LUDLUM MODEL 12
COUNT RATEMETER

Revised October 1990
Serial No. 78629 and Succeeding
Serial Numbers

LUDLUM MEASUREMENTS, INC.
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1. GENERAL

The Ludlum 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, maintenance instructions and theory of operation.

2. SPECIFICATIONS

- **POWER**: Two flashlight batteries, standard "D" cells; Mercury or rechargeable cells directly interchangeable

- **HIGH VOLTAGE**: Adjustable from 200 to 2,500 volts; electronically regulated to 1%; HV support of scintillation loads to 1,500 volts, proportional to 2,500 volts

- **SENSITIVITY**: Adjustable from 2 to 60 millivolts

- **INPUT IMPEDANCE**: 0.1 megohm

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

- **RANGE**: 0-500,000 counts/minute (cpm)

- **LINEARITY**: ±5% full scale

- **BATTERY DEPENDANCE**: Instrument calibration change less than 3% within battery check limits on meter

- **CALIBRATION CONTROLS**: Individual 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", 706 U/G; BNC or MHV may also be provided

- **SIZE** : 10.67cm (4.2")H x 8.9cm (3.5")W x 21.6cm (8.5")L, exclusive of handle

- **WEIGHT**: 1.3kg (3 lbs.), less detector and batteries

- **FINISH**: Drawn-and-cast aluminum fabrication, with computer-beige polyurethane enamel and silk-screened nomenclature

- **CABLE** : 39-inch "C" connector

3. DESCRIPTION OF CONTROLS AND FUNCTIONS

- **Range Selector Switch:** A six-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.

- **AUD 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, the higher the audio frequency. The audio should be turned OFF when not required to reduce battery drain.

- **F-S Toggle Switch**: Provides meter response. Selecting the fast, "F", position of the toggle switch provides 90% of full scale meter deflection in four seconds. In the slow, "S", position, 90% of full scale meter deflection takes 22 seconds. In "F" position, there is fast response and large meter deviation. "S" position should be used for slow response and damped, meter deviation.

- **RES Pushbutton Switch**: When depressed, this switch provides a rapid means to drive the meter to zero.

- **HV Pushbutton Switch**: When depressed, displays the detector high voltage on the meter.

  Test high voltage with detector connected. High voltage will decline with scintillation detectors, due to internal resistance.

- **HV Adjustment**: Provides a means to vary the high voltage from 200 to 2500 volts.

- **Range Calibration Adjustments**: Recessed potentiometers located under the calibration cover, on the right side of the front panel. These adjustment controls allow individual calibration for each range multiplier.

- **Discriminator Adjustment**: Allows the input sensitivity to be adjusted from 2 to 60 millivolts.

4. OPERATING PROCEDURES

✓ NOTE: To open the Battery Lid, twist the lid button counterclockwise 1/4 turn. To close, twist clockwise 1/4 turn.

- 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.

- Close the battery box lid.

- Adjust the range switch to BAT. The meter should deflect to the battery check portion of the meter scale. If the meter fails to respond, check that the batteries have proper polarity.

- 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.

- 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.

- Depress the RES Button. The meter should zero.

- The operating point for the instrument and probes is established by setting the probe voltage and instrument sensitivity (HV and DIS). 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; DIS (Discriminator) 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 a better operating point, the following guides are presented:

☐ G-M DETECTORS: The output pulse height of the G-M Detector is not proportional to the energy of the detected radiation. Adjusting DIS will have minimal effect on observed count rate unless the DIS setting is so low that the instrument will double pulse.

For most G-M Detectors, set DIS for 30-40 millivolts and adjust HV to the G-M tube recommended high voltage. Most G-M detectors operate at 900 volts, although, some miniature detectors operate at 400-500 volts. If a recommended setting is unavailable, run a plateau of HV settings vs. count rate and set on the low side of center. For mixed detector use, both sensitivity and high voltage may be adjusted for other detectors and the G-M tube will work if the high voltage is above the minimum required to see counts from the G-M tube (ie; threshold voltage).

