LUDLUM MODEL 177-50
LOG RATEMETER

October 2013

Serial Number 158004 and Succeeding

Serial Numbers

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LUDLUM MEASUREMENTS, INC
501 OAK STREET, P.O. BOX 810
SWEETWATER, TEXAS 79556
325-235-5494, FAX: 325-235-4672

STATEMENT OF WARRANTY

Ludlum Measurements, Inc. warrants the products covered in this manual to be free of defects due to workmanship, material, and design for a period of twelve months from the date of delivery. The calibration of a product is warranted to be within its specified accuracy limits at the time of shipment. In the event of instrument failure, notify Ludlum Measurements to determine if repair, recalibration, or replacement is required.

This warranty excludes the replacement of photomultiplier tubes, G-M and proportional tubes, and scintillation crystals which are broken due to excessive physical abuse or used for purposes other than intended.

There are no warranties, express or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description of the face there of. If the product does not perform as warranted herein, purchaser's sole remedy shall be repair or replacement, at the option of Ludlum Measurements. In no event will Ludlum Measurements be liable for damages, lost revenue, lost wages, or any other incidental or consequential damages, arising from the purchase, use, or inability to use product.

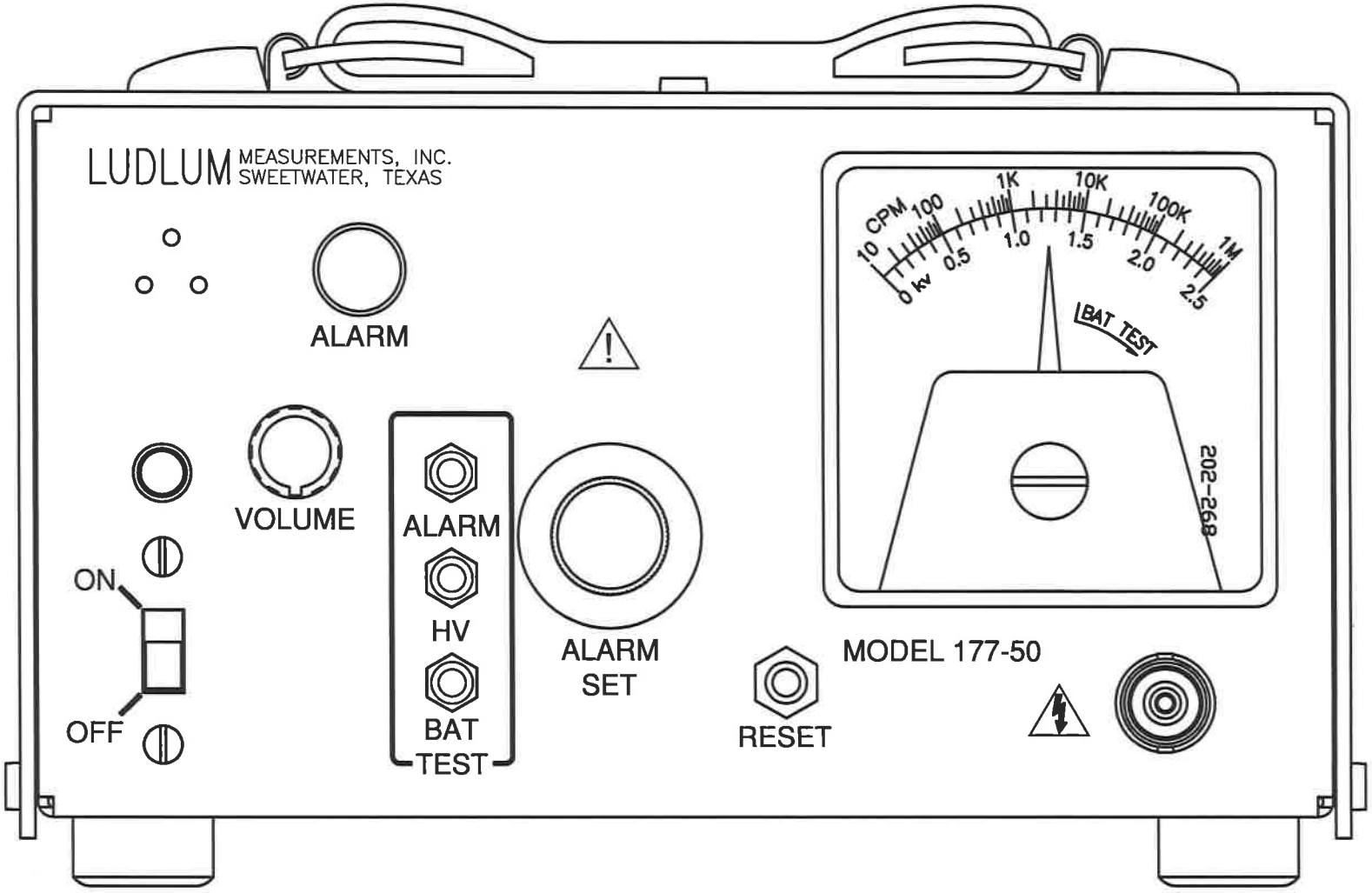
RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair or calibration, please send to the address below. All shipments should include documentation containing return shipping address, customer name, telephone number, description of service requested, and all other necessary information. Your cooperation will expedite the return of your equipment.

LUDLUM MEASUREMENTS, INC.
ATTN: REPAIR DEPARTMENT
501 OAK STREET
SWEETWATER, TX 79556

800-622-0828 325-235-5494
FAX 325-235-4672

REV #	ALTERATIONS	DATE	BY
1	VALID	8/8/91	BK
2	ADDED SYMBOLS	11/16/05	CMC



DWN	DATE	CHK	DATE	APP	DATE
CMC	11-15-05				

DWG NUM: 4328-015	SCALE: FULL ☒ OTHER ☐
TITLE: M 177-50 LOG RATEMETER	
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556	SERIES 328 / SHEET 22

REV #	ALTERATIONS	DATE	BY
1	VALID	8/8/91	BK
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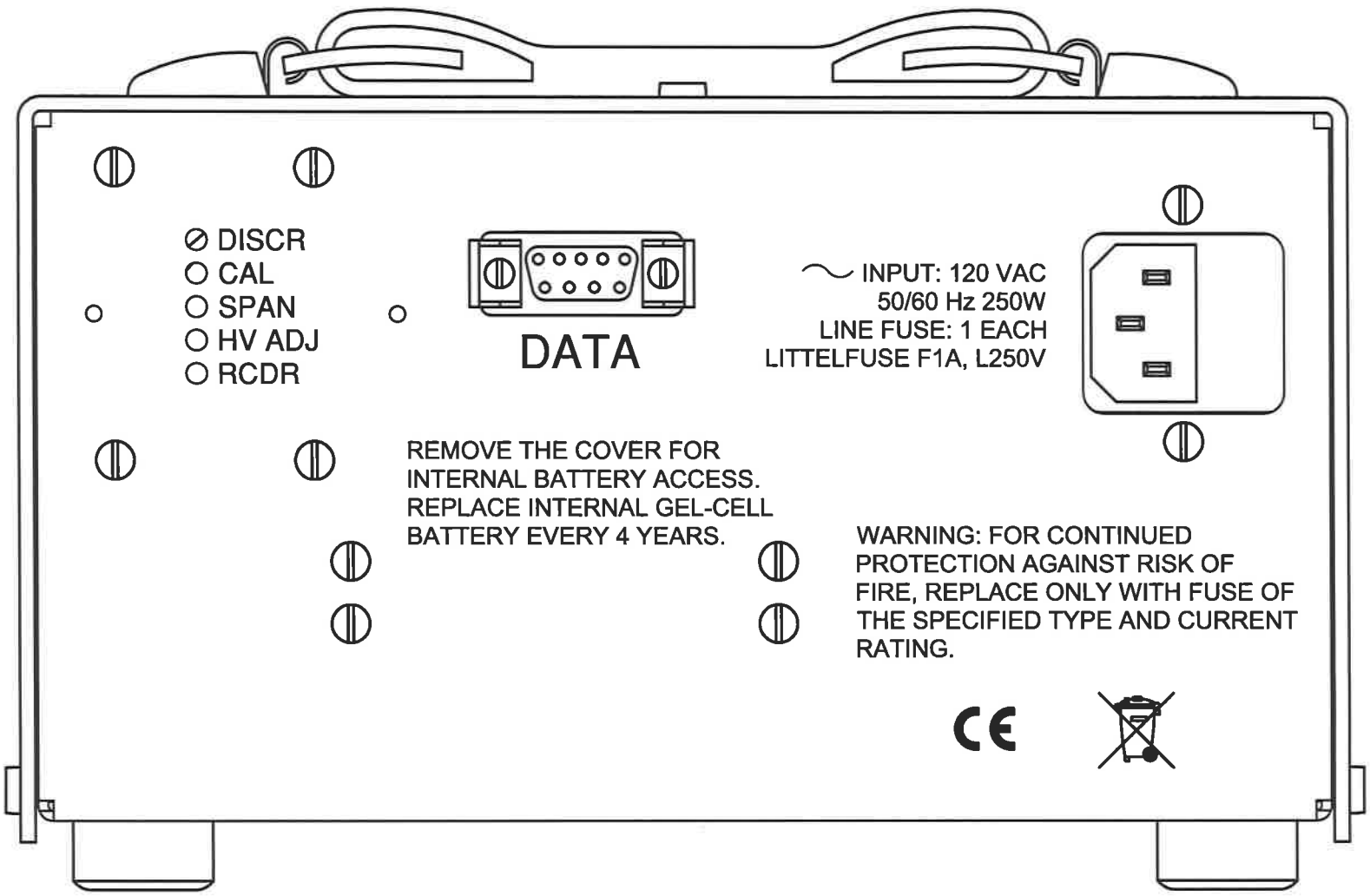


