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The Addendum to the Site Safety and Health Plan (SSHP) presented in this document has been developed for the US Army Corps of Engineers (USACE) Louisville District (CELRL) under the guidance of the Environmental & Munitions Design Center, US Army Corps of Engineers (USACE) Baltimore District. The PIKA personnel referenced below have reviewed and approved this addendum to the SSHP for implementation once approval has been received from USACE.

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ADDENDUM TO THE FINAL SITE SAFETY AND HEALTH PLAN TIME CRITICAL REMOVAL ACTION (TCRA) AT THE ROCKET RIDGE AREA (RRA) WITHIN RVAAP-004-R-01 OPEN DEMOLITION AREA #2 MRS

Ravenna Army Ammunition Plant (RVAAP)
Ravenna, Ohio

Contract No. W912QR-09-P-0033

Submitted to

U.S. Army Corps of Engineers, Louisville
600 Dr. Martin Luther King, Jr. Place
Louisville, KY 40202

Submitted by

PIKA International, Inc
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July 17, 2009

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BRACO – Base Realignment and Closure Technical Support Office

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Ohio EPA-DERR – Ohio Environmental Protection Agency NE District-DERR

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PIKA – PIKA International Inc.

REIMS – Ravenna Environmental Information Management System

RVAAP – Ravenna Army Ammunition Plant

USACHPPM – United States Army Center for Health Promotion and Preventative Medicine

USACE – United States Army Corps of Engineers – Louisville District

USAEC – United State Army Environmental Center

ADDENDUM TO THE SITE SAFETY AND HEALTH PLAN APPROVAL

Project: Time Critical Removal Action (TCRA) at the Rocket Ridge Area (RRA) within RVAAP-004-R-01 Open Demolition Area #2 MRS

Site: Rocket Ridge Area Ravenna Army Ammunition Plant

Site Location: Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio

The Addendum to the Site Safety and Health Plan (SSHP) presented in this document has been developed for the US Army Corps of Engineers (USACE) Louisville District (CELRL) under the guidance of the Environmental & Munitions Design Center, US Army Corps of Engineers (USACE) Baltimore District. The PIKA personnel referenced below have reviewed and approved this addendum to the SSHP for implementation once approval has been received from USACE.

Reviewed by: ______________________ Date: July 17, 2009
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PIKA Project Manager

Reviewed by: ______________________ Date: July 17, 2009
Lew Kovarik
PIKA UXO Safety Officer/Site Safety and Health Officer

Reviewed and Approved by: ______________________ Date: July 17, 2009
Joel I. Cehn, CHP
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1 Radiological Monitoring Equipment

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1 PIKA Radiological Procedures and Instrument Manuals

1.0 INTRODUCTION

The purpose of this addendum is to provide clarification regarding the proposed precautionary radiological monitoring prior to and during intrusive activities of the Time Critical Removal Action (TCRA) at the Rocket Ridge Area (RRA) of Open Demolition Area #2 (ODA2) at the Ravenna Army Ammunition Plant (RVAAP) in Ravenna, Ohio.

The approved WP describes the procedures, operational sequence, and resources PIKA International, Inc. (PIKA) will use to accomplish the main objective of the TCRA. The objective of this project is to mitigate or abate the immediate explosive hazards, investigate the approximate nature, extent, and volume of the MEC and MD and to prepare a Removal Action Report (RAR) that will describe the action taken to remove the threat to human health and the environment. The report will also present data from the MEC and MD survey to aid in scoping future removal actions at Rocket Ridge. In addition, some road improvements and vegetation removal will be required to facilitate access to the site.

Authorization for performance is contained in contract W912QR-09-P-0033 issued to PIKA by U.S. Army Corps of Engineers - Louisville District (CELRL), Louisville, Kentucky. The work will be performed on behalf of the CELRL.

The U.S. Army Technical Center for Explosives Safety (USATCES) has granted an interim approval to the TCRA Explosives Safety Submission (ESS) that was prepared by PIKA. The ESS has been forwarded to the Department of Defense (DoD) Explosives Safety Board (DDESB) for final approval. Work will be commenced under the interim approval from USATCES.

A Site Safety and Health Plan (SSHP) has also been developed for the field activities associated with this project. The Accident Prevention Plan (APP) to which the SSHP is attached will be the overall safety and health management document of the project while the SSHP will present more of the site specific data associated with the Scope of Work (SOW).

2.0 RADIOLOGICAL SCREENING

Based on a review of literature (Radiation Survey Report No. CESWT-SO-R2-05-98) and site history, there is no evidence that radioactive materials were used or stored at the Rocket Ridge Area within RVAAP-04 in the Open Demolition Area #2 at RVAAP. Consequently, there is no reasonable expectation that radioactive materials will be encountered during the field work in the Rocket Ridge Area.

