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**LUDLUM MODEL 16  
ANALYZER**

**July 2011**

**Serial Number 95362 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.

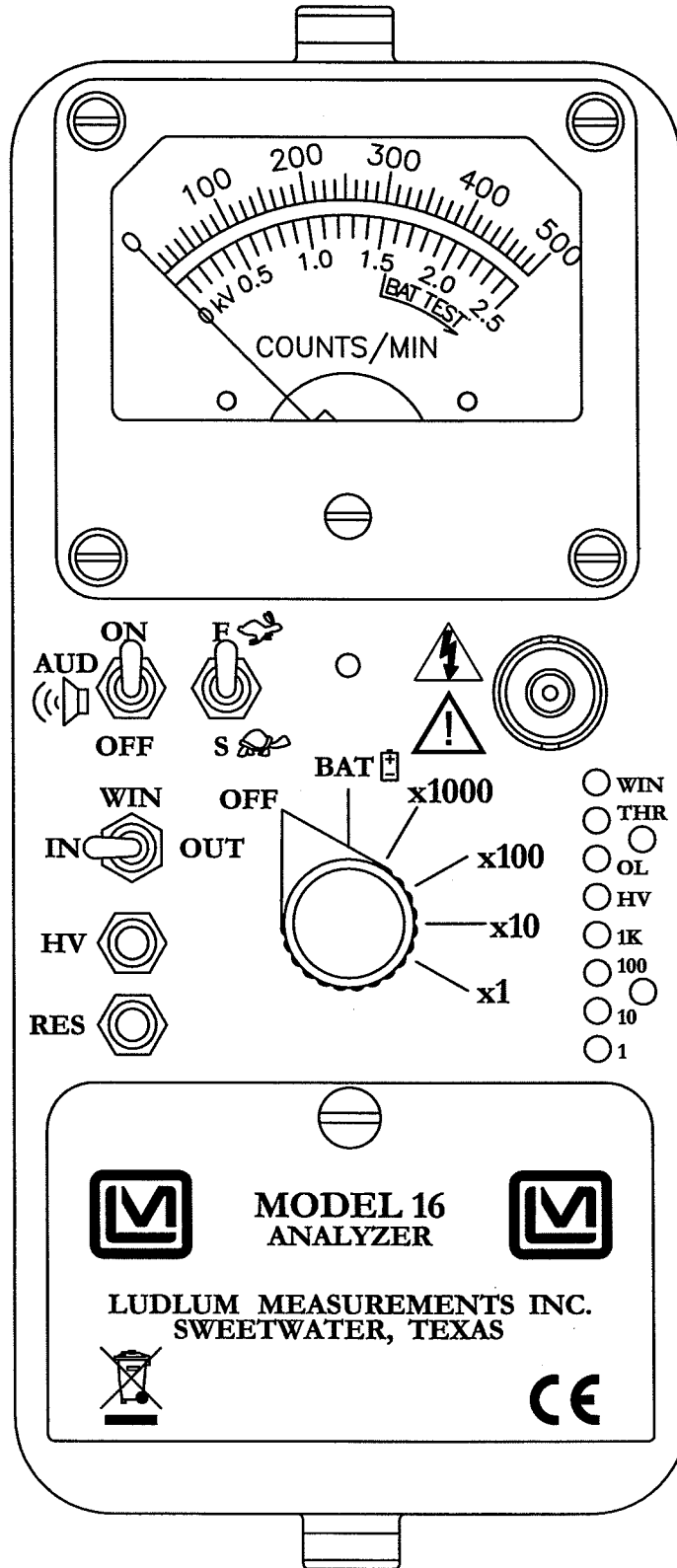
## **RETURN OF GOODS TO MANUFACTURER**

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	10-8-92	BK
2	ADDED SYMBOLS	6-24-06	CMC



DWN	DATE	CHK	DATE	DATE
CMC	6-24-06			6-24-06
PART NUM: 4363-718		SCALE: FULL <input checked="" type="checkbox"/> OTHER <input type="checkbox"/>		
TITLE MODEL 16 ANALYZER				
	LUDLUM MEASUREMENTS, INC. 501 DAK STREET SWEETWATER, TEXAS 79556	SERIES 363	SHEET 595	

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## Section

## 1

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## Introduction

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**T**he Ludlum Model 16 Analyzer supplies the complete electronic requirements for scintillation, proportional, or GM monitoring with the added feature of a window discriminator circuit.

A two-position switch, marked WIN IN/OUT allows the instrument to operate as a gross count ratemeter or as a single-channel analyzer. With the WIN switch in the OUT position, the discriminator level is controlled by the THR potentiometer, which is adjustable from 2 to 60 mV. In this mode, the instrument performs as a gross count ratemeter. With the WIN switch in the IN position, the WIN potentiometer controls the high discriminator level. The high discriminator level may be adjusted between the THR level and two times the threshold level (not to exceed 60 mV). Other features include AUD ON/OFF and fast/slow (F/S) meter response switches, meter RESET and high voltage (HV) test buttons.

## Section

## 2

## Getting Started

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### Unpacking and Repacking

Remove the calibration certificate and place it in a secure location. Remove the instrument and accessories (batteries, cable, etc.) and ensure that all of the items listed on the packing list are in the carton. Check individual item serial numbers and ensure calibration certificates match. The Model 16 serial number is located on the front panel below the battery compartment. Most Ludlum Measurements, Inc. detectors have a label on the base or body of the detector for model and serial number identification.