DWN	DATE	CHK	DATE	APP	DATE
CMC	11-15-05				11/16/05
DWG NUM: 4328-015				SCALE: FULL ☒ OTHER	
TITLE: M 177-50 LOG RATEMETER					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556				SERIES 328	SHEET 22A

Table of Contents

Section

1

Introduction

The Ludlum Model 177-50 Alarm Ratemeter provides the required electronic circuitry for radiation monitoring with proportional, scintillation and GM (Geiger-Mueller) type detectors. Provided on the unit is a five-decade, 6.4 cm (2.5 in.) logarithmic meter with full-scale count rate of 1,000,000 counts per minute (CPM) on the standard meter dial (others are available). Detector operating voltage is adjustable from 400 to 2500 volts.

The unit incorporates an adjustable alarm set point. Audible and visual enunciators are triggered when the meter reading rises above the alarm setpoint. An alarm adjust potentiometer is located on the front panel. The alarm setting may be checked by depressing the front-panel TEST button. Accessory outputs include: Supply Voltage, Negative Pulse Output, Recorder and, Alarm Sink for Remote Relay. The unit may be operated from an internal rechargeable battery or by line AC power.

Section

2

Getting Started

The Ludlum Model 177-50 Alarm Ratemeter is designed for use with GM (Geiger Mueller), scintillation, or proportional detectors that operate from 400 to 2500 volts. Typical applications include area monitoring, contamination monitoring, and personnel frisking.

Preparing the Instrument for Use

Turn the power switch ON. Depress the BAT TEST button. Check that the meter reads above the BAT TEST indication. If the battery does not check, the instrument will operate on AC line power only. The battery may be trickle-charged from line power.

Connect the instrument to line power if necessary.

Operating the Instrument

Connect a detector to the instrument. Obtain a meter reading from a check source or calibrated source, if available. Remove the source.

If the alarm point is not already set, press the ALARM TEST switch and adjust ALARM SET for the desired alarm point.

Note:

The meter displays the alarm setpoint when the ALARM TEST switch is depressed. Recheck the setpoint after locking the ALARM SET control.

If a radiation source is available, increase the meter count to exceed the alarm threshold. Both the alarm lamp and audio alarm signal should activate.

Depress the RESET button. The meter needle should drive to zero and the alarm circuit should de-energize, shutting off both visual and audible alarms.

Depress HV TEST and ensure that the high voltage is properly set.

Proceed with use.

Section

3

Specifications

Linearity: within 10% full scale, typically within 2% of full-scale reading when measured with an electronic pulse generator

High Voltage: variable from 400 to 2500 volts

Input Sensitivity: adjustable from -2 through -100 millivolts

Response: dependent on number of counts present, typically not greater than 8 seconds from 10%-90% of final reading

Meter: 1 mA, size 6.4 x 6.4 cm (2.5 x 2.5 in.), DC movement

Meter Scale: 5-decade log ranging from 10 cpm to 1M cpm; high-voltage test reading from 0 to 2.5 kV; BAT TEST

Recorder Output: correlated to meter reading (adjustable to 1 volt of 1 mA)

Audio: unimorph speaker with volume control located on the front panel

Alarm Output: current sink to 200 mA DC, available at Pin 4 of the 9-pin DATA output connector. Open circuit voltage is not to exceed 50 volts DC.

Alarm Range: adjustable from 0 through 150% of full scale

Alarm Indicators: visual indicator (lamp), audible tone via unimorph speaker

Alarm Control: factory set to latching, non-latching alarm available through the removal of main board resistor R51

Connector: Series "C"

Fuse: 1 amp, LITTLEFUSE F1A L250V

Power: 95-135 Vac (178-240 Vac available) (sealed lead-acid) battery

Battery Life: approximately 50 hours in a non-alarming condition with fully charged battery

Battery Dependence: meter readings vary less than 3% within battery check limits

Finish: powder coat paint

Size: 12.7 x 20.3 x 15.2 cm (5 x 8 x 6 in.) (H x W x D), excluding handle

Weight: 1.9 kg (4.2 lb)

Section

4

Description of Controls and Functions

Front Panel

Power ON-OFF Switch: provides line power of 120 Vac 50/60 Hz to the instrument and trickle-charges the standby battery. In case of line power failure, the battery automatically comes online to power the instrument. The battery will provide up to 50 hours of operation.

> Note:
>
> To recharge the battery, the ON-OFF switch must be in the ON position.

Power-on Lamp: a red lamp that comes on when power is supplied to the instrument.

VOLUME Control: varies the volume of the audio output through the unimorph speaker. This control has minimal effect on the audio when the alarm is active.

Audio Speaker: a unimorph speaker, located behind the front panel.

ALARM Lamp: a red lamp that comes on when the alarm threshold has been exceeded. The lamp will remain on (unless the alarm is configured to "non-latching") until the reset button is depressed, driving the meter needle below the alarm threshold.

Ratemeter: a five-decade linear log meter with a range of 10 cpm to 1,000,000 cpm. Readout is on a 6.4 cm (2.5 in.) scale panel meter. A separate scale is provided for battery check and high-voltage readout. Other meter faces are available depending on the application.

Connector: a Series "C" connector. (Series BNC and MHV connectors are also available.) The connector is provided on the front of the device to connect the detector to the instrument.

RESET Button: This button, when depressed, provides a rapid means to drive the meter needle to zero. It is also used to reset the alarm when the factory default alarm setting ("latching") is used.

BAT TEST Button: When this button is depressed, battery status is displayed on the meter. A sufficiently charged battery is indicated when the meter needle is on or within the BAT TEST range.

H V TEST Button: When this button is depressed, it displays the detector high voltage on the meter.

ALARM TEST Button: When this button is depressed, the alarm setpoint displays on the meter.

ALARM SET: used to adjust the alarm setpoint. Note the locking knob below the control.

Back Panel

120V AC plug: provides power to the instrument from a 120 volt AC, 50/60 Hz, 250W line.

LINE FUSE: provides line protection with a 1 amp fuse, LITTLEFUSE F1A L250V

Data: A 9-pin type D data plug with connections as follows:

PIN 1: Battery terminal. This is a direct connection and does not go through the front-panel ON-OFF switch. It is used to parallel battery or use external charger.

PIN 2: Unregulated supply from approximately 6 volts, battery only to 9.5 volts with AC power on. Limit current drain to 50 milliamperes.

PIN 3: Instrument common (Ground).

PIN 4: Alarm sink. It is the open collector of a 2N7000. It limits sink current to 200 milliamperes with open circuit voltage limited to a range of 0 to +50 volts. Unit conducts when in alarm state.

PIN 5: Pulse Out. This is a negative pulse connected to the discriminator output through a 0.001 µF capacitor, typically -5.0 volts.