☐ For proportional detectors, set the DIS 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.

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

☐ For scintillators, set the DIS for 10 millivolts. Carefully increase the HV until the instrument plateaus on the background count. This provides the most stable operating point for the detector.

○ Check the calibration and proceed to use the instrument.

5. CALIBRATION

Calibration controls are located on the front of the instrument under the calibration cover. 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.

✓NOTE: Measure High Voltage with a Model 500 Pulser or a High Impedance voltmeter with a high meg probe. If one of these instruments is not available use a voltmeter with a minimum of 1000 megohm input resistance.

True Reading Calibration requires the following steps:

☐ 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 0.01μF, 3,000-volt capacitor unless the pulse generator is already protected.

☐ Adjust the pulser frequency to correspond to the 3/4-scale value of the instrument. Increase the pulser output voltage until the pulse height is twice the input sensitivity. Adjust the calibration potentiometer for a 3/4-scale reading. Repeat for each range.

☐ 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 calibration 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 DIS controls will change the apparent detector efficiency for many sources.

Geometry calibration is often used when the instrument is utilized to measure radiation with a limited spectrum, for example, a single isotope calibration. 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.

☐ Internal Calibration After Overhaul: Connect instrument to a Model 500 Pulser. Adjust HV for 1500 volts. Depress HV Test and adjust R132 for Model 12 meter reading of 1500 volts.

6. MAINTENANCE

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

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.

Recalibration should be accomplished after any maintenance or adjustment of any kind has been performed on the instrument. Battery replacements are not considered to be maintenance and do not normally require the instrument to be recalibrated.

Ludlum Measurements recommends recalibration at intervals no greater than one year. Check the appropriate regulatory agencies regulations to determine required recalibration intervals.

The batteries should be removed and the battery contacts cleaned of any corrosion at least every three months. 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.

NOTE

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

7. THEORY OF OPERATION

7.1 INPUT

Detector pulses are coupled from the detector through C57 to emitter follower Q96. R83, 89 provide bias. R137 protects Q96 from input shorts. R27 couples the detector to the high voltage supply.

7.2 AMPLIFIER

A self-biased amplifier provides gain in proportion to R63 divided by R70. Transistor (pin 6 of U1) provides amplification. Pin 12,15 of U1 are coupled as current mirror to provide a load for pin 6 of U1. The output self-biases to 2 Vbe (approximately 1.4 volts) at pin 7 of U1. This provides just enough bias current through pin 6 of U1 to conduct all of the current from the current mirror.

Positive pulses from pin 7 of U1 are coupled to the discriminator.

7.3 DISCRIMINATOR

Comparator U2 provides discrimination. The discriminator is set by the DIS (Discriminator) control located on the front panel, coupled to pin 3 of U2. These pulses are coupled to pin 5 of U3 for meter drive and pin 12 of U3 for audio.

7.4 AUDIO

Discriminator pulses are coupled to univibrator pin 12 of U3. Front panel audio ON-OFF selector controls the reset at pin 13 of U4. When ON, pulses from pin 10 of U3 turns on oscillator U5, which drives the can mounted unimorph through Q149 and T136. Speaker tone is set by R84, C112; duration by R86.

7.5 DIGITAL ANALOG CONVERTOR

Pin 12, 15 of U4 are coupled as a current mirror. For each pulse of current through R72, and equal current is delivered to C105. This charge is drained off by R74. The voltage across C105 is proportional to the incoming count rate.

7.6 SCALE RANGING

Detector pulses from the discriminator are coupled to univibrator pin 5 of U3. For each scale, the pulse width of pin 6 of U3 is increased by a factor of 10 with the actual pulse width being controlled by the front panel calibration controls and their related capacitors. This arrangement allows the same current to be delivered to C105 by one count on the X1 range as 1,000 counts on X1K range.

