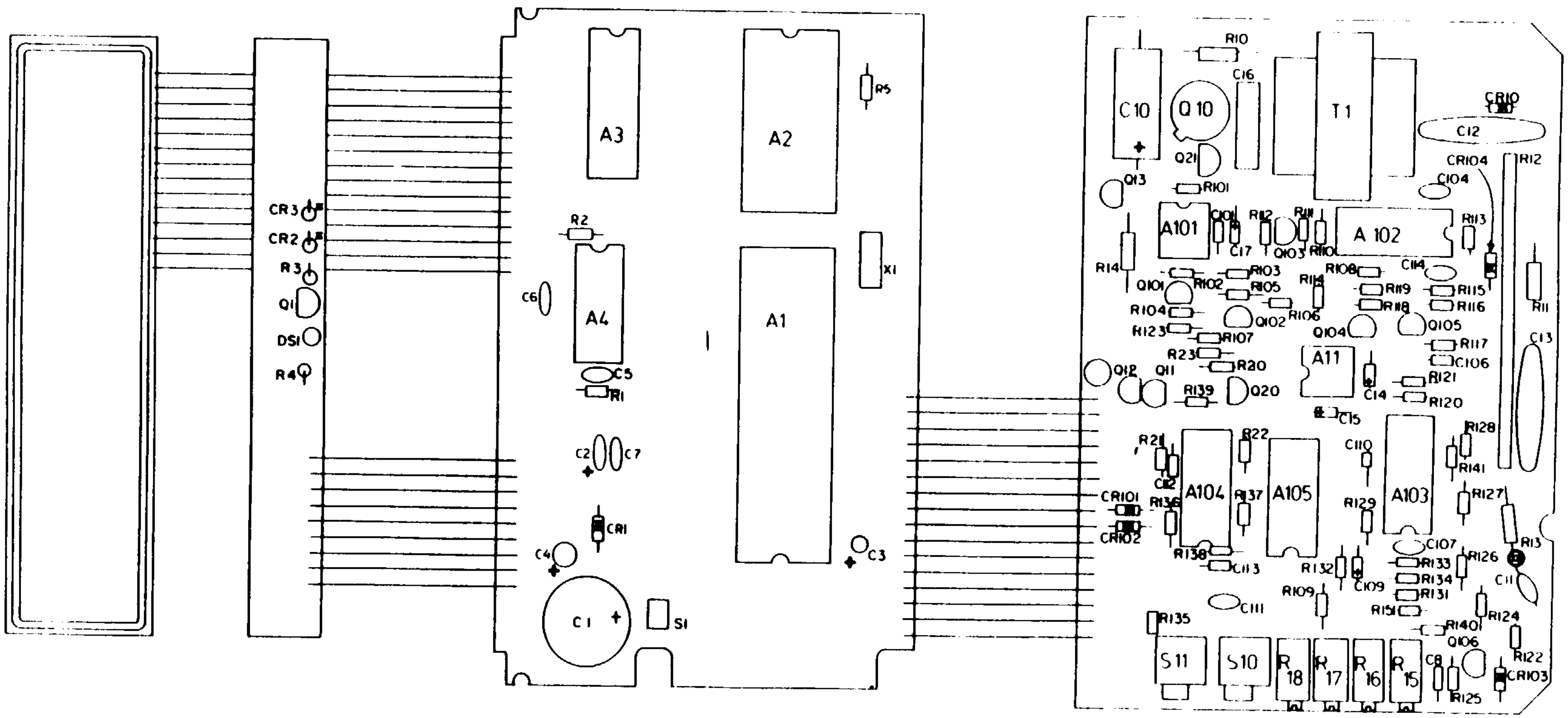


Figure 7-5. Component Layout, 11292-C17B

NOTES:
1. RESISTORS ARE 1/8 W, 5%, EXCEPT AS NOTED. RESISTOR VALUES ARE IN OHMS, $K = 10^3$, $M = 10^6$
2. CAPACITOR VALUES ARE IN MICROFARADS EXCEPT AS NOTED.

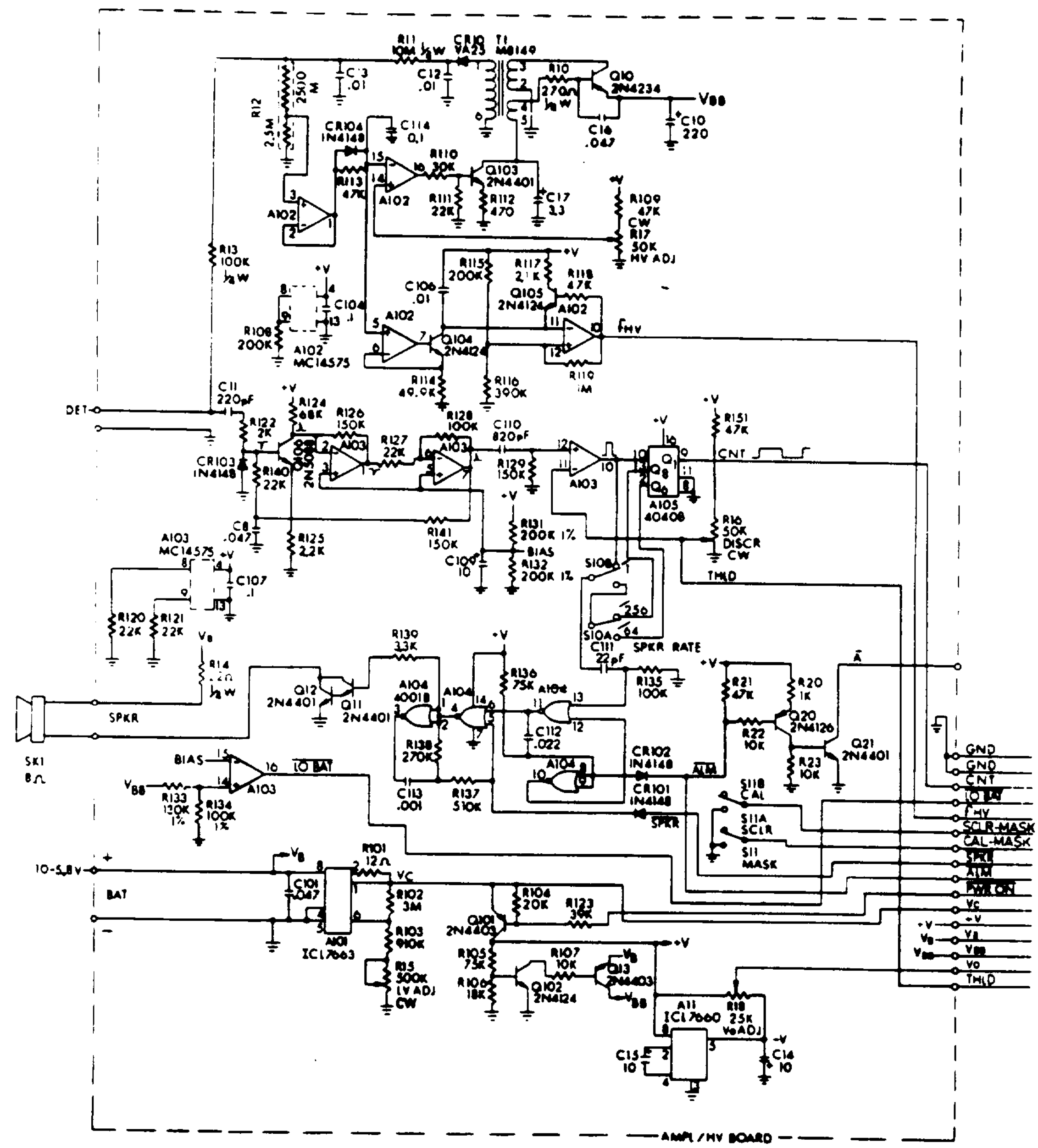


Figure 7-6. Amplifier/High Voltage Schematic, 11292-D04D (sheet 2 of 2)

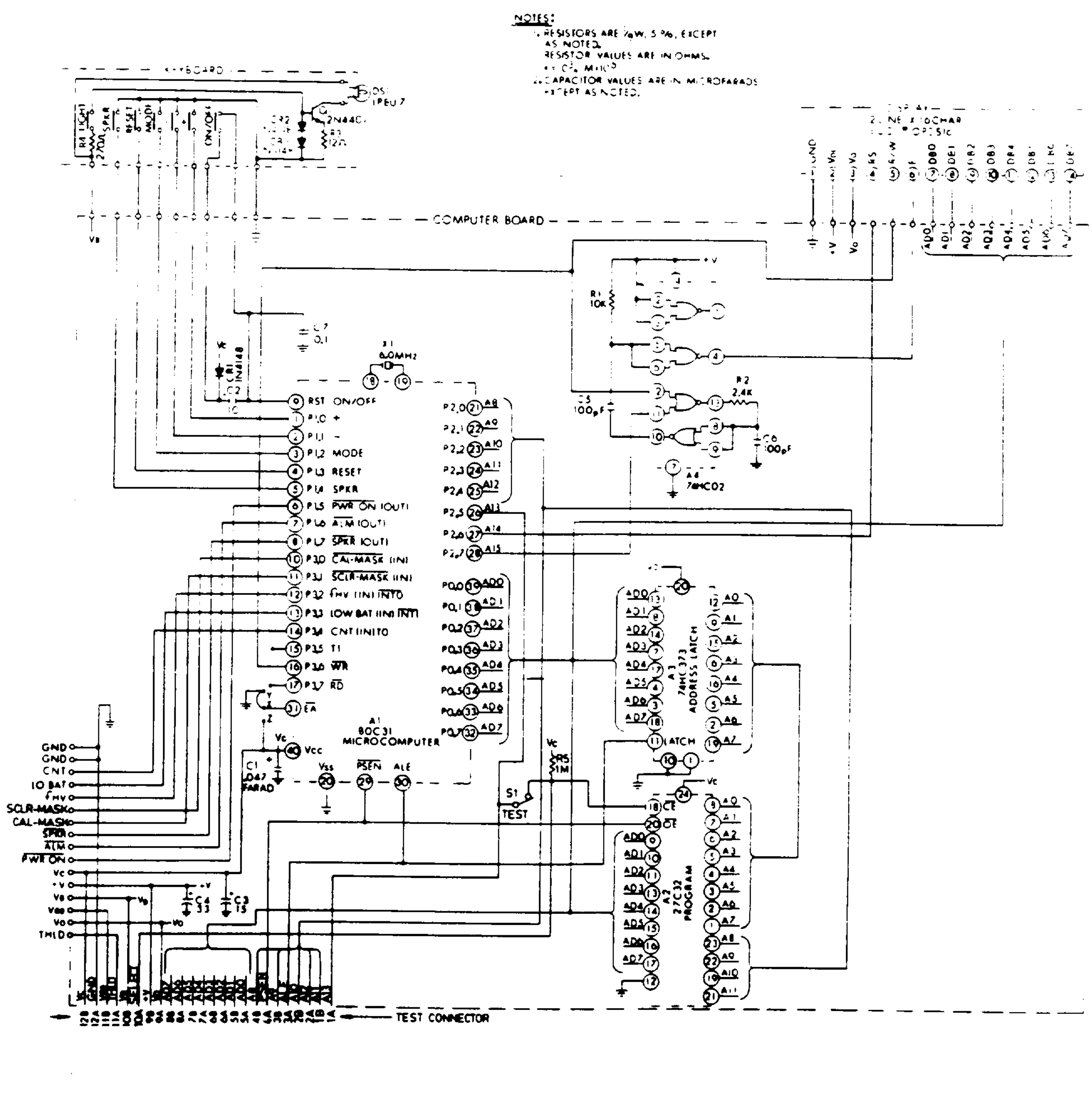
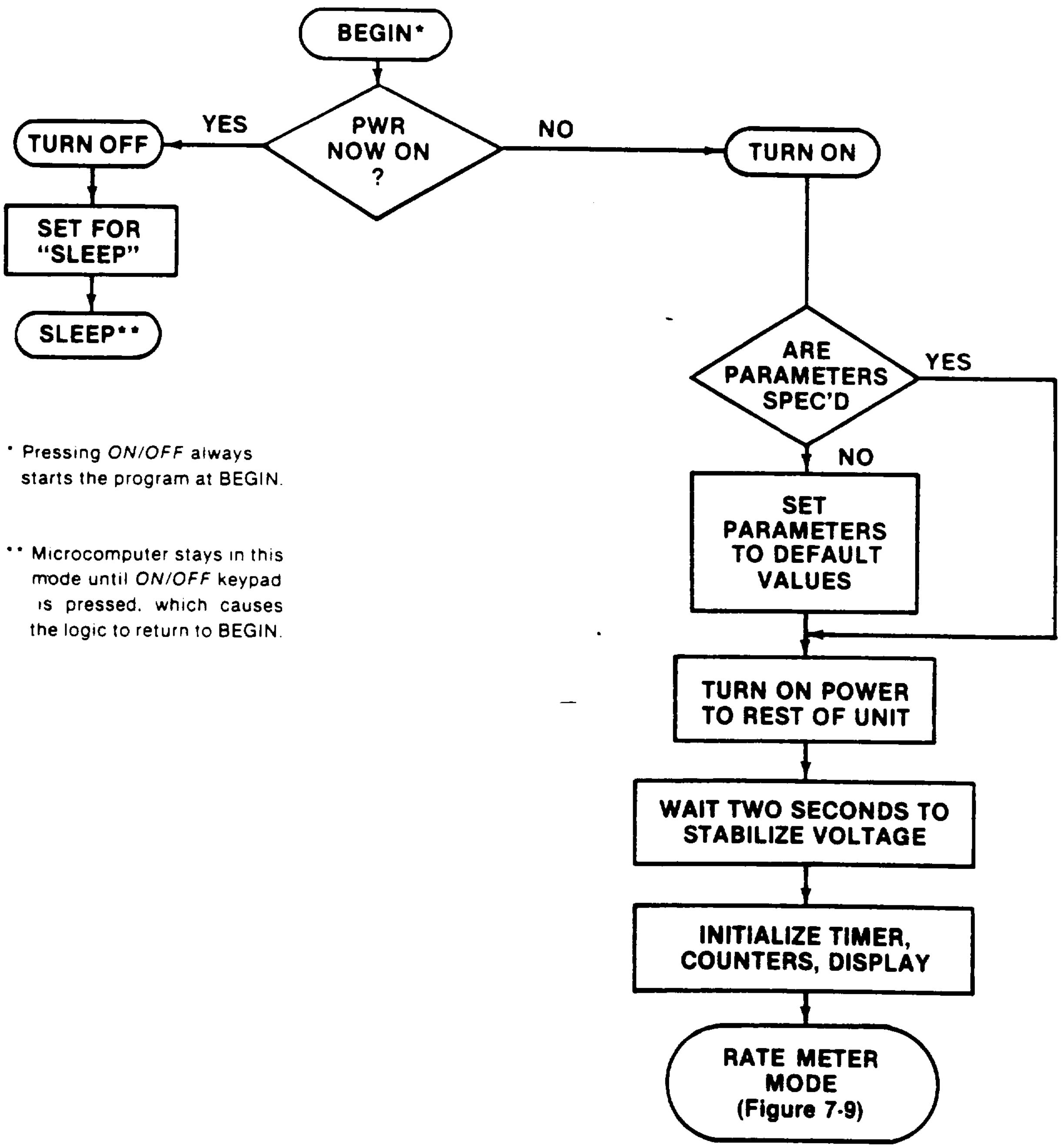


Figure 7-7. Microcomputer Schematic, 11292-D04D (sheet 1 Of 2)



* Pressing *ON/OFF* always starts the program at BEGIN.

** Microcomputer stays in this mode until *ON/OFF* keypad is pressed, which causes the logic to return to BEGIN.

Figure 7-8. Logic Flow-Applying Power

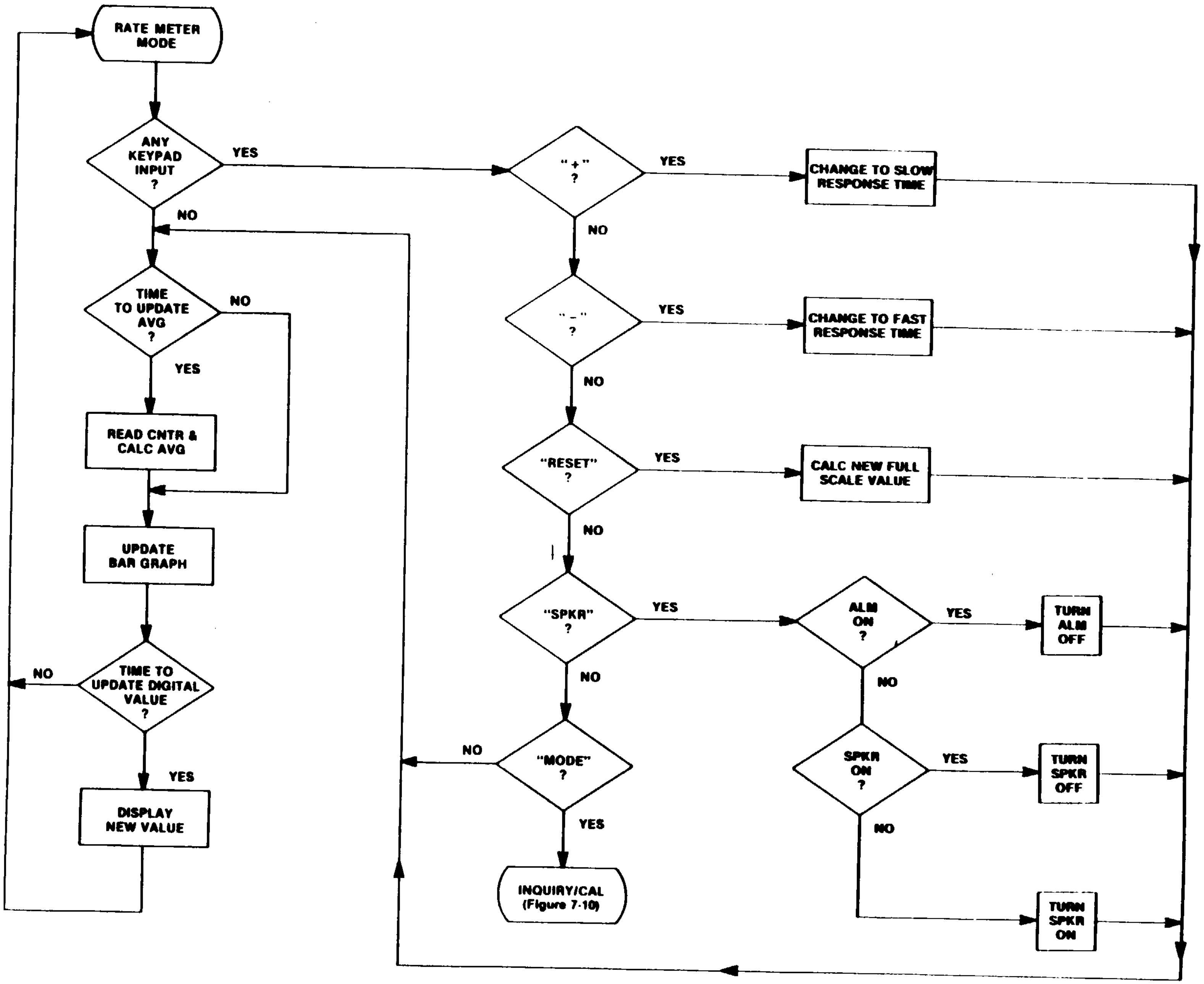


Figure 7-9. Logic Flow-Rate Meter Mode

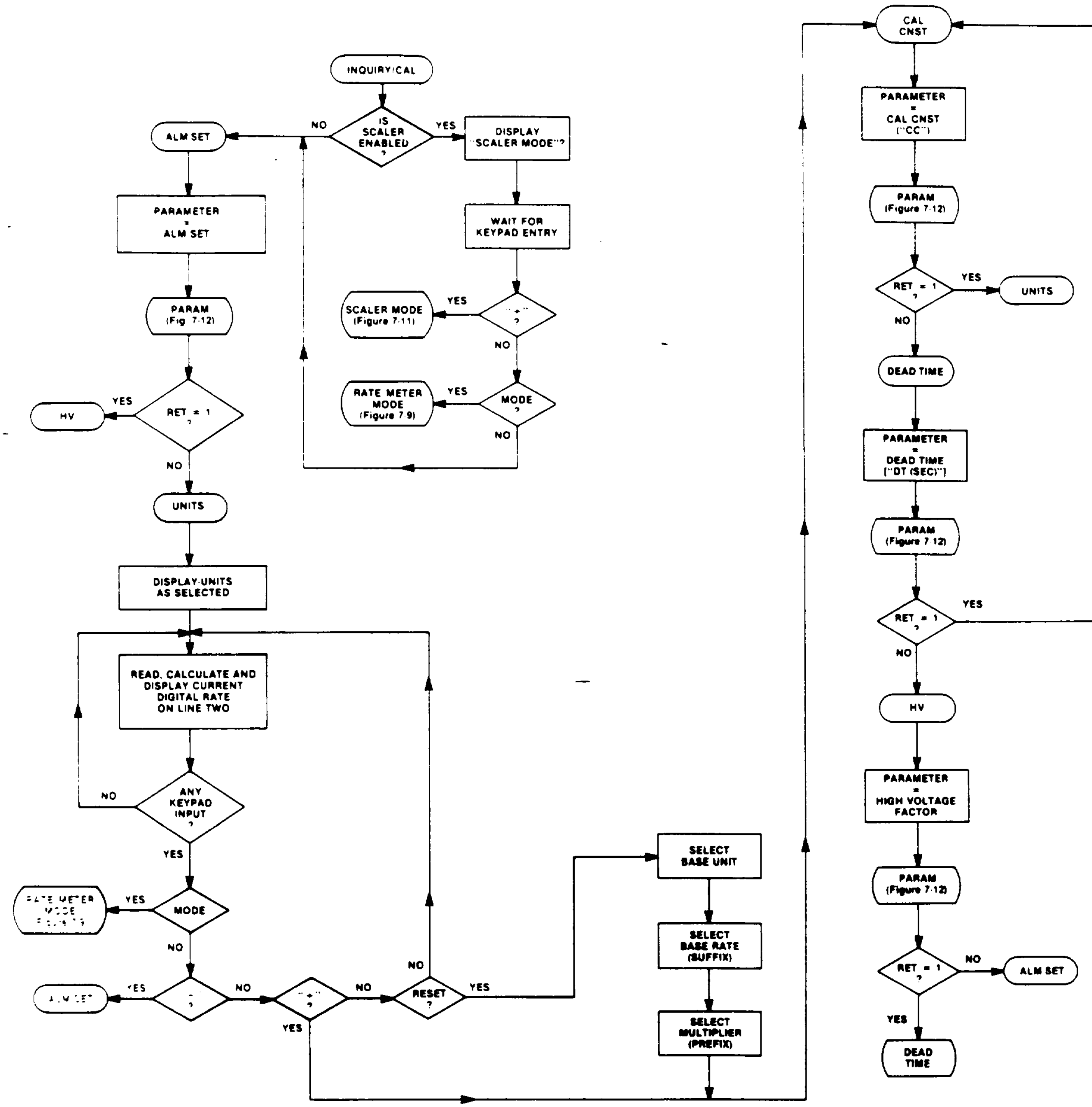


Figure 7-10. Logic Flow-Inquiry/Calibration

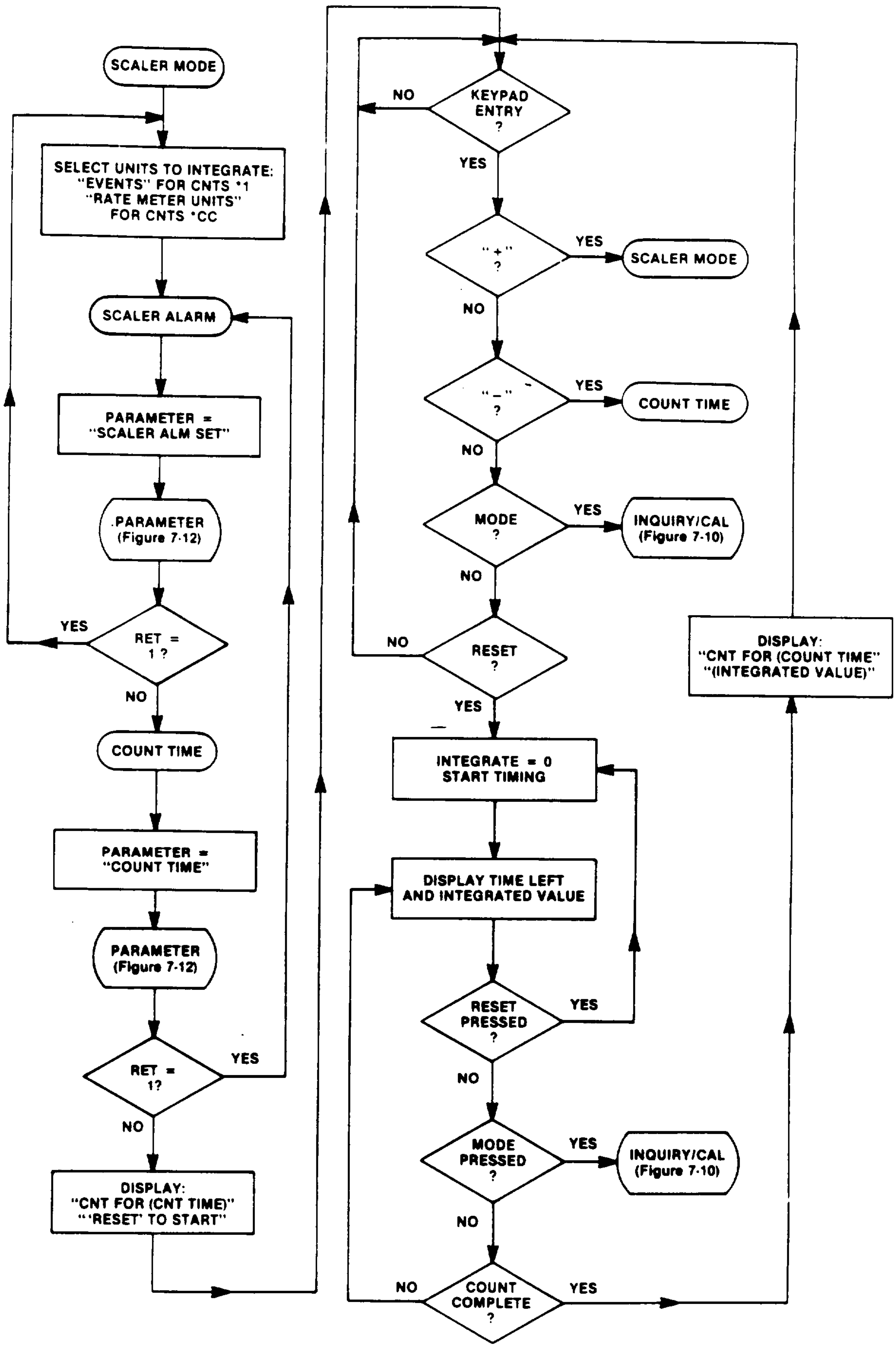


Figure 7-11. Logic Flow-Scaler Mode

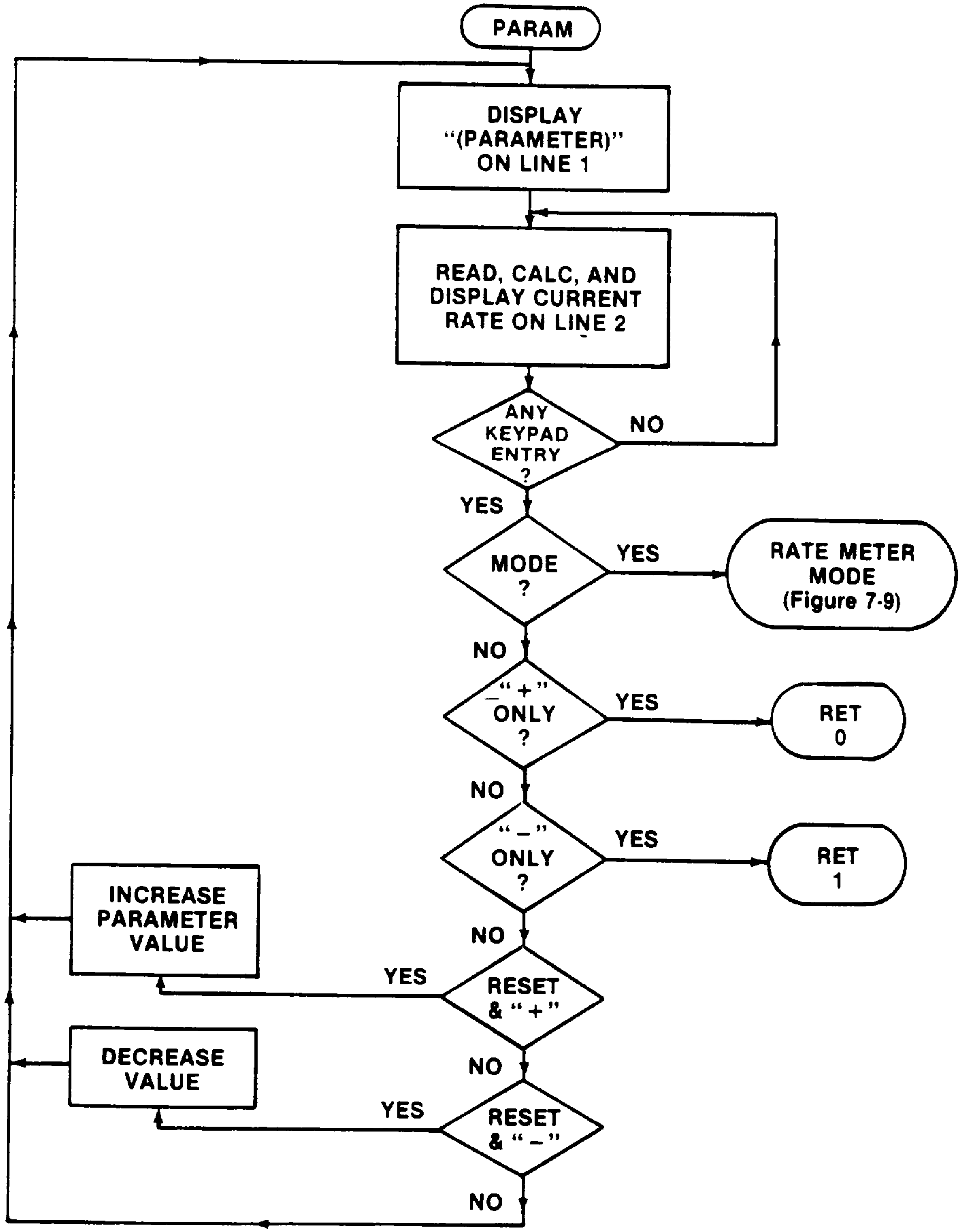


Figure 7-12. Logic Flow-Parameter Setting

SECTION VIII
DETECTORS AND ACCESSORIES

DETECTORS RECOMMENDED FOR USE WITH ESP-1

MODEL NO.	TYPE MEASUREMENT	RANGE WITH ESP-1	
		USEFUL	+/−5 PERCENT*
HP-270	Exposure or Exposure Rate	Background to 3000 mR/h	1 to 3000 mR/h
HP-290	Exposure or Exposure Rate	0.005 to 60 R/h	0.01 to 40 R/h
HP-190A	Beta-gamma Contamination	Background to 25,000 cnts/s	14 to 25,000 cnts/s
HP-210L	Beta-gamma Contamination	Background to 100,000 cnts/s	14 to 100,000 cnts/s
HP-210T	Beta-gamma Contamination	Background to 100,000 cnts/s	14 to 100,000 cnts/s
HP-260	Beta-gamma Contamination	Background to 100,000 cnts/s	14 to 100,000 cnts/s
AC-3	Alpha Contamination	Background to 50,000 cnts/s	14 to 50,000 cnts/s
NRD	Neutron Dose Equivalent or Dose Equivalent Rate	0.001 to 200 rem/h	0.02 to 200 rem/h
LEG-1	Low Energy Gamma or X-Ray	Background to 50,000 cnts/s	14 to 50,000 cnts/s
SPA-3	High Sensitivity Gamma	Background to 50,000 cnts/s	14 to 50,000 cnts/s
SPA-6	Medium Sensitivity Gamma	Background to 50,000 cnts/s	14 to 50,000 cnts/s

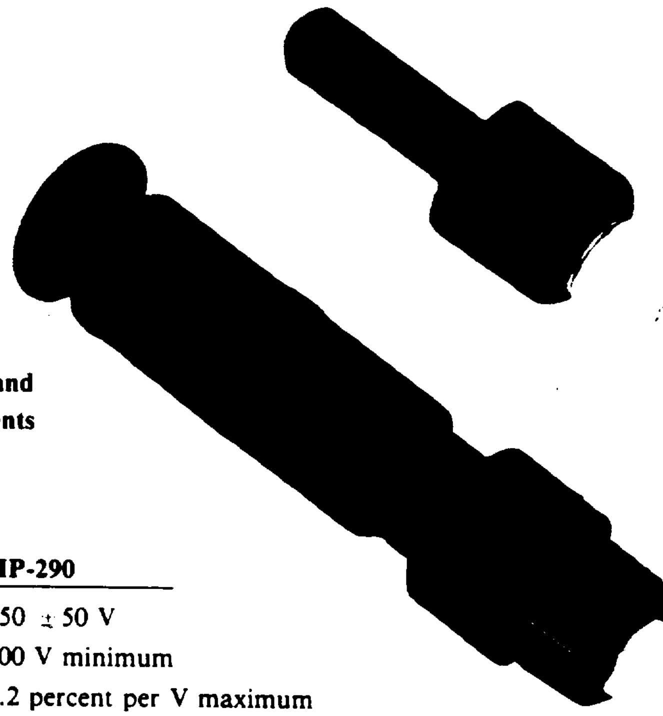
*Rate Meter Mode provides +/− 5 percent standard deviation readout capability or better over the indicated range.

Models HP-270 and HP-290 Hand Probes

A. GENERAL DESCRIPTION

The HP-270 is an excellent general purpose G-M probe with energy compensation and a beta shield, making it the choice for most health physics applications. The energy compensation permits reliable exposure rate measurement from background to 3000 mR/h.

The HP-290 is a higher range G-M probe with energy compensation, providing reliable exposure rate measurement from 0.1 mR/h to 40 R/h.

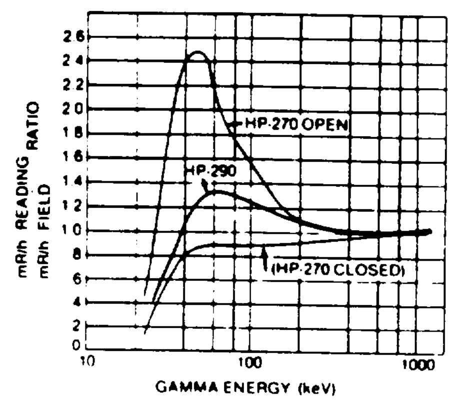


Model HP-270

- **Energy Compensated for Gamma and Exposure Rate Measurements**

B. SPECIFICATIONS

	HP-270	HP-290
Operating Voltage:	900 ±50 V	550 ±50 V
Plateau Length:	100 V minimum	100 V minimum
Plateau Slope:	0.1 percent per V maximum	0.2 percent per V maximum
Dead Time:	100 μs maximum	20 μs maximum
Temperature Range:	−40 °F to +167 °F (−40 °C to +75 °C)	−40 °F to +167 °F (−40 °C to +75 °C)
Wall Thickness:	30 mg/cm^2 (tube only)	90 mg/cm^2 (tube only)
Wall Material:	Stainless steel	Stainless steel
Gamma Sensitivity:	≅1200 cpm/mR/h (^{137}Cs)	≅80 cpm/mR/h (^{137}Cs)
Energy Response:	See curve	See curve
Housing:	ABS plastic	ABS plastic
Connector:	BNC series coaxial	BNC series coaxial
Size:	1 3/8 inches in diameter × 6 inches long (3.5 cm × 15.2 cm)	1 1/8 inches in diameter × 3½ inches long (2.9 cm × 8.9 cm)
Weight:	5 ounces (142 g)	2 ounces (57 g)



C. AVAILABLE ACCESSORIES

Cable: CA-16-60

Check Source: CS-7A

Models HP-210 and HP-260 Hand Probes

A. GENERAL DESCRIPTION

These hand probes provide a sensitive beta detector featuring a "Pancake" GM tube with a thin mica window. They are designed for contamination surveys on personnel, table tops, floors and equipment. The open window, which is protected by a sturdy wire screen, permits useful beta sensitivities down to 40 keV. The detector is alpha sensitive (above 3 MeV).

The HP210-L with a lead shield and the HP-210T with a tungsten shield permit relatively low-level beta monitoring in a gamma background. The shielding ration for ^{60}Co gamma (front: back) is 4:1. The HP-260 is a lightweight probe without any gamma shielding.

B. SPECIFICATIONS

Operating Voltage: 900 ±50 V

Plateau Length: 100 V minimum

Plateau Slope: 0.1 percent per V maximum

Dead Time: 50 μs maximum

Temperature Range: −22 °F to +167 °F (−30 °C to +75 °C)

Mica Window Thickness: 1.4 to 2.0 mg/cm^2

Mica Window Size: 1.75-inch-diameter (4.45 cm); 2.4 in^2 (15.5 cm^2)

Gamma Sensitivity: ≅3600 cpm/mR/h (^{137}Cs) **(into window)**

***Beta Efficiency:**
- ≅45 percent ^{90}Sr-^{90}Y
- ≅30 percent ^{99}Tc
- ≅10 percent ^{14}C

Alpha Sensitivity: 3 MeV at window

Connector: BNC series coaxial

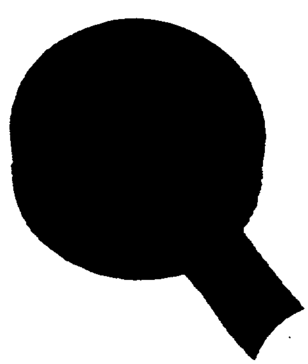
C. AVAILABLE ACCESSORIES

Sample Holder: SH-4A for use with HP-210

Cable: CA-16-60

Check Source: CS-7A

*Efficiencies with screen in place. Screen removal will increase efficiency by ≅45 percent of stated value. Efficiencies listed as percentage of 2π emission rate, from a one-inch-diameter source.



Model HP-210T/Model HP-210L

Model HP-260

Model NRD
Neutron rem Detector

A. GENERAL DESCRIPTION

The Model NRD neutron rem detector is a nine-inch-diameter, cadmium-loaded polyethelene sphere with a BF_3 tube in the center for use as an area monitor. This detector has been shown to have an energy response which closely follows the theoretical dose from neutrons over the energy range from 0.025 eV (thermal) to about 10.00 MeV.[1] [2] The BF_3 tube allows excellent gamma rejection.

B. SPECIFICATIONS

Detector: BF_3 tube in nine-inch cadmium-loaded polyethelene sphere.

Plateau: Approximately 200 V with a slope of 5 percent per 100 V.

Operating Voltage: Dependent on sensitivity of counter and cable length. Typically 1600 to 2000 V.

Directional Response: Within ±10 percent.

Energy Range: Thermal to approximately 10 MeV.

Gamma Rejection: Up to 500 R/h, dependent on high voltage setting.

Sensitivity: Approximately 50 cpm per mrem per hour (3000 counts per mrem).

Connector: MHV Series coaxial.

Size: 9-inch-diameter × 9⁷/₈-inch overall height (22.9 cm × 25.1 cm).

Weight: 13.75 pounds (6.24 kg).

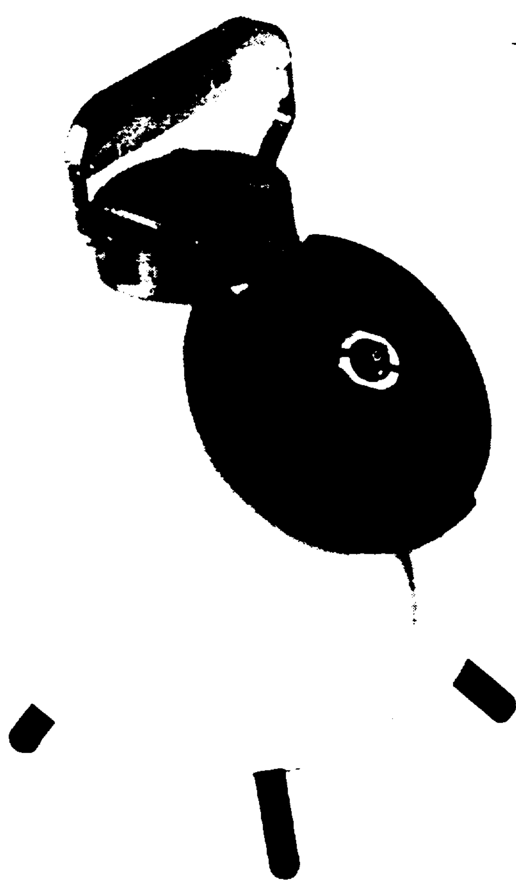
C. AVAILABLE ACCESSORIES

Cable: CA-15-36

Bracket: Wall Mounting Model ZP10478021

[1] "A Modified Sphere Neutron Detector," D.E. Hankins, LA-3595.

[2] "The Substitution of a BF_3 Tube for the LiI Crystal in Neutron rem Meters". D.E. Hankins: *Health Physics Journal;* Volume 14, Number 5, May 1968.



NRD

- MEASURES NEUTRON DOSE RATE FROM THERMAL THROUGH FAST
- BF_3 TUBE GIVES HIGH GAMMA REJECTION

Model HP-280
Neutron Sphere

A. GENERAL DESCRIPTION

The Model HP-280 is a three-inch-diameter cadmium-covered polyethylene sphere which uses the same BF_3 tube as the NRD nine-inch sphere. HP-280 readings are to be taken with the same tube as the NRD. No tube is supplied with the HP-280.

The cadmium covering over the HP-280 will cause the detector to reject thermal neutrons. Because of the smaller moderating volume of polyethylene of the HP-280, it will overrespond to lower energy neutrons and underrespond to higher energy neutrons as compared to the nine-inch sphere. Thus, in the energy range in which the HP-280 responds, a ratio of reading between the nine-inch and three-inch spheres will give information as to the energy spectrum of the neutron flux.

This energy information has been correlated to the energy dependence of the albedo neutron TLD dosimeter (see references 1 and 2 below). This energy correlation is shown as a calibration factor which would be applied to the neutron response of an albedo dosimeter.

For a more complete understanding of the phenomenon described above, refer to the following papers:

"A Modified Sphere Neutron Detector," D.E. Hankins, LA-3595.

"The Substitution of a BF_3 Tube for the LiI Crystal in Neutron rem Meters." D.E. Hankins: *Health Physics Journal;* Volume 14, Number 5, May 1968.

B. SPECIFICATIONS

Detector: BF_3 tube is not supplied with this sphere. Use the same tube as in nine-inch sphere.

Electronics: Suitable for use with many Eberline counters and scalers.

Length: Approximately 6¼ inches (15.9 cm).

Weight: 2 pounds (0.91 kg) less detector tube.

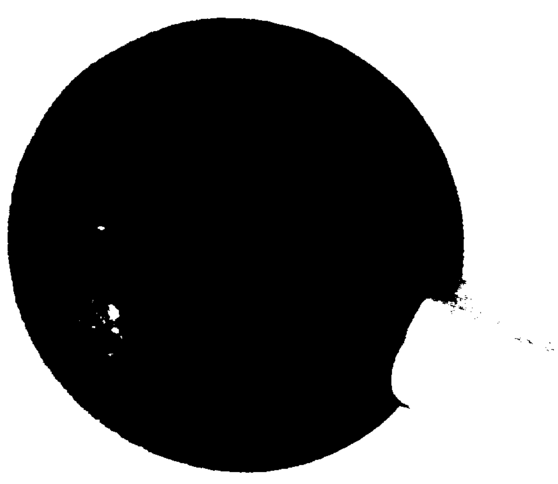
Calibration with Monoenergetic Neutrons by National Bureau of Standards

Energy, keV	Typical Response PRS-2P/NRD	cpm per mrem/h PRS-2P/HP-280
2	215	1835
24	240	1320
144	80	200
235	70	160
515	35	35
754	35	25
1054	35	15

C. AVAILABLE ACCESSORIES

Detector: BF_3 Tube

Cable: CA-15-36



HP-280

Model AC-3
Alpha Scintillation Probe

A. GENERAL DESCRIPTION

To meet the various requirements in the field of alpha monitoring and the different types of instruments, the AC-3 alpha scintillation probe has been designed for alpha surveys or for personnel monitoring. The AC-3 is a rugged alpha probe designed to work with several Eberline portable survey or radiation monitoring instruments.

There are two versions of the AC-3, differing only in the window assembly. The AC-3-7 designates a maximum open area window for alpha surveys, and the AC-3-8 designates a rugged window which has a fine mesh protector over the Mylar® for personnel monitoring.

The Mylar® window is a "sandwich" assembly which can be replaced by the removal of six screws. This window can also be used on older AC-3 probes without modification.

There is a clear plastic probe face cover supplied to protect the window when the probe is not in use.

B. SPECIFICATIONS

Active Area: 9.1-in^2 (59 cm^2) within 5.75-inch × 2-inch (14.6 cm x 5.1 cm) sampling area.

Window Thickness: 0.5 mg/cm^2 aluminized Mylar®.

Efficiency: From a 1-inch-diameter source or from 59 cm^2 of a large distributed area ^{239}Pu source (2π).

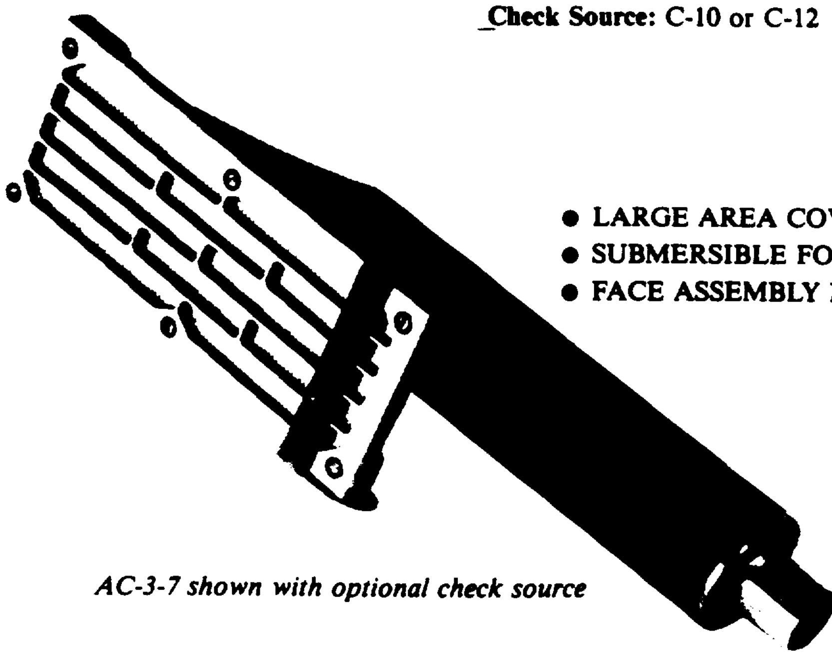
AC-3-7 window: 28 percent minimum, 31 percent typical.

AC-3-8 window: 18 percent minimum, 20 percent typical.

C. ACCESSORIES

Cable: CA-12-60

Check Source: C-10 or C-12



- LARGE AREA COVERAGE
- SUBMERSIBLE FOR DECONTAMINATION
- FACE ASSEMBLY EASILY CHANGED

AC-3-7 shown with optional check source

Model LEG-1
Low-Energy Gamma Probe

A. GENERAL DESCRIPTION

The LEG-1 is a gamma scintillation probe for detection of low-energy gamma and x-rays. It is designed for the detection of ^{125}I and other low-energy gamma emitters.

B. SPECIFICATIONS

Crystal: 1-inch-diameter × 0.04-inch-thick with 0.001-inch window (2.54-cm-diameter × 1-mm-thick NaI(Tl) scintillation crystal with a 0.025-mm aluminum window). The total window thickness of the probe, including the housing, is 0.011 inch (0.28 mm) aluminum or 75.4 mg/cm^2.

Sensitive Area: 0.79 in^2 (5.1 cm^2)

Photomultiplier Tube: 1-inch-diameter (2.54 cm), 11-dynode with S11 response. The PM tube is enclosed in a magnetic shield.

Maximum Voltage: 1500 V

Operating Voltage: Variable depending upon application.

Current Requirement: Divider string is approximately 110 MΩ, using 10 μA at 1100 V.

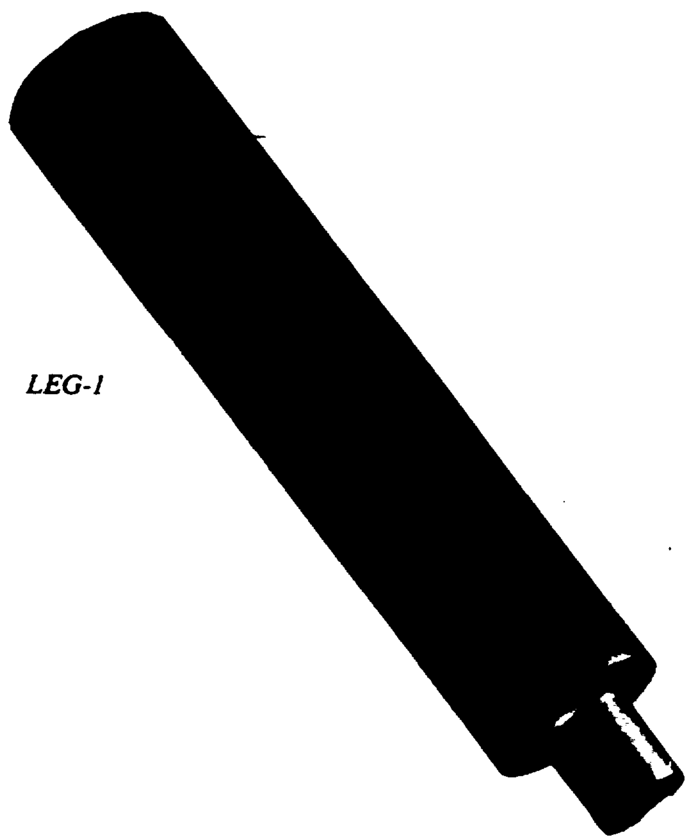
Dimensions: 1.65 inches in diameter × 7.9 inches long (4.2 cm × 20 cm).

Weight: 12 ounces (340 g)

Connector: Eberline CJ-1 which mates with Eberline CP-1. Cable must be specified.

C. AVAILABLE ACCESSORIES

Cable: CA-12-60



LEG-1

Model SPA-3
Scintillation Probe

A. GENERAL DESCRIPTION

The Model SPA-3 scintillation probe is a rugged, waterproof gamma detector designed for high sensitivity of pulse-height applications.

The SPA-3 contains a 2-inch-diameter, 2-inch-long NaI(Tl) crystal, a 2-inch, 10-stage photomultiplier tube, tube socket with a dynode resistor string, and a magnetic shield.

B. SPECIFICATIONS

Crystal: NaI(Tl), 2-inch-diameter × 2 inches long (5.1 cm × 5.1 cm).

Photomultiplier Tube: ≅2-inch-diameter, 10-dynode, end-window with S-11 photocathode.

Operating Voltage: Variable dependent upon application.

Maximum Voltage: +1600 V

Sensitivity: ≅1200k cpm per mR/h with ^{137}Cs

Current Drain: ≅120 MΩ resistance string yields 10 μA at 1200 V.

Wall Material: Aluminum

Wall Thickness: 1/8-inch (0.32 cm), 1/16-inch (0.16 cm) at crystal.

Connector: Mates with Eberline CP-1.

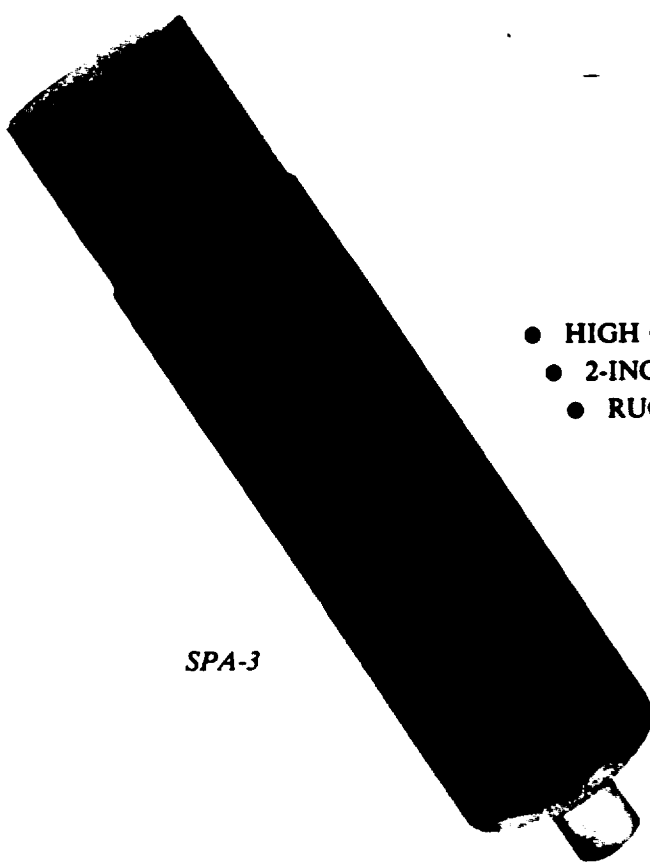
Finish: Enameled body with chrome-plated connector.

Size: 2 5/8-inch-diameter × 11 1/8 inches long (6.7 cm × 28.3 cm).

Weight: 3.25 pounds (1.5 kg)

C. AVAILABLE ACCESSORIES

Cable: CA-12-60



- HIGH GAMMA SENSITIVITY
- 2-INCH × 2-INCH NaI(Tl) CRYSTAL
- RUGGED CONSTRUCTION

SPA-3

Model HP-190-A
Hand Probe

A. GENERAL DESCRIPTION

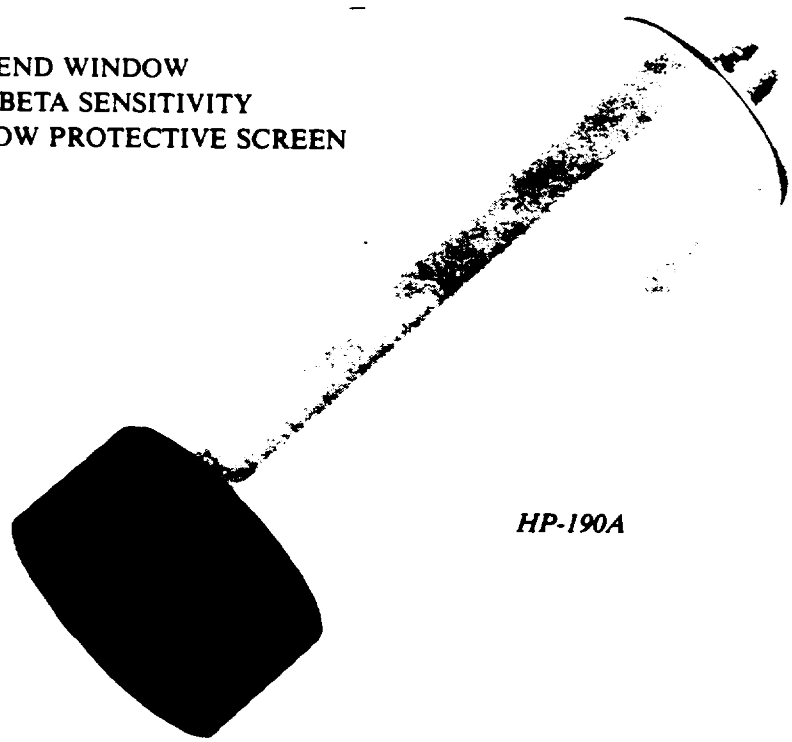
The Model HP-190A hand probe uses a thin end-window GM tube for detection of relatively low energy beta and provides a limited sensitivity to high energy alpha particles. The HP-190A does not have energy compensation; therefore, it is not recommended for gamma exposure rate measurements.

B. SPECIFICATIONS

Operating Voltage: 900 ± 50V
Plateau Length: 100 V minimum
Plateau Slope: 0.1 percent per V maximum
Dead Time: 200 μs maximum
Temperature Range: −67° F to +167° F (−55° C to +75° C)
Mica Window Thickness: 1 1/8- inch-diameter (2.9 cm)
Gamma Sensitivity: ≅2500 cpm/mR/h (^{137}Cs) (into window)
***Beta Efficiency:**
≅35 percent ^{90}Sr-^{90}Y
≅25 percent ^{99}Tc
≅10 percent ^{14}C
Alpha Sensitivity: 3 MeV at window
Connector: BNC series coaxial
Size: 1 3/8 inches in diameter × 4 7/8 inches long (3.5 cm × 12.4 cm)
Weight: 5.5 ounces (155 g)

*Measured without screen cap. With cap in place, efficiency will be ≅50 percent of values listed. Efficiencies listed as percent of 2π emission rate from a one-inch-diameter source.

- THIN END WINDOW
- HIGH BETA SENSITIVITY
- WINDOW PROTECTIVE SCREEN



HP-190A

NNA.871116.0070

Instruction Manual

LUDLUM MODEL 65 PORTABLE GAS PROPORTIONAL COUNTER

LUDLUM MEASUREMENTS, INC.

501 OAK 915 - 235-5494 P. O. BOX 810

SWEETWATER, TEXAS, U.S.A., 79556

DESIGNER AND MANUFACTURER

OF

Scientific and Industrial

INSTRUMENTS.

WARRANTY CERTIFICATE

Ludlum Measurements, Inc. warrants the products covered in this Instruction Manual to be free of defects due to workmanship, materials, and design for a period of twelve months from date of delivery, with the exception of photo tubes and geiger tubes, which are warranted defect free to 90 days.

In event of instrument failure, notify Ludlum Measurements Inc. for repair or replacement. Liability of this warranty is limited to the purchase price of the instrument.

RECEIVING CONDITION EXAMINATION

Be sure to verify that the shipping carton is received in perfectly good condition. For example, that no damage should be visible.

Should the instrument be received in a damaged condition, save the shipping container and the packing material and request an immediate inspection by the carrier.

Ludlum Measurements, Inc. is not responsible for the damage which occurs during shipment but will make every effort to help obtain restitution from the carrier.

RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair, calibration, etc., please do so by the appropriate method of shipment. All shipments should include documentation containing shipping address, customer name and telephone number, and all other necessary information.

Your cooperation will expedite the return of your equipment.

LUDLUM MODEL 65 PORTABLE GAS PROPORTIONAL COUNTER

TABLE OF CONTENTS

LUDLUM MODEL 65 PORTABLE GAS PROPORTIONAL COUNTER

1. GENERAL

The Ludlum Model 65 Portable Gas Proportional Counter is a self-contained unit utilizing a gas proportional detector mounted to the counting unit. It is designed to respond to Alpha or Beta/Gamma Radiation and uses Butane as the counting gas. The butane supply comes from commercially available cigarette lighter refill bottles.

2. SPECIFICATIONS

LINEARITY: plus or minus 5% of full scale

DISCRIMINATION: 4 millivolt for proportional use

HIGH VOLTAGE: variable from 700 to 2500 volts

BATTERY: NEDA 1604 (9-volt, rectangular transistor radio); 30 hour life

AUDIO: built-in unimorph speaker

COUNTING RANGES: meter presentation of 0 to 500 Counts-per-Minute with multipliers of X1, X10, X100, X1K

METER: 50 micro-amp, 1 3/4-inch scale with pivot-and-jewel movement

FINISH: aluminum case with computer-beige polyurethane enamel

SIZE: 10 inches x 8 inches x 6 1/2 inches (L x H x W)

WEIGHT: 5lbs. 8oz.

DETECTOR: 100 cm^2 open area gas proportional type using butane as counting gas.

3. DESCRIPTION OF CONTROLS AND FUNCTIONS

(1) Fast-Slow Toggle Switch, when in the F position, provides a 90% of full-scale meter deflection of two (2) seconds. In S position, a 90% of full scale meter deflection takes six (6) seconds. Set on "F" for fast response and large meter deviation. The "S" position should be used for slow response and damped meter deviation.

(2) Range Multiplier Selector Switch is a 5-position switch marked OFF, X1K, X100, X10, X1. Moving the range selector switch from OFF to one of the range multiplier postions (X1, X10, X100, X1K) provides the operator with an overall range of 0-500K Counts/Minute. Multiply the scale reading by the multiplier for determining the actual count rate.

(3, 5, 8, 9) Range Calibration Adjustments are 1/8" holes with recessed potentiometers located underneath the cover plate on the front panel of the instrument. These adjustment controls allow individual calibration for each range multiplier.

(4) High Voltage Adjustment is also a recessed potentiometer adjustment located underneath the cover plate. This control provides a means to vary the high voltage from 700 to 2500 volts. The high voltage setting may be checked at the high voltage connector with an appropriate voltmeter, by pressing the HV TEST and noting the reading on the meter.

(6) HV TEST pushbutton, when pressed, indicates the high voltage setting on the meter.

(7) BAT TEST, when depressed, provides a visual means of checking the battery charge status. The instrument must be turned on to do this check.

(10) Unimorph speaker, located behind the front panel, provides the audio for the instrument.

(11) RESET Button provides a rapid means to discharge the meter to zero.

(12) AUDIO ON-OFF Toggle Switch, in the ON position, operates the unimorph speaker. The frequency of the clicks is relative to the rate of the incoming pulses. The audio should be turned OFF when not required, reducing the battery drain.

(13) COUNTS/MIN readout is on a dual scale meter with a range of 0 to 500 COUNTS/MIN and a scale of 0 to 2.5 KV. There is also a battery check area on the meterface to be used with the BAT TEST button.

(14) ON/OFF Gas toggle valve, is actually 2 valves connected by a bar. These valves shut off the detector gas outlet and inlet.

(15) FLUSH/FLOW toggle valve controls the gas flow rate. The flow rates are adjusted by needle valves within the lower case.

(16) Pressure regulator makes certain that only vapor enters detector. The regulator set knob is covered by an aluminum cap located above the FLUSH/FLOW valve.

4. OPERATING PROCEDURES

4.1 Turn the instrument range multiplier switch to X1K. Depress the TEST button and check the condition of the battery. The meter should deflect to the battery check portion of the meter scale. If the meter does not respond, check the battery and replace if necessary by removing the clip underneath and to the front of the instrument.

4.2 Place spout of butane bottle into hole in mounting bracket and push in. HUTTON or ZIPPO cigarette lighter refill bottles will work in this unit. Slide holding plate behind neck of bottle to secure in place. Turn ON/OFF toggle valves to the ON position and turn the FLUSH/FLOW toggle valve to the FLUSH position. Flush the detector for approx. 1 min. Turn FLUSH/FLOW valve to FLOW.

4.3 Expose the detector to a radiation check source. The speaker should click with the audio switch to the ON position.

4.4 Move the range to the lower scales until a meter reading is indicated. The toggle switch labeled F-S should have fast response in the "F" position and slow response in the "S" position.

4.5 Depress the RES switch. The meter should zero.

4.6 Check calibration and proceed to use the instrument.

4.7 After use turn gas flow valve OFF and remove butane bottle.

CAUTION: REMOVING BUTANE BOTTLE SHOULD BE DONE OUTSIDE OR IN LARGE WELL VENTILATED ROOMS.

5. CALIBRATION

5.1 Remove the counter and connect a pulse generator. Determine the pulse rate for 3/4-scale deflection on one calibrated range. Using this as a reference, increase (or decrease) this rate by factors of 10 for calibrating each succeeding range.

5.2 GAS FLOW RATE CALIBRATION: Insert butane bottle spout into seat and push in. Secure bottle in place by sliding holding plate behind neck of bottle. Connect exhaust tube to a flowmeter and switch FLUSH/FLOW valve to FLUSH. Allow a few minutes for flow to stabilize and check for a rate of approximately 50 cc/m. To adjust rate, look thru holes in lower case on FLUSH/FLOW and locate the flush and flow adjustments. Flush adjustment is closest to side of case. Turning screw head adjusts flow rate. To adjust FLOW, ignite the end of the metal tube protruding from the lower case. Adjust flow to make flame approximately 1/4 inch high. This is a flow rate of less than 10 cc/m.

5.3 Detector Operating Point: The instrument sensitivity is set at 4 millivolt discrimination. After flushing the detector, adjust HV to 1800 volts.

5.4 Place detector on alpha check source and increase HV in steps of 50 volts until a reading of approximately 50% of alpha test source value is obtained with 2 cpm or less background counts. Record H.V.

5.5 Run background on High Voltage, starting at the voltage recorded in step 5.4. Increase voltage in 50 volt increments to excessive background counts, greater than 500 cpm. Record voltage.

5.6 Place detector on Beta calibration source. Run plateau starting at voltage recorded in step 5.4 to maximum voltage recorded in step 5.5.

5.7 EXPECTED EFFICIENCIES:

TH-230	50%
C-14	15%
Tc-99	30%
Cs-137	30%

LUDLUM MODEL 65 PORTABLE GAS PROPORTIONAL COUNTER

6. MAINTENANCE

NOTE: NEVER STORE THE INSTRUMENT OVER 30 DAYS WITHOUT REMOVING BATTERY. ALTHOUGH THIS INSTRUMENT WILL OPERATE AT VERY HIGH AMBIENT TEMPERATURES, BATTERY SEAL FAILURE CAN OCCUR AT TEMPERATURES AS LOW AS 100° FAHRENHEIT.

Instrument maintenance consists of keeping the instrument clean and periodically checking the battery and calibration.

An instrument operational check should be performed prior to each use by exposing detector to a known source and confirming proper reading on each scale.

Remove the battery when not in daily use. Test the reinstalled battery with the battery test switch.

7. OVERHAUL

To remove the counter, remove the four thumbscrews.

To remove the probe face, remove the face screws. Keep the probe clean. Replace the face.

To open the counting instrument: (1) remove it from the probe, (2) remove the four screws on the bottom of the adaptor plate, (3) lift open the counting instrument.

CAUTION: With the instrument open, the 2500-volt high voltage contact is exposed.

To access flow valves, remove the six screws holding the probe onto lower case.