PIN 7: recorder output, adjustable from 0 to 1.5 volts at 1 milliamperes.

PIN 6, PIN 8, and PIN 9: Spares.

CAL Control

Remove the calibration (cal) cover plate to access the following calibration potentiometers:

DISCR: Discrimination Control, set at 40 ±10 millivolts for most applications. Control is adjustable from 2 to 60 millivolts. A Ludlum Model 500 Pulser may be used to determine the discrimination level.

CAL: used to adjust meter reading vs. calibrated input.

HV ADJ: used to set the detector operating voltage.

RCDR: used to calibrate the recorder output, factory set at 1 volt out at full scale.

Internal Controls (Overhaul Only)

The following controls are located internally, on the circuit board mounting bracket:

BAT C: used to adjust charge voltage to 6.825 volts.

BAT T: used to adjust meter test voltage reading to 5.97 volts at the BAT OK line.

HV T: used to adjust the high-voltage test reading to correspond with the actual high-voltage output.

Section

5

Safety Considerations

Environmental Conditions for Normal Use

Indoor use only

No maximum altitude

Temperature range of -20 to 50 °C (-4 to 122 °F)

Maximum relative humidity of less then 95% (non-condensing)

Mains supply voltage range of 95-135 Vac (178-240 Vac available), 50/60Hz single phase (less than 100mA)

Maximum transient voltage of 2500 Vac

Installation Category II (Overvoltage Category as defined by IEC 1010-1)

Pollution Degree 2 (as defined by IEC 664) (Normally only nonconductive pollution occurs. Temporary conductivity caused by condensation is to be expected.)

Cleaning Instructions and Precautions

The Model 177-50 Alarm Ratemeter may be cleaned externally with a damp cloth, using only water as the wetting agent. Do not immerse the instrument in any liquid. Observe the following precautions when cleaning:

1. Turn the instrument OFF and disconnect the instrument power cord.

2. Allow the instrument to sit for one minute before cleaning.

Warning Markings and Symbols

Caution!

The operator or responsible body is cautioned that the protection provided by the equipment may be impaired if the equipment is used in a manner not specified by Ludlum Measurements, Inc.

The Model 177-50 Alarm Ratemeter is marked with the following symbols:

ALTERNATING CURRENT (AC) (IEC 417, No. 5032) - designates an input receptacle that accommodates a power cord intended for connection to AC voltages. This symbol appears on the back panel.

PROTECTIVE CONDUCTOR TERMINAL (per IEC 417, No. 5019) – designates the central grounding point for the safety ground. This symbol is visible inside the chassis.

CAUTION (per ISO 3864, No. B.3.1) – designates hazardous live voltage and risk of electric shock. During normal use, internal components are hazardous live. This instrument must be isolated or disconnected from the hazardous live voltage before accessing the internal components. This symbol appears on the front panel. **Note the following precautions:**

Warning!

The operator is strongly cautioned to take the following precautions to avoid contact with internal hazardous live parts that are accessible using a tool:

1. Turn the instrument power OFF and disconnect the power cord.
2. Allow the instrument to sit for one minute before accessing internal components.

CAUTION, RISK OF ELECTRIC SHOCK (per ISO 3864, No. B.3.6) – designates a terminal (connector) that allows connection to a voltage exceeding 1 kV. Contact with the subject connector while the instrument is on or shortly after turning off may result in electric shock. This symbol appears on the front panel.

The "**crossed-out wheelie bin**" symbol notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol is placed near the AC receptacle. See section 9, "Recycling," for further information.

The "CE" mark is used to identify this instrument as being acceptable for use within the European Union. This symbol is located on the back panel.

Replacement of Main Fuse (Back Panel)

Warning!

For continued protection against risk of fire, replace only with fuse of the specified type and current rating!

Section

6

Calibration and Maintenance

Calibration

> Note:
>
> Local procedures may supersede the following.

Connect the instrument to a Ludlum Model 500 Pulser (Pulse Generator) or equivalent.

Set the pulser count rate to 1000 cpm, and adjust the Model 177-50 back-panel CAL control for a meter reading of 1K.

Check the response of the meter at pulser count rates of 100, 1K, 100K, and 1M. If the meter calibration is out of tolerance, alternate between CAL and SPAN controls for meter correction. Adjust CAL for the lower reading (1K) and SPAN for the upper reading (100K or 1M).

Adjust DISCR for 40 ±10 millivolts for GM detectors. To lower input sensitivity/detector operating voltage (for scintillators and proportional detectors), adjust the pulse generator amplitude to the desired pulse height. Then, adjust DISCR until the meter reaches 75% of the generated incoming count rate.

Adjust HV for the detector operating voltage requirement.

Adjust RCDR (recorder output) for 1 volt output (equivalent to full scale).

Set ALARM SET point as desired.

Establishing an Operating Point

The operating point for the instrument and detectors is established by setting the detector 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 vary from unit to unit. However, the selection of the operating point makes a significant difference in the contribution of these three sources of count.

The purpose of setting the operating point is to establish the system gain so that the desirable signal pulses (including background) are above the discrimination level, and the unwanted pulses from noise are below the discrimination level. The pulses above the discrimination level are counted by the instrument, while those below are not.

The total system gain is controlled by adjusting the instrument gain or the high voltage. Voltage affects the output of the detector. Amplifier gain is controlled by the DIS (discriminator) control.

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

The operating point for each detector is set at a compromise point between 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 guidelines are presented:

GM Detectors: The output pulse height of the GM detector is not proportional to the energy of the detected radiation. Adjusting DIS will have minimal effect on the observed count rate unless the setting is so low that the instrument double pulses.

For most GM detectors, set DIS for 30-40 millivolts and adjust HV to the GM tube recommended high voltage. Most GM detectors operate at 900 volts; however, some miniature detectors operate at 400-600 volts. If a recommended setting is unavailable, run a plateau of HV setting vs. count rate. Then set the high voltage on the low side of "center."

Proportional Detectors: Set DIS for 2 millivolts. Increase HV until the detector just breaks down (shown by a rapid increase of count rate without a source present). Measure the high-voltage output. Then decrease HV to operate 100 volts below "breakdown."

Scintillators: Set DIS for 10 millivolts. Carefully increase HV until the instrument plateaus on the background count. This provides the most stable operating point for the detector.

Maintenance

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 the detector to a known source and confirming the proper reading on each scale.

Recalibration should be accomplished after any maintenance or adjustment has been performed on the instrument. Ludlum Measurements recommends recalibration at intervals no greater than one year. Local regulations may have precedence over this recommendation.

To maintain the life of the battery, it is recommended that the instrument be constantly connected to line power with the power switch in the ON position, even when the instrument is not in use. This will keep the internal battery fully charged.

When the instrument is used without line power, adequate charge time must be allowed for the internal battery to recharge. If possible, leave the instrument on with line power applied overnight and weekends. At a minimum, allow one hour of charge time for each hour of use. If the battery is inadvertently allowed to fully discharge, and is left in that state, constant charging for 500 hours (3 weeks) may be required for battery recovery.

Note:

The ON-OFF switch must be in the ON position to charge the batteries. If the unit is out of service for extended periods of time, charge the battery every six months.

It is recommended that the internal gel-cell battery be replaced every four years.

Section

7

Troubleshooting

Occasionally, you may encounter problems with your LMI instrument or detector that may be repaired or resolved in the field, saving turn-around time and expense in returning the instrument to us for repair. Toward that end, LMI electronics technicians offer the following tips for troubleshooting the most common problems. Where several steps are given, perform them in order until the problem is corrected. Keep in mind that the most common problems encountered with this particular instrument are detector cables and sticky meters.

Note that the first troubleshooting tip is for determining whether the problem is with the electronics or with the detector. A Ludlum Model 500 Pulser can be invaluable at this point because of its ability to simultaneously check high voltage, input sensitivity or threshold, and the electronics for proper counting.

We hope these tips will prove to be helpful. As always, please call if you encounter difficulty in resolving a problem or if you have any questions.

Troubleshooting Electronics that utilize a G-M, Proportional, or Scintillation Detector

SYMPTOM	**POSSIBLE SOLUTION**
No power (or meter does not reach BAT TEST or BAT OK mark)	1. Check battery and charge if necessary. 2. Check for loose or broken wires, especially between the main board and the calibration board.