**Important!**

If multiple shipments are received, ensure that the detectors and instruments are not interchanged. Each instrument is calibrated to specific detectors, and therefore, not interchangeable.

To return an instrument for repair or calibration, provide sufficient packing material to prevent damage during shipment. Also provide appropriate warning labels to ensure careful handling. Include detector(s) and related cable(s) for calibration. Include brief information as to the reason for return, as well as return shipping instructions:

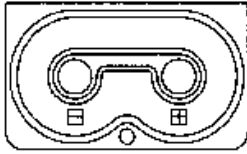
- **Return shipping address**
- **Customer name or contact**
- **Telephone number**
- **Description of service requested and all other necessary information**

### Battery Installation

Ensure the Model 16 range selector switch is in the OFF position. Open the battery lid by pushing down and turning the quarter-turn thumbscrew



counterclockwise a quarter of a turn. Install two "D" size batteries in the compartment.



Note the (+) and (-) marks inside the battery door. Match the battery polarity to these marks. Close the battery box lid, push down, and turn the quarter-turn thumb screw clockwise a quarter of a turn.

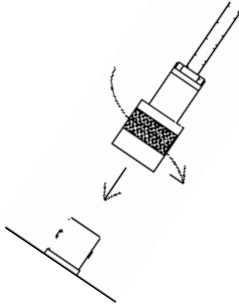
#### Note:

Center post of a flashlight battery is positive. The batteries are placed in the battery compartment in opposite directions.

## Connecting a Detector to the Instrument

#### Caution!

The detector operating voltage (HV) is supplied to the detector via the detector input connector. A mild electric shock may occur if you make contact with the center pin of the input connector. Switch the Model 16 range selector switch to the OFF position before connecting or disconnecting the cable or detector.



Connect one end of a detector cable to the detector by firmly pushing the connectors together while twisting clockwise a quarter of a turn. Repeat the process in the same manner with the other end of the cable and the instrument.

## Battery Test

The batteries should be checked each time the instrument is turned on. Move the range switch to the BAT position. Ensure that the meter needle deflects to the battery check portion on the meter scale. If the meter does not respond, check to see if the batteries have been correctly installed. Replace the batteries if necessary.

## Instrument Test

After checking the batteries, turn the instrument range switch to the  $\times 1000$  position. Place the AUD ON-OFF switch in the ON position and the WIN IN/OUT switch to the OUT position. Expose the detector to a check source.

The instrument speaker should emit "clicks" relative to the rate of counts detected. The AUD ON/OFF switch will silence the audible clicks if in the OFF position. It is recommended that the AUD ON/OFF switch be kept in the OFF position when not needed in order to preserve battery life.

Rotate the range switch through the lower scales until a meter reading is indicated. While observing the meter fluctuations, select between the fast and slow response time ("F/S") positions to observe variations in the display. The "S" position should respond approximately 5 times slower than the "F" position.

**Note:**

The slow response position is normally used when the instrument is displaying low numbers, which require a more stable meter movement. The fast response position is used at high rate levels.

Check the meter reset function by depressing the RES pushbutton and ensuring the meter needle drops to "0." When the RES pushbutton is released the meter needle recovers to the original reading.

Depress the HV pushbutton and note that the meter indicates the high-voltage set point.

**Note:**

HV power supply has an output impedance of 5.7 megohms. HV load should not exceed 25  $\mu$ A. Calculate the scintillation detector loading if an exact high-voltage setting is required.

See calibration procedures for details on the WIN IN/OUT operation.

Once this procedure has been completed, the instrument is ready for use.

## Operational Check

To assure proper operation of the instrument between calibrations and periods of nonuse, an instrument operational check including battery test and instrument test (as described above) should be performed prior to use.

A reference reading with a check source should be obtained at the time of initial calibration or as soon as possible for use in confirming proper instrument operation. In each case, ensure a proper reading on each scale. If the instrument fails to read within 20% of a proper reading, it should be sent to a calibration facility for recalibration.

## Section

## 3

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## Specifications

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Compatible Detectors: GM, proportional, and scintillation

Power: two "D" cell batteries housed in a sealed externally accessible compartment

Battery Life: typically 600 hours with alkaline batteries (battery condition may be checked on the meter)

Multipliers:  $\times 1$ ,  $\times 10$ ,  $\times 100$ , and  $\times 1000$  selected by a front panel range selector switch

High Voltage: adjustable from 400 to 2500 V; can be read on the meter face

Threshold: adjustable from 2 to 60 mV

Window: adjustable from 0 to 60 mV above threshold (can be turned on or off)

Overload: senses detector saturation; indicated by red lamp meter and full-scale meter deflection (adjustable depending on the detector selected)

Meter: 6.4 cm (2.5 in.) arc, 1 mA analog type

Meter Dial: 0-500 counts per minute (cpm), 0-2.5 kV, BAT TEST (others available)

Range: typically 0-500,000 cpm

Linearity: reading within 10% of true value with detector connected

Battery Dependence: instrument calibration change less than 3% within battery check limits on the 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 (greater than 60 dB at 0.6 m {2 ft})

Response: toggle switch for 4 seconds in the fast (F) position or 22 seconds in the slow (S) position from 10% to 90% of final reading

Connector: series "C" (other available)

Reset: pushbutton to zero the meter

Operating Temperature: -20 to 50 °C (-4 to 122 °F)

Size: 16.5 x 8.9 x 21.6 cm (6.5 x 3.5 x 8.5 in.) (H x W x L)

Weight: 1.6 kg (3.5 lb), including batteries

Construction: cast and drawn aluminum with beige powder coating and silk-screened nomenclature

## Section

## 4

## Identification of Controls and Functions

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**Range Selector Switch:** a six-position switch marked OFF, BAT,  $\times 1000$ ,  $\times 100$ ,  $\times 10$ ,  $\times 1$ . Turning the range selector switch from OFF to BAT 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 ( $\times 1000$ ,  $\times 100$ ,  $\times 10$ ,  $\times 1$ ) provides the operator with an overall range of 0 to 500,000 cpm. Multiply the scale reading by the multiplier to determine the actual scale reading.