LUDLUM MODEL 65 PORTABLE GAS PROPORTIONAL COUNTER

BILL OF MATERIALS

CHASSIS WIRING, DRAWING 312 X 6

SWITCHES

S1	MRB 2-5	08-6514
S2-S3	MST 105D	08-6511
S4	30-1 GRAYHILL	08-6517
S5-S6	923 SWITCH CRAFT	08-6518

METER

M1	BEEDE 2 1/2" 912847 0-50 MA	15-8014

SPEAKER

DS1	UNIMORPH	21-9251

BATTERY

BT1	9 VOLT ALKALINE	21-9282

JACK

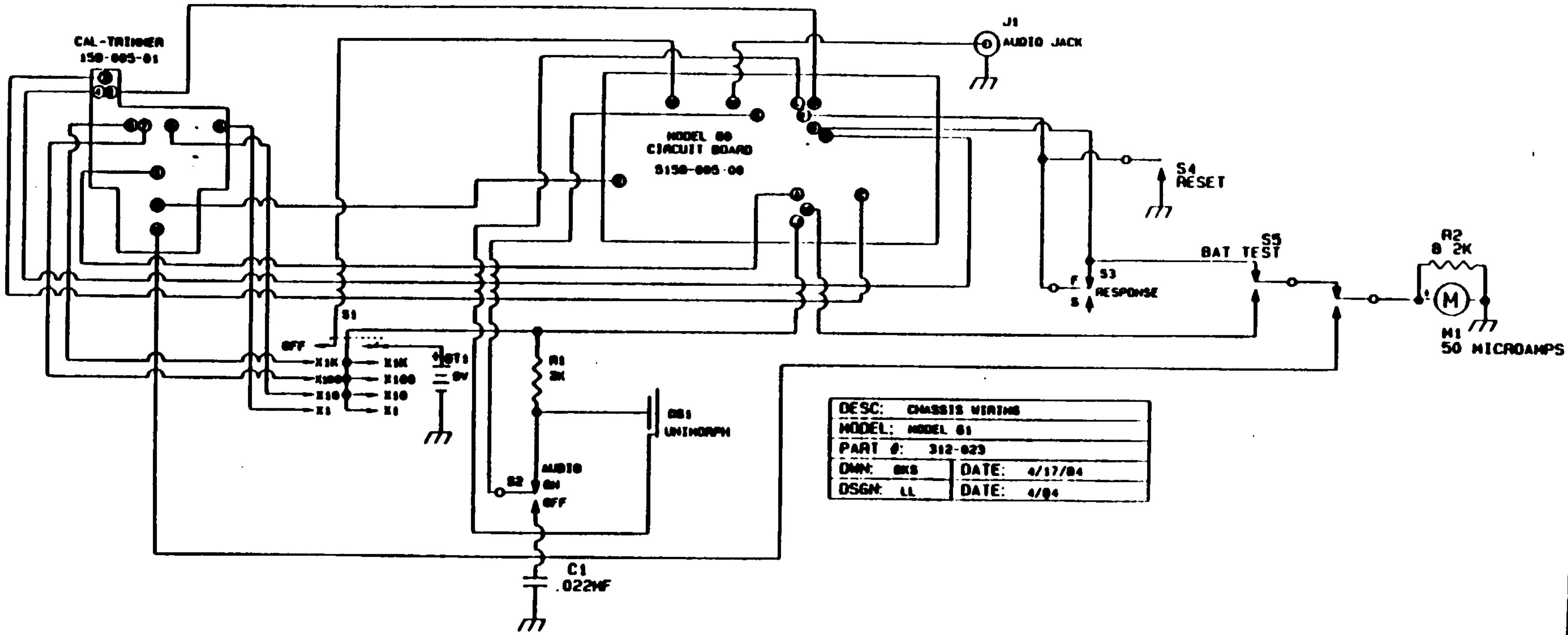
J1	TINIJAX #41	21-9287

RESISTORS

R1	2K	10-7011
R2	8.2K	10-7015

CAPACITORS

C1	.022MF, 100V, P	04-5516



DESC:	CHASSIS WIRING
MODEL:	MODEL 61
PART #:	312-023
DWN: BKS	DATE: 4/17/84
DSGN: LL	DATE: 4/84

DATE 4/17/84	SCALE: FULL	
TITLE MODEL 61 WIRING DIAGRAM		
LUDLUM MEASUREMENTS, INC	SERIES 312	SHEET 6

LUDLUM MODEL 65 PORTABLE GAS PROPORTIONAL COUNTER

BILL OF MATERIALS

CIRCUIT BOARD, DRAWING 312 X 9

CAPACITORS

C1-C2	.0015uF, 3KV, C	04-5518
C3	.0027uF, 3KV, C	04-5520
C4	.0015uF, 3KV, C	04-5518
C5-C6	100PF, 3KV, C	04-5532
C7-C9	.1uF, 35V, T	04-5574
C10	.1uF, 10V, C	04-5521
C11	100PF, 3KV, C	04-5532
C12	.01uF, 50V, C	04-5523
C13	.1uF, 10V, C	04-5521
C14	100PF, 3KV, C	04-5544
C15	.01uF, 100V, C	04-5523
C16	.001uF, 600V, C	04-5562
C17	100uF, 10V, DST	04-5576
C18	100PF, 100V, NPO	04-5527
C19	.1uF, 10V, C	04-5521
C20	.01uF, 50V, C	04-5523
C21	.001uF, 500V, C	04-5546
C22	.1uF, 10V, C	04-5521
C23	.0022uF, 100V, P	04-5580
C24-C25	100uF, 10V, DST	04-5576
C26	.0047uF, 100V, P	04-5513
C27	100uF, 10V, OST	04-5576
C28	100PF, 100V, C	04-5527

TRANSISTORS

Q1	MPS6534	05-5763
Q2	2N2714	05-5755
Q3	MPS6534	05-5763
Q4	VN2222L	05-5816
Q5	2N2714	05-5755

INTEGRATED CIRCUITS

U1	LM358	06-6024
U2	CA3096	06-6023
U3	CD4093	06-6030
U4	CA3096	06-6023

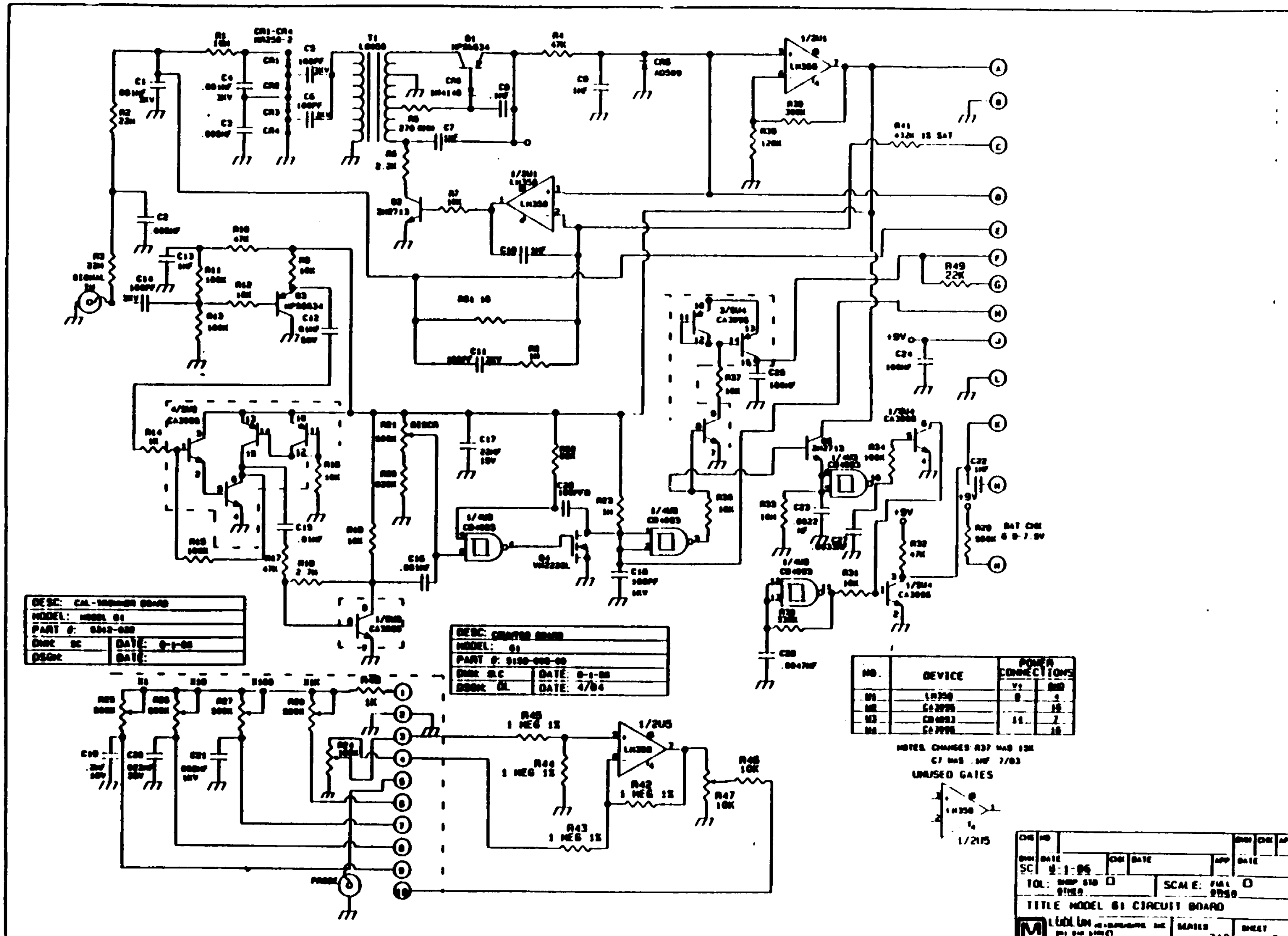
LUDLUM MODEL 65 PORTABLE GAS PROPORTIONAL COUNTER

DIODES

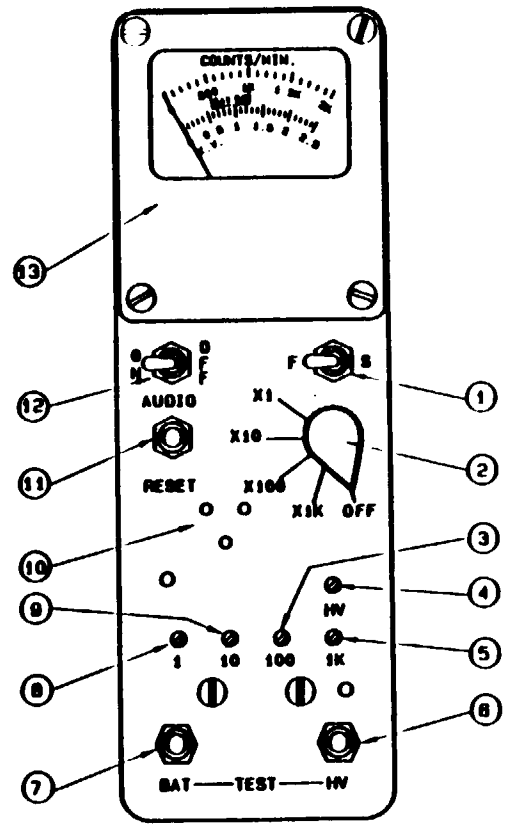
CR1-CR4	MR250-2	07-6266
CR5	AD589	07-6057
CR6	1N4148	07-6272

RESISTORS

R1	10M	10-7031
R2-R3	22M	10-7034
R4	47K	10-7020
R5	270 OHM	10-7007
R6	2.2K	10-7012
R7	10K	10-7016
R8	1M	10-7028
R9	10K	10-7016
R10	47K	10-7020
R11	100K	10-7023
R12	10K	10-7016
R13	100K	10-7023
R14	1K	10-7009
R15	100K	10-7023
R16	10K	10-7016
R17	47K	10-7020
R18	2.7M	10-7029
R19	10K	10-7016
R20	2.2M	10-7052
R21	500K TRIMMER POTENTIOMETER	09-6792
R23	10M	10-7031
R24	100K TRIMMER POTENTIOMETER	09-6789
R25-R28	500K TRIMMER POTENTIOMETER	09-6792
R29	560K	10-7027
R30	330K	10-7051
R31	10K	10-7016
R32	47K	10-7020
R33	10M	10-7031
R34	100K	10-7023
R35-R36	10K	10-7016
R37	2.7K	10-7055
R38	120K	10-7050
R39	390K	10-7069
R41	150K	10-7024
R42-R45	1 MEG	10-7028
R46	10K	10-7016
R47	10K TRIMMER POT	09-6794
R48	1K	10-7009
R49	22K	10-7070
R50	68K	10-7049
R51	1GIG	12-7686



TITLE MODEL 81 CIRCUIT BOARD
SERIES 312
SHEET 9
SCALE:
TOL:
DESC: CAL-RANGE BOARD
MODEL: MODEL 81
PART #:
DWN: BC
DATE: 8-1-86
DSGN:
DESC: COUNTER BOARD
MODEL: 81
DWN: BC
DATE: 8-1-86
DSGN: DL
DATE: 4/84
NO.
DEVICE
POWER CONNECTIONS
NOTES: CHANGES R37 WAS 13K
C7 WAS .1MF 7/83
UNUSED GATES
1/2U5
R49 22K
R45 1 MEG 1%
R44 1 MEG 1%
R42 1 MEG 1%
R43 1 MEG 1%
R46 10K
R47 10K
PROBE
SIGNAL
BAT CHK



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TITLE MODEL 61 ALPHA COUNTER		
LUDLUM	312	SHEET 11

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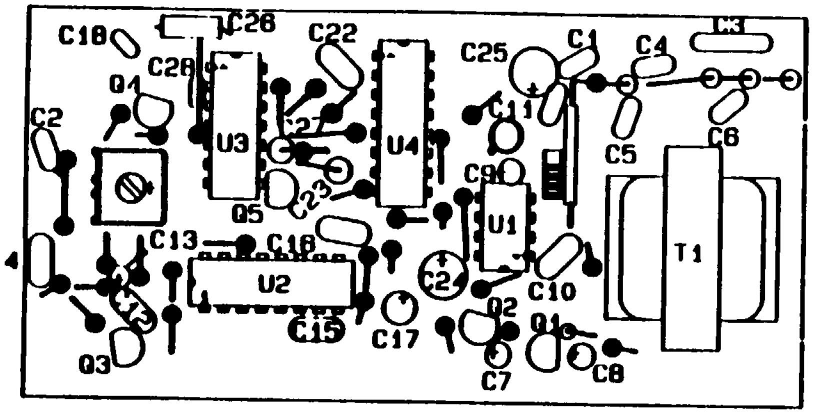
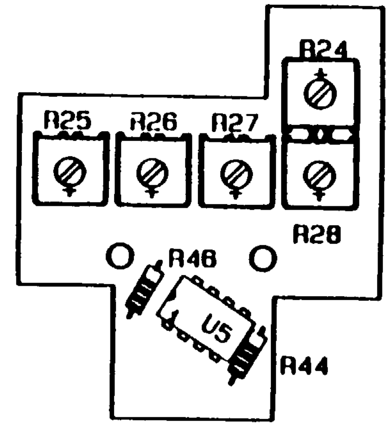
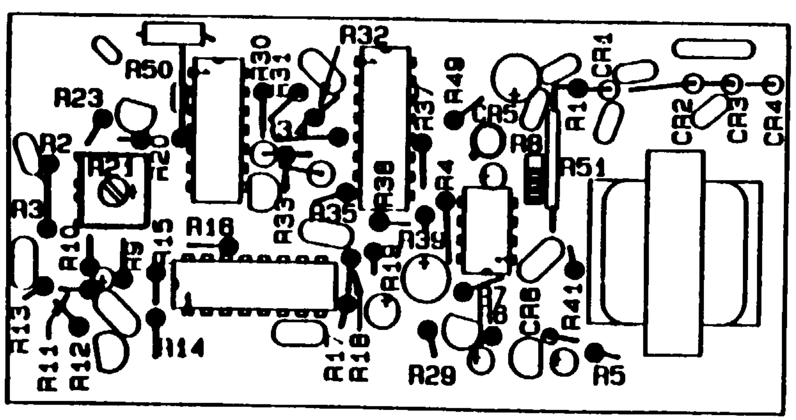
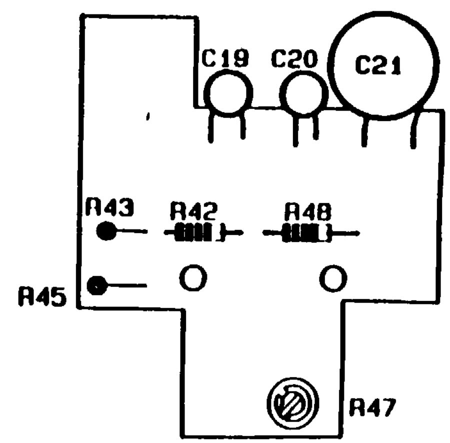
BOARD #: 6312-022	
DWN: S.L.C.	DATE: 1-5-86
DSGN:	DATE:









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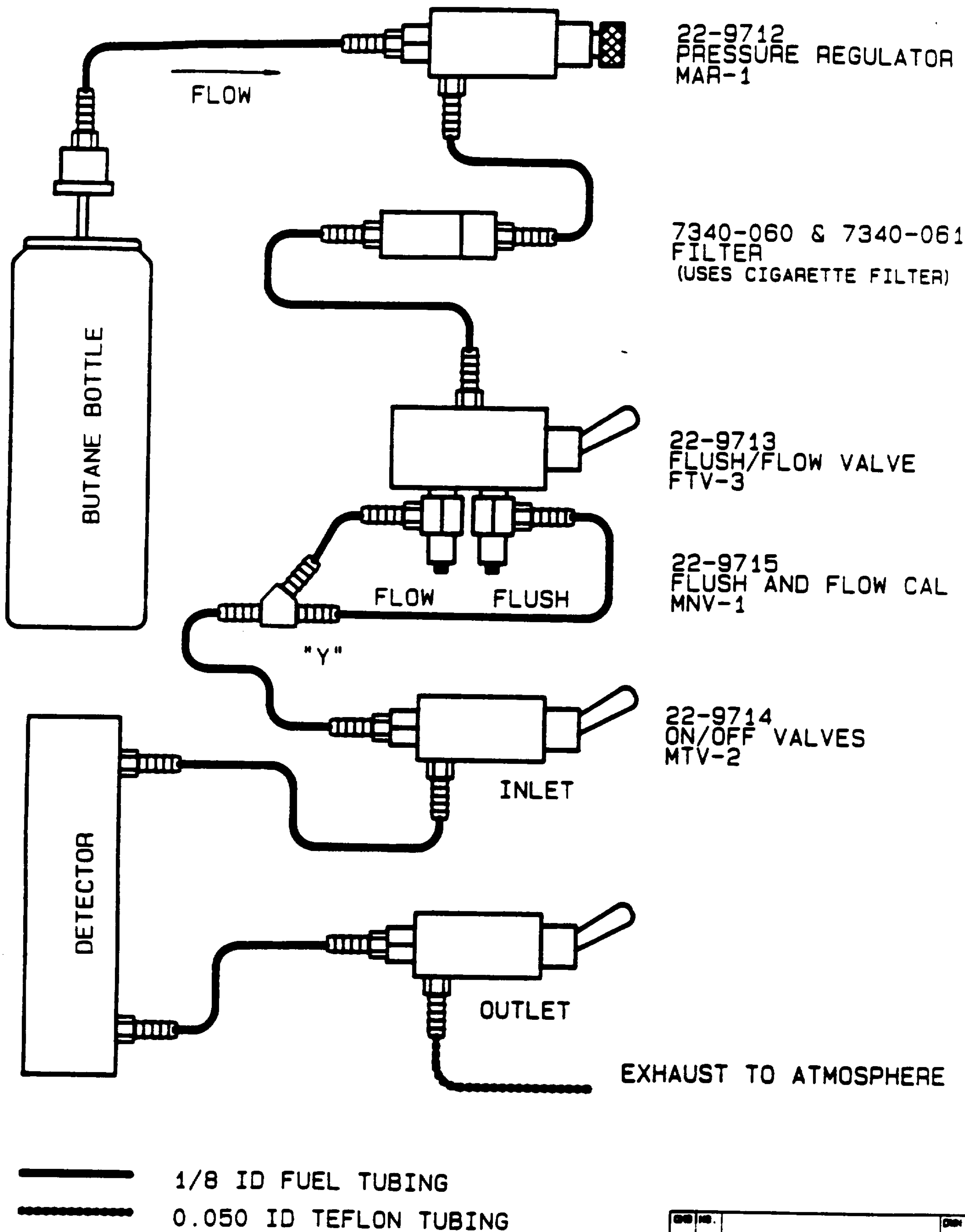
BOARD #: 5159-005	
DWN: S.L.C.	DATE: 12-31-86
DSGN:	DATE:

DATE 12-31-86	CHK DATE [illegible]	APP	DATE
TOL:		SCALE: FULL	
TITLE MODEL 60 & 61			
[illegible]		SERIES [illegible]	SHEET [illegible]



DWN JGM DATE 4/21/87	CHK (GJ) DATE 4/21/87
TOL:	SCALE:
TITLE M 85 PNEUMATIC SCHEMATIC	
LUDLUM MEASUREMENTS, INC.	

Instruction Manual

LUDLUM MODEL 19 MICRO R METER

LUDLUM MEASUREMENTS, INC.

DESIGNER AND MANUFACTURER

Scientific and Industrial

INSTRUMENTS

Instruction Manual

LUDLUM MODEL 19 MICRO R METER

LUDLUM MEASUREMENTS, INC.

[illegible] OAK | 915 · [illegible] | P. O. BOX [illegible]

SWEETWATER, TEXAS, U.S.A., [illegible]

DESIGNER AND MANUFACTURER
OF
Scientific and Industrial
INSTRUMENTS

WARRANTY CERTIFICATE

Ludlum Measurements, Inc. warrants the products covered in this Instruction Manual to be free of defects due to workmanship, materials, and design for a period of twelve months from the date of delivery, with the exception of photomultiplier tubes and geiger tubes, which are warranted defect free to 90 days.

In the event of instrument failure, notify Ludlum Measurements, Inc. for repair or replacement. Liability of this warranty is limited to the purchase price of the instrument.

RECEIVING CONDITION EXAMINATION

Be sure to verify that the shipping carton is received in perfectly good condition. For example, that no damage should be visible.

Should the instrument be received in a damaged condition, save the shipping container and the packing material and request an immediate inspection by the carrier.

Ludlum Measurements, Inc. is not responsible for the damage which occurs during shipment, but will make every effort to help obtain restitution from the carrier.

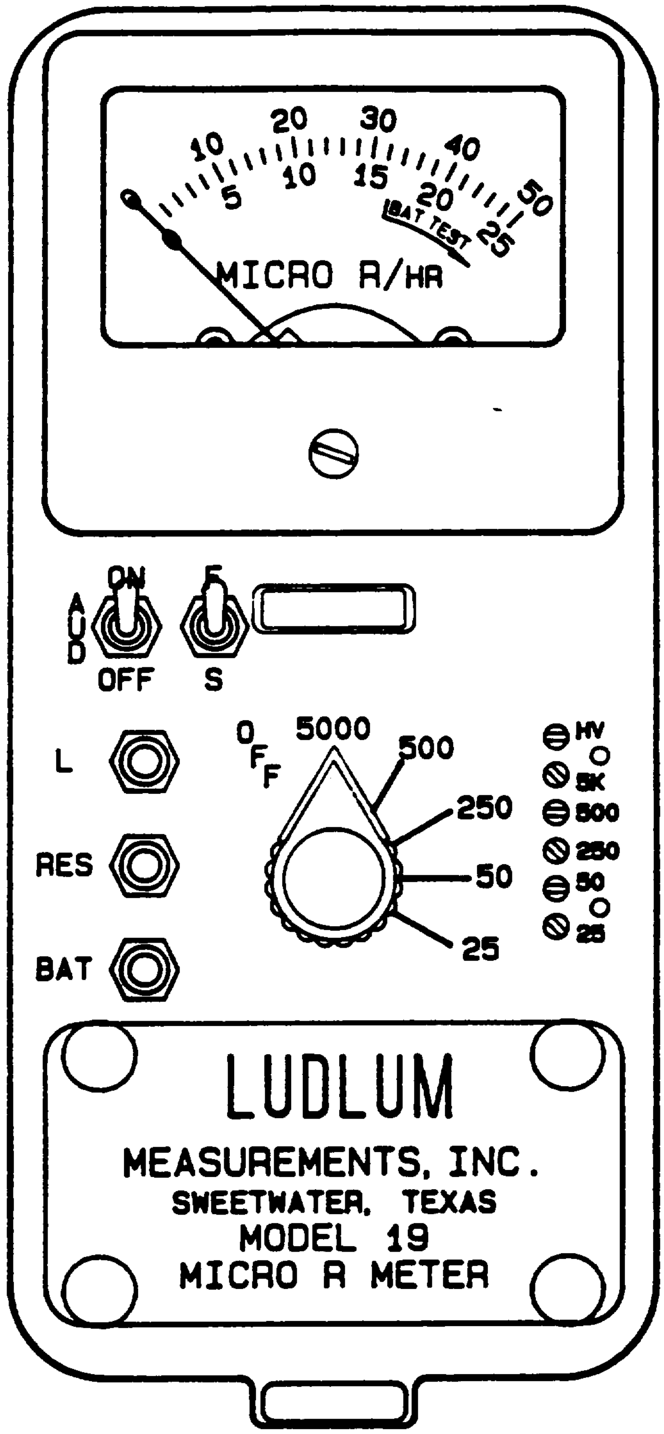
RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair, calibration, etc., please do so by the appropriate method of shipment. All shipments should include documentation containing shipping address, customer name and telephone number, and all other necessary information.

Your cooperation will expedite the return of your equipment.

MODEL 19 ADDENDUM SHEET

Q5 AND Q6 HAVE BEEN CHANGED FROM 2N3877 TO 2N3904.



DATE 8/2/87	DATE	APP	DATE
TOL:		SCALE:	
TITLE M19 MICRO R METER			
LUDLUM		387	5

LUDLUM MODEL 19 MICRO R METER

TABLE OF CONTENTS

1. GENERAL

The Ludlum Model 19 Micro R Meter utilizes an internally-mounted, 1" x 1" NaI(Tl) scintillator to offer an optimum performance in counting low-level gamma radiation. Designed to be moisture and dust resistant, conveniences are not overlooked as the unit features a pushbutton lighted meter.

Five range divisions are provided from which to select the most desirable range in the 0-5000 micro R/Hr spectrum. The meter face is made up of two scales, 0-50 and 0-25, plus battery test. The 0-50 scale corresponds to the 50, 500 and 5000 positions on the range selector switch. The 0-25 scale corresponds to the 25 and 250 positions on the range selector switch.

The instrument is capable of using either the standard flashlight battery or the nickel-cadmium, rechargeable battery. However, the Model 19 does not include circuitry for recharging the batteries.

All controls, including a calibration potentiometer for each range, are located on the front panel. Two "D" cell batteries are located in an isolated compartment and easily changed from the front panel. The meter is housed in a rugged, two-piece aluminum bezel with waterproof seals.

2. SPECIFICATIONS

LINEARITY: plus or minus 5% of full scale

INPUT IMPEDANCE: 0.1 megohm

HIGH VOLTAGE: variable from 400 to 1500 volts DC, electronically regulated to within -1%

CALIBRATION STABILITY: less than 15% variance to battery end point

BATTERY COMPLEMENT: two standard size "D" cell batteries, secured with screws and a gasket for dust and moisture proofing

AUDIO OUTPUT: built-in unimorph speaker and ON-OFF switch provided on front panel

COUNTING RANGES: 2-scale meter face presenting 0-50 Micro R/Hr with full scale range positions of X5000, X500 and X50; and 0-25 Micro R/Hr with range selections of X250 and X25

METER: 1mA, 2 1/2-inch scale

HV Adjustment provides a means to vary the high voltage from 400 to 1500 volts.

Range Calibration Adjustments are recessed potentimeters located under the calibration cover, on the right side of the front panel. These adjustment controls allow individual calibration for each range multiplier.

4. OPERATING PROCEDURES

The Model 19 is a simple instrument to operate. All controls and adjustments are located on the front panel along with the battery compartment. The 1" x 1" NaI(Tl) Scintillator is mounted internally, deleting external cords or cables.

4.1 Prior to Turn-on

a. Check the batteries -- type installed and condition.
b. Adjust the audio ON-OFF switch as desired.
c. Adjust the meter response switch as desired.

4.2 Turn-on

a. Range Selector Switch: Select the 0-5000 range.
b. BAT TEST Button: Depress. Check the BAT test on the appropriate scale. Replace the batteries if the meter pointer is below the battery CHK line.
c. Light Button: Depress. Check for light on the meter face.
d. Meter Response Switch: Check the response in the "F" and "S" positions.
e. Audio ON-OFF Switch: Check for audio indication.
f. Check the instrument for the proper scale indication with a known source. Check all the ranges for the appropriate scale indication.
g. Reset Button: Depress. Check to see that the meter pointer returns to the zero position.
h. The instrument is ready for monitoring.

5. CALIBRATION

The Model 19 radiation response is energy-sensitive. The detector plateau-characteristic must be determined for the anticipated radiation nuclide. The following is an example calibration:

5.1 Remove the instrument from its case.

DETECTOR: RCA 6199 coupled to a 1" x 1" NaI(Tl) crystal mounted inside the instrument housing

FINISH: instrument housing of drawn-and-cast aluminum fabrication with computer-beige, polyurethane enamel and silk-screened nomenclature; rubber-booted switches

SIZE: 6.4 inches x 3.4 inches x 8.0 inches (H x W x L exclusive of handle)

WEIGHT: 4.5 pounds

3. DESCRIPTION OF CONTROLS AND FUNCTIONS

Range Selector Switch is a 6-position switch marked OFF, 5000, 500, 250, 50 and 25. Moving the range selector switch to one of the range positions (5000, 500, 250, 50, 25) provides the operator with an overall range of 0-5000 Micro R/Hr. Note that the range positions 5000, 500 and 50 are screened in black and correspond to the meter scale, screened in black. The range positions 250 and 25 are screened in red and correspond to the meter scale, screened in red.

AUDIO ON-OFF Toggle Switch, in the ON position, operates the unimorph speaker, located on the left side of the instrument. The frequency of the clicks is relative to the rate of the incoming pulses. The higher the rate is, the higher the audio frequency. The audio should be turned OFF when not required to reduce battery drain.

Fast-Slow Toggle Switch provides meter response. Selecting the "F" position of the toggle switch provides 90% of full scale meter deflection in 3 seconds. In "S" position, 90% of full scale meter deflection takes 11 seconds. In "F" position, there is fast response and large meter deviation. "S" position should be used for slow response and damped, meter deviation.

BATTERY Pushbutton Switch, when depressed, indicates the battery charge status on the meter. The range selector switch must be out of the OFF position.

RES Button, when depressed, provides a rapid means to drive the meter to zero.

Light Pushbutton Switch, when depressed, lights the meter face. This switch is marked with an "L".

NOTE: NEVER STORE THE INSTRUMENT OVER 30 DAYS WITHOUT REMOVING THE BATTERIES. ALTHOUGH THIS INSTRUMENT WILL OPERATE AT VERY HIGH AMBIENT TEMPERATURES, BATTERY SEAL FAILURE CAN OCCUR AT TEMPERATURES AS LOW AS 100° FAHRENHEIT. NEGLECTED BATTERY SEAL FAILURE WILL SURELY CAUSE ONE AWFUL MESS!

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and calibration. Once initial calibration is performed, recalibration should not be required if the batteries are maintained in good condition.

An instrument operational check should be performed prior to each use by exposing the detector to a known source and confirming the proper reading on each scale.

Under certain conditions, the NRC requires instrument recalibration every three months. Check the appropriate regulations to determine the recalibration schedule.

Also at three month intervals, the batteries should be removed and the battery contacts cleaned of any corrosion. If the instrument has been exposed to a very dusty or corrosive atmosphere, more frequent battery servicing should be used.

Use a spanner wrench to unscrew the battery contact insulators, exposing the internal contacts and battery springs. Removing the handle will facilitate access to these contacts.

5.2 With the instrument off, remove the HV jumper at the C19-R5 junction.

5.3 Connect a pulser to the C1-R5 junction.

a. Set the pulse height at 80 millivolts, negative.
b. Calibrate the scales as follows:

Scale	Reading	Pulses/Minute
25	20	3,200
50	40	6,400
250	200	32,000
500	400	64,000
5,000	4,000	640,000

5.4 Connect the jumper back to the C19-R5 junction.

5.5 Replace instrument can
Note: The detector is not light-tight outside of the can.

5.6 Plateau instrument using Americium-241 using H.V. adjust potentionmeter on front panel.

5.7 Determine the plateau center voltage

a. Remove can
b. Measure H.V. at the detector plug on circuit board.

NOTE: The voltmeter must have a 1,000 megohm/volt, or greater input impedance or use a Model 500 Pulser.

5.8 Replace instrument can.

5.9 Take the Model 19 to a certified calibration range. Calibrate each scale for best fit at 1/5 and 4/5 scale. If the reading error exceeds 10% of reading, record the field versus the meter reading at 5 points on the scale. Place a copy of this meter correction on the instrument case.

5.10 If the calibration range background is too high for the Micro R scales, calibrate the 5000 scale as in Step 5.9.

a. Turn instrument off and remove instrument from can.
b. Remove H.V. Jumper
c. Turn instrument on
d. Connect pulser and determine pulse rate verses micro R/hr calibration point on 5000 scale.
e. Calibrate the lower scales with Pulser using information in step (c).
f. Turn instrument off and reconnect H.V. Jumper.
g. Replace can

5.11 Recheck all operating functions of the instrument prior to use.

6. MAINTENANCE

R5	22k	10-7070
R6	18k	10-7018
R7-R8	1 M	10-7028
R9	3.3k	10-7013
R10	560k	10-7027
R11	10k	10-7016
R13	1 M	10-7028
R14	2.7 M	10-7029
R15	82k	10-7022
R17	22k	10-7070
R18	10k	10-7016
R20	270k	10-7007
R21	8.2k	10-7015
R22	82k	10-7022
R23	100k	10-7023
R28	SAT.	
R29	330 OHM	10-7053
R31	75k	10-7074
R32	10k	10-7016
R33	4.7k	10-7014
R34	100k 1%	12-7557
R35	16.5k 1%	12-7541
R36	10k	10-7016
R37	1k	10-7009
R38	200 OHM	10-7006
R39-R40	1 M	10-7028
R41	SAT (Typical 2.2k)	10-7012
R51	75k	10-7074
R52	1G	12-7686

TRANSFORMERS

T1	L8050	40-0902
T2	LVPS	40-0944

MISCELLANEOUS

6 EACH	RECPT-CLOVERLEAF 011-6809	18-8771
2 EACH	PIN-MOLEX 16060007 (SM)	18-8792
1 EACH	PIN-MOLEX 16060004 (LG)	18-8795
1 EACH	JACK-TEST 1128-09-0319	18-8806

ASSEMBLED CIRCUIT BOARD 5120-006-00

BILL OF MATERIALS

CIRCUIT BOARD, DRAWING NO. 120 X 6

CAPACITORS

C1	100pF, 3kV, C	04-5532
C2	100kF, 100V, C	04-5527
C3	470pF, 100V, C	04-5555
C4	47pF, 100V, C	04-5533
C5	.01uF, 100V, C	04-5523
C6	22uF, 15V, DT	04-5579
C7-C8	100uF, 10V, DST	04-5576
C9	4.7uF, 10V, DT	04-5578
C10	.1uF, 100V, C	04-5521
C11	4.7uF, 10V, DT	04-5578
C12	22uF, 15V, DT	04-5579
C13	.01uF, 100V, DT	04-5523
C14-C15	100uF, 10V, DT	04-5576
C16	1uF, 35V, DT	04-5575
C17	.1uF, 100V, C	04-5521
C18	100pF, 3kV, C	04-5532
C19	.0056uF, 3kV, C	04-5522
C20-C23	.0015uF, 3kV, C	04-5518
C24	.01uF, 100V, C	04-5523

TRANSISTORS

Q4	MPS6534	05-5763
Q5-Q6	2N3904	05-5755
Q7	MPS6534	05-5763

INTEGRATED CIRCUITS

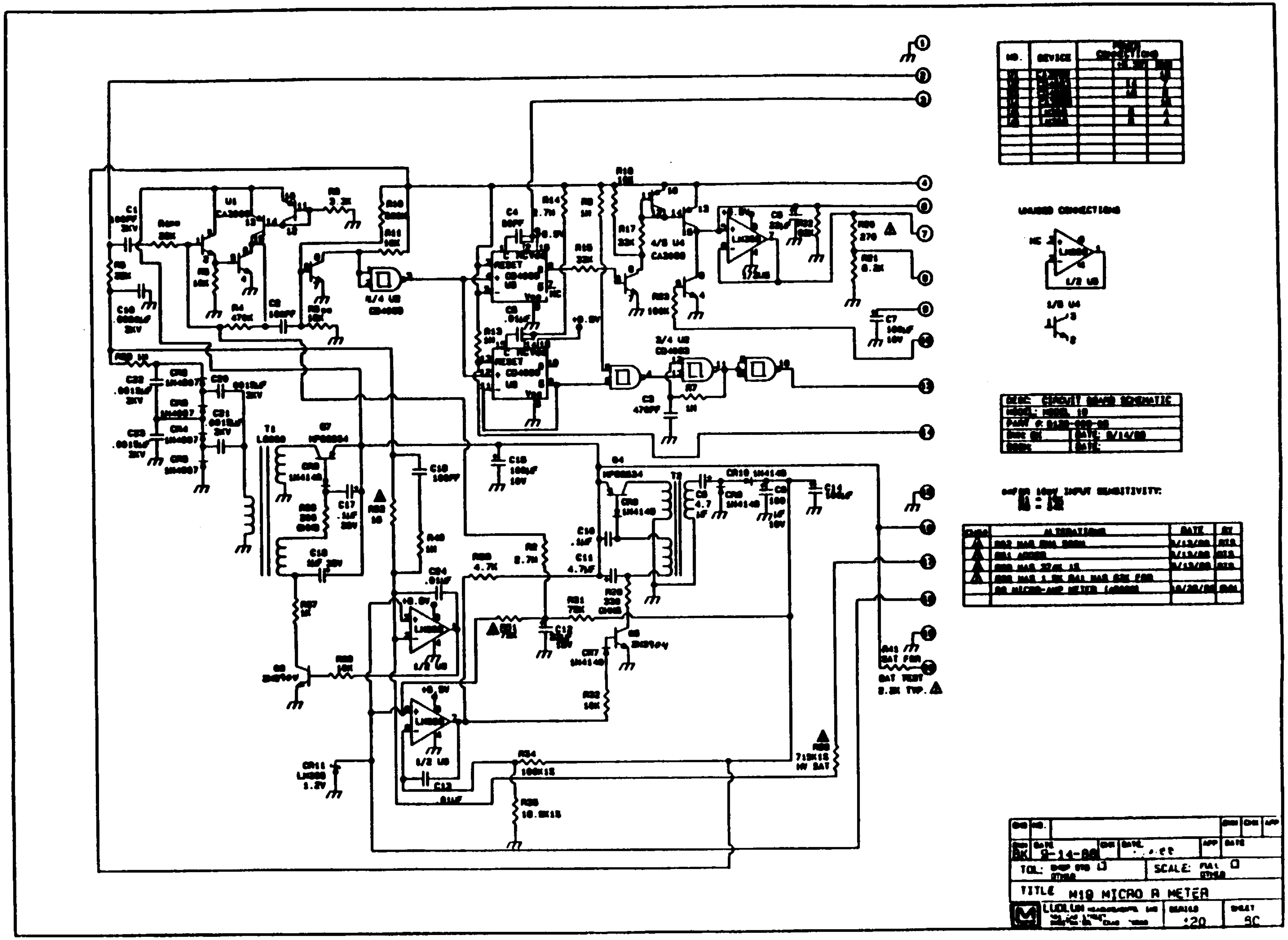
U1	CA3096	06-6023
U2	CD4093	06-6030
U3	CD4098	06-6066
U4	CA3096	06-6023
U5-U6	LM358	06-6024

DIODES

CR2-CR5	1N4007	07-6274
CR6-CR10	1N4148	07-6272
CR11	LM385Z-1.2	05-5808

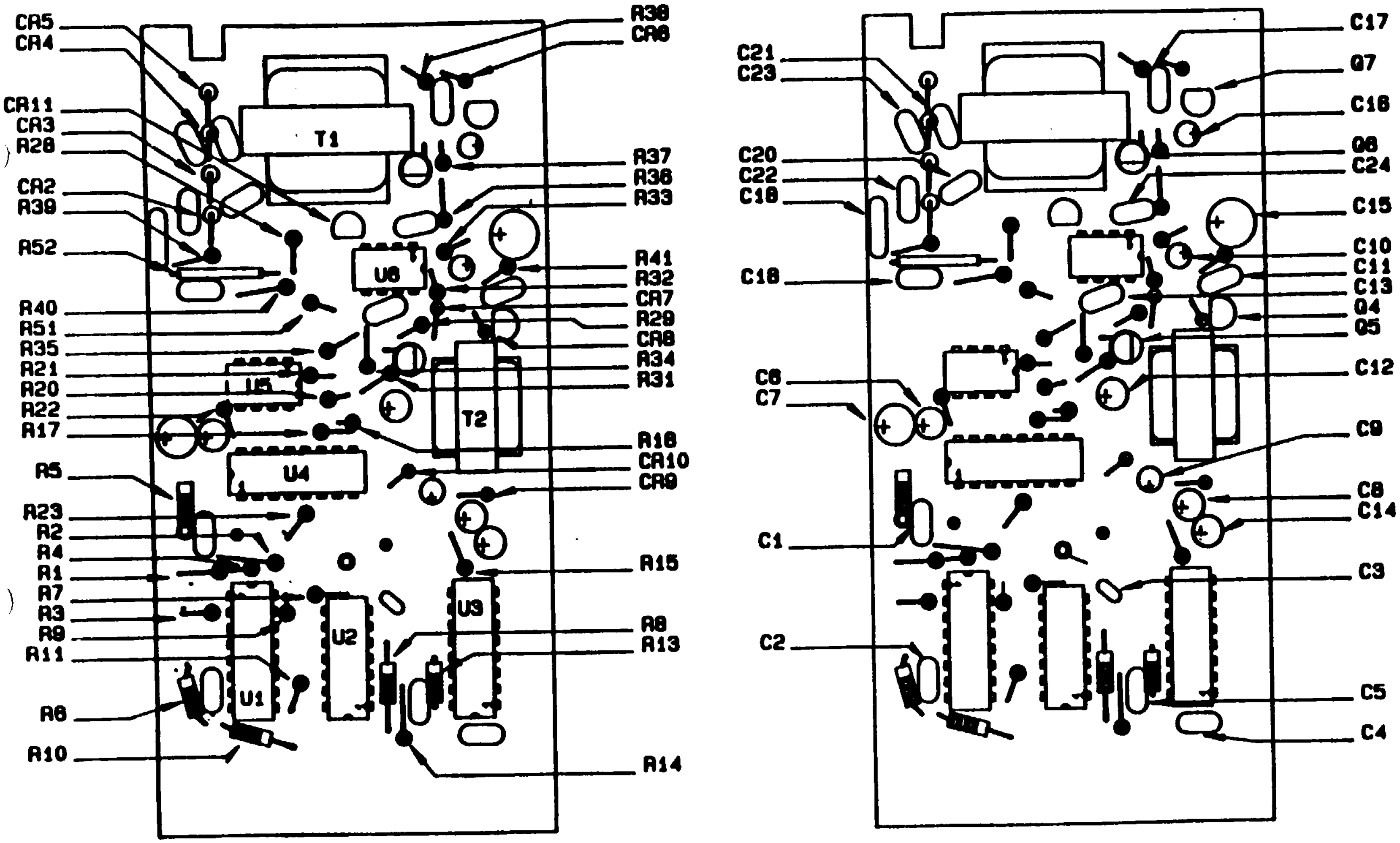
RESISTORS

R1	22k	10-7070
R2	2.7 M	10-7029
R3	10k	10-7016
R4	470k	10-7026



CIRCUIT BOARD SCHEMATIC
ALTERATIONS
DATE
UNUSED CONNECTIONS
INPUT SENSITIVITY:
U1 CA3096
4/5 U4 CA3096
CD4098
CD4093
LM358
1/2 U8
Q7 MPS6534
Q4 MPS6534
T1
T2
CR11 LM385 1.2V
BAT TEST 2.2K TYP.
TOL:
SCALE:
TITLE M19 MICRO R METER
LUDLUM
9-14-88
:20
9C

DESC: MODEL 19 CIRCUIT BOARD	
BOARD #: 5120-006-00	
DWN: BK	DATE: 9-14-88
DSGN:	DATE:



NOTE: C1 & R5 ARE ON THE BOTTOM

BK 9-14-88		
TOL:	SCALE: FULL	
TITLE M19 MICRO R METER		
LUDLUM	120	27

BILL OF MATERIALS

WIRING DIAGRAM, DRAWING NO. 120 X 5

AUDIO

DS1	UNIMORPH 60690	21-9251

CONNECTORS

P1	RIBBON-050-010-455 10PIN	13-8064

SWITCHES

S1	PA-600-210	08-6501
S2	7101-SYZ-QE TOGGLE	08-6511
S3	7101-SYZ-QE TOGGLE	08-6511
S4	30-1-PB GRAYHILL	08-6517
S5	30-1-PB GRAYHILL	08-6517
S6	923 PB SWTCHCRFT	08-6518

BATTERY

BT1	"D" DURACELL BATTERY	21-9313
BT2	"D" DURACELL BATTERY	21-9313

DETECTOR

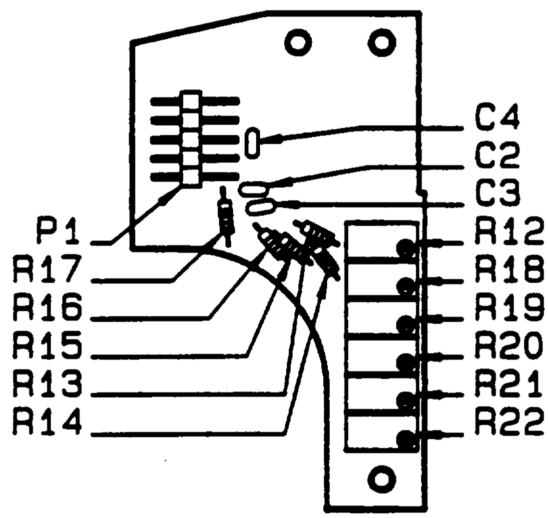
R1	1M	10-7028
R2-R10	10M	10-7031
R11	18.2M	10-7033

CAPACITORS

C1	0.01uF, 2kV	04-5525

MISCELLANEOUS

*	M19 BATTERY BOX LID	9120-023
*	BATTERY CONTACT SET	40-1707
*	DEEP CAN	40-0266
*	M19 CASTING	9367-004
*	M19 MAIN HARNESS	8120-009-00
*	M19 RIBBON HARNESS	8367-005
M1	M19 METER	40-1808
*	PORTABLE HANDLE	7001-012-01
*	PORTABLE KNOB	08-6613



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MODEL: 19	
PART #: 5367-002	
DWN: BK	DATE: 9-13-88
DSGN:	DATE:

BK 9-13-88

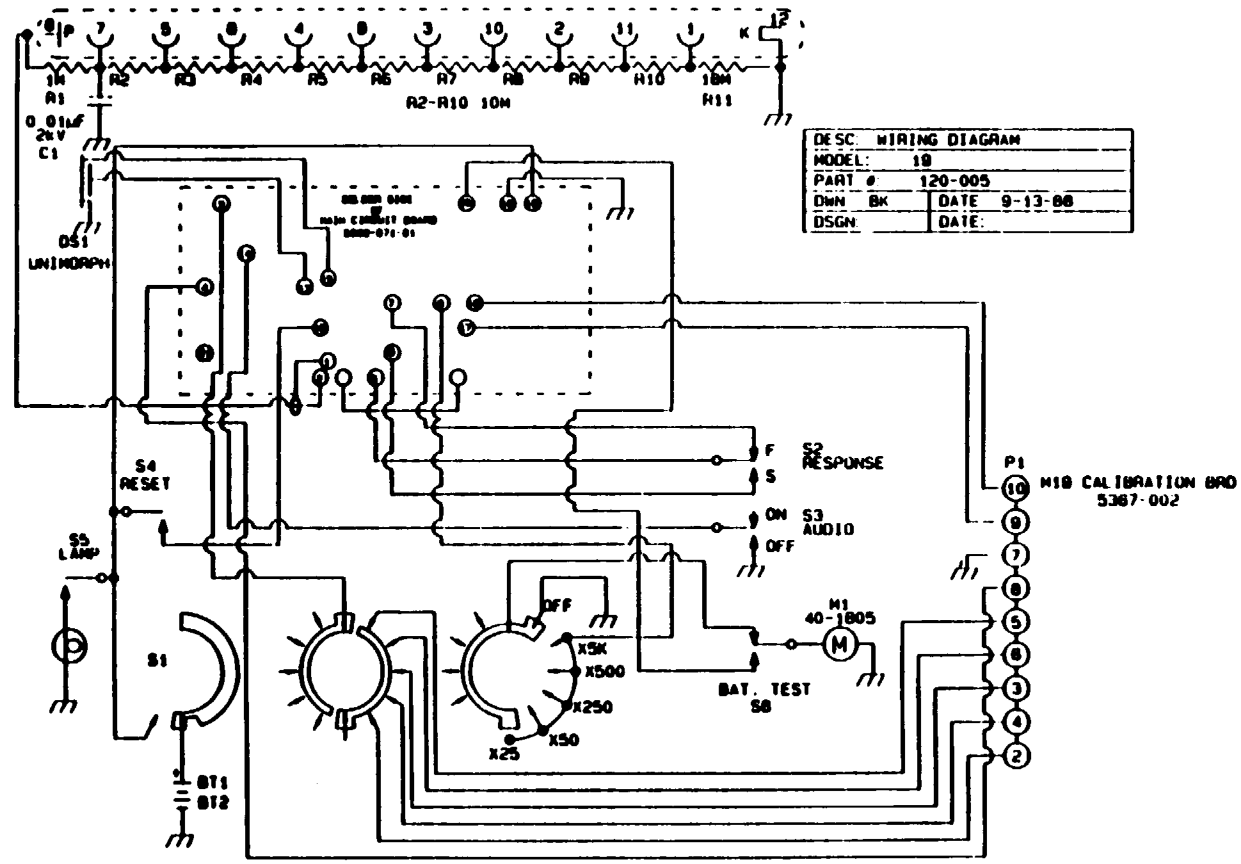
TOL:

SCALE:

TITLE M19 MICRO R METER

LUDLUM

387



DESC: WIRING DIAGRAM	
MODEL: 19	
PART #: 120-005	
DWN: BK	DATE: 9-13-88
DSGN:	DATE:

TITLE MODEL 19 MICRO R METER

DWN BK DATE 9-13-88

SCALE

LUDLUM MEASUREMENTS INC

BILL OF MATERIALS

CALIBRATION BOARD, DRAWING NO. 367 X 6

CAPACITORS

C2	0.0022uF, 100V, C	04-5564
C3	0.001uF, 100V, C	04-5519
C4	220pF, 100V, C	04-5530

RESISTORS

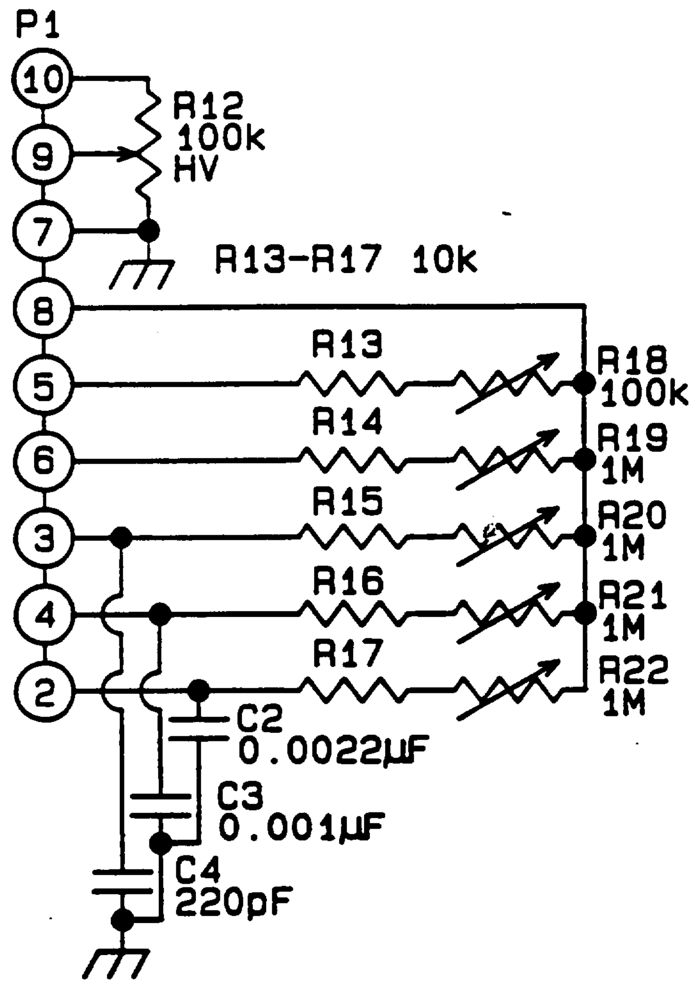
R12	100k TRIMMER	09-6813
R13	10k TRIMMER	12-7719
R14	10k TRIMMER	12-7719
R15	10k TRIMMER	12-7719
R16	10k TRIMMER	12-7719
R17	10k TRIMMER	12-7719
R18	100k TRIMMER	09-6813
R19	1M TRIMMER	09-6814
R20	1M TRIMMER	09-6814
R21	1M TRIMMER	09-6814
R22	1M TRIMMER	09-6814

MISCELLANEOUS

P1	STRIP-102888-5 10PIN	13-8110

ASSEMBLED CALIBRATION BOARD 5367-002

DESC: HV CAL BOARD	
BOARD #: 5367-002	
DWN: BK	DATE: 9-13-88
DSGN:	DATE:



BK 9-13-88

TOL:

SCALE: FULL

TITLE M19 MICRO R METER

387

8

Instruction Manual

MODEL 12 COUNT RATEMETER

Instruction Manual

MODEL 12 COUNT RATEMETER

LUDLUM MEASUREMENTS, INC.

[illegible] OAK [illegible] P. O. BOX [illegible]

SWEETWATER, TEXAS, U.S.A., [illegible]

DESIGNER AND MANUFACTURER

OF

Scientific and Industrial

INSTRUMENTS

WARRANTY CERTIFICATE

Ludlum Measurements, Inc. warrants the products covered in this Instruction Manual to be free of defects due to workmanship, materials, and design for a period of twelve months from the date of delivery, with the exception of photomultiplier tubes and geiger tubes, which are warranted defect free to 90 days.

In the event of instrument failure, notify Ludlum Measurements, Inc. for repair or replacement. Liability of this warranty is limited to the purchase price of the instrument.

RECEIVING CONDITION EXAMINATION

Be sure to verify that the shipping carton is received in perfectly good condition. For example, that no damage should be visible.

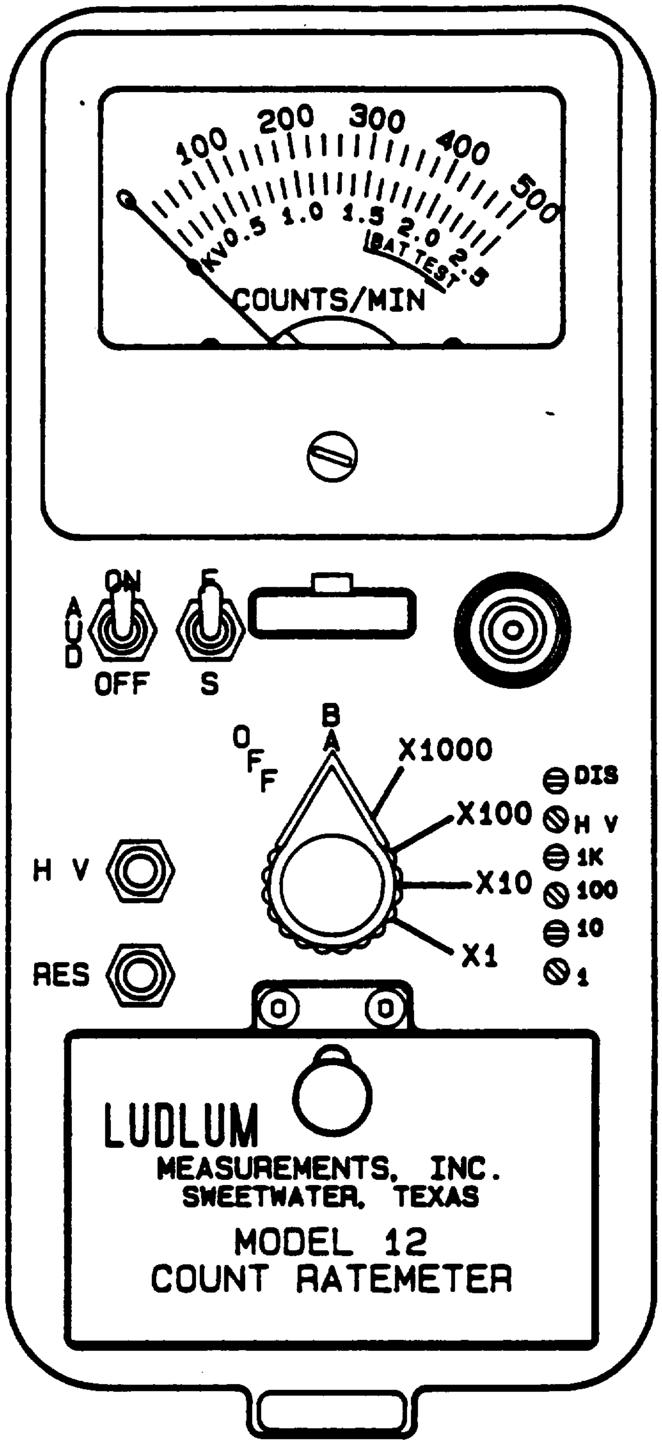
Should the instrument be received in a damaged condition, save the shipping container and the packing material and request an immediate inspection by the carrier.

Ludlum Measurements, Inc. is not responsible for the damage which occurs during shipment, but will make every effort to help obtain restitution from the carrier.

RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair, calibration, etc., please do so by the appropriate method of shipment. All shipments should include documentation containing shipping address, customer name and telephone number, and all other necessary information.

Your cooperation will expedite the return of your equipment.



DRN MH	DATE 8/11/87	CHK	DATE
TOL: SHOP STD ☐ OTHER		SCALE: FULL ☐ OTHER	
TITLE M12 CASTING ASSY.			
LUDLUM		SERIES 383	SHEET 27

LUDLUM MODEL 12 COUNT RATEMETER

TABLE OF CONTENTS

1. GENERAL

The Model 12 Count Ratemeter provides the required electronic circuitry for radiation monitoring with proportional, scintillation and G-M detectors.

This manual includes general description, control functions, operation, calibration and maintenance instructions. In the event that further information is desired, please contact the factory or our field representatives.

2. SPECIFICATIONS

POWER: two flashlight batteries, standard "D" cells; Mercury or rechargeable cells directly interchangeable

HIGH VOLTAGE: adjustable from 200 to 2,400 volts; electronically regulated to 1%; HV support of scintillation loads to 1,500 volts, proportional to 2,400 volts.

SENSITIVITY: adjustable from 2 to 60 millivolts.

INPUT IMPEDANCE: 0.1 Megohm

METER: 1mA, 2 1/2-inch scale, pivot-and-jewel movement

RANGE: 0 to 500,000 Counts/Minute (CPM)

LINEARITY: ±5% full scale

CALIBRATION STABILITY: less than 5% variance to battery endpoint

CALIBRATION CONTROLS: individual, locking potentiometers for each range; accessible from the front cover while in operational status

AUDIO: built-in unimorph speaker with On-Off switch

RESPONSE: 4 or 22 seconds for 90% of final meter reading

CONNECTOR: Series "C"

SIZE: 4.2 inches by 3.4 inches by 8.0 inches (H x W x L, exclusive of handle)

WEIGHT: 3.5 pounds

FINISH: drawn-and-cast aluminum fabrication, with computer-beige pclyurethane enamel and silk-screened nomenclature

3. DESCRIPTION OF CONTROLS AND FUNCTIONS

Range Multiplier Selector Switch is a 6-position switch marked OFF, BAT, X1000, X100, X10, X1. Turning the range selector switch from OFF to BAT position provides the operator with a battery check of the instrument. A BAT check scale on the meter provides a visual means of checking the battery-charge status. Moving the range selector switch to one of the range multiplier positions (X1000, X100, X10, X1) provides the operator with an overall range of 0 to 500,000 CPM. Multiply the scale reading by the multiplier for determining the actual scale reading.

AUDIO ON-OFF Toggle Switch in the ON position operates the unimorph speaker, located on the left side of the instrument. The frequency of the clicks is relative to the rate of the incoming pulses. The higher the rate is, the higher the audio frequency. The audio should be turned OFF when not required to reduce battery drain.

Fast-Slow Toggle Switch provides meter response selection. Selecting the "F" position of the toggle switch provides 90% of the final meter reading in 4 seconds. In "S" position, 90% of the final meter reading takes 22 seconds. Set on "F" for fast response and large meter deviation. "S" position should be used for slow response and damped meter deviation.

RES Button, when depressed, provides a rapid means to drive the meter to zero.

HV Test Button, when depressed, displays the detector high voltage on the meter.

Range Calibration Adjustments are recessed potentiometers located on line with each multiplier position. These adjustment controls allow individual calibration for each range multiplier.

HV is a screwdriver adjustment that provides a means to vary the high voltage from 200 to 2,400 volts. The high voltage setting may be checked at the connector with an appropriate voltmeter.

GAIN Adjustment allows the input sensitivity to be adjusted from 2 to 60 millivolts. The GAIN is normally set for 10 millivolts at the factory.

4. OPERATING PROCEDURES

4.1 Slide the battery box button down. Open the lid and install two "D" size batteries. Note (+) (-) marks on the inside of the lid. Match the battery polarity to these marks.

NOTE: Center post of flashlight battery is positive.

DO NOT TWIST LID BUTTON - It slides to the rear.

Close the battery box lid.

4.2 Switch the range switch to BAT. The meter should deflect to the battery check portion of the meter scale. If the meter does not respond, recheck that the batteries have proper polarity.

4.3 Turn the instrument range multiplier switch to X1000. Expose the detector to a radiation check source. The speaker should click with the audio switch turned to the ON position.

4.4 Move the range switch to the lower scales until a meter reading is indicated. The toggle switch labeled F-S should have fast response in "F" position and slow response in "S" position.

4.5 Depress the RES switch. The meter should zero.

4.6 The operating point for the instrument and probes is established by setting the probe voltage and instrument sensitivity (HV and GAIN). The proper selection of this point is the key to instrument performance. Efficiency, background sensitivity, and noise are fixed by the physical makeup of the given detector and rarely varies from unit to unit. However, the selection of the operating point makes a marked difference in the apparent contribution of these three sources of count.

In setting the operating point, the final result of the adjustment is to establish the system GAIN so that the desirable signal pulses are above the discrimination level and the unwanted pulses from background radiation and noise are below the discrimination level and are not counted.

The total system gain can be controlled by adjusting either the instrument GAIN or the high voltage. Voltage affects control in the probe; GAIN controls the amplifier gain.

In the special case of G-M detectors, a minimum voltage must be applied to establish the Geiger-Mueller characteristic. Further changes in gain will not affect this type probe.

The operating point for each detector is set at a compromise point of sensitivity, stability and background contribution. These operating points are best for general monitoring. In application, these arbitrarily selected points may not be the best. In order to select a better operating point, the following guides are presented:

a. G-M detectors are not capable of amplitude discrimination; so, the discriminator control has no function. The ratemeter will operate at any setting of the GAIN control with a G-M detector. Set the GAIN control at 50% clockwise and adjust the HV control for 900 volts. If a voltmeter is not available, increase the output voltage until a sharp increase in count rate is observed without a source. Then back off slightly and check the probe with a source. AFTER SETTING THE VOLTAGE, RECHECK THE GAIN SETTING TO INSURE THAT THE INSTRUMENT DOES NOT DOUBLE PULSE.

b. For proportional detectors, set the GAIN control for 2-millivolt discrimination (near maximum clockwise). Expose the detector to a check source. Adjust the HV until the low energy source is detected. Refine the HV adjustment for an optimum source count with a minimum acceptable background count.

c. For air proportional alpha detectors, set the GAIN for 2-millivolt discrimination. Adjust the HV until the detector just breaks down (shown by a very rapid increase of count rate without a source present). Measure the HV output; then decrease the HV setting to operate 100 volts below breakdown.

d. For scintillators, set the GAIN for 10 millivolts. Carefully increase the HV until the instrument plateau's on the background count. This provides the most stable operating point for the detector.

4.7 Check the calibration and proceed to use the instrument.

5. CALIBRATION

Calibration controls are located on the instrument cover in line with the multiplier index of each scale. The controls may be adjusted with an 1/8-inch blade screwdriver.

The instrument may be calibrated to true reading; or, when used with a single source, geometry calibration may be used. Both methods are described below. Unless otherwise specified, the instrument is calibrated to true reading at the factory.

5.1 True Reading Calibration requires the following steps:

a. Connect the input of the instrument to a negative pulse generator.
CAUTION: The instrument input operates at a high potential. Connect the pulse generator through a 0.01 MFD, 2,000-volt capacitor unless the pulse generator is already protected.

b. Adjust the pulser frequency to correspond to the 3/4-scale value of the instrument. Increase the pulser output voltage until a stable meter reading is obtained. Adjust the calibration potentiometer for a 3/4-scale reading. Repeat for each range.

c. To correlate this calibration to detected radiation value, probe efficiency must be determined. Select the operating point for the probe used as outlined in the previous section. Then determine the count-rate with the probe exposed to a calibrated source. The ratio of the instrument count-rate versus the known source value is the probe efficiency. This degree will be different for various types of probes and sources. By using probe efficiency, one determines the actual emission rate of an unknown source.

NOTE: For proportional and scintillation detectors, changes in the HV and GAIN controls will change the apparent detector efficiency for many sources.

5.2 Geometry calibration is often used when the instrument is utilized to measure radiation with a limited spectrum, for example, a single isotope contamination. To calibrate the instrument using this technique, obtain calibration sources with a spectrum similar to the unknown radiation. Expose the probe to the source and adjust the calibration control until the meter reading corresponds to the source value. Repeat this procedure with scaled sources for each instrument range.

NOTE: In the event that only one source is available, calibrate the corresponding range to that source. Disconnect the probe and connect a pulse generator to the instrument. Determine the pulse rate for 3/4-scale deflection on the calibrated range. Using this reading as a reference, increase (or decrease) this rate by factors of ten for calibrating each succeeding range.

6. MAINTENANCE

NOTE: NEVER STORE THE INSTRUMENT OVER 30 DAYS WITHOUT REMOVING THE BATTERIES. ALTHOUGH THIS INSTRUMENT WILL OPERATE AT VERY HIGH AMBIENT TEMPERATURES, BATTERY SEAL FAILURE CAN OCCUR AT TEMPERATURES AS LOW AS 100°F. NEGLECTED BATTERY SEAL FAILURE WILL SURELY CAUSE ONE AWFUL MESS.

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and calibration. It is recommended that automatic recalibration not be used with this instrument. The instrument design is quite redundant and once initial calibration is performed, recalibration should not be required if the batteries are maintained in good condition.

An instrument operational check should be performed prior to each use by exposing the detector to a known source and confirming the proper reading on each scale.

Under certain conditions, the NRC requires instrument recalibration every three months. Check the appropriate regulations to determine the recalibration schedule.

Also at three month intervals, the batteries should be removed and the battery contacts cleaned of any corrosion. If the instrument has been exposed to a very dusty or corrosive atmosphere, more frequent battery servicing should be used.

Use a spanner wrench to unscrew the battery contact insulators, exposing the internal contacts and the battery springs. Removing the handle will facilitate access to these contacts.