SYMPTOM	POSSIBLE SOLUTION
Non-linear Readings	1. Check the high voltage (HV) by pressing the HV TEST button. If a multimeter is used to check the HV, ensure that one with high impedance is used, as a standard multimeter could be damaged in this process. 2. Check for noise in the detector cable by disconnecting the detector and placing the instrument on the lowest range setting. Wiggle the cable and observe the reading for significant changes. 3. Check for "sticky" meter movement. Does the reading change when you tap the meter? Does the meter needle "stick" at any spot? 4. Check the "meter zero." Turn the power switch OFF. The meter should come to rest on "0."
Meter goes full-scale or "pegs out"	1. Replace the detector cable to see if it has failed, causing excess noise. 2. Check the HV and, if possible, the input threshold for proper setting. 3. Check for loose wires, especially between the main board and the calibration board.

Troubleshooting GM Detectors

1. If the tube has a thin mica window, check for window breakage. If damage is evident, the tube must be replaced.

2. Check the HV. For most GM tubes, the voltage is normally 900 Vdc, or 460-550 Vdc for "peanut" tubes (Ludlum Model 133 series).

3. If the input sensitivity is too low, the user could see some double-pulsing. See Page 4-3, "**DISCR,**" for further information on sensitivity/discrimination control.

4. Wires to the tube may be broken, or the crimped connector could have a loose wire.

Troubleshooting Scintillators

1. Alpha or alpha/beta scintillators are prone to light leaks. They can be tested for this problem in a dark room or with a bright light. If a light leak is determined, changing the metalized polyester window assembly will usually fix the problem.

Note:

When replacing the window, make sure to use a window made with the same thickness metalized polyester and the same number of layers as the original window.

2. Verify that the HV and input sensitivity are correct. Alpha and gamma scintillators typically operate from 10-35 mV. High voltage varies with photomultiplier tubes (PMT), from as low as 600 Vdc, to as high as 1400 Vdc.

3. On a gamma scintillator, visually inspect the crystal for breakage or humidity leakage. Water inside the crystal will turn it yellow and gradually degrade performance.

4. Check the PMT to see if the photocathode still exists. If the end of the PMT is clear (not brownish), this indicates a loss of vacuum, which will render the PMT useless.

Troubleshooting Proportional Detectors

1. Check the HV and input sensitivity settings. In gross counting of alpha particles, gas proportional detectors normally operate at

1250 Vdc and 4 mV threshold. In gross counting of beta or alpha and beta particles, gas proportional detectors normally oprerate at 1650 Vdc and 4 mV threshold. In simultaneous counting of alpha and beta particles, the HV is normally about 1600 Vdc, the alpha threshold is normally 120 mV, and the beta threshold and window are normally 3.5 mV and 30 mV. Neutron ^{3}He detectors typically require a 2 mV threshold and about 1700 Vdc. Neutron BF_3 detectors typically operate at 1750 Vdc and 30 mV threshold.

2. Gas proportional detectors need P-10 gas, so check the window for tears or leaks and ensure an adequate supply of gas.

3. If the window is torn, the anode wires are likely to be broken as well, shorting against the detector. Replace broken wires, clean the lacquer thinner, then bake at 93 °C (200 °F).

4. Humidity can also be a problem for proportional detectors. Dry and/or check the desiccants.

Section

8

Technical Theory of Operation

Amplifier

Negative detector pulses are coupled through C112 to emitter follower Pins 1, 2 and 3 of U3. R31 protects the input from inadvertent HV shorts.

Negative pulses from emitter Pin 2 of U3 are coupled through C74 to amplifier Pin 5 through Pin 9 of U3. This amplifier is self-biased with DC and bias voltage at Pin 7 of U3 equal to one Vbe (approximately 0.6 volts). Amplifier gain is in proportion to the ratio of R26 to R29. Positive pulses at Pin 7 of U3 are coupled to discriminator control, connected to circuit board connector 5. These attenuated pulses are then coupled to a second amplifier, stage U11. This unit self biases at 2 Vbe (approximately 1.2 volts) at Pin 7 of U11. Gain is proportional to the ratio of R43 to R42.

Discriminator

Negative pulses from Pin 7 of U11 are coupled to Pin 5 of comparator U12. Pulses larger than -0.4 volts cause Pin 7 of U12 to go from +5.0 volts to 0 volts.

Digital Analog Conversion

Pin 7 of U12 is connected to the dual univibrator, U4. For each low pulse from Pin 7 of U12, Pin 6 of U4 goes high. The pulse of Pin 6 of U4 is typically 5.0 volts. This pulse is connected to the constant current drive U10. The pulse width control (R16 on calibration board) is utilized for calibration adjustment.

For each positive pulse connected to Pin 8 of U10, a constant current pulse is sourced at Pin 15 of U10. This current pulse charges C91, which is then connected to the Log Convertor Board (Drawing 328 x 46).

Time Constant

The charge in C91 is proportional to the pulses per minute from the detector. This charge is drained off by the transistor (Pins 1, 2 and 3 of U18, drawing 328 x 46) connected as a diode. The voltage across this transistor increases approximately 60 millivolts for each 10-fold increase in current.

The log diode (Pins 1, 2 and 3 of U18) typically develops 0.55 to 0.7 volts across it, depending on the low or high count rate. A second diode (Pins 4, 5 and 6 of U18) is biased at a voltage equal to the lowest expected voltage across the log diode (Pins 1, 2 and 3 of U18).

Both diodes are isolated by voltage followers (Pins 1, 7 of U9), which are coupled to a ground-referencing op amp (Pin 1 of U10). Pin 1 of U10 goes positive with increasing count rate.

Meter Drive

The panel meter is driven by Pin 7 of U14 (main board, drawing 328 x 17). Input of count rate, high-voltage test, battery test, and alarm set point is coupled to P3-2 with chassis mounted switches.

Alarm

An alarm is provided by U12, Pins 1, 2 and 3. The alarm set control biases the op amp U12 for a low output. When the meter signal at Pin 3 exceeds the bias of Pin 2, the output at Pin 1 goes high. Q76 and Q84 saturate, allowing supply voltage to be coupled to:

Lamp voltage through R22

Audio oscillator U16 through CR114

Through CR116 to audio transformer T1, allowing full voltage for full volume

Through R57 to saturating current sink Q77 for external use

Reset

Reset is provided by coupling a voltage to the base of 1, 2 and 3 of U10 and 4, 5 and 6 of U10. Both transistors saturate. One discharges C91, causing the meter to zero. Pin 3 of U10 turns Q76 off, allowing the alarm to reset.

Audio

A high on Pin 4 of U16 turns the oscillator on, saturating Q83 with each positive swing of the oscillator. T1 couples the pulses to the unimorph. Audio volume is controlled by voltage, applied to Pin 2 T1. This is either 4.3 volts from the alarm circuit or 0 to 4.3 volts from external volume control through emitter follower Q78.

For counting, audio pulse width is set by R48/C121 of U4 with one pulse per count. For alarm condition, Pin 4 of U16 is held high through CR114 until alarm is reset. Alarm tone is controlled by R60 C69.

High Voltage (HV)

The high-voltage power supply is a blocking oscillator, utilizing Q401-T411 and quadrupler CR123, CR421, CR422 and through CR423. The HV output is controlled by conduction to ground through Q302. With Q302 saturated, the HV output is maximum.

The op amp, U311 Pins 1, 2 and 3, is used as a comparator to compare the voltage reference at Pin 3 to the feedback voltage at Pin 2 through R322 for voltage control and regulation. High voltage is adjusted by HV control R311 changing bias on Pin 2 U311. With the HV control wiper at ground, HV output is maximum.

Low Voltage

Low voltage is supplied by internal battery B1 (wiring diagram, 328 x 15) or line power T1. Unregulated power at C125 is coupled to voltage regulator VR211 and battery charger U201-Q301.

Regulated low voltage is supplied to the balance of the circuit through VR131 at 5.0 volts and U301 at 1.2 volts.

Battery Charge

Battery charge is provided by voltage regulator U201 and power transistor Q301. R402 limits charge current for discharged battery. A negative voltage coefficient of -0.0063 volts per degree F is provided by ratio of R013/R201. R013 sets output voltage to 6.825 volts.