**Battery Compartment:** The sealed compartment houses two "D" cell batteries.

**RES Pushbutton Switch:** When depressed, this switch provides a rapid means of driving the meter needle to zero.

**AUD ON/OFF Toggle Switch:** in the ON position, this switch 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.

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

**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 the "F" position, there is fast response and large meter deviation. The "S" position should be used for slow response and damped meter deviation.

**WIN IN/OUT:** This toggle switch disables the window circuit for gross counting.

HV Adjustment: This recessed potentiometer located under the calibration cover provides a means of varying the high voltage from 400 to 2500 V.

Range Calibration Adjustment: recessed potentiometers located under the calibration cover. These controls allow for individual calibration of each range multiplier.

THR: recessed potentiometer located under the calibration cover, which allows the input sensitivity (threshold) to be adjusted from 2 to 60 millivolts. The threshold is normally set for 10 millivolts at the factory.

WIN: recessed potentiometer located under the calibration cover, which allows the window width to be adjusted from 0 to 2.0 times the threshold setting (input sensitivity). The window is normally set for 1.5 times the threshold.

OL: This recessed potentiometer is located under the calibration cover, which allows for calibration of the detector overload function.

## Section

## 5

## Safety Considerations

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### Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude

Temperature range of -20 to 50 °C (-4 to 122 °F); may be certified for operation from -40 to 65 °C (-40 to 150 °F)

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

Pollution Degree 3 (as defined by IEC 664) (Occurs when conductive pollution or dry nonconductive pollution becomes conductive due to condensation. This is typical of industrial or construction sites.)

### 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 16 Analyzer is marked with the following symbols:



**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.





**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 remove the batteries.
2. Allow the instrument to sit for one minute before accessing internal components.



The “**crossed-out wheeled 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 on the battery compartment lid. See section 8, “Recycling,” for further information.



The “CE” mark is used to identify this instrument as being acceptable for use within the European Union.

## Cleaning and Maintenance Precautions

The Model 16 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 or performing maintenance on the instrument:

1. Turn the instrument OFF and remove the batteries.
2. Allow the instrument to sit for one minute before cleaning the exterior or accessing any internal components for maintenance.

## Section

## 6

## Calibration and Maintenance

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### Establishing an Operating Point

The operating point for the instrument and probes is established by setting the probe voltage and instrument sensitivity (HV and THR). 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 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 (including background) are above the discrimination level, and the unwanted pulses from noise are below the discrimination level, and are therefore, not counted.

Total system gain is controlled by adjusting either the instrument threshold or high voltage. Voltage affects control in the probe; THR (threshold) controls the amplifier gain.

In the special case 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 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. However, the factory set point may be adjusted for your specific operation.

### Calibration

To access the calibration controls, remove the front-panel calibration cover. In performing the following, use a Ludlum Model 500 Pulser or equivalent for generation of pulse height, HV testing, and count rate generation.

**GM DETECTORS****Note:**

The GM detector pulse is NOT proportional to Gamma Energy. WINDOW operation has no function.

1. Check GM detector specifications for proper operating high voltage. Select this voltage with the HV calibration control. Press HV test and confirm the proper high-voltage reading.
2. Set THR control for  $40 \pm 10$  mV.
3. Set WIN IN/OUT to OUT.
4. Set F/S and AUD ON/OFF as per local requirements.
5. Connect GM detector and confirm proper operation with a radiation source.

**PROPORTIONAL DETECTORS**

1. Set THR for 2 mV.
2. Set WIN IN/OUT to OUT.
3. Expose detector to a radiation source and observe count rate with and without the source as voltage is increased in 50 volt increments. Plot this Data vs High Voltage.
4. Select an operating High Voltage point with minimum change in Count Rate vs High Voltage (i.e. on the plateau).
5. Record this High Voltage for future operational check.

**Note:**

Gas proportional detectors and some pure argon detectors will develop a very rapid increase of background count. This is called "voltage breakdown." Operate at least 100 V below this point.

### SCINTILLATION DETECTORS

1. Set THR for 10 mV.
2. Set WIN IN/OUT to OUT.
3. Expose detector to a radiation source and observe count rate with and without the source as voltage is increased in 50-volt increments. Plot this Data vs High Voltage.
4. Select an operating High Voltage point with minimum change in Count Rate vs High Voltage (i.e. on the plateau).
5. Record this High Voltage for future operational check.

### WINDOW CALIBRATION

Window calibration will be valid only with the specific detector to be used with the Model 16. A check source will be required. A Model 500 Pulser will be required if the WIN calibration is shifted to another energy.

1. To find the peak energy of an isotope, the operating characteristics of the detector must be determined. A plateau graph of 50-volt increments should be taken with the WIN IN/OUT switch in the OUT position and plotted for both background and a reference source, such as  $^{137}\text{Cs}$  for high energy or  $^{241}\text{Am}$  for low energy.

#### Example:

Using the pulser, set THR on at 10 mV and WIN OFF at 15 mV.