BILL OF MATERIALS

CIRCUIT BOARD, DWG. NO. 363 X 127

CAPACITORS

		PART NO.
C1	100pF, 3kV, C	04-5532
C2-C3	470pF, 100V, C	04-5555
C4	100pF, 100V, C	04-5527
C5	.01uF, 100V, P	04-5512
C6	22uF, 15V, DT	04-5579
C7-C8	100uF, 10V, DT	04-5576
C9	4.7uF, 10V, DT	04-5578
C10	.1uF, 100V, C	04-5521
C11	4.7uF, 10V, DT	04-5578
C12	22uF, 15V, DT	04-5579
C13	.01uF, 100V, C	04-5620
C15	100uF, 10V, DT	04-5576
C16	1uF, 35V, DT	04-5575
C17	.1uF, 100V, C	04-5521
C18	100pF, 3kV, C	04-5532
C19	.0056uF, 3kV,C	04-5522
C20-C21	.0015uF, 3kV, C	04-5518
C22-C23	.0056uF, 3kV, C	04-5522
C24	.01uF, 100V, C	04-5620
C26	.1uF, 100V, C	04-5521
C27	.01uF, 100V, C	04-5620
C28	100uF, 10V, DT	04-5576
C29	.0056uF, 3kV, C	04-5522
C30	100uF, 10V, DT	04-5576
C32	100uF, 10V, DT	04-5576

TRANSISTORS

Q1	MPS6534	05-5763
Q2	2N3904	05-5755
Q3-Q4	MPS6534	05-5763
Q6	2N3904	05-5755
Q7	MPSU51	05-5765

INTEGRATED CIRCUITS

U1	CA3096	06-6023
U2	CD4093	06-6030
U3	CD4098	06-6066
U4	CA3096	06-6023
U5-U6	LM358	06-6024
U7	CA3096	06-6023

DIODES

CR1	1N34A	07-6253
CR2-CR5	MR250-2	07-6266
CR6-CR10	1N4148	07-6272
CR11	LM385 Z 1.2V	05-5808

RESISTORS

R1	1M	10-7028
R2	100k	10-7023
R3	10k	10-7016
R4	100k	10-7023
R5	10M	10-7031
R6	10k	10-7016
R7	1M	10-7028
R8	6.8k	10-7047
R9	1k	10-7009
R10	10k	10-7016
R11	100k	10-7023
R12	75k	10-7074
R13	1M	10-7028
R14	2.7M	10-7029
R15	82k	10-7022
R16	330k	10-7051
R17	15k	10-7017
R18	100k	10-7023
R19	10k	10-7016
R20	270 OHM	10-7007
R21	8.2k	10-7015
R22	82k	10-7022
R23	100k	10-7023
R24	10k	10-7016
R25	47k	10-7020
R26	560k	10-7027
R27	1k	10-7009
R28	2.2k	10-7012
R29	330 OHM	10-7053
R31	75k	10-7074
R32	10k	10-7016
R33	4.7k	10-7014
R34	100k 1%	12-7557
R35	16.5k 1%	12-7541
R36	10k	10-7016
R37	1k	10-7009

R38	200 OHM	10-7006
R39-R40	1M	10-7028
R41	SAT (TYPICAL 432k 1%)	
R42	33k	10-7019
R43	100k	10-7023
R46	10k	10-7016
R49	1G	12-7686
R50	1k	10-7009

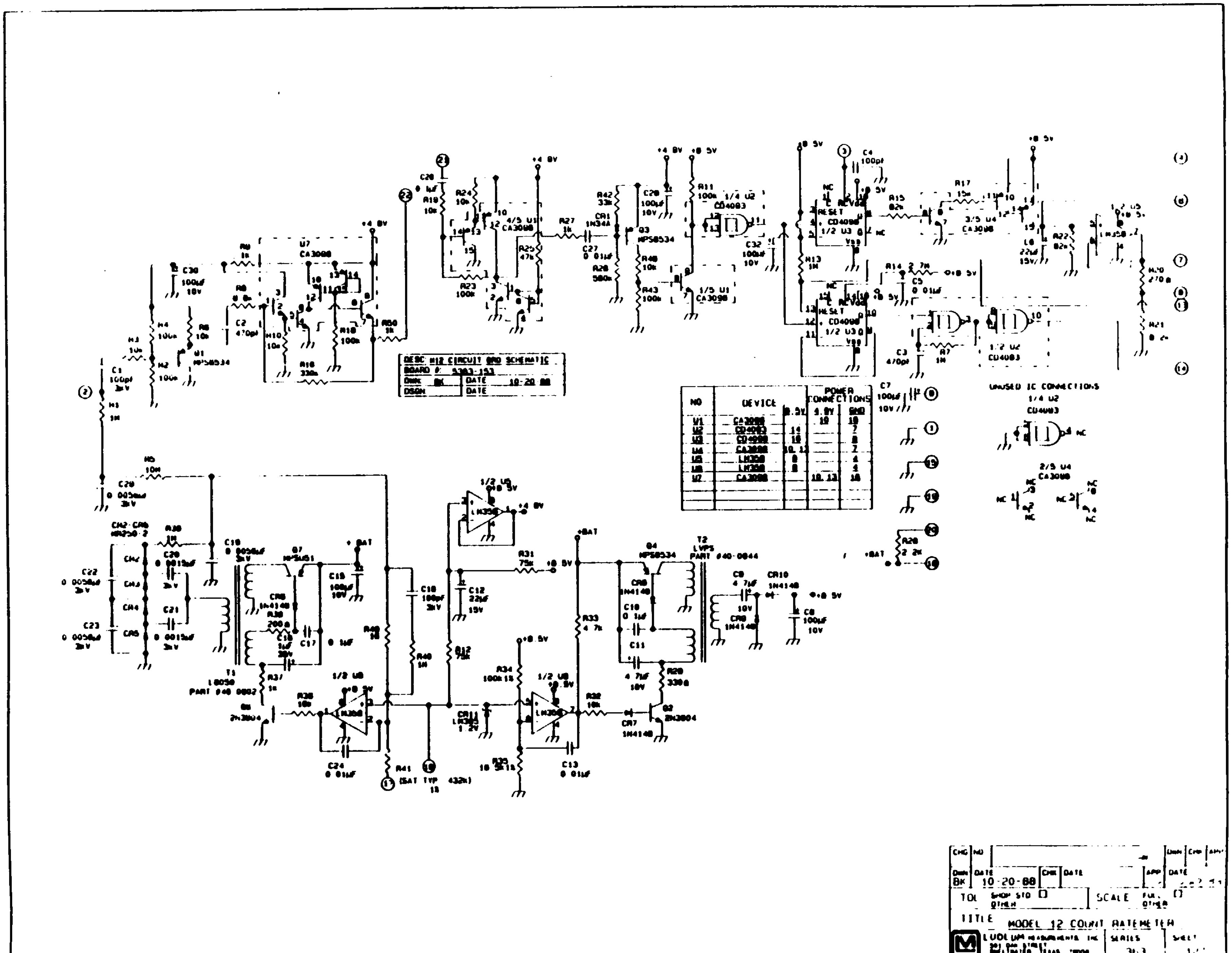
TRANSFORMERS

T1	L8050	40-0902
T2	LVPS	40-0944

MISCELLANEOUS

8 EACH	RECPT-CLOVERLEAF 011-6809	18-8771
1 EACH	WALDON 16-06-0007 SM. RECEPTACLE	18-8792
1 EACH	WALDON 16-06-0004 LRGE. PIN	18-8795

ASSEMBLED CIRCUIT BOARD 5363-153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BOARD # 5363-153
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DSGN DATE
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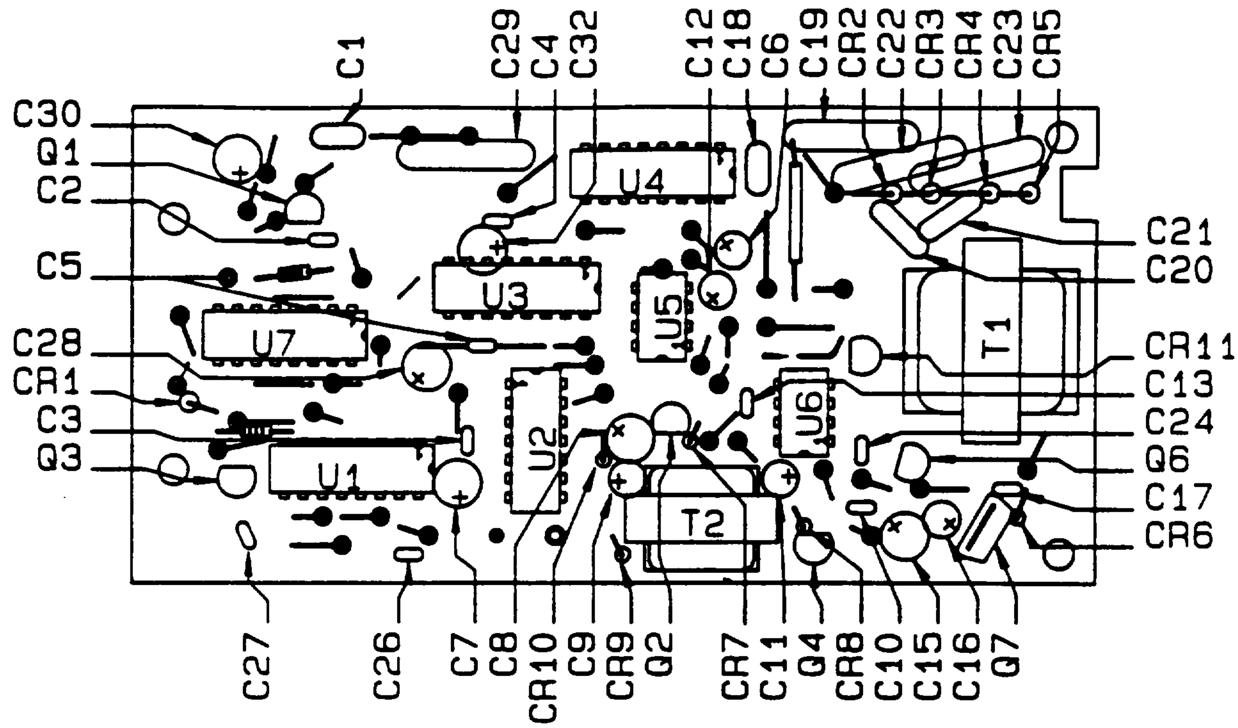
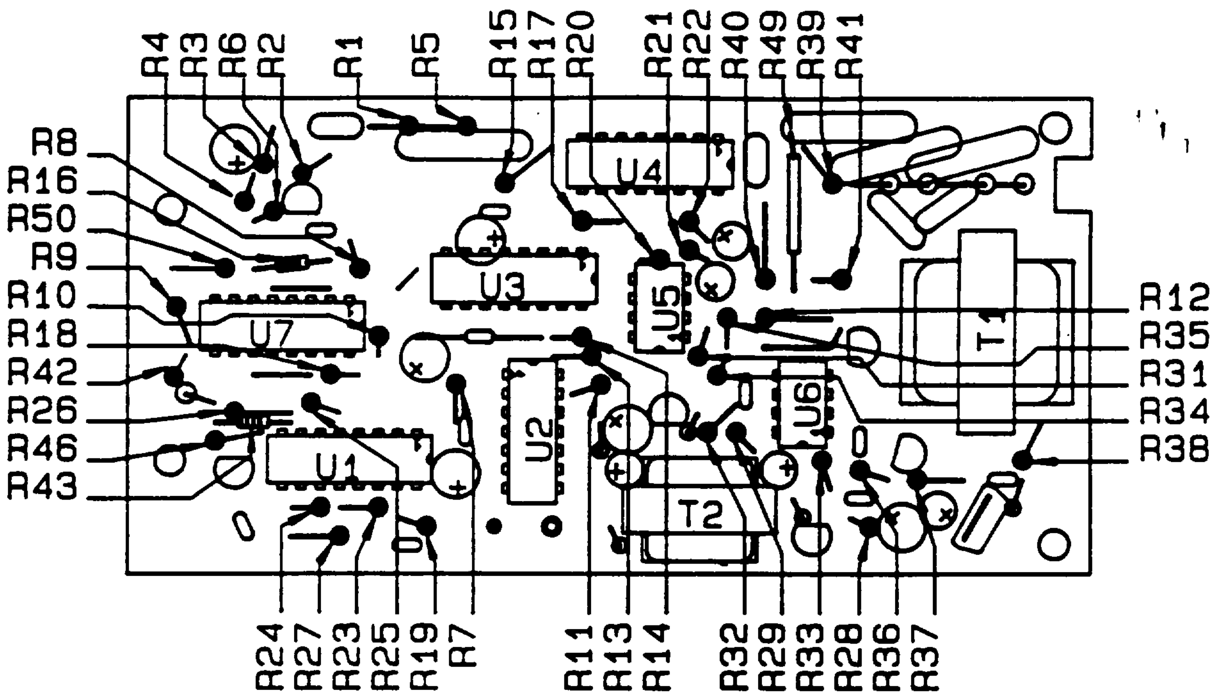
U1 CA3096 10 16
U2 CD4093 14 7
U3 CD4098 16 8
U4 CA3096 10,12 7
U5 LM358 8 4
U6 LM358 8 4
U7 CA3096 10,12 16
UNUSED IC CONNECTIONS
1/4 U2 CD4093
2/5 U4 CA3096
DWN BK DATE 10-20-88
TOL SHOP STD OTHER
SCALE FULL OTHER
TITLE MODEL 12 COUNT RATEMETER
LUDLUM MEASUREMENTS INC
SERIES 363
SHEET



DESC: BOARD LAYOUT	
MODEL: 12	
PART #: 5363-153	
DWN: BK	DATE: 8/8/88
DSGN:	DATE:

DWN BK	DATE 8-8-88	CHK DATE	APP DATE
TOL:		SCALE: FULL	
TITLE MODEL 12 COUNT RATEMETER			
LUDLUM		383	132



DESC: BOARD LAYOUT	
MODEL: 12	
PART #: 5363-153	
DWN: BK	DATE: 10-13-88
DSGN:	DATE:

BK 10-13-88

TOL:

SCALE: FULL

TITLE MODEL 12 COUNT RATEMETER

LUDLUM

383

132A

LUDLUM MODEL 12 C[illegible]T RATEMETER

BILL OF MATERIALS

WIRING DIAGRAM, DWG. NO. 363 X 59

AUDIO

DS1	UNIMORPH 60690	21-9251

CONNECTORS

J1	UG706/U SERIES C CONNECTOR	13-7751
P1	RIBBON-499568-2 14PIN	13-7971

SWITCHES

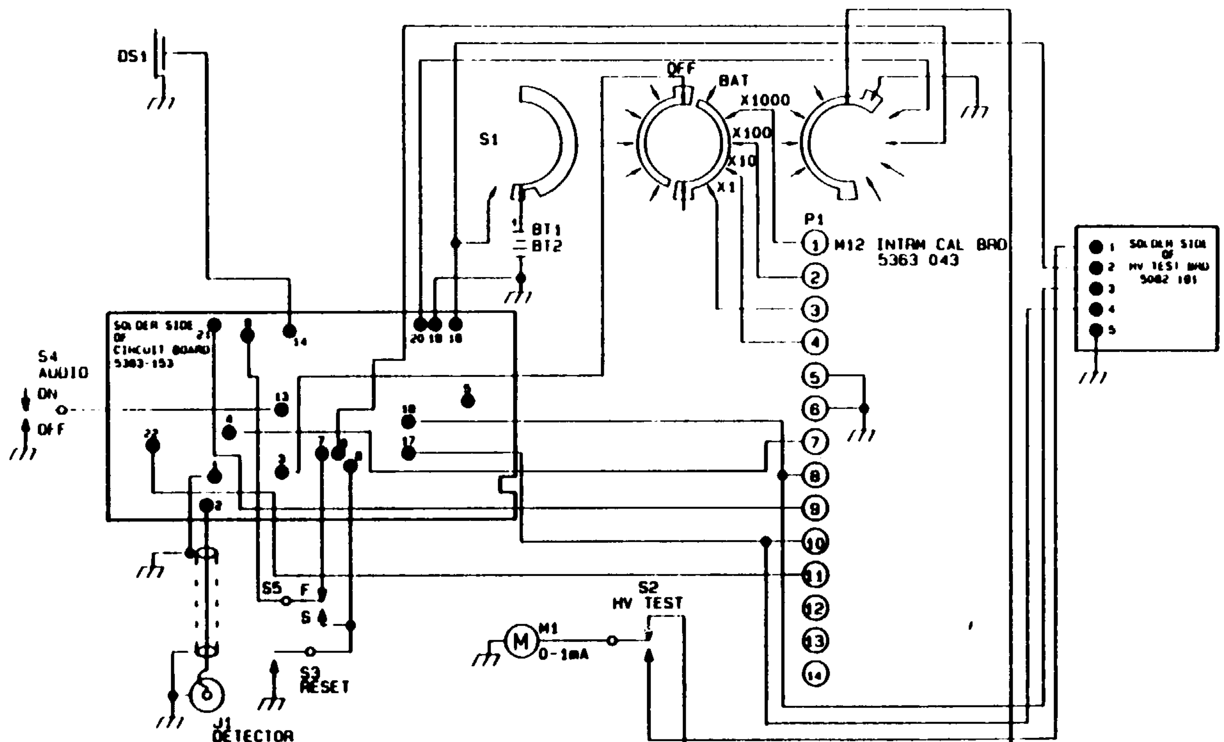
		PART NO.
S1	PA600-210	08-6501
S2	SWTCHCRFT 923 PB	08-6518
S3	GRAYHILL 30-1 PB	08-6517
S4	7101-SYZ-QE TOGGLE	08-6511
S5	7101-SYZ-QE TOGGLE	08-6511

BATTERY

BT1	"D" DURACELL BATTERY	21-9313
BT2	"D" DURACELL BATTERY	21-9313

MISCELLANEOUS

*	MODEL 12 BATTERY BOX LID	9062-112
*	BATTERY CONTACT SET	40-1707
*	MODEL 12 CASTING	9363-045
*	MODEL 12 MAIN HARNESS	8062-030-00
*	MODEL 12; 139 RIBBON HARNESS	8363-049
*	PORTABLE CAN	40-0045
*	PORTABLE HANDLE	7001-012-01
*	PORTABLE KNOB	08-6613
M1	PORTABLE METER (15-8030)	40-1805



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PART #: 363-091	
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DSGN:	DATE:

CHG NO				DWN	CHK	APV
DWN BK	DATE 9 9 88	CHK	DATE	APV	DATE	
TOL	SHOP STD ☐ OTHER		SCALE	FULL ☐ OTHER		

TITLE MODEL 12 COUNT RATEMETER

LUDLUM MEASUREMENTS INC. | SERIES 363 | SHEET 59

BILL OF MATERIALS

CAL BOARD, DWG. NO. 363 X 25

CAPACITORS

		PART NO.
C1	.0047uF, 100V, C	04-5513
C2	.047uF, 100V, C	04-5565

RESISTORS

R1	10k TRIMMER POT	09-6787
R2	100k TRIMMER POT	09-6813
R7-R8	1M TRIMMER POT	09-6814
R9	2M TRIMMER POT	09-6834
R10	250k TRIMMER POT	09-6819

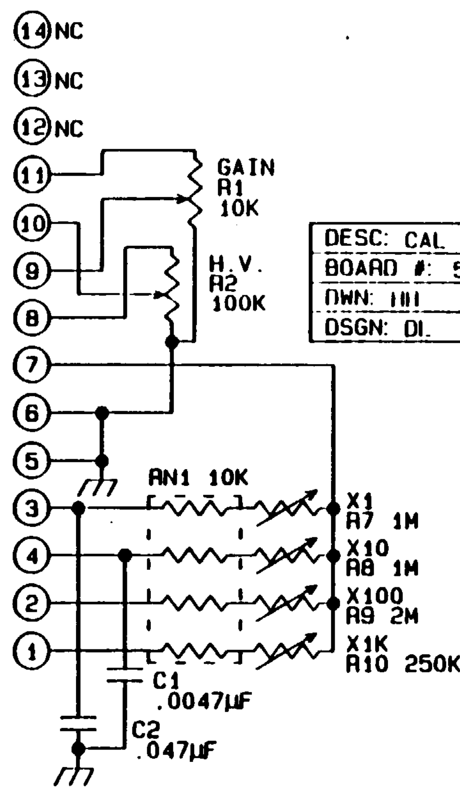
RESISTOR NETWORK

RN1	NETWORK 10k SIP 8PIN	12-7720

MISCELLANEOUS

8 EACH	IC-F4093-C EYELETS	06-6106
P1	STRIP-102888-7 14PIN M	13-8111

ASSEMBLED CALIBRATION BOARD	5363-043



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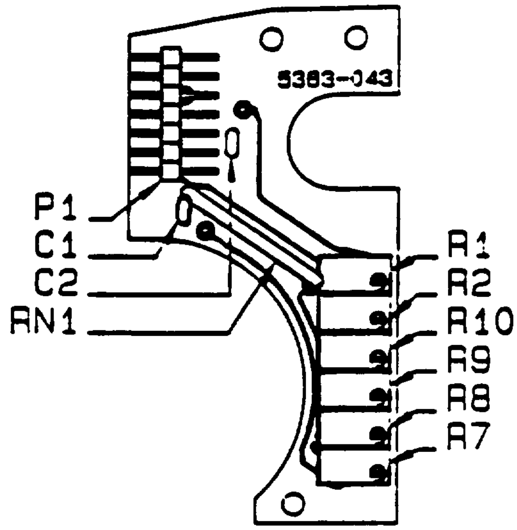
DSGN: DL	DATE: 7/87

DWN	DATE	CHK	DATE	APP	DATE
HH	1/12/88				

TITLE M12 CAL BOARD

	SERIES	SHEET
LUDLUM MEASUREMENTS, INC	363	25C



DESC: CAL BOARD	
MODEL: 12	
PART #: 5363-043	
DWN: HH	DATE: 8/7/87
DSGN: DL	DATE: 7/87

TOL: | SCALE:

TITLE M12 CAL BOARD

SERIES 383 | SHEET 29

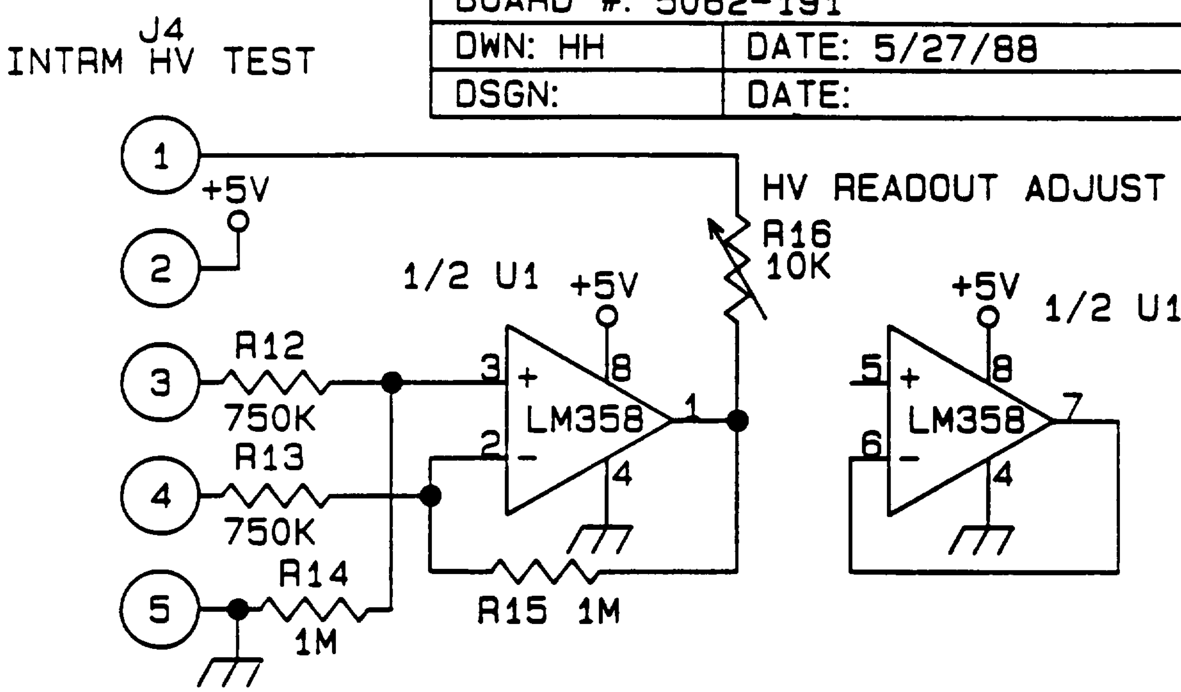
LUDLUM MODEL 12 COUNT RATEMETER

BILL OF MATERIALS

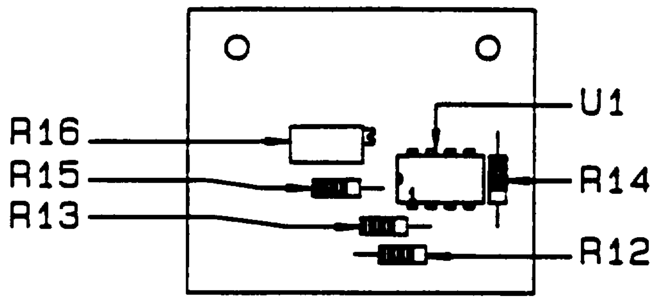
HV TEST BRD, DWG. NO. 363 X 126

INTEGRATED CIRCUITS		**PART NO.**
U1	ICL 7621	06-6171
RESISTORS		
R12-R13	750K 1%	12-7693
R14-R15	1M 1%	12-7609
R16	10K TRIMMER POT	09-6822
ASSEMBLED HV TEST BOARD		5062-191

DESC: HV TEST BOARD	
BOARD #: 5062-191	
DWN: HH	DATE: 5/27/88
DSGN:	DATE:



DWG NO.			
DWN HH	DATE 5/27/88	CHK	DATE
TOL:		SCALE:	
TITLE M18 HV TEST BOARD			
LUDLUM		SERIES 32	SHEET 128



DESC: INTRM HV TEST	
MODEL: M18	
PART #: 5062-191	
DWN: HH	DATE: 8/14/87
DSGN:	DATE:

HH	DATE 8/14/87		
TOL:		SCALE:	
TITLE M18 HV TEST BOARD			
LUDLUM		SERIES 383	SHEET 33

Received w/Ltr Dated 8/30/88
PART V

INSTRUCTIONAL MANUAL

1540 SERIES

DIGITAL PORTABLE MASS FLOW CALIBRATORS

KURZ INSTRUMENTS, INC.
2411 Garden Road
Monterey, CA 93940
(408) 646-5911
(800) 4-AIRFLO

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December 1983

SECTION 1

Description

The KURZ Series 1540 Digital Portable Mass Flow Calibrators are highly accurate easy-to-use, battery-powered instruments for measuring Mass Flow rates.

The Series 1540 instruments provide accurate measurements of extremely low flow rates, with exceptional sensitivity and readability.(down to 10SCCM) KURZ solid-state "DuraFlow" sensing elements are extremely rugged, and their large size renders them immune from particulate contamination. The standard probe's -55°C to +125°C operating range permits use in a wide variety of industrial applications.

KURZ Digital Portable Mass Flow Calibrators have unsurpassed accuracy and repeatability: ±2% accuracy for each full-scale range, and ±.025% of full scale reproducibility. The large LCD display improves speed and accuracy of readout, and it is easily read outdoors. A linear, analog output voltage permits time history recordings with easy-to-interpret linear amplitude calibration. The analog output is in engineering units, with a maximum of 0 to 2 VDC full scale.

All series 1540 systems come complete with Kurz Instruments Flow Transducer; a 3" long ¼" NPT pipe nipple for flow straightening (*); a hose nipple for ¼" tubing; a fifteen foot cable; LCD Readout Meter; 115 VAC, 60 Hz or 230 VAC, 50 Hz Battery Charger; rugged carrying case and operation Manual.

*CAUTION: The flow straightener or an equivalent length of pipe must be used on the inlet side (marked "in") of the flow body for proper operation. Otherwise insufficient flow straightening will occur, and turbulent air may hit the sensor causing an error. (Note, in extreme situations, such as when using an 1/8" inlet line or a swedgelok with an 1/8" hole, a longer straight section may be needed to prevent "jet" effects.)

SECTION 2

Principle of Operation

The mass flow transducer incorporates the Kurz "DuraFlo" unique temperature and flow sensors. The flow sensor is heated and operated as a constant-temperature thermal anemometer and responds to the mass flow by sensing the cooling effect of the air as it passes over the heated flow sensor. The temperature sensor accurately compensates for a wide range of ambient temperature variations. The output is directly displayed in mass flow units of Standard Liters Per Minute. (SLPM) (referenced to 25°C and 760 mm Hg.) Because the sensors are large and rugged, they are breakage resisitant, insensitive to dirt, and are easily cleaned. The flow-through design of the transducer minimizes pressure drop and eliminates susceptability to plugging as experienced with capillary tube type thermal flow sensors.

It should be noted that both sensors are constructed from high density aluminum oxide, wound with platinum, and have a special glass coating. It is a similar construction to that used by the National Bureau of Standards for their reference platinum resistance temperature standards. This construction gives the extremely high repeatability of the Kurz mass flow calibrators.

It should also be noted that the mass flow readings of the Series 1540 Portable Mass Flow Calibrators are refferenced to standard conditions of 25°C and 760 mm Hg pressure and if volumetric flowrate is desired, the following relation should be used:

$$Q_{act} = Q_{ind} \times \frac{d_s}{d_a}$$

d_s = air density at standard conditions of 25°C and 760 mm Hg,

d_a = actual air density inside the transducer,

Q_{act} = Volumetric flow rate (LPM), and

Q_{ind} = Indicated mass flow rate (SLPM)

SECTION 3

Operating Instructions

All KURZ portable meters are shipped with the battery in a low-charge condition. With the range switch in the "OFF" position, charge the batteries before use. Plug the charger into the front panel receptacle labeled "CHARGER". Plug the other end of the charger into an AC Wall socket. Charge the unit for a period of at least on hour before operating.

A charge of 12-16 hours is recommended to achieve a full charge. The charger is intended for charging purposes only. It's use is not recommended during operation.

To check the battery voltage, turn the control knob to the "BATT OK" position. For proper operation, the indicator should read in excess of 9 volts. A fully-charged condition is approximately 10.2 volts. At full charge, the instrument can be operated for about 8 hours of typical use. For maximum operating time between charges, turn the system off between measurements.

To operate, plug the probe connector into the "PROBE" receptacle, preferably when the control switch is in the "OFF" Position. Allow about 30 seconds for warm up.

Please Note: The markings on the flow body orient the unit so the air ALWAYS flows from "In" to "Out". Next, turn the range switch past "Battery" to the highest flow range position and the down range if necessary. The Portable Mass Flow Calibrator is now operating and will respond to the slightest air movement. Set the control knob to the "FAST" position. If the digital indication is not stable, switch to the "SLOW" position. The "FAST" and "SLOW" positions have time constants corresponding to 1 second and 2 seconds.

You have a choice of continuous measurement in the "DISPLAY" mode, or you can stop the display from updating and hold a reading in the "HOLD" mode. Switch to the lower range, if provided, to obtain increased resolution at low flows.

Remember to turn the range switch "OFF" when putting the system back into the carrying case. It is also suggested, to save battery time, to turn the meter "OFF" if there are long periods between measurements. If possible, operate the transducer with clean air. The use of an upstream air filter is highly recommended. This will insure long-term calibration accuracy.

All Series 1540 Portable Mass Flow Calibrators have an analog output signal available via jacks on the front panel. The voltage is proportional to the mass flow rate in standard liters per minute.

(Continued)

SECTION 3

Operating Instructions (cont'd)

The output signal level is directly related to engineering units of the measured variable, with a maximum of 2 VDC full scale. For example, a range of 0 to 200 LPM has an output of 0 to 2 V; a range of 0-50 LPM has 0 to .5 V; 0-3 LPM has 0 to 0.3 V.

****

SECTION 4

Specifications

The specifications for Kurz Series 1540 are listed on th following page.

SECTION 5

Maintenance

A. BATTERY LIFE

As with all rechargeable nickel-cadmium battery systems, the batteries will have longer life if they are not allowed to become overly discharged. It is recommended that the batteries be kept fully charged whenever possible and that the battery voltage be checked from time to time while using the instrument. Simply set the control knob to the "BATT OK" position and read battery voltage on the display. At full charge, the reading will be about 10.2 volts. Minimum voltage for instrument operation is about 9 volts. When the batteries are fully charged, the instrument can be typically used for about eight hours unless high flow rates are measured for extended periods of time. It is recommended that the instrument be turned off between measurements.

Temporary degradation, peculiar to nickel-cadmium batteries, may cause a decrease in operating period between recharges. If this occurs, let the batteries discharge to below 9 volts and then fully recharge them. This should correct the temporary degradation.

B. PROBE

Although the relatively large diameter of the velocity sensor renders it immune to particulate contamination in most environments, continuous use in dirty environments may necessitate periodic cleaning. Clean the sensor with a camel's hair brush and clean water, followed by an alcohol rinse. The sensor should be dry before resuming operation.

Store or transport the meter and probe in the convenient foam-padded carrying case to prevent shock damage.

USERS SHOULD NOTE THAT PROBES ARE NOT INTERCHANGEABLE. Each probe is matched, for temperature compensation and calibration, by circuit components in the instrument with which it was delivered. Accurate measurements can be made only when an instrument is used with the probe with which it was delivered.

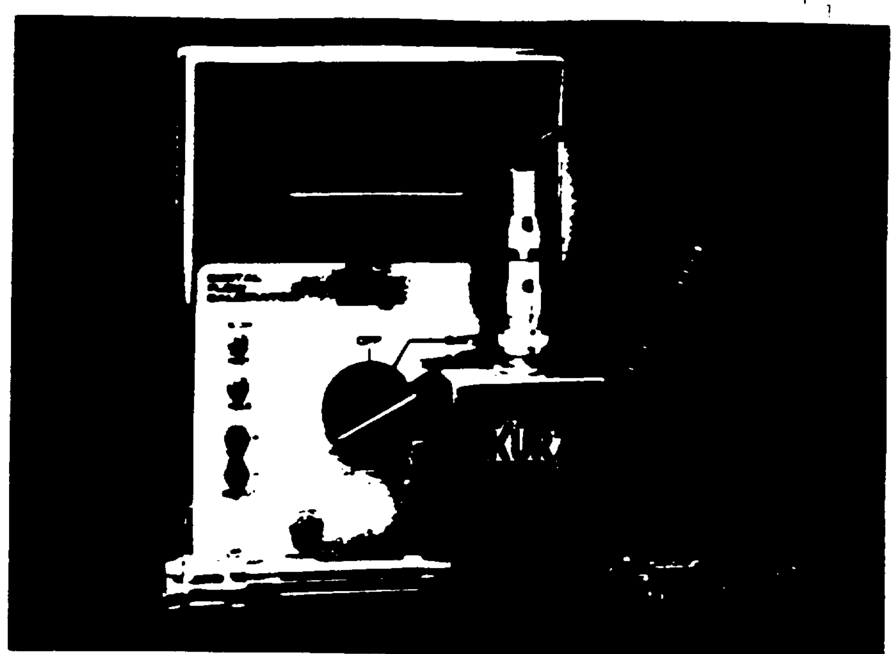
C. Calibration

Calibration should be checked periodically, normally anually, depending on accuracy requirements and extent of instrument use. The meter must be returned to Kurz Instruments, Inc.(*) for recalibration. Calibrations are traceable to the National Bureau of Standards (NBS). Before sending the meter to Kurz, you must contact the Factory Service Department for a Return Authorization Number. Units that do not have the Return Authorization Numbers on the box or the packing slip will be returned to the sender.

(continued)

THE FLAGSHIP OF OUR MASS FLOW CALIBRATOR LINE, THE 1540 PRESENTS A FULL COMPLEMENT OF FEATURES!

The Kurz 1540 Series digital mass flow calibrator features the unique *"DuraFlo"*™ sensor incorporated in the mass flow transducer. It is rugged, dirt-resistant, and gives exceptional low-flow sensitivity. This combination gives accurate flow calibration and low pressure drop without affecting the flow being measured. A large .7-inch liquid crystal display insures fast, easy-to-read flow rates. The 1540 features the finest accuracy of any portable mass flow calibrator in the world with standard accuracy of ±(2% reading + ½% full scale) and ¼% repeatability. Each unit is built into a rugged, break-resistant, shock-protected case. Engineered for ease of use, reliability, and ruggedness, these instruments are versatile and easy to use anywhere. Self-contained rechargeable nickel cadmium batteries provide up to 8 hours of operation between charging. Several models are available for a large spectrum of applications. Standard features include: .7-inch LCD display, normal and slow response time, sample and hold, and a recordable output. Each unit comes with the Kurz *"DuraFlo"*™ probe in the mass flow transducer, 15-foot transducer cable, 115 VAC battery charger, and a foam-padded carrying case. Adaptors for convenient connection to filter holders, and pipe and tube fittings are available. Other flow ranges and materials of construction are also available.



MODEL 1540 Digital Flow Calibrator

PRINCIPLE OF OPERATION

The mass flow transducer incorporates the Kurz *"DuraFlo"*™ unique temperature and flow sensors. The flow sensor is heated and operated as a constant-temperature thermal anemometer and responds to the mass flow by sensing the cooling effect of the air as it passes over the heated flow sensor. The temperature sensor accurately compensates for a wide range of ambient temperature variations. The output is directly displayed in mass flow units of standard liters per minute (SLPM) (referenced to 25°C and 760 mm Hg). Because the sensors are large and rugged, they are break-resistant, insensitive to dirt, and easily cleaned. The flow-through design of the transducer minimizes susceptibility to plugging such as that experienced with capillary tube-type thermal flow sensors.

FEATURES

- Large .7-inch LCD display
- Portable
- Easy to use
- Normal/slow response time
- Sample and hold
- Lightweight
- Highest accuracy available in the marketplace
- Low pressure drop
- Measures mass flow independent of temperature or pressure changes
- Calibration traceable to NBS

APPLICATIONS

- Laboratory and field use
- Calibration of personal calibrators in the field
- Quality assurance in air pollution and industrial hygiene studies
- Calibration of gas analyzers, bubblers, impactors, various samplers, and gas chromatography carrier gases
- In laboratory and industrial research, air mass flow measurements are easy with the 1540

KURZ INSTRUMENTS INC.

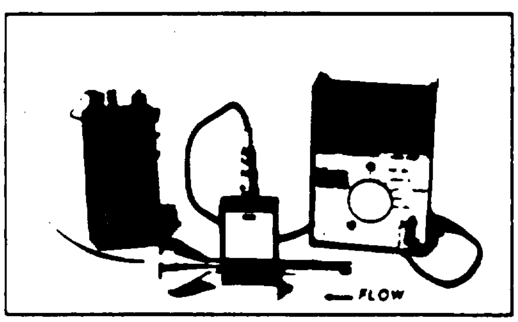
OFFERING THE WORLD'S WIDEST LINE OF MASS FLOW CALIBRATORS

SERIES 1540
DIGITAL FLOW CALIBRATOR

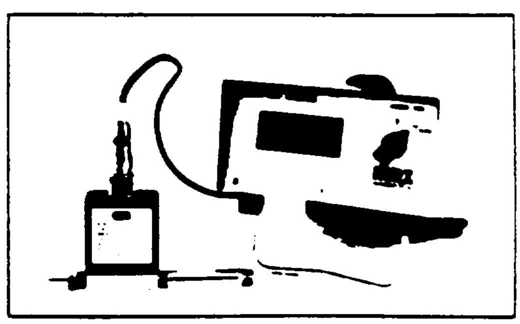
SPECIFICATIONS

MODEL NUMBER	1540	1541	1542	1543	1544
FLOW RANGES (SLPM) (REFERENCED TO 25°C AND 760 mm Hg)	0-.3 0-3	0-5	0-20	0-50	0-200

ACCURACY	±(2% of reading + ½% of full scale) for each flow range over a temperature range of −20°C to +60°C and a pressure range of .25 to 2 atmospheres (applicable above 10 sccm)
REPEATABILITY	±0.25% of full scale for each range
TEMPERATURE RANGES	Transducer: −65°C to +125°C; Meter: 0°C to 50°C
RESPONSE TIME	Transducer: 0.1 second; Meter Readout: 0.5 second
MAXIMUM PRESSURE DROP	4.5 cm H_2O high range (1.8 in H_2O) 0.18 cm H_2O mid-range (.07 in H_2O) 0.007 cm H_2O low range (.003 in H_2O)
PRESSURE RANGE OF TRANSDUCER	50 psi (accuracy guaranteed to 30 psi)
POWER	Nickel-cadmium battery with 115/230 VAC, 50/60 HZ charger, operates up to eight hours between charges
NET WEIGHT OF METER AND TRANSDUCER	1.25 Kg/ 2.75 lb.
SHIPPING WEIGHT	2.3 Kg/ 7 lb.
METER READOUT	Custom ruggedized, self-shielding .7-inch liquid crystal display, self-storing handle, shock-proof
FLOW TRANSDUCER MATERIAL	Nickel-plated aluminum and lexan flow body; ceramic, platinum and epoxy sensors; stainless steel available
TRANSDUCER DIMENSIONS	2.54 cm x 8 cm x 5.32 cm, ¼" NPT female inlet and outlet, except for 1544 with ¾" male threaded, 10" long
CONTROLS	Zero and span controls inside meter Range and battery test switch on front panel
DIMENSIONS	Meter: 2" x 5" x 7"; Carrying Case: 3" x 10" x 14"
FILTER CASSETTE ADAPTOR OPTIONS (All models except 1544)	Allows direct attachment to standard 37 mm cassettes (add "–B" to model number) or 47 mm cassettes (add "–F" to model number)
PREFILTER (47 mm) CASSETTE	Eliminates wind effects when calibrating virtual impactors (add "–C" to model number when ordering)
RECTRACTILE CABLE OPTION	6 feet of rectractile cable (11 inches when coiled) replaces standard 8-foot cable (add "–R" to model number)
STAINLESS STEEL OPTION	Add "–SS(316)" for 316 stainless steel flow body
WARRANTY	1 full year parts and labor



Calibration of Personal Sampling Pump shown with "B" Cassette Adaptor Option



Optional SERIES 545 Digital Display Bench Cabinet

SPECIFICATION SHEET NO. 1540-2/87

2411 GARDEN ROAD
MONTEREY, CA 93940
(408) 646-5911
USA TELEX 172275
FAX (408) 646-8901

SECTION 5

Maintenance

C. CALIBRATION (cont'd)

Be sure to include the battery charger and probe as well as the user's name, address and phone number to expedite the recalibration process. Allow 4 to 6 weeks turn around time.

* KURZ INSTRUMENTS, INC.
2411 Garden Road
Monterey, CA 93940
Attn; Service Dept.

****

SECTION 6

Warranty

All products manufactured by Kurz Instruments, Inc. carry a warranty against defective parts and workmanship to the original purchaser for a period of ONE YEAR after date of delivery. Damage caused by heat or corrosives, misuse, or negligence is not covered by this warranty.

"DuraFlow" probes are NOT interchangeable and are not covered by warranty. Please inspect and verify that the unit is operational upon receipt of all Kurz products. All units are shipped after NBS-traceable calibration.

NOTE

This manual documents the Model 8024B and its assemblies at the revision levels shown in Appendix A. If your instrument contains assemblies with different revision letters, it will be necessary for you to either update or backdate this manual. Refer to the supplemental change/errata sheet for newer assemblies, or the backdating sheet in Appendix A for older assemblies.

8024B
Digital Multimeter

Instruction Manual

P/N 616052
July 1981
Rev. 1 5/82

FLUKE®

Dear Customer:

Congratulations! We at Fluke are proud to present you with the Model 8024B Multimeter. This instrument represents the very latest in integrated circuit and display technology. As a result, the end product is a rugged and reliable instrument whose performance and design exhibit the qualities of a finely engineered lab instrument.

To fully appreciate and protect your investment, we suggest you take a few moments to read the manual. As always, Fluke stands behind your 8024B with a full 2-year warranty and a worldwide service organization. If the need arises, please don't hesitate to call on us.

Thank you for your trust and confidence.

John Fluke Mfg. Co., Inc.

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List of Illustrations

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LIST OF ILLUSTRATIONS, *continued*

Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. Your John Fluke Model 8024B is a pocket-size digital multimeter that is ideally suited for application in the field, laboratory, shop, or home. Some of the features of your instrument are:

FUNCTIONS: All standard VOM measurement functions -- ac/dc voltage, ac/dc current, resistance -- plus:

Conductance: A new multimeter function that allows fast, accurate, noise-free resistance measurements up to 10,000 MΩ.

Temperature: Used with a K-type thermocouple, this function provides direct display in degrees Celsius for K-type thermocouples.

Peak-Hold: Provides short-term memory for capturing the peak value of transient ac or dc signals such as motor starting current.

Continuity: Provides an immediate visual and audible indication when continuity is detected (use for passive circuit testing).

Level Detector: Senses logic levels and other active signals less than 250V dc or ac rms. Visual and audible indications of the results are provided.

RANGE for each function has:

Full autopolarity

Overrange indication

Effective protection from overloads

Dual slope integration measurement technique to ensure noise-free measurements

OPERATOR CONVENIENCE:

3 1/2-digit liquid crystal display: A high contrast display that can be easily read from across the room. No more worries about bent needles, parallax, etc.

Long term calibration stability: 2 years. Easy calibration - few adjustments.

Lightweight: .482 kg (17 ounces).

Safety Designed Test Leads: Finger guards on the probe and shrouded contacts on connectors reduce the chance of accidental contact with circuit voltages.

POWER:

Up to 100 hours of continuous operation can be expected from a single, inexpensive, 9-volt, alkaline battery (transistor radio/calculator type).

Low battery voltage is automatically detected and displayed. The low battery indication, BT, appears in the display when about 10 hours of operation remain.

Line operation is possible using a Model A81 Battery Eliminator. (See Section 6.)

ACCESSORIES:

A full line of accessories are available to extend the range and scope of your instrument. They are listed in Table 1-1 and described in detail in Section 6.

1-3. SPECIFICATIONS

1-4. Table 1-2 lists the specifications of your 8024B.

Table 1-1. 8024B Accessories

MODEL NO.	DESCRIPTION
C90	Deluxe Carrying Case (Soft Vinyl)
Y8105	Rugged Carrying Case (Molded Plastic)
Y8102	Type K Sheathed Thermocouple
Y8103	Type K Beaded Wire Thermocouple
Y8104	Thermocouple Termination Kit
80T-150C	Temperature Probe °C
80T-150F	Temperature Probe °F
80K-6	High Voltage Probe
80K-40	High Voltage Probe
83RF	High Frequency Probe
85RF	High Frequency Probe

Table 1-1. 8024B Accessories (cont)

MODEL NO.	DESCRIPTION
80I-600	Current Transformer, 2" jaw opening
80J-10	Current Shunt
A81	Battery Eliminator
Y8100	AC/DC Current Probe
Y8101	Current Transformer 7/16" jaw opening
Y8132	Safety Designed Test Lead Set
Y8134	Deluxe Test Lead Set
Y8140	Slim Flex Test Lead Set

Table 1-2. 8024B Specifications

The following electrical specifications assume a 2-year calibration cycle and an operating temperature of 18° C to 28° C (64° F to 82° F) at relative humidity up to 90% unless otherwise noted.

FUNCTIONS: DC Volts, AC Volts, DC Current, AC Current, Resistance, Diode Test, Conductance, Temperature, Peak-Hold, Continuity, and Level Detection.

DC VOLTS

RANGE	RESOLUTION	ACCURACY FOR 2 YEARS
±200 mV	100 µV	±(0.1% of reading + 1 digit)
±2V	1 mV	
±20V	10 mV	
±200V	100 mV	
±1000V	1 V	

Response Time .... Less than 1 sec.

Overvoltage Protection ...... 1000V dc or peak ac on all ranges, except 200 mv (15 sec max above 300V dc or rms)

Input Impedance .... 10 MΩ, all ranges

Normal Mode Rejection Ratio > 60 dB at 50 Hz and 60 Hz

Common Mode Rejection Ratio (1 kΩ unbalance) ..... > 100 dB at dc, 50Hz and 60 Hz

Table 1-2. 8024B Specifications (cont)

AC VOLTS (Average Sensing, RMS Calibrated Sinewave):

RANGE	RESOLUTION	ACCURACY		
		45 Hz to 1 kHz	1 kHz to 2 kHz	2 kHz to 5 kHz
200 mV	100 µV	±(0.75% of reading +2 digits)	±(1.5% of reading +3 digits)	±(5% of reading +5 digits)
2V	1 mV			
20V	10 mV			Not Specified
200V	0.1V			
750V	1V	±(1% of reading +2 digits)	Not Specified	

Response Time .... Less than 2 seconds

Overload Protection .... 750V rms or 1000V peak continuous, except 200 mV ac ranges (15 seconds maximum above 300V rms).

Common Mode Rejection Ratio (1 kΩ unbalance) ..... >60 dB at 50 Hz and 60 Hz

Volt-Hz Product .... 10^7 max (200V at 50 kHz)

Input Impedance .... 10 MΩ in parallel with <100 pF

DC CURRENT

RANGE	RESOLUTION	ACCURACY FOR 2 YEARS	BURDEN VOLTAGE
2 mA	1 µA	+(0.75% of reading +1 digit)	0.3V max
20 mA	10 µA		
200 mA	100 µA		
2000 mA	1 mA		0.9V max

Response Time .... Less than 1 second

Overload Protection .... 2A/250V fuse in series with 3A/600V fuse.

Table 1-2. 8024B Specifications (cont)

AC CURRENT

RANGE	RESOLUTION	ACCURACY for 2 Years		BURDEN VOLTAGE
		45 Hz to 450 Hz	450 Hz to 1 kHz	
2 mA	1 µA	±(3% of reading ±2 digits)	Not Specified	0.3V rms
20 mA	10 µA	±(1.5% of reading +2 digits)		0.9V rms max
200 mA	100 µA			
2000 mA	1 mA			

Response Time .... Less than 2 seconds

Overload Protection .... 2A/250V fuse in series with 3A/600V fuse.

RESISTANCE

RANGE	RESOLUTION	ACCURACY FOR 2 YEARS	FULL-SCALE VOLTAGE	MAXIMUM TEST CURRENT
200Ω	0.1Ω	±(0.2% of reading +3 digits)	<0.25V	.35 mA
2 kΩ (diode symbol)	1Ω	±(0.1% of reading +1 digit)	>1.0V	1.1 mA
20 kΩ	10Ω		<0.25V	13 µA
200 kΩ	100Ω		>0.7V	13 µA
2000 kΩ	1 kΩ	±(0.15% +1 digit)	<0.25V	0.13 µA
20 MΩ	10 kΩ	±(2% of reading +1 digit)	>.7V	0.13 µA

Overload Protection .... 500V dc/ac rms on all ranges (15 sec max above 300V dc or rms ac)

Open Circuit Voltage .... Less than 1.5V on all ranges except 2 kΩ range is less than 3.5V.

Diode Test .... The three ranges—2 kΩ, 200 kΩ, 20 MΩ—have enough open circuit voltage to turn on silicon junctions allowing a diode test. The 2 kΩ range is preferred and is marked with a diode symbol. The three non-diode test ranges — 200Ω, 20 kΩ, and 2000 kΩ — will not turn on silicon junctions when making in-circuit resistance measurements.

Table 1-2. 8024B Specifications (cont)

CONDUCTANCE*

Range	200 nS
Equivalent Resistance Range	5MΩ to 10,000 MΩ
Accuracy	±(2.0% of reading + 10 digits)
Resolution	0.05% of range (10^{-10} S)
Overload Protection	500V dc/rms ac (15 sec max above 300V dc or rms ac)
Diode Test	Will forward bias a typical PN junction

*Conductance is the inverse of ohms (1/Ω) and is expressed in siemens (S). A decrease in conductance is equivalent to an increase in resistance.

PEAK HOLD Use for Measuring Transient Signals

FUNCTIONS, RANGES	AC or DC, VOLTS or CURRENT ALL RANGES
AC Accuracy (48 — 450 Hz)	3% of reading + 10 digits, all ranges (except 2 mA, 6% of reading + 10 digits). Average sensing, calibrated to read highest rms value of sine wave.
AC Acquisition Time	150 ms**
DC Accuracy	3% of reading + 10 digits, positive pulses
DC Acquisition Time	10 ms** square pulse (3 ms square or 8 ms half sine typ.)
Display Decay Rate	<1 digit/sec

**Acquisition Time is the minimum duration of peak or surge for rated accuracy.
Accuracy improves for longer peak duration.

TEMPERATURE (Thermocouple accessory required)

Temperature Sensor	K-Type Thermocouple (Chromel-Alumel) See accessories
Range	-20° C to +1265° C
Resolution	1° C
Accuracy	±3° C ±1 digit, -20° to +300° C 3% of reading, +300° C to +1265° C (Accuracy includes NBS conformity, calibration stability, zero, and reference junction but not thermocouple errors.)
Connection	Dual banana isothermal termination provided with FLUKE thermocouple accessories. Use Y8104 termination accessory for any K-Type thermocouple.
Overload Protection	2A/250V fuse in series with 3A/600V fuse.

Table 1-2. 8024B Specifications (cont)

CONTINUITY Use for Passive Circuit Testing*

Ranges	All Resistance and Conductance ranges
Indication	Open Circuit: " ▲ " Display Continuity: " ▼ " Display + 2 kHz audio tone (selectable)
Response Time (2 kΩ range)	50 μS (Minimum duration of continuity or open to toggle display or audio tone. Pulse stretcher holds display and tone for approx. 100 ms.)
Overload Protection	500V dc or rms ac all ranges (15 sec max above 300V dc or rms ac)

*See section 2 for additional information.

LEVEL DETECTOR Use for Active Circuit Testing

Reference Level	+0.8V dc nominal on 200 kΩ range
Display	" ▲ " for inputs greater than reference " ▼ " for inputs less than reference " ▲ ▼ " for inputs toggling above and below reference Audio tone coincident with " ▼ " (switch selectable)

Table 1-2. 8024B Specifications (cont)

Pulse Response (200 kΩ range)	50 µS (Minimum width of 0 to +3V pulse required to toggle display. Pulse stretcher holds display for approx. 100 ms when short pulses are detected.)
Input Impedance	>100 kΩ in parallel with <100 pF
Overload Protection	500V dc or rms ac (15 sec max above 300V dc or rms ac)

ENVIRONMENTAL

Temperature	
OPERATING	0° C to 50° C (32° F to 122° F)
STORAGE	-35 to +60° C
Relative Humidity	0 to 90% from 0° C to 35° C except 0 to 80% from 0° C to 35° C on 2MΩ, 20MΩ, and 200 nS ranges; 0 to 70% from 35° C to 50° C
Temperature Coefficient	<0.1 times the applicable accuracy specification per °C for 0° C to 18° C and 28° C to 50° C (32° F to 64.4° F and 82.4° F to 122° F), except temperature (<0.02 X accuracy per °C)

GENERAL:

Protection Class 2	(Relates solely to insulation or grounding properties defined in IEC 348)
Maximum Common Mode Voltage	500V dc or rms
Power Requirements	Single 9V battery, NEDA 1604
BATTERY LIFE	Alkaline: 100 hours typical Zinc carbon: 50 hours typical
BATTERY INDICATOR	"BT" in display illuminates when approximately 20% of life remains
Display	3½ digit LCD (1,999 count), autozero, autopolarity
Size	L x W x H: 18.0 cm x 8.6 cm x 4.5 cm (7.1 in x 3.4 in x 1.8 in)
Weight	.48 Kg. (17 oz)

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. To fully utilize the measurement capabilities of your 8024B, a basic understanding of its measurement techniques and limitations is required. This section of the manual provides that information.

2-3. PREPARING FOR OPERATION

2-4. Unpacking

2-5. Your 8024B, this manual, one 9V battery, and two test leads (one red and one black) were shipped to you in a specially designed container. Check the shipment carefully and contact the place of purchase immediately if anything is wrong. If the place of purchase fails to satisfy you, contact the nearest John Fluke Service Center. A list of these service centers is located at the end of this manual.

2-6. If reshipment is necessary, please use the original shipping container. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please state the instrument model number when requesting a new shipping container.

2-7. **Battery or Fuse Installation/Replacement** inexpensive, 9V battery of the
2-8. Your 8024B is designed to operate on a single, inexpensive, 9V battery of the
transistor radio/calculator variety (NEDA 1604). When you receive your 8024B, the
battery will not be installed in the DMM. Once the battery is installed, you can expect a
typical operating life of up to 100 hours with an alkaline battery or 50 hours with a carbon-
zinc battery. When the battery has exhausted about 80% of its useful life the BT indicator
will appear in the upper left corner of the display. Your 8024B will operate properly for at
least 10 hours on an alkaline battery after BT appears in the display. Use the following
procedure to install or replace the battery or fuse:

CAUTION

To ensure operation within the accuracy specifications, the battery should be replaced when the voltage measured at the center of the battery eliminator connector falls below -3.00 volts (with respect to the COMMON input). If the

battery voltage falls to a point where the 'BT' is displayed and the digital display is inactive or no longer responds to a signal input, the battery should be replaced immediately to prevent damage to the LCD.

WARNING

TO AVOID ELECTRICAL SHOCK, BATTERY OR FUSE REPLACEMENT SHOULD ONLY BE PERFORMED AFTER THE INPUT SIGNAL AND TEST LEADS HAVE BEEN REMOVED FROM THE INPUT TERMINALS AND THE POWER SWITCH HAS BEEN SET TO OFF.

1. Set the 8024B POWER switch to OFF.

2. Remove test leads from external circuit connections and from the 8024B input terminals.

3. Open the battery compartment on the bottom of the 8024B as shown in Figure 2-1.

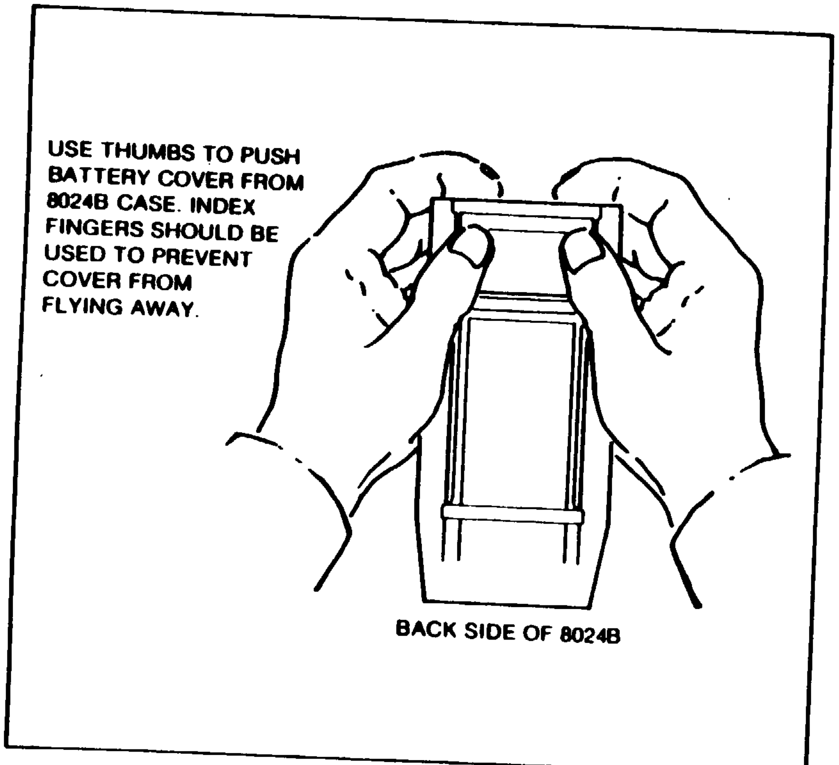


Figure 2-1. Removing the Battery Cover

4. Tilt the battery out as shown in Figure 2-2.

5. If fuse F1 is to be replaced, use a pointed tool, such as a probe tip or small screwdriver to pry F1 from its holder. Replace the defective fuse with type AGX2. (Instruments that accommodate metric fuses use type 171100-2.)

6. Carefully pull the battery clip free from the battery terminals as shown in Figure 2-2.

7. Press the battery clip onto the replacement battery and return both to the battery compartment.

8. Make sure the battery leads are routed to the side of the battery and are completely within the confines of the battery compartment before sliding the cover into place.

WARNING

DO NOT OPERATE THE 8024B UNTIL THE BATTERY COVER IS IN PLACE AND FULLY CLOSED.

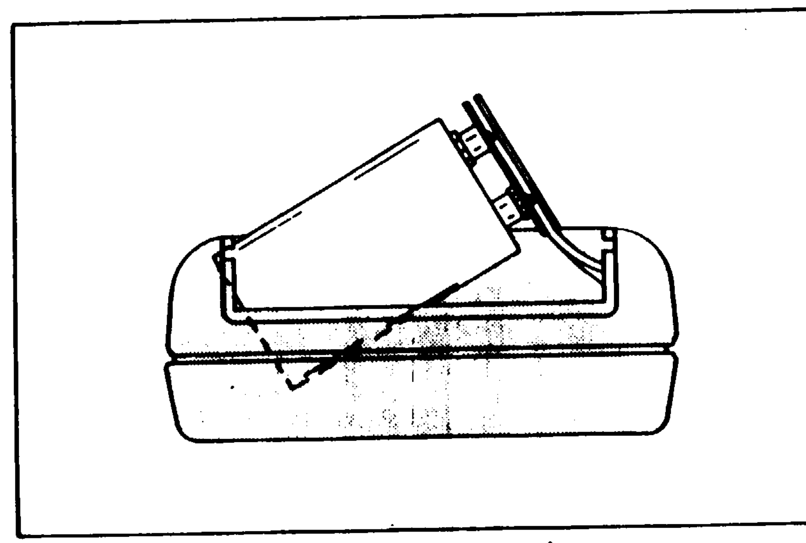


Figure 2-2. Battery Removal

2-9. PHYSICAL FEATURES

2-10. Before you try to use your 8024B, we suggest you take a few minutes to get acquainted with your instrument. All of the externally accessible physical features of your 8024B are shown in Figure 2-3 and described in Table 2-1. Locate each feature on your 8024B as you read the description.

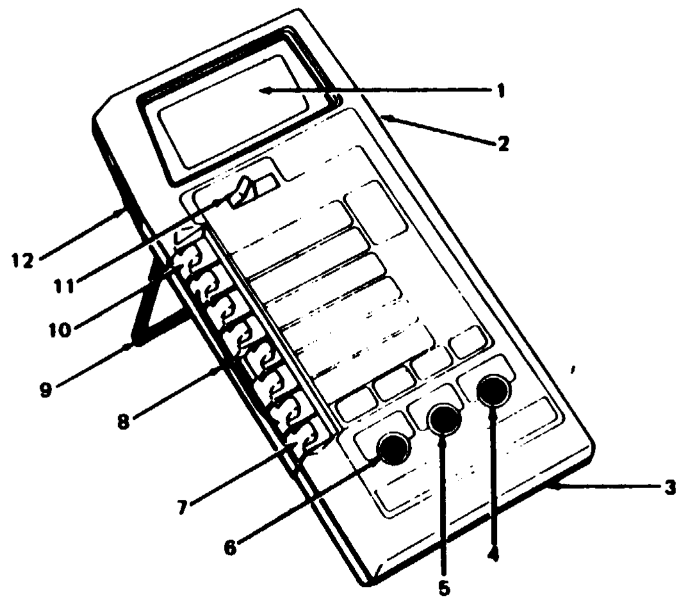


Figure 2-3. Controls, Indicators and Connectors

Table 2-1. Controls, Indicators, and Connectors

ITEM NO.	NAME	FUNCTION
1	Display	A 3½ digit display (1999 max) with decimal point and minus polarity indication. Used to indicate measured input values, overrange condition, low battery condition and level.
2	Battery Eliminator Connector	An external input power connector for use with the Model A81 Battery Eliminator accessory. (A81 is available in a variety of voltage and plug configurations. See Section 6.)
3	Battery Compartment and Cover	Cover for the 9V battery and current-protection fuse F1. Refer to figure 2-1 for battery cover removal instructions.

Table 2-1. Controls, Indicators, and Connectors (cont)

ITEM NO.	NAME	FUNCTION
4	V/Ω/S Input Connector	Protected test lead connector used as the high input for all voltage, conductance, continuity, level detector, and resistance measurements. This connector will accept standard banana plugs.
5	COMMON Input Connector	Protected test lead connector used as the low or common input for all measurements. Will accept banana plugs.
6	mA/°C Input Connector	Protected test lead connector used as the high input for all current and temperature.
7	Function Switch mA/°C/V/Ω/S	A push-push switch (push on - push off, do not pull to select a function), which works in conjunction with the high input connectors and the TEMP °C switch to select DMM measurement function.
8	Range Switches	Interlocked push-button switches for selecting ranges, i.e., pressing the desired range switch selects that range and cancels previous switch depressions. Do not pull switches to select a range. Voltage: 200 mV, 2V, 20V, 200V, 1000V dc/750V ac Current: 2 mA, 20 mA, 200 mA, 2000 mA Resistance: 200Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2000 kΩ, 20 MΩ Conductance: 200 nS (S = Siemens = 1/Ω = International unit of conductance). Requires simultaneous depression of two range switches. Temperature: °C
9	Tilt Bail	A removable fold-out stand which allows the instrument to be either tilted for bench-top use or hung from a hook in the absence of a work area.

Table 2-1. Controls, Indicators, and Connectors (cont)

ITEM NO.	NAME	FUNCTION
10	DC/AC/Audible tone Switch	A push-push switch (push on - push off, do not pull). When using V or mA functions, the in position selects AC measurement functions and the out position selects the DC measurement function. When used with Ω or S functions, the in position enables the audible tone feature and the out position disables the audible tone feature.
11	PEAK HOLD Switch	A push-push switch (push on - push off, to the right only, do not push or pull to the left), that enables or disables the Peak-Hold function.
12	POWER Switch	A slide switch used to turn the instrument off and on.

2-11. OPERATING NOTES

2-12. The following paragraphs will familiarize you with the capabilities and limitations of your Model 8024B.

2-13. Input Overload Protection

CAUTION

Exceeding the maximum input overload limits can damage your instrument. The transient overload protection circuit is intended to protect against short duration high energy pulses. The components used limit the protection to approximately five pulses per second for 6 kV, 10microsecond pulses, and about 0.6 watts average for lower pulses. Fast rep rate pulses as from a TV set can damage the protection components; RV1 - RV4, R1 and R2*, if replaced, use only Fluke replacement parts to maintain product safety. * R2 is a fusable resistor. Use exact replacement to insure safety.

2-14. Each measurement function and its associated ranges are equipped with input overload protection. The overload limits for each function and range are given in Table 2-2.

2-15. Input Connection to COMMON

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE COMMON INPUT TERMINAL TO ANY SOURCE OF MORE THAN 500 VOLTS DC OR 500V RMS AC ABOVE EARTH GROUND.

Table 2-2. Input Overload Limits

SELECTED FUNCTION	INPUT TERMINALS	MAX. INPUT OVERLOAD
Voltage	V/Ω/S and COMMON	1000V dc or peak ac on all ranges except 200 mV (15 sec max above 300V dc or rms).
Current and Temperature	mA - °C and COMMON	2A maximum, fuse protected to 600V dc/ac rms. DO NOT USE ABOVE 600V.
Resistance, Continuity, Level Detector and Conductance	V/Ω/S and COMMON	500V dc/ac rms.
Any	COMMON	500V dc/ac rms with respect to earth ground.

2-16. The 8024B may be operated with the COMMON input terminal at a potential of up to 500V dc or 500V rms ac above earth ground. If this limit is exceeded, instrument damage may occur. This, in turn, may result in a safety hazard for the operator.

2-17. Fuse Check

2-18. The current (mA) function contains two fuses. Check them as follows:

1. Complete the setup steps for the RESISTANCE (Ω) function and select the 2 kΩ range.
2. Touch the red test probe to the mA input jack so that the V-Ω input and mA input are connected together.
3. If the display reads approximately .100 kΩ, both fuses are good.
4. If the display reads overrange 1 followed by blank digits, one or both fuses need replacement. See the following paragraph for replacement instructions.

2-19. Fuse Replacement

2-20. All ac and dc current ranges are fuse protected. Two series fuses are used: (1) F1, 2A/250V, replaceable at the battery compartment (see Section 2 "Battery or Fuse Installation/Replacement") and (2) F2, 3A/600V battery fuse (see Section 4 "Battery/Backup Fuse Replacement").

WARNING

TO AVOID ELECTRICAL SHOCK DO NOT OPERATE THE 8024B UNTIL THE BATTERY COVER IS IN PLACE AND FULLY CLOSED.

2-21. The Display

2.22 As Figure 2-4 shows, your 8024B has a 3-1/2 digit liquid crystal display. Displayed values can range from 000 through 1999 (1999 is rounded to 2000 for ease of discussion). The decimal point position is determined by the selected range and is independent of selected function, except temperature. When the °C function is selected, the decimal point is not displayed. If the dc voltage or current measurement function is selected, the minus sign indicates that the input signal is negative with respect to the COMMON input terminal. If the °C measurement function is selected, the minus sign indicates that the input temperature is below zero. The absence of a minus sign indicates a positive reading. The minus sign is also used in conjuncton with the up and down ⬍ arrows when analyzing the input signal using the level detector function.

NOTE

The minus sign (-) may flash momentarily as the 8024B comes out of an overrange condition. This will most likely be seen in the ohms mode as the open circuit test leads are applied to an in-range resistance value. If the minus sign remains on for in-range ohms readings, the circuit is live (a negative voltage is present at the input terminals due to charged capacitors, etc.) and incorrect resistance readings will be displayed.

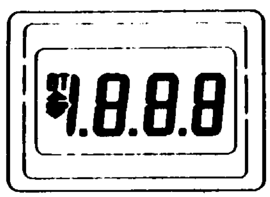


Figure 2-4. Display

2-23. The up and down ⬍ arrows (above and below the minus sign) are enabled by selecting the resistance or conductance functions. These arrows are visual indicators for the continuity and level detector functions.

2-24. The display has two abnormal status indicators (Figure 2-5), low battery power and instrument overrange. A BT is displayed when approximately 20% of battery life remains (battery replacement is indicated). A 1 followed by three blanked digits is displayed (decimal point may be present) as an overrange indication. It means that the next higher range should be selected. It does not necessarily mean that the instrument is being exposed to a damaging input condition. For example, when measuring resistance an open-input will cause an overrange indication.

NOTE

When the 8024B is powered with the A-81 Battery Eliminator the "BT" indicator may come on. However, instrument operation will be normal.

2-25. The liquid crystal display used in the 8024B is a rugged and reliable unit which will give years of satisfactory service. Display life can be extended by observing the following practices:

1. Protect the display from extended exposure to bright sunlight.
2. Keep the multimeter out of high temperature, high humidity environments (such as the dash of a car on a hot, sunny day). Otherwise the display may temporarily turn black. Recovery occurs at normal operating temperature.
3. The display operation may be slowed in extremely low temperature environments. No damage will occur to the LCD, but response time is greatly increased. Recovery occurs at normal operating temperature.

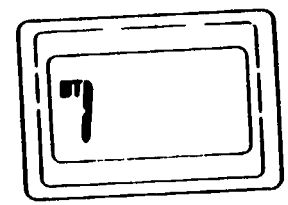


Figure 2-5. Abnormal Status Indicators

2-26. OPERATION

2-27. The following paragraphs describe how to operate your 8024B in each of its nine functions. Proceed to the description for the function you want to use.

2-28. AC/DC Volts (V) Operation

2-29. Figure 2-6 shows operation for the voltage measurement function. Perform each of the steps listed in sequence and comply with the warning.

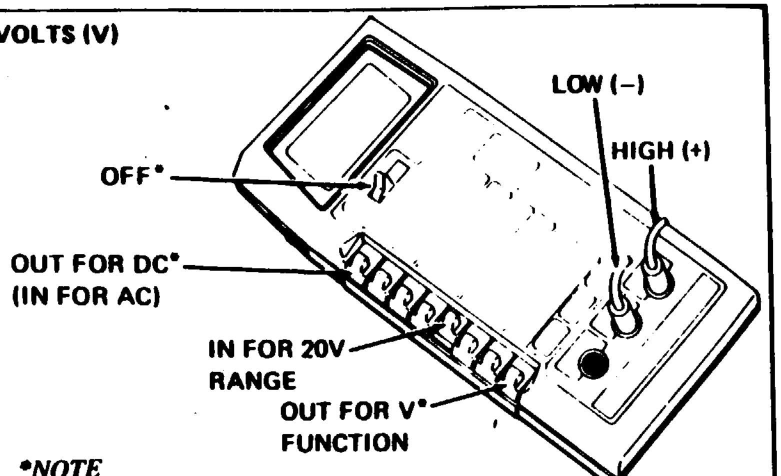
2-30. AC/DC Current (mA) Operation

2-31. Figure 2-7 shows operation for the current measurement function. Perform each of the steps listed in sequence and comply with the warning.

2-32. Resistance (Ω) Operation

2-33. Figure 2-8 shows operation for the resistance measurement function. To make resistance measurements, complete each of the steps listed in the figure sequentially, and comply with the warning.

VOLTS (V)



**NOTE*
The PEAK-HOLD switch and Function switches are push-push type. Operate these switches by pushing to the RIGHT▶only! Do not push or pull these switches to the left (out or off) positions.

- Connect the test leads as shown above.
- Depress the grey switch beside the range desired (20V is shown selected).
- Set the AC/DC switch out for DC or in For AC (DC is shown selected).