A historical assessment of radiological use at RVAAP was conducted in 1990 by Olin Ordnance. The assessment report identified a Monazite Sand Storage and Projectile Radiography operations. These operations were licensed by the Atomic Energy Commission [now the US Nuclear Regulatory Commission (NRC)] and both licenses were subsequently terminated.

Radioactive materials (RAM) were known to be used or stored at four locations on RVAAP. The four areas are as below:

- Monazite Sand Storage Area
- Projectile Radiography on Load Line 3
- Building 2F4
- Building 130

Of these the Monazite Sand Storage Area was the most significant one. All four locations are very distant from the Rocket Ridge Area to have any impact at all at this site. The monazite ore contains less than 10 percent natural Thorium. Records indicate that there was a total of 170,000 pounds of Thorium. This is approximately 6% of the total weight of the ore. Monazite ore was only stored at RVAAP. Monazite is a very insoluble and stable crystal structure and does not degrade in typical environmental conditions. Thorium is not very mobile in the environment and is normally distributed by physical means.

Due to the history of work with the Monazite sands and the Radiography operations at the RVAAP Installation, the RVAAP Facility Manager requested that screening for radioactive materials shall conducted prior to and during intrusive activities at the work site strictly as a precautionary measure to ensure personnel safety.

The screening shall be performed by a qualified health physics technician using a scintillation (sodium iodide) detector coupled with a ratemeter/scaler. This instrument is effective in detecting uranium and thorium as well as most other gamma emitting radionuclides. Additional instruments will be made available to the technician during this project for detecting alpha and beta contamination on the equipment surfaces and personnel (Table 1). All radiological survey instruments for the project shall be calibrated within one year of use, and checked daily for proper operation. They will be used and maintained in accordance with appropriate PIKA radiological procedures (see Attachment 1).

TABLE 1

Available Radiological Monitoring Equipment

Manufacturer	Model	Description	Type of Survey
Ludlum	Model 19	mR-meter	Gamma Exposure Rates
Ludlum	Model 2360 / Model 43-93	Digital alpha/beta data logger / Alpha /Beta scintillator	Alpha/ Beta Static, Scanning
Ludlum	Model 12 / Model 44-9	Rate meter/ Pancake G-M probe	Beta/Gamma Static, Scanning
Ludlum	Model 2221 / Model 44-10	Digital scaler/ratemeter / 2x2 NaI gamma scintillator	Gamma Scanning

In the event that radioactivity exceeding twice background levels is encountered, work shall be stopped, and notifications shall be made as appropriate. Personnel shall be evacuated to the entry control point and frisked to verify no contamination. Equipment in the immediate vicinity shall be surveyed and/or swipe counted to verify no contamination is present. Appropriate alpha/beta instruments will be used for contamination checks. The work area will be secured, and the potential radiological hazard will be evaluated to determine nature and extent of contamination. If contaminated material is found, it will be removed by the qualified technician using standard decontamination methods. The RVAAP Facility Manager and the USACE Project Manager will be kept informed and consulted to effect any changes to the Work Plan/SSHP and seek necessary approvals from all stakeholders.

3.0 PROJECT EXPOSURE ESTIMATES

Based on the limited information available, the estimated maximum Total Effective Dose Equivalent (TEDE), a sum of potential external and internal doses, is less than 0.005 rem for personnel assigned to the project. For comparison, the NRC limit for occupational exposure to ionizing radiation is 5 rem annually and As Low As Reasonably Achievable (ALARA) (10 CFR 20.1201), and 0.1 rem annually to members of the public (10 CFR 20.1301). The administrative limit for occupational exposure to USACE personnel is 0.1 rem annually and ALARA (ER 385-1-80). Should elevated levels of radioactivity be encountered, the TEDE shall be revised as necessary and procedures will be implemented for the protection of the workers and other essential personnel at the work site.

4.0 DOSIMETRY

4.1 External Dosimetry

Dosimetry to measure exposure to radiation is only required by Federal regulations (10 CFR 20.1502) if personnel are expected to receive 0.5 rem in one year. Based on the extremely low probability of encountering radioactive materials during excavation; the short duration of site activities; the stop work/trigger level of twice background; and the extremely low projected accumulated dose for this project (much less than 0.005 rem), external dosimetry is not required and will not be employed. If the TEDE changes during the course of the project, the external dosimetry requirements will be re-visited.

4.2 Internal Dosimetry

Based on the extremely low probability of encountering radioactivity above natural background levels during excavation, sampling for airborne radioactive constituents, as well as baseline and post-work bioassays, are not warranted. In the event that significant amounts of radioactive materials are encountered, the need for internal dosimetry (bioassays) will be re-visited.