High Voltage Test

High-voltage test is supplied by R001 through HV TEST switch, BAT TEST switch, ALARM TEST, Pin 5 of U311, then to the meter. The HV readout is calibrated by R001.

Alarm Set Voltage

Alarm set voltage is coupled from ALARM SET control through the ALARM TEST switch, voltage follower Pin 5 of U311, and to the meter.

Battery Test Voltage

Battery test voltage is controlled by R002 through BAT TEST switch, ALARM TEST switch, then voltage follower Pin 5 of U311 to the meter.

Section

9

Recycling

Ludlum Measurements, Inc. supports the recycling of the electronics products it produces for the purpose of protecting the environment and to comply with all regional, national, and international agencies that promote economically and environmentally sustainable recycling systems. To this end, Ludlum Measurements, Inc. strives to supply the consumer of its goods with information regarding reuse and recycling of the many different types of materials used in its products. With many different agencies – public and private – involved in this pursuit, it becomes evident that a myriad of methods can be used in the process of recycling. Therefore, Ludlum Measurements, Inc. does not suggest one particular method over another, but simply desires to inform its consumers of the range of recyclable materials present in its products, so that the user will have flexibility in following all local and federal laws.

The following types of recyclable materials are present in Ludlum Measurements, Inc. electronics products, and should be recycled separately. The list is not all-inclusive, nor does it suggest that all materials are present in each piece of equipment:

Batteries	Glass	Aluminum and Stainless Steel
Circuit Boards	Plastics	Liquid Crystal Display (LCD)

Ludlum Measurements, Inc. products that have been placed on the market after August 13, 2005 have been labeled with a symbol recognized internationally as the "crossed-out wheelie bin." This notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol will be placed near the AC receptacle, except for portable equipment where it will be placed on the battery lid.

The symbol appears as such: 

Section

10

Parts List

	Reference	Description	Part Number
Model 177-50 Log Ratemeter	UNIT	Completely Assembled Model 177-50 Log Ratemeter	48-1202
Main Board, Drawing 328 × 17	BOARD	Completely Assembled Main Circuit Board	5328-026
CAPACITORS			
	C5	3300µF, 35V	04-5543
	C66	0.01µF, 100V	04-5523
	C67	0.001µF, 100V	04-5519
	C69	470pF, 100V	04-5555
	C70	0.1µF, 100V	04-5521
	C71	0.001µF, 100V	04-5519
	C72-C73	0.1µF, 100V	04-5521
	C74	100pF, 100V	04-5527
	C85	10µF, 20V	04-5592
	C87	100µF, 10V	04-5576
	C88	100µF, 10V	04-5576
	C90	10µF, 20V	04-5592
	C91	4.7µF, 10V	04-5578
	C92	1µF, 35V	04-5575
	C95	0.0047µF, 3KV	04-5547
	C97	0.0015µF, 3KV	04-5518
	C99	0.0047µF, 3KV	04-5547
	C101	0.0015µF, 3KV	04-5518
	C103	0.0047µF, 3KV	04-5547
	C106	100pF, 3KV	04-5532
	C107	0.0056µF, 3KV	04-5522
	C109	0.0056µF, 3KV	04-5522
	C112	100pF, 3KV	04-5532
	C120	0.001µF, 100V	04-5519

	Reference	Description	Part Number
	C121	0.01µF, 100V	04-5523
	C127	10µF, 20V	04-5592
	C128	100µF, 10V	04-5576
	C129	10µF, 20V	04-5592
	C130	0.001µF, 100V	04-5519
	C133	0.01µF, 100V	04-5523
	C136	0.001µF, 100V	04-5519
	C137	0.1µF, 100V	04-5521
TRANSISTORS			
	Q18	MPS-U01	05-5778
	Q76	2N3904	05-5755
	Q77	2N7000	05-5820
	Q78	2N3904	05-5755
	Q79	MPS6534	05-5763
	Q80	2N3904	05-5755
	Q83	2N3904	05-5755
	Q84	MPS-U51	05-5765
VOLTAGE REGULATORS			
	VR130	LM2931AZ-5.0	05-5819
	VR131	LM2931AZ-5.0	05-5819
INTEGRATED CIRCUITS			
	U3	CA3096	06-6023
	U4	CD4098	06-6066
	U10-U11	CA3096	06-6023
	U12	CA3290	06-6140
	U13	ICL7660	06-6132
	U14	ICL7621	06-6171
	U15	ICL7663	06-6221
	U16	ICM7555	06-6136
	U17	LM358	06-6024
	U93	LM385Z-1.2 (Z DIODE)	05-5808
DIODES			
	CR94	GI250-2	07-6266
	CR96	GI250-2	07-6266
	CR98	GI250-2	07-6266
	CR100	GI250-2	07-6266
	CR102	GI250-2	07-6266
	CR113	1N4148	07-6272

	Reference	Description	Part Number
	CR114	1N4148	07-6272
	CR115	1N4148	07-6272
	CR116	1N4148	07-6272
	CR117	1N5817	07-6290
	CR118	1N4001	07-6268
	CR119	1N4148	07-6272
	CR124	1N4148	07-6272
	CR134	1N34A	07-6253
POTENTIOMETERS			
	R6	1M, HV T	09-6752
	R7	25K, BAT T	09-6755
	R8	1M, BAT C	09-6752
RESISTORS			
	R20	15, 1W	12-7738
	R21	470K	10-7026
	R22	10	10-7046
	R23	1K	10-7009
	R25	10K	10-7016
	R26	220K	10-7066
	R27-R28	10K	10-7016
	R29	22K	10-7070
	R30	1K	10-7009
	R31	10K	10-7016
	R32	200K	10-7075
	R33	100K	10-7023
	R34	47K	10-7020
	R35	82K	10-7022
	R36	1K	10-7009
	R37	10K	10-7016
	R38	1K	10-7009
	R39	82K	10-7022
	R40-R41	3.9K	10-7084
	R42	4.7K	10-7014
	R43	470K	10-7026
	R44	820	10-7060
	R45	10K	10-7016
	R46	10M	10-7031
	R47	10K	10-7016
	R48	2.7M	10-7029
	R49	4.7K	10-7014

	Reference	Description	Part Number
	R50	100K	10-7023
	R51	56K	10-7021
	R52	1K	10-7009
	R54-R55	100K	10-7023
	R56	8.2K	10-7015
	R57	1K	10-7009
	R58	75K	10-7074
	R59	100K	10-7023
	R60	1.2M	10-7037
	R62	1.5K	10-7065
	R63	22K	10-7070
	R64	3.3K	10-7013
	R65	1M	10-7028
	R104	1M	10-7028
	R105	1G	12-7686
	R108	10M	10-7031
	R110	1G	12-7686
	R111	1M	10-7028
	R122	470	10-7008
	R123	165K, 1%	12-7544
	R125	432K, 1%	12-7689
	R126	3.3K	10-7013
	R132	100K	10-7023
	R135	4.7K	10-7014
TRANSFORMERS			
	T1	AUDIO	4275-083
	T2	HVPS	4275-086
CONNECTORS			
	P1	POWER 640445-7 MTA 156	13-8020
	P2	INDICATOR 1-640456-0 MTA 100	13-8066
	P3	FRONT PANEL 1-640456-7 MTA 100	13-8121
	P4	CONTROL 1-640456-1 MTA 100	13-8059
	P5	DISCRIMINATOR 640456-3 MTA 100	13-8081

	Reference	Description	Part Number
Calibration Board, Drawing 328 × 18	BOARD	Completely Assembled Calibration Board	5328-027
POTENTIOMETERS			
	R15	10K, DISCRIMINATOR	09-6787
	R16	250K, CAL	09-6819
	R17	10K, SPAN	09-6787
	R18	100K, HV	09-6813
	R19	10K, RECORDER	09-6787
RESISTOR			
	R13	10K	10-7016
MISCELLANEOUS			
	P6	1-640457-3 MTA100	13-8113
Log Board, Drawing 328 × 46	BOARD	Completely Assembled Log Board	5328-046
INTEGRATED CIRCUITS			
	U9-U10	TLC27M7IP	06-6248
	U18	CA3096	06-6023
RESISTORS			
	R3-R4	26.7K	12-7559
	R5	200K	12-7643
	R7	200K	12-7643
	R13	1G	12-7686
	R15	10K	10-7016
MISCELLANEOUS			
	P15	640456-4 MTA100	13-8088
Wiring Diagram, Drawing 328 × 15			
AUDIO			
	DS1	UNIMORPH (60690)	21-9251