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE 8024B TERMINALS TO SOURCES THAT EXCEED THE FOLLOWING LIMITS WHEN MEASURING VOLTAGES:

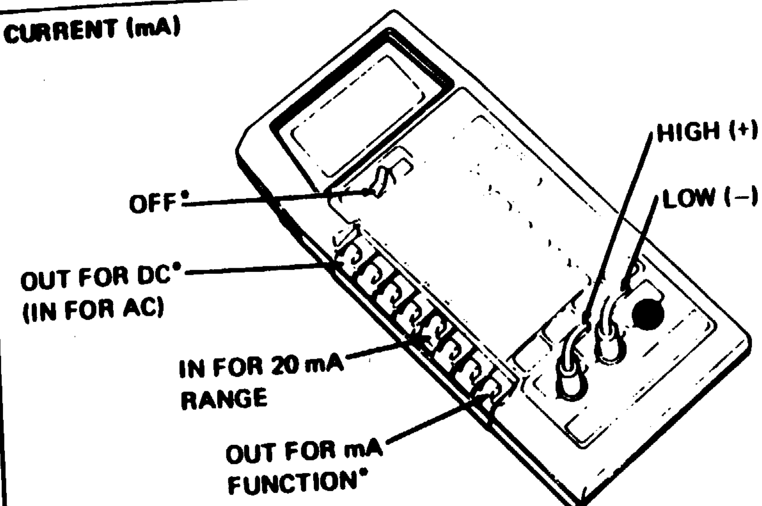
COMMON: 500V DC OR AC RMS WITH RESPECT TO EARTH GROUND.

V-Ω-S: 1000V DC OR 750V AC RMS WITH RESPECT TO THE COMMON TERMINAL (IN THE 200mV RANGE, SOURCES GREATER THAN 300V DC OR AC RMS SHOULD NOT BE CONNECTED LONGER THAN 15 SECONDS).

- Connect the test leads to the circuit being measured.
- Read the measured value on the display. The minus sign will appear if the V-Ω-S terminal is negative with respect to the COMMON terminal.

Figure 2-6. Volts Operation

CURRENT (mA)



**NOTE:*
The PEAK-HOLD switch and Function switches are push-push type. Operate these switches by pushing to the RIGHT▶only! Do not push or pull these switches to the left (out or off) positions.

- Connect the test leads as shown.
- Depress the grey switch beside the range desired (20 mA range shown selected).
- Set the AC/DC switch out for DC or in for AC.
- Insure that all other switches are at the out or OFF positions.

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE 8024B TERMINALS TO SOURCES THAT EXCEED THE FOLLOWING LIMITS WHEN MEASURING CURRENT:

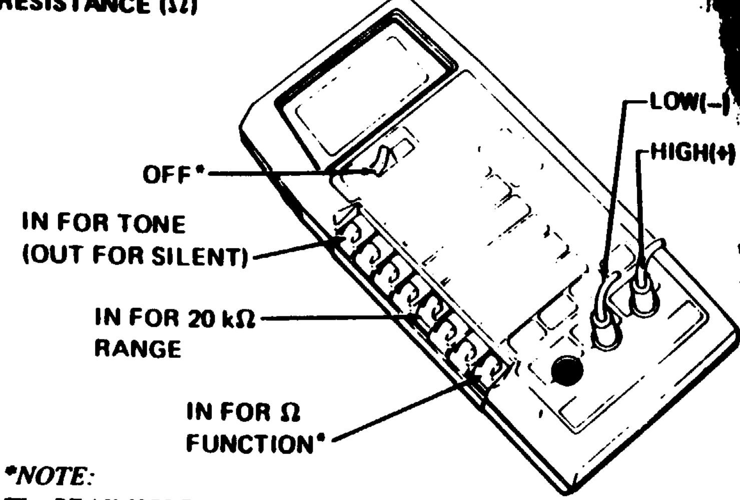
COMMON: 500V DC OR AC RMS WITH RESPECT TO EARTH GROUND.

mA-°C: CURRENT OF 2 AMPS OR OPEN CIRCUIT VOLTAGE OF 600V DC/AC RMS.

- Connect the test leads to the circuit being measured.
- Read the measured value on the display. In DC the minus sign will appear if the mA-°C terminal is negative with respect to the COMMON terminal.

Figure 2-7. Current Operation

RESISTANCE (Ω)



***NOTE:**

The PEAK-HOLD switch and Function switches are push-push type. Operate these switches by pushing to the RIGHT ▶ only! Do not push or pull these switches to the left (out or off) positions.

- Connect the test leads as shown.
- Depress the mA·°C·V·Ω·S switch.
- Depress the grey switch beside the range desired (20k is shown selected.
- Insure that all other switches are at the out or OFF positions.
- Make sure that the device being measured contains no electrical energy.

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE 8024B TERMINALS TO SOURCES THAT EXCEED THE FOLLOWING LIMITS WHEN MEASURING RESISTANCE OR CONTINUITY:

COMMON: 500V DC OR AC RMS WITH RESPECT TO EARTH GROUND.

V-Ω-S: 500V DC OR AC RMS WITH RESPECT TO THE COMMON TERMINAL.

- Connect the test leads across the device being measured.
- Read the measured value on the display.

Figure 2-8. Resistance Operation

Continuity Testing

The 2 kΩ range of your 8024B can be used to make fast continuity tests. Select the 2 range, Ω function, and depress the AC/DC switch (to enable the audible alarm). The ▲ arrow will appear in the display. If continuity is measured between the test lead tips (touch the tips together momentarily), the audible tone will sound, then the up▲arrow will disappear from the display and the down▼arrow will appear. Typically, 600Ω or less will activate the down▼arrow and audio tone. Comply with the kΩ warning.

2-36. Diode Testing

2-37. The 2 kΩ, 200 kΩ, and 20 MΩ ranges of the kΩ function will turn on PN junctions. The 2 kΩ is preferred and is marked with a diode symbol on the front panel of your 8024B. The open circuit voltage is less than 3.5V on the 2 kΩ range and less than 1.5V on all other ranges. When testing diodes in conjunction with the audio tone, use the 200 kΩ range.

NOTE

The 200Ω, 20 kΩ, and 2000 kΩ ranges can be used for in-circuit resistance measurements.

2-38. Conductance (S) Operation

2-39. Figure 2-9 shows operation for the conductance measurement function. To make conductance measurements, complete each of the steps listed in the figure sequentially, and comply with the warning. Siemens, the displayed units, is equal to 1/Ω. For the resistance equivalent to the displayed value, refer to the conductance-to-resistance conversion material presented later in this section under Measurement Techniques.

2-40. Temperature (°C) Operation

WARNING

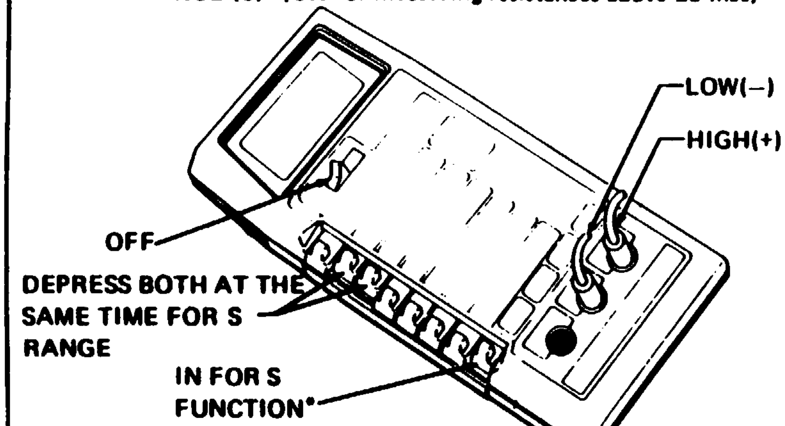
TO AVOID ELECTRICAL SHOCK, DO NOT USE THE THERMOCOUPLE ACCESSORIES WHEN VOLTAGES EXCEEDING 30V AC RMS OR 60V DC ARE PRESENT. THE PROBE TIP MAY BE ELECTRICALLY CONNECTED TO THE ACCESSORY OUTPUT TERMINALS.

2-41. Figure 2-10 describes operation for the temperature measurement function with the thermocouple accessories and with the John Fluke Model 80T-150 Temperature Probe. To find the Fahrenheit equivalent of the °C display, go to the Temperature Conversion portion of the Measurement Techniques material presented later in this section.

NOTE

Thermocouple connections must be made using approved isothermal connectors (such as the Y8104) and thermocouple wire that is the same type as the thermocouple. Failure to use these materials will result in erroneous temperature measurement.

CONDUCTANCE (S) (Use for measuring resistances above 20 MΩ)



**NOTE:*
The PEAK-HOLD switch and Function switches are push-push type. Operate these switches by pushing to the RIGHT ▶ only! Do not push or pull these switches to the left (out or off) positions.

- Connect the test leads as shown.
- Depress the mA-°C-V-Ω-S function switch.
- AT THE SAME TIME, depress both of the grey S range switches.
- Insure that all other switches are at the out or OFF positions.
- Insure that the device being measured contains no electrical energy.

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE 8024B TERMINALS TO SOURCES THAT EXCEED THE FOLLOWING LIMITS WHEN MEASURING CONDUCTANCE:

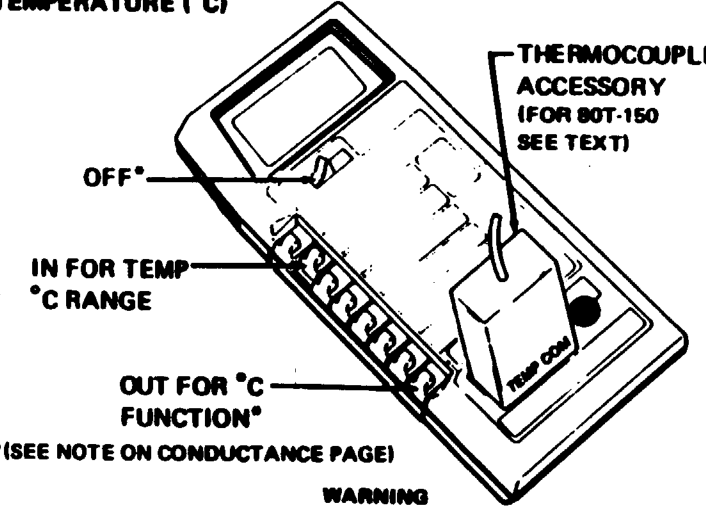
COMMON: 500V DC OR AC RMS WITH RESPECT TO EARTH GROUND.

V-Ω-S: 500V DC OR AC RMS WITH RESPECT TO THE COMMON TERMINAL.

- Connect the test leads across the device being measured (connect the red test lead to the + end of polarized capacitors for leakage measurements.
- Read the measured value in the display.
- See Measurement Techniques section for Conductance-Resistance Conversion chart.

Figure 2-9. Conductance Operation

TEMPERATURE (°C)



*(SEE NOTE ON CONDUCTANCE PAGE)

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT EXCEED THE MAXIMUM VOLTAGE AND TEMPERATURE LIMITS FOR THE ACCESSORY USED.

John Fluke Thermocouple ACCESSORIES

- Connect the thermocouple termination across the mA-°C and Common terminals with the TEMP side plugged into the mA-°C terminal,
- Depress the grey TEMP °C range switch.
- Insure that all other switches are at the out or OFF positions.
- Read the measured value in the display. See Measurement Technique section for °F conversion.
- If unit fails to function properly, see FUSE CHECK para. 2-17.

John Fluke 80T-150 ACCESSORY

- Connect the 80T-150 termination across the V-Ω-S and COMMON terminals with the HI side plugged into the V-Ω-S terminal.
- Select the appropriate range (200 mV or 2V).
- Insure that all other switches are at the out or OFF positions.
- Set the 80T-150 POWER switch to the ON position and read the display in units indicated on the accessory label.

Figure 2-10. Temperature Operation

2-42. Not all applications for temperature measurement use just one thermocouple. The applications material at the end of this section describes how to use your 8024B to sequentially measure different thermocouples of the same type. Your 8024B is intended for use with K-type thermocouples. If you use another type of thermocouple, the measurement will be in error. See the Temperature Measurement Techniques material presented later in this section.

2-43. Level Detector Operation

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE 8024B TERMINALS TO SOURCES THAT EXCEED THE FOLLOWING LIMITS WHEN USING THE LEVEL DETECTOR FUNCTION:
COMMON: 500V DC OR 500V AC RMS WITH RESPECT TO EARTH GROUND
V/Ω/S: 500V DC OR 500V AC RMS WITH RESPECT TO THE COMMON TERMINAL.

2-44. Use the level detector function for sensing logic levels and other active signals less than 250V dc or ac rms in amplitude. Select the 200 kΩ range on the Ω function. The 200 kΩ range is marked with a step function symbol (⨼) on the front panel of your 8024B to indicate its use in the level detector function. The level detector compares the input signal to a +0.8V (nominal) reference. There is both audible and visual indication of the results of the comparison. The audible indication is a 2 kHz tone that can be enabled by depressing the AC/DC switch or disabled by releasing the AC/DC switch. The visual indication is an up and/or down arrow that appears on the display above and/or below the minus sign position. Figure 2-11 shows the indications for some typical input signals. Starting from left to right:

1. The level is above the +0.8V reference so the ▲up arrow appears in the display and the audible tone does not sound.

2. The input level is below the +0.8V reference, but above 0V. The audible tone sounds and the ▼down arrow appears in the display but the minus sign is absent.

3. The input level is below both the +0.8V reference and 0V. The ▼down arrow appears, the tone is audible, and the minus sign appears.

4. The input signal is very near 0V. The ▼down arrow appears, the audible tone sounds, and the minus sign flickers off and on.

5. The input is a train of pulses that pass above +0.8V but whose average value is positive. Each time a pulse goes above +0.8V, the ▲up arrow appears and the audible tone is silent. Each time the pulse goes below +0.8V, the ▼down arrow appears and the audible tone sounds. The minus sign does not appear. For a fast pulse train, both arrows will be on.

6. The input signal is a sine wave whose positive peaks pass above +0.8V but whose average value is negative. The audible tone and arrows behave as described in step 5 and the minus sign appears in the display.

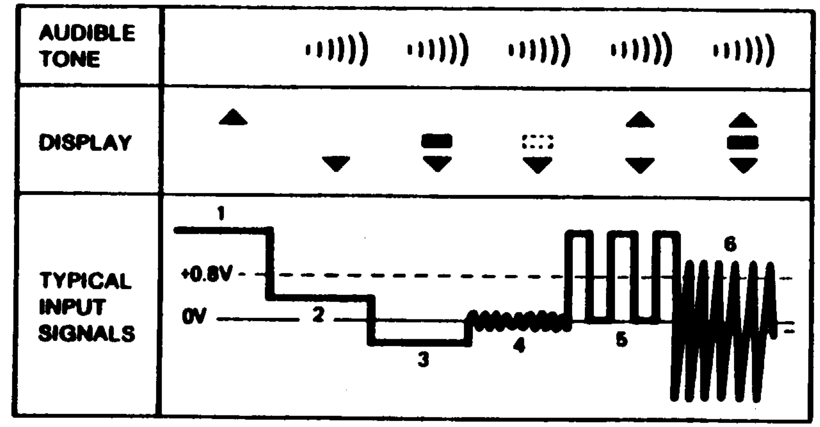


Figure 2-11. Level Detector Operation

7. For short pulses, your 8024B has a pulse stretcher circuit that captures and holds the pulses long enough for the display and tone to respond, typically for 100 ms. The input impedance of the level detector is >100 kΩ so as not to load logic circuits. The level detector is also usable on the 2 kΩ range. On this range, the reference level is +0.4V nominal. See Measurement Techniques for additional information.

2-45. Peak Hold Operation

CAUTION

The PEAK HOLD switch is a push-push type. Operate this switch by pushing to the right only. Do not push or pull the switch to the left (off).

2-46. The peak hold function provides short term memory of the most positive dc or ac rms level (Figure 2-12). The peak hold function is intended to be used for voltage and current measurements. Proceed with the steps of operation for the measurement function being used with the peak hold function. When the test leads have been connected to the circuit to be measured, set the PEAK HOLD switch to ON. For a new reading, set the PEAK HOLD switch to OFF then back to ON. To read negative peak signals, reverse the test connections. An example peak hold operation would be as follows:

1. Set the PEAK HOLD switch to OFF.

2. Select the DC, V (volts) functions.

3. Insert the red test lead into the V/Ω/S input, and select the 20V range.

4. Locate the battery eliminator connector on the right side of the unit.

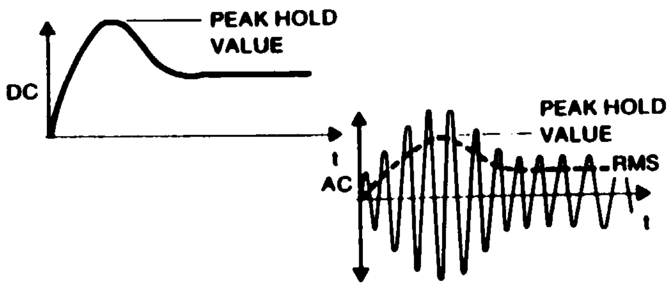


Figure 2-12. Peak Hold Operation

5. Measure the voltage on the side contact (bottom of hole) of the connector (approximately +2.90V).

6. Set the PEAK HOLD switch to ON and momentarily touch the test lead to the side contact.

7. The reading should be the same as step 5, within a few digits.

8. False readings may result if the range or function switches are changed while the PEAK HOLD switch is set to ON. To avoid these errors, reset the PEAK HOLD circuit after each range or function change.

9. Static electricity and noise pickup may cause errors when using the PEAK HOLD function. While the PEAK HOLD switch is ON, avoid touching the probe tips to fingers or other objects which may contain a static charge. The potential for noise pickup is worst whenever the test leads are open circuited. This is particularly true on the 200 mV, 2V and 2 mA ranges. Refer to AC/DC current measurement section of MEASUREMENT TECHNIQUES for additional information.

NOTE

For DC voltages and currents, the peak hold function measures the "most positive" value of the input waveform. If the "most positive" excursion of the waveform is negative with respect to common, a negative sign will be displayed, i.e., when a negative sign is display, the measured value is not the negative peak, but is, instead the least negative (or most positive) portion of the applied waveform.

10. PEAK HOLD accuracy may be affected by mechanical shock. If your 8024B has suffered mechanical shock during a peak measurement, reset the PEAK HOLD circuit and repeat the measurement.

2-47. INITIAL CHECK-OUT PROCEDURE

2-48. Now that you have installed the battery, and know where everything is and how it works, let's make sure that the unit is working properly. We'll run through a simple check-out procedure starting with turn-on. No equipment other than test leads will be required. If a problem is encountered, please check battery, fuse, switch setting, and test lead connection before contacting your nearest John Fluke Service Center.

NOTE

This procedure is intended to verify overall instrument operation, and is not meant as a substitute for the formal Performance Tests given in Section 4. Limits shown exceed the specifications because the procedure uses one measurement to check another.

1. Set the POWER switch to OFF and all range and function switches to the released (out) position.

2. Set the POWER switch to ON and observe the display. It should read between -00.1 and 00.1.

3. Connect the red test lead to the V/Ω/S input terminal. Depress Ω function switch to select Ω function.

4. Touch the red probe tip to the COMMON input terminal, and sequentially depress each of the six dark range switches starting at the top (20 MΩ). The display should read zero ±1 digit and the decimal point should be positioned as follows:

a. 20 MΩ - 0.00
b. 2000 kΩ - 000
c. 200 kΩ - 00.0
d. 20 kΩ - 0.00
e. 2 kΩ - .000
f. 200Ω - 00.0

5. Press the 20V range switch and remove the probe from the COMMON input terminal. Release function switch to select volts function.

6. Look inside the battery eliminator connector on the right side of the 8024B and locate the connector contacts.

7. Touch the red probe to the center post of the battery eliminator connector. The display should read approximately -6.1V dc. (Note: this voltage varies with condition and type of battery.)

8. Touch the probe tip to the side contact of the battery eliminator connector located at the bottom of the hole. The display should read approximately 2.9V dc. Notice that the sum of the two readings is equal to the battery voltage (typically 8 to 10V dc). Remove the probe from the battery eliminator connector.

9. Depress the Ω function switch and the AC/DC switch. The ▲ up arrow will appear in the display. Sequentially depress each of the six range switches. The display will indicate an overrange condition and the decimal point will change position.

10. Touch the red probe tip to the COMMON input terminal, the audible tone will sound and the ▼ down arrow will appear in the display. Sequentially depress each of the grey range switches. The display should read zero at each range setting. Lead resistance may be sufficient to cause a one or two tenths (0.1 or 0.2Ω) indication on the 200Ω range. Release the AC/DC switch to silence the audio tone.

11. Touch the red probe tip to the mA -°C input connector and press the 200Ω switch. The display should read 99.0 to 101.0.

12. Press the 2 kΩ switch. The display should read .099 to .101. Remove the probe from the mA -°C input connector.

13. Simultaneously depress the two range switches to select the 200 nS range. The display should read 00.0 to 01.0 (minimum conductance, maximum resistance).

14. Touch the red probe tip to the COMMON input terminal. An overrange indication should be displayed since conductance is the reciprocal of resistance.

15. Connect the black test lead to the COMMON input connector.

16. Depress both the AC/DC switch and the 750V ac range switch. Set the function switch to the voltage (out) position. (Use 750V range for 230V line.)

WARNING

THE LOCAL LINE VOLTAGE IS MEASURED IN THE FOLLOWING STEP. BE CAREFUL NOT TO TOUCH THE PROBE TIPS WITH FINGERS, OR TO ALLOW THE PROBE TIPS TO CONTACT EACH OTHER.

17. Measure the local ac line voltage at a convenient output receptacle.

18. Set the PEAK HOLD switch to the ON position. The value of the line voltage will be locked on the display. The display value should decay no faster than 1 digit per second. Set the PEAK HOLD switch to the OFF position.

19. Remove the test leads from the line power receptacle and set PEAK HOLD to OFF, function to DC, PEAK HOLD to ON, and reinsert probes; observe 1.41 X ac voltage. (This is the instantaneous peak of a single half wave of line voltage.) Set PEAK HOLD to OFF.

20. Select the 200 kΩ range of the Ω function switch (level detector), and depress the AC/DC switch (to enable the audible tone).

21. Connect the test leads to the line voltage receptacle. You will hear the audible tone modulated by the line frequency and see both arrows displayed.

22. Remove the test leads from the line power receptacle.

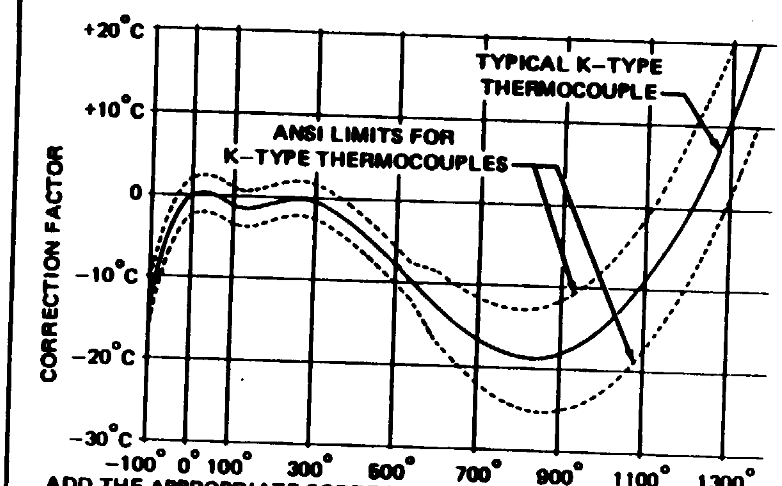
23. If your 8024B has responded properly to this point, it is operational and ready for use.

2-49. MEASUREMENT TECHNIQUES

2-50. The following paragraphs offer you techniques that can improve the accuracy of measurements made with your 8024B. While most of these techniques are in general use throughout the electronics industry, these paragraphs offer specific information for use with your 8024B. (Figure 2-13 presents a temperature correction factor for K-type thermocouples.) Use this chart for accuracy enhancement above 300°C.

2-51. Temperature Conversion

2-52. The temperature measurements made with your 8024B are displayed in °C. To find the equivalent temperature in °F, either use the conversion tables in Table 2-3 or the formula: 1.8 (°C) + 32° = °F.



ADD THE APPROPRIATE CORRECTION FACTOR TO THE DISPLAYED VALUE

EXAMPLE: DMM READS +800°C.
FROM PLOT, CORRECTION FACTOR = −19°C
ACTUAL TEMPERATURE = 800 − 19 = 781°C
ERROR = $\frac{19}{781}$ = 2.4%

Figure 2-13. Temperature Correction Factor for K-Type Thermocouples

Table 2-3. Celsius-to-Fahrenheit Conversion Scale

°C	°F	°C	°F	°C	°F
−40	−40.0	5	41.0	40	104.0
−38	−36.4	6	42.8	41	105.8
−36	−32.8	7	44.6	42	107.6
−34	−29.2	8	46.4	43	109.4
−32	−25.6	9	48.2	44	111.2
−30	−22.0	10	50.0	45	113.0
−28	−18.4	11	51.8	46	114.8
−26	−14.8	12	53.6	47	116.6
−24	−11.2	13	55.4	48	118.4
−22	−7.6	14	57.2	49	120.2
−20	−4.0	15	59.0	50	122.0
−19	−2.2	16	60.8	55	131.0
−18	−0.4	17	62.6	60	140.0
−17	1.4	18	64.4	65	149.0
−16	3.2	19	66.2	70	158.0
−15	5.0	20	68.0	75	167.0
−14	6.8	21	69.8	80	176.0
−13	8.6	22	71.6	85	185.0
−12	10.4	23	73.4	90	194.0
−11	12.2	24	75.2	95	203.0
−10	14.0	25	77.0	100	212.0
−9	15.8	26	78.8	105	221.0
−8	17.6	27	80.6	110	230.0
−7	19.4	28	82.4	115	239.0
−6	21.2	29	84.2	120	248.0
−5	23.0	30	86.0	125	257.0
−4	24.8	31	87.8	130	266.0
−3	26.6	32	89.6	135	275.0
−2	28.4	33	91.4	140	284.0
−1	30.2	34	93.2	145	293.0
0	32.0	35	95.0	150	302.0
1	33.8	36	96.8	155	311.0
2	35.6	37	98.6	160	320.0
3	37.4	38	100.4	165	329.0
4	39.2	39	102.2	170	338.0

Table 2-3. Celsius-to-Fahrenheit Conversion Scale (cont)

°C	°F	°C	°F	°C	°F
175	347	350	662	750	1382
180	356	355	671	800	1472
185	365	360	680	850	1562
190	374	365	689	900	1652
195	383	370	698	950	1742
200	392	375	707		
205	401	380	716		
210	410	385	725		
215	419	390	734		
220	428	395	743		
225	437	400	752		
230	446	405	761		
235	455	410	770		
240	464	415	779		
245	473	420	788		
250	482	425	797		
255	491	430	806		
260	500	435	815		
265	509	440	824		
270	518	445	833		
275	527	450	842		
280	536	455	851		
285	545	460	860		
290	554	465	869		
295	563	470	878		
300	572	475	887		
305	581	480	896		
310	590	485	905		
315	599	490	914		
320	608	495	923		
325	617	500	932		
330	626	550	1022		
335	635	600	1112		
340	644	650	1202		
345	653	700	1292		

2-53. Conductance-to-Resistance Conversion

2-54. The conductance measurement function of your 8024B displays in siemens. To convert siemens to ohms, use either the conversion scale and interpolation table in Figure 2-14 or the formula: siemens = 1/Ω.

2-55. AC Measurements

2-56. The ac ranges of the 8024B employ an average responding ac converter. This means that the unit measures the average value of the input, and displays it as an equivalent rms value for a sine wave. As a result, measurement errors are introduced when the input wave form is distorted (non-sinusoidal). The amount of error depends upon the amount of distortion. Figure 2-15 shows the relationship between sine, square, and triangular waveforms, and the required conversion factors. To convert the display reading for a given input waveform to a known measurement value, multiply the reading by the appropriate Display Multiplier.

2-57. AC/DC Voltage Measurements

2-58. The 8024B is equipped with five ac and five dc voltage ranges; 200 mV, 2V, 20V, 200V, 750V ac/1000V dc. All ranges present an input impedance of 10 MΩ. On the ac ranges, this is shunted by less than 100 pF. When making measurements, be careful not to exceed the overload limits given earlier in Table 2-2.

2-59. Measurement errors due to circuit loading can result when making either ac or dc voltage measurements on circuits with high source resistance. However, in most cases the error is negligible (≤0.1%) as long as the source resistance of the measurement circuit is 10 kΩ or less. If the circuit does present a problem, the percentage of error can be calculated using the appropriate formula in Figure 2-16.

2-60. AC/DC Current Measurements

WARNING

INSTRUMENT DAMAGE AND OPERATOR INJURY MAY RESULT IF THE FUSE BLOWS WHILE CURRENT IS BEING MEASURED IN A CIRCUIT WHICH EXHIBITS AN OPEN CIRCUIT VOLTAGE GREATER THAN 600V. DO NOT ATTEMPT IN-CIRCUIT CURRENT MEASUREMENT WHERE THE POTENTIAL IS GREATER THAN 600V DC OR AC RMS.

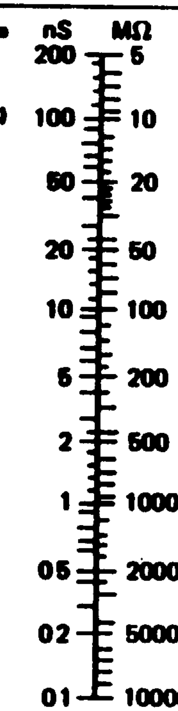
2-61. Four ac and four dc current ranges are included on the 8024B; 2 mA, 20 mA, 200 mA, and 2000 mA. Each range is diode protected to 2 amps and fuse protected above 2 amps. If the fuse blows, refer to fuse replacement information given earlier in this section.

2-62. In high electrical noise environments (near ignition switches, fluorescent lights, relay switches, etc.) unstable or erroneous readings (exceeding specifications) may occur. The effect is most obvious when measuring low level current on the 2 mA range. If an erratic or erroneous reading is suspected, temporarily jumper the V/Ω/S connector to the mA connector. This will ensure an accurate measurement. Remove this temporary jumper when the measurement has been completed. This is recommended only for the 2 mA and 20 mA ranges.

CAUTION

To avoid possible instrument damage and/or erroneous measurements, remove the temporary V/Ω/S-to-mA jumper before attempting voltage or resistance measurements.

Conversion Scale
***nS-to-MΩ**
200 nS Range
(1000/nS = MΩ)



*S = siemens = 1/Ω = International unit of conductance formerly known as the mho.

Find the approximate resistance value using the scale above. Then, on the table below, locate the most significant digit of the display reading on the vertical NO. column, and the next digit on the horizontal NO. row. The number at the intersecting coordinates represents the unknown resistance value. For example, a reading of 52.0 nS is equal to 19.2 MΩ. Decimal point location is determined from the scale approximation.

Interpolation Table (1/no.)

NO.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1	1	.909	.833	.769	.714	.667	.625	.588	.556	.526
2	.500	.476	.455	.435	.417	.400	.385	.370	.375	.345
3	.333	.323	.313	.303	.294	.286	.278	.270	.263	.256
4	.250	.244	.238	.233	.227	.222	.217	.213	.208	.204
5	.200	.196	.192	.187	.186	.182	.179	.175	.172	.169
6	.167	.164	.161	.159	.156	.154	.152	.149	.147	.145
7	.143	.141	.139	.137	.135	.133	.132	.130	.128	.127
8	.125	.123	.122	.121	.119	.118	.116	.115	.114	.112
9	.111	.110	.109	.108	.106	.105	.104	.103	.102	.101

Figure 2-14. Conductance-to-Resistance Conversion

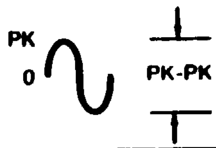
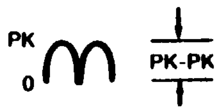
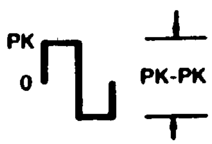
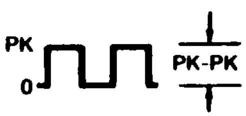
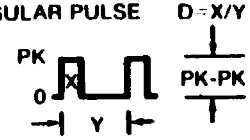
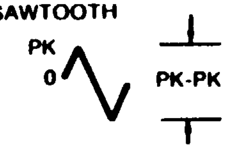
GIVEN INPUT WAVEFORM	8024B DISPLAY MULTIPLIER FOR MEASUREMENT CONVERSION			
	PK-PK	0-PK	RMS	AVG
SINE 	2.828	1.414	1.000	0.900
RECTIFIED SINE (FULL WAVE) 	1.414	1.414	1.000	0.900
RECTIFIED SINE (HALF WAVE) 	2.828	2.828	1.414	0.900
SQUARE 	1.800	0.900	0.900	0.900
RECTIFIED SQUARE 	1.800	1.800	1.272	0.900
RECTANGULAR PULSE D=X/Y 	0.9/D	0.9/D	$0.9/D^{1/2}$	0.9D
TRIANGLE SAWTOOTH 	3.600	1.800	1.038	0.900

Figure 2-15. Waveform Conversion

1. DC VOLTAGE MEASUREMENTS

Loading Error in % = 100 x Rs ÷ (Rs + 10^7)
Where: Rs = Source resistance in ohms of circuit being measured.

2. AC VOLTAGE MEASUREMENTS

First, determine input impedance, as follows: *

$$Z\,in = \frac{10^7}{\sqrt{1 + (2\pi F \cdot Rin \cdot C)^2}}$$

Where: Zin = effective input impedance
Rin = 10^7 ohms
Cin = 100×10^{-12} Farads
F = frequency in Hz

Then, determine source loading error as follows: *

$$\text{Loading Error in \%} = 100 \times \frac{Zs}{Zs + Zin}$$

Where: Zs = source impedance
Zin = input impedance (calculated)

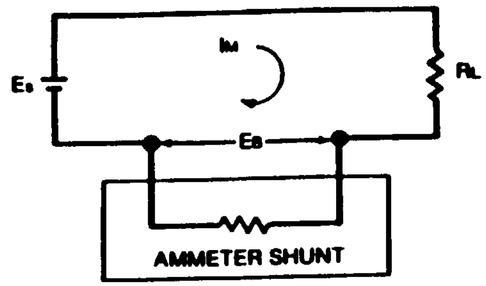
* Vector algebra required.

Figure 2-16. Voltage Measurement Error Calculations

2-63. Full-scale burden voltage (voltage drop across the input terminals) for all ranges except 2000 mA is less than 300 mV. The 2000 mA range has full-scale burden voltage of less than 900 mV. This voltage drop can affect the accuracy of a current measurement if the current is unregulated and the DMM resistance represents a significant portion (1/1000 or more) of the source resistance. If burden voltage does present a problem, the percentage of error can be calculated using the formula in Figure 2-17. This error can be minimized by using the highest current range that gives the necessary resolution. For example, if 20 mA is measured on the 2000 mA range the burden voltage is approximately 5 mV.

2-64. Resistance Measurements

2-65. Six direct reading resistance ranges are provided on the 8024B; 20 MΩ, 2000 kΩ, 200 kΩ, 20 kΩ, 2 kΩ, and 200Ω. All ranges employ a two wire measurement technique. As a result, test lead resistance may influence measurement accuracy on the 200Ω range. To determine the error, short the test leads together and read the lead resistance. Correct the measurement by subtracting the lead resistance from the unknown reading. The error is generally on the order of 0.2 to 0.3 ohms for a standard pair of test leads.



E_S = Source voltage
R_L = Load resistance + Source resistance
I_M = Measured current (display reading in mA)
E_B = Burden voltage (calculated), i.e.: Display reading expressed as a % of full-scale $(100 \times \frac{READING}{FULL\text{-}SCALE})$ times full-scale burden voltage for selected range. See Table.

RANGE	MAXIMUM BURDEN VOLTAGE
2 mA to 200 mA	0.3V
2000 mA	0.9V

current error due to Burden Voltage

$$\text{IN \%} = 100 \times \frac{E_B}{E_S - E_B}$$

$$\text{IN mA} = \frac{E_B \times I_M}{E_S - E_B}$$

Example: E_S = 14V, R_L = 9Ω, I_M = 1497 mA,

$$E_B = 100 \times \frac{1497}{2000} \times 0.9 \text{ (from Table)} =$$

74.9% or 0.9 = 0.674V

$$\text{Error in \%} = 100 \frac{.674}{14 - .674} = 100 \frac{.674}{13.326} = 5.06\%$$

Increase displayed current by 5.06% to obtain true current.

$$\text{Error in mA} = \frac{.674 \times 1497}{14 - .674} = \frac{1009}{13.326} = 76 \text{ mA}$$

Increase displayed current by 76 mA to obtain true current.

Figure 2-17. Current Measurement Calculations

2-66. Three resistance ranges have a high enough open circuit voltage to turn on a silicon junction. These ranges - 2 kΩ, 200 kΩ, and 20 MΩ - can be used to check silicon diodes and transistors. The preferred 2 kΩ range is marked with a diode symbol. The 200Ω, 20 kΩ and 2000 kΩ ranges can be used to make in-circuit resistance measurements. Typical full scale voltage and short circuit current for each resistance range is given in Table 2-4. All values shown are referenced to the COMMON input terminal; i.e., the V/Ω/S terminal is positive.

NOTE

Any changes (greater than one or two digits) in apparent resistance when test leads are reversed may indicate either the presence of a diode junction or a voltage in the circuit.

CAUTION

Turn test circuit power off and discharge all capacitors before attempting in-circuit resistance measurements.

Table 2-4. Voltage/Current Capability of Resistance Ranges

RANGE	FULL-SCALE VOLTAGE (TYPICAL)	SHORT CIRCUIT CURRENT (TYPICAL)
20 MΩ	+800 mV	+0.12 μA
2000 kΩ	+200 mV	+0.12 μA
200 kΩ	+800 mV	+12 μA
20 kΩ	+200 mV	+12 μA
2 kΩ ⊣▶⊢	+1.1V	+1.0 mA
200Ω	+56 mV	+0.3 mA

2-67. APPLICATIONS

2-68. The test applications described in the following paragraphs are suggested useful extensions of the 8024B measurement capabilities. However, they are not intended as the equivalent of manufacturer's recommended test methods. They are intended to provide repeatable and meaningful indications which will allow the operator to make sound judgments concerning the condition of the device tested; i.e. good, marginal, or defective.

2-69. THERMOCOUPLES

2-70. Introduction

2-71. In 1821, Seebeck found that when two dissimilar metals are connected at two junctions and the junctions are at different temperatures, a current will flow in the loop (Figure 2-18, Part A) and will continue to flow as long as there is a difference in temperature. This principle is used by your 8024B when making temperature measurements.

2-72. The K-type thermocouple that is used with your 8024B is made from two dissimilar metals, Chromel and Alumel. As long as the same two types of metal are used throughout the loop (Figure 2-18, Part B), there are still only two junctions. The copper conductors of

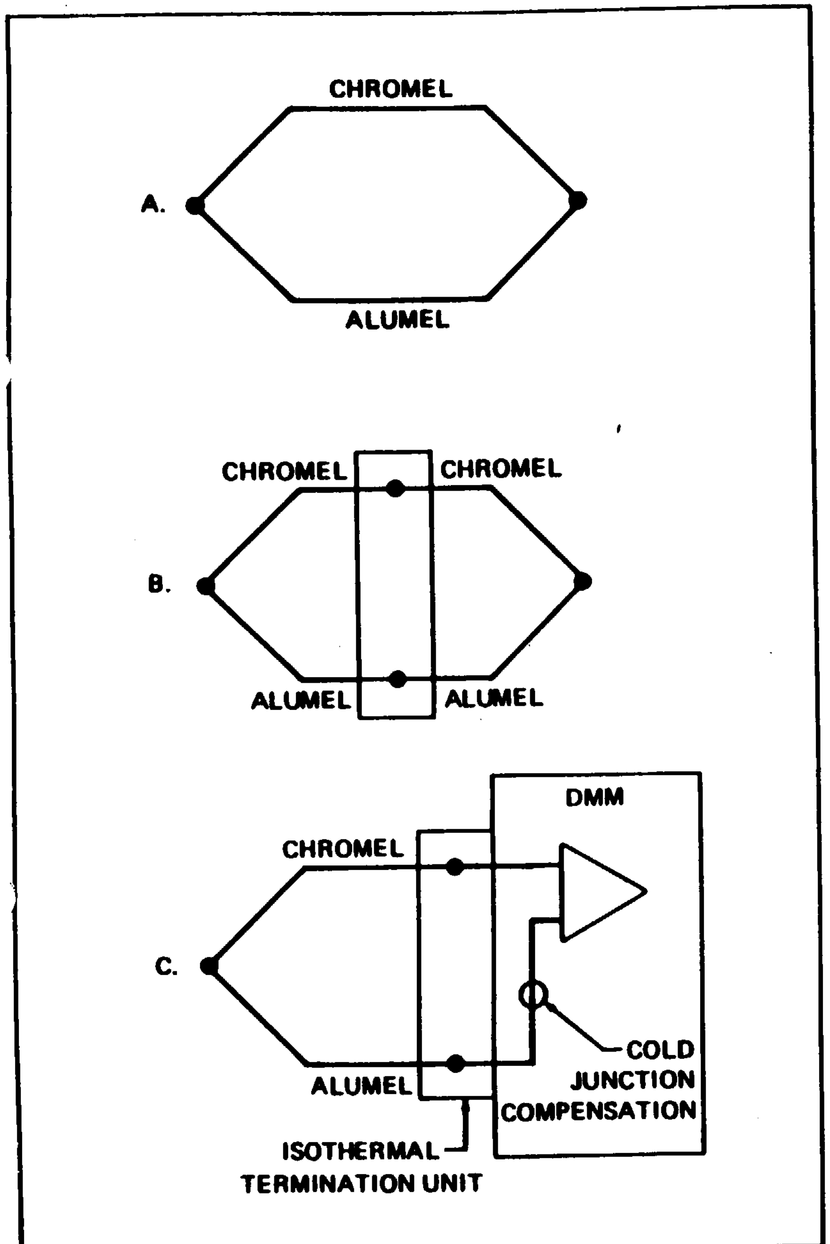


Figure 2-18. Thermocouples

your 8024B are different from both the Alumel and the Chromel (Figure 2-18, Part C) which would seem to add a third junction to the loop. But, remember there is no current or voltage in a thermocouple loop if both junctions are at the same temperature. The isothermal characteristics of the special termination unit for John Fluke thermocouples insures that the two junctions at your DMM are at the same temperature. This leaves the original circuit as shown in Figure 2-18, Part A. If you are going to connect your own K-type thermocouple, use a John Fluke Model Y8104 Thermocouple Termination Unit (see Section 6 for details).

2-73. Monitoring More Than One Thermocouple

2-74. You can use your 8024B to monitor more than one thermocouple – even thermocouples that are permanently mounted in your system. If your present K-type thermocouples are permanently mounted in a system and have individual remote reading stations, you can attach your present K-type thermocouple quick-connect to a John Fluke Model Y8104 Thermocouple Termination Unit via K-type thermocouple wire (Figure 2-19). Then plug the Y8104 into your 8024B, and carry the meter and thermocouple quick-connect assembly from station to station reading the various temperatures. If your thermocouples are routed to a centralized point (Figure 2-20), use one or more John Fluke Model 2161A Multipoint Selectors. Connect the last 2161A to your 8024B via a Y8104 Thermocouple Termination Unit and select the thermocouple(s) you want to read.

2-75. Leakage Tester

2-76. The 200 nS conductance range effectively extends the resistance measurement capability of the 8024B (up to 10,000 MΩ) to the point where it can be used to provide useful leakage measurements on passive components. For example, you can detect leaky capacitors, diodes, cables, connectors, printed circuit boards (pcbs), etc. In all cases, the test voltage is <5V dc.

2-77. Leakage testing on purely resistive components such as cables and pcbs is straightforward. Select the 200 nS range, install the test leads in the V/Ω/S and COMMON input terminals, connect the leads to the desired test points on the unit-under-test, and read leakage conductance. If an overrange occurs, select the resistance range that provides on-scale reading.

NOTE

Under high humidity conditions (>80%) conductance measurements may be in error. To ensure accurate measurement, connect clean test leads to the 8024B and (with the leads open) read the residual leakage in nanosiemens. Correct subsequent measurements by subtracting the residual from the readings. (Fingerprints or other contamination on the pcb may also cause residual conductance readings.)

2-78. DIODES

2-79. Diode leakage (IR) tests require that the diode junction be reverse biased when being measured. This is accomplished by connecting the diode's anode to the COMMON input terminal and its cathode to the V/Ω/S input terminal. Leakage can then be read in terms of conductance. In the event of an overrange, select the resistance range that provides on-scale reading.

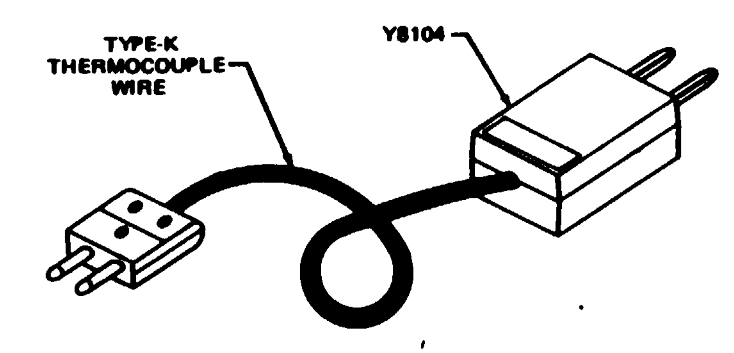
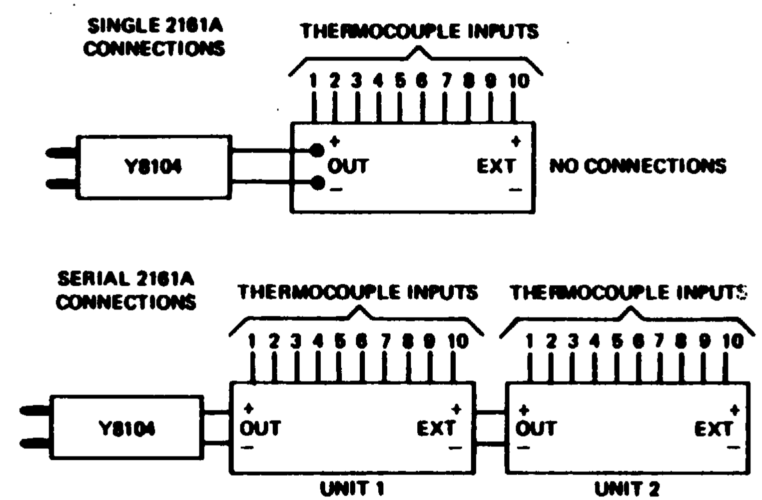


Figure 2-19. Thermocouple Termination Unit



NOTE:
In both configurations all interconnects are made using a thermocouple wire type that is identical to the input thermocouples.

Figure 2-20. Multipoint Selection

Section
Theory of Operatio

3-1. INTRODUCTION

3-2. This section of the manual describes the theory of operation of your 8024B. Th overall function of your 8024B is presented first at an overall functional level. Then t operation of the a/d converter and each function of your 8024B is described in more detai A detailed schematic of your 8024B can be found in Section 7.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. Figure 3-1 shows the major circuits of your 8024B arranged in a simplifie functional block diagram. Input signals are routed by the range and function switch through the appropriate signal conditioners so that a dc analog signal that is proportion to the input signal is applied to the input of the a/d converter if the PEAK HOLD switch at the OFF position. If the PEAK HOLD switch is at the ON position, the dc analog sign will be stored on a capacitor in the peak hold circuit which will drive the a/d converter wi a dc voltage that is the same as the stored charge on the peak hold capacitor until t PEAK HOLD switch is set to the OFF position. The a/d converter will drive the display a digital display that is numerically the same as the proportional input signal. Decim point position is determined by the range switch selected. When the Ω function is selecte the input signal is also routed to the level detector circuit. The level detector circu compares the input signal level to a +0.8V reference (200 kΩ range). If the signal is mo positive than the reference, the level detector circuit will cause the ▲ up arrow to b displayed (over the minus sign position). If the input signal is less positive than t reference, the level detector will cause the down arrow to be displayed (under the mini sign position). If the audible tone is enabled (AC/DC switch at the AC position) the lev detector circuit will cause the audible tone to sound when the input signal is less positi than the reference.

3-5. A/D Converter

3-6. The entire analog-to-digital conversion process is accomplished by a single custo a/d converter and display driver IC, U8. The a/d converter employs the dual slope metho of a/d conversion and requires a series of external components to establish the bas timing and reference levels required for operation. These include an integrating capacito an autozero capacitor, and a flying capacitor (for applying a reference level of eith polarity). Since the power consumed for display operation is very low, the a/d convert IC also contains the display latches, decoders, and drivers.

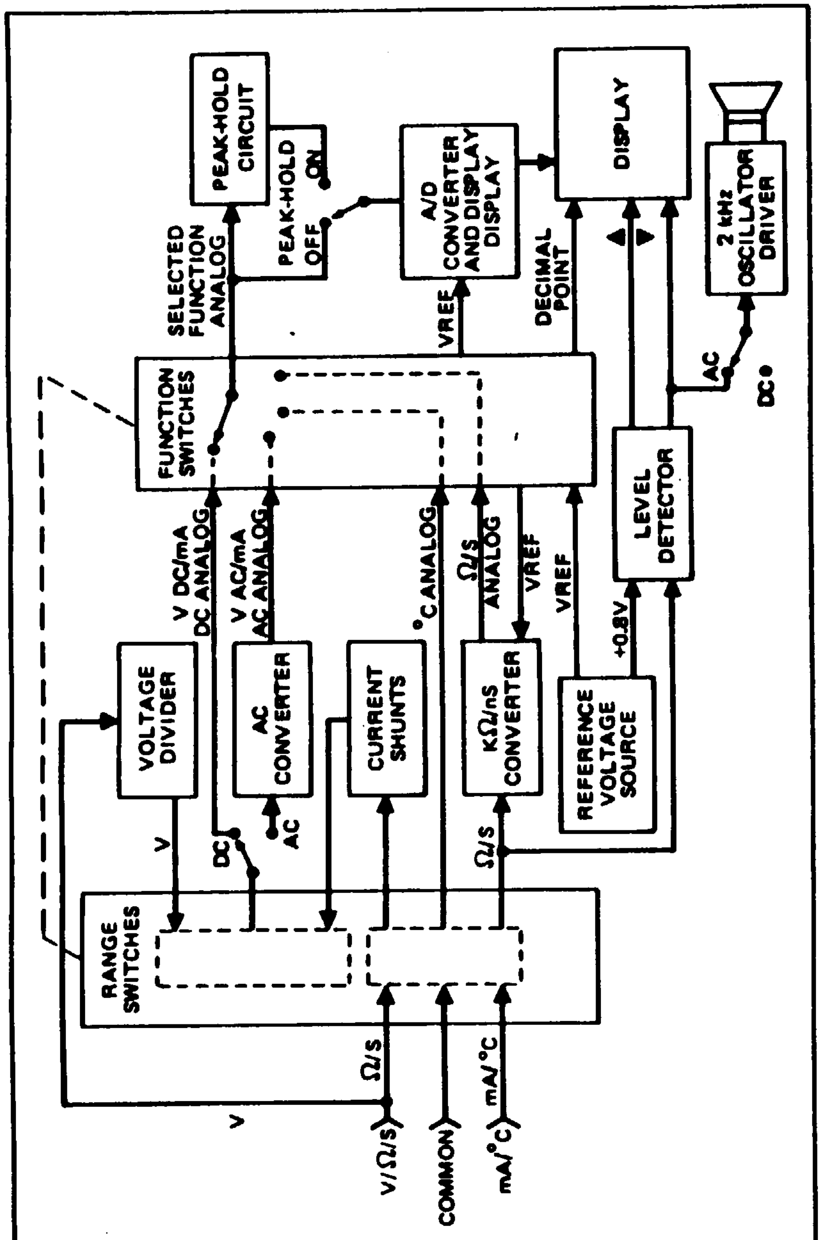


Figure 3-1. 8024B Block Diagram

3-7. The digital control portion of the a/d converter process is an internal function of U8, and is keyed to the external crystal frequency. As a result, the conversion process is continuously repeated, and the display is updated at the end of every conversion cycle.

3-8. A simplified circuit diagram of the analog portion of the a/d converter is shown in Figure 3-2. Each of the switches shown represent analog gates which are operated by the digital section of the a/d converter. (Sheet 1 of the Schematic also illustrates the a/d converter in a block form.) Basic timing for switch operation and, therefore, a complete measurement cycle is shown in Figure 3-3.

3-9. Any given measurement cycle performed by the a/d converter can be divided into three consecutive time periods, autozero (AZ), integrate (INTEG), and read. Both autozero and integrate are fixed time periods whose lengths are multiples of the clock frequency. A counter determines the length of both time periods by providing an overflow at the end of every 10,000 clock pulses. The read period is a variable time which is proportional to the unknown input voltage. The value of the voltage is determined by counting the number of clock pulses that occur during the read period.

3-10. During autozero, a ground reference is applied as an input to the a/d converter. Under ideal conditions the output of the comparator would also go to zero. However, input-offset-voltage errors accumulate in the amplifier loop, and appear at the comparator output as an error voltage. This error is impressed across the AZ capacitor where it is stored for the remainder of the measurement cycle. The stored level is used to provide offset voltage correction during the integrate and read periods.

3-11. The integrate period begins at the end of the autozero period. As the period begins, the AZ switch opens and the INTEG switch closes. This applies the unknown input voltage to the input of the a/d converter. The voltage is buffered and passed on to the integrator to determine the charge rate (slope) on the INTEG capacitor. At the end of the fixed integrate period, the capacitor is charged to a level proportional to the unknown input voltage. This voltage is translated to a digital indication by discharging the capacitor at a fixed rate during the read period, and counting the number of clock pulses that occur before it returns to the original autozero level.

3-12. As the read period begins, the INTEG switch opens and the read switch closes. This applies a known reference voltage to the input of the a/d converter. The polarity of this voltage is automatically selected to be opposite that of the unknown input voltage, thus causing the INTEG capacitor to discharge at a fixed rate (slope). When the charge is equal to the initial starting point (autozero level), the read period is ended. Since the discharge slope is fixed during the read period, the time required for discharge is proportional to the unknown input voltage.

3-13. The autozero period, and thus a new measurement cycle, begins at the end of the read period. At the same time the counter is released for operation by transferring its contents (previous measurement value) to a series of latches. This stored data is then decoded and buffered before being used for driving the liquid crystal display.

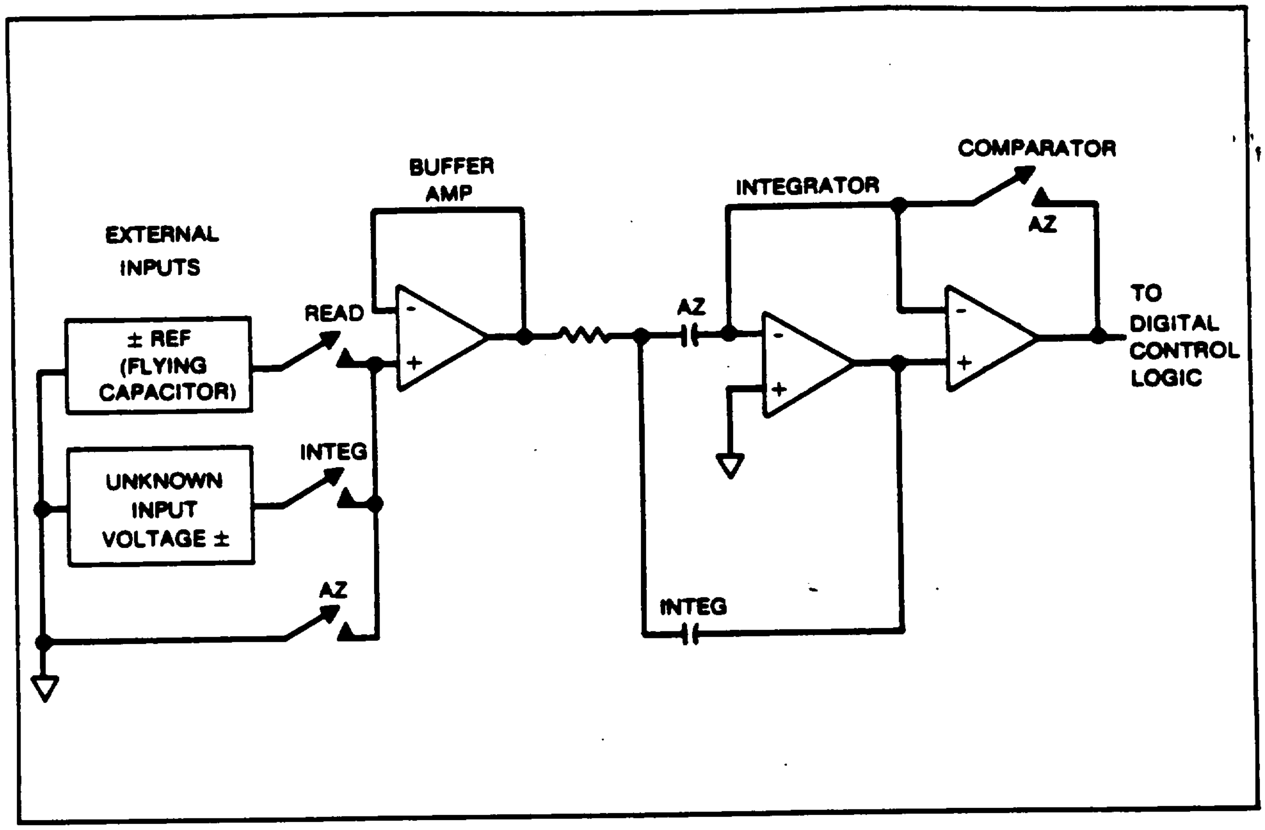


Figure 3-2. A/D Converter Functional Diagram

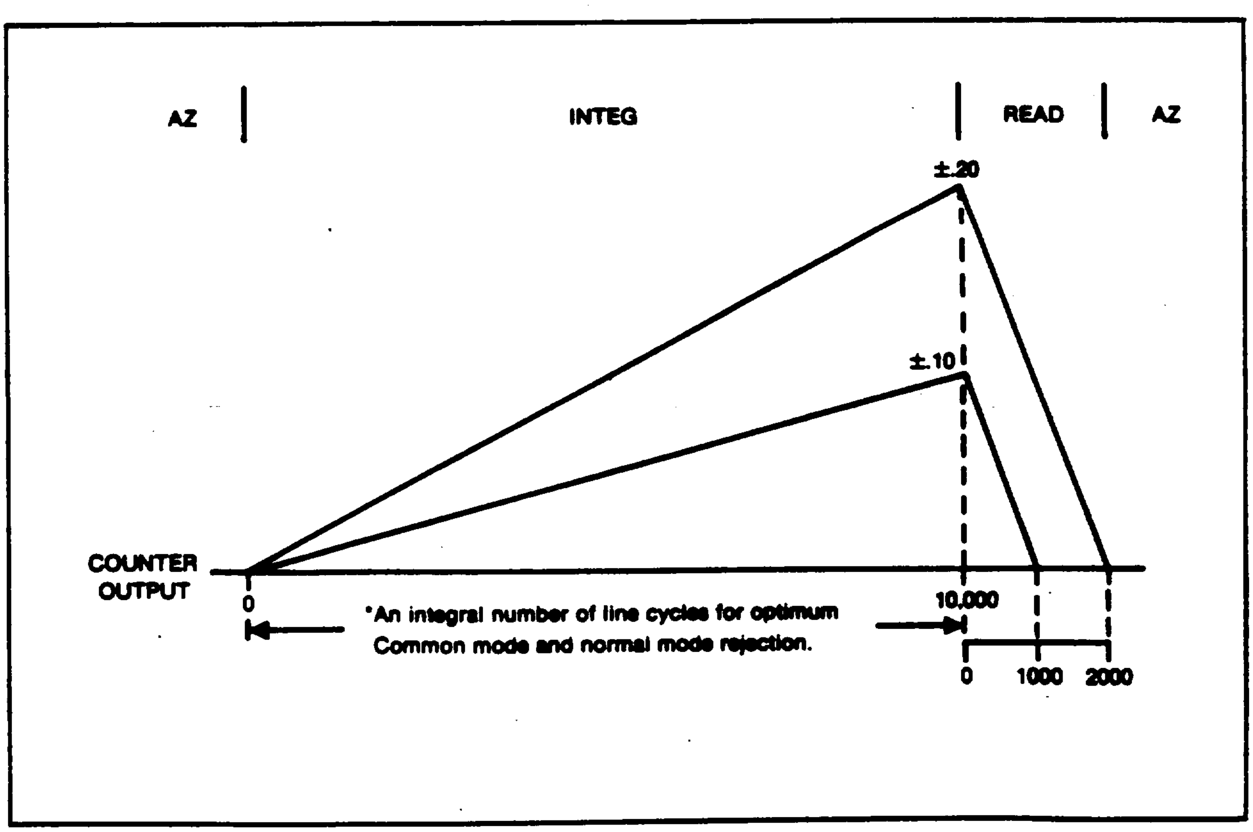


Figure 3-3. Integrate Capacitor Waveform

3-14. Voltage Measurement Function

3-15. Both ac and dc voltage measurement functions use an overvoltage protected 10 MΩ input divider to scale down the input voltage. Under normal conditions (assuming a dc input signal on the proper range) the divider output is a dc voltage that is directly proportional to the input signal level. If the AC function is selected, the output of the divider is ac coupled to an active full-wave rectifier whose dc output is calibrated to equal the rms level of the ac input (for sine wave inputs). If the PEAK HOLD switch is at the OFF position, the dc voltage from the divider or the ac converter is passed through a filter and applied to the a/d converter as the unknown input (Figure 3-4). Peak Hold operation will be covered later.

3-16. Current Measurement Function

3-17. Current measurements are made using a fuse protected, switchable, current shunt (0.1Ω, 1Ω, 10Ω, or 100Ω) to perform the current-to-voltage conversion required by the a/d converter (Figure 3-5). The voltage (IR) drop produced across the selected shunt may be either ac or dc. If the input current is dc and the DC function is selected, the IR drop is passed through a low-pass filter, and presented as the unknown input to the a/d converter. However, if the input current is ac and the AC function is selected, the IR drop is rectified by the ac converter. If the PEAK HOLD switch is at the OFF position, the dc signal from either the ac converter or the current shunt is routed through a filter to the a/d converter. This unknown input voltage to the a/d converter is proportional to the current passing through the current shunt.

3-18. Temperature (°C) Measurement Function

3-19. As Figure 3-6 shows, the input from the thermocouple accessory is applied across the mA and COMMON terminals. If the PEAK HOLD switch is in the OFF position the input will be routed through a filter to the a/d converter unknown input. The COMMON terminal is thermally tied to the collector and base leads of transistor Q3. This provides reference junction temperature compensation. Q3 changes with temperature and provides an offset voltage to counter the thermocouple at the input jacks to ensure the integrity of the reading at the measurement end.

3-20. Resistance Measurement Function

3-21. Resistance measurements are made using a ratio technique as shown in Figure 3-7. When the kΩ function is selected, a simple series of circuits are formed by the internal reference voltage, a reference resistor from the voltage divider (selected by range switches), and the external unknown resistor. The ratio of the two resistors is equal to the ratio of their respective voltage drops. Therefore, since the value of one resistor is known, the value of the second can be determined by using the voltage drop across the known resistor as a reference. This determination is made directly by the a/d converter.

3-22. Overall operation of the a/d converter during a resistance measurement is basically as described earlier in this section, with oneexception. The reference voltage present during a voltage measurement is replaced by the voltage drop across the reference resistor. This allows the voltage across the unknown resistor to be read during the integrate period, and compared against the reference resistor during the read period. As before, the length of the read period is a direct indication of the value of the unknown. The PEAK HOLD switch should always be in the OFF position when making resistance measurements.