7.7 METER DRIVE

The meter is driven by the emitter to Q6, coupled as a voltage follower in conjunction with pin 1 of U6. For ratemeter drive, the meter is coupled to C105 at P1-15.

For high voltage, the meter is coupled to R132 at P1-11.

For Battery Test, the voltage follower is bypassed and the meter movement is directly coupled to the battery through R150.

7.8 METER COMPENSATION

When the unit is provided with a high torque meter movement, with 1.2 volt drive, a temperature compensation package may be located at the meter, internal or external.

7.9 FAST/SLOW TIME CONSTANT

For slow time constant, C104 is switched from the output of the meter drive to parallel C105.

7.10 LOW VOLTAGE SUPPLY

Battery voltage is coupled to U7 and associated components (a switching regulator) to provide 5 volts at pin 5 to power all logic circuits. Unregulated battery voltage is used to power the meter drive (Q6) and the high voltage blocking oscillator Q145.

7.11 LOW VOLTAGE REFERENCE

U101 provides a 1.22 volt precision reference for HV supply. This unit also biases Q96.

7.12 HIGH VOLTAGE SUPPLY

High voltage is developed by blocking oscillator Q145-T165 and rectified by voltage multiplier CR166, 167, 169 and 175. Output voltage increases as current through Q44 increases, with maximum output voltage with Q44 saturated.

High voltage is coupled back through R47, R90 to opamp pin 6 of U6. R147 completes the high voltage circuit to ground. High voltage output is set by front panel control HV, which sets bias of pin 5 of U6. During stable operation, the voltage at pin 6 of U6 will equal the voltage at pin 5 of U6. Pin 7 of U6 will cause conduction of Q44 to increase or decrease until the high voltage seeks a level for stability.

PARTS LIST

Ref. No.	Description	Part No.
Model 12 Count Ratemeter		
UNIT	Completely Assembled Model 12 Count Ratemeter	48-1609
Circuit Board, Drawing 363 X 336		
BOARD	Assembled Circuit Board	5363-452
• **CAPACITORS**		
C38	0.0047μF, 3kV, C	04-5547
C40-C41	0.0047μF, 3kV, C	04-5547
C42	0.0056μF, 3kV, C	04-5522
C50	100pF, 3kV, C	04-5532
C56	100μF, 10V, DT	04-5576
C57	100pF, 3kV, C	04-5532
C102	100μF, 10V, DT	04-5576
C103	10μF, 20V, DT	04-5592
C104	100μF, 10V, DT	04-5576
C105	22μF, 35V, DT	04-5594
C106	0.001μF, 100V, C	04-5519
C109	0.01μF, 100V, C	04-5523
C111	0.01μF, 100V, C	04-5523
C112	470pF, 100V, C	04-5555
C113	0.01μF, 100V, C	04-5523
C115	0.01μF, 100V, C	04-5523
C117	47pF, 100V, C	04-5533
C119	0.001μF, 100V, C	04-5519
C121	330pF, 100V, C	04-5531
C122	0.0047μF, 3kV, C	04-5549
C126	10μF, 20V, DT	04-5592
C134	100μF, 10V, DT	04-5576
C163	0.001μF, 100V, C	04-5519
C170	0.1μF, 100V, C	04-5521
C171	1μF, 50V, DT	04-5607
C176	0.0047μF, 3kV, C	04-5547
C178	0.1μF, 100V, C	04-5521
C179	0.01μF, 100V, C	04-5523

- **TRANSISTORS**

Q6	2N3904	05-5755
Q15	MPSU51	05-5765
Q44	2N3904	05-5755
Q96	2N3904	05-5755
Q145	MPSU51	05-5765

- **INTEGRATED CIRCUITS**

U1	CA3096	06-6023
U2	TLC372	06-6265
U3	CD4098	06-6066
U4	CA3096	06-6023
U5	ICM7555	06-6136
U6	TLC27M7IP	06-6248
U7	MAX631	06-6249
U101	LM385Z-1.2	05-5808