1. The peak energy of the source is located where the count from the source "just starts" to appear above background. Take note of the high voltage in this area. This will be the region of the operating point for the reference source.
2. Place the WIN IN/OUT switch to IN, and set the WIN and THR controls. Reduce the high voltage below the point where the source count is not seen above background.

3. Expose the source to the detector. Slowly increase the high voltage. The source count should increase, then decrease with increasing high voltage.
4. Reduce and refine the high voltage until the source count peaks. When the source is peaked, the unit may be recalibrated for another energy using a pulse generator.

**Example:**

With THR at 10 mV and WIN at 15 mV, high voltage adjusted for a  $^{137}\text{Cs}$  peak, then the center of the peak would be in the center of the window, or 12.5 mV would be equivalent to 662 KeV for  $^{137}\text{Cs}$ . This gives 53 KeV per mV. Ten millivolts is equivalent to 53 KeV, and the 5 mV wide window (window setting minus threshold setting) is equivalent to 265 KeV or the window is between 530 KeV, and 795 KeV.

To repeak for 1.25 MeV with a window width of 300 KeV, (i.e. threshold at 1.1 MeV max, window at 1.4 MeV max) reset THR to 21 mV and WIN to 26 mV.

**HV CALIBRATION**

High voltage may be adjusted by the HV control. Press the HV pushbutton to observe high voltage reading on the meter.

**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.

High-voltage readout may be calibrated with an internal control. Remove instrument can. Connect the Model 16 to the Model 500 Pulser. Observe the high-voltage reading on the Model 500. Press the HV pushbutton. Adjust R16 on the internal HV test board for the same reading.

### RATEMETER CALIBRATION

The ratemeter may be calibrated by adjusting calibration controls labeled 1, 10, 100, and 1K. Starting with the 1000 range, apply 400,000 CPM from the Model 500 Pulser. Adjust for proper reading. Drop pulse rate to 100,000 CPM and confirm reading at 100,000  $\forall$ 10,000 CPM. Repeat this procedure for the lower scales with scaled pulse rates.

### DETECTOR OVERLOAD CALIBRATION

**Note:**

The detector operating voltage (HV) must be determined and set before the OL (overload) adjustment is performed. If the detector operating voltage is changed, the overload adjustment may need to be changed also.

Adjust the OL control to the maximum counterclockwise position.

#### With Scintillation Detectors

1. For alpha or beta scintillators, expose the detector photomultiplier tube (PMT) to a small light leak by loosening the detector window. The meter should start to decrease toward zero as light saturates the scintillation material.
2. Expose just enough light to where the meter starts to decrease. Adjust the OL control until the overload LED just begins to flicker on the meter dial. The ratemeter should deflect above full meter scale at this point.
3. Reseal the detector window and expose the detector to an alpha or beta source that will drive the meter near full scale. Confirm that the LED does not turn on and the meter remains on scale.

#### With GM Detectors

1. For GM detectors, place the detector in a high radiation field to where the meter no longer increases or decreases with an increase in field intensity (referred to from this point on as detector overload point).

2. With the detector positioned at the overload point, adjust the OL control until the overload LED just starts to flicker on the meter dial. The meter should be deflecting above full scale at this point.
3. Position the detector in a radiation field between the equivalent near full-scale meter field and the overload field. Ensure that the overload LED is off. Adjust the OL control as required to fine adjust between the two fields

**Example:**

Overload point = 1000 mR/hr;  
Full-scale meter reading = 200 mR/hr

Adjust the OL control until the LED flickers at 1000 mR/hr, and then place the detector at 500 mR/hr to ensure the LED is disabled.

**Note:**

When a GM and Scintillation detector is used, the overload set point must be adjusted for the GM detector due to the greater current drain from the GM detector.

## Maintenance

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and the calibration. The Model 16 instrument may be cleaned with a damp cloth (using only water as the wetting agent). Do not immerse instrument in any liquid. Observe the following precautions when cleaning:

1. Turn the instrument OFF and remove the batteries.
2. Allow the instrument to sit for one minute before accessing internal components.

**RECALIBRATION**

Recalibration should be accomplished after maintenance or adjustments have been performed on the instrument. Recalibration is not normally required following instrument cleaning or battery replacement.

**Note:**

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

Ludlum Measurements offers a full-service repair and calibration department. We not only repair and calibrate our own instruments but most other manufacturers' instruments. Calibration procedures are available upon request for customers who choose to calibrate their own instruments.

**BATTERIES**

The batteries should be removed any time the instrument is placed into storage. Battery leakage may cause corrosion on the battery contacts, which must be scraped off and/or washed using a paste solution made from baking soda and water. Use a spanner wrench to unscrew the battery contact insulators, exposing the internal contacts and battery springs. Removal of the handle will facilitate access to these contacts.

**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 may occur at temperatures as low as 37 °C (100 °F).



## Section

## 7

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## Troubleshooting

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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 with this instrument, the most common problems encountered are: (1) detector cables, (2) sticky meters, (3) battery contacts.

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 is 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 which utilize a GM, Scintillator or Proportional Detector

**SYMPTOM**

No power (or meter does not reach BAT TEST or BAT OK mark)

**POSSIBLE SOLUTION**

1. Check batteries and replace if weak.
2. Check polarity (See marks inside batter lid). Are the batteries installed backwards?