Attachment 1

PIKA Radiological Procedures and Instrument Manuals:

PIKAP-001 Operation of Contamination Survey Meters
PIKAP-003 Operation of Micro-R Survey Meters
PIKAP-008 – Radiation and Contamination Surveys
PIKAP-018 Radioactive Check Sources
PIKAP-020 Unconditional Release of Materials from Radiological Controls

Ludlum Model 12 Survey Meter_June07
Ludlum Model 19 Micro R Meter_Jul06
Ludlum Model 43-93 and Model 43-93-2 Alpha Beta Scintillators_ Dec06
Ludlum Model 44-10 Gamma Scintillator_July09
Ludlum Model 44-9 Alpha, Beta, Gamma Detector_May07
Ludlum Model 2221 Portable Scaler Ratemeter_Jan02
Ludlum Model 2360 Scaler/Ratemeter Data Logger_Sep06

PIKAP-001

PROCEDURE

Operation of Contamination Survey Meters

PIKA International, Inc.
12919 Southwest Freeway, #190
Stafford, TX 77477

PIKA

PROCEDURE

APPROVAL PAGE

Procedure Number/Title: PIKAP-001, ***Operation of Contamination Survey Meters,*** has been reviewed and approved by the following:

APPROVAL SIGNATURES

___________________________________ ___________________

Shahrukh Kanga Date
Principal, QA/QC
PIKA International, Inc.

___________________________________ ___________________

Joel Cehn, CHP Date
Radiation Safety Officer
PIKA International, Inc.

___________________________________ ___________________

Terry Kasnavia Date
President
PIKA International, Inc.

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1.0 PURPOSE AND SCOPE

This procedure provides the methods for selecting and preparing contamination survey meters for operations. Adherence to this procedure will provide reasonable assurance that the surveys performed will have reproducible results.

This procedure will be used by PIKA International, Inc. (PIKA) personnel and subcontractors when performing radiological surveys.

2.0 GENERAL

2.1 Definitions

2.1.1 Radiation Survey – A survey to determine ambient radiation levels.

2.1.2 Alpha/Beta Contamination Survey - A survey to determine fixed and/or removable alpha/beta contamination.

2.1.3 Acceptance Range - A range of values that describe an acceptable daily instrument source check result.

2.2 Precautions

2.2.1 Technicians will ensure that the thin Mylar or mica window on the probe face is protected from punctures during survey operations.

2.2.2 Check sources will be controlled in accordance with PIKAP-020, Radioactive Check Sources, at all times to prevent accidental loss or release of radioactive materials.

2.2.3 If any instrument inconsistencies are observed (e.g., unusually high or low background counts, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the Site Supervisor.

2.2.4 Pre-operational instrument checks including a battery check, general observation of instrument condition and source response check shall be performed each day before instrument use. Additionally, work instructions for survey activities with a high emphasis on data quality, such as final status surveys, may require that the instrument checks be performed again at the end of each shift.

2.2.5 Survey instrument calibrations shall be performed by an NRC or Agreement State approved calibration facility with NIST traceable sources.

2.2.6 Review and follow the specific PIKA procedure for the instrument being used.

2.3 Quality Control

2.3.1 Survey meters will be checked with a check source daily when in use to ensure the instrument is operating within the calibrated specifications.

2.3.2 Survey meters will have current/valid calibration documentation attached to the meter or file in a PIKA office.

3.0 REFERENCES, RECORDS AND EQUIPMENT

3.1 References

- RSM, Radiation Safety Manual
- Manufacturer's Technical Manual(s)
- PIKAP-020, Radioactive Check Sources
- ANSI N323-1997, American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments

3.2 Records

Administrative forms included in this procedure shall not be modified without the written authorization of the Project Manager and the documented concurrence of the RSO or designee. In no case shall modifications reduce the content required by the original form.

- PIKA Form 1-1, Survey Meter Source Check

3.3 Equipment

- Selected survey meter
- Check source
- Check source performance test jig

4.0 RESPONSIBILITIES

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of operating contamination survey meters are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the contamination survey meters. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM) - The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Health Physics Technicians - Technicians using contamination survey meters are responsible for knowing and complying with this procedure.

5.0 PROCEDURE

5.1 Inspections and Tests

The following inspections and tests are documented on PIKA Form 1-1, Survey Meter Source Check.

5.1.1 Select the contamination survey meter and probe to be used in the survey and verify that the instrument is intact, has a valid calibration and that it has no visible damage or defects.

5.1.2 Turn the instrument selector switch to BATTERY TEST position and verify the batteries have proper voltage to operate the instrument. Replace the batteries if the indication is below the acceptable range.

5.1.3 Turn the instrument selector switch to "ON" and let the instrument warm up for one minute.

5.1.4 Switch the audio toggle switch to "ON" and adjust speaker volume (if so equipped).

5.1.5 Check alpha detectors for light leaks by pointing the sensitive area on the detector toward a light source and observe the meter indication and listen for an increase of audible clicks on the