- **DIODES**

CR94	1N4148	07-6272
CR166-CR167	MR250-2	07-6266
CR169	MR250-2	07-6266
CR175	MR250-2	07-6266

- **RESISTORS**

R18	1k	10-7009
R27	1 MEG	10-7028
R28	4.7 MEG	10-7030
R36	1 MEG	10-7028
R46	10k	10-7016
R47-R48	1 G	12-7686
R63	82k	10-7022
R64	1k	10-7009
R65	10k	10-7016
R66	1k	10-7009
R68	8.2k	10-7015
R70	4.7k	10-7014
R72	10k	10-7016
R74	82k	10-7022
R75	33k	10-7019
R76	100 OHMS	10-7004
R77	2.2k	10-7012
R78	22k	10-7070
R79	100k	10-7023
R81	10k	10-7016

R83	100k	10-7023
R84	470k	10-7026
R86	2.7 MEG	10-7029
R87	10k	10-7016
R89	100k	10-7023
R90	100k	10-7023
R91	4.7k	10-7014
R128	100k	10-7023
R132	1 MEG TRIMMER	09-6814
R137	10k	10-7016
R138	1 MEG	10-7028
R147	SAT TYP. 432k	
R150	2.37k, 1/8 W, 1%	12-7648
R159	10k	10-7016
R172	47k	10-7020
R173	1 MEG	10-7028
R177	200 OHMS	10-7006

- **INDUCTOR**

L13	IM6-470UH-5	21-9600

- **TRANSFORMERS**

T165	L8050	40-0902

- **MISCELLANEOUS**

1 EA.	M 12-7 XFMR SHIELD	7363-439
	SCREW-0-80 X 5/8 BH	17-8866
	NUT-0-80 HEX	20-9104
	WASHER-0-80 SPLIT LOCK	20-9105
7 EA.	CLOVERLEAF RECEP-TACLES-011-6809	18-8771
1 EA.	CONN-640456-2 MTA100	13-8073
1 EA.	CONN-1-640456-5	13-8355

Wiring Diagram, Drawing 363 X 320

- **AUDIO**

DS1	UNIMORPH 60690	21-9251

- **CONNECTORS**

J1	CONN-1-640442-5 MTA100	13-8383
J2	CONN-640442-2 MTA100	13-8178
J3	CONN-640442-5 MTA100	13-8140
J4	CONN-640442-4 MTA100	13-8170
J5	RECPT-UG706/U SCREW-IN "C"	13-7751

- **SWITCHES**

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

- **BATTERY**

B1-B2	BATTERY-DURACELL "D"	21-9313

- **MISCELLANEOUS**

M1	PORTABLE BEZEL FRONT ASSEMBLY	4363-188
*	METER BEZEL W/GLASS, W/O SCREWS	4363-352
*	METER MOVEMENT (1mA)	15-8030
*	PORTABLE METERFACE	7363-136
*	M 295 BATTERY CONTACT SET	40-1707
*	M 12 CASTING	9363-364
*	M 12-8 MAIN HARNESS	8363-447
*	M 12-7 CAN ASSEMBLY	4363-441
*	PORTABLE KNOB	08-6613
*	UNIMORPH W/WIRES, O'RING	40-0034
*	BATT LID W/LATCH SET	9363-365
*	PORT LATCH KIT W/O BATTERY LID	4363-349

*	PORT CALIBRATION COVER W/SCREWS	9363-200
*	PORT HANDLE (ROLLED) W/SCREWS	7363-139*
*	PORT HANDLE FOR CLIP W/SCREWS	7363-203
*	REPLACEMENT CABLE (STD 39")	40-1004
*	CLIP (44-3 TYPE) W/SCREWS	7002-026-01
*	CLIP (44-7 TYPE) W/SCREWS	7010-007-01
*	CLIP (44-6 TYPE) W/SCREWS	7010-008-01