<b><u>SYMPTOM</u></b>	<b><u>POSSIBLE SOLUTION</u></b>
No power (or meter does not reach BAT TEST or BAT OK mark) (continued)	<ol style="list-style-type: none"><li>3. Check battery contacts. Clean them with rough sandpaper or use an engraver to clean the tips.</li><li>4. Check for loose or broken wires, especially between the main board and the calibration board.</li></ol>
Nonlinear Readings	<ol style="list-style-type: none"><li>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.</li><li>2. Check for noise in the detector cable by disconnecting the detector, placing the instrument on the lowest range setting, and wiggling the cable while observing the meter face for significant changes in readings.</li><li>3. Check for “sticky” meter movement. Does the reading change when you tap the meter? Does the meter needle “stick” at any spot?</li><li>4. Check the “meter zero.” Turn the power OFF. The meter should come to rest on “0.”</li></ol>
Meter goes full-scale or “pegs out”	<ol style="list-style-type: none"><li>1. Replace the detector cable to determine whether or not the cable has failed, causing excessive noise.</li><li>2. Check the HV and, if possible, the input threshold for proper setting.</li></ol>

<u>SYMPTOM</u>	<u>POSSIBLE SOLUTION</u>
Meter goes full-scale or “pegs out” (continued)	<ol style="list-style-type: none"><li>3. Check for loose wires, especially between the main board and the calibration board.</li><li>4. Ensure that the instrument’s “can” is properly attached. When attached properly, the speaker will be located on the left side of the instrument. If the can is on backwards, interference between the speaker and the input preamplifier may cause noise.</li></ol>
No Response to Radiation	<ol style="list-style-type: none"><li>1. Substitute a “known good” detector and/or cable.</li><li>2. Has the correct operating voltage been set? Refer to the calibration certificate or detector instruction manual for correct operating voltage. If the instrument uses multiple detectors, confirm that the high voltage is matched to the current detector being used.</li></ol>
No Audio	<ol style="list-style-type: none"><li>1. Ensure that the AUD ON-OFF switch is in the ON position.</li><li>2. Remove the instrument housing and check the connection between the circuit board and the speaker. Plug in the 2-pin connector if necessary.</li></ol>

## 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.
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 the 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 operate 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.

2. Neutron  $^3\text{He}$  detectors typically require a 2 mV threshold and about 1700 Vdc. Neutron  $\text{BF}_3$  detectors typically operate at 1750 Vdc and 30 mV threshold.
3. Gas proportional detectors need P-10 gas, so check the window for tears or leaks and ensure an adequate supply of gas.
4. 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).
5. Humidity can also be a problem for proportional detectors. Dry and/or check the desiccants.

## Section

## 8

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## Recycling

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Ludlum Measurements, Inc. supports the recycling of the electronic 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, which 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  
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## Parts List

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	<u>Reference</u>	<u>Description</u>	<u>Part Number</u>
Model 16 Analyzer	UNIT	Completely Assembled Model 16 Analyzer	48-1612
Main Board, Drawing 363 × 558	BOARD	Completely Assembled Main Circuit Board	5363-708
CAPACITORS	C001-C002	0.0047 $\mu$ F, 3kV	04-5547
	C021	68 $\mu$ F, 6.3V	04-5654
	C022	330pF, 100V	04-5657
	C101-C103	0.0047 $\mu$ F, 3kV	04-5547
	C111	0.1 $\mu$ F, 50V	04-5663
	C112	1 $\mu$ F, 35V	04-5656
	C113-C114	0.01 $\mu$ F, 50V	04-5664
	C121-C122	68 $\mu$ F, 6.3V	04-5654
	C201	0.0047 $\mu$ F, 3kV	04-5547
	C202	100pF, 3kV	04-5532
	C203-C204	0.0047 $\mu$ F, 3kV	04-5547
	C211	0.01 $\mu$ F, 50V	04-5664
	C212	0.022 $\mu$ F, 50V	04-5667
	C221	47 $\mu$ F	04-5666
	C222	470pF, 100V	04-5668
	C301	10 $\mu$ F, 20V	04-5655
	C302	100pF, 3kV	04-5532
	C303	0.001 $\mu$ F, 100V	04-5659
	C311	47pF, 100V	04-5660
	C312	68 $\mu$ F, 6.3V	04-5654
	C313-C314	47pF, 100V	04-5660
	C401	10 $\mu$ F, 20V	04-5655
	C402	0.01 $\mu$ F, 50V	04-5664
	C403	47pF, 100V	04-5660
	C404-C405	0.001 $\mu$ F, 100V	04-5659

	<u>Reference</u>	<u>Description</u>	<u>Part Number</u>
	C411	0.1 $\mu$ F, 50V	04-5663
	C412	100pF, 100V	04-5661
	C413	0.01 $\mu$ F, 50V	04-5664
	C421	10 $\mu$ F, 20V	04-5655
TRANSISTORS	Q021	MJD210	05-5843
	Q111	MMBT3904T	05-5841
	Q121	MMBT4403LT	05-5842
	Q211	MMBT3904T	05-5841
	Q301	MMBT3904T	05-5841
INTEGRATED CIRCUITS	U021	MAX631AESA	06-6285
	U111	TLC27M7ID	06-6292
	U211	ICM7555CBA	06-6300
	U311-U312	CD74HC4538M	06-6297
	U321	LM285M-2.5	06-6291
	U322	LM285M-1.2	05-5845
	U401	CA3096M	06-6288
	U402	TLC372ID	06-6290
	U411	CA3096M	06-6288
	U412	TLC372ID	06-6290
DIODES	CR001-CR003	MR250-2	07-6266
	CR101-CR102	MR250-2	07-6266
	CR111	MMBD914L	07-6353
THERMISTORS	R211	250	07-6366
POTENTIOMETERS	R423	500K, (HV) HV READOUT	09-6913
	R421	1M, HV LIMIT (LIM)	09-6906
RESISTORS	R111	200 OHM, 1%	12-7846
	R112	2.21k, 1%	12-7835
	R113	22.1k, 1%	12-7843
	R114	1 M, 1%	12-7844
	R121	2.21k, 1%	12-7835
	R122	2.37k, 1%	12-7861
	R201	1 M, 5%	10-7028
	R202	1 G	12-7686
	R203	4.7 M	10-7030
	R212	301 OHM	12-7863
	R213	10k, 1%	12-7839
	R214	22.1k, 1%	12-7843