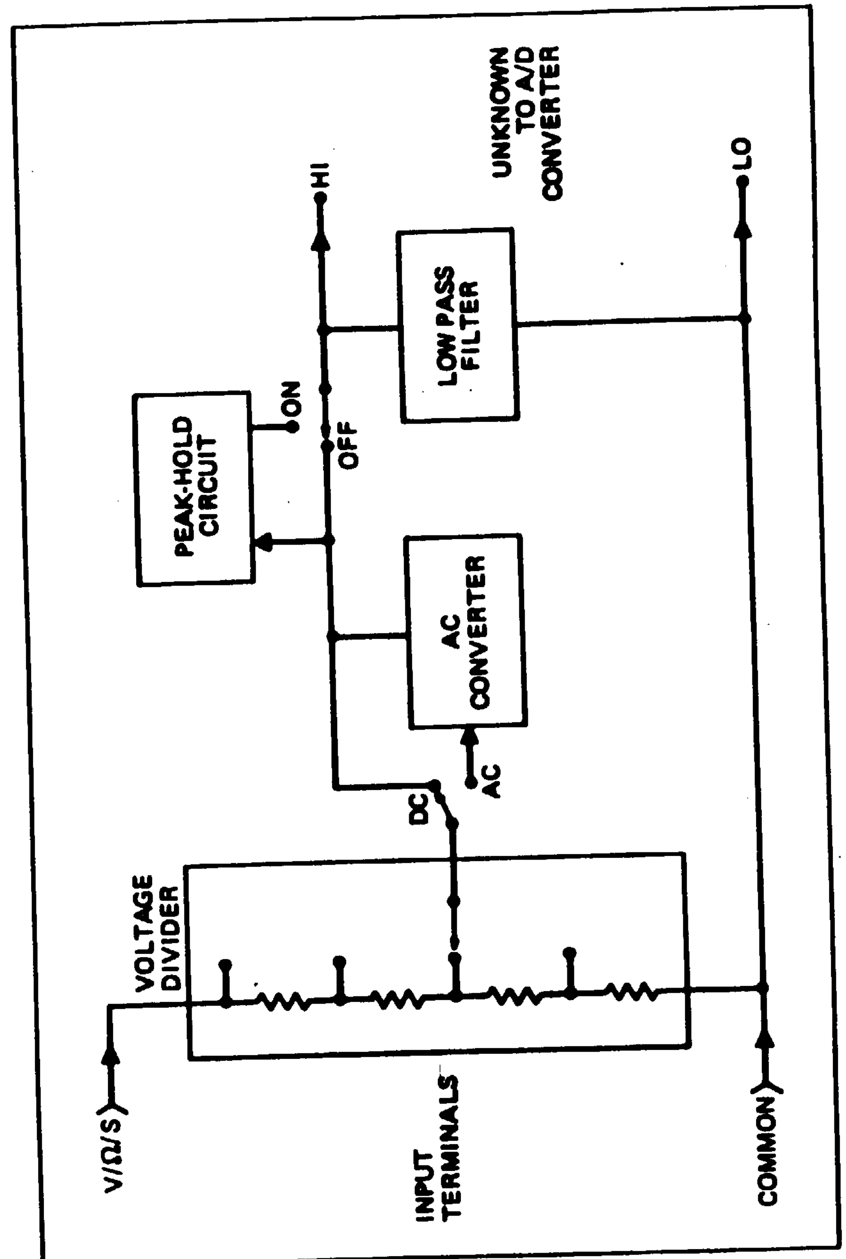


Figure 3-4. Voltage Measurement

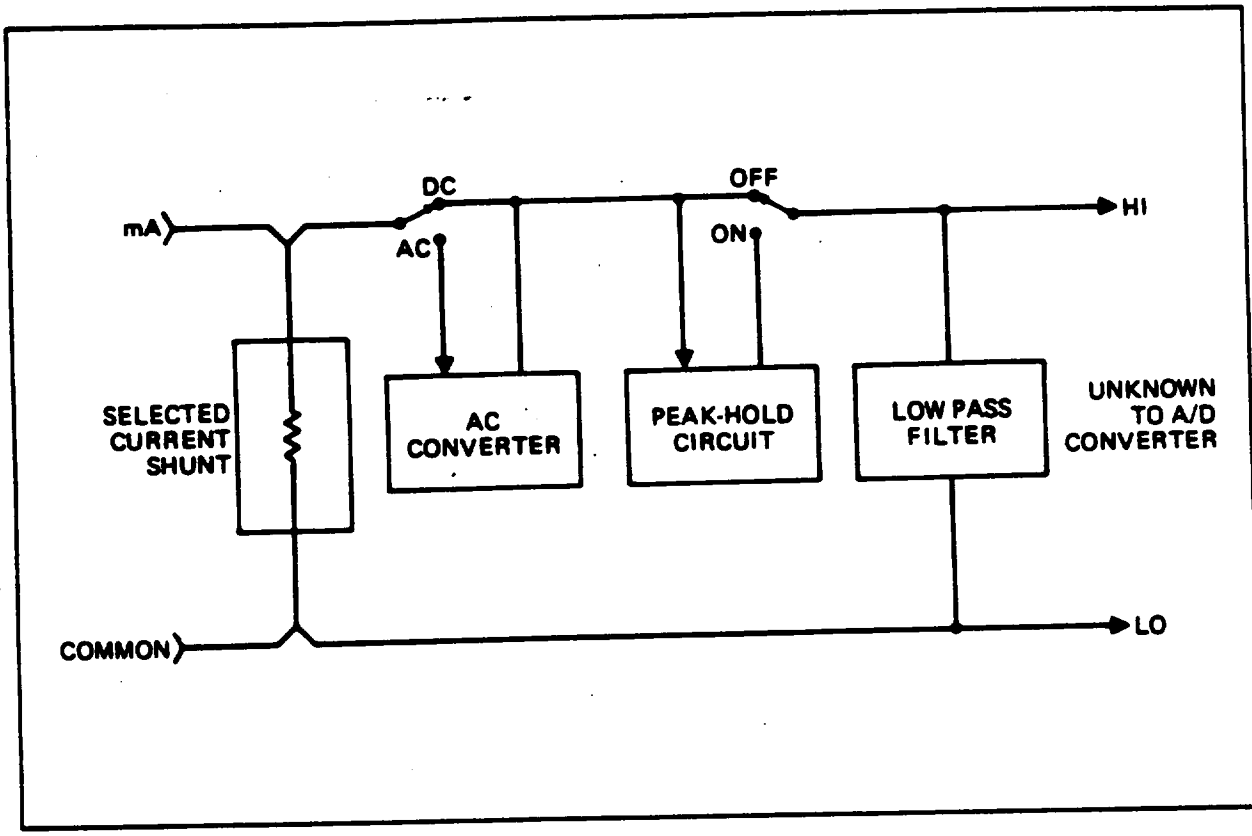


Figure 3-5. Current Measurement

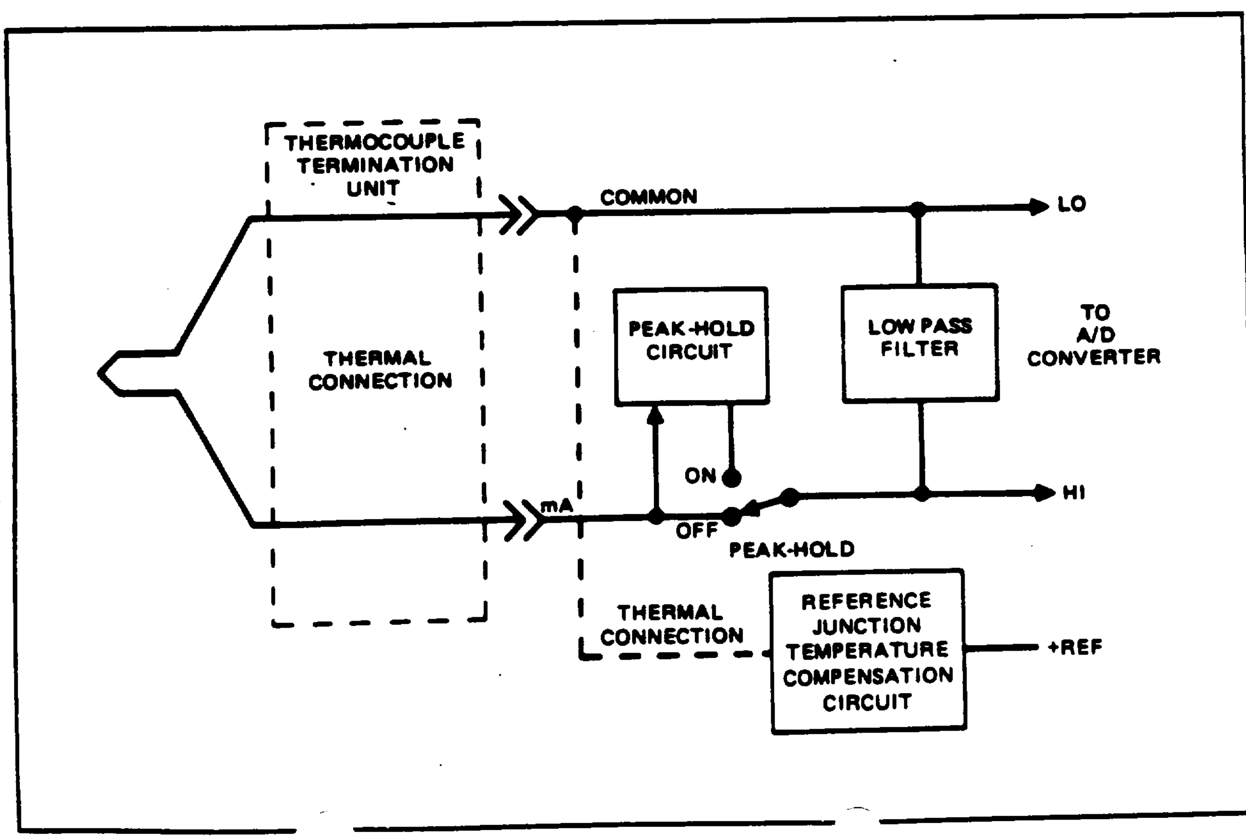


Figure 3-6. Temperature Measurement

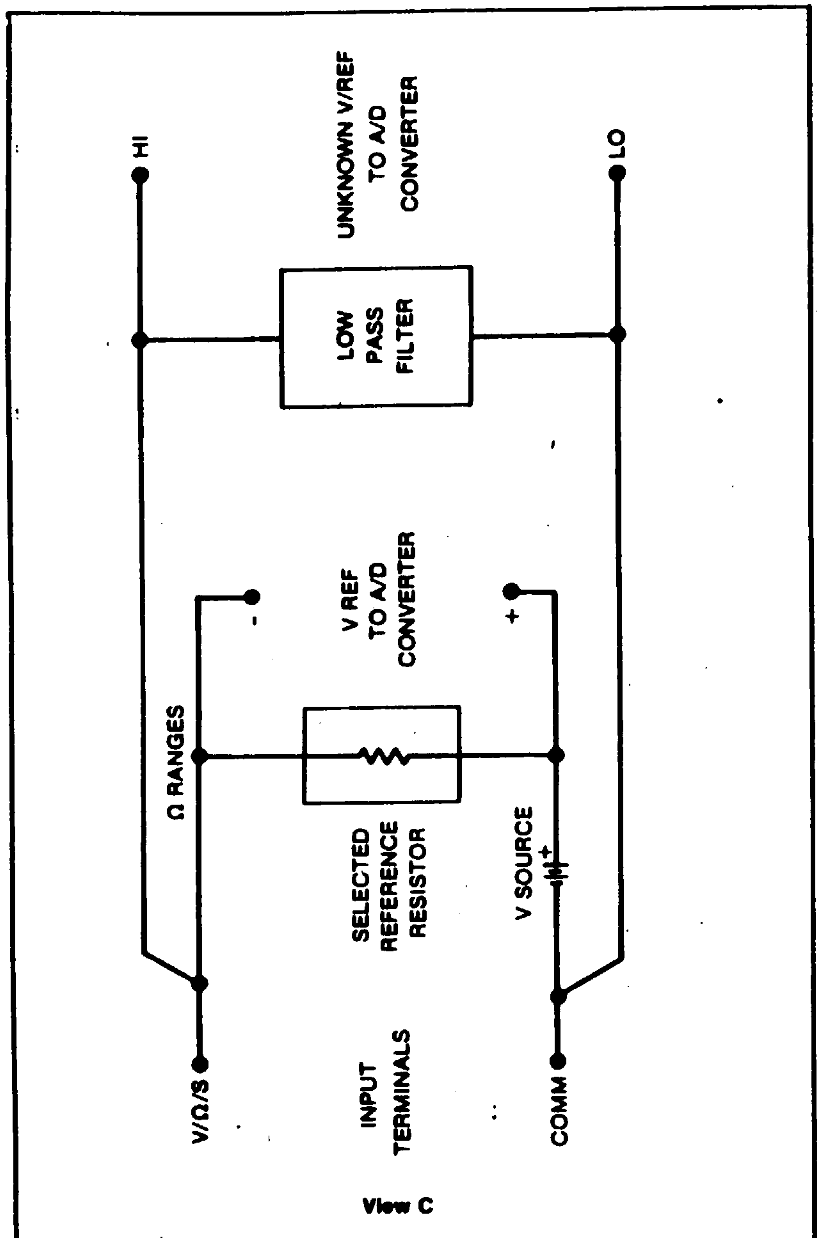


Figure 3-7. Resistance/Conductance Measurement

3-23. Conductance Measurement Function

3-24. Conductance measurements are made using a ratio technique similar to that used in making resistance measurements (Figure 3-7). The main differences are: only one range is provided (200 nS), and the function of the range resistor and the unknown resistor in the measurement cycle is reversed. That is, the voltage drop across the range resistor is used as the unknown input during the integrate period, and the voltage across the unknown resistor is used for the reference input during the read period. As a result, the display provides a reading that is the reciprocal (1/Ω) of the unknown input resistance; i.e., the higher the input resistance, the lower the display reading. The PEAK HOLD switch should always be in the OFF position when making conductance measurements.

3-25. Peak Hold Circuit Level

3-26. As Figure 3-8 shows, the peak hold circuit consists of an operational amplifier (U19) and a capacitor (C19) which is across the a/d converter (U8) input. When the PEAK HOLD switch is set to the ON position, switch action removes the normal input to the a/d converter and routes the output of the signal conditioners to U19. The operational amplifier charges C19 to the peak positive input signal to the DMM. The charge on C19 is the unknown value that the a/d converter reads to determine the displayed value. As the charge on C19 bleeds off through U19, U14, and Q10, the display value will decay. Peak-Hold AC will give the peak rms value of a sine wave since the signal is routed through the AC Converter. Peak-Hold DC should give the positive peak of any input waveform.

3-27. Level Detector Circuit

3-28. As Figure 3-9 shows, when the Ω or S functions are selected, the DMM input is routed both to the resistance/conductance signal conditioner and to the comparator of the level detector circuit. The other input to the comparator is a +0.8V reference level (200 kΩ range). When the DMM input is open circuited or greater than the reference, the level detector circuit causes the ▲up arrow to appear in the display. If the DMM input is less than the reference level, the level detector circuit causes the ▼down arrow to appear in the display and the audible tone to sound if the AC/DC switch is at the AC position.

NOTE

The Peak-Hold switch should be in the OFF position when using the Level Detector Circuit.

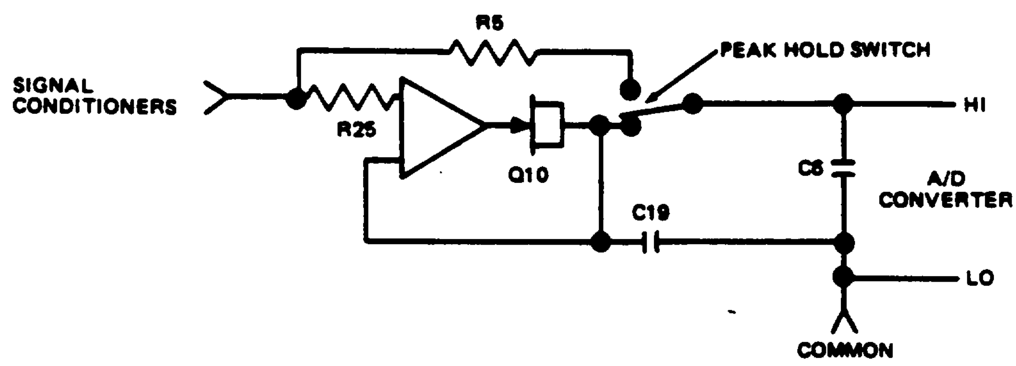


Figure 3-8. Simplified Peak Hold Circuit

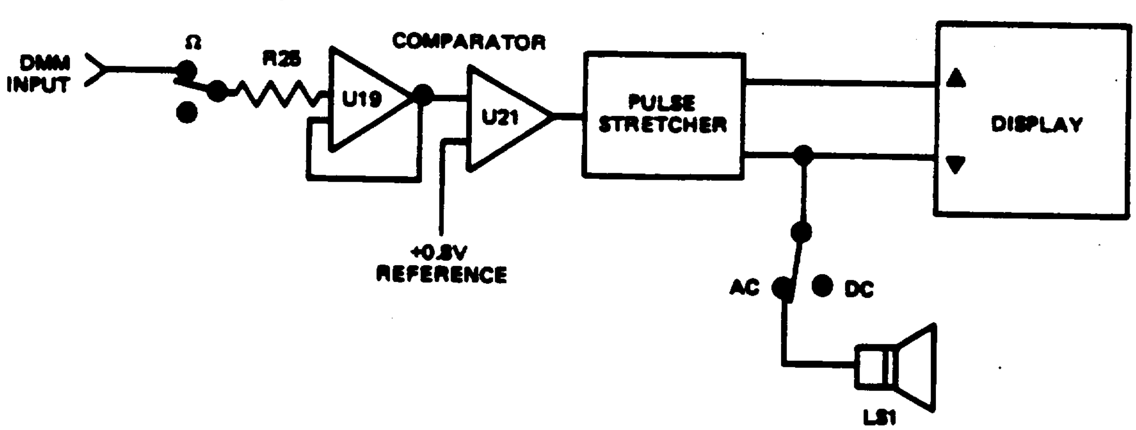
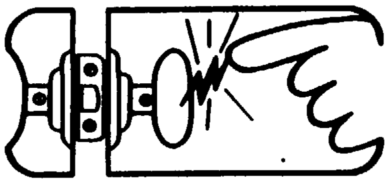


Figure 3-9. Simplified Level Detector Circuit

static awareness

A Message From
John Fluke Mfg. Co., Inc.



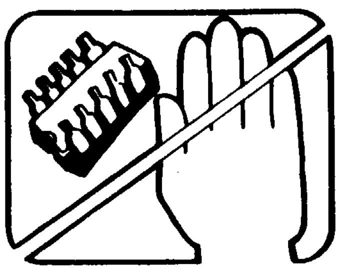
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

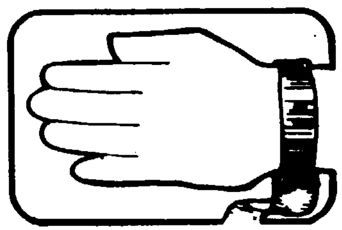
The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol

"Ⓢ"

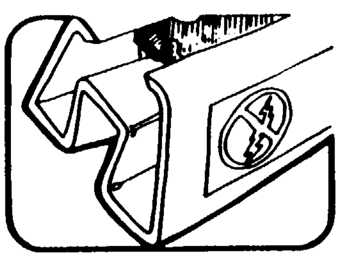
The following practices should be followed to minimize damage to S.S. devices.



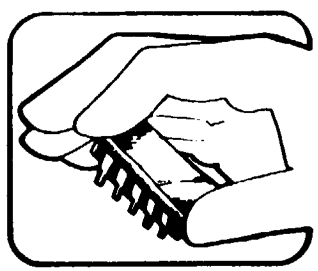
1. MINIMIZE HANDLING



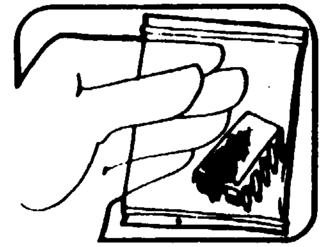
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



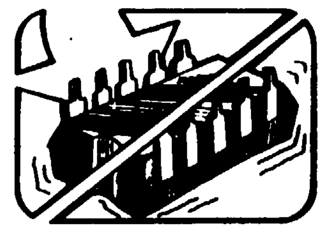
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



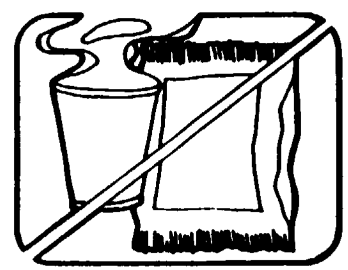
4. HANDLE S.S. DEVICES BY THE BODY



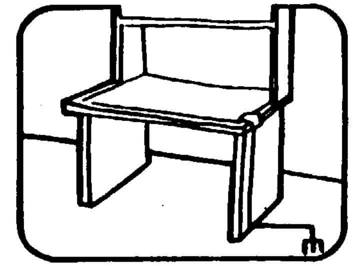
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM IN WORK AREA



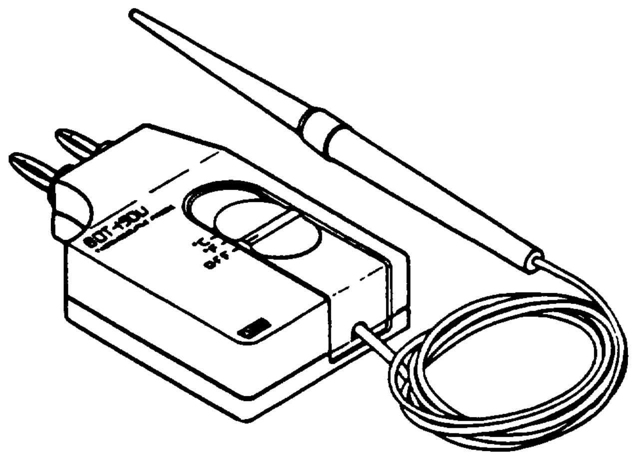
8. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

9. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

10. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Bag Size
453522	6" x 8"
453530	8" x 12"
453548	16" x 24"
454025	12" x 15"



FLUKE®

Instruction Sheet

80T-150U

Universal Temperature Probe

INTRODUCTION

The Model 80T-150U Universal Temperature Probe is a self-contained temperature-to-voltage converter. The probe is designed to provide a direct temperature reading when it is connected to any high impedance DMM that is capable of 1 mV resolution and at least a 300-count full scale readout capability. Output is l mV per degree (Celsius or Fahrenheit). Two switch-selected temperature output scalings are provided: -50 to +150°C or -58 to +302°F. The probe will stand off 350V dc or peak ac.

The unit is housed in two separate but attached assemblies: a temperature probe and a temperature-to-voltage converter. The probe contains the temperature-sensing element and is electrically connected to the temperature-to-voltage converter through a 46-inch shielded cable. A three-position switch on the converter acts as a power switch and is used for selecting Celsius or Fahrenheit scaling for the output. Two banana plugs with standard 0.75-inch spacing are provided for connecting the 80T-150U to the DMM.

Operating power for the 80T-150U is derived from a standard 9V battery. Typically, an alkaline battery provides more than 1600 hours of continuous operation before replacement is necessary. An OFF switch is provided on the temperature-to-voltage converter to allow battery conservation when the unit is not in use. In addition, the OFF position of the power switch allows the battery condition to be determined via the external DMM.

Temperature is measured by exposing the probe tip directly to the material to be measured (non-corrosive liquid, gas, or solid). A direct temperature reading is displayed on the DMM.

SPECIFICATIONS

The 80T-150U will achieve rated accuracy when it is used with any 0.25% DMM that has an input impedance of ≥ 1 MΩ.

ELECTRICAL

Measurement Range: -50 to +150 degrees Celsius
-58 to +302 degrees Fahrenheit

Accuracy:

AMBIENT °C	ACCURACY
+15 to +35°C	±1°C from 0 to +100°C, decreasing linearly to ±3°C at -50 and +150°C
0 to 15°C and +35 to +50°C	±2°C from 0 to +100°C, decreasing linearly to ±4°C at -50 and +150°C

AMBIENT °F	ACCURACY
+59 to +95°F	±1.8°F from +32 to +212°F, decreasing linearly to ±5.4°F at -58 and 302°F
+32 to +59 °F and +95 to +122 °F	±3.6°F from +32 to +212°F, decreasing linearly to ±7.2 °F at -58 and 302°F

Sensitivity (80T-150U output): 1 mV dc / °C or °F

Voltage Standoff: 350V dc or peak ac

Settling Time: 5.5 seconds to settle within 2° for a 50° change

ENVIRONMENTAL

Ambient Operating Range for Unit: 0 to +50°C (+32 to +122°F)

Maximum Temperature Probe Body and Cable: +70°C (160°F) See Probe Limitations

Storage Temperature for Unit: -40 to +70°C (-40 to +160°F)

Humidity: 0% to 90% (0°C to 35°C) noncondensing
0% to 70% (35°C to 50°C) noncondensing

Altitude: Operating: ≤ 10,000 feet
Storage: ≤ 50,000 feet

Application Force: 20 pounds maximum (probe tip to measured surface)

GENERAL

Weight: 5.7 ounces, 161.5 grams

Overall Length: 53.8 inches, 1.36 meters

Battery: Standard 9V battery (NEDA #1604,6F22,006P)

Battery Life: 1600+ hours, typical (Alkaline Battery), 6.5V minimum

Output Termination: Standard 0.75-inch spaced double banana plug

Probe Material: Glass-filled valox

Probe Size: 0.6 in. maximum diameter

Tip Material: Aluminum

Tip Size: 0.07 to 0.08 in. diameter, 30% convexed

OPERATING NOTES

The following paragraphs are intended to familiarize the operator with the 80T-150U. The operator should read these paragraphs before attempting to operate the probe.

Probe Limitations

The 80T-150U probe is constructed of a highly durable plastic and is suitable for measuring the temperature of liquids, gases, and solid surfaces up to 150°C. When measuring temperature, observe the following precautions to prevent damage to the probe:

1. Do not expose the probe end (probe tip plus about 2 inches of the probe body) to temperatures exceeding +150°C (302°F). The remainder of the probe body should not be exposed to temperatures above +70°C (160°F).
2. For liquid measurements, recommended applications range from water, lubricants, and fuels to most solvents. Liquids as shallow as ½ inch can be measured since the temperature sensor is in the probe tip.

WARNING

TO AVOID ELECTRICAL SHOCK, DO NOT USE THIS INSTRUMENT WHEN VOLTAGES EXCEEDING 350V DC OR PEAK AC ARE PRESENT. THE PROBE TIP IS ELECTRICALLY CONNECTED TO THE OUTPUT TERMINALS.

P/N 778134 FEBRUARY 1986 Rev. 2, 1/88

CAUTION

Long-term exposure of the probe to corrosive environments will result in pitting and deterioration of the aluminum probe tip.

Error Sources

When the probe tip is applied to a solid surface, it draws or sinks heat from the surface. Therefore, if the measured surface has a low mass (e.g., a transistor case), the indicated temperature may be lower than the actual temperature.

Similarly, a steady-state error or gradient exists between the measured surface and the sensing device in the probe tip. This is due to the flow of heat from the measurement surface to the probe body. The effect of the steady-state error increases as the differential between ambient and surface temperature increases.

To determine the actual surface temperature of a device, both the heat-sinking and steady-state errors must be considered. The correction curve given in Figure 1 approximates the effect of both error sources on TO-3, TO-5, and TO-18 transistor cases.

RF signals applied to the 80T-150U probe tip can also cause errors in temperature measurement. Figure 2 defines the rf signal limits that can be tolerated without degrading measurement accuracy.

OPERATION

Use the following procedure to operate the 80T-150U probe:

1. Connect the banana plugs on the 80T-150U to the input terminals of a high impedance DMM. Observe polarity.
2. Select a dc voltage range that will provide at least 1 mV resolution (1 mV/degree) and a full scale readout that will encompass the expected temperature. The 2V range of a 3 ½-digit DMM is adequate. Ignore readings of less than 1° when a more sensitive DMM is used.
3. Set the 80T-150U power switch to °C or °F, and energize the DMM.
4. Firmly touch the probe tip to the surface to be measured, or expose it to a liquid or gas. The DMM will display the temperature in degrees. Vary the probe angle and pressure when measuring solid surface temperatures. The highest stabilized reading will be the most accurate. (See the following measuring technique.)

CAUTION

The force exerted on the probe tip should not exceed 20 pounds.

MEASURING TECHNIQUE

Here are some suggestions for improving the accuracy of your temperature measurements:

1. When measuring higher than ambient temperatures, adjust the connection between the probe and the surface until you get the highest temperature reading.
2. When measuring lower than ambient temperatures, adjust the connection between the probe and the surface until you get the lowest temperature reading.
3. When measuring near ambient temperatures, make the reading when the multimeter readout is most stable.

THEORY OF OPERATION

The Model 80T-150U uses the negative temperature coefficient of a semiconductor (P-N) junction to measure temperature. The PN junction is thermally integrated into the probe tip and comprises one leg of a bridge circuit as shown in the simplified circuit diagram of Figure 3. One 9V battery is used to power both the bridge circuit and operational amplifier AR1. Since the bridge must be balanced to provide 0°C and 0°F indications, separate range or temperature scale resistors R7 and R6 are included in the bridge circuit. When R6 and R2 are shorted by S1, the °C scale is selected and the bridge is calibrated by R3 to null at 0°C. Conversely, when S1 is open, the 0°F scale is selected, and the bridge is calibrated by R2 to null at 0°F. Deviations above and below 0° provide a bridge output of approximately 2.45 mV/°C.

Operational amplifier AR1 is used to measure the bridge output and scale it to a 1 mV/degree signal. Since the °C and the °F scale are sloped differently, the scale for AR1 must be matched with the scale selected for the bridge circuit. Shorting resistors R15 and R18 selects the °C scale. Conversely, when S1 is open, the °F scale is selected. Resistor R4 calibrates both scales.

The output voltage used to drive the external voltmeter is taken from the output of AR1 (P2) and the reference side of the bridge (P1). Since AR1 is operating as an inverting amplifier, its output is used as the low input to the voltmeter. This enables the voltmeter to display an increase in temperature as an increase in voltage.

GENERAL MAINTENANCE

Access Information

The battery and the calibration pots are located on the interior of the temperature-to-voltage converter assembly. Access to these locations is accomplished by removing the screw from the bottom side of the assembly and removing the top of the plastic case.

Battery Condition Test

1. Set the power switch to the OFF position.
2. Connect the 80T-150U to the DMM.
3. Set the DMM to the 200 or 300 mV dc range.
4. Read the battery test voltage on the DMM. A minimum reading of 100 mV is acceptable and indicates that approximately 100 hours of battery life remain.

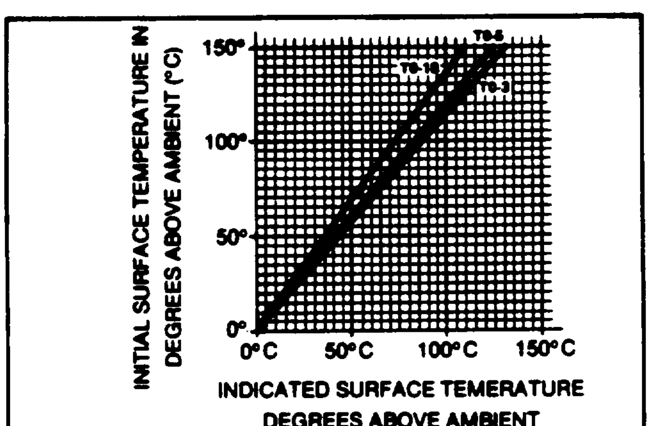


Figure 1. Initial Case Temperature Above Ambient vs. Meter Reading Above Ambient

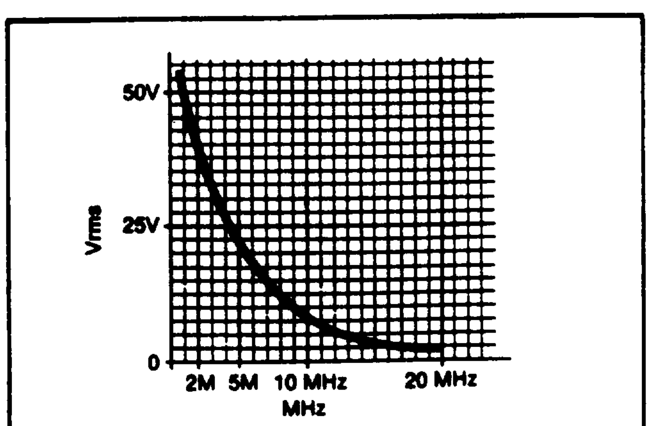


Figure 2. Maximum Signal RF Limits (Vrms) at Probe Tip

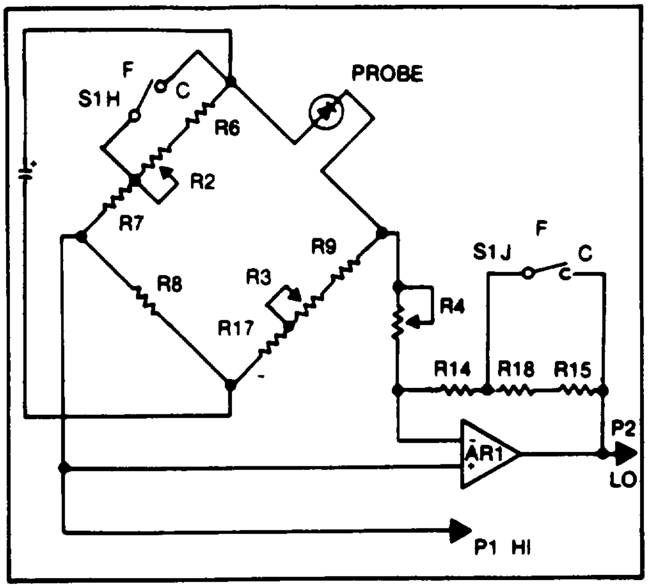


Figure 3. Simplified Circuit Diagram

Battery Replacement

WARNING

TO AVOID ELECTRICAL SHOCK, REMOVE THE PROBE FROM THE MEASUREMENT SURFACE BEFORE OPENING THE CASE. TOTALLY REASSEMBLE THE INSTRUMENT BEFORE ATTEMPTING TO USE IT.

1. Set the power switch to the OFF position.
2. Disconnect the 80T-150U from the DMM.
3. Turn the 80T-150U so the power switch is facing down. Remove the single screw located between the banana plugs.
4. Grasp one case half in each hand. Pull the two halves apart, beginning at the end with the banana plugs.
5. Remove and replace the battery.
6. Reassemble the 80T-150U as follows. Mate the two case halves at the end where the cable enters the case, then "hinge" the two halves together. Replace the case screw, being careful not to pinch the probe cable or battery wires.

PERFORMANCE TEST

Complete the calibration procedure without opening the temperature-to-voltage converter assembly and without making any calibration adjustments. Observe the readings given in [brackets]. Other readings are for calibration only.

CALIBRATION

A calibration cycle of one year is recommended to maintain the unit within the specifications given earlier. The equipment required for calibration is listed in the table following the calibration procedure.

NOTE

Values given in brackets apply to the Performance Test.

Perform the following steps to calibrate the 80T-150U:

1. Access the interior of the temperature-to-voltage converter by removing the bottom case screw and separating the case halves.
2. Connect the 80T-150U to a DVM with 10 μV resolution, and select mV dc range.
3. Select the °C position of the switch. Immerse the probe tip 2 inches into a mercury thermometer monitored 0°C bath, and allow 60 seconds for the readings to stabilize.
4. Adjust R3 (see Figure 4) to obtain the following reading:

   0.00 ± 0.05 mV dc [0 ± 2 mV dc]
5. Select the °F position of the switch, and adjust R2 to obtain the following reading:

   32.0 ± 0.1 mV dc [32.0 ± 4 mV dc]
6. Select the °C position, and move the probe tip to a 70°C to 90°C bath and again allow the readings to stabilize.
7. Adjust R4 to obtain a DVM reading that agrees with the bath temperature (BT) as monitored by a mercury thermometer.

   °C BT ± 0.05 mV dc [BT ± 2 mV dc]
8. Select the °F position, and verify that the output is within ± 4 mV dc of the bath thermometer reading. If necessary, change the DVM range to obtain an on-scale reading.
9. Return the probe tip to the 0°C bath and check the output. If readjustment is necessary, repeat steps 4 through 8 until readings can be obtained without adjustment.
10. Set the 80T-150U switch to the OFF position, and remove the 80T-150U from the DVM.
11. Reassemble the 80T-150U.
12. The 80T-150U is now calibrated.

PROBE REPLACEMENT

A probe kit (80T-150-7001K, PN 431023) is available for replacing damaged or defective probes. The kit includes a probe and cable assembly and an installation and calibration instruction sheet.

LIST OF REPLACEABLE PARTS

A Schematic of the 80T-150U is shown in Figure 4. A list of replaceable parts is shown in Figure 5. When ordering parts, provide the description, Fluke part number, and the quantity required.

Test Equipment Requirements

INSTRUMENT TYPE	MINIMUM USE SPECIFICATIONS	RECOMMENDED MODEL
Mercury Thermometer	0.1°C Resolution	Princo Model SAMA-CP45
Dewar Flask and Cap	1-Pint Capacity (for Ice Bath)	Thermos Bottle
Metal or Glass Container	1-Pint Capacity	Suitable for Boiling Water
Digital Voltmeter	100 mV Range with 10 μV Resolution 1000 mV Range with 100 μV Resolution	Fluke Model 8840A

For application or operation assistance or information on Fluke products call:

800-426-0361 in most of U.S.A.
206-356-5400 from AK, HI, and WA
206-356-5500 from other countries

John Fluke Mfg. Co., Inc
P.O. Box C9090
Everett,WA 98206

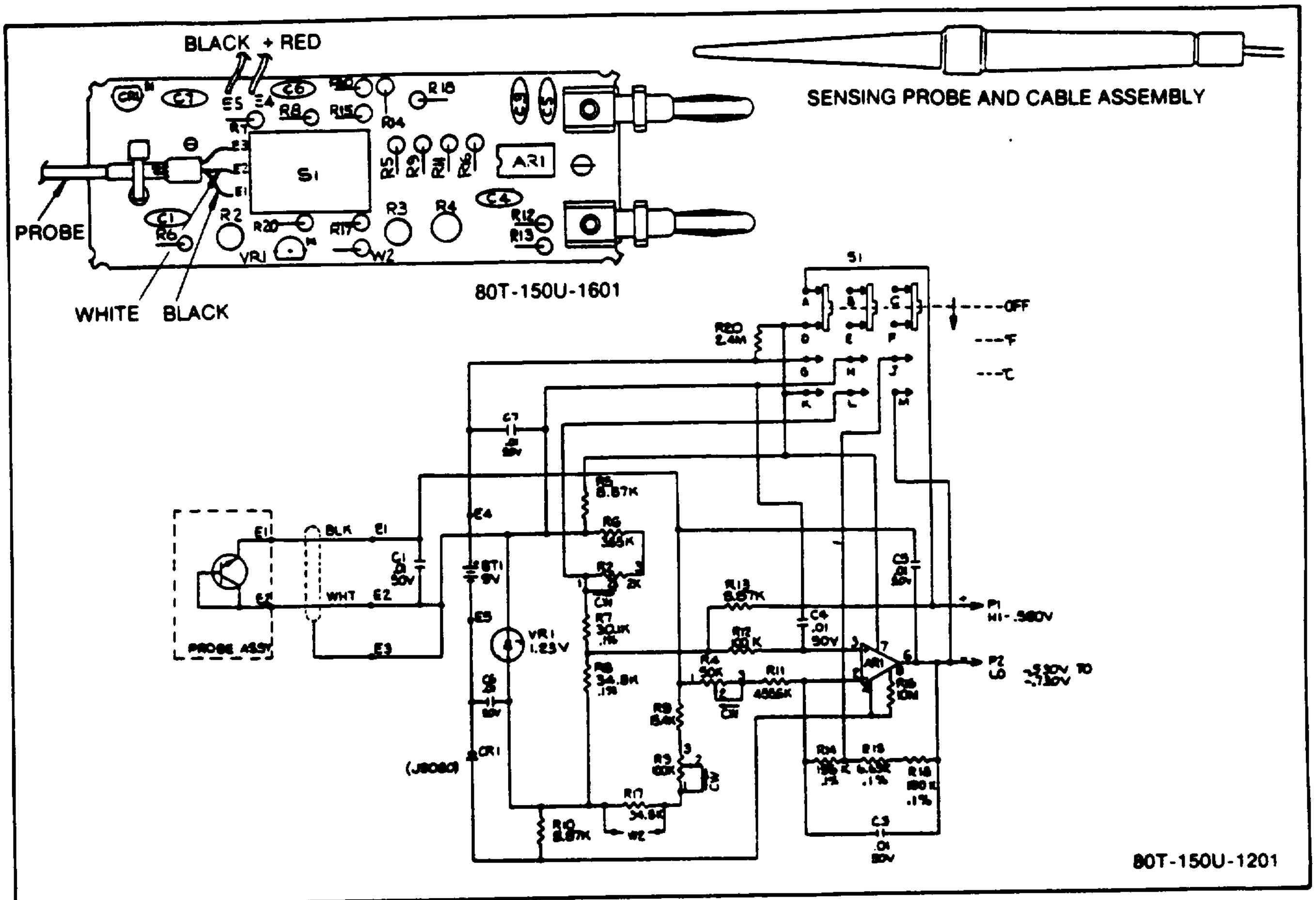


Figure 4. 80T-150U Temperature Probe Schematic

Figure 5. List of Replaceable Parts

REFERENCE DESIGNATOR	JF P/N	DESCRIPTION
CR1	741512	DIODE,CURRENT REG.
VR1	729202	IC,1.23V,150 PPM T.C.,BANDGAP REF
C1,3-7	697284	CAP,CER,.01UF,50V
R2	810770	RES,VAR,CERM. 2K OHMS,.3W.
R3	721829	RES,VAR,CERM,100K,.3W
R4	769950	RES,VAR,CERM,50K,.3W
R16	720870	RES,CF,10M,5%,¼W
R20	772566	RES,CF,2.4M,5%,¼W
R5,10,13	656922	RES,MF,8.87K,1%,⅛W
R6	810754	RES,MF,3.65K ,.1%,⅛W
R7	772574	RES,MF,30.1K,.1%,⅛W
R8	772582	RES,MF,34.8K,.1%,⅛W
R9	772038	RES,MF,15.4K,1%,⅛W
R11	810762	RES,MF,455.6K ,.1%,⅛W
R12	757807	RES,MF,160K,1%,⅛W
R14	772533	RES,MF,196K,.1%,⅛W
R15	772558	RES,MF,150K,.1%,⅛W
R17	772319	RES,MF,34.8K,1%,⅛W
R18	772541	RES,MF,6.65K,.1%,⅛W
W2	682575	RES,CF,.02,¼W
AR1	418913	IC,OP AMP,BIPOLAR
S1	772301	SWITCH,SLIDE,3P3T
	738179	CONNECTOR,BATTERY
	736033	PLUG,BANANA
	747501	SCREW,PHPO,4-40X¼
	431023	SENSING PROBE AND CABLE ASSY 80T-150-7001K
	172080	CABLE TIE
	778050	CASE,BOTTOM
BT1	696534	BATTERY,NEDA 1604,9V
	129682	SCREW,PHP,4-40X3/16
	769034	CASE,TOP
	735860	COVER,SWITCH
	428441	SHOCK ABSORBER

WARRANTY
ONE YEAR LIMITED WARRANTY

John Fluke Mfg. Co., (Fluke) warrants your accessory to be free from defects in material and workmanship under normal use and service for 1 year from the date of purchase if you are the original purchaser. The warranty does not apply to batteries or fuses or when the accessory has been misused, altered, or damaged by accident or abnormal conditions of operation.

For warranty service, send the accessory with a description of the difficulty, postage prepaid to a Fluke Service Center. Fluke assumes no risk for damage in transit. Fluke will, at our option, repair or replace the defective instrument free of charge. However, if we determine that the failure was caused by misuse, alteration, accident, or an abnormal condition of operation, you will be billed for the repair. The repaired accessory will be returned, transportation prepaid.

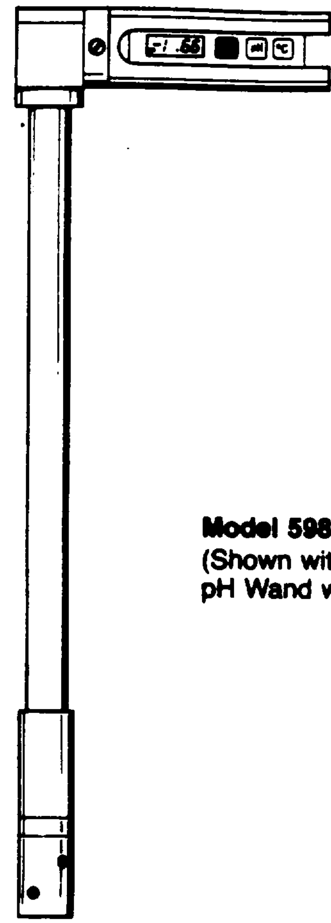
FLUKE MAKES NO WARRANTY OTHER THAN THE LIMITED WARRANTY STATED ABOVE. ALL WARRANTIES, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE, ARE LIMITED TO A PERIOD OF 1 YEAR FROM THE DATE OF PURCHASE. FLUKE SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

NOTE (USA only): Some states do not allow limitation of implied warranties, or the exclusion of incidental or consequential damages, so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights, and you may have other rights, which vary from state to state.

Operating Instructions

Cole-Parmer Series 5985 Submersible Assembly

For use with Cole-Parmer pH Wands



Model 5985-77
(Shown with 5985-75 pH Wand with ATC)

Cole-Parmer Instrument Company
7425 North Oak Park Avenue, Chicago, Illinois 60648
Phone 1-312-647-7600 or Toll-free 1-800-323-4340

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General Description

This submersible assembly is designed specifically for use with Cole-Parmer's Series 5985 pH Wands. The assembly lets you measure pH in tanks, large baths, drums, etc., or wherever a submersible extension is necessary or desirable.

The assembly installs between the pH wand and the electrode, to extend the measurement reach to a full 26". The upper section holding the pH wand, the meter holder, rotates a full 360° for comfortable viewing from all angles. The lower portion, the assembly shaft, has a PVC sleeve with watertight Viton® O-ring, to protect the electrode from bumps or jolts during measurements.

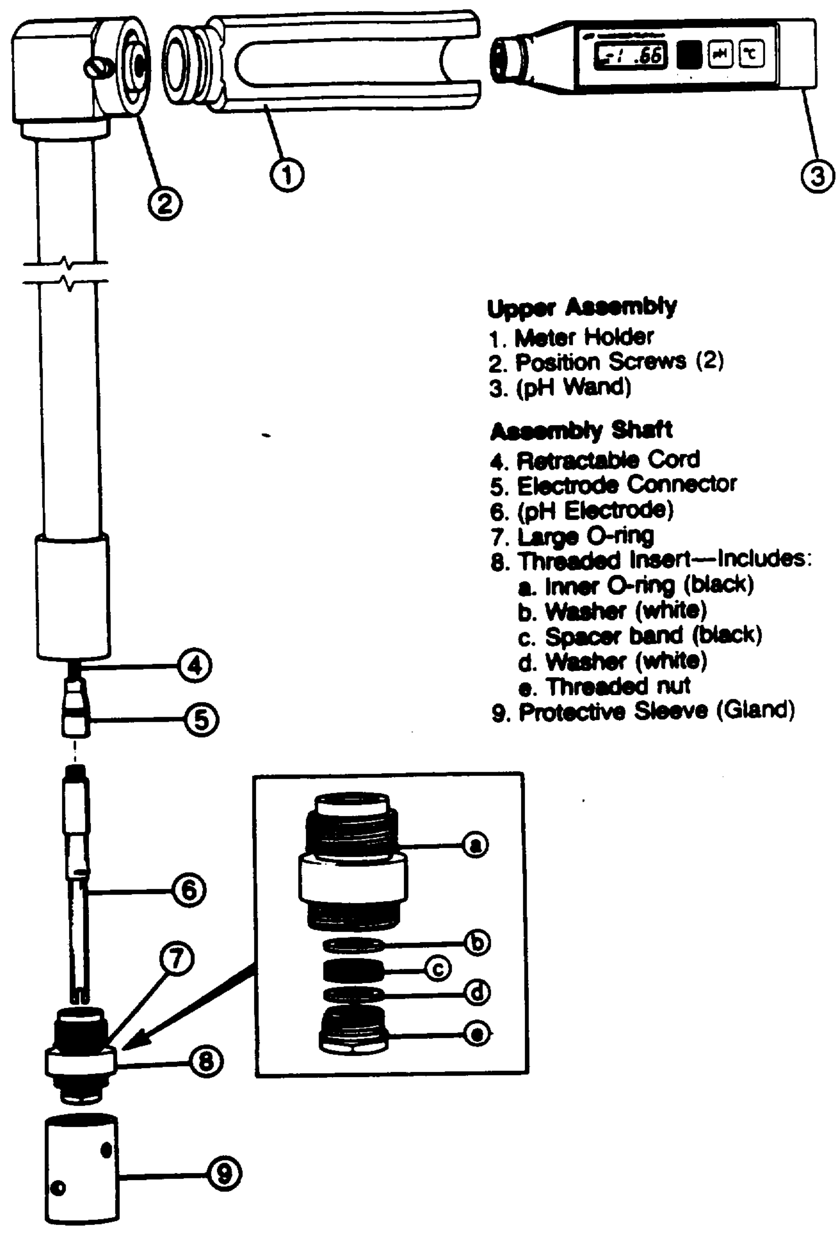
Two assemblies are available:

Model 5985-65, for use with Model 5985-50 pH Wand
Model 5985-77, for use with Model 5985-75 pH Wand with ATC

Specifications

Model numbers:	5985-77:	For 5985-75 ATC pH Wand
	5985-65:	For 5985-50 pH Wand
Assembly shaft:	Length:	26.0" (71.1 cm)
	Diameter:	1.25" (3.2 cm)
Meter holder:	Length:	7.25" (18.4 cm)
	W x D:	2.0" x 1.5" (5.1 x 3.8 cm)
Protective sleeve:	PVC, w/Viton® O-ring	
Shipping weight:	31 lbs. (1.4 kg)	

Assembly Diagram



Upper Assembly
1. Meter Holder
2. Position Screws (2)
3. (pH Wand)

Assembly Shaft
4. Retractable Cord
5. Electrode Connector
6. (pH Electrode)
7. Large O-ring
8. Threaded Insert—Includes:
   a. Inner O-ring (black)
   b. Washer (white)
   c. Spacer band (black)
   d. Washer (white)
   e. Threaded nut
9. Protective Sleeve (Gland)

Assembly Instructions

The submersible assembly consists of two major sections, the electrode holder and the meter holder. Refer to **Assembly Diagram** as needed.

To install the electrode:

1. Unscrew and remove the protective sleeve (gland) from the bottom of the assembly shaft. Put it to one side.
2. Next unscrew and remove the double-threaded insert, which houses a threaded nut, spacer band, two washers and O-ring. Put it aside, also.
3. At this point the end of the electrode connector is exposed, hanging from a retractable cord. Pull it out from the assembly shaft until the electrode connector is accessible.
4. Unscrew and remove the electrode from the pH wand, and screw it into the electrode connector in the assembly shaft.
5. Remove the threaded nut from the bottom of the double-threaded insert. Push the tip of the electrode all the way through the insert, until the insert touches the rubber sleeve of the electrode's refill cap.

   NOTE: Some of the parts—washers, O-ring or spacer band—may fall out from the threaded nut when it is removed from the insert.
6. When the insert is in place on the electrode sheath, screw the threaded nut (and whatever other parts have become disassembled in the process) back into place and hand tighten to secure.
7. Replace the protective sleeve (gland) at the bottom of the threaded insert and screw it back into position.
8. Next, push the electrode (with insert and sleeve) back up into the assembly shaft and screw it into position. The lower portion of the assembly is now ready.

   NOTE: Make sure to hand tighten all threaded connections in the lower assembly before use.

To install the pH wand:

1. Push the pH wand (without electrode) as far into the meter holder as possible. This will ensure electrical contact with the connection cable in the assembly shaft.

   NOTE: Make sure that the front panel controls are exposed.
2. To position pH wand at comfortable viewing angle, loosen the two screws at the neck of the meter holder. The upper portion of the assembly rotates 360°, for a wide range of comfortable angles. Tighten the screws again to lock the meter holder in place.

Operation

After assembly, put the assembly shaft into the liquid to be measured. To make sure that the electrode tip is fully submerged, cover the protective PVC sleeve completely with the liquid.

Push the "On/Off" switch on the pH wand and allow approximately 3 minutes for the pH wand to stabilize, then read the display. When measurements have been taken, turn off the pH wand and remove the assembly from the drum or tank.

Refer to pH wand instruction manual for more details on operation.

Cleaning

Because the assembly shaft is submerged in liquid during use, it should be cleaned periodically to prevent clogging. The assembly should also be cleaned when changing from one liquid to another to avoid contaminating samples being measured.

Between uses, wipe the assembly dry with a clean cotton cloth. For a more thorough cleaning, use a good general-purpose laboratory or industrial cleaning solution, or mild soap and water to clean the PVC sheath and meter holder.

NOTE: The cleaning solution used will depend on the liquids being measured. For advise on selecting a cleaner, call us for technical assistance.

Warranty

The Cole-Parmer Instrument Company warrants this product to be free from defects in material and workmanship for a period of six months from date of purchase. If repair or adjustment is necessary and has not been the result of abuse or misuse within the six month period, please return—freight prepaid—and correction of the defect will be made without charge.

Out-of-warranty products will be repaired on a charge basis.

Return of Items

Authorization must be obtained from our Customer Service Department before returning items for any reason. When applying for authorization, please include data regarding the reason the items are to be returned.

For your protection, items must be carefully packed to prevent damage in shipment and insured against possible damage or loss. Cole-Parmer will not be responsible for damage resulting from careless or insufficient packing. A 15% restocking charge will be made on all unauthorized returns.

NOTE: The Cole-Parmer Instrument Company reserves the right to make improvements in design, construction and appearance of our products without notice.

Cole-Parmer Instrument Company
7425 North Oak Park Avenue, Chicago, Illinois 60648
Phone 1-312-647-7600 or Toll-free 1-800-323-4340

HAND-HELD BAROMETER

OPERATOR'S GUIDE

Model AIR-HB-1A

Atmospheric Instrumentation Research, Inc.
1880 S. Flatiron Court
Boulder, Colorado 80301
3003-443-7187

Version 1.1
October 18, 1985

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HAND-HELD BAROMETER/ALTIMETER CALIBRATION REPORT

SERIAL NUMBER: 00572
CALIBRATION ID: 8803250914

REFERENCE PRESSURE (mb)	TEMPERATURE Degrees C	INDICATED PRESSURE (mb)	ERROR (mb)
1099.95	38.04	1099.98	0.02
1000.00	38.06	999.85	-0.14
899.97	38.06	899.98	0.01
799.90	38.15	799.80	-0.10
699.94	38.39	700.00	0.06
600.36	38.44	600.41	0.05
550.28	38.23	550.34	0.06
649.93	38.22	650.02	0.09
750.01	38.14	749.65	-0.36
849.89	38.02	849.79	-0.11
949.80	37.94	949.91	0.11
1049.96	37.94	1049.96	0.00
1099.94	28.82	1100.13	0.18
999.97	28.81	1000.00	0.03
899.93	28.78	900.04	0.10
800.19	28.76	800.19	0.00
700.21	28.78	700.01	-0.20
599.98	28.74	600.06	0.08
549.92	28.77	549.89	-0.02
649.87	28.81	649.83	-0.04
749.98	28.81	749.88	-0.10
849.87	28.71	849.79	-0.08
950.07	28.78	949.93	-0.14
1049.94	28.78	1049.95	0.01
1099.91	23.92	1100.05	0.14
999.98	23.94	999.97	-0.01
899.95	23.95	900.14	0.19
800.19	23.96	800.27	0.08
700.16	23.95	700.07	-0.09
600.29	23.93	600.38	0.09
549.92	23.91	549.87	-0.04
649.85	23.91	649.83	-0.02
749.95	23.93	749.93	-0.01
850.19	23.88	850.14	-0.06
950.09	23.88	949.93	-0.16
1050.24	23.90	1050.23	-0.01
1100.23	15.02	1100.06	-0.17
1000.30	15.04	1000.25	-0.05
899.93	14.96	899.83	-0.10
800.18	14.96	800.12	-0.06
700.19	14.96	700.01	-0.18
599.96	14.96	600.09	0.13
549.90	14.98	549.80	-0.11
649.84	14.95	649.84	-0.01
749.94	14.96	749.92	-0.03
849.84	14.96	850.00	0.16
950.08	14.96	949.99	-0.09
1050.23	14.93	1050.18	-0.05
1099.90	5.22	1099.86	-0.04
999.95	5.17	1000.03	0.08
899.92	5.14	900.22	0.30
799.84	5.13	800.02	0.18

549.90	5.14	[illegible]9.74	-0.16
650.16	5.12	[illegible]3.00	-0.16
749.95	5.13	[illegible]9.98	0.03
849.84	5.09	849.83	-0.01
949.71	5.11	949.53	-0.18
1049.92	5.12	1049.93	0.01
1099.90	14.85	1099.82	-0.09
1000.28	14.88	1000.27	-0.01
899.92	14.89	900.12	0.20
800.17	14.93	800.29	0.12
700.15	14.90	700.46	0.32
599.97	14.91	600.07	0.10
549.93	14.96	549.79	-0.13
649.85	14.95	649.91	0.06
749.94	14.94	749.87	-0.07
849.87	14.96	850.01	0.14
949.72	14.96	949.57	-0.15
1049.90	14.94	1049.93	0.02
1099.90	23.80	1099.83	-0.07
999.96	23.84	999.91	-0.05
899.93	23.92	900.15	0.22
800.16	23.87	800.25	0.09
700.16	23.86	700.29	0.13
599.97	23.89	600.13	0.16
549.93	23.88	549.80	-0.13
649.88	23.88	649.83	-0.04
749.98	23.88	749.96	-0.03
850.17	23.89	850.11	-0.06
950.08	23.88	949.86	-0.22
1049.93	23.93	1049.97	0.04
1099.89	28.66	1099.84	-0.05
999.95	28.70	1000.01	0.06
899.92	28.71	900.14	0.22
800.15	28.72	800.19	0.05
700.15	28.66	700.19	0.03
599.97	28.65	600.12	0.15
550.21	28.66	550.12	-0.09
649.83	28.68	649.74	-0.09
749.93	28.70	749.83	-0.11
650.16	28.66	850.07	-0.08
950.04	28.65	949.90	-0.14
1050.27	28.61	1050.33	0.05
1099.88	37.92	1099.99	0.10
999.93	37.92	999.87	-0.06
899.93	37.97	900.00	0.07
800.15	37.99	799.99	-0.16
700.16	38.00	700.12	-0.03
599.97	38.02	599.99	0.02
549.90	38.04	550.15	0.25
650.15	37.99	650.24	0.08
749.92	38.00	749.96	0.04
850.15	38.00	850.07	-0.08
950.03	38.00	950.13	0.09
1050.21	38.04	1050.24	0.04

ERROR STATISTICS

MIN. = -0.36
MAX. = 0.32
AVE. = 0.00
S.D. = 0.12

Section 4
Maintenance

WARNING

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual contains maintenance information for the Model 8024B. This includes service information, general maintenance, performance test, calibration, adjustments, and troubleshooting. The performance test is recommended as an acceptance test when the unit is first received, and later as a preventive maintenance tool to verify proper instrument operation. A 2-year calibration cycle is recommended to maintain the specifications given in Section 1 of this manual. The test equipment required for both the performance test and calibration adjustments is listed in Table 4-1. If the recommended equipment is not available, instruments having equivalent specifications may be used.

4-3. SERVICE INFORMATION

4-4. The 8024B is warranted for a period of 2 years upon delivery to the original purchaser. Conditions of the warranty are given at the end of this manual.

4-5. Malfunctions that occur within the limits of the warranty will be corrected at no charge. Simply mail the instrument (postpaid) to your nearest authorized (in-warranty) Fluke Technical Service Center. A complete list of service centers is provided at the end of this manual. Dated proof-of-purchase will be required for all in-warranty repairs.

4-6. Factory authorized centers are also available for calibration and/or repair of instruments that are beyond their warranty period. Contact your nearest Fluke Technical Service Center for a cost quotation. Ship the instrument and remittance in accordance with instructions received.

Table 4-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	RECOMMENDED EQUIPMENT
DMM Calibrator	AC VOLTS: Voltage Range: 0V to 200V to 750V Accuracy Required: ±.1%, ±0.35%, ±0.1% Frequency: 5 kHz to 2 kHz to 1 kHz to 100 Hz, ±0.25% DC VOLTS Voltage Range: 0 to 1000V Accuracy: ±0.025% AC CURRENT: Current Range: 0 to 1900 mA Frequency Range: 100 Hz to 1 kHz Accuracy: ±0.1% DC CURRENT: Current Range: 0 to 1900 mA Accuracy: ±0.1% RESISTANCE: Value: 100Ω Accuracy: ±0.05% Value: 1 kΩ, 10 kΩ, 100 kΩ, 1000 kΩ Accuracy: ±0.025% Value: 10 MΩ Accuracy: ±0.5%	John Fluke Model 5100B
DMM	0 to 12V dc ±.1%	John Fluke Model 8020B
Temperature Reference Monitor	0.4° C resolution at 0° C	PRINCO ASTM 56C
Thermocouple Accessory	8024B compatible	John Fluke Model Y8102 or Y8103
Vacuum Insulated Bottle	1 quart capacity minimum	Thermos
2 Hole Cork	To fit mouth of Vacuum Insulated Bottle	
Pulse Generator	Can generate 25 μsec pulses at 5V p-p	Hewlett Packard Model 8003A

4-7. GENERAL INFORMATION

4-8. Access Information

NOTE

To avoid contaminating the pcb with oil from the fingers, handle it by the edges or wear gloves. If the pcb does become contaminated, refer to the cleaning procedure given later in this section.

4-9. BACKUP FUSE (F2) AND CALIBRATION ADJUSTMENTS

4-10. Use the following procedure to access F2 and the 8024B calibration adjustments:

1. Set the power switch to OFF.
2. Disconnect test leads and battery eliminator, if attached.
3. Remove the three phillips-head screws from the bottom of the case.
4. Turn the instrument face-up and grasp the top cover at both sides of the input connectors. Then, pull the top cover from the unit.
5. All adjustments necessary to complete the calibration procedure are now accessible (see Figure 4-1).

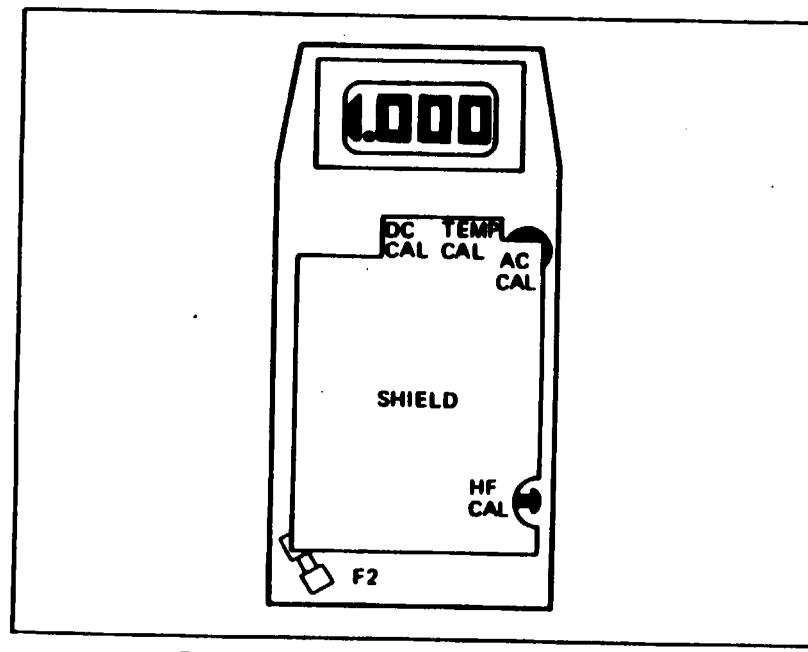


Figure 4-1. Calibration Adjustments Location

4-11. PCB

4-12. There are two PCB assemblies, Main and Switch. Use the following procedure to remove the Main PCB Assembly from the case:

1. Complete the Calibration Adjustments access procedure.
2. Remove the screw from the shield covering the assembly.
3. Using your index finger, lift up the lower right-hand corner of the pcb until it is free. Then pull the pcb to the right until it clears the shelf under the buttons.
4. Reassemble in the logical reverse order.

NOTE

When installing the pcb, route battery-clip wires behind the post on the left-hand side of the bottom case. Also make sure that the removable plastic lip located beneath the range switch pushbuttons is properly installed in the bottom case and that the green power-switch cap is mounted on the power switch.

4-13. DISPLAY ACCESS

4-14. Refer to Figure 4-2 and the following procedure to remove/replace the LCD assembly.

1. Remove the Main PCB Assembly using the PCB access procedure.
2. Place your thumbs on either side of the display lens and carefully push the lens out of the LCD bracket.
3. Turning LCD bracket upside down gently tap into your palm, LCD shouldfall out.

NOTE

When installing the LCD make certain that its flat surface is facing out and its connector pattern is on top of and makes contact with, the flexible layered connector.

4-15. LSI (U8) ACCESS

4-16. Use the following procedure to remove/replace the a/d converter and display driver IC, U8:

1. Remove the pcb assembly using the PCB access procedure.
2. On the bottom of the pcb locate and remove the two phillips-head screws from the display assembly.

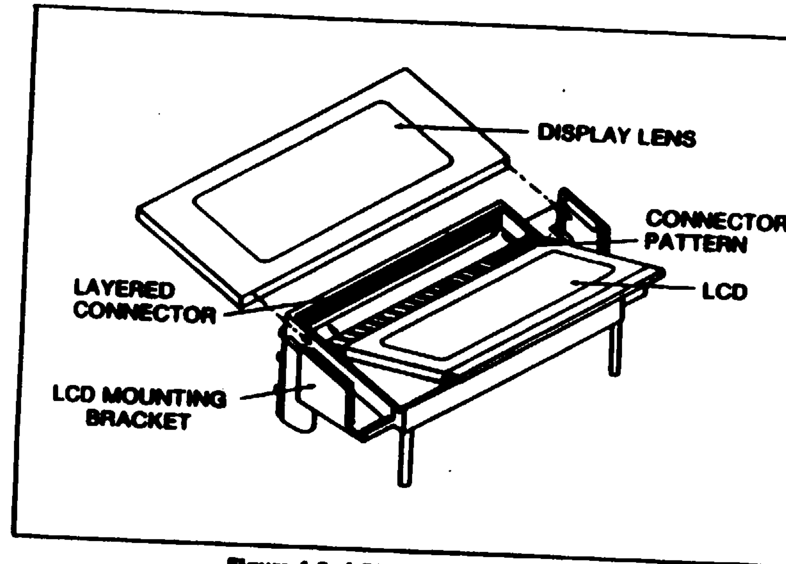


Figure 4-2. LCD Display Assembly

3. Lift the display assembly from the pcb to expose U8.

CAUTION

U8 is a MOS device and is subject to damage by static discharge. Observe the precautions given later in this section under Troubleshooting before attempting to remove or replace U8.

4. Use a screwdriver or a reasonable substitute to rock (by prying up on each end of the IC) the IC out of its socket.
5. When installing U8 make sure all pins are lined up in the socket, and then press U8 carefully into place.

4-17. Cleaning

CAUTION

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These solutions will react with the plastic materials used in the instrument.

CAUTION

Do not allow the liquid crystal display to come in contact with moisture. Remove the Display Assembly before washing the pcb and do not install it until the pcb has been fully dried.

4-18. Clean the front panel and case with a mild solution of detergent and water. Clean dust from the circuit board with low pressure (<20 psi) dry air. Contaminants can be removed from the circuit board with demineralized water and a soft brush (remove the Display Assembly before washing, and avoid getting excessive amounts of water on the switches). Dry with clean, dry air at low pressure, and then bake at 50 to 60°C (124 - 140°F) for 24 hours.

4-19. Battery/Backup Fuse Replacement

WARNING

BATTERY/FUSE REPLACEMENT SHOULD ONLY BE PERFORMED AFTER THE TEST LEADS HAVE BEEN REMOVED FROM THE INPUT JACKS, AND THE POWER SWITCH IS SET TO OFF. BACKUP FUSE REPLACEMENT PROCEDURE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY. USE ONLY THE RECOMMENDED REPLACEMENT TYPE.

4-20. Refer to Section 2 of this manual for battery and main fuse (F1) replacement procedure. Use the following procedure to replace the backup fuse (F2).

1. Complete the "Backup Fuse and Calibration Access Procedure" located earlier in this section.

2. Using a pointed tool such as a probe tip, pry the backup fuse from its holder.

3. Replace the defective backup fuse with a 3A, 600V type BBS-3 only.

4-21. PERFORMANCE TEST

4-22. The performance tests are used to compare the 8024B performance with the list of specifications given in Section 1 of this manual. It is recommended for incoming inspection, periodic maintenance, and to verify specifications. If the instrument fails any test, calibration adjustment and/or repair is indicated. The 8024B being tested will be referred to as the UUT (Unit Under Test).

4-23. Initial Procedure

4-24. Each of the performance tests assume that the following conditions exist:

1. The unit has been allowed to stabilize and will be tested at an ambient temperature of 23 ±5°C (73 ± 9°F).

2. The fuse and battery have been checked and, if necessary, replaced.

3. Set the UUT switches to the following positions:

POWER	ON
PEAK HOLD	OFF
All other switches	out

4-25. Display Test

4-26. Use the following procedure to verify the proper operation of all LCD indications except BT.

1. Select the Ω function and connect a short between the COMMON input terminal and the V/Ω/S input terminal. Then for each step in Table 4-2, select the range indicated and verify that the corresponding decimal point position and digit display in the table and the LCD are the same.

2. Select the DC V function, 2.0V range on the UUT.

3. Connect the equipment as shown in Figure 4-3.

Table 4-2. Display Test

STEP	SELECT RANGE	UUT DISPLAY
1	200Ω	00.0*
2	2 kΩ	.000
3	20 kΩ	0.00
4	200 kΩ	00.0
5	2000 kΩ	000
6	20 MΩ	0.00
7	200 nS	1

*One or two digits may appear if a test lead is used to connect the two terminals.

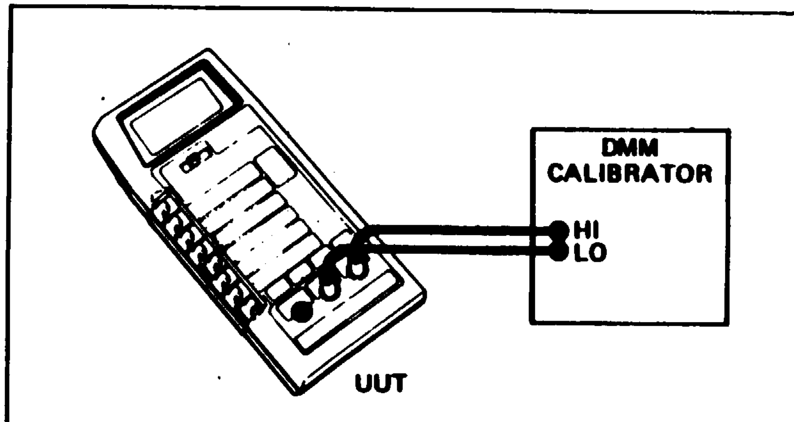


Figure 4-3. General Equipment Connection

4. Program the DMM Calibrator for a UUT input of -1.0V dc and verify that the - sign appears in the UUT display.

5. Program the DMM Calibrator for a UUT display of +1.888 and verify that all segments of each digit appear in the LCD.

6. Program the DMM Calibrator so that each possible number appears in each digit of the display (3-1/2 digit unit).

7. Program the DMM Calibrator for a UUT input of 0V dc.

8. On the UUT, depress the mA-°C-V/Ω/S switch.

9. Verify that the ▼ down arrow appears in the UUT display.

10. Program the DMM Calibrator for a UUT input of +15V dc.

11. Verify that the ▼ down arrow disappears from the UUT display and the ▲ up arrow appears in the UUT display.

4-27. Voltage Test

4-28. Use the following procedure to verify the proper operation of both the AC and DC V measurement functions:

1. Connect the equipment as shown in Figure 4-3 and release the mA-°C-V/Ω/S function switch.

2. For each step of Table 4-3 set the AC/DC switch to the indicated position, select the listed range, program the DMM Calibrator for the corresponding UUT input, and verify that the UUT displayed value is within the limits listed.

4-29. Current Test

4-30. Use the following procedure to verify the proper operation of both the AC and DC mA measurement functions:

1. Connect the equipment as shown in Figure 4-4.

2. For each step of Table 4-4 set the AC/DC switch to the indicated position, select the listed range, program the DMM Calibrator for the corresponding UUT input, and verify that the UUT displayed value is within the indicated limits.

4-31. Resistance/Conductance Test

4-32. Use the following procedure to verify the proper operation of both the kΩ and nS measurement functions:

1. On the UUT set the mA-°C-V/Ω/S function switch to the in position (nS).

2. Connect the equipment as shown in Figure 4-3.

3. For each step of Table 4-5 set the AC/DC switch to the indicated position, select the listed range, program the DMM Calibrator for the corresponding UUT input, and verify that the UUT displayed value is within the indicated limits.