Calibration Board, Drawing 363 X 337

BOARD	Assembled Calibration Board	5363-432

- **CAPACITORS**

C1	0.047μF, 100V, C	04-5565
C2	0.0047μF, 100V, C	04-5570

- **RESISTORS**

R1	1 MEG TRIMMER	09-6814
R2	1 MEG TRIMMER	09-6814
R3	250k TRIMMER	09-6819
R4	2 MEG TRIMMER	09-6834
R5	100k TRIMMER	09-6813
R6	47k	10-7020
R7	100k TRIMMER	09-6813
R8	1k, 1/3 W, 5%	12-7750

- **RESISTOR NETWORK**

RN1	10k SIP 8 PIN	12-7720

- **MISCELLANEOUS**

P3	CONN-640456-5 MTA100	13-8057
P4	CONN-640456-4 MTA100	13-8088

Temperature Compensation Board
Drawing 363 X 327

BOARD	Assembled Temperature Compensation Board	5363-440

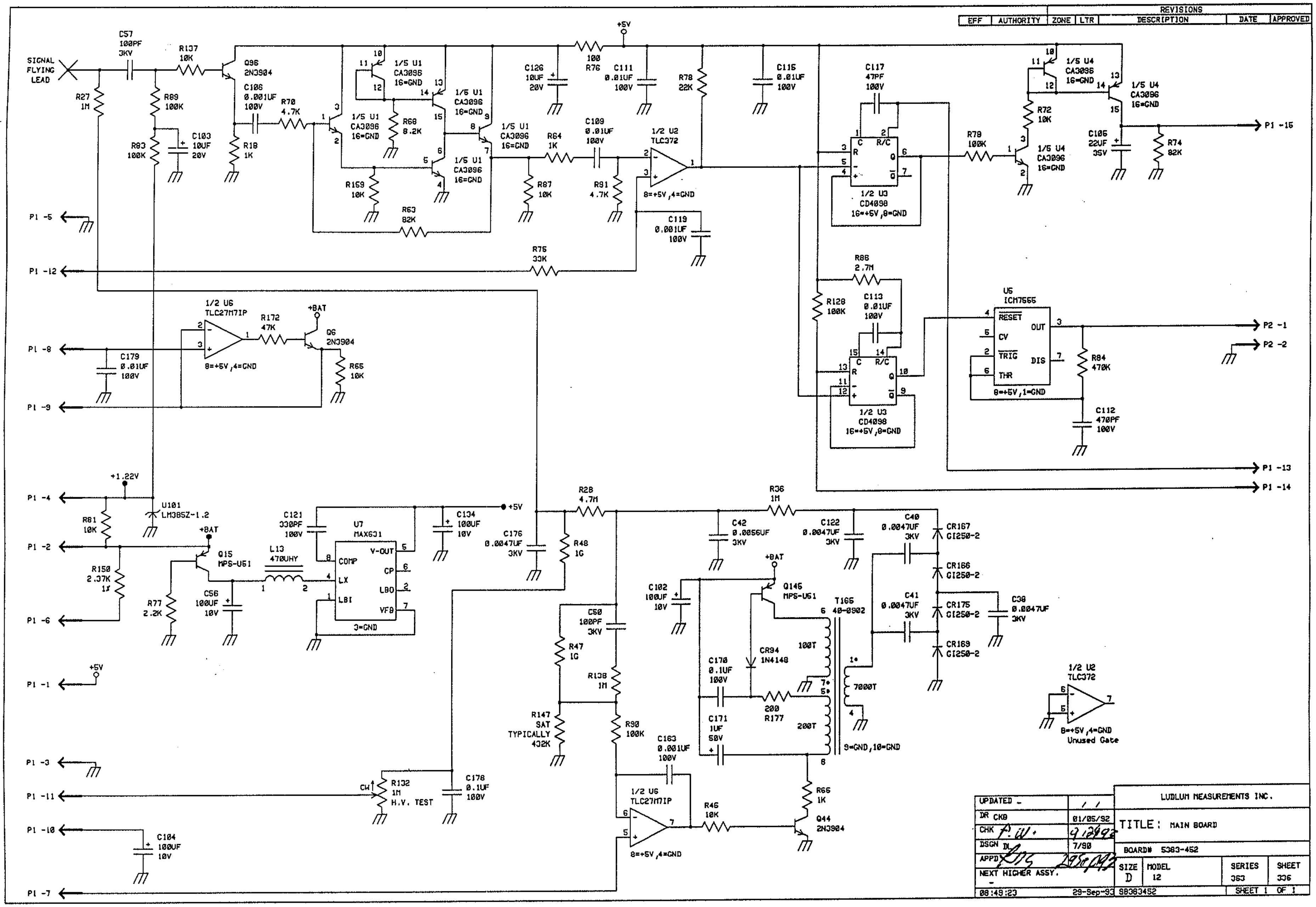
- **THERMISTORS**

RT1-RT2	RL1006-98.4-59-D1	07-6332

- **RESISTORS**

R1	634R, 1/3W, 1%	12-7808

Main Circuit Board, Drawing No. 363 x 336
Main Circuit Board, Drawing No. BS363452
Wiring Diagram, Drawing No. 363 x 320
Calibration Board, Drawing No. 363 x 337
Calibration Board, Drawing No. 363 x 341
Temperature Compensation Board, Drawing No. 363 x 327
Temperature Compensation Board, Drawing No. 363 x 329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DSGN 7/90
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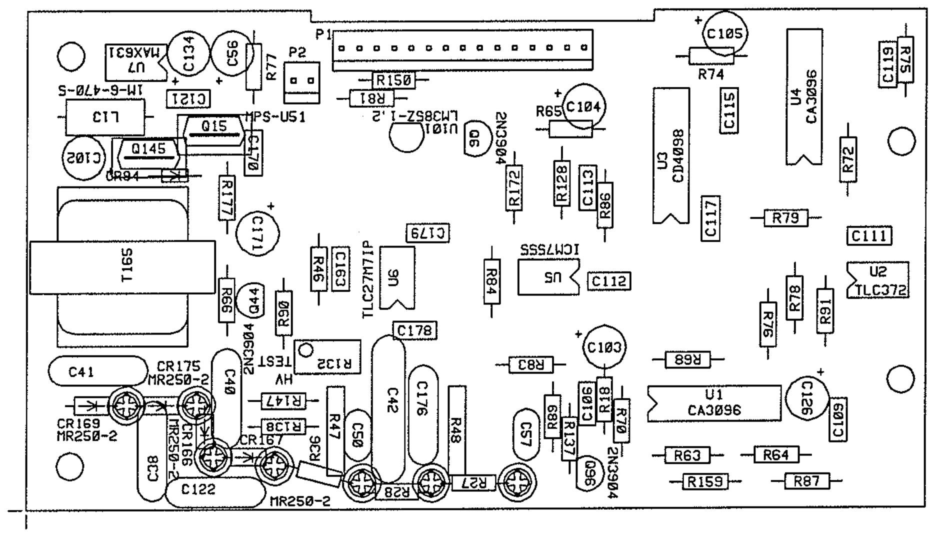
SB383452