	<u>Reference</u>	<u>Description</u>	<u>Part Number</u>
	R215	1 M, 1%	12-7844
	R216	475k, 1%	12-7859
	R217	10k, 1%	12-7834
	R218	1 G	12-7686
	R219	1 M	12-7844
	R301	1 M	10-7028
	R302	100k, 1%	12-7834
	R303	10k, 1%	12-7839
	R304	100k, 1%	12-7834
	R305	4.75k, 1%	12-7858
	R306	1k, 1%	12-7832
	R307	8.25k, 1%	12-7838
	R308	10k, 1%	12-7839
	R309	82.5k, 1%	12-7849
	R311-R312	100 OHM, 1%	12-7840
	R424	182k, 1%	12-7860
	R422	1 M, 1%	12-7844
	R313-R315	100k, 1%	12-7834
	R321	10k, 1%	12-7839
	R401	10k, 1%	12-7839
	R402	4.75k, 1%	12-7858
	R403	1k, 1%	12-7832
	R404	10k, 1%	12-7839
	R411	100k, 1%	12-7834
	R412	249k, 1%	12-7862
	R413	10k, 1%	12-7839
	R414	100k, 1%	12-7834
	R415	200 OHM, 1%	12-7846
	R416-R417	22.1k, 1%	12-7843
CONNECTORS	P1	CONN-1-640456-1 ,MTA100	13-8059
	P2	CONN-1-640456-3, MTA100	13-8100
	P4	CONN-640456-2, MTA100	13-8073
INDUCTOR	L021	470 UHY	21-9699
TRANSFORMER	T011	L8050	40-0902
MISCELLANEOUS	10 EA.	CLOVERLEAF- 011-6809-000-599	18-8771
	2 EA.	M-F SPACER 4-40 X 1/4	18-8914

	<u>Reference</u>	<u>Description</u>	<u>Part Number</u>
Calibration Board, Drawing 363 × 511	BOARD	Completely Assembled Calibration Board	5363-656
CAPACITORS	C1	0.0047 $\mu$ F, 100V	04-5570
	C2	0.047 $\mu$ F, 100V	04-5565
LED	DS1	LED-HLMP4700	07-6356
	*	LED-SPACER 456-500	07-6349
POTENTIOMETERS	R1	250k, $\times$ 1000	09-6819
	R2	2 M, $\times$ 100	09-6834
	R3	1 M, $\times$ 10	09-6814
	R4	1 M, $\times$ 1	09-6814
	R6	1M, OVERLOAD	09-6814
	R7	250k, HV	09-6819
	R9	250k, THRESHOLD	09-6819
	R10	250k, WINDOW	09-6819
RESISTORS	R11	3.3k	10-7013
	R8	680k, 5%	12-7694
	R5	1 M, 1%	12-7609
RESISTOR NETWORK	RN1	10k SIP, 8P	12-7720
CONNECTORS	P3	CONN-640456-9 MTA100	13-8094
	P5	CONN-640456-6 MTA100	13-8095
Wiring Diagram, Drawing 363 × 515	S1-S2	7101-SYZ-QE	08-6511
SWITCHES	S3	#923PB SWITCHCRFT	08-6518
	S4	PA-600-210	08-6501
	S5	7101-SYZ-QE	08-6511
	S6	30-1-PB GRAYHILL	08-6517
CONNECTORS	J1	CONN-1-640442-1, MTA100	13-8137
	J2	CONN-1-640442-3, MTA100	13-8138
	J3	CONN-640442-9, MTA100	13-8169
	J4	CONN-640442-2, MTA100	13-8178
	J5	CONN-640442-7, MTA100	13-8187
	J6	UG706/U SCREW "C"	13-7751

	<u>Reference</u>	<u>Description</u>	<u>Part Number</u>
AUDIO	DS1	UNIMORPH	21-9251
BATTERIES	B1-B2	“D” CELL BATTERY	21-9313
METER	M1	PORT BEZEL W/OL & MVMNT ASSY	4363-720
MISCELLANEOUS	*	BATTERY BOX LID Model 16	9363-301
	*	BATTERY CONTACT SET	40-1701
	*	CASTING, Model 16	9363-695
	*	MAIN HARNESS, Model 16	8363-721
	*	PORTABLE CAN ASSY.	4363-441
	*	PORTABLE KNOB	08-6613
	*	PORT MTR. BEZEL W/GLASS, SCREWS	4363-352
	*	PORTABLE METERFACE W/OL	7363-719
	*	PORT CAL COVER W/SCREWS	9363-200
	*	UNIMORPH W/WIRES & O’RING	40-0034
	*	PORT HANDLE (GRIP) W/SCREWS	7363-139
	*	PORT HANDLE FOR CLIP W/SCREWS	7363-203
	*	M44-3 TYPE CLIP W/SCREWS	7002-026-01
	*	M44-7 TYPE CLIP W/SCREWS	7010-007-01
	*	M44-6, 44-9 TYPE CLIP W/SCREWS	7010-008-01