Table 4-3. Voltage Test

STEP	UUT SWITCH POSITION		INPUT		DISPLAY LIMITS
	DC/AC	RANGE	LEVEL	FREQ.	
1	DC	200 mV	+190 mV dc	DC	189.7 to 190.3
2			−190 mV dc		−189.7 to −190.3
3		2V	1.9V dc		1.897 to 1.903
4			0.0V dc		0.001 to −0.001
5		20V	19V dc		18.97 to 19.03
6		200V	190V dc		189.7 to 190.3
7		1000V	1000V dc		998 to 1002
8	AC	200 mV	Short	—	00.0 to 00.2
9			190 mV ac rms	100 Hz	188.4 to 191.6
10				2 kHz	186.8 to 193.2
11				5 kHz	180.0 to 199.9
12		2V	1.9V ac rms	100 Hz	1.884 to 1.916
13				2 kHz	1.868 to 1.932
14				5 kHz	1.800 to 1.999
15			190 mV ac rms	5 kHz	0.175 to 0.205
16		20V	19V ac rms	100 Hz	18.84 to 19.16
17				2 kHz	18.68 to 19.32
18				5 kHz	18.00 to 19.99
19		200V	100V ac rms	100 Hz	99.0 to 101.0
20				2 kHz	98.2 to 101.8
21		750V	750V ac rms	100 Hz	740 to 760
22				1 kHz	740 to 760

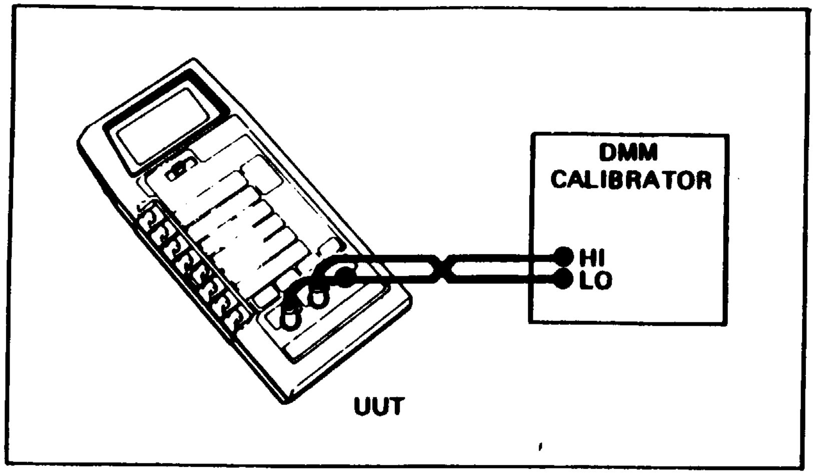


Figure 4-4. General Equipment Connection - Current

Table 4-4. Current Test

STEP	UUT SWITCH POSITION		INPUT		DISPLAY LIMITS
	AC/DC	RANGE	LEVEL	FREQ.	
1	DC	2 mA	+1.9 mA dc		+1.885 to +1.915
2	DC	20 mA	+19 mA dc		+18.85 to +19.15
3	DC	200 mA	+190 mA dc		+188.5 to +191.5
4	DC	200 mA	−190 mA dc		−188.5 to −191.5
5	DC	2000 mA	+1.9A dc		+1885 to +1915
6	AC	2 mA	Short		0.000 to 0.002
7	AC	2 mA	1.9 mA ac rms	100 Hz	1.841 to 1.959
8	AC	2 mA	1.9 mA ac rms	400 Hz	1.841 to 1.959
9	AC	20 mA	19 mA ac rms	100 Hz	18.69 to 19.31
10	AC	20 mA	19 mA ac rms	1 kHz	18.69 to 19.31
11	AC	200 mA	190 mA ac rms	100 Hz	186.9 to 193.1
12	AC	200 mA	190 mA ac rms	1 kHz	186.9 to 193.1
13	AC	2000 mA	1.9A ac rms	100 Hz	1869 to 1931
14	AC	2000 mA	1.9A ac rms	1 kHz	1869 to 1931

Table 4-5. Resistance/Conductance Test

STEP	SELECT RANGE	INPUT	DISPLAYED VALUE SHOULD BE	
			NO LESS THAN	NO MORE THAN
1	200Ω	100Ω	99.5	100.5
2	2 kΩ	1 kΩ	0.998	1.002
3	20 kΩ	10 kΩ	9.98	10.02
4	200 kΩ	100 kΩ	99.8	100.2
5	2000 kΩ	1 MΩ	997	1003
6	20 MΩ	10 MΩ	9.79	10.21
7	200 nS	10 MΩ	97.0	103.0

4-33. Peak Hold Test

4-34. Use the following procedure to verify proper operation of the peak hold function:

1. Select the AC V function, 2V range.

2. Connect the equipment as shown in Figure 4-3.

3. Program the DMM Calibrator for a UUT input of 1.9V ac rms at 100 Hz.

4. Push the PEAK HOLD switch to the ON position and verify that the UUT display is between 1.833 and 1.967, ±(3% of rdg + 10 digits).

5. Program the DMM Calibrator for an output of 0.1 mV ac rms at 100 Hz.

6. Verify that the UUT display changes less than 10 digits in 10 seconds.

7. Push the PEAK HOLD switch to the OFF position.

4-35. Continuity Test

4-36. Use the following procedure to verify proper operation of the continuity function:

1. Select the Ω function and 2 kΩ range.

2. Connect the test leads to the COMMON and V/Ω/S terminals.

3. When the test leads are open circuited, the ▲ up arrow will be displayed.

4. Short the test leads together and observe that the ▲ up arrow disappears and the ▼ down arrow is displayed.

5. Depress the AC/DC switch to activate the audible tone.

6. Momentarily short the test leads together and observe that the tone sounds coincident with the ▼down arrow. The ▲up arrow may or may not be displayed, depending on the duration of the short.

4-37. Level Detector Test

4-38. Use the following procedure to verify the proper operation of the level detector function:

1. Select the Ω functions, 200 kΩ range.

2. Program the pulse generator for a single pulse that is greater than 50 usec wide and 0 to 3V ±0.5% in amplitude.

3. Connect the pulse generator to the UUT: + to the V/Ω/S terminal and - to the COMMON terminal.

4. Cause the pulse generator to output single pulses and verify that the ▲up arrow appears momentarily in the LCD of the UUT for each single pulse.

5. On the UUT depress the AC/DC switch to enable the audible tone. The audible tone should be on continuously.

6. Cause the pulse generator to output 500 ms pulses and verify that the ▲up arrow appears in the LCD and the audible tone stops for each pulse.

7. Release the AC/DC switch to disable the audible tone. The ▼down arrow should appear in the UUT display.

4-39. BT Test

4-40. Complete the following procedure to verify that the BT indicator appears on the LCD at the correct battery level, and that the accuracy of the UTT remains unaffected at this battery voltage level:

1. Connect the equipment as shown in Figure 4-5.

2. Set the UUT switches to the following positions:

200 mV	in
AC/DC	DC (out)

3. Set the DMM controls to the following positions:

20V	in
AC/DC	DC

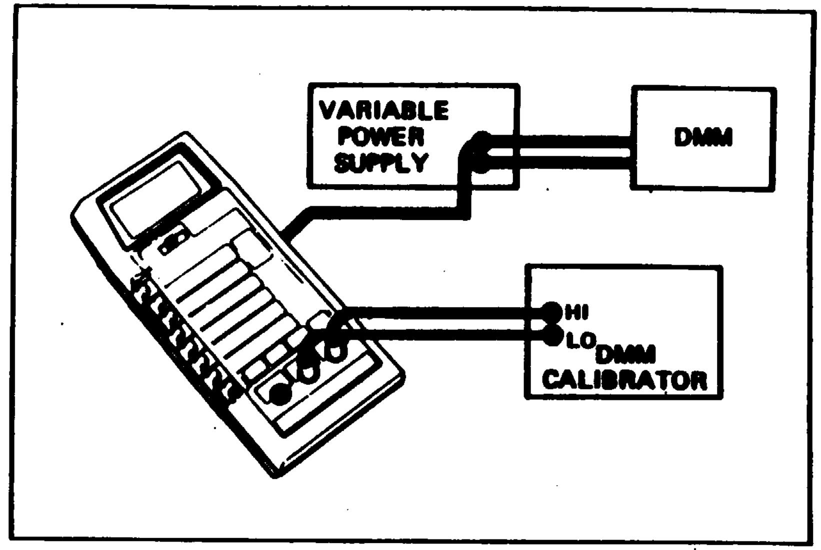


Figure 4-5. BT Test

4. Program the DMM Calibrator for a UUT input of 190.0 mV dc.

5. Adjust the variable power supply until the BT indicator appears in the UUT display.

6. Verify that the DMM display is between +6.5 and +7.5V dc.

7. Decrease the output of the variable supply until the DMM displays +6.0V.

8. Verify that the UUT display is between 189.8 and 190.2 mV dc.

9. Program the DMM Calibrator for an input of 0V dc.

10. On the UUT, depress the Ω/S function switch and 2 kΩ switch.

11. Adjust the variable power supply until the DMM displays +10.0V dc.

12. Program the DMM Calibrator for a UUT input of 1 kΩ.

13. Verify that the UUT display is between 0.998 and 1.002.

14. Adjust the variable power supply until the DMM displays +6V dc.

15. Verify that the UUT display is between 0.998 and 1.002.

4-41. Temperature Test

WARNING

DO NOT PERFORM THIS PROCEDURE IF THE TIP OF THE THERMOCOUPLE ACCESSORY HAS BEEN EXPOSED TO TOXIC MATERIALS. INSTEAD USE THE ALTERNATE PROCEDURE DESCRIBED IN THE FOLLOWING CALIBRATION ADJUSTMENTS PROCEDURE.

4-42. The following procedure takes advantage of the inherent stability of human body temperature to verify proper operation of the °C temperature function. If there is any doubt about this procedure, if the thermocouple tip has been exposed to toxic materials, or if extremeaccuracy of measurement is desired, use (as a reference) the lag bath described in the °C Adjustment procedure in the following Calibration portion of this section.

1. Depress the TEMP °C range switch and release the Ω/S switch on the UUT.
2. Connect the John Fluke thermocouple accessory to the UUT.
3. Wipe the tip of the thermocouple accessory clean and place the tip between your thumb and index finger until the UUT display readings stabilize.

NOTE

Normal body temperature of humans is 37°C (98.6° F).

4. Verify that the UUT display is between 34 and 39°C.

4-43. CALIBRATION ADJUSTMENTS

4-44. Under normal operating conditions the 8024B should be calibrated once every two years to maintain the specifications given in Section 1 of this manual. If your 8024B has been repaired or if your 8024B has failed any of the Performance Tests, immediate calibration is indicated. Test equipment needed for the calibration adjustment is listed in Table 4-1. If the test equipment is not available, your nearest John Fluke Service Center will be glad to help. A list of these centers is given in Section 5 of this manual. For verification, complete the Performance Tests after the calibration adjustments are made. The 8024B being calibrated will be referred to as the UUT (Unit Under Test).

4-45. Use the following procedure to perform the calibration adjustments:

1. Allow the UUT to stabilize for at least 30 minutes at an ambient temperature of 21°C to 25°C (70°F to 77°F).
2. Complete the calibration access procedure presented earlier in this section.
3. Select the DC V function, 200 mV range on the UUT.
4. Connect the equipment as shown in Figure 4-3.
5. Program the DMM Calibrator for a UUT input of +190.0 mV dc.

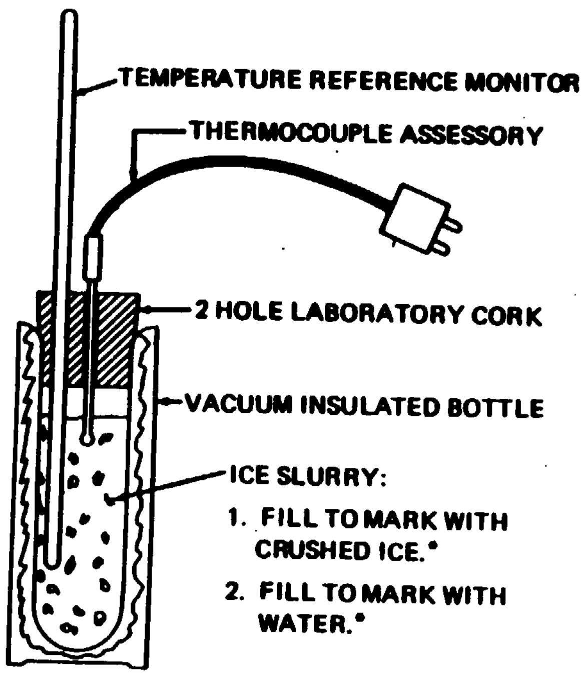
6. Adjust the DC CAL (R6) for a UUT display of exactly 190.0.
7. Connect a jumper across Q10.
8. Push the PEAK HOLD switch to the ON position.
9. Adjust R17 (Peak Hold offset) for a UUT display of exactly 190.0.
10. Remove the jumper from across Q10.
11. Push the PEAK HOLD switch to the OFF position.
12. Connect the equipment as shown in Figure 4-3.
13. On the UUT, depress the AC/DC switch.
14. Program the DMM Calibrator for a UUT input of 190.0 mV ac rms at 100 Hz.
15. Adjust the AC CAL (R4) for a UUT display of exactly 190.0.
16. On the UUT, depress the 2V range.
17. Program the DMM Calibrator for a UUT input of 1.9V ac rms at 5 kHz.
18. Adjust the HF CAL (C1) for a UUT display between 1.805 and 1.995.
19. Establish a lag bath (ice point environment) as shown in Figure 4-6 and allow the lag bath to sit for 30 minutes to reach thermal equilibrium.
20. Connect the Thermocouple Accessory to the UUT.
21. Adjust the TEMP CAL (R10) for a UUT display the same as the Temperature Reference Monitor reading.

4-46. TROUBLESHOOTING

CAUTION

Static discharge can damage MOS components contained in the 8024B. Avoid instrument damage by complying with the precautions on the Static Awareness sheet when troubleshooting or repairing the 8024B.

4-47. Never remove, install, or otherwise connect or disconnect components without first turning the 8024B POWER switch to OFF. Table 4-6 is a troubleshooting guide for the 8024B. To properly use the guide, complete the performance tests given earlier in this section and note any discrepancies. Then locate the heading of the procedure in question in the Test and Symptom column (Table 4-6). Under that heading isolate the symptom that approximates the observed malfunction. Possible causes are listed to the right of the selected symptom. Details necessary to isolate a particular cause can be derived from the Theory of Operation in Section 3 and the schematic diagrams in Section 7.



*Both the ice and the water for the ice slurry should be either distilled water or Reagent Grade II DI water.

Figure 4-6. Lag Bath

Table 4-6. Troubleshooting Guide

TEST AND SYMPTOM	POSSIBLE CAUSE
INITIAL PROCEDURE	
BT is displayed when unit is turned on (see BT procedure also). Note, BT will normally be displayed for some line voltages when the A81 line eliminator accessory is used.	Low battery voltage, U18C, U7, U8
Display blank.	Dead battery, POWER switch (S9), VR2 shorted, U8, J5A
DISPLAY TEST	
One or more segments will not light through entire test.	Display interconnection, Display (U9) U8
Decade inoperative or one or more segments always lit.	U8
Improper decimal point indication.	Check signals at U7. Are they OK? YES: Display (U9). NO: Range switches or interconnect.
Minus sign improperly displayed.	U8
Display lit but does not respond to changes in input.	PEAK HOLD switch is at the ON position (if you pushed toward the left to set the PEAK HOLD switch to the OFF position, the switch is still at the ON position), VR1, U8, Y1, C8 shorted, or interconnect.
VOLTAGE TEST	
DC: Display reading is out of tolerance on 200 mV range.	DC CAL (R6) out of calibration, VR1 U5, U8, S8
Display readings out of tolerance on all ranges except 200 mV.	U1, U2, U3
AC: Display reading out-of tolerance on the 2V range with 1.9V ac rms, 5 kHz, input.	AC CAL (R4) out of calibration, AC Converter
Display readings out of tolerance on all ranges except the 200 mV range.	U1

Table 4-6. Troubleshooting Guide (cont)

TEST AND SYMPTOM	POSSIBLE CAUSE
PEAK HOLD TEST	
Value does not appear in the display.	U19, (U14, Q10), C5, C6
Value decays too fast.	U19, C19, U14, Q10
LEVEL DETECTOR TEST	
UP arrow doesn't appear and audible tone doesn't sound when the input is low.	U21, U17, U16, U10, U9, or interconnect.
Down arrow doesn't appear and audible tone doesn't sound when the input is low.	Ω switch (S1E), U21, U17, U16 S8B, or interconnect, U10, U9, LS1 U18 Q8
Down arrow appears, but tone doesn't sound when input is low.	AC/DC switch (S8B), U10, Q8, U18A, LS1
CURRENT TEST	
Input does not affect display.	F1, F2, CR1, CR2
Displayed reading is out of tolerance on one or more ranges..	If 2000 mA and 200 mA ranges are OK, U2 is defective. Otherwise, U3 is defective.
°C TEST	
Display reading out of tolerance.	TEMP COMPENSATION (R10) out of calibration. Room temp should be displayed if °C input and common are shorted together. Check also fuse and battery connector.

Section 5
List of Replaceable Parts

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. A similar parts listing for each of the options will be found in Section 6. Components are listed alphanumerically by assembly. Both electrical and mechanical components are listed by reference designation. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

1. Reference Designation.
2. Description of each part.
3. FLUKE Stock Number.
4. Federal Supply Code for Manufacturers. (See Table 5-4 for Code-to-Name list.)
5. Manufacturer's Part Number.
6. Total Quantity per assembly or component.
7. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or its authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

1. Quantity
2. FLUKE Stock Number
3. Description
4. Reference Designation
5. Printed Circuit Board Part Number
6. Instrument Model and Serial Number

CAUTION

Indicated devices are subject to damage by static discharge.

Table 5-1. 8024B Final Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
	8024B FINAL ASSEMBLY FIGURE 5-1 (8024B-T&B)	8024B	89536	8024B			
A1	CASE ASSEMBLY				1		1
A2	MAIN PCB ASSEMBLY				1		1
A3	SWITCH ASSEMBLY				1		1
BT1	BATTERY, 9V (NOT SHOWN)	446823	89536	446823	1		
F1	FUSE, 2A, 250V (USA)	376582	71400	AGX2	2	5	2
F2	FUSE, FAST ACTING, 3 AMP	475004	71400	BBS-3	1	5	
H1	SCREW, PHP, 4-40 X 3/16	129882	89536	129882	5		
H2	SCREW, PHP, 3/8 HI-LO THD/FORM	448456	89536	448456	2		
H3	SCREW, PHP, 3/4 HI LO, THD/FORM	447953	89536	447953	3		
MP1	BUTTON (PEAK/HOLD)	607333	89536	607333	1		
MP2	DECAL (PEAK/HOLD)	535104	89536	535104	1		
MP3	INSERT, SILICONE	525089	89536	525089	2		
MP4	INTERCONNECT	508127	89536	508127	1		
MP5	RETAINER, FLEX	514935	89536	514935	2		
MP6	BUTTON (POWER SWITCH)	456491	89536	456491	1		
MP7	TEST LEAD & PROBE ASSY (NOT SHOWN)	516666	89536	516666	1		
TM1	INSTRUCTION MANUAL (8024B)	616052	89536	616052	1		
TM2	OPERATOR GUIDE (8024B)	616763	89536	616763	1		
U30	LIQUID CRYSTAL DISPLAY	504324	89536	504324	1	1	
	RECOMMENDED SPARE PARTS KIT, 8024B	653436	89536	653436			
	1 ORDER AT COMPONENT LEVEL						
	2 EUROPEAN USAGE: FUSE, 5X20MM, 2A, 250V	460972	75915	212002	1	5	

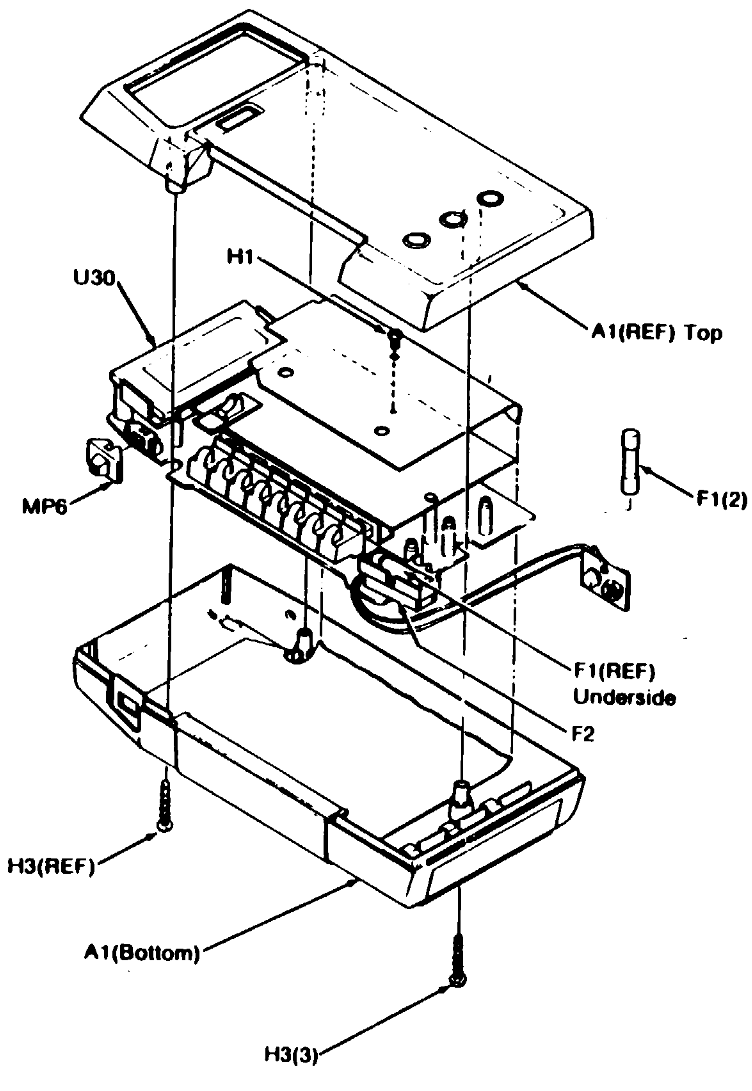


Figure 5-1. 8024B Final Assembly

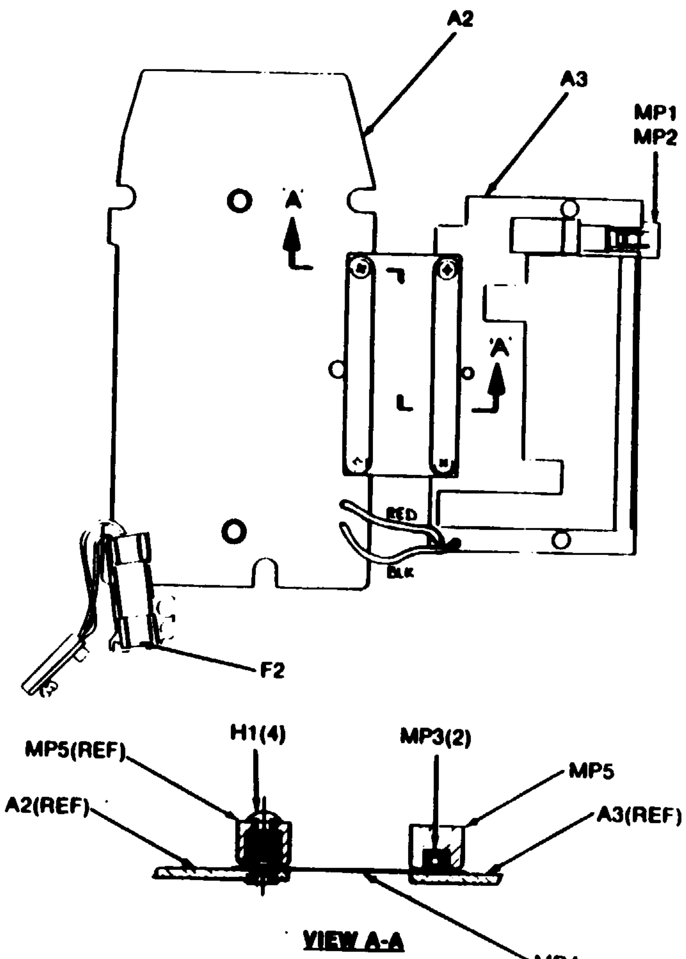


Figure 5-1. 8024B Final Assembly, Interior (cont)

Table 5-2. A1 Case Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
A1	CASE ASSEMBLY FIGURE 5-2 (8024B-4201)				1		1
MP1	BAIL, PLASTIC	616961	89536	616961	1		
MP2	CASE, BOTTOM	613950	89536	613950	1		
MP3	CASE, TOP	542027	89536	542027	1		
MP4	DECAL (CASE TOP)	604462	89536	604462	1		
MP5	DECAL, WARNING	428938	89536	428938	AR		
MP6	COVER, BATTERY	613968	89536	613968	1		
MP7	FLANGE, SWITCH	455881	89536	455881	1		
MP8	SHIELD (NOT SHOWN)	508101	89536	508101	1		
MP9	SHOCK ABSORBER	428441	89536	428441	1		
MP10	SPACER (CASE)	458588	89536	458588	2		
MP11	FOOT, NON-SKID	604397	89536	604397	4		

1 ORDER CASE PARTS SEPARATELY.

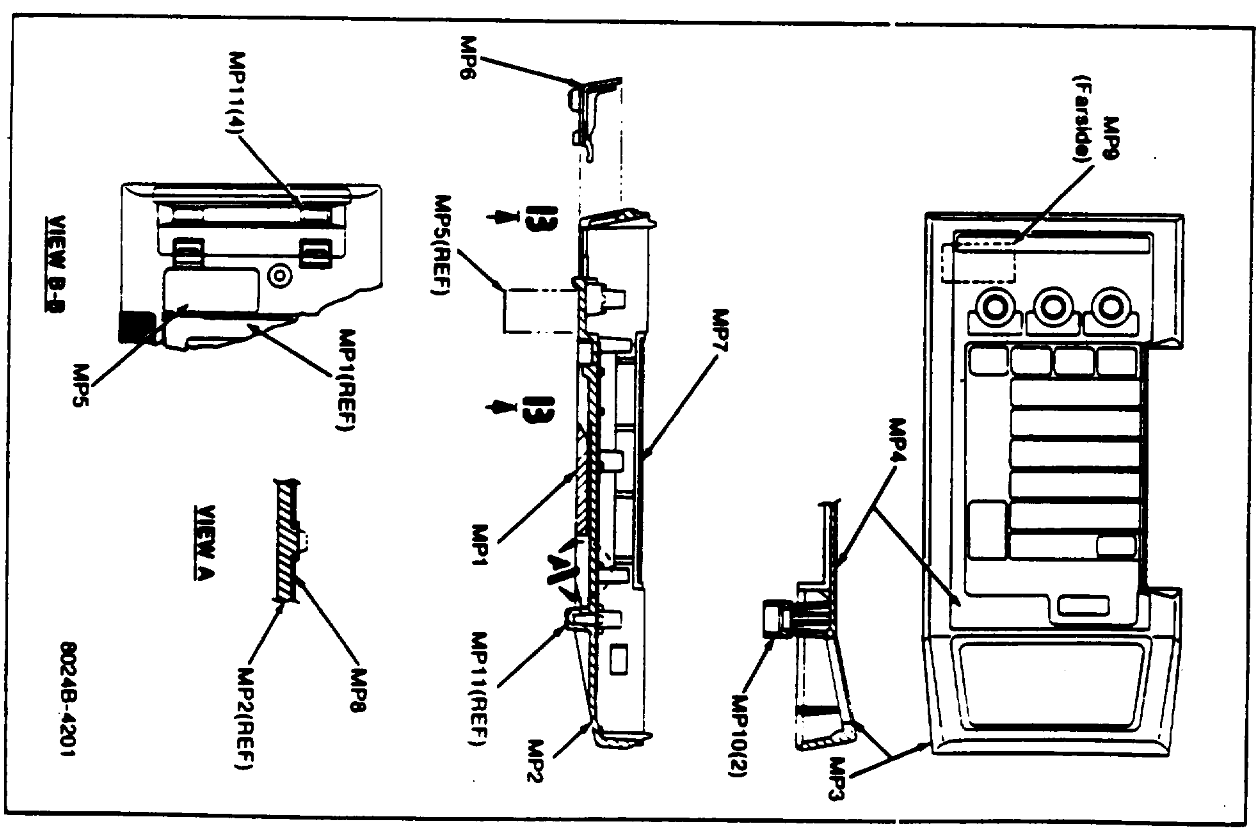


Figure 5-2. A1 Case Assembly

Table 5-3. A2 Main PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
A2	MAIN PCB ASSEMBLY FIGURE 5-3 (8024A-4011/4011S)	ORDER	ONLY	AT COMPONENT LEVEL	REF		1
C5	CAP, CER, 0.22 UF +/-20%, 50V	519157	51406	RPE111Z5U224M50V	1		
C6	CAP, POLY, 0.047 UF +/-10%, 100V	446773	89536	446773	2		
C7	CAP, CER, 500 PF +/-110%, 1KV	105692	71590	2DDH60N501K	2		
C8	CAP, POLYPROP, .047 UF +/-10%, 100V	446773	89536	446773	REF		
C9	CAP, POLY, 0.10 UF +/-10%, 100V	446781	89536	446781	1		
C10	CAP, AL. ELECT, 22 UF +/-20%, 16V	614750	89536	614750	1		
C11	CAP, MYLAR, 0.22 UF +/-10%, 100V	436113	73445	C280MAH/A220K	1		
C12	CAP, CER, 500 PF +/-110%, 1KV	105692	71590	2DDH60N501K	REF		
C13	CAP, MICA, 150 PF +/-5%, 500V	148478	72136	CM15F151J	1		
C14	CAP, MYLAR, 0.022UF +/-10%, 400V	369165	73445	C281A/A22K	2		
C15	CAP, MTL, .022 UF +/-10%, 400V	369165	73445	C281A/A22K	REF		
C19	CAP, POLY, 1.0 UF +/-10%, 50V	615427	84411	X463UW-1.0-10P-50V	1		
C20	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	2		
C21	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C24	CAP, CER, 470 PF +/-20%, 100V	358275	72982	8141-A100-W5R-471M	1		
CR1	DIODE, SI	347559	14099	1N5400	2	1	
CR2	DIODE, SI	347559	14099	1N5400	REF		
CR8	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	1	1	
J4	JACK, DC POWER, PC MOUNT	423897	89536	423897	1		
J5	CONTACT ASSEMBLY	535278	89536	535278	1		
J6	WIRE ASSEMBLY (RED)	516088	89536	516088	1		
J7	WIRE ASSEMBLY (BLK)	516070	89536	516070	1		

Table 5-3. A2 Main PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
LS1	TRANSDUCER	513101	89536	513101	1		
MP1	FUSE CAP	540716	89536	540716	1		
MP2	FUSE CLIP	534925	89536	534925	1		
MP3	FUSE CLIP	535203	89536	535203	1		
MP4	SPRING, FUSE (USA)	535211	89536	535211	1		
MP6	INSULATOR (NOT SHOWN)	175125	89536	175125	1		
MP7	SPRING, FUSE (EUROPEAN)	535229	89536	535229	1		
Q3	XSTR, SI, NPN	168716	07263	S19254	1	1	
Q8	XSTR, SI, PNP	195974	04713	2N3906	1	1	
Q10	XSTR, J-FET	357905	89536	357905	1	1	
R1	RES, COMP, 100K +/-10%, 1W	109397	01121	GB1041	1		
R2	RES, WW, 1000 +/-10%, 2W	474080	89536	474080	1		
R5	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	3		
R6	RES. VAR. 500 +/-10%, 0.5W	447730	89536	447730	1		
R8	RES, DEP. CAR, 220K +/-5%, 1/4W	348953	80031	CR251-4-5P220K	2		
R10	RES, VAR, 5K +/-10%, 0.5W	478883	89536	478883	1		
R13	RES, COMP, 10M +/-5%, 1/4	194944	01121	CB1065	3		
R14	RES, COMP, 10M +/-5%, 1/4W	194944	01121	CB1065	REF		
R16	RES, DEP. CAR, 220K +/-5%, 1/4W	348953	80031	CR251-4-5P220K	REF		
R17	RES, VAR, 1M +/-10%, 0.5W	461343	89536	461343	1		
R20	RES, DEP. CAR, 30K +/-5%, 1/4W	368753	80031	CR251-4-5P30K	1		
R21	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	1		
R22	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
R24	RES, COMP, 10M +/-5%, 1/4	194944	01121	CB1065	REF		
R25	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	1		

Table 5-3. A2 Main PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
R28	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	1		
R29	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R30	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
RV1	VARISTOR, +/-10%, 430V	447672	09214	V43MA7B	4	1	
RV2	VARISTOR, +/-10%, 430V	447672	09214	V43MA7B	REF		
RV3	VARISTOR, +/-10%, 430V	447672	09214	V43MA7B	REF		
RV4	VARISTOR, +/-10%, 430V	447672	09214	V43MA7B	REF		
S9	SWITCH, SLIDE	453365	79727	G1-116-0005,G-20-32	1		
U5	RESISTOR NETWORK	513044	89536	513044	1	1	
U6	RESISTOR NETWORK	513002	89536	513002	1		
U7	⊘IC, C-MOS, QUAD, EXCLUSIVE OR GATES	355222	02735	CD4030AE	2	1	
U8	⊘IC, C-MOS, LSI, LCD INTERFACING (40-PIN)	429100	89536	429100	1	1	
U10	⊘IC, C-MOS, QUAD, EXCLUSIVE OR GATES	355222	02735	CD4030AE	REF		
U12	RESISTOR NETWORK	513051	89536	513051	1		
U14	⊘IC, C-MOS (SELECTED)	539437	89536	539437	1	1	
U15	RESISTOR NETWORK	513036	89536	513036	1		
U16	⊘IC, C-MOS, NAND GATE QUAD 2-INPUT	453241	02735	CD4011BE	1	1	
U17	⊘IC, C-MOS, RE-TRIG/RESET MULTIVIBRATOR	393512	02735	CD4098AE	1	1	
U18	IC, LINEAR, 5-XSTR ARRAY	248906	12040	LM3046N	1	1	
U19	⊘IC, C-MOS (SELECTED)	526608	89536	526608	1	1	
U21	IC, LINEAR, OP AMP	539643	89536	539643	1	1	
VR1	IC, LINEAR, LO-VOLT REF (SELECTED)	508259	89536	508259	1		
VR2	DIODE, ZENER, 12V	113456	04713	1N963A	1	1	
XU8	SOCKET, IC, 40-PIN	429282	09922	DILB40P-108	1		
Y1	CRYSTAL, QUARTZ, 3.2 MHZ (50 HZ)	513937	89536	513937	1	1	

1 ORDER SPARES BY COMPONENT LEVEL.

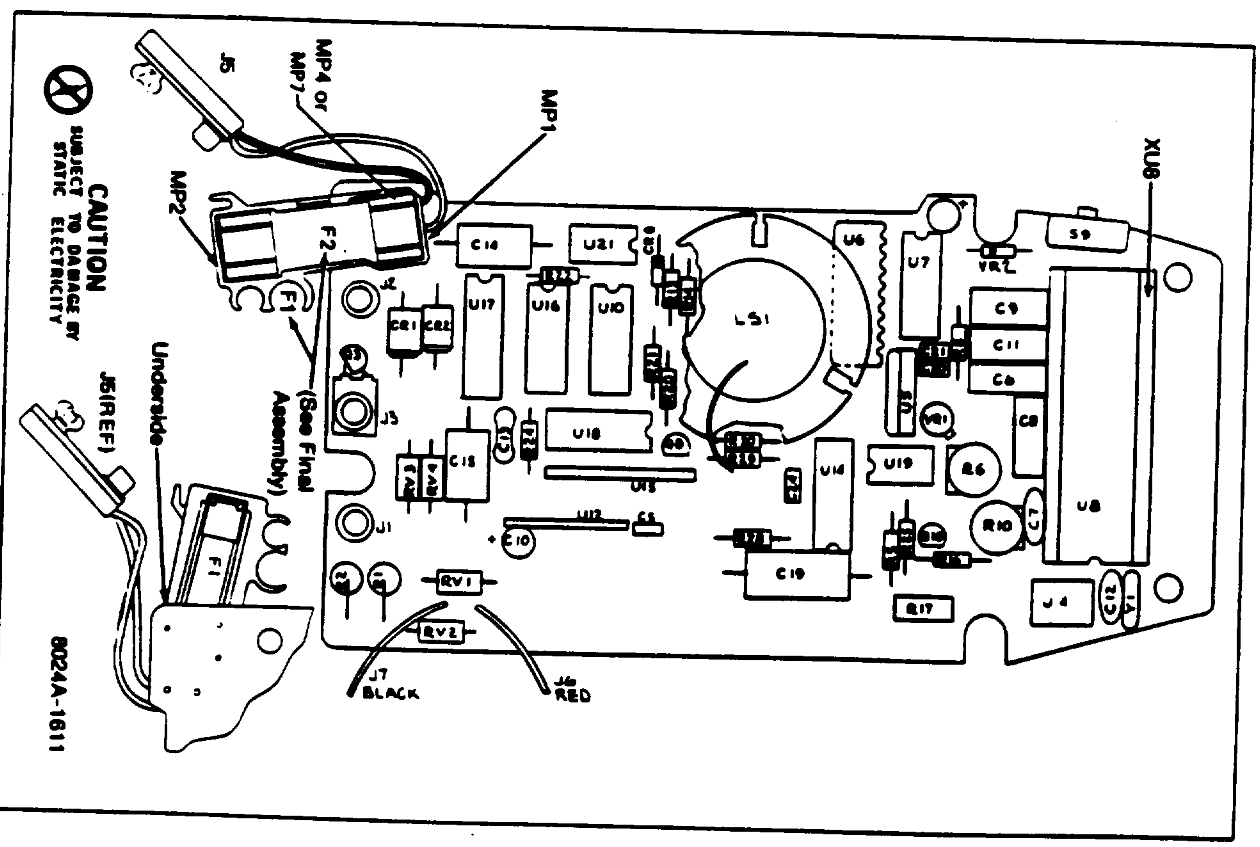


Figure 5-3. A2 Main PCB Assembly

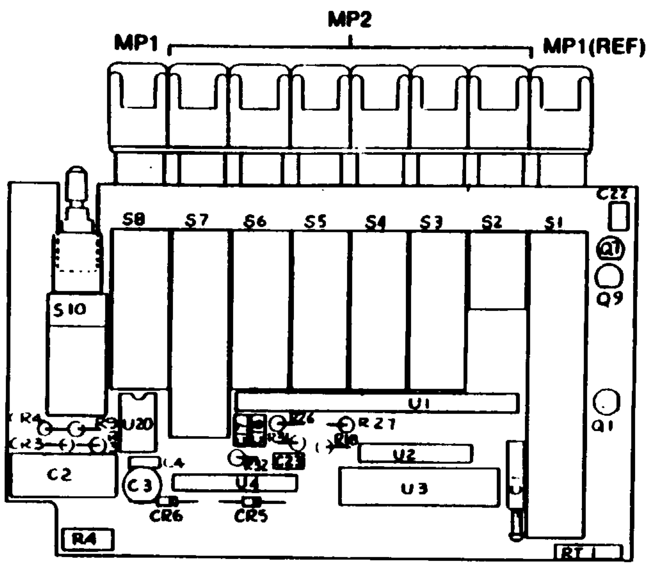
Table 5-4. A3 Switch PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
A3	SWITCH PCB ASSEMBLY FIGURE 5-4 (D804-4031/8024A-4021)	ORDER	ONLY	AT COMPONENT LEVEL	REF		
C1	CAP, VAR, TRIMMER, 1.5 - 0.25 PF 2000VDC	435016	72982	530-006	1		
C2	CAP, FILM, 0.022 UF +/-10%, 1000VDC	448183	52763	MKT-1822-322/10+10%	1		
C3	CAP, AL. ELECT, 22 UF +/-20%, 16V	614750	89536	614750	1		
C4	CAP, CER, 33 PF +/-2%, 100V	354852	72982	8121-A100-COG-330G	1		
C17	CAP, CER, 0.047 UF +/-20%, 50V	460733	71590	CW20C473M	1		
C18	CAP, CER, 0.22 UF +/-20%, 50V	519157	51406	RPE111Z5U224M50V	2		
C22	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	1		
C23	CAP, CER, 0.22 UF +/-20%, 50V	519157	51406	RPE111Z5U224M50V	REF		
CR3	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	4	1	
CR4	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR5	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR6	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
MP1	BUTTON,SW,"Function" (S1,S8)	606889	89536	606889	2		
MP2	BUTTON, SW, "Range" (S2-S7)	606871	89536	606871	6		
Q1	TRANSISTOR, SI, NPN	218396	04713	2N3904	3	1	
Q7	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q9	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
R1,R2	SEE U3						
R3	RES, COMP, 2.2M +/-5%, 1/4W	198390	01121	CB2275	1		
R4	RES, VAR, 300 +/-10%, 250VDC/RMS	513424	89536	513424	1		
R9	RES, COMP, 10K +/-5%, 1/4W	148106	01121	CB1035	1		
R18	RES, DEP. CAR, 240K +/-5%, 1/4W	442459	80031	CR251-4-5P240K	1		

Table 5-4. A3 Switch PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
R26	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
R27	RES, DEP. CAR, 51K +/-5%, 1/4W	376434	80031	CR251-4-5P51K	1		
R31	RES, DEP. CAR, 390K +/-5%, 1/4W	442475	80031	CR251-4-5P390K	1		
R32	RES, DEP. CAR, 200K +/-5%, 1/4W	441485	80031	CR251-4-5P200K	1		
RT1	RES, CURRENT LIMITING, 1K +/-40%, 2W	446849	89536	446849	1		
S1-S8	SWITCH ASSEMBLY	508119	89536	508119	1		
S10	SWITCH, "Peak Hold"	525121	89536	525121	1		1
U1	RESISTOR NETWORK	515874	89536	515874	1		
U2	RESISTOR NETWORK	447706	89536	447706	1		
U3	RESISTOR SHUNT (W/R1,R2)	435727	89536	435727	1		
U4	RESISTOR NETWORK	513028	89536	513028	1		
U20	IC, LINEAR, OP-AMP	418566	12040	LM358N	1	1	

1 "Peak Hold" BUTTON P/N, SEE FINAL ASSY., MP1.



8024A-1621

Figure 5-4. A3 Switch PCB Assembly

Table 5-5. Federal Supply Codes for Manufacturers

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

02735
Replaces 18725
RCA - Solid State Div.
Somerville, New Jersey

04713
Motorola Inc.
Semiconductor Group
Phoenix, Arizona

05277
Westinghouse Electric Corp.
Semiconductor Division
Youngwood, Pennsylvania

07263
Fairchild Camera & Instrument Corp.
Semiconductor Division
Mountain View, California

07910
Replaced by 15818

09214
General Electric Co.
Semiconductor Products
Power Component Operation
Auburn, New York

09922
Burndy Corp.
Norwalk, Connecticut

12040
National Semiconductor Corp.
Danbury, Connecticut

14099
Semtech Corp
Newbury Park, California

15818
Teledyne Semiconductors
Formerly Amelco Semiconductor
Mountain View, California

18736
Voltronics Corp
Hanover, New Jersey

19647
Caddock Electronics Inc.
Riverside, California

22526
DuPont, El DeNemours & Co. Inc.
Berg Electronics Div.
New Cumberland, Pennsylvania

30035
Jol Industries Inc.
Garden Grove, California

50157
Midwest Components Inc.
Muskegon, Mississippi

51404
Corning Glass Works
Medical & Scientific Instruments
Medfield, Maryland

51406
Murata Corporation of America
Marietta, Georgia

52763
Stettner-Trush Inc.
Cazenovia, New York

56289
Sprague Electric Co.
North Adams, Massachusetts

71400
Bussman Manufacturing
Div. of McGraw-Edison Co.
St. Louis, Missouri

71590
Centralab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

72136
Electro Motive Mfg. Co.
Florence, South Carolina

72982
Erie Technical Products Inc.
Erie, Pennsylvania

73445
Amperex Electronic Corp.
Hicksville, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

Table 5-5. Federal Supply Codes for Manufacturers (cont)

79727 C - W Industries Warminster, Pennsylvania	84411 TRW Electronic Components TRW Capacitors Ogallala, Nebraska
80031 Mepco/Electra Corp Morristown, New Jersey	89536 John Fluke Manufacturing Co., Inc Everett, Washington

Section 6
Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information concerning the accessories available for use with the Model 8024B Digital Multimeter. (There are no options available at this time.) The accessories, some of which are shown in Figure 6-1, are described in general terms under a separate major heading containing the accessory model number. The depth of detail is intended to give the prospective user an adequate first acquaintance with the features and capabilities of each accessory. Additional information, when necessary, is supplied with the accessory.

6-3. DELUXE CARRYING CASE (C90)

6-4. The C90 Deluxe Carrying Case is a pliable, vinyl, zipper-closed pouch that provides in-field-transport protection for your DMM, as well as convenient storage locations for test leads, operator's guide, and other small accesssories. A finger or belt loop is included on the case as a carrying convenience.

6-5. RUGGED CARRYING CASE (Y8105)

6-6. Your Y8105 is a rigid plastic case that provides protection from dirty, damp, abusive environments. The rugged case is large enough to hold your DMM, test leads, operator's guide card, a temperature measuring accessory, an ac current measuring accessory, a spare battery, and a spare fuse.

6-7. TYPE K SHEATHED THERMOCOUPLE (Y8102)

6-8. Introduction

6-9. Your Y8102 can be used for almost any application, but is best suited for use as a liquid immersion type probe. In most liquids, the grounded measuring junction of your Y8102 provides fast response time. The special isothermal termination unit that plugs into your DMM eliminates temperature gradient problems by keeping the two DMM junctions at the same temperature. See Section 2 of this manual for applications.

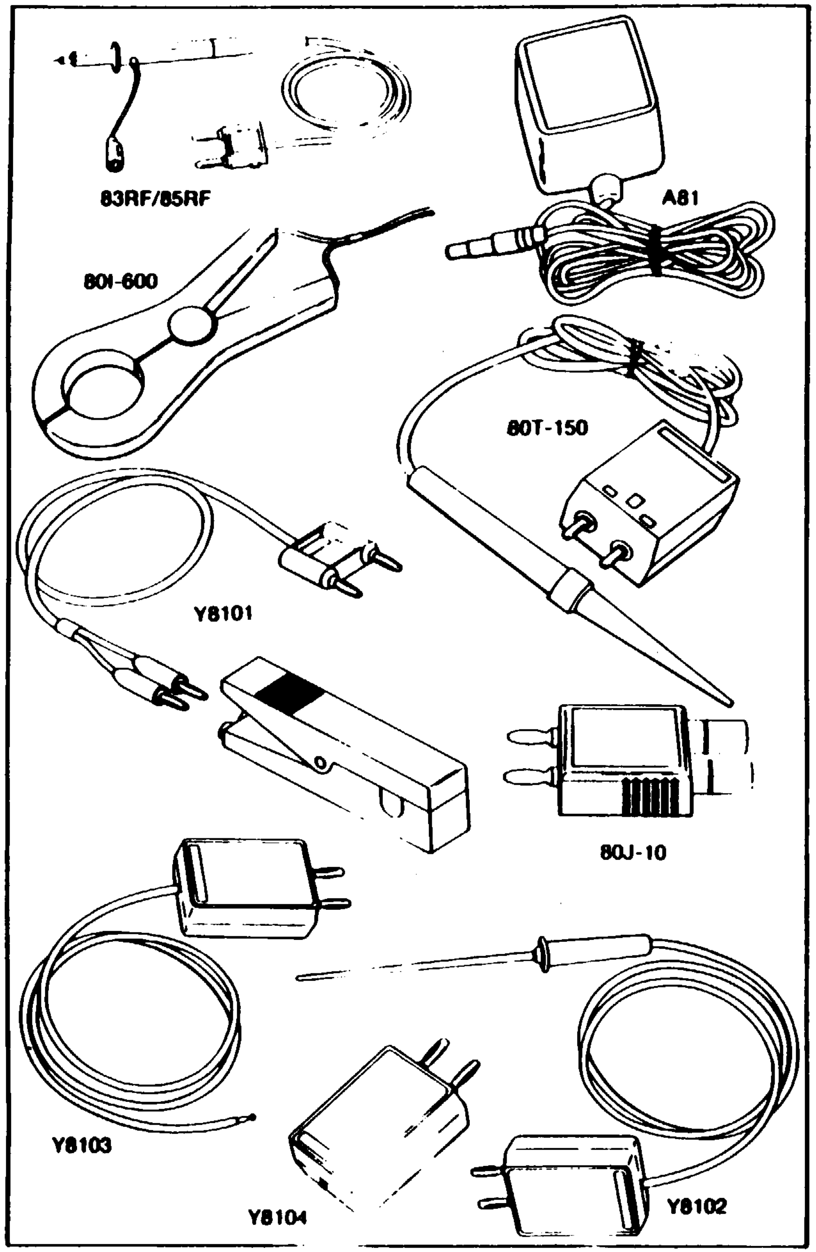


Figure 6-1. 8024B Accessories

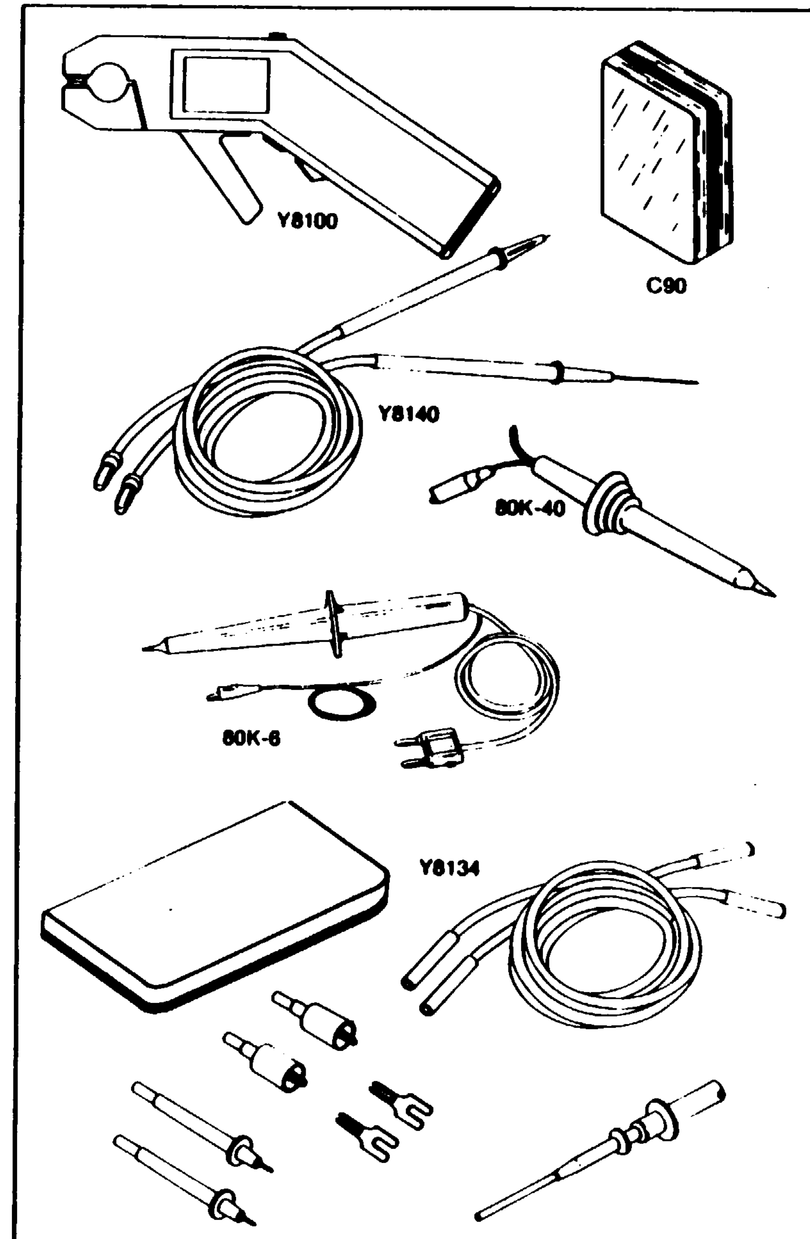


Figure 6-1. 8024B Accessories (cont)

6-10. Specifications

TYPE	K (Chromel vs Alumel).
ACCURACY (with respect to NBS tables)	±2.2°C (4°F) over the range of 0°C to 276.7°C (32°F to 530°F). ±3/4% of temperature over the range of 276.7°C to 926.7°C (530°F to 1700°F). (Above accuracy and range specifications apply to thermocouple accessory only. Use 8024B Temperature function specifications when using the Y8102 accessory with the 8042B multimeter.)
TIME CONSTANT	10 seconds (for air at room temperature and one atmosphere of pressure moving at 65 ft/sec).
SAMPLING TIP	
Maximum Temperature Rating	927°C (1700°F).
Sheath Material	Inconel.
DIMENSIONS	3.175 mm (1/8 inch) in diameter, 15.24 cm (6 inches) in length. Conductor length 48 inches nominal.

6-11. TYPE K BEAD THERMOCOUPLE (Y8103)

6-12. Introduction

6-13. Your Y8103 can be used for any measuring application (in Teflon compatible environments) except penetration. The exposed tip means extremely fast response time. The special isothermal termination unit that plugs into your DMM eliminates thermal gradient problems by keeping the two DMM junctions at the same temperature. See Section 2 of this manual for applications.

6-14. Specifications

TYPE	K (Chromel vs Alumel).
RANGE	-150°C to 260°C (-238°F to 500°F) continuous.
ACCURACY (with respect to NBS tables)	±2.2°C (4°F) over the range of -17.8°C to 260°C (0°F to 500°F). (Above accuracy and range specifications apply to thermocouple accessory only. Use 8024B Temperature function specifications when using the Y8103 accessory with the 8024B multimeter.)
TIME CONSTANT	2 seconds (for air at room temperature and one atmosphere of pressure moving with a velocity of 65 ft/sec).
INSULATION TYPE	Teflon Fused Tape

6-15. THERMOCOUPLE TERMINATION (Y8104)

6-16. The Y8104 is a special isothermal termination kit that is designed to provide a junction between a dual male banana plug and thermocouple wire. The termination unit eliminates thermal gradient errors by keeping the two DMM terminals at the same temperature. The maximum thermocouple wire size is 14. The dual banana plug spacing is .75 inches.

6-17. TEMPERATURE PROBES (80T-150C and 80T-150F)

6-18. Introduction

6-19. The 80T-150 Temperature Probe converts the instrument into a direct-reading (1 mV dc/°)°C or °F thermometer. It is ideally suited for surface, ambient and liquid measurement, and lends itself easily to a wide range of design, troubleshooting, and evaluation applications. A rugged, fast-responding probe-tip with a 350V dc standoff makes the 80T-150 one of the most versatile and easy-to-use temperature probes available.

6-20. Specifications

RANGE (°C/°F) (field selectable by internal jumpers)	-50°C to +150°C (80T-150C); -58°F to +302°F (80T-150F)
ACCURACY	±1°C (1.8°F) from 0°C to 100°C, decreasing linearly to ±3°C (5.4°F) at -50°C and +150°C
RESOLUTION	0.1°C on 200 mV range
VOLTAGE STANDOFF	350V dc or peak ac
POWER	Internal disposable battery; 1,000 hours of continuous use

6-21. HIGH VOLTAGE PROBE (80K-6)

6-22. Introduction

6-23. The 80K-6 is a high voltage probe designed to extend the voltage measuring capability of an ac dc voltmeter to 6000 volts. A 1000:1 voltage divider provides the probe with a high input impedance. The divider also provides high accuracy when used with a voltmeter having a 10 megohm input impedance. A molded plastic body houses the divider and protects the user from the voltage being measured.

6-24. Specifications

VOLTAGE RANGE	0 to 6 kV, dc or peak ac
INPUT IMPEDANCE	75 megohms nominal
DIVISION RATIO	1000:1
ACCURACY	
DC to 500 Hz	±1%
500 Hz to 1 kHz	±2%
Above 1 kHz	Output reading falls. Typically, -30% at 10 kHz.

6-25. HIGH VOLTAGE PROBE (80K-40)

6-26. Introduction

6-27. The Model 80K-40 extends the voltage measurement capability of the instrument up to 40 kV. Internally, the probe contains a special 1000:1 resistive divider. Metal-film resistor with matched temperature coefficients comprise the divider and provide the probe with its excellent accuracy and stability characteristics. Also, an unusually high input impedance (1000 MΩ) minimizes circuit loading, and thereby contributes to measurement accuracy.

6-28. Specifications

VOLTAGE RANGE	1 kV to 40 kV dc or peak ac, 28 kV rms ac
INPUT RESISTANCE	1000 MΩ
DIVISION RATIO	1000:1
ACCURACY DC (OVERALL)	20 kV to 30 kV ±2% (calibrated at 25 kV)
UPPER LIMIT	Changes linearly from 2% at 30 kV to 4% at 40 kV
LOWER LIMIT	Changes linearly from 2% at 20 kV to 4% at 1 kV
ACCURACY AC (OVERALL)	±5% at 60 Hz

6-29. HIGH FREQUENCY PROBE (83RF)

6-30. Introduction

6-31. The 83RF Probe extends the frequency range of the instrument voltage measurement capabiltity to include 100 kHz to 100 MHz input from 0.25 to 30V rms. It operates in conjunction with the instrument's dc voltage ranges, and provides a dc output that is calibrated to be equivalent to the rms value of a sine wave input.

6-32. Specifications

FREQUENCY RESPONSE ...... ±1 dB from 100 kHz to 100 MHz (relative to ac/dc transfer ratio)

AC-TO-DC TRANSFER RATIO (23 ±5°C)

RMS Input (100 kHz)	DC Output
0.25 - 0.5V	0.25 - 0.5V ±1.5 dB
0.5 - 2.0V	0.5 - 2.0V ±0.5 dB
2.0 - 30V	2.0 - 30V ±1.0 dB

EXTENDED FREQUENCY RESPONSE	Useful for relative readings from 20 kHz to 250 MHz.
RESPONSE	Responds to peak value of input; calibrated to read the rms value of a sine wave.
VOLTAGE RANGE	0.25 to 30V dc
MAXIMUM DC INPUT	200V dc
TEMPERATURE COEFFICIENT (0 to 18°C, 28 to 50°F)	±0.1 of ac-to-dc transfer ratio specifications per °C
INPUT CAPACITANCE	<5 pF

6-33. HIGH FREQUENCY PROBE (85RF)

6-34. Introduction

6-35. The Model 85RF High Frequency Probe allows measurements over a frequency range of 100 kHz to 500 MHz from .25V to 30V rms. It operates in conjunction with the instruments dc voltage ranges and provides a dc output that is calibrated to be equivalent to the rms value of a sinewave input.

6-36. Specifications

FREQUENCY RESPONSE	
100 kHz to 100 MHz	±0.5 dB
100 MHz to 200 MHz	±1.0 dB
200 MHz to 500 MHz	±3.0 dB
EXTENDED FREQUENCY RESPONSE	Useful for relative readings from 20 kHz to 700 MHz.
RESPONSE	Responds to peak value of input; calibrated to read rms value of a sine wave.
VOLTAGE RANGE	0.25V dc to 30V rms
MAXIMUM DC INPUT	200V dc
INPUT CAPACITANCE	<5 pF
AC-TO-DC TRANSFER RATIO	1:1
RATIO ACCURACY	0.5 dB at 10 MHz

6-37. CURRENT TRANSFORMER (801-600)

6-38. Introduction

6-39. The Model 801-600 extends the ac current measurement capability of the instrument up to a maximum of 600 amps. A clamp-on transformer designed into the probe allows measurements to be made without breaking the circuit under test. In use, the current carrying conductor being measured serves as the transformer's primary while the 801-600 serves as the secondary. Because of a high efficiency, quadrature-type of winding, wire size and location of the conductor within the transformer jaws do not affect accuracy of the current measurement.

6-40. Specifications

RANGE	1 to 600A ac
ACCURACY	±3%
FREQUENCY RESPONSE	30 Hz to 1 kHz, 10 kHz typical
DIVISION RATIO	1000:1
WORKING VOLTAGE	750V rms maximum.
INSULATION DIELECTRIC WITHSTAND VOLTAGE	5 kV.
MAXIMUM CONDUCTOR SIZE	2-inch diameter.

6-41. CURRENT SHUNT (80J-10)

6-42. Introduction

6-43. The Model 80J-10 Current Shunt extends the current measuring capability of your meter to 10 amps continuous (20 amps for periods not exceeding 1 minute) DC to 10 kHz at an accuracy of 0.25% in excess of the voltmeter accuracy.

6-44. Specifications

SHUNT	10 amps at 100 mV
ACCURACY (18°C to 28°C)	
DC to 10 kHz	±0.25%
10 kHz-100 kHz	Rising to 1 dB at 100 kHz typical

TEMPERATURE COEFFICIENT	0.005%/°C
INDUCTANCE	8.3 nH in series w/0.01Ω shunt
OVERLOAD	Up to one minute at 20A with a 1/4 duty cycle for recovery after currents between 10A and 20A
CONNECTS TO	3/4 inch center banana jacks
CONNECTORS	5-way binding posts (red and black)

6-45. BATTERY ELIMINATOR (A81)

WARNING

DO NOT SUBSTITUTE A CALCULATOR TYPE BATTERY ELIMINATOR FOR THE A81. THESE UNITS DO NOT PROVIDE THE PROTECTION NECESSARY FOR COMMON MODE MEASUREMENTS UP TO 500V DC. ALWAYS USE THE MODEL A81 FOR AC-LINE OPERATION.

6-46. The A81 Battery Eliminator replaces the output of the DMM battery to allow ac-line operation of the DMM. Select the correct A81 configuration according to the list below:

NOTE

The "BT" indicator may come on when using the A81. This does not adversely affect the operation of the 8024B.

1. For 100V ac ±10%, 48 to 62 Hz operation, use A81-100.
2. For 115V ac ±10%, 48 to 62 Hz operation, use A81-115.
3. For 230V ac ±10%, 48 to 62 Hz (U.S. type plug) operation, use A81-230-1
4. For 230V ac ±10%, 48 to 62 Hz (European type plug) operation, use A81-230.

6-47. AC/DC CURRENT PROBE (Y8100)

6-48. Introduction

6-49. The Fluke Y8100 DC/AC Current Probe is a clamp-on probe that is used with a voltmeter, multimeter, or oscilloscope to read dc, ac, or composite (ac on dc) current measurements. The jaws on the Y8100 are designed to clamp around conductors up to 3/4 inch in diameter. The pistol shape allows safe, easy, one-hand operation when making current measurements. The Model Y8100 probe is battery powered with size AA cells. It measures current to 200A dc or ac rms using most any voltmeter. Two ranges, 20A and 200A, produce a 2V output at full-range current.

6-50. Specifications

RANGES	20A ac or dc 200A ac or dc
RATED OUTPUT	2V at full range
ACCURACY	
DC to 200 Hz	±2% of range
200 Hz to 1 kHz	<100A add ±3% reading >100A add ±6% reading
CALIBRATION CYCLE	1 year
FREQUENCY RESPONSE	dc to 1.0 kHz
RECOMMENDED LOAD	≥3.0 kΩ
TEMPERATURE RANGE	+15°C to +35°C; for specified accuracy -10°C to +50°C; storage and operation at reduced accuracy.
HEATING LIMITATION	Prolonged operation above 200A ac or 1 kHz can cause damage to the Y8100.
WORKING VOLTAGE RATING	Core to output; 600V dc or 480V ac Maximum output to ground; 42V dc or 30V ac
APERTURE SIZE	3/4" (19 mm) diameter
SIZE-OVERALL	9" x 4-1/2" x 1-7/16" (230 mm x 115 mm x 37 mm)
WEIGHT	14 ounces (0.4 kg), with batteries
POWER	Four "AA" cells
BATTERY LIFE	Alkaline-20 hours continuous

6-51. AC CURRENT TRANSFORMER (Y8101)

6-52. Introduction

6-53. The Model Y8101 (Figure 6-1) is a small clamp-on current transformer designed to extend the current measuring capability of an ac current meter up to 150 amperes. A clamp-on coil desinged into the probe allows measurements to be made without breaking the circuit under test. This coil serves as the secondary of a 1:1000 transformer. The current-carrying conductor being measured serves as the primary.

6-54. Specifications

CURRENT RANGE	2A to 150A
ACCURACY, (48 Hz TO 10 kHz)	±2%, 10A to 150A ±8%, 2A to 10A
DIVISION RATIO	1000:1
WORKING VOLTAGE	300V ac rms maximum
INSULATION DIELECTRIC WITHSTAND VOLTAGE	3 kV rms
MAXIMUM CONDUCTOR SIZE	7/16" (1.11 cm)

6-55. SAFETY DESIGNED TEST LEAD SET (Y8132)

6-56. This test lead set is equivalent to the set originally supplied with the 8020B multimeter. The set includes one red and one black test lead. Each probe has an anti-slip shoulder near the test tip and is connected to the multmeter via a safety-designed shrouded banana connector. This set will fit John Fluke instruments with safety-designed input jacks.

6-57. DELUXE TEST LEAD SET (Y8134)

6-58. The Y8134 is a deluxe test lead set. The attachments provided allow interconnection with a wide variety of leads and electronic components. Included in the kit are:

1. Two test leads (one red and one black). The Y8134 leads have a shrouded banana connectors on each end.
2. Two test probes
3. Two insulated alligator clips
4. Two spade lugs
5. One squeeze hook
6. One test lead pouch
7. One instruction sheet

6-59. SLIM FLEX TEST LEAD SET (Y8140)

6-60. The Y8140 Test Lead Set (Figure 6-1) consists of one red and one black 60-inch (1.52 meter) test lead, each with a standard banana plug on one end and an extendable tip probe on the other end. This flexible metallic tip conductor may be extended up to 2.5 inches and is insulated to within 0.1 inch of its tip. This insulation reduces the chance of creating an inadvertent short circuit while using the probes in their extended configuration. Intended primarily for measuring voltages, the Y8140 leads may also be used for measuring modest currents.