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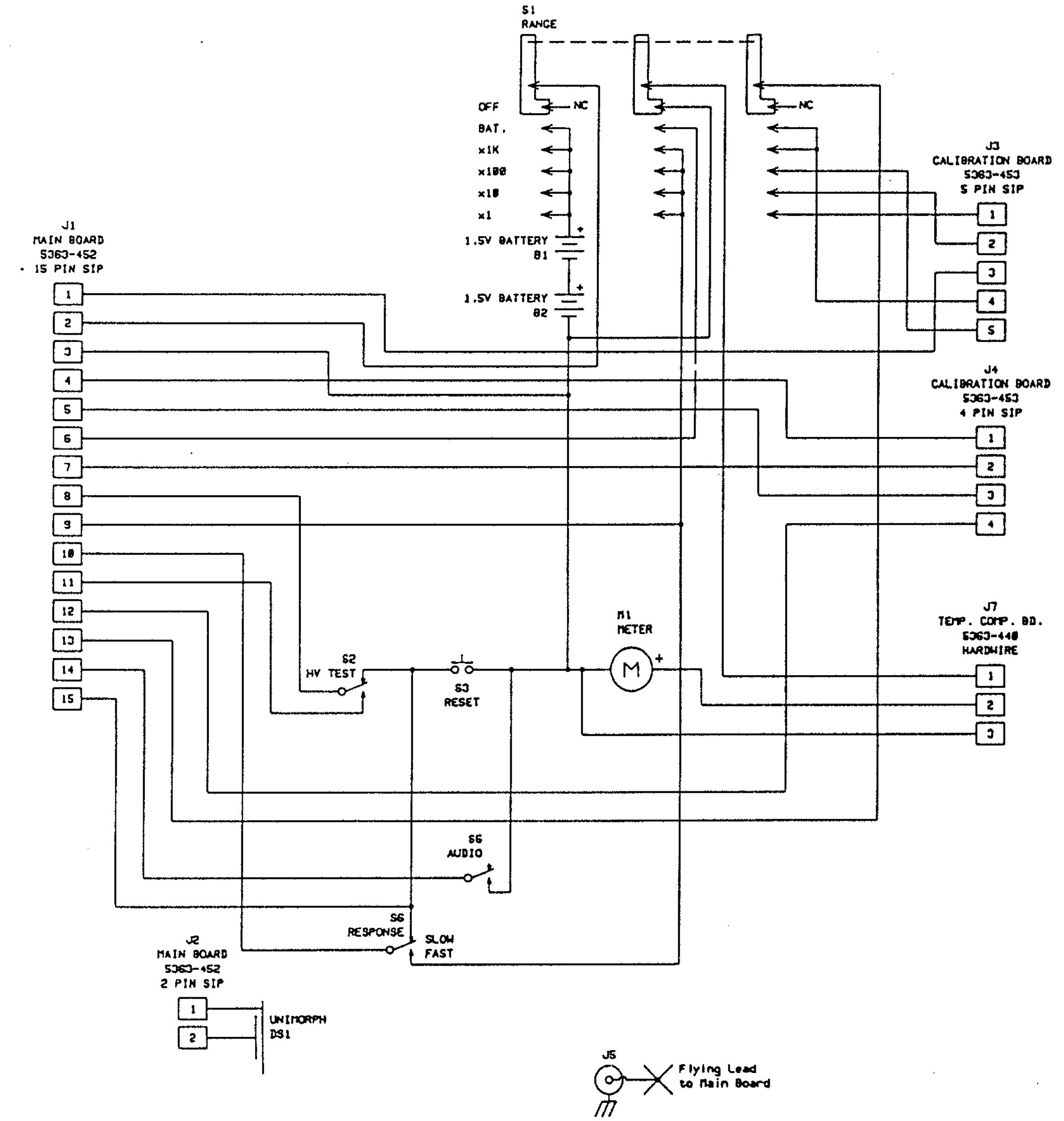

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DSGN DL	07/98	BOARD# 363-433
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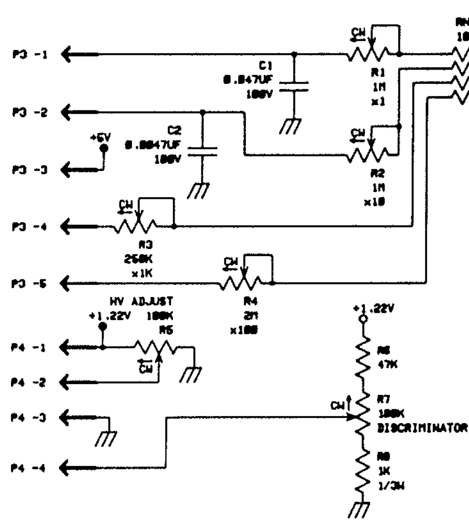