Section  
10

## Drawings

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MAIN CIRCUIT BOARD SCHEMATIC, Drawing 363 × 558

MAIN CIRCUIT BOARD LAYOUT, Drawing 363 × 559

CALIBRATION BOARD SCHEMATIC, Drawing 363 × 511

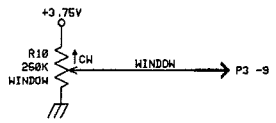
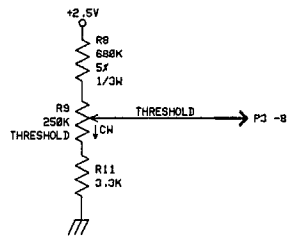
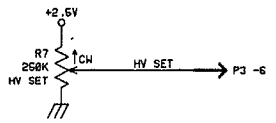
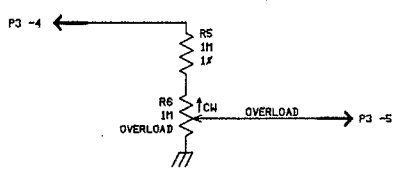
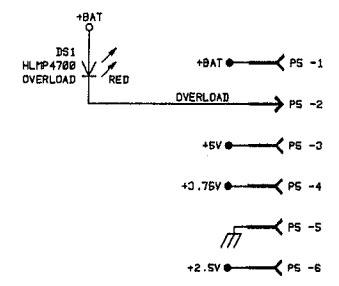
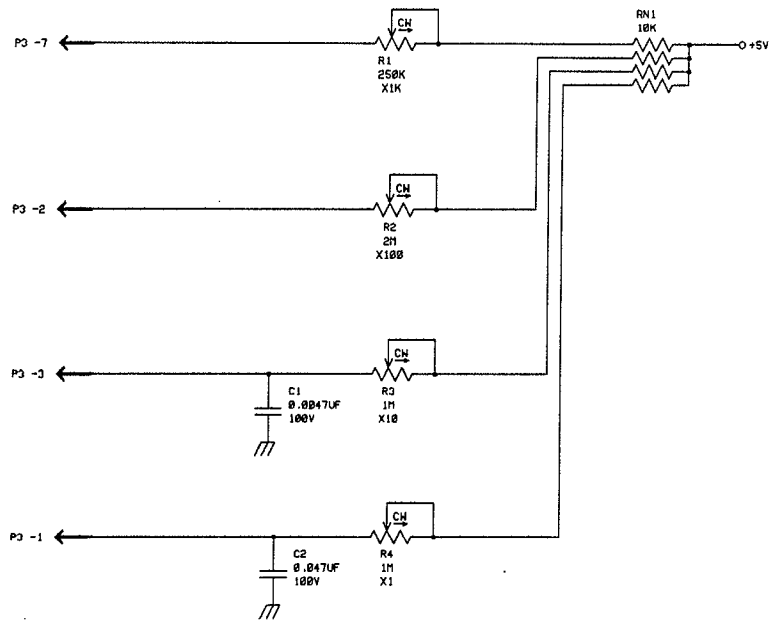
CALIBRATION BOARD LAYOUT, Drawing 363 × 512

WIRING DIAGRAM, Drawing 363 × 515

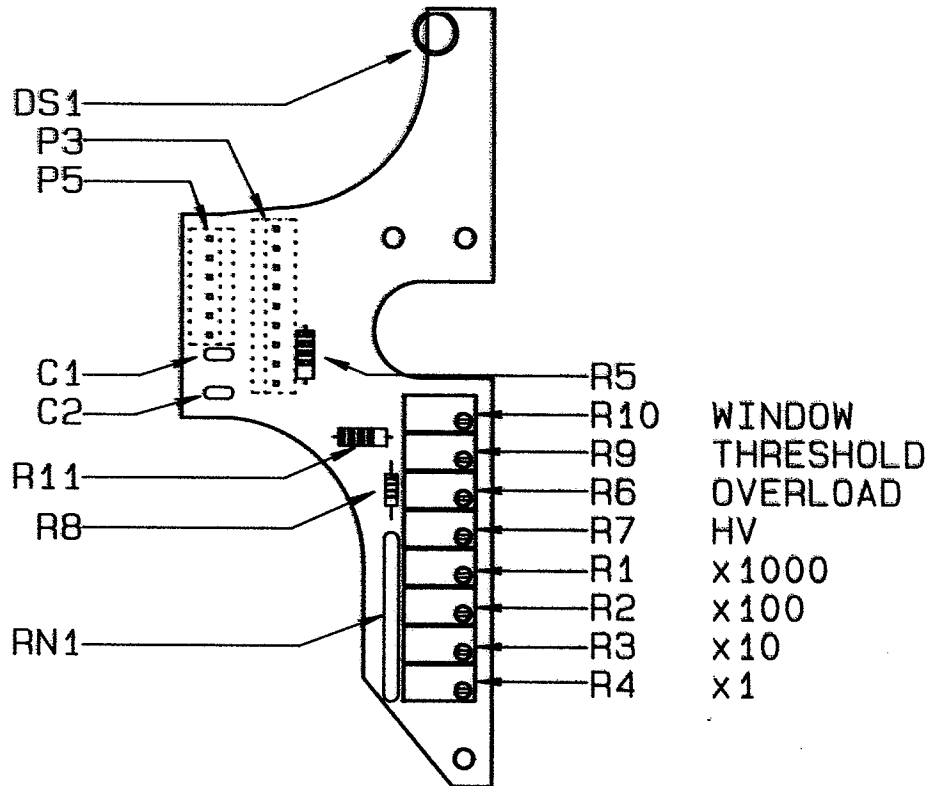




REVISIONS				
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION
				DATE
				APPROVED