	Reference	Description	Part Number
CONNECTORS			
	J1	MAIN BOARD 5328-026, MTA 156X7 (640428-7 MTA 156)	13-7802
	J2	MAIN BOARD 5328-026, MTA 100X10-26AWG (1-640442-0 MTA 100)	13-8136
	J3	MAIN BOARD 5328-026, MTA 100X17-26AWG (1-640442-7 MTA 100)	13-8505
	J4	MAIN BOARD 5328-026, MTA 100X11-26AWG (1-640441-1 MTA 100)	13-8161
	J5	MAIN BOARD 5328-026, MTA 100X3-26AWG (640441-3 MTA 100)	13-8160
	J6	CAL BOARD 5328-027, MTA 100X13-26AWG (1-640441-3 MTA 100)	13-8162
	J7	ACRECEP W/FUSE HLDR.	13-8427
	J8	DATA OUT 9 PIN "D"	13-8003
	J15	LOG BOARD 5328-046, MTA 100X4-26AWG (640442-4 MTA100)	13-8170
	J16	UG706/U	4478-011
SWITCHES			
	S1	BAT TEST (SWTCHCRFT-923)	08-6518
	S2	HV TEST (SWTCHCRFT-923)	08-6518
	S3	ALARM TEST (SWTCHCRFT-923)	08-6518
	S5	RESET (30-1-PB GRAYHILL)	08-6517
	S7	POWER, ON/OFF (46206-LR SLIDE)	08-6523
BATTERY			
	B1	6V (PS610 GELL CELL)	21-9385
POTENTIOMETERS			
	R1	100K, ALARM	09-6795
	R2	10K, VOLUME	09-6753
TRANSFORMER			
	T1	P6465, SECONDARY/PRIMARY	21-9329

	Reference	Description	Part Number
MISCELLANEOUS			
	F1	1 AMP (FUSE #312001 AGC-1)	21-9277
	DS2	ALARM LAMP (BULB-#338)	21-9307
	*	LAMP-HLDR	21-9410
	*	LENS-RED 140-1471	21-9411
	DS3	PILOT (LAMP-RED)	21-9296
	M1	METER (ASSY)	4173-166
	*	POWER CORD, BELDEN	21-9394
	*	CABLE "C" 39 inch or 5 ft	40-1004