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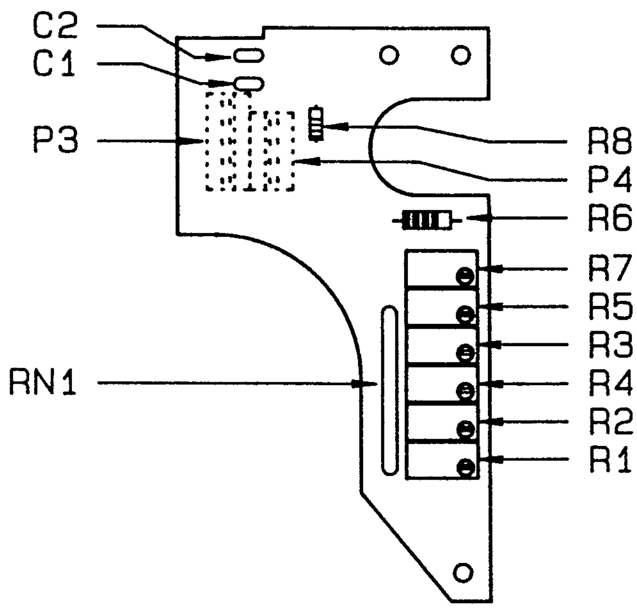

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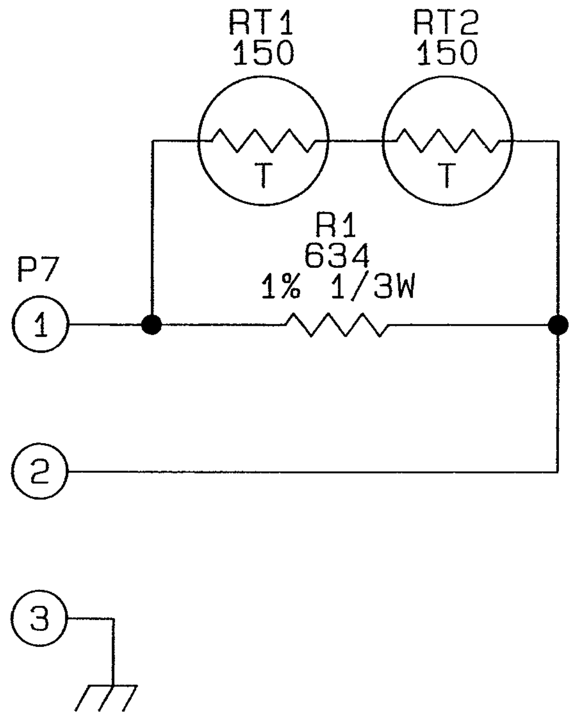

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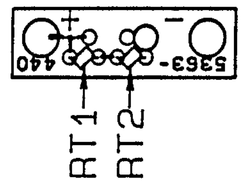
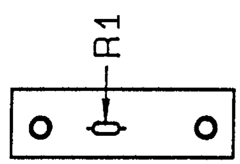
TITLE TEMPERATURE COMPENSATION BD.					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		SERIES 363		SHEET 327	



TOP SIDE OF BOARD



BACK SIDE OF BOARD

DESC: TEMP COMP BOARD	
MODEL: ALL PORTABLES	
PART #: 5363-440	
DWN: PW	DATE: 8/21/90
DSGN: PW	DATE: 8/21/90

CHG	NO.				DWN	CHK	APP
DWN PW	DATE 8/21/90	CHK	DATE	APP	DATE		
TOL: SHOP STD ☐ OTHER				SCALE: FULL ☐ OTHER			
TITLE TEMP COMPENSATION BOARD							
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556				SERIES 363		SHEET 329	