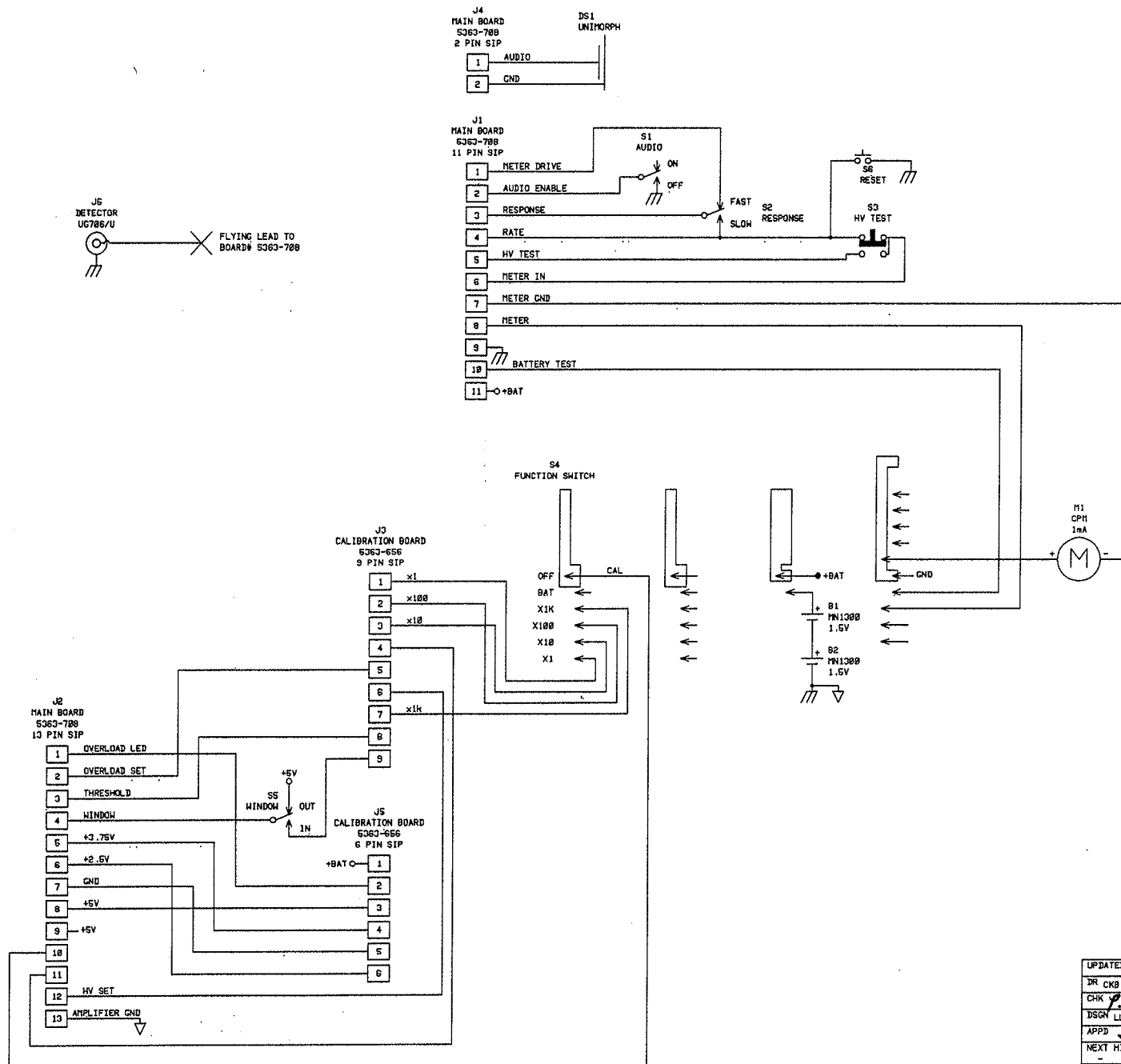
UPDATED -	///	LUDLUM MEASUREMENTS INC.		
DR CKB	05/15/92	TITLE: CALIBRATION BOARD		
CHK P.W.	10/9/92	BOARD# 5363-656		
DSGN LL	3/28/92	SIZE D	MODEL 16	SHEET 511
APPD JGW	10/8/92	NEXT HIGHER ASSY.	363	SHEET 1 OF 1
14:33:43	18-JUL-92	SB363656		



DESC: CALIBRATION BOARD	
MODEL: 16	
PART #: 5363-656	
DWN: CKB	DATE: 07/27/92
DSGN:	DATE:

REV	DATE	BY	CHKD	DATE
1	07/27/92	CKB		07/27/92
TOL: 0.0005		SCALE: 1:1		
TITLE: MODEL 16 CALIBRATION BOARD				
LID: 16		REV: 20	QTY: 300	542





UPDATED -	/ /	LUDLUM MEASUREMENTS INC.			
DR CKB	08/22/92	TITLE: WIRING DIAGRAM			
CHK P.W.	10/28/92	BOARD# 363-658			
DSGN LL	3/28/92	SIZE D	MODEL 16	SERIES 363	SHEET 515
APPD J.C.W.	10/28/92	NEXT HIGHER ASSY.			
08.151.159	24-Aug-92	58363658	SHEET 1 OF 1		