Section 7
Schematic Diagrams

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8024B

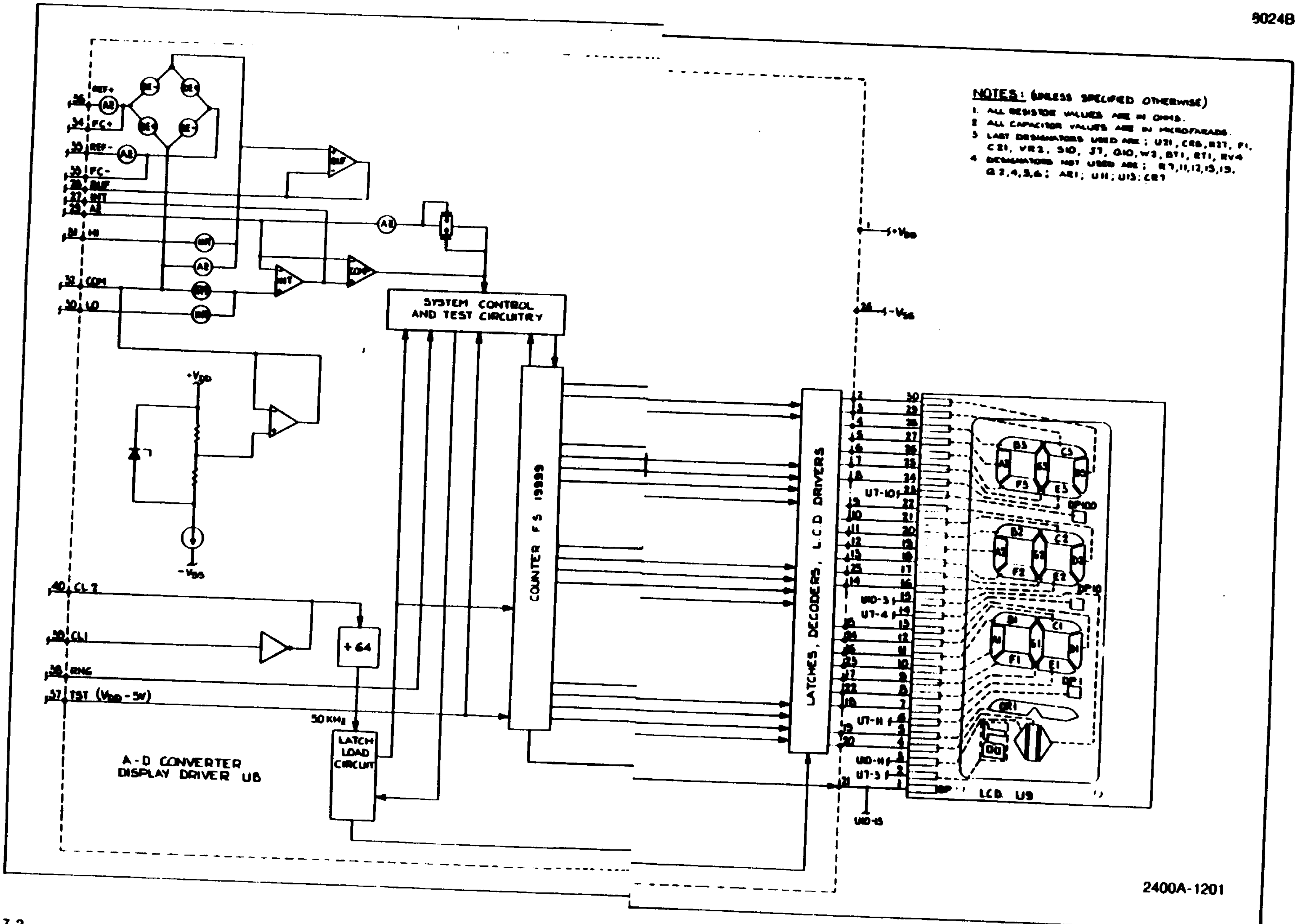

Figure 7-1. 8024B Schematic Diagram

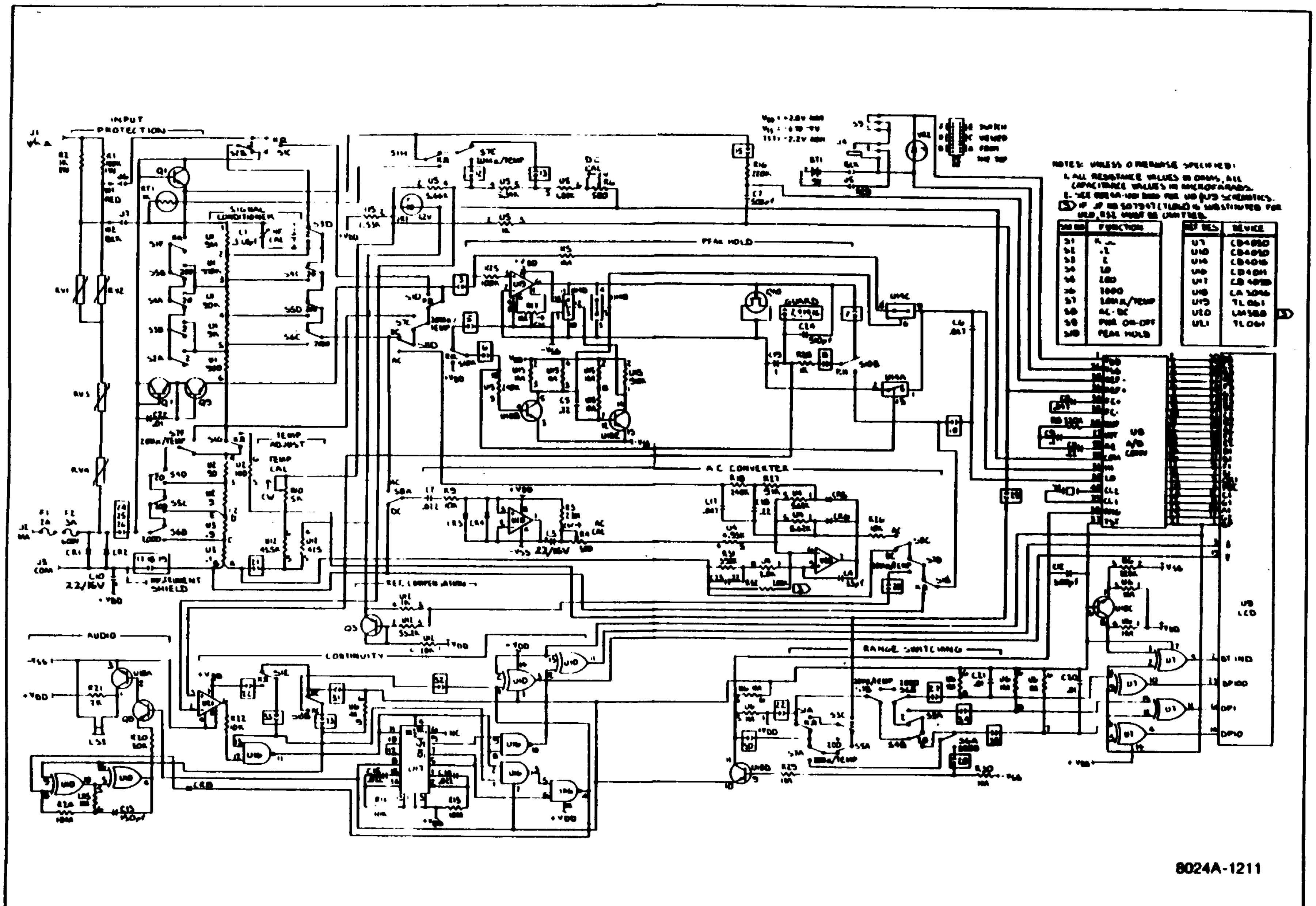

Figure 7-1. 8024B Schematic Diagram (cont)

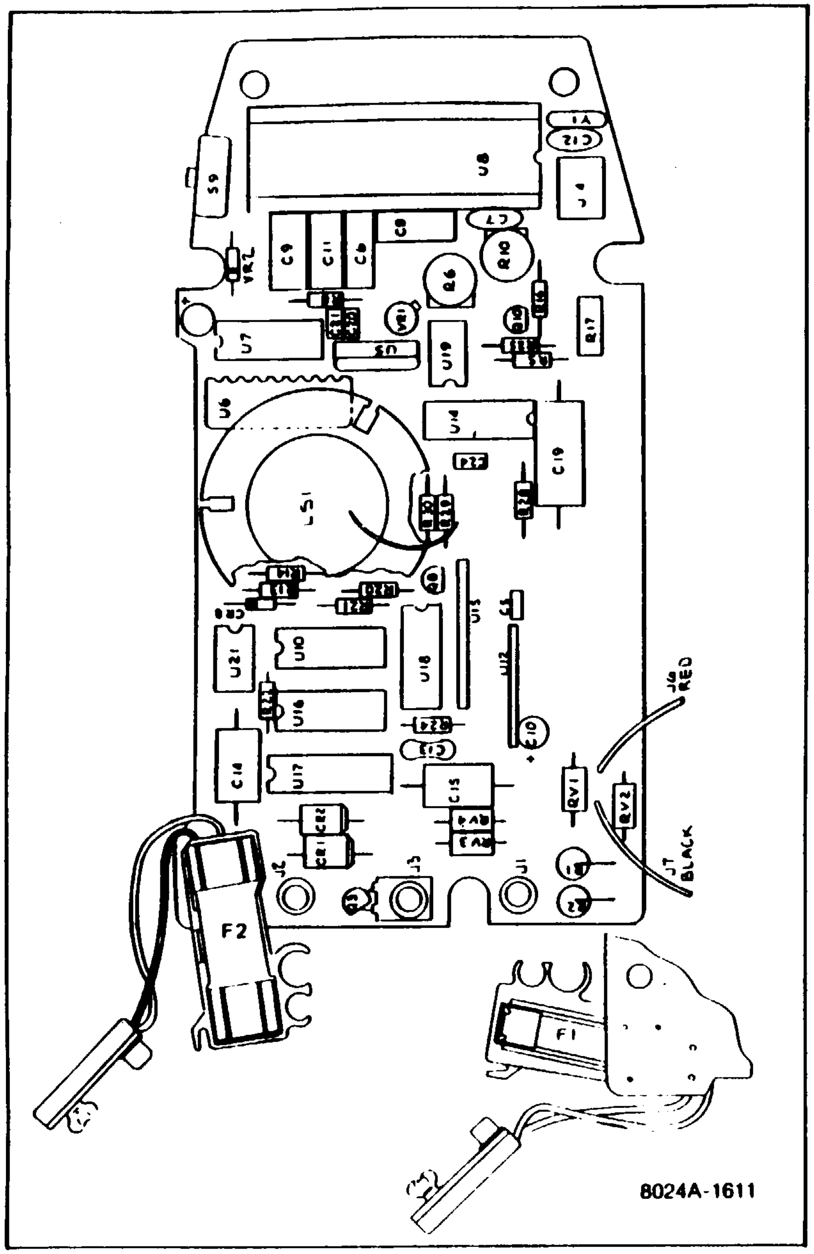

Figure 7-1. 8024B Schematic Diagram (cont)

Appendix A
Manual Change and Backdating Information

INTRODUCTION

This appendix contains information necessary to backdate the manual to conform with earlier pcb configuations. To identify the configuration of the pcbs used in your instrument, refer to the revision letter (marked in ink) on the component side of each pcb assembly. Table A-1 defines the assembly revision levels documented in this manual.

NEWER INSTRUMENTS

As changes and improvements are made to the instrument, they are identified by incrementing the revision letter marked on the affected pcb assembly. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted at the front of the manual.

OLDER INSTRUMENTS

To backdate this manual to conform with an earlier assembly revision level, perform the changes indicated in Table A-1.

CHANGES

There are no backdating changes at this printing. All pcb assemblies are documented at their original revision level.

Table A-1. Manual Status and Backdating Information

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in descending order (by no.), ending with change under desired rev letter																					
			–	A	B	C	D	E	F	G	H	J	K	L	M	N	P							
A2	MAIN PCB ASSEMBLY	[illegible]	•	X																				
A3	SWITCH PCB ASSEMBLY	[illegible]	•	X																				

* X = The PCB revision levels documented in this manual
● = These revision letters were never used in the instrument
– = No revision letter on the PCB

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive

The JOHN FLUKE MFG CO INC, warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 2 years from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargable type batteries are warranted for 90 days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co. Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 2 years from date of purchase, provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 2 years of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

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1. Notify the JOHN FLUKE MFG CO INC, or nearest Servicefacility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

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162 04 Vallingby Sweden
Tel (8) 380370 TLX (854) 15770

Switzerland •
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Jenatschstrasse 1
8002 Zurich Switzerland
Tel (1) 2010711 TLX (845) 54318

Syria •
Mabek (Electronic Division)
P O Box 4238
Damascus, Syria

Taiwan •
Schmidt Scientific Far East Ltd
608, Chia Hsin Bldg
96, Chung Shan N Rd, Sec 2
Taipei Taiwan
Tel 5414600 TLX 11111

Thailand •
Measuretronix Ltd
1008/10 Ramkhamhaeng Rd
Huamark Bangkok 24 Thailand
Tel 3143088 TLX 81143

Tunisia •
Selep S A R L
6, Rue de Sparte
Tunis - 1000 RP Tunisia
Tel (1) 248093 TLX (934) 13030

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Tecarel Anonim Sirketi
Necatibey Cad 92/3
Karakoy, Istanbul, Turkey
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TLX (821) 23353

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Al Sanani Trad Est
P O Box 7187
Abu Dhabi, United Arab Emirates
Tel 821370 or 821371
TLX 22888

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Fluke (Great Britain) Ltd
Colonial Way
Watford Herts WD2 4TT
United Kingdom
Tel (0923) 40511, TLX 934583
Rapifax (0923) 25067

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Coasin Uruguaya S A
Casilla de Correo 1400
Libertad 2529
Montevideo, Uruguay
Tel 79-69-16, TLX UY6571

U.S.S.R. •
Amtest Associates Ltd
Clarence House, 31 Clarence St
Staines Middlesex TW18 4SY
United Kingdom
Tel (784) 63555 TLX 928855

Venezuela •
Coasin C A
Calle 9 Con Calle 4 Edif Edinurbi
Apartado De Correos
NR-70 136 Los Ruices
Caracas 1070A Venezuela
Tel 239 0967 TLX (395) 21027

Yemen •
Fluke (Holland) B V
P O Box 5053 5004 EB Tilburg
Zevenheuvelenweg 53 5048 AN Tilburg
The Netherlands
Tel (013) 673973 TLX 52237

Yugoslavia •
Amtest Associates Ltd
Clarence House 31 Clarence St
Staines Middlesex TW18 4SY
United Kingdom
Tel (784) 63555 TLX 928855

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Zevenheuvelenweg 53 5048 AN Tilburg
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Everett WA 98206 U S A
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TLX 152662 JOHN FLUKE EVT

FLUKE

FLUKE John Fluke Mfg. Co., Inc. / PO Box C9090 / Everett, WA 98206 / (206) 356 5400

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John Fluke Mfg Co Inc
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CO, Denver
John Fluke Mfg Co Inc
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FL, Orlando
John Fluke Mfg Co Inc
(305) [illegible]

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(214) [illegible]

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John Fluke Mfg Co Inc
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Tel [illegible]
TLX 122284 COASIN AR

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Tel (02) 736-2888
TLX (790) 25887

Australia, Mount Waverley
Elmeasco Instruments Pty Ltd
Tel 03-233-4044
TLX 36206

Australia, Brisbane
Elmeasco Instruments Pty Ltd
Tel (07) 229-3161

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Walter Rekirsch Elektronische Gerate
GmbH & Co
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TLX 134759

Belgium, Brussels
Fluke (Belgium) SA/NA
Tel (02) 2164090
TLX 26312

Brazil, Sao Paulo
Fluke Brasil-Industria E Comercio Ltda
Tel (011) 421-3000
TLX 01130000 FLKE BR

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Allan Crawford Associates Ltd
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Allan Crawford Associates Ltd
Tel (514) 731-8564

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Intronica Chile Ltda
Tel [illegible]
TLX [illegible]

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Beijing Radio Research Institute
Tel [illegible]

Colombia, Bogota
Sistemas E Instrumentacion, Ltda
Tel [illegible]
TLX [illegible] COASIN CO

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Tage Olsen A/S
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Egypt, Cairo
Electronic Engineering Liaison Office
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TLX 934583

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Oy Findip AB
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TLX 123129

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M B Electronique S A
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Hellenic Scientific Representations
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TLX 74766 SCHMC HX

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Hinditron Services Pvt Ltd
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TLX 953-112326 HSPL IN

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Hinditron Services Pvt Ltd
Tel 33139
TLX 0845741

India, New Delhi
Hinditron Services Pvt Ltd
Tel 619118
TLX 031-4890 SRMP IN

Indonesia, Jakarta Selatan
P T Dwi Tunggal Jaya Sakti
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TLX 47308 DJS IA

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R D T Electronics Engineering Ltd
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TLX 32143

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TLX 334643

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TLX 68356

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John Fluke Mfg Co , Inc
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Korea, Seoul
Electro-Science Korea Co
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TLX K25381

Malaysia, Petaling Jaya
Mecomb Malaysia SDN BHD
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TLX MA37605

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Electronica y Tecnologia
Avanzada S A de C V (ETA)
Tel [illegible]
TLX 017/2297 ELOSME

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TLX 47128

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TLX 52237

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McLean Information Technology, Ltd
Tel [illegible]
TLX NZ21570 THERMAL

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Morgenstierne & Co A/S
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TLX 71719

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Peru, Lima
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TLX [illegible]

Philippines, Metro Manila
Spark Radio & Electronics Corp
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TLX 27901 RLA PH

Portugal, Lisbon
Decada Equipamentos de
Electronica, Lda
Tel (19) 574984
TLX 18469

Republic of Singapore, Singapore
Rank O'Connor's (PTE) Limited
Tel 637944, 239052
TLX OCONSIN RS21023

Republic of South Africa, Bramley
Fluke S A (Pty) Ltd
Tel (011) 786-3170
TLX 424328

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Hispano Electronica S A
Tel (01) 6194108
TLX 22404/42634

Sweden, Vallingby
Teleinstrument AB
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TLX 15770

Switzerland, Zurich
Traco Electronic AG
Tel (01) 2010711
TLX 54318

Taiwan, Taipei
Schmidt Scientific Far East Ltd
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TLX 11111 Schmidt

Thailand, Bangkok
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TLX 81143 DEJOBKK TH

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TLX 23353

Uruguay, Montevideo
Coasin Uruguaya S R L
Tel 29-31-957
TLX UY 6571 OROCUER

Venezuela, Caracas
Coasin, C A
Tel [illegible]
TLX 21027 EMVEN VE

West Germany, Ismaning
Fluke (Deutschland) GmbH
Tel (089) 96050
TLX 0522472

FLUKE

John Fluke Mfg Co , Inc , P O Box C9090, Everett WA 98206
Fluke (Holland) B V , P O Box 5053 5004 EB, Tilburg The Netherlands Phone (013) 673973
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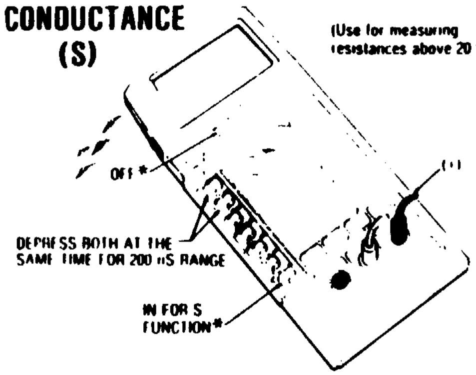
CONDUCTANCE (S)

(Use for measuring resistances above 20 MΩ)



NOTE The function switches are push push type Do not pull them to the out or OFF positions

- Connect the test leads as shown
- Depress the mA C V Ω S function switch
- AT THE SAME TIME depress both of the 200 nS range switches
- Insure all other switches are at the out or OFF positions
- Insure the device being measured contains no electrical energy including charged capacitors

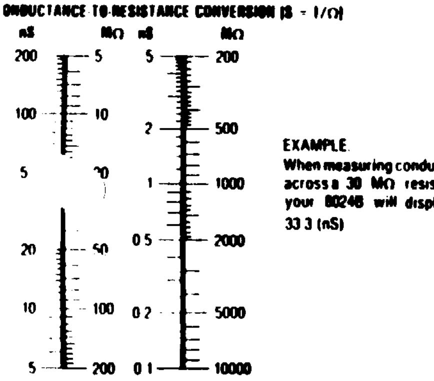
WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, OBSERVE THE FOLLOWING MAXIMUM LIMITS WHEN MEASURING RESISTANCE

OVERLOAD PROTECTION

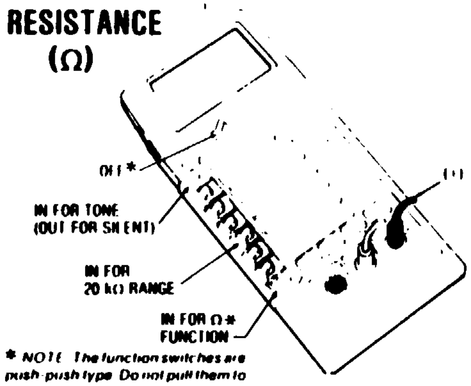
- Connect the test probes across the device being measured
- Conductance is displayed in Siemens which equals 1/Ω Use the conversion scales below to determine the equivalent resistance

CONDUCTANCE TO RESISTANCE CONVERSION (S = 1/Ω)



EXAMPLE: When measuring conductance across a 30 MΩ resistance, your 8024B will display 33.3 (nS)

RESISTANCE (Ω)



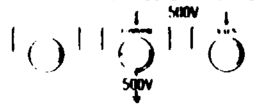
** NOTE The function switches are push push type Do not pull them to the out position*

- Connect the test leads as shown
- Depress the mA C V Ω S switch
- Depress the switch beside the range desired (20 kΩ is shown selected)
- Insure that all other switches are at the out or OFF positions
- Make sure that the device being measured contains no electrical energy including charged capacitors

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, OBSERVE THE FOLLOWING MAXIMUM LIMITS WHEN MEASURING CONDUCTANCE

OVERLOAD PROTECTION**



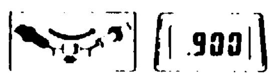
**Protection 15 seconds maximum for overloads above 300V

- Connect the test probes across the device being measured
- Read the measured value on the display (See overrange VOLTS page)

DIODE TEST (⊣)

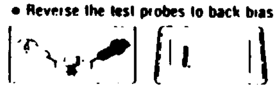
2 kΩ, 200 kΩ, and 20 MΩ ranges will turn on P-N junction diodes

- Select the Ω function, 2 kΩ range and comply with the warning
- Connect the test probes to forward bias the the diode as shown below



Typical reading for forward biased silicon diode

- Reverse the test probes to back bias the diode as shown below



Overrange will be displayed provided parallel resistors are > 2 kΩ

- Use 200 kΩ range for testing diodes with audible tone indication

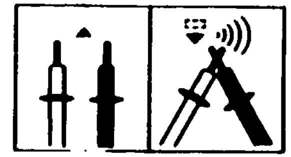
IN-CIRCUIT RESISTANCE MEASUREMENTS

The 200Ω, 20 kΩ, 2000 kΩ ranges can be used to measure resistance values connected in parallel with silicon diodes

On these ranges the test voltage is less than the voltage required to turn on a normal silicon diode

CONTINUITY TESTING

(Use for passive circuit testing)



- Select the kΩ function, 2 kΩ range
- If the audible tone is desired, depress the AC/DC switch
- Insure that the device being measured contains no electrical energy

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, COMPLY WITH THE WARNING FOR THE RESISTANCE (Ω) FUNCTION.

- Connect the test probes to the circuit being measured
- Continuity between the test leads will cause the down arrow (▼) to appear on the display and the audible tone to sound (if enabled)

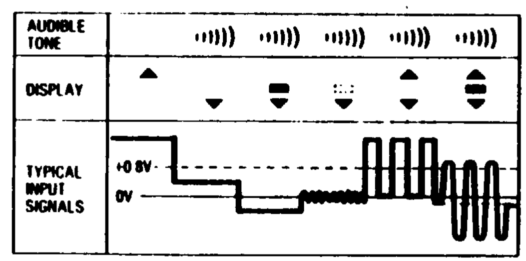
LEVEL DETECTOR [▲▼)))))]

(Use for ACTIVE circuit testing)

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, COMPLY WITH THE WARNING FOR THE RESISTANCE (Ω) FUNCTION.

- Use this function for sensing logic levels and other active signals less than 250V dc or ac rms in amplitude.
- Select the Ω function, 200 kΩ range (Zin > 100 kΩ)
- If the audible tone in desired, depress the AC/DC switch.
- Comparison is made between a +0.8V dc reference voltage and the input signal, with respect to the COMMON terminals. If the input signal:
  - Is more positive than +0.8V, the 8024B displays an up arrow (▲)
  - Is less positive than +0.8V, 8024B displays a down arrow (▼). If enabled, the audible tone sounds
  - Passes back and forth through +0.8V, the 8024B displays both arrows. If enabled, the audible tone sounds.
  - Average value is negative, the minus sign appears.
  - Average value is very near zero, the minus sign may flicker (⁝)



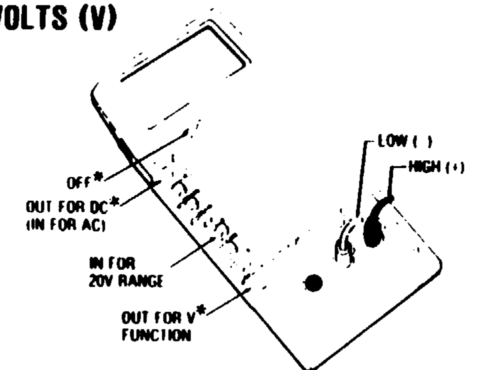
FLUKE 8024B Operator Guide

J.F. P/N 616763 July 1981

WARNING

REMOVE INPUT SIGNAL AND TEST LEADS FROM 8024B INPUT TERMINALS BEFORE OPENING THE BATTERY COMPARTMENT OR OTHERWISE ACCESSING OR TOUCHING THE FUSE AND/OR BATTERY. DO NOT OPERATE THE INSTRUMENT UNLESS BATTERY COVER IS IN PLACE AND FULLY CLOSED.

VOLTS (V)

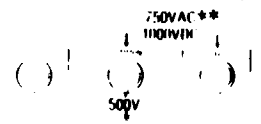


NOTE: The function switches are push-push type. Do not pull them to the out or OFF positions.

- Connect the test leads as shown above.
- Depress the switch beside the desired range (20V is shown selected).
- Set the AC/DC switch out for DC or in for AC (DC is shown selected).
- Insure that all other switches are at the out or OFF positions.

WARNING

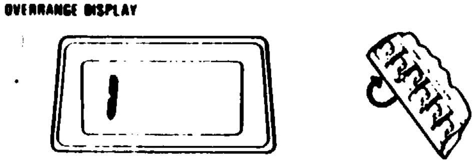
TO AVOID ELECTRICAL SHOCK AND OR INSTRUMENT DAMAGE OBSERVE THE FOLLOWING MAXIMUM LIMITS WHEN MEASURING VOLTAGE.



***Protection on 200 mV range allows 15 sec. max for overload above 300V*

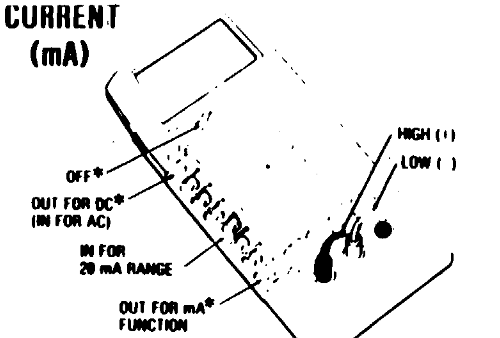
- Connect the test probes to the circuit being measured.
- Read the measured value on the display. The minus sign will appear if the V·Ω·S terminal is negative with respect to the COMMON terminal.

OVERRANGE DISPLAY



If the value of the parameter being measured exceeds the range selected, a 1, as shown above, is displayed as an overrange indicator. Select the next higher range until an in-range reading is displayed.

CURRENT (mA)

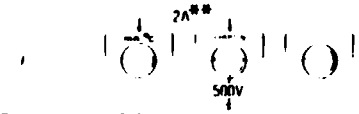


** NOTE: The function switches are push-push type. Do not pull them to the out position.*

- Connect the test leads as shown.
- Depress the switch beside the range desired (20 mA range is shown selected).
- Set the AC/DC switch out for DC or in for AC (DC shown selected).
- Insure that all other switches are at the out or OFF positions.

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, OBSERVE THE FOLLOWING MAXIMUM LIMITS WHEN MEASURING CURRENT.



***Protected by 2A 250V fuse and 3A 600V backup fuse.*

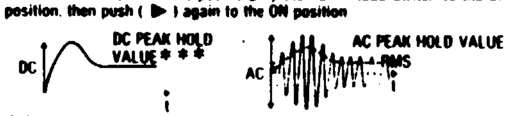
- Connect the test probes to the circuit being measured.
- Read the measured value on the display. In DC, the minus sign will appear if the mA·°C terminal is negative with respect to the COMMON terminal.

FUSE CHECK (The mA·°C input contains two fuses.)

- Select the RESISTANCE (Ω) function and 2 kΩ range.
- Touch the red test probe to the mA·°C input jack so that the V·Ω·S input and the mA·°C input are connected together.
- If the display reads approximately 100 kΩ, both fuses are good.
- If the display reads overrange, one or both fuses need replacement.
- See facing page for replacement instructions.

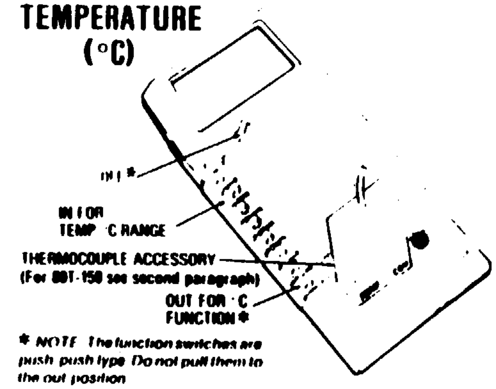
PEAK HOLD

- PEAK HOLD can be used in AC or DC for V (volts) and mA (current) functions.
- Complete the steps and comply with the WARNING for the function selected.
- Push (▶) the PEAK HOLD switch to the ON position. NOTE: The PEAK HOLD switch is a push-push type. Push to the right (▶) only.
- The value of the most positive dc peak or ac rms level (see waveforms) will be captured in the display. (Reverse test leads for negative peaks.)
- For a new measurement, push (▶) the PEAK HOLD switch to the OFF position, then push (▶) again to the ON position.



****NOTE: Minus sign will be displayed if most positive excursion is negative with respect to common.*

TEMPERATURE (°C)



** NOTE: The function switches are push-push type. Do not pull them to the out position.*

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT EXCEED THE MAXIMUM VOLTAGE AND TEMPERATURE LIMITS FOR THE ACCESSORY USED.

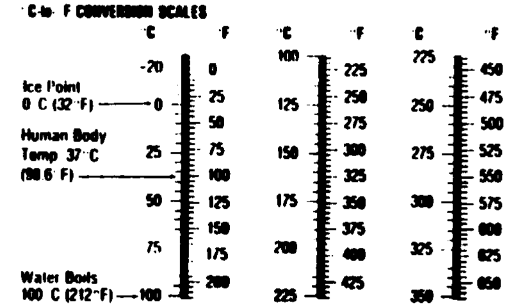
JOHN FLUKE THERMOCOUPLE ACCESSORIES

- Connect the thermocouple termination across the mA·°C and COMMON terminals with the TEMP side plugged into the mA·°C terminal.
- Depress the TEMP °C range switch.
- Insure that all other switches are at the out or OFF positions.
- The measured temperature is displayed in °C. For °F use either the conversion scales below or the formula °F=1.8°C+32°. If unit fails to read properly, see FUSE CHECK on facing page.

JOHN FLUKE 80T-150 ACCESSORIES (C° or °F)

- Connect the 80T-150 termination across the V·Ω·S and COMMON terminals with the HI side plugged into the V·Ω·S terminal.
- Select the appropriate range (200 mV or 2V).
- Insure that all other switches are at the out or OFF positions.
- Set the 80T-150 POWER switch to the ON position and read the display as indicated on the accessory label.

°C-to-°F CONVERSION SCALES



BATTERY/FUSE TYPES

MAIN FUSE: 2A/250V Type AGX2 (inside battery compartment)

BACKUP FUSE: 3A/600V Type BBS-3 (inside instrument case)

Caution

Replacement of backup fuse by qualified personnel only. See service manual.

BATTERY: 9V carbon-zinc or alkaline NEDA Type #1604

BT appears in display when approximately 20% of battery life remains.

ECHNICAL SERVICE CENTERS

S.A.

, Burbank
ohn Fluke Mfg Co Inc
713) 849 71[illegible]

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ohn Fluke Mfg Co Inc
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ohn Fluke Mfg Co Inc
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, Rockville
ohn Fluke Mfg Co Inc
301) 770-1570

, Paramus
ohn Fluke Mfg Co Inc
201) 262-9550

Dallas
ohn Flu[illegible] Co Inc
214) 869 [illegible]

, Seattle
ohn Fluke Mfg Co Inc
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LX (790) AA25887

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Imeasco Instruments Pty Ltd
el 879-2322
LX (790) AA30418

stralia, Salisbury
Imeasco Instruments Pty Ltd
el 875-1444
LX (790) AA44082

stria, Vienna
Walter Rekirsch
lektronische Gerate GmbH & Co
el 253626
LX (847) 134759

lgium, Brussels
luke (Belgium) NV/SA
el 216[illegible]
LX [illegible]

azil, S.
Teh Ele[illegible] Ltda
el 421-5477
LX (1391) 1171413

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llen Crawford Associates Ltd
el (403) 295-0822
LX 03821186

nada, Mississauga, ON
llen Crawford Associates Ltd
el (416) 890-2010
LX 0696 1235

Canada, St. Laurent, PQ
Allen Crawford Associates Ltd
Tel (514) 731-8564
TLX 05824944

Chile, Santiago
Intronica Chile Ltda
Tel 232 1886
TLX (332) 340351

China, Peoples Republic of
Instrimpex - Fluke Service Center
Tel 66-7201

Colombia, Bogota
Sistemas E Instrumentacion, Ltda
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TLX (396) 45787

Denmark, Ballerup
Tage Olsen A/S
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TLX (855) 35293

Ecuador, Quito
Proteco Coasin Cia., Ltda
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England, Watford, Herts
Fluke (Great Britain) Ltd
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TLX (842) 695414

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Hellenic Scientific Representations
Tel 7211140
TLX (863) 219330

Hong Kong, Wanchai
Schmidt & Co (H.K.) Ltd
Tel 8330-222
TLX (780) 74766

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Hinditron Services Pvt Ltd
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TLX (953) 845741

India, Bombay
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Tel 6300043
TLX (953) 11-72247

India, New Delhi
Hinditron Services Pvt Ltd
Tel 6433675
TLX (953) 310468

India, Secunderabad
Hinditron Services Pvt Ltd
Tel 821117
TLX (953) 1558073

Indonesia, Jakarta Pusat
P.T. Lamda Triguna
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John Fluke Mfg. Co., Inc. calibrates all its instruments using standards and instruments the accuracy of which is traceable to the National Bureau of Standards, in the USA, or to nationally accepted measuring systems. The standards and instruments used in calibration are supported by a calibration system which meets or exceeds the requirements of MIL-STD-45662.

The reference standards which support this calibration system are calibrated on a schedule which is adjusted to maintain traceability at the required accuracy level. NBS Test Report numbers or copies of these reports can be obtained by contacting:

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John Fluke Mfg. Co., Inc.
P.O. Box C9090
Everett, WA 98206, USA

A serialized and dated Certificate of Calibration for any individual instrument can be obtained from any Fluke Technical Service Center listed on the back page. A nominal calibration fee will be charged.

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RAL	Ralph's Electronics
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REA	Radco East
REM	REM Electronics
RIO	Riordan Electronic Products
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ROU	Route Electronics
RRI	R&R Instrumentation
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SCO	Scott Electronics
SEE	Southeastern Elect
SHD	Shand Electronics
SHR	Shelley-Ragon
SKO	Sargent-Welch Scientific Co
SML	Standard Meter Lab
SPD	Specialty Distributing
SPE	Specialized Products
SSC	Standard Supply Co
STA	Stark Electronic Supply

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THX	ThermX Southwest
TKS	Tool Kit Specialists
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TRA	Transcat
TRE	Tech. Representations
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WAL	Walter & Associates
WAS	WASSCO
WBA	W.B. Allen Supply
WES	Wholesale Elec. Supply
WHO	Wholesale Electronics
WIE	Wholesale Ind. Elec.
WIS	Wise Components
WSJ	WS Jenks
WYL	Wyle Lab Mkt. Group
YDI	You-Do-It Electronics
ZAC	Zack Electronics

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January 1988

CHANGE/ERRATA INFORMATION

ISSUE NO: 2 9/86

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCB is equal to or higher than that given with each change.

2. No revision letter is indicated at the beginning of the change/errata.

MANUAL

Title:	8024B
Print Date:	July 1981
Rev.- Date:	1-5/82

C/E PAGE EFFECTIVITY

Page No.	Print Date
1	5/84
2	9/86

ERRATA #1
On page 4-13, paragraph 4-40, step 6:
CHANGE: ... +7.5V dc.
TO: ... +8.0V dc.

CHANGE #1 - 16274
Rev.-C, A2 Main PCB Assembly (8024A-4011)

On page 5-8, Table 5-3,
CHANGE: J5|JACK, DC POWER, PC MOUNT|535278|89536|535278|1
TO: J5|CONTACT ASSEMBLY |651653|89536|651653|1

CHANGE #2 - 16547

On page 5-6, Table 5-2,
CHANGE: MP6|COVER, BATTERY|613968|89536|613968|1
TO: MP6|COVER, BATTERY|637686|89536|637686|1

CHANGE #3 - 17001
Rev.-D, A2 Main PCB Assembly (8024A-4011

On page 5-10, Table 5-3,
ADD: R33|RES,VAR,CERMET,1M +/-20%,0.1W,50V
|682211|51406|RVG0607H-310-105M|1

On pages 5-11, Figure 5-3 and 7-6, Figure 7-1, add R33 as shown in Figure 1.

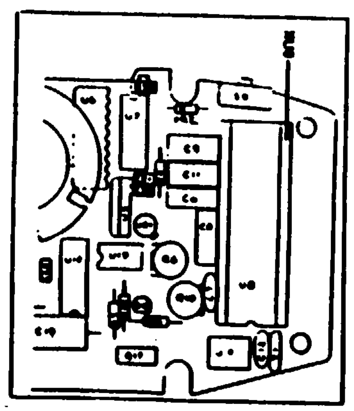


Figure 1.

On page 7-5, Figure 7-1, add R33 as shown in Figure 2.

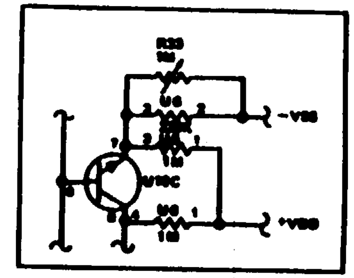


Figure 2.

CHANGE #4 - 17671
On page 4-5, replace Figure 4-2 with Figure 3.

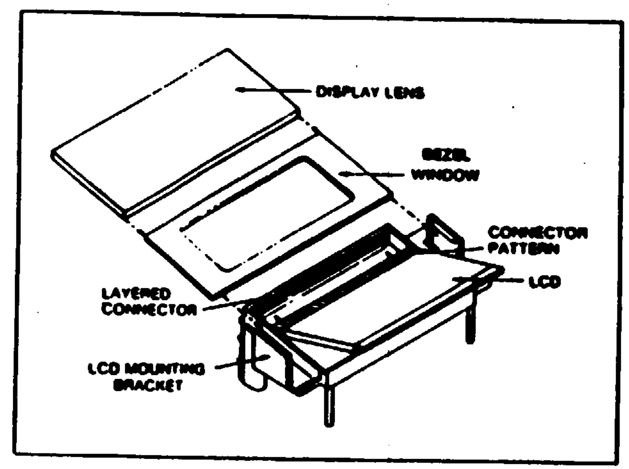


Figure 3.

ERRATA #2
On page 4-11, paragraph 4-24, step 5,
CHANGE: ... 0.1 mV ...
TO: ... 1.0 mV ...

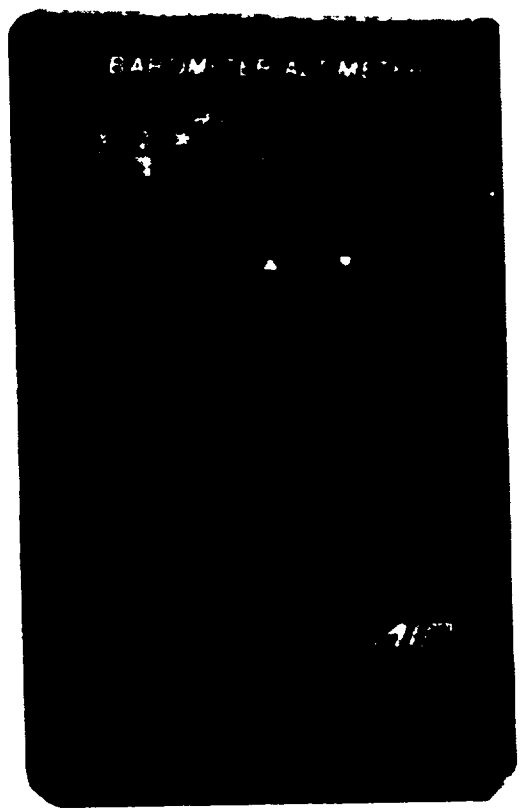
ERRATA #3
On page 5-9, Table 5-3, add a "2" under the note column on the R2 line item and add the following note at the end of the table and on page 7-5.

2 = R2 is a fusible resistor. Use exact replacement to insure saftey.

1.0 INTRODUCTION

The Hand-Held Barometer (HHB) is a small, light instrument which can accurately measure and display atmospheric pressure and pressure altitude. A microprocessor computes instantaneous readings of ambient pressure and pressure altitude from the output of an accurate pressure sensor. A standard 9-volt transistor battery powers the unit.

A five-digit Liquid Crystal Display (LCD) displays the instrument's readings. Display annunciators indicate the type of data and the unit of measure that are currently displayed. The instrument is operated from an easy-to-use five-key keypad.



1.1 The LCD

The Hand-Held Barometer's LCD offers the following features:

- Data readings of up to five digits, with decimal point and minus sign as required
- The current operating mode
- Annunciators for the units of measure
- Battery low warning: "BAT" in lower right corner to indicate that the battery needs to be replaced

1.2 Keypad

The five keys on the Hand-Held Barometer can be used to turn the device on or off, to select operating modes, to select the type of units in which data are displayed, and, in some operating modes, to set reference values.

ON/OFF Key

The ON/OFF key powers the instrument on or off. The key works as a toggle switch; pressing the ON/OFF key when the instrument is off turns it on, and pressing the key when the instrument is on turns it off.

To conserve power, an internal jumper's default setting allows the Hand-Held Barometer to automatically shut itself off. When more than two minutes have transpired since any key was pressed, the instrument shuts off. (Refer to section 1.7 "The Sleep State Jumper" for instructions on changing this jumper setting to disable automatic sleep state.)

To reactivate the HHB, press the ON/OFF key. The Hand-Held Barometer always remembers the operating mode and the units of measure that were displayed during the last power on, and automatically returns to this display when the unit is turned on.

MODE Key

The MODE key allows you to select the operating mode. These modes are identified by an annunciator on the left side of the display. Modes are presented in a cyclic fashion as follows:

Operating Mode	Annunciator
Barometer	PRESSURE
Standard Altitude	ALTITUDE (AS)
Temperature-Compensated Altitude	ALTITUDE (TC)
Differential Altitude	▲ ALTITUDE
Differential Barometer	▲ PRESSURE

Each time MODE is pressed, the display advances to the next operating mode. When MODE is pressed from Differential Barometer mode (▲ PRESSURE), the display returns to Barometer mode (PRESSURE).

In addition to the modes listed in the preceding chart, a Calibration mode may be selected by simultaneously pressing the SET/ZERO key and the MODE key.

Operating Mode	Annunciator
Calibration	CAL

Arrow Keys

The arrow keys are used either separately to select the units in which data readings are displayed, or with the SET/ZERO key to set a known reference level. Used by itself, an arrow key causes the display to change to the next unit. Reference values may be set by displaying the current reference value, then simultaneously pressing an arrow key with the SET/ZERO key until the desired reference value is displayed.

SET/ZERO Key

The SET/ZERO key is used either separately to "zero" the differential altitude or differential pressure, or with the arrow keys to set the barometric or altitude reference level. Used alone, the SET/ZERO key in a differential mode sets the current zero reference level. Non-zero reference values may be set by displaying the current reference value, then simultaneously pressing an arrow key with the SET/ZERO key until the desired reference value is displayed.

1.3 Operating Modes

Atmospheric pressure or pressure altitude may be displayed by selecting one of five operating modes. To select a mode, you "scroll" through the modes by pressing the "MODE" key. These modes are Barometer mode, Standard Altitude mode, Temperature-Compensated Altitude mode, Differential Altitude mode, and Differential Barometer mode.

Barometer Mode

When you select the Barometer mode, the instrument acts as a simple barometer. Atmospheric pressure can be displayed in one of six units of measure, as described in section 2.0.

Altitude Modes

Barometric pressure is converted to a pressure altitude when the Standard Altitude mode is selected. In this mode the instrument operates as a normal aircraft altimeter would operate; that is, altitude above sea level in the ICAO Standard Atmosphere is displayed. Since atmospheric conditions are rarely "standard," you may correct this altitude reading for current atmospheric conditions by entering the local "altimeter setting," as recorded by the local airport. Alternatively, if your current altitude is known, you may enter this value as an altitude reference level. Refer to section 3.0 for more information.

If, however, neither the "altimeter setting" nor the current altitude are available, you can use the Temperature-Compensated Altimeter mode. Accuracy is improved by entering the ambient temperature to correct for the difference in temperature between the site atmosphere and the Standard Atmosphere. This mode is described in detail in section 4.0.

Differential Modes

Differential Altimeter mode can display a change in altitude between a "zero" reference level and your current site position. A surveyor might use this mode, for example, to directly measure the height of a hill. The surveyor could zero the differential altimeter reading to make a benchmark at the bottom of the hill and then walk to the top; the reading at the top would be the height of the hill above the benchmark. Refer to section 5.0 for instructions on using this mode.

Similarly, Differential Barometer mode measures the change in atmospheric pressure between your selected zero reference level and the current pressure. This mode allows you, for example, to quickly determine the change in pressure from one day to the next. This mode is described in detail in section 6.0.

Calibration Mode

Calibration mode is entered by simultaneously pressing the MODE and SET/ZERO keys. This mode allows you to set the barometric pressure in millibars when a reading from an external, highly accurate barometer is available. This procedure is required only infrequently to correct for long-term drifts in instrumentation. Refer to section 7.0.

1.4 Measurement Averaging

The HHB makes four measurements each second. Any measurement displayed by the Hand-Held Barometer is an average of the last eight measurements. Each time a new measurement is made, it replaces the oldest of the eight stored measurements, and is averaged with the seven previous measurements. The display is continuously updated with these new averages.

The averaging of pressure and altitude readings removes short-term fluctuations from ambient pressure bursts that are caused by wind or by rapid movement of the instrument. If a sudden, large change in pressure or altitude has occurred, the display is stable and accurate after two seconds. Averaging also removes fluctuations from the residual noise of the electronic circuits.

1.5 Replacing the Battery

The Hand-Held Barometer is shipped with a 9-volt alkaline battery installed. This should be replaced when the "BAT" annunciator is constantly illuminated. A 9-volt alkaline battery, NEDA No. 1604A (Eveready No. 522), should be used. A new alkaline battery should last for approximately 80 hours of continuous usage.

Note: When the battery is replaced, the pressure offset from Calibration mode is lost; the offset is reset to zero. Enter Calibrate mode and write down this offset BEFORE removing the battery, and reenter this value after replacing the battery. In addition, any reference values (such as the temperature in Temperature-Compensated Altitude mode and the altimeter setting in Standard Altitude mode), are lost and must also be reentered.

To replace the battery, loosen and remove the four screws from the back cover. Lift off the back cover. The battery will be visible in the lower left corner of the instrument. Remove the old battery, gently prying the connector on the battery terminal up and off of the battery.

Snap the two-position battery connector onto the new battery and set the new battery into position. Replace the back cover and tighten the four screws. Turn the unit on by pressing the ON/OFF key and verify that the LCD works properly and that the "BAT" annunciator is no longer visible. Reenter the pressure offset, altimeter setting, and temperature.

1.6 Handling Precautions

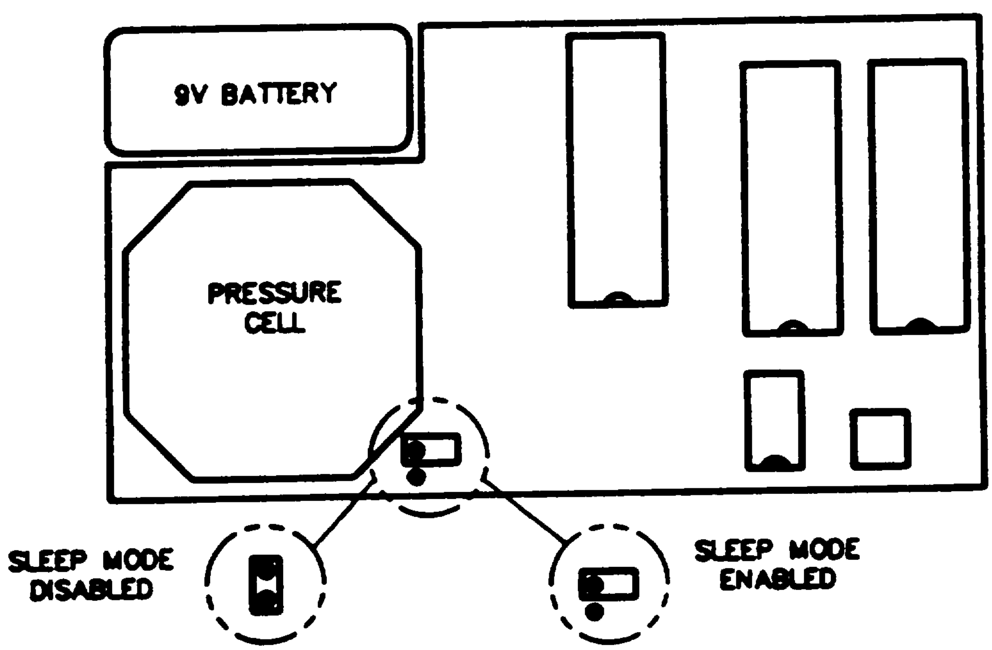
The electronics and pressure sensor are housed in an impact-resistant plastic case. The case is, however, NOT water tight. Do not immerse the instrument under any circumstances. Also note that the front cover is somewhat pliant. If you press hard against the front of the unit you can cause erroneous readings.

AIR's patented dual-diaphram pressure sensor has extremely low sensitivity to shock, vibration, acceleration, and changes in orientation or temperature, while maintaining high sensitivity to pressure variations.

1.7 The Sleep State Jumper

To conserve power, an internal jumper is set to enable a sleep state. With this jumper on one pin only (the setting at shipment), the Hand-Held Barometer will automatically shut off when more than two minutes have transpired since any key was pressed. Changing the jumper position allows the instrument to turn off only when the ON/OFF key is pressed.

To set this jumper, loosen and remove the four screws from the back cover. Lift off the back cover. The following illustration shows the jumper location:



As shipped from AIR, Inc., the jumper covers one pin only, and does not connect to the second pin. This jumper position causes automatic shut down after two minutes.

To disable automatic shut down and allow the HHB to turn off only when the ON/OFF key is pressed, install this jumper on both pins.

After you have set the jumper position, replace the back cover and tighten the four screws.

2.0 BAROMETER MODE

The Barometer mode measures atmospheric pressure. To use Barometer mode, press the MODE key until the display shows "PRESSURE" in the upper left corner of the display.

2.1 Selecting Units

Units are selected by pressing the up or down arrow keys. The units are presented in a cyclic fashion, allowing you to scroll up or down through all available units. The barometer mode units are in the following relative order:

Unit of Measure	Annunciator
Millibars	mb
Inches of mercury	in Hg
Millimeters of mercury	mm Hg
Pounds per square inch absolute	PSIA
Kilopascals	kPa
Inches of water	in H2O

3.0 STANDARD ALTITUDE MODE

The Standard Altitude mode measures the current pressure altitude above sea level. To select this mode, press the MODE key until the "ALTITUDE (AS)" annunciator appears.

The Hand-Held Barometer determines the altitude based upon the relationship between altitude and atmospheric pressure in the ICAO Standard Atmosphere. At any site, however, conditions can differ significantly from the standard atmospheric conditions. To obtain an accurate altitude reading, you must therefore enter either the current "altimeter setting" (as available from a local airport) or your current altitude (as available from an accurate topographical map) which the HHB can use as a reference or "benchmark."

Altitude can be displayed in feet or meters. A reference (benchmark) altitude can also be set from this display. The current altimeter setting can be displayed (and set) in either millibars (mb) or inches of mercury (in Hg).

Note: Since the HHB cannot be connected to an aircraft static pressure port, it is not suitable as an aircraft pressure altimeter.

3.1 Entering a Benchmark Altitude

To calibrate the instrument to a known altitude at a benchmark, press an arrow key until the desired units, feet (ft) or meters (m), are displayed. Set this value by holding down the SET/ZERO key while pressing the up arrow key to increment the altitude reading or the down arrow key to decrement the reading.

When you set either an altitude or altimeter reference value, you can hold an arrow key depressed. The longer you hold the key down, the faster the reading changes values.

Note that at a given site the altitude reading will change with time due to weather induced pressure changes. New benchmark settings may therefore be required periodically to assure accurate readings.

Standard Altitude mode can also be used to determine the altimeter setting when the current altitude is known. To determine the altimeter setting from Standard Altitude mode, select feet (ft) or meters (m), and enter the present altitude. Select millibars (mb) or inches of mercury (in Hg) to see the current altimeter setting.

3.2 Entering an Altimeter Setting

To calibrate the instrument by entering an altimeter setting, press an arrow key until the desired altimeter units, millibars (mb) or inches of mercury (in Hg), are displayed. (When you set a value in one unit, the instrument automatically corrects all corresponding units.) The default value (Standard Atmosphere) is 29.92 in Hg or 1013.25 mb. Set the current altimeter setting by holding down the SET/ZERO key while pressing the up arrow key to increment the altimeter setting or the down arrow key to decrement the setting.

When you set either an altitude or altimeter reference value, you can hold an arrow key depressed. The longer you hold the key down, the faster the reading changes values.

If you do not know the local "altimeter setting" or a topographical benchmark, use the Temperature-Compensated Altitude mode for best accuracy, described in section 4.0.

Note that the altitude reading will change due to weather induced pressure changes, in which case a second altimeter setting may be required to assure accurate readings.

3.3 Selecting Units

Altitude readings can be displayed in feet (ft) and meters (m). Altimeter settings can be displayed in inches of mercury (in Hg) and millibars (mb). These units are presented in the following relative order:

Unit of Measure	Annunciator(s)	
Feet	ft	
Meters	m	
inches of mercury	in Hg	ALT SETTING
millibars	mb	ALT SETTING

4.0 TEMPERATURE-COMPENSATED ALTITUDE MODE

The Temperature-Compensated Altitude mode measures the pressure altitude above sea level. This mode should be used when the ambient air temperature is known but neither the "altimeter setting" nor an altitude benchmark is known.

Altitude can be displayed in feet (ft) or meters (m). The current air temperature can be displayed (and then set) in degrees Fahrenheit or degrees Celsius.

To enter Temperature-Compensated Altitude mode, press the MODE key until the "ALTITUDE (TC)" annunciator is displayed.

4.1 Setting the Temperature

To calibrate the instrument with a known ambient temperature, press an arrow key until the temperature is displayed in degrees Fahrenheit or degrees Celsius. (When you set the temperature in either unit, the HHB will automatically correct the other unit.) Hold down the SET/ZERO key and press the up arrow key to increment the temperature value or the down arrow key to decrement the temperature.

Note that when you set the temperature, you can hold an arrow key depressed. The longer you hold the key down, the faster the reading changes values.

The temperature setting is stored in the Hand-Held Barometer's memory until you physically change it. This setting is used by both the Temperature-Compensated Altitude mode and the Differential Altitude mode, described in section 5.0.

If you do not know the "altimeter setting," a benchmark height, or the ambient air temperature, you should approximate the ambient air temperature as best you can and use the Temperature-Compensated Altitude mode. This method generally offers the most accurate altitude readings under those circumstances.

To obtain the most accurate altitude measurements, you should enter the ambient air temperature at each new altitude that you wish to measure.

4.2 Selecting Units

Altitude readings can be displayed in feet (ft) and meters (m). Temperature settings can be displayed in degrees Fahrenheit (oF) and degrees Celsius (oC). These units are presented in the following relative order:

Unit of Measure	Annunciator(s)
Feet	ft
Meters	m
degrees Fahrenheit	oF TEMP SETTING
degrees Celsius	oC TEMP SETTING

5.0 DIFFERENTIAL ALTITUDE MODE

Differential Altitude mode is used to measure the change in altitude relative to a reference height. For accuracy of measurement, the ambient air temperature should be entered.

To use Differential Altitude mode, press the MODE key until the display shows "Δ ALTITUDE" in the lower left corner of the display.

Altitude can be displayed in feet (ft) or meters (m). The current air temperature can be displayed (and then set) in degrees Fahrenheit or degrees Celsius.

5.1 Setting the Temperature

To calibrate the instrument with a known ambient temperature, press an arrow key until the temperature is displayed in degrees Fahrenheit or degrees Celsius. (When you set the temperature in either unit, the HHB will automatically correct the other unit.) Hold down the SET/ZERO key and press the up arrow key to increment the temperature reading or press the down arrow key to decrement the reading.

Note that when you set the temperature, you can hold an arrow key depressed. The longer you hold the key down, the faster the reading changes values.

The temperature setting is stored in the Hand-Held Barometer's memory until you physically change it. This setting is used by both the Differential Altitude mode and the Temperature-Compensated Altitude mode, described in section 4.0.

If you do not know the local ambient air temperature, use an estimated value. You can expect reasonable accuracy over a limited range of differential altitude.

Note: To obtain the best accuracy of differential altitude measurements, enter the ambient air temperature at each altitude that is measured.

5.2 Setting a Zero Reference Height

To set a specific altitude as a zero reference height, simply press the SET/ZERO key. All subsequent differential altitude readings will be relative to this zero altitude, until you physically set another altitude at zero.

The display uses a minus sign to indicate altitudes that are below the reference level. For example, if you were to climb 100 feet above your current reference level, the display will show "100 ft" and conversely, if you were to climb 100 feet below your current reference level, the display will show "-100 ft."

Atmospheric pressure changes will cause errors in differential height, therefore you should reset to zero at the reference site as often as practicable.

5.3 Selecting Units

Altitude readings can be displayed in feet (ft) and meters (m). Temperature settings can be displayed in degrees Fahrenheit (oF) and degrees Celsius (oC). These units are presented in the following relative order:

Unit of Measure	Annunciator(s)
Feet	ft
Meters	m
degrees Fahrenheit	oF TEMP SETTING
degrees Celsius	oC TEMP SETTING

6.0 DIFFERENTIAL BAROMETER MODE

The Differential Barometer mode is used to read the change in barometric pressure relative to a reference pressure. To use Differential Barometer mode, press the MODE key until the display shows "Δ PRESSURE".

6.1 Setting Zero Reference Pressure

A reference point for barometric pressure is established by defining the current barometric pressure as zero. To set pressure at zero, simply press the SET/ZERO key. All subsequent differential barometric readings will be relative to this zero pressure level, until you physically set another pressure reading at zero.

The display uses a minus sign to indicate pressure readings that are below your reference level. For example, if pressure were to drop 0.2 millibars, the display would show "-0.2 mb," and conversely, if pressure were to rise by 0.2 millibars the display would show "0.2 mb."

6.2 Selecting Units

The barometric reading can be displayed in the following units: millibars (mb), inches of mercury (in Hg), millimeters of mercury (mm Hg), pounds per square inch absolute (PSIA), kilopascals (kPa), and inches of water (in H2O).

Units are selected by pressing the up or down arrow keys. The units are presented in a circular fashion, in the following relative order:

Unit of Measure	Annunciator
Millibars	mb
Inches of mercury	in Hg
Millimeters of mercury	mm Hg
Pounds per square inch absolute	PSIA
Kilopascals	kPa
Inches of water	in H2O

7.0 CALIBRATION MODE

The Calibration mode allows you to enter a pressure offset to compensate for slight long-term drifts that occur during normal operation. This offset is stored in the Hand-Held Barometer's battery powered memory. When the battery is changed you will have to reenter this pressure offset.

To use the Calibration mode, enter Barometer mode by pressing the MODE key until the PRESSURE annunciator is displayed, then press an arrow key until the desired units is displayed. Make a careful comparison of the barometric pressure standard to the HHB's reading, averaging one minute's readings. Determine the offset by subtracting the HHB value from the barometric pressure standard. The resulting difference (retaining the algebraic sign) is the offset.

Press and hold down the SET/ZERO key, then press and hold down the MODE key. The display will show the letters CAL for one second. The current pressure offset is then displayed. The HHB is shipped with a pressure offset of 0.0.

Holding the SET/ZERO and MODE keys depressed, press the up arrow key to increment this offset, or the down arrow key to decrement the offset. The pressure offset must be in the range of -1.28 mb to 1.27 mb. (Refer to section 10.0 for unit conversion factors.) If the measured offset exceeds +/-1.2 mb, the accuracy of the reference barometer should be verified. If the reference barometer proves to be correct, return the Hand-Held Barometer to AIR, Inc. for factory recalibration.

This calibration should only be necessary every few months, and only if you have a pressure standard available which is more accurate than the Hand-Held Barometer.

To exit Calibration mode and return to Barometer mode, release the MODE key then the SET/ZERO key. Verify your offset by comparing the current HHB reading to the barometric pressure standard. HHB readings (averaged for one minute) and the barometric pressure standard should now be equal.

8.0 SPECIFICATIONS

Calibration range (standard):	+40 to 105 oF (+5 to +40 oC) 17.7 to 32.5 in Hg (600 to 1100 mb) -2300 to 13800 ft (-700 to 4200 m) Custom calibration ranges are also available)
Accuracy (std. range):	+/-0.009 inHg, 23.6 to 31.3 inHg +/-0.3 mb, 800 to 1060 mb (or) +/-0.015 inHg, 17.7 to 32.5 inHg +/-0.5 mb from 600 to 1000 mb
Operating Environment:	-13 oF to +122 oF (-25oC to +50oC) 8.9 to 38.4 inHg (300 to 1300 mb) -7000 to 30000 ft (-2100 to 9100 m)
Size:	1.2 in x 3.6 in x 5.7 in (3.0 cm x 9.1 cm x 14.5 cm)
Weight:	10.0 oz (280 g)
Power Requirements:	Standard 9V transistor battery
Power off:	Battery life > 1 year
Power on:	Current drain: 4 ma. Voltage: 9V battery Battery life: 80 hrs of operation at 22 degrees Celsius

9.0 EQUATIONS

Mathematical equations are used by the HHB to calculate the output parameters.

Pressure in millibars is calculated by a fifth-order polynomial equation with temperature dependent cross product terms. The equation is used to convert raw data to a numeric pressure value.

9.1 Altitude Equations

The equation for standard altitude is:

H = 44330.77 * (1 - [Po / Pr] ** 0.19026)

Where: H = altitude above sea level in meters.
Po = site pressure as measured by the instrument in mb.
Pr = the "altimeter setting" in millibars.

Note: This instrument uses the altimeter equations for the standard atmosphere between sea level (h = 0 m) and the top of the troposphere (h = 11000 m) (lapse rate assumed to be 0.0065 deg C / m). This same assumption is made for negative altitudes even though the standard atmosphere is not defined below sea level.

You may correct the altimeter by adjusting Pr to the correct altimeter setting or by adjusting H to a known height. If you adjust H, a new Pr in millibars is calculated according to the following equation:

Pr = (Po) / (1 - H / 44330.77) ** [1/0.19026]

The equation for temperature compensated altitude is:

H = (To / 0.0065) * ([1013.25 / Po] ** 0.19026 - 1)

Where: H = altitude above sea level in meters.
Po = site pressure as measured by the instrument in mb.
To = site temperature in deg K as measured by the operator.

When using this mode the operator may correct the altitude reading by adjusting To to the site ambient air temperature.

The equation for differential altitude is:

$$DH = (To / 0.0065) * [(Ps / Po) ** 0.19026 - 1]$$

Where: To = site temperature in deg K as measured by the user.
Po = site pressure as measured by the instrument in mb.
Ps = set equal to Po whenever the differential altitude is zeroed with the SET/ZERO key.

10.0 Conversion Chart

1.0 inch of mercury	= 33.8639	millibars
1.0 millimeter of mercury	= 1.333224	millibars
1.0 pound sq. in. absolute	= 68.9476	millibars
1.0 kilopascal	= 10.00	millibars
1.0 inch of water	= 2.491	millibars
1.0 meter	= 3.28	feet
1.0 foot	= 0.30488	meters
degrees K	= 273.15 + deg C	
degrees K	= 273.15 + 5/9 (degrees F - 32)	
degrees C	= 5/9 (degrees F - 32)	

2900F OPERATING INSTRUCTIONS

"QUICK DRAW" SOILMOISTURE PROBE

3/83

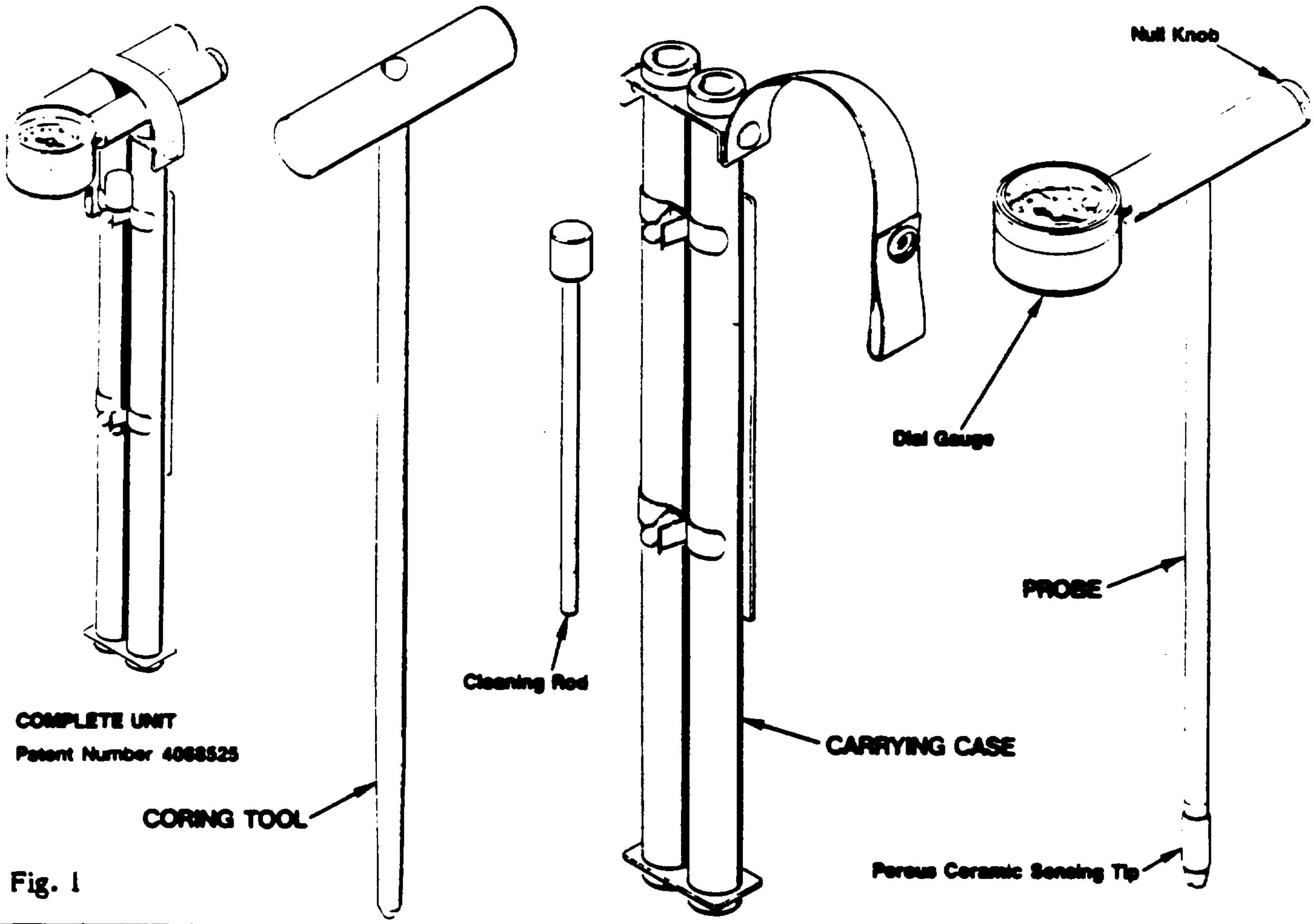


Fig. 1

SOILMOISTURE EQUIPMENT CORP.
P. O. Box 30025
Santa Barbara, CA 93105
U.S.A.

Telephone No. (805) 964-3525
Telex No. 65-8424
Cable Address: SOILCORP

SOILMOISTURE

THE NEW MODEL 2900F SOILMOISTURE PROBE is the most effective portable moisture measuring instrument available. Designed for rugged field use, the patented thermos construction utilizing capillary tube connections and super porous ceramic tip assures fast response and accurate readings, independent of temperature differences. The new self-servicing feature, unique in tensiometer construction, eliminates the need for accessory service kits, assuring fast response times after years of use.

The Probe is now shipped in a dry condition for greater convenience in handling and storage over a period of time. Follow the simple instructions to water fill your unit in preparation for use.

ACQUAINT YOURSELF WITH THE PARTS OF THE PROBE, as shown in Fig. 1, front page

A strap across the top of the Carrying Case holds the Probe and Coring Tool in place. To remove the Probe and Coring Tool, simply pull out on the free end of the strap to undo it from its snap. NOTE that the Probe fits into the side of the Carrying Case marked "PROBE" on the nameplate. The Coring Tool fits into the other side of the case marked "CORING TOOL".

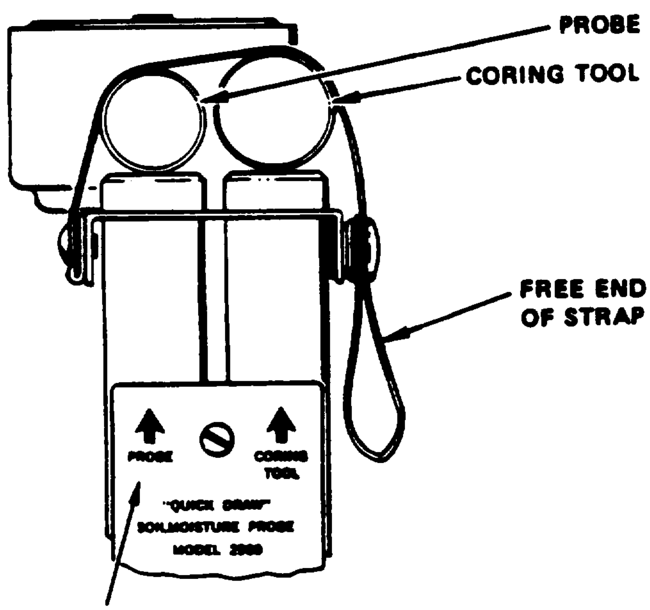


Fig. 2

As illustrated in Fig. 2, it is very important that the Probe always be kept in the side of the Carrying Case marked "PROBE" when it is not actually being inserted in the soil, since this side of the Carrying Case has a water storage reservoir at the bottom. During the "Initial Filling" operation, pictured and described on pages 2 thru 5, you will fill the water storage reservoir. Thereafter the sensing tip of the Probe will be kept moist.

An Accessory Kit is provided with each Probe. It consists of a small screwdriver, a 3/32" size Allen wrench, and a replacement sensing tip and seals. The screwdriver is used to vent and adjust the dial gauge, and to replace the sensing tip. The Allen wrench is used in the event the dial gauge needs replacement.

With proper care the Probe will give you many, many years of excellent service.

IF YOU LIVE AT ALTITUDES APPRECIABLY ABOVE SEA LEVEL

You will notice on delivery that the pointer on the dial gauge may not read zero and the diaphragm on the bottom side of the dial gauge may be bulged out. This is due to the lower atmospheric pressure at your elevation. To correct this condition, the gauge must be vented. The procedure for venting and adjusting the pointer is covered in the "Care and Maintenance" section.

High altitude limits the operating range of the Probe due to the reduced atmospheric pressure. Read about the effect of high altitude under "More About the Soilmoisture Probe" on page 14 of the instructions.

The dial gauge readings mentioned in the filling instructions apply for elevations in the range from sea level to approximately 2000 ft. At higher elevations the readings will be somewhat less. This is again called to your attention at appropriate places in the instruction information.

INITIAL FILLING

STEP 1.

Turn Null Knob all the way clockwise as far as it will go and then insert porous ceramic sensing tip in water.

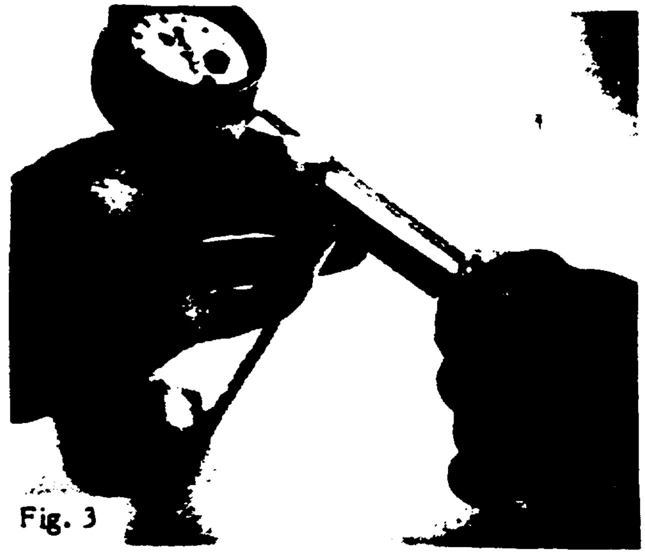


Fig. 3

STEP 2.

Keep sensing tip in water. Turn Null Knob counterclockwise until you just see the red ring.