Section

11

Drawings

Main Board, Drawing 328 × 17

Main Board Component Layout, Drawings 328 × 23-23B

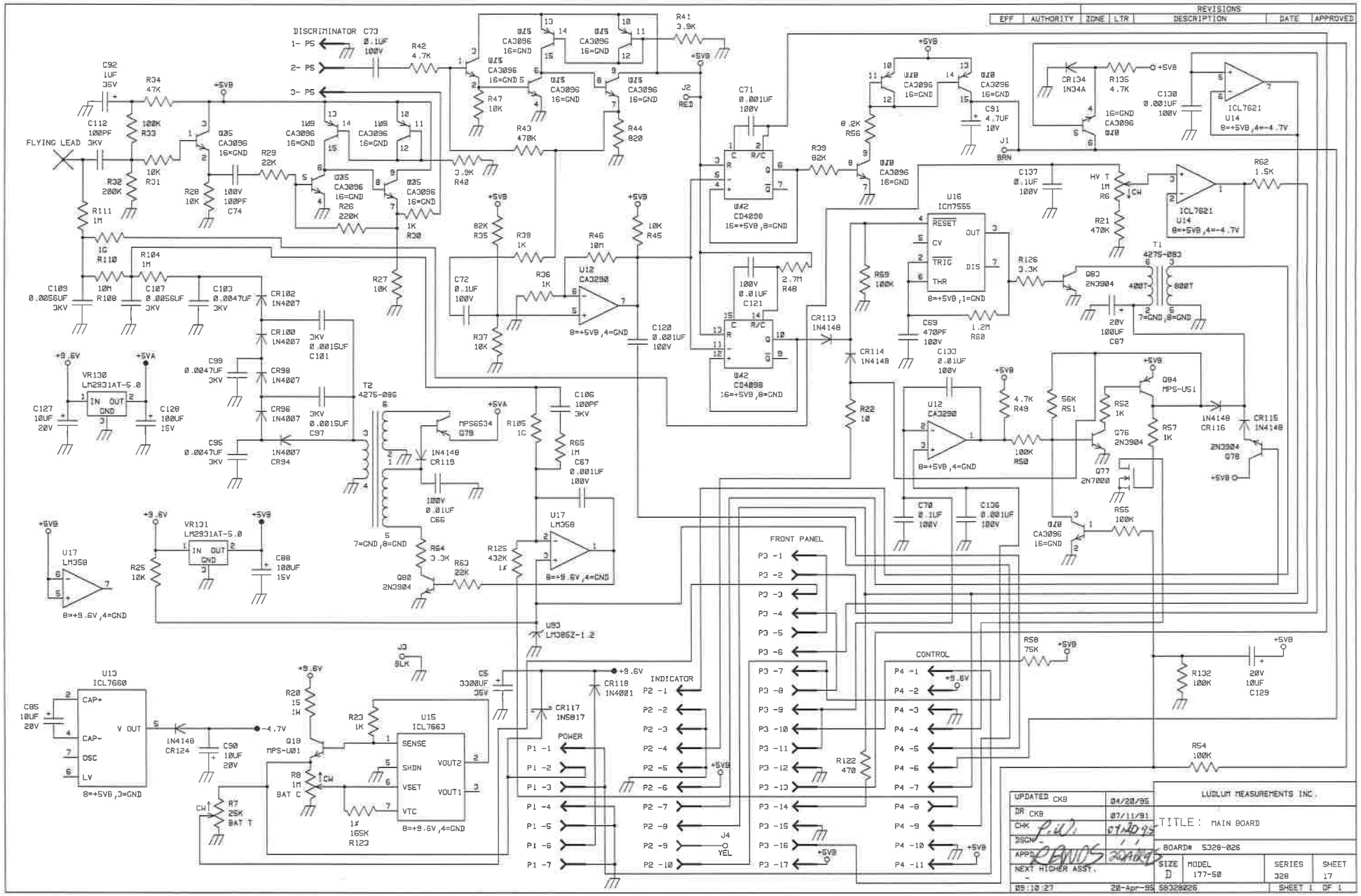
Calibration Board, Drawing 328 × 18

Calibration Board Component Layout, Drawing BS328027

Log Board, Drawing 328 × 46

Log Board Component Layout, Drawing 328 × 47

Wiring Diagram, Drawing 328 × 15


REVISIONS
EFF | AUTHORITY | ZONE | LTR | DESCRIPTION | DATE | APPROVED
DISCRIMINATOR C70
1- PS
2- PS
3- PS
FLYING LEAD
FRONT PANEL
INDICATOR
POWER
CONTROL
LUDLUM MEASUREMENTS INC.
TITLE : MAIN BOARD
BOARD# 5328-026
UPDATED CKB 04/20/95
DR CKB 07/11/91
CHK P.W. 5/4/95
DSGN -
APPD
NEXT HIGHER ASSY. -
SIZE D | MODEL 177-50 | SERIES J28 | SHEET 17
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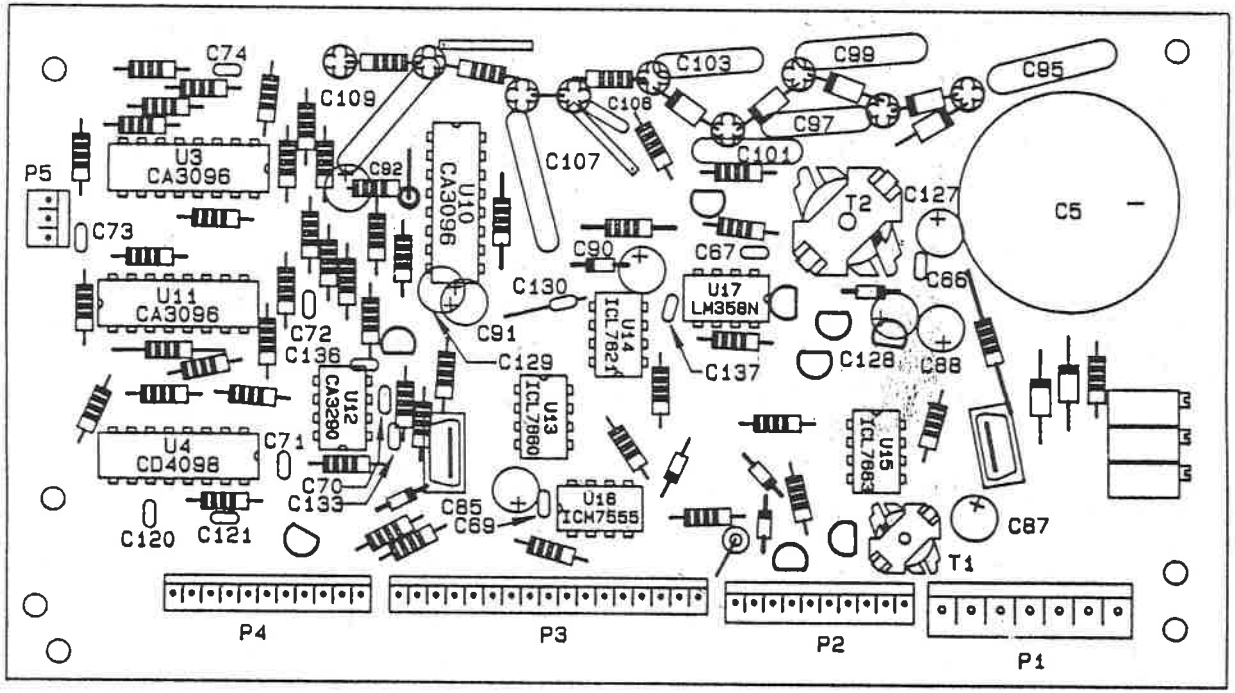
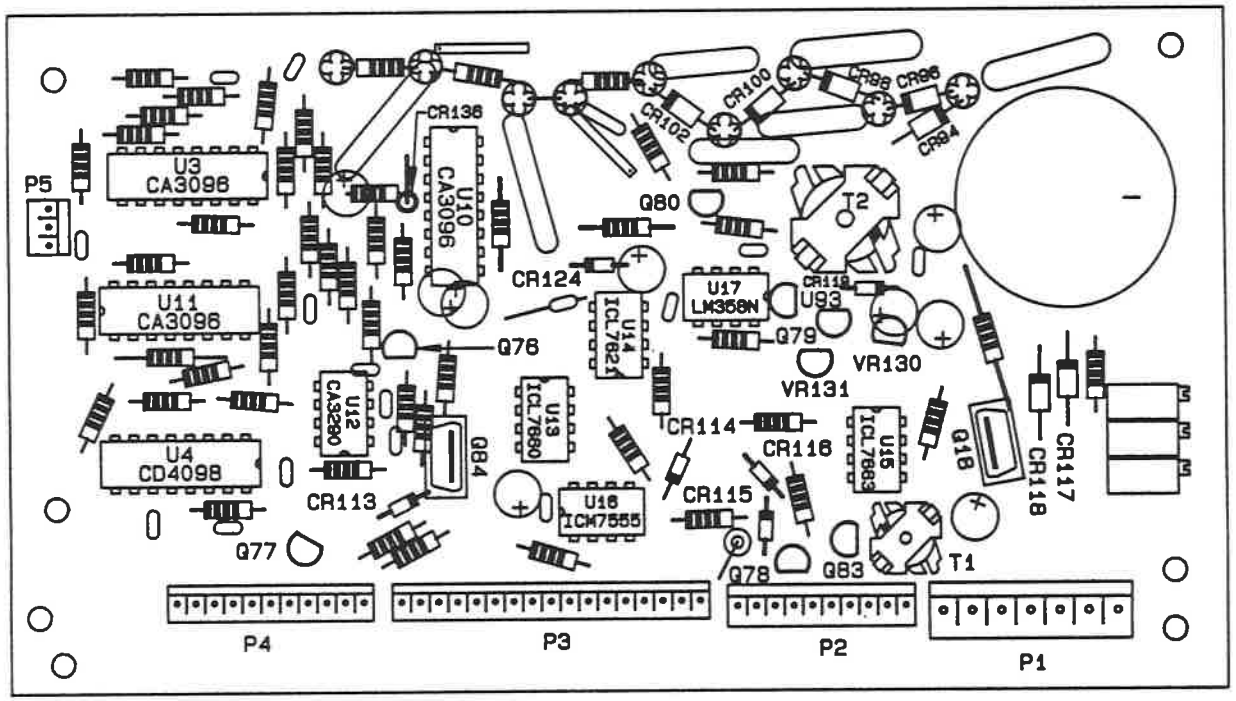


DESC: MAIN BOARD	
MODEL: 177-50	
PART #: 5328-026	
DWN: CKB	DATE: 08/09/91
DSGN:	DATE:

CHG	NO.		DWN	CHK	APP
DWN	DATE	CHK DATE	APP	DATE	
CKB	08/09/91	8-13-91		8-13-91	
TOL: SHOP STD ☐ OTHER		SCALE: FULL ☒ OTHER			
TITLE MODEL 177-50					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		SERIES 328		SHEET 23A	



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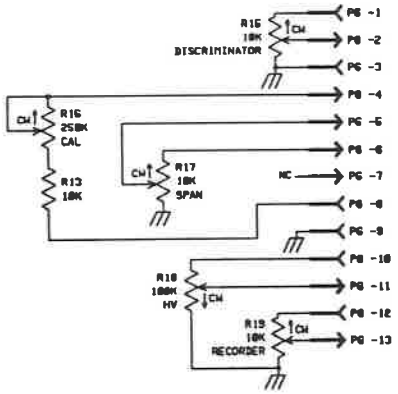
MODEL: 177-50	
PART #: 5328-026	
DWN: CKB	DATE: 08/09/91
DSGN:	DATE:

CHD	NO.			DWN	CHK	APP
DWN CKB	DATE 08/09/91	CHK	DATE	APP	DATE
TOL: SHOP STD ☐ OTHER		SCALE: FULL ☐ OTHER			
TITLE MODEL 177-50					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		DRAWING 328		SHEET 238	

REVISIONS					
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	APPROVED



CONTRACT -		LUDLUM MEASUREMENTS INC.	
DR CKD	07/05/91	TITLE: CALIBRATION BOARD	
CHK R.W.	7/11/91		
DSGN -	/ /	BOARD# 5328-827	
APPS J.C.W.	7/11/91	SIZE D / MODEL 177-60 / SERIES 328 / SHEET 10	
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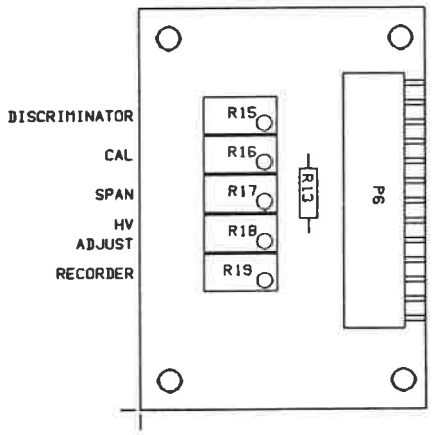

BOARD
DIMENSIONS:
WIDTH =1.473"
HEIGHT=2.062"

MOUNTING HOLE
LOCATIONS:
1. X=0.156"
Y=0.156"
2. X=1.354"
Y=0.156"
3. X=1.346"
Y=1.906"
4. X=0.156"
Y=1.906"