On initial filling, the pointer will normally rise to a reading of 40 to 50.

Let pointer drop to zero.

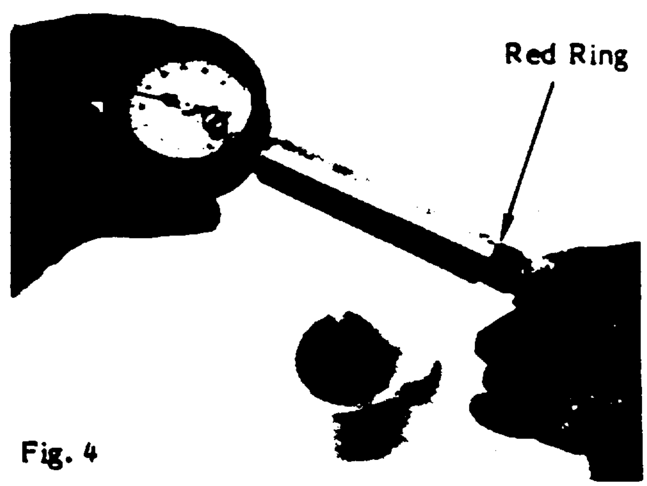


Fig. 4

STEP 3.

Keep sensing tip in water. Continue to turn Null Knob slowly counterclockwise until it is loose and can be removed.

Fig. 5

STEP 4.

Fill handle with water. A teaspoon works well for this operation. Water should be poured into the handle slowly and carefully so that air bubbles are not trapped. If you see a bubble clinging to the smooth wall or bottom of the handle cavity, you can nudge it free with the sharp end of a pencil.

Fig. 6

STEP 5.

Screw Null Knob completely back in handle, which will push out excess water.

While you are doing this, water will ooze out through the porous ceramic tip and drip off the end.

Fig. 7

STEP 6.

Turn Null Knob clockwise as far as it will go.

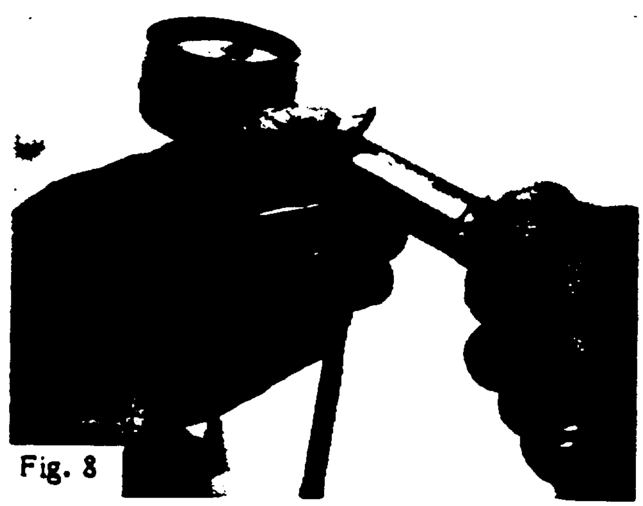


Fig. 8

STEP 7.

Remove tip from water and dry with Kleenex or similar absorbent tissue. Dial pointer will rise to a reading of 20 or 30 as moisture is pulled into the dry tissue.

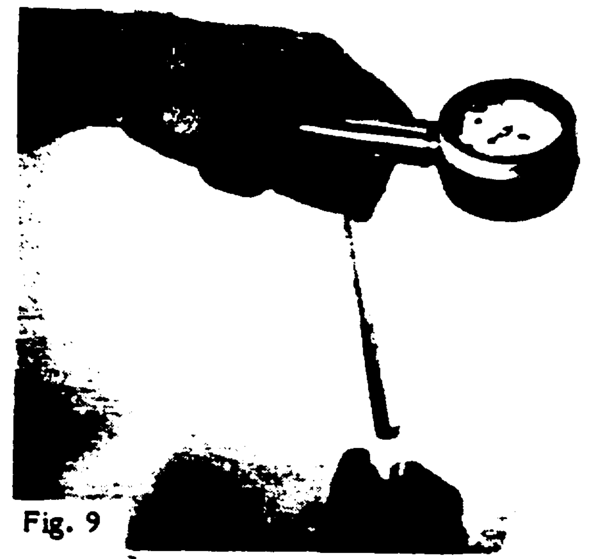


Fig. 9

STEP 8.

Turn Null Knob counterclockwise until you just see red ring. Pointer will normally rise to a reading of 80 or 90 centibars if you live at an elevation between sea level and about 2000 ft. If you live at higher elevations, the maximum reading will be somewhat lower. See page 14 which describes the effect of altitude on the operation of the Probe.

If the pointer does not rise, it can mean that the porous ceramic sensing tip has been cracked by rough handling. See section on "Care and Maintenance" for corrective action.

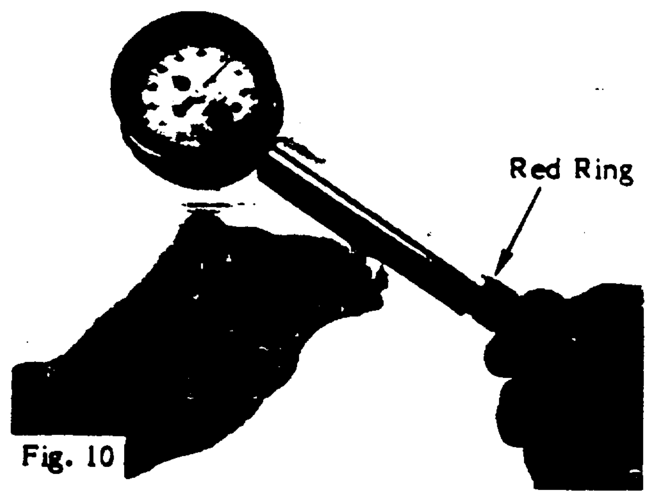


Fig. 10

STEP 9.

Immerse porous sensing tip again in water and wait until pointer drops to zero.

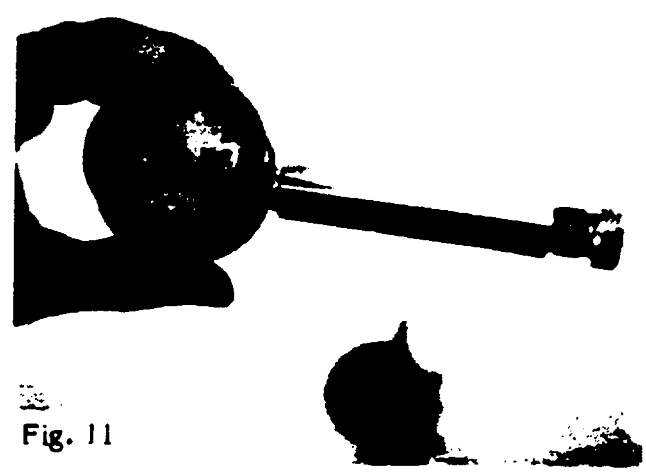


Fig. 11

STEP 10.

Repeat Step 3, removing Null Knob again while sensing tip is in water. Repeat Steps 4, 5, and 6, again refilling handle with water and insert Null Knob and turn clockwise as far as it will go.

STEP 11.

Check Response Time

To do this, wipe the Probe and porous ceramic tip with absorbent tissue, to remove all excess water. Turn Null Knob until pointer reaches a reading of 50 on the dial. Now when you dip the sensing tip in water the pointer will normally drop from a reading of 50 to a reading of 10 in approximately one second -the time that it takes to say "one, one thousand". The Probe is ready for use if the response time is approximately one second.

STEP 12.

Fill the Carrying Case tube which is labeled "PROBE" with water and allow to stand for a minute or two. This will fill the sponge cartridge with water. Empty excess water out and insert the Probe. The sponge cartridge in the Carrying Case will now keep the porous ceramic sensing tip wet so that is ready to use at any time in the field.

In the future, always keep the Probe in the Carrying Case when not in use.

When examining the Probe, DO NOT leave the porous ceramic sensing tip exposed to the air for prolonged periods. When the Probe is removed from the Carrying Case and the sensing tip is not kept moist, evaporation of moisture from the tip will pull the dial gauge up to a very high centibar reading.

Under these conditions, air can diffuse through the water in the pores of the sensing tip and enter the Probe, which can result in a decrease in sensitivity and require a refilling cycle.

NOTE: IF THE RESPONSE TIME IS TOO LONG

If the response time, after initial filling, is considerably more than one second, it usually indicates that an air bubble has been trapped in the handle. To correct this, simply repeat Steps 8 and 9 and then Steps 3, 4, 5, and 6, again looking into the handle cavity after filling to see if there are any bubbles clinging to the internal wall. In the event that there are, simply nudge them loose with a sharp end of a pencil. Fill the cavity in the handle to the top, replace the Null Knob, wipe dry and again check the response time.

Each filling cycle removes more air until the Probe is virtually free of all air and is very responsive.

NOTE: THE POINTER MAY NEED ADJUSTMENT

The pointer may have to be adjusted after the filling operation. First read the following section concerning the Dial Gauge and then refer to the "Care and Maintenance" section for specific instructions for adjusting the dial gauge pointer.

ABOUT THE DIAL GAUGE AND CARRYING CASE

The Bourdon dial gauge was filled with an ethylene glycol mixture at the factory. This assures protection against freezing for an extended period of time. As a matter of precaution, however, it is always desirable to store the Probe at temperatures above freezing so as to avoid any possible damage to the unit through the formation of ice crystals.

When the Probe is in the Carrying Case and is held vertically, the pointer on the dial gauge should read zero. You will note, however, that if the Carrying Case is tipped horizontally, the pointer on the dial gauge will read below zero. This is caused by the shift in weight of the water column within the Probe itself. For normal use, the dial pointer is set at zero when the Probe is held vertically and when only the ceramic sensing tip is immersed in water. For pointer setting instructions see "Care & Maintenance" section.

Intense heat can cause the plastic Carrying Case to distort, and can result in the evaporation of all water from the sponge within the Carrying Case, which will be detrimental to the operation of the Soilmoisture Probe. It will also result in frequent servicing for removal of air. Do not store or transport the Soilmoisture Probe where it is subject to intense heat. Very high temperatures can develop within a closed cab of a truck or the trunk of a car.

MAKING A SOIL MOISTURE MEASUREMENT

STEP 1 - CORING A HOLE

The first operation in taking a reading is to core a hole in the soil with the Coring Tool to accept the Probe. The Coring Tool is pushed vertically down into the soil, as shown in Fig. 12. After reaching the depth desired, the Coring Tool is removed.

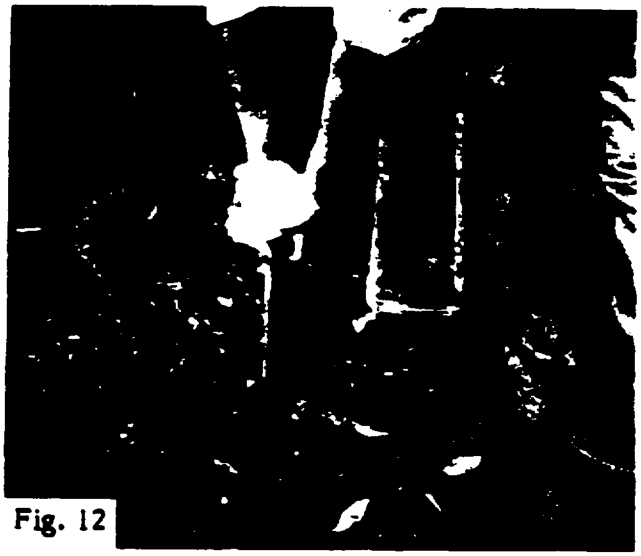


Fig. 12

This operation will pull out the soil core and will provide a proper sized hole in the soil for insertion of the Probe.

The soil should be cleaned from the Coring Tool after each coring operation, in order to make sure that the succeeding core will be properly cut. The core is removed simply by inverting the Coring Tool so that the core can slip out the handle end, see Fig. 13. The core, itself, gives a good profile of the soil below the surface. The Cleaning Rod can be used to remove any remaining soil from the cutting tip, as shown in Fig. 14. In the event soil becomes lodged inside the Coring Tool, striking the side of the steel Coring Tool with the side of the Cleaning Rod will jar the soil inside so that it will fall out.

If in coring the hole an impediment is encountered, such as a rock or a hard root, simply move to an adjacent location and core another hole. After the reading has been made, no attempt should be made to plug the hole, since the small diameter hole is not detrimental and will provide desirable aeration.

The Coring Tool makes a hole in the the soil

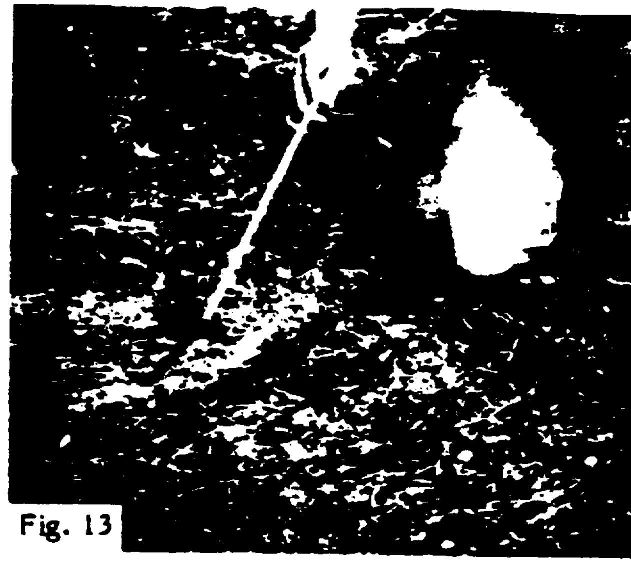


Fig. 13


Fig. 14

which is tapered at the bottom. The larger portion of the hole provides clearance for the Probe when it is inserted into the hole, until it reaches the proper depth for measurement. When the sensing tip of the Probe reaches the bottom of the hole, it is pushed firmly into the tapered portion of the hole so that a tight contact is made between the sensing tip and soil. This tight contact is essential to make a good, fast, soil suction measurement. See Fig. 15, page 7.

The Coring Tool is made from strong, chromemoly steel, and will stand considerable punishment. If, however, the soil surface is too hard or dry for the Coring Tool to penetrate, the surface soil can be broken with a larger soil sampling tool or shovel. The Coring Tool can then be pushed into the hole created to provide a proper-sized hole to accept the Probe.

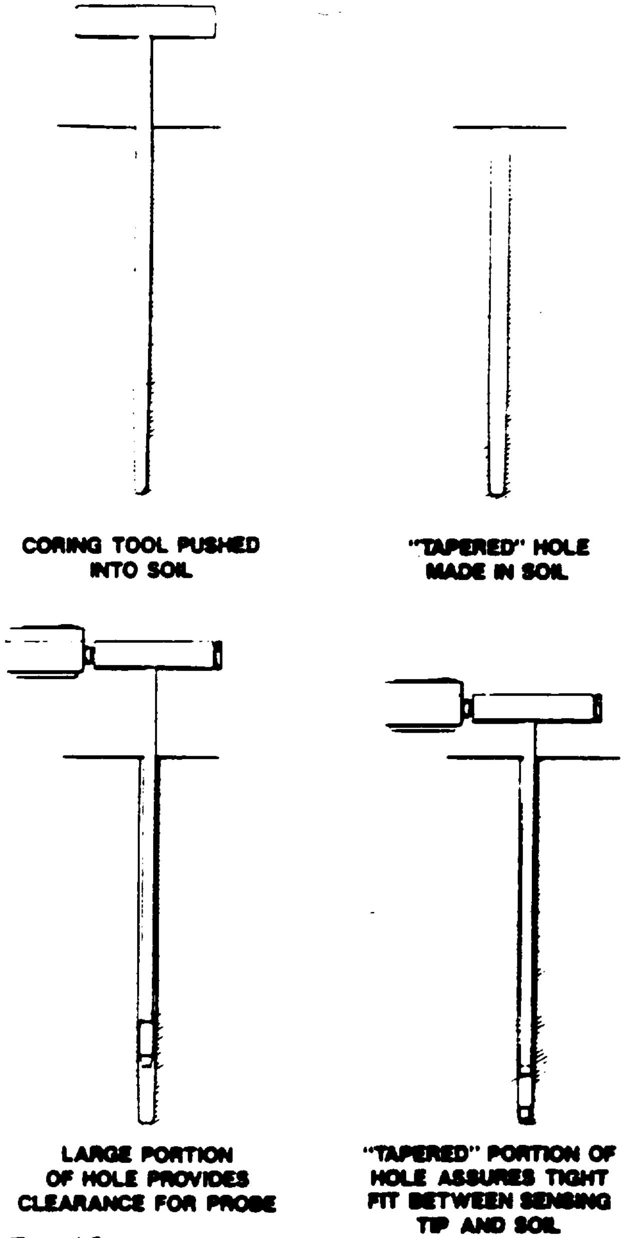


Fig. 15

In loose, cultivated soils and planting mixes, the Probe can frequently be pushed down directly into the soil without coring a hole. Some precautions should be exercised in taking measurements in these loose soils to make sure that the porous ceramic sensing tip is in good contact with the soil, and that undue force in inserting the Probe is avoided.

STEP 2 - INSERTING THE PROBE

Prior to removing the Probe from the Carrying Case, turn the Null Knob clockwise as far as it will go and then undo the knob (counterclockwise) approximately 1/2 turn. This operation will provide the proper range for the Null Knob when taking a reading. See

Fig. 16

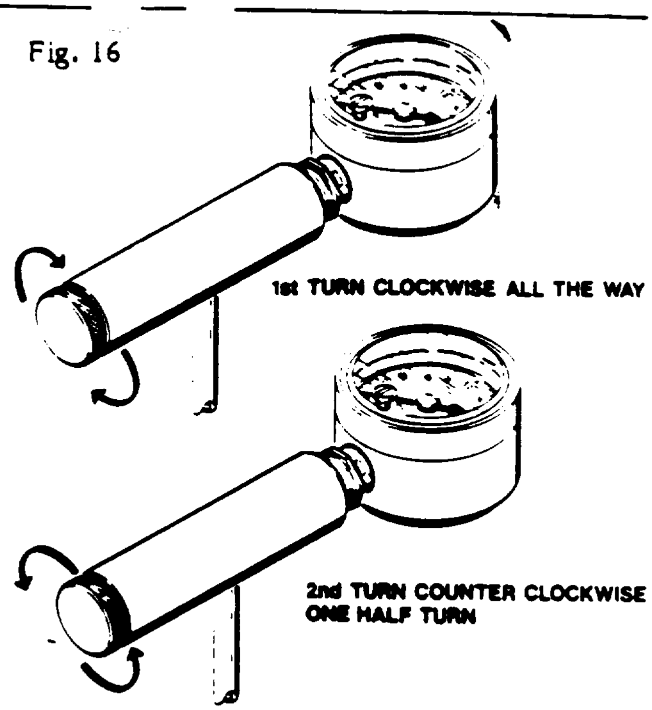


Fig. 16.

The Probe is now removed from the Carrying Case and inserted into the hole made by the Coring Tool, and pushed in so that the sensing tip is in firm contact with the soil.

NOTE: If the Probe has been stored in a very hot environment, such as in the back of a truck, you should leave the Probe in the initially cored hole for two to three minutes to bring the Probe to approximate temperature equilibrium with the soil. The Model 2900F Probe has been designed to have very minimum temperature effects. However, it is desirable to eliminate extreme temperature variations between the soil and the Probe in order to obtain the fastest response and ease of use. After the initial temperature adjustment, when necessary, return the Probe to the Carrying Case to drop the pointer reading to zero; core an adjacent hole, and reinsert the Probe.

If the soil is saturated with water, the pointer of the dial gauge will remain at zero. Otherwise, the pointer will immediately start to rise when the Probe is inserted into the hole. After insertion, allow the Probe to remain undisturbed for approximately one minute, and at the end of this time observe the pointer reading.

Turn the Null Knob counterclockwise to bring the pointer up to a value which is one and one-half times the initial reading after the

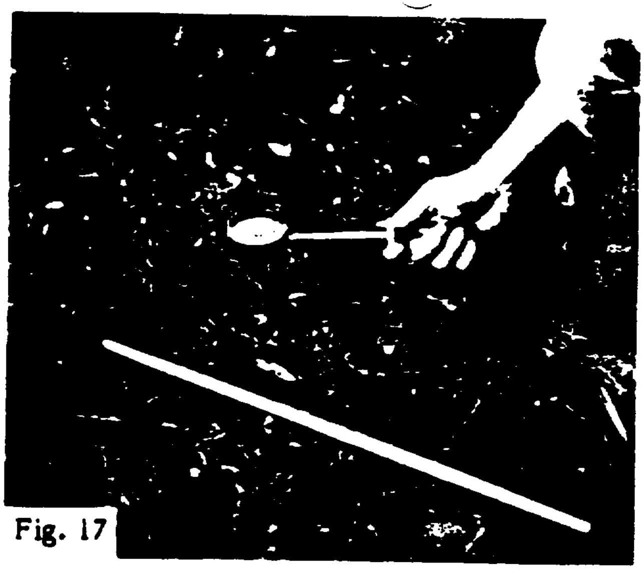


Fig. 17

one minute period. In other words, if the reading after one minute is 20 centibars, turn the Probe so that the reading is adjusted to 30 centibars. If the reading is 40 centibars, turn the Null knob so that the pointer is at 60 centibars, etc. See Fig. 17.

After making the first adjustment, observe the pointer movement after 15 to 30 seconds. Tapping the dial gauge lightly with the finger while observing the pointer movement will tend to reduce the normal internal friction so that changes in the pointer position will be observable with minimum lapsed time. If the pointer is moving down to a lower value than the one set, you know that the correct soil suction value is somewhere between the initial reading at one minute and the adjusted value. In this case, turn the Null Knob in a clockwise direction to lower the pointer to read one-half way between the initial value and the first set value. After this second adjustment, again observe the direction in which the pointer is moving and then make a subsequent adjustment to an intermediate value. By this process, you "bracket" the actual soil suction value and can very quickly adjust the Probe to the true soil suction value. When the pointer is adjusted to the true soil suction value, it will not move up or down, but will remain in a fixed position.

If after the first adjustment the pointer continues to move up to a higher rather than a lower reading, you should immediately move the pointer approximately 10 centibars higher and observe the pointer movement. If it continues to move up to a higher value, advance the pointer an additional 10 centibars. Once you reach a level where the pointer starts to move back down, you have then "bracketed" the reading, and adjustments can be made as described above to arrive at the correct value.

In many moist soils, the Probe will come to equilibrium very quickly without any appreciable adjustment of the Null Knob.

Through experience in using the Probe in your soils, you will soon be able to estimate the final dial gauge reading from the speed that the pointer moves after insertion of the Probe. It is best to minimize the use of the Null Knob to limit disturbance to the soil moisture conditions being measured.

After making a reading, the Soilmoisture Probe should be wiped free of surplus, clinging soil with the hand and returned immediately to the Carrying Case, so that the sensing tip is in contact with the water storage sponge and remains moist, with the dial gauge reading zero. If when making field measurements the soil suction value exceeds the highest operating value corresponding to your elevation, the Probe should not be left in the soil for extended period.

Soil moisture values can vary considerably within a given area because of differences in root action, drainage and exposure. For this reason, it is desirable to make several readings in a given area in order to fully evaluate the soil moisture conditions.

APPLICATION OF READING

A zero soil suction reading indicates that the soil is saturated. Under this condition, all of the soil pores are filled with water and any additional water will flow through the soil if there is drainage, or pond on the surface or run off if there is not. Saturated conditions, of course, should be avoided since they are detrimental to plant growth, and the Soilmoisture Probe will immediately detect this undesirable condition.

In medium textured soils most plants grow best where the soil suction readings are kept between 20 and 60 centibars. At this moisture level, you have good aeration as well as good movement of moisture. Turf is frequently grown at lower soil suction values.

In sandy soils the optimum range is usually 10 to 30 centibars.

In heavy clay soils that can store greater amounts of water, maximum readings of 70 or 80 centibars will not be harmful to growing plants.

If soil suction values are allowed to reach 80 centibars, it can be detrimental to the plant, particularly for sandy and sandyloam soils. At this moisture level, the supply of water for the roots is becoming limited and the water films are becoming so thin the soil moisture movement within the soil is very slow. This means that moisture withdrawn by a root, in a given area, is not readily replaced. As a result, under conditions of bright sun and wind, destructive stress conditions can develop in the plant.

It has been determined in recent years that it is better to keep soils somewhat more moist than was originally practiced in order to get the best water penetration when irrigating, and also to provide the healthiest environment for optimum crop production. The best thinking in this regard at the present time is to keep soil suction values at a maximum of 40 to 50 centibars, and to arrange irrigation so that you do not create a saturated condition (0 to 10 centibars of soil suction) for any length of time in the feeder root zone.

Where you are working with sandy soils which have extremely limited water storage capacity, irrigation is started at lower soil suction values, frequently in the range of 15 to 20 centibars.

Where you are working with drip irrigation systems and the readings are made approximately 12" away from the emitter, soil suction should be maintained at a relatively low value (usually in the range from 10 to 25 centibars, depending upon soil type).

CARE AND MAINTENANCE

VENTING THE DIAL GAUGE

The vent screw is in the plastic coverplate of the dial gauge, as shown in Fig. 18. To vent the dial gauge, simply remove this screw momentarily, as shown in Figs. 19 and 20, and replace the screw. The vent screw will accept the small flat blade screwdriver such as supplied with the Accessory Kit.

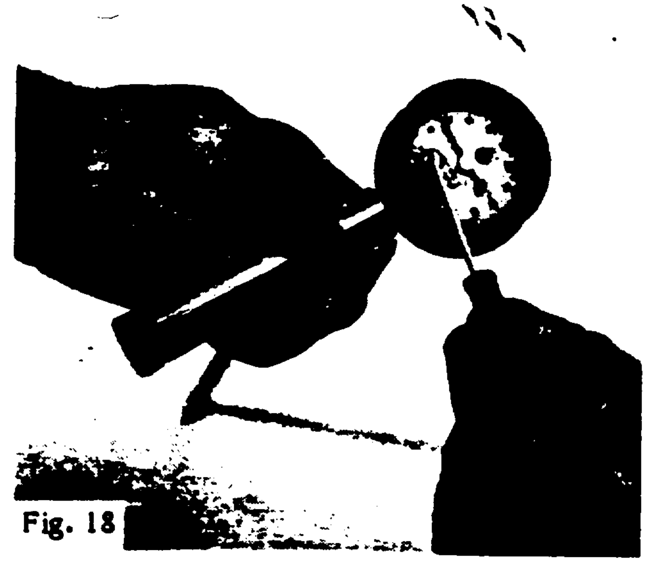


Fig. 18

Fig. 19

Fig. 20

ADJUSTING THE DIAL GAUGE POINTER

First remove the vent screw from the dial gauge and insert a flat blade 1/8" wide screwdriver such as supplied with the Accessory Kit through the hole in the gauge cover plate to engage the slot in the adjusting screw. See Fig. 21.

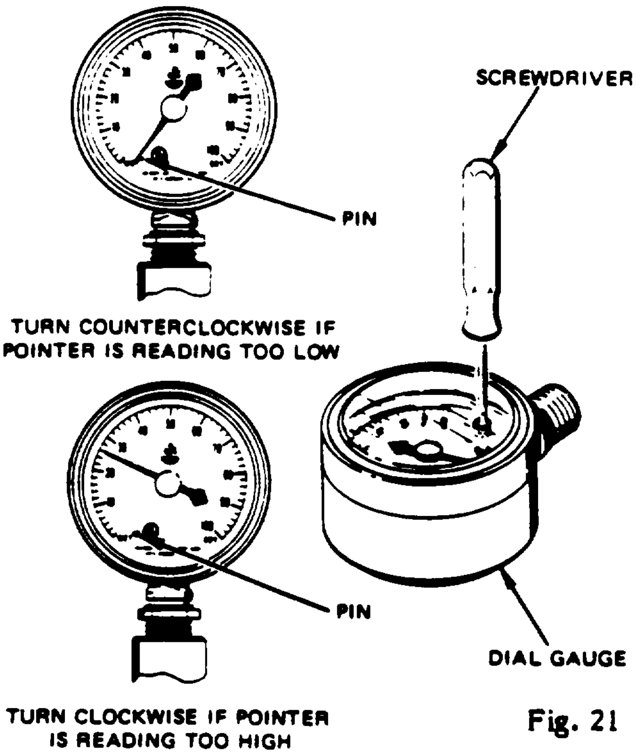


Fig. 21

If the gauge was reading high, turn the screwdriver clockwise an estimated amount to correct the error.

If the gauge was reading low, turn the screwdriver counterclockwise an estimated amount to correct the error.

Repeat the process, if necessary, until the pointer is on the zero position.

REPLENISHING MOISTURE IN CARRYING CASE

Periodically remove the Probe from the Carrying Case and fill the Probe side with water and then empty. This process flushes accumulated soil particles from the case and keeps the sponge at the bottom of the Carrying Case moist.

TESTING THE RESPONSE TIME

The successful operation of the Model 2900F Soilmoisture Probe is due to its structural rigidity and the fact that the air has been almost completely removed from the water and the internal structure of the Probe. For these reasons, any small amount of movement of water through the porous ceramic sensing tip will result in a substantial change of the vacuum level within the Probe. This very responsive action, coupled with the use of the Null Knob, results in only a small disturbance to the water films in the surrounding soil which are being measured, and hence, accurate measurements of soil suction can be made quickly.

If air is present in the unit, then a substantial amount of water must flow through the wall of the porous ceramic sensing tip to change the vacuum level within the Probe. The air within the Probe expands as the pressure is reduced (centibar reading increased) and, as a result, a larger amount of water moves into and out of the surrounding soil. This in turn, results in a less responsive movement of the pointer on the dial gauge, a "spongy" action of the Null Knob, and a longer time to obtain an accurate soil moisture measurement.

The response time is defined as the time required for the dial pointer to drop from 50 centibars to 10 centibars when the porous ceramic sensing tip is plunged into a container of water.

If at any time the operation of the Probe appears to be "spongy", and excessive time seems to be required to make a soil suction reading, simply remove the Probe from the Carrying Case and wipe the porous sensing tip with an absorbent tissue, and turn the Null Knob so that the pointer on the dial gauge registers 50 centibars. Then plunge the sensing tip of the Probe into a container of water and note the time required for the pointer to drop from 50 centibars to 10 centibars. If this time is appreciably in excess of one second, then it would indicate that there is air accumulated within the Probe. To remove the air from the Probe and restore the fast response time, the Probe should be refilled with water as described under Initital Filling, page 2.

If the porous ceramic sensing tip has been cracked during use, this will permit air to enter the system. A very fine crack may exist and not be readily observable. Under these circumstances, it is usually not possible to obtain a reading of 50 centibars to conduct the response time test. If a dial reading of 50 centibars cannot be reached by drying the sensing tip and turning the Null Knob, then there is too much air in the system and there may also be a crack in the sensing tip. To replace the porous ceramic sensing tip, see the section on this.

Over a period of many months or years, there is a tendency for the pores in the ceramic sensing tip to become clogged with deposits which decrease the permeability of the ceramic. Such clogging will, of course, slow down the response time of the Probe. If the Probe has been carefully filled with water to remove all accumulated air, and the response time is still in excess of 2 seconds, it would be advisable to replace the porous ceramic sensing tip with a new one.

REPLACING THE POROUS CERAMIC SENSING TIP

If the porous ceramic sensing tip has been broken or cracked during use, or if the pores of the ceramic have been clogged over a long period of time and the response time of the Probe is too long, the porous ceramic sensing tip can be readily replaced with a new one. When replacing the porous ceramic sensing tip, the "O" ring seals must also be replaced.

To replace the sensing tip, the slotted cap nut at the end of the Probe is first removed. A large screwdriver that fits the slot in the cap nut can be used, or the small pointer adjusting screwdriver can be used by putting the side of the screwdriver into the slot in the nut, as shown in Fig. 22. When facing the end of the Probe, turn the cap nut COUNTERCLOCKWISE to loosen it. Completely remove the cap nut, the porous ceramic sensing tip, and the two "O" ring seals at either end of the sensing tip. In removing the parts, be sure that the smooth surfaces on the cap nut and on the stem of the Probe where the "O" rings seat are not scratched or marred, since it is essential that these surfaces be kept smooth in order to assure a complete vacuum seal when the new sensing tip is installed. Clean off any accumulated corrosion from the stem of the Probe.

Fig. 22

Fig. 23

Fig. 23 shows the stem of the Probe, with the two small cross holes. The "O" ring seals, porous ceramic sensing tip, and slotted cap nut are arranged in this photo in the same manner as they fit on to the stem of the Probe.

Figs. 24 through 28 show the successive operations in mounting the parts on the stem of the Probe.

Fig. 24

Fig. 25

Fig. 26

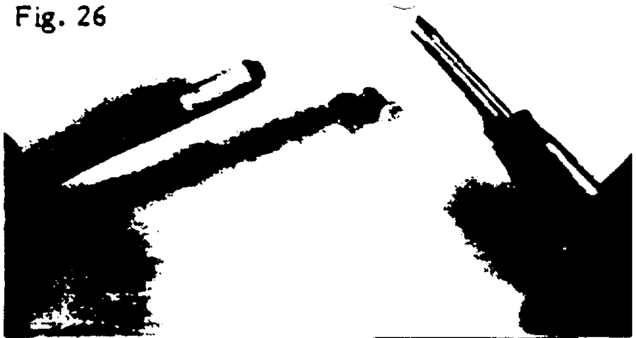


Fig. 27

Fig. 28

The final assembly operation is screwing on the slotted cap nut and tightening it securely with a screwdriver. The slotted cap screw should be tightened as far as it will go. Parts have been carefully machined so that the "O" ring seals are properly squeezed when the slotted cap nut is screwed completely on until it seats on the end of the Probe stem. The "O" rings make a vacuum-tight seal between the brass surfaces of the Probe stem parts and the ends of the porous ceramic sensing tip. The ends of the porous ceramic sensing tip have been machined smooth to assure a vacuum-tight seal. In handling the porous ceramic sensing tip when mounting it on the Probe, make sure that the sensing tip is not scratched or chipped.

The Porous Ceramic Sensing Tip is supplied with a tapered configuration. The taper matches the taper of the Coring Tool. The taper assures better contact with the soil which increases sensitivity and speed of response.

When replacing the tip, special care must be taken to see that the "top" arrow marked on the tip points in the direction as shown in Fig. 29.

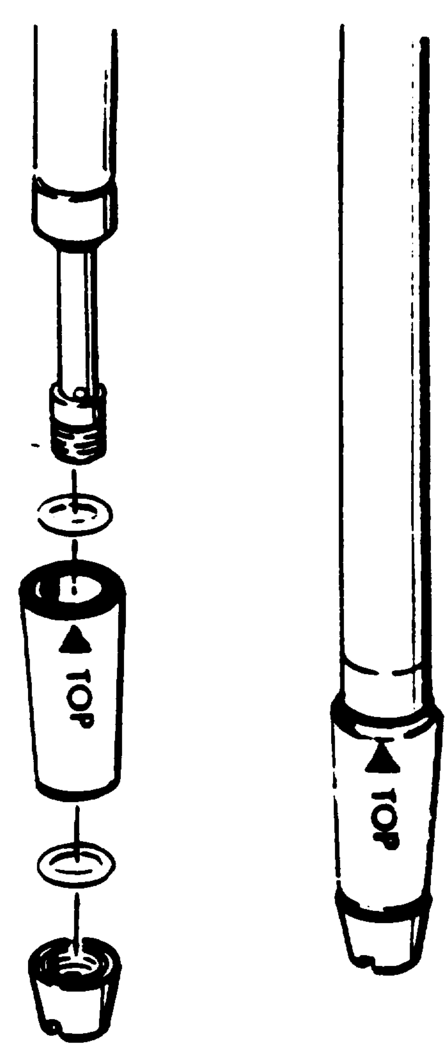


Fig. 29

After replacing the tip, fill the probe as described under Initial Filling.

REPLACING THE DIAL GAUGE

If the dial gauge has been mechanically damaged so that it is inoperative, it may be replaced in the field. First remove the socket head set screw from the handle, as shown in Fig. 30. This is an "Allen" head set screw that accepts a 3/32" size Allen wrench, such as supplied in the Accessory Kit. Then grasp the dial gauge firmly, as shown in Fig. 31, and turn counterclockwise until it is free from handle. Fig. 32 shows the dial gauge removed from the handle. The internal connecting tube usually remains in the dial gauge. Carefully pull out the internal connecting tube from the dial gauge. Fig. 33 shows an "exploded" view of the various parts. The internal connecting tube has "O" ring seals at each end. Push the internal connecting tube all the way into the recess in the handle of the Probe, as shown in Fig. 34. Then screw the new replacement dial gauge

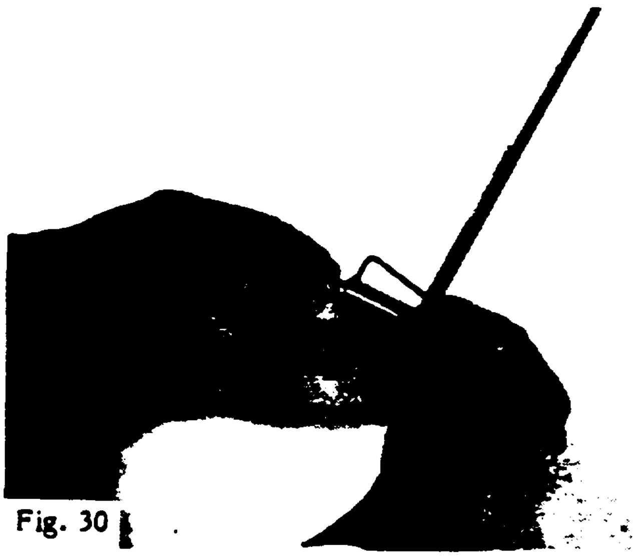


Fig. 30

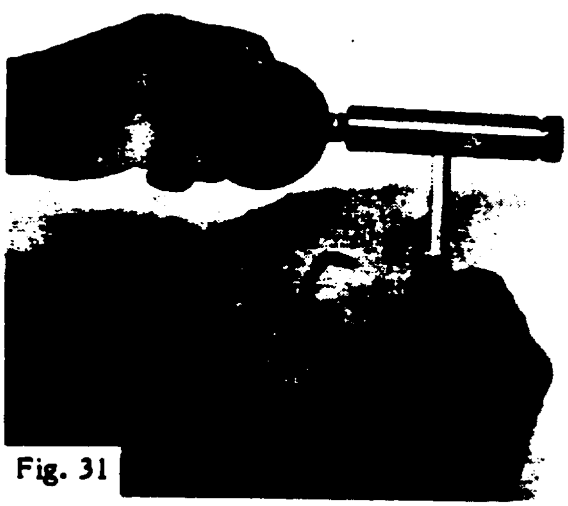


Fig. 31

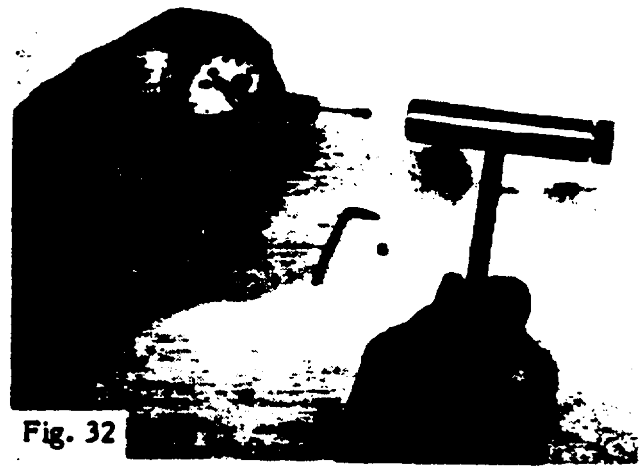


Fig. 32

Fig. 33

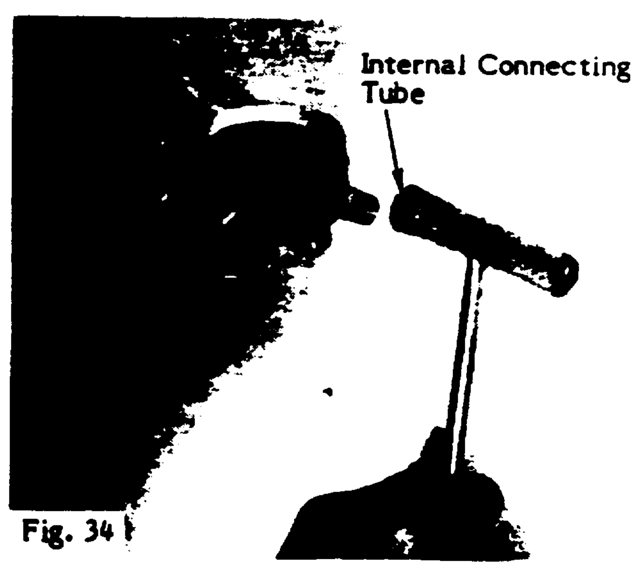


Fig. 34

into the handle, also illustrated in Fig. 34, making sure that the internal connecting tube enters the hole in the stem of the dial gauge. If the "O" ring seals on the ends of the internal connecting tube seem to resist entering the Probe handle and dial gauge stem, wipe on a thin layer of vasoline or vacuum grease on the "O" ring seals to reduce the friction. After screwing the replacement dial gauge completely into the Probe handle and orienting it at the proper angle, replace the Allen head set screw and wrench it down to hold the dial guage firmly in place.

After replacing the dial gauge the Probe must be refilled with water as described under Initial Filling.

Replacement dial gauges suppled by the factory have been filled under high vacuum with a mixture of ethylene glycol and water. This procedure protects the gauge from freezing damage when in use and also makes it easy to remove the air from the Probe during the filling operation. If the replacement dial gauge has lost some of the filling fluid through mishandling, it can still be used. However, it will require a number of Probe filling cycles to remove all the air from the gauge before the desired response time is obtained.

STORAGE AND GENERAL CARE

When the Probe is not in use, it can be stored in almost any location that is not subject to freezing or high temperatures. Before storing for any extended length of time, fill the Probe section of the Carrying Case with water to make sure that the water storage sponge is completely saturated with water.

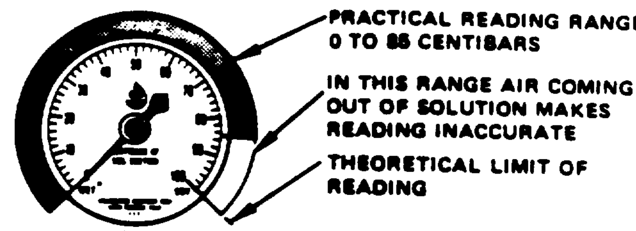
In the event the sponge does dry out during storage, and the response time of the Probe is greater than required, the Probe should be filled with water, as given under Initial Filling.

The Soilmoisture Probe is quite rugged; however, care should always be taken to protect the dial gauge of the Probe from severe mechanical shocks.

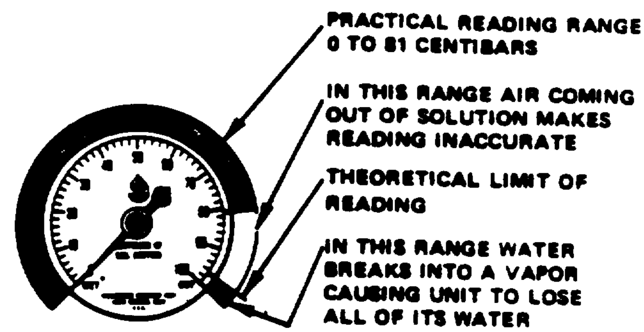
Soilmoisture Equipment Corp. maintains a stock of replacement parts, as carried in the attached Parts List. If severe damage does occur to the Probe, it can also be returned to the factory for refurbishing. When returning the Probe for repair work, be sure to return the complete Soilmoisture Probe assembly, including Carrying Case and other parts. Return shipments must be made on a prepaid basis and packed securely to protect the equipment in transit.

MORE ABOUT THE SOILMOISTURE PROBE

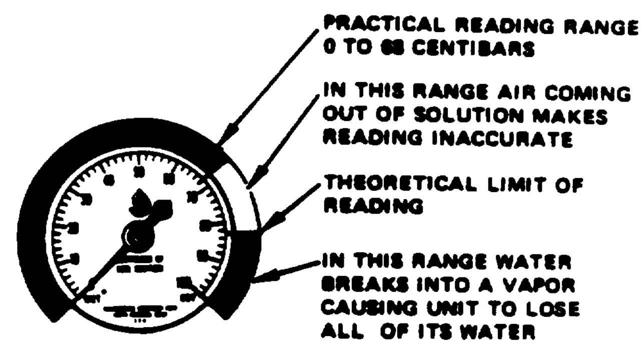
EFFECT OF ALTITUDE ON PROBE



At Sea Level



At 1000 Ft. above Sea Level



At 5000 Ft. above Sea Level

The Reading Range is Reduced Approximately 3.5 Centibars for Each 1000 Ft. Increase in Elevation

PRINCIPLES INVOLVED IN THE OPERATION OF A TENSIOMETER-TYPE MEASURING INSTRUMENT

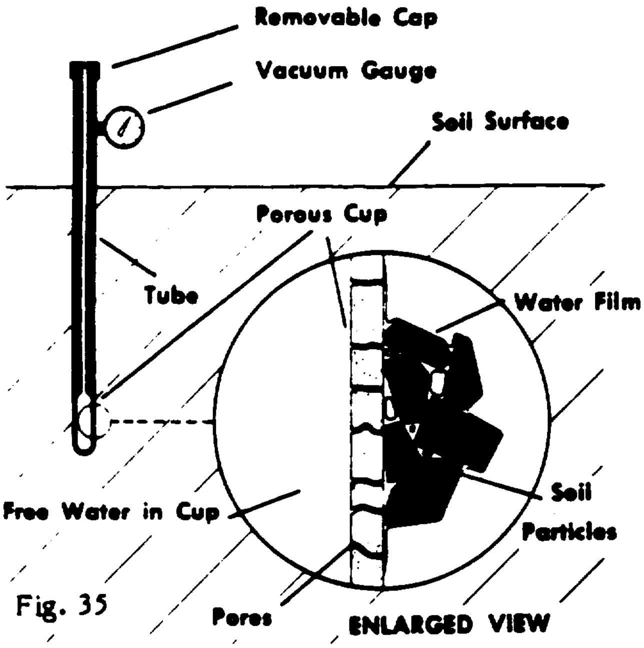


Fig. 35

Fig. 35 above shows a section view of a tensiometer in place in the soil. A tensiometer consists essentially of a tube, sealed at one end by a porous ceramic cup which is in contact with the soil. The other end of the tube is above ground and is connected to a vacuum gauge. This end of the tube is sealed with a removable cap after the tube has been filled completely with water.

The insert in Fig. 35 shows a magnified view of the porous cup in contact with the soil particles. The special thing about the porous ceramic is the size of the pores. The pores are reasonably uniform and of controlled maximum size. When the porous ceramic is wetted and the pores filled with water, the surface tension of the water at the air-water interface at each of the pores, seals the pores. Water can flow through the pores, but the water film at each pore acts like a thin rubber diaphragm and will not let free air pass, throughout the working range of the tensiometer.

The insert also shows the water film which surrounds each soil particle. These films of water are bound to each of the soil particles by strong molecular forces. As soil dries out, these water films become thinner and more tightly bound. The "tension" thus produced within these water films causes water to be sucked from the tensiometer through the pores in the ceramic cup. These same strong molecular forces make it increasingly difficult for plants to extract moisture from the soil as the soil dries out.

As water is sucked from the tensiometer by the soil, a partial vacuum is created in the tensiometer, since the unit is completely sealed except for the porous cup. As more water is removed, the vacuum inside the unit becomes higher. The amount of the vacuum is registered on the vacuum dial gauge. Water is sucked from the tensiometer by the soil until such time as the vacuum created inside the tensiometer is just sufficient to overcome the suction of the soil. At this point, an equilibrium is reached and water ceases to flow from the cup. The tensiometer then reads directly the amount of "soil suction". As the soil moisture is further depleted through evaporation, drainage, or the action of plant roots, the soil suction increases. More water is then sucked from the tensiometer until the vacuum in the unit is increased and a new equilibrium point reached.

When water is added to the soil from rainfall or irrigation, the soil suction is reduced. Then the high vacuum in the tensiometer causes soil moisture to be drawn from the soil through the walls of the porous cup into the unit. This flow of water back into the tensiometer reduces the vacuum. The flow continues until the vacuum in the tensiometer drops to the value where it is just balanced by the soil suction. If water is added to the soil until the soil is completely saturated, then the vacuum dial gauge on the tensiometer will drop until it reads zero.

As outlined above, a tensiometer always is maintaining a balance with the soil suction, and the vacuum gauge on the unit indicates the value of the soil suction at the porous cup.

MEANING OF READINGS —

The Model 2900F Soilmoisture Probe is a tensiometer-type instrument that reads soil suction directly. The "soil suction" reading is a direct measure of the availability of moisture for plant growth, and the standard unit of measurement is the "bar". The bar*is a unit of pressure in the metric system and is used to define positive pressure (above atmospheric pressure), or negative pressure or vacuum (below atmospheric pressure).

The gauge on the Probe is calibrated in hundredths of a bar (or centibars) of vacuum, and is graduated from zero to 100.

In scientific work, it is becoming customary to express pressures and vacuums in a unit of measure called a "Pascal", and a "Kilopascal" which is 1000 times as large as a Pascal. A "centibar", as used above is exactly equal to a Kilopascal. Therefore the dial gauge on the Probe also reads in kilopascals and is graduated from zero to 100 kilopascals (KPa).

Soil suction is actually created by the attraction that each soil particle has for the water in the soil. Because of this attraction, water forms a film around each particle of soil and collects in the capillary spaces between the soil particles. As the soil becomes drier, these films become thinner and the attraction or soil suction increases. The plant root has to overcome this soil suction, or attraction force, in order to withdraw moisture from the soil. The measurement of soil suction then gives a direct indication of the amount of work the plant root must do to get water from the soil. The only moisture measuring instruments that are able to accurately measure soil suction are those using the tensiometer principle. These instruments read centibars of soil suction directly without calibration for soil type, salinity, or temperature.

WHAT HAPPENS WHEN THE PROBE IS INSERTED INTO THE SOIL

When the Probe is inserted into the cored hole, there are various effects associated with the movement of the porous ceramic sensing tip through the soil. The soil surrounding the tip is slightly compacted and the wiping action of the porous ceramic through the soil causes small thermal effects. It takes a few moments for these disturbances to disperse, and it is for this reason that it is not desirable to move the Null Knob for the first minute after insertion of the Probe.

In order to obtain a soil suction reading, it is necessary that a small amount of water transfer between the sensing tip of the Probe and the soil. When the Null Knob is turned clockwise, water is forced out of the Probe sensing tip and into the surrounding soil. When the Null Knob is turned counterclockwise, a vacuum is created within the Probe which causes moisture to move from the soil through the ceramic sensing tip and into the Probe. In order to obtain an accurate reading within the minimum amount of time, one must be careful not to disturb the moisture conditions surrounding the sensing tip. For this reason, adjustment with the Null Knob should be kept to a minimum. After you have had a little experience with your particular soils, you will find that adjusting the Null Knob to bring the pointer to the correct soil suction value will become quite simple and direct.

TIME REQUIRED TO MAKE A READING

The time that it takes to make a soil suction reading varies with soil types and amount of moisture. In order to make a soil suction reading, a small amount of water must be transferred between the soil and the sensing tip of the Probe. Although this transfer is reduced to a minimum by the use of the Null Knob, the water that is transferred must move through the soil itself. The rate at which this water moves through the soil is determined by the "capillary conductivity" of the soil. The capillary conductivity not only varies from soil to soil, but also with the soil suction value for any given soil. In moist soils, the capillary conductivity is higher, and in dry soils the capillary conductivity is lower.

Since capillary conductivity drops off rapidly as soil suction values increase, it requires a longer time to make a soil suction reading in dry, as compared to moist soil. The type of soil will also influence the time required to make a reading. To illustrate the effect of varying capillary conductivity, Fig. 36 shows

* *The bar is defined as 10^6 dynes/cm^2 and is approximately equivalent to 1 atmosphere (.987 atmosphere) or 14.5 psi of pressure. It is approximately equal to the force exerted by a height of 30 inches of mercury or 750mm of mercury, or 33½ ft. of water, or 1000 cm of water.*

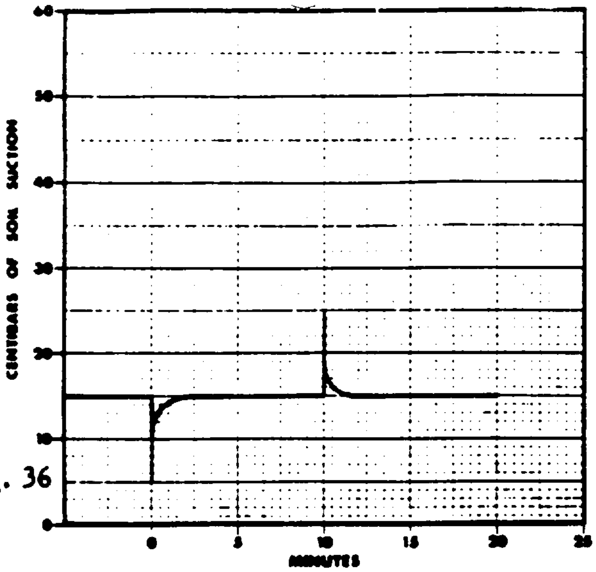


Fig. 36

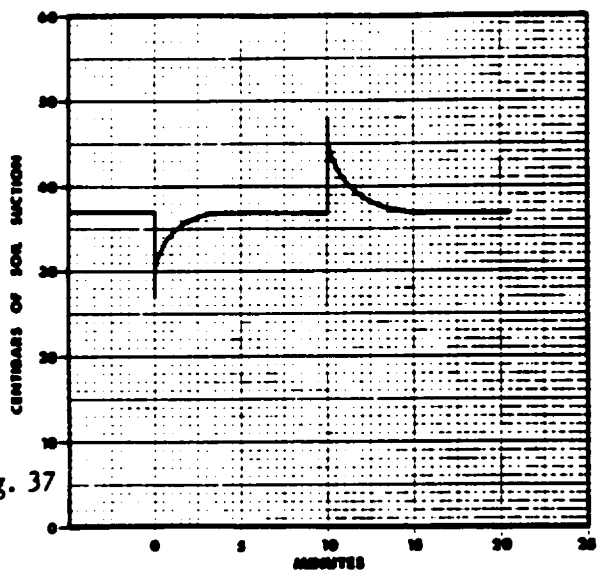


Fig. 37

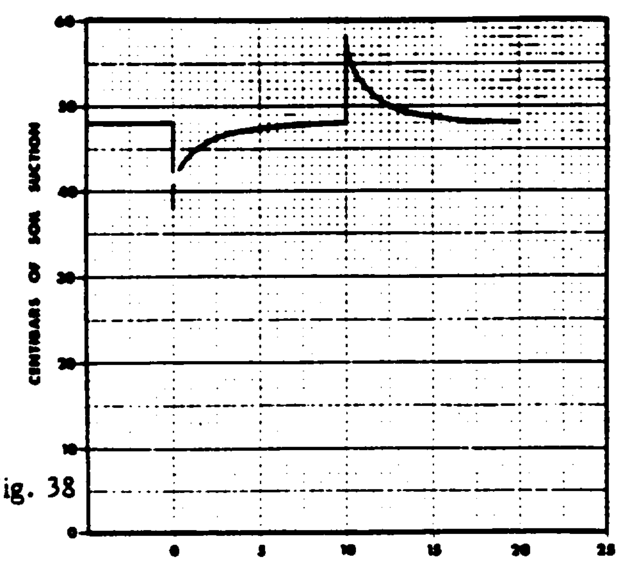


Fig. 38

the time required for the Probe to recover to a reading of 15 centibars in a sandy-loam soil when soil suction value in the Probe is arbitrarily reduced to 5 centibars of soil suction. The experiment is repeated with the soil suction value in the Probe increased to 25 centibars of soil suction. Under these conditions, you will note that the recovery time is approximately 1 to 2 minutes. Fig. 37 shows the same experiment in the same soil when the equilibrium soil suction value was 37 centibars. Here, you will note that the recovery time is approximately 5 minutes in each case. The experiment is again repeated in the same soil when the soil suction value is approximately 48 centibars. Fig. 38 shows this graph, and you will note that in this case the recovery time is approximately 8 to 9 minutes. These experiments demonstrate the change in rate at which moisture moves along the water films in the soil as soil suction values change, and convey a feeling for the response of the Probe to adjustments of the Null Knob when making a reading.

PROBE TIPS

It has been our experience that accurate, reliable moisture readings can be made within a few minutes at any one given location. In general, the readings can be made more quickly when soil suction levels are in the low range than when they are in the high range.

No problems in measurement will be encountered in sandy or sandy-loam soils. In the event you are confronted with the making of measurements in extremely heavy clay soils, more time than normal will be required to reach equilibrium because of the extremely slow movement of water through this type of soil.

CAUTION

In wet clay soils, the plastic soil itself can make an airtight closure around the sensing tip as the Probe is being pushed into the soil. If this happens, pressure can be built up in the Probe by the air trapped in front of the Probe, see Fig. 39. Since this air is sealed by the wet clay soil, a high air pressure can be developed as the Probe is pushed further and further into the soil.

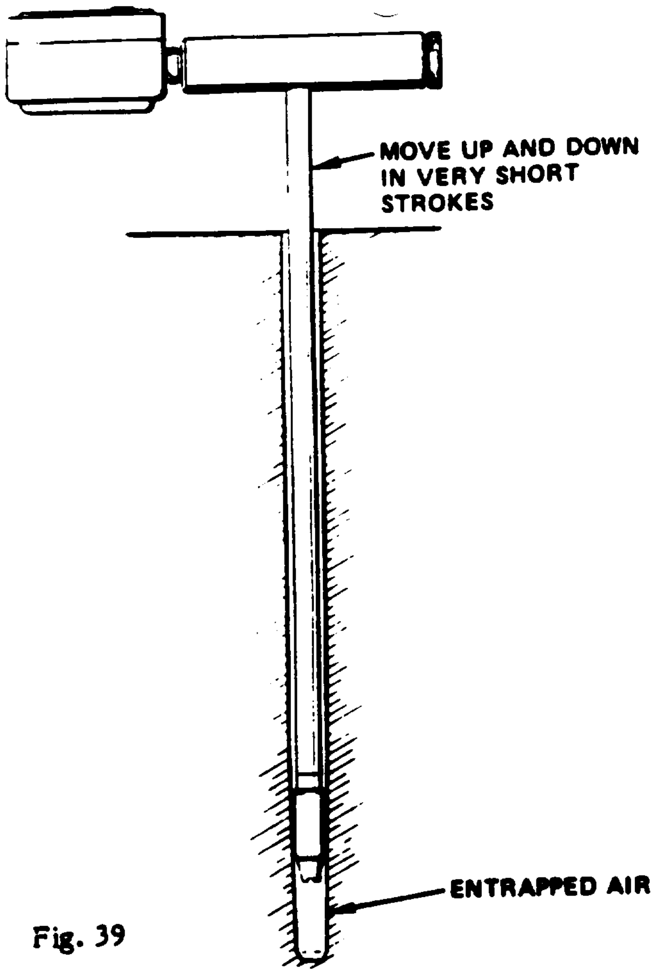


Fig. 39

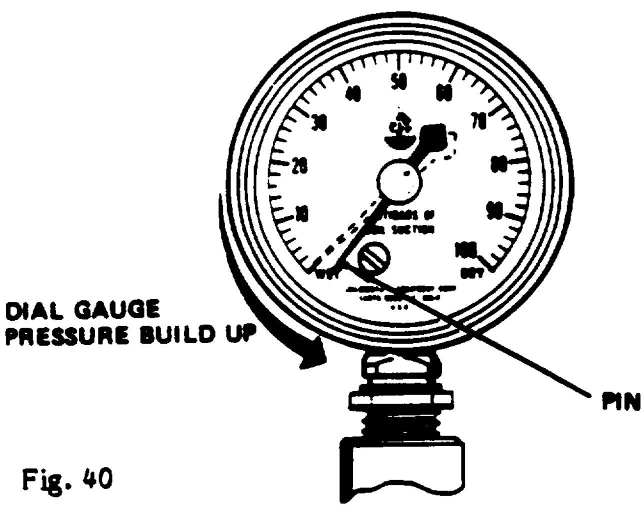


Fig. 40

To detect such a condition, observe the dial pointer when pushing the Probe down into the soil. If the pointer moves below the zero mark and touches the pin, see Fig. 40, pressure is being built up. Stop further pushing, and pull the Probe up to relieve the pressure. Then push the Probe down and then pull up again in short strokes to enlarge the hole in the sensing tip area to prevent the entrapment of air. Then push the Probe to full depth, and make a reading.

POTTED PLANTS

The Model 2900F Soilmoisture Probe is particularly valuable in determining moisture conditions in potted plants, such as in commercial buildings or in nurseries. The Probe responds quickly in planting mixes used in potted plants, and can usually be pushed directly down into the root zone without coring a hole. Its portability eliminates the necessity of attention to vandalism that must be given to fixed moisture measuring instruments. After thoughtful use, a watering plan can be developed that keeps maintenance and water costs to a minimum.

USING A NUMBER OF PROBES AT THE SAME TIME

Where one is engaged in frequently evaluating moisture conditions in large irrigated fields, the use of several Probes can speed up the work. As an example, an agricultural consultant who has the responsibility of programming irrigation for his client can walk out into a field and insert a number of Probes without taking immediate readings. When the crop is high, the Probes are flagged with a red cloth on a wire stake so they can be readily found. The consultant then makes his other crop observations. After completing his other work, he returns to pick up the Soilmoisture Probes. By this time, the Probes have reached equilibrium, and the readings can be quickly noted down.

FOR PRICES ON PARTS SEE CURRENT PARTS PRICE LIST.

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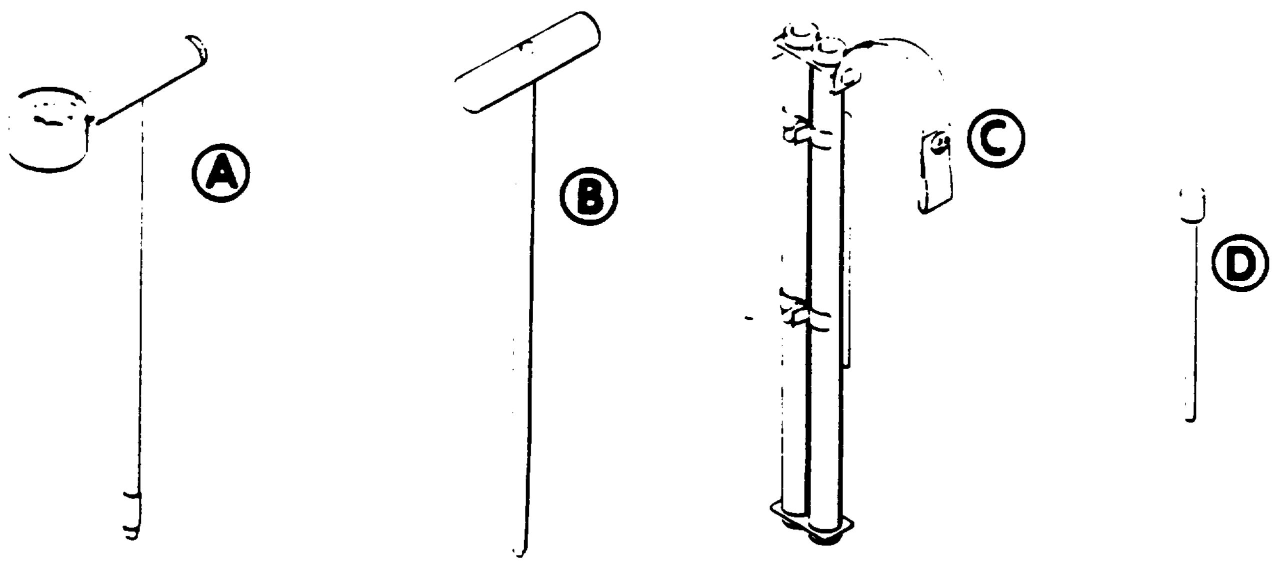
2900F PARTS LIST

SOILMOISTURE PROBE PARTS

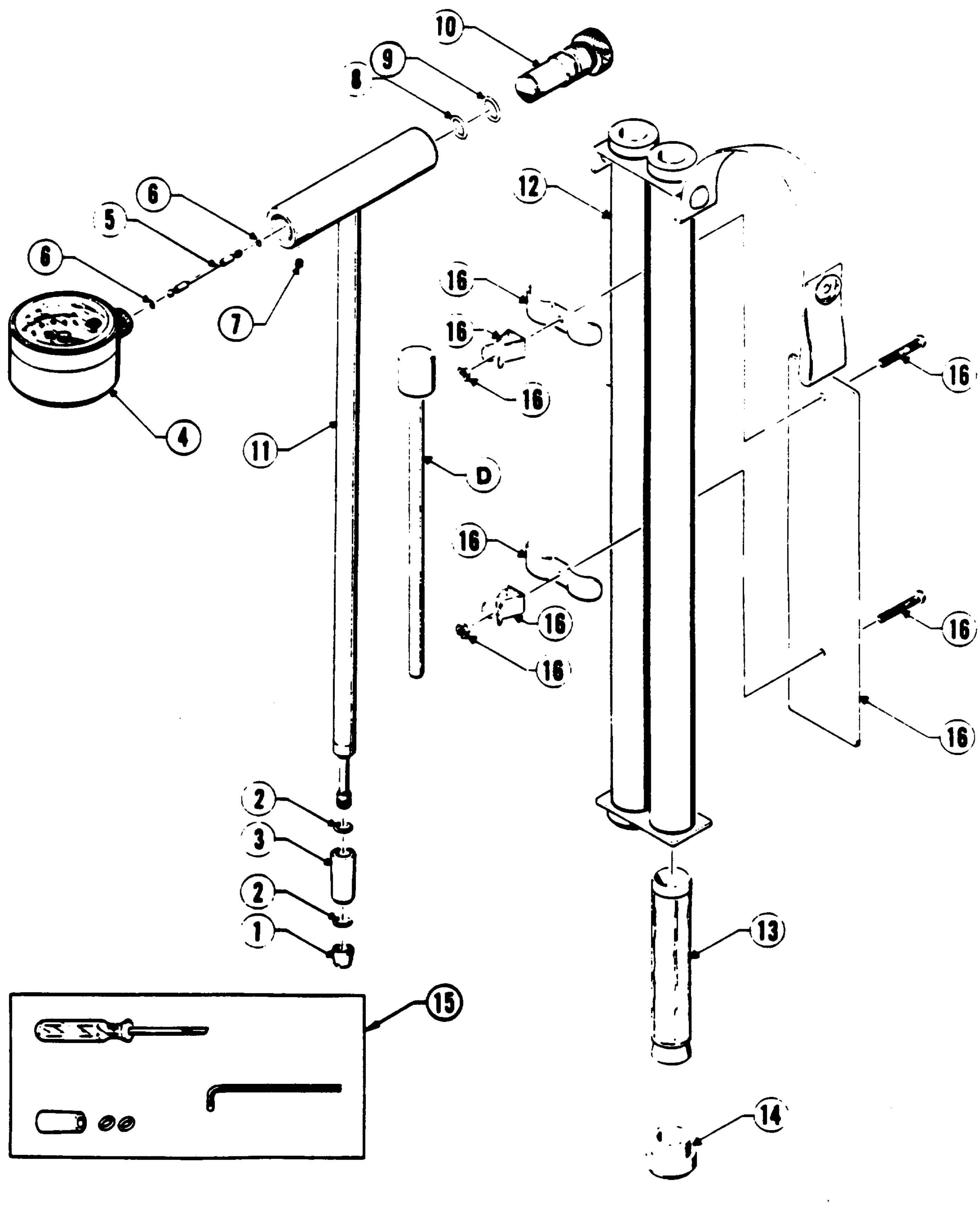


COMPLETE ASSEMBLIES

ITEM	PART NO.	DESCRIPTION
A	2901FL12	PROBE ASSEMBLY, 12"
	2901FL18	PROBE ASSEMBLY, 18"
B	2902L12	CORING TOOL 12"
	2902L18	CORING TOOL 18"
C	2903L12	CARRYING CASE 12"
	2903L18	CARRYING CASE 18"
D	2953	CLEANING ROD

INDIVIDUAL REPLACEMENT PARTS
(See Reverse Side for Illustrated Parts Break Down)

ITEM NO.	PART NO.	DESCRIPTION
1	2901-1	PROBE CAP
2	801X008	"O" RING SEAL
3	2901-2	REPLACEMENT SENSING TIP
4	2060G5	VACUUM DIAL GAUGE, 2" dial, 1/4 NPT Gauge Stem, Recalibrator Type
5	2901F-300	GAUGE CAPILLARY ASSY.
6	801X003	"O" RING SEAL (2 req'd)
7	Q1032CAE03	SET SCREW, 10-32 X 3/16"
8	801X013	"O" RING SEAL
9	801X014	"O" RING SEAL
10	2901F-001	NULL ADJUSTING KNOB
11	2901FL12-100	PROBE BODY ASSY., 12"
	2901FL18-100	PROBE BODY ASSY., 18"
12	2903L12-300	SHEATH ASSEMBLY, 12"
	2903L18-300	SHEATH ASSEMBLY, 18"
13	2903-100	SPONGE CARTRIDGE
14	2903-1	SHEATH CAP
15	2900FK1	ACCESSORY KIT FOR 2900F
16	2903-007K1	INSTRUCTION PLATE KIT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