BOARD# 5328-027	
TITLE CALIBRATION BOARD	
MODEL 177-50	
COMPONENT OUTLINES	
DR CKB	07/05/91
CHK P.W.	09/20/95
DSGN -	/ /
APPD VGW	9/21/95
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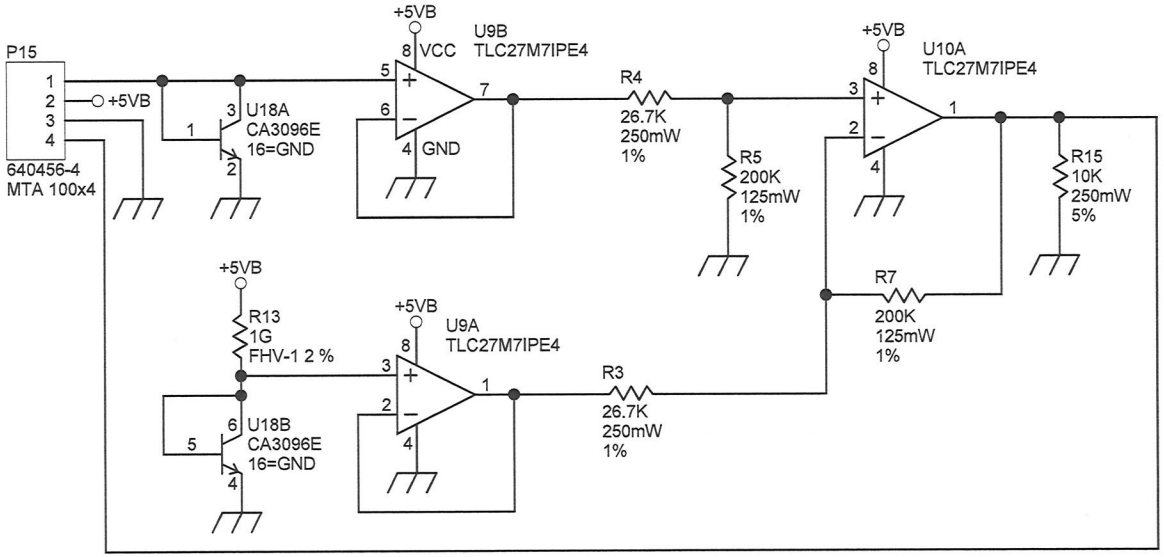

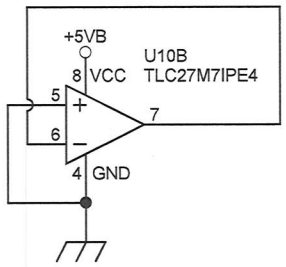

LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: ALC	06/19/2013	**Title:** LOG BOARD	
Design: RC	05/14/1999	**Model:** 177-50	
		Board#: 5328-046	
Approve: RMS	20Jun13	**Sheet:** 1 of 1	**Series** 328 / **Sheet** 46
Print Date: 6/19/2013 3:58:32 PM		**Rev:** 1	
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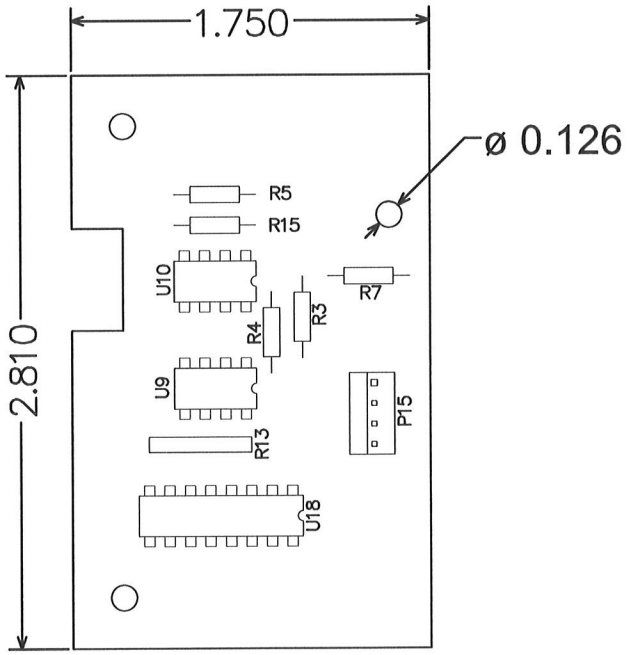

LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828	
Title: LOG BOARD			
Drawn: ALC	06/19/2013	**Model:** 177-50	
Design: RC	05/14/1999	**Board#:** 5328-046	
Approve: RJS	20Jun13	**Rev:** 1	
Print Date: 6/19/2013 4:07:17 PM		**SCALE: 1.00** Top Overlay	**Series** 328 / **Sheet** 47
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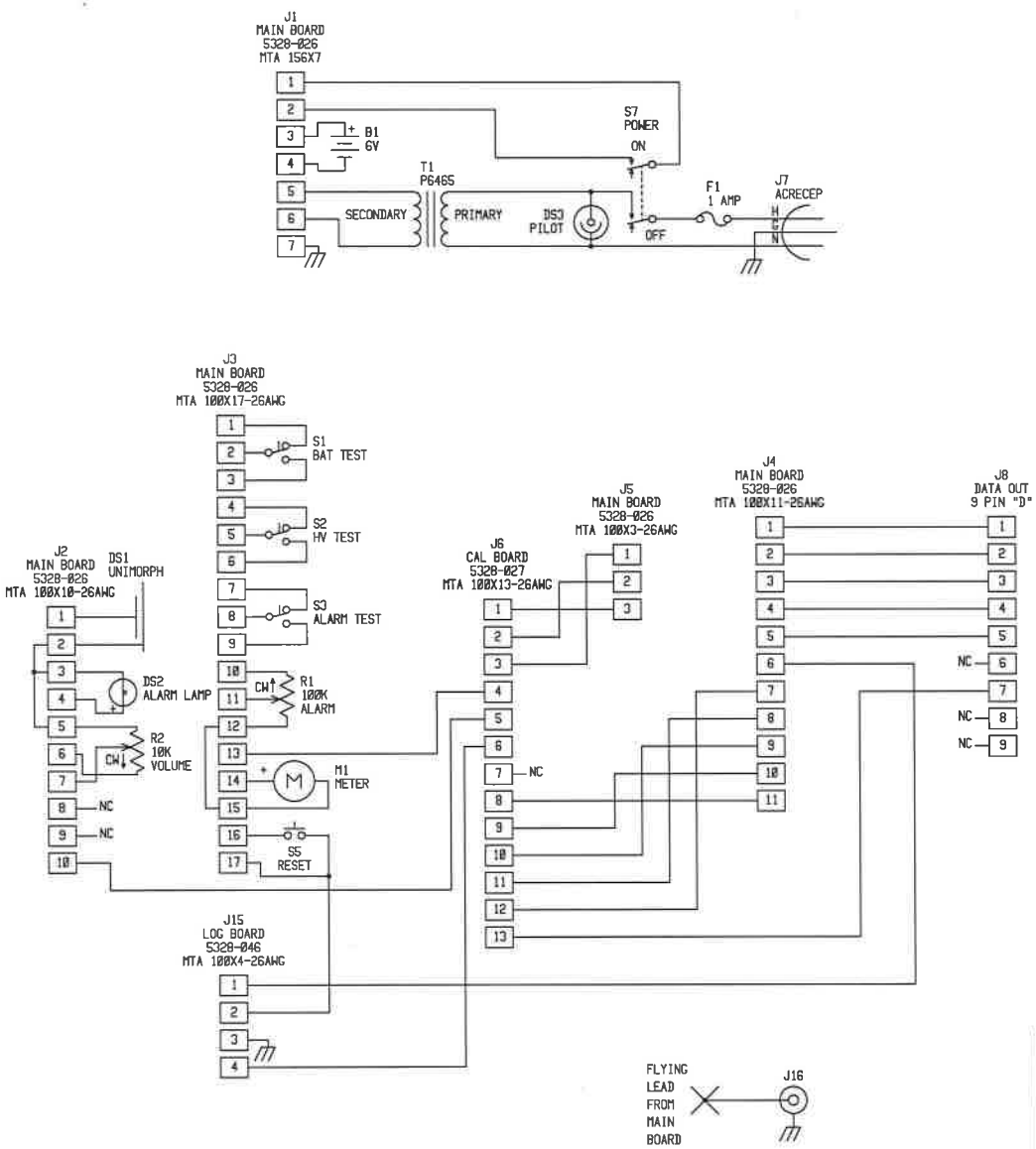

UPDATED	-	
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DSGN	DW	15-JAN-93
APPD	RDS	17JUN99
NEXT HIGHER ASSY.	-	
11:35:31	17-Jun-99	W328024

LUDLUM MEASUREMENTS INC.

TITLE: WIRING DIAGRAM

BOARD# 328-024

SIZE	MODEL	SERIES	SHEET
C	177-50	328	15

SHEET 1 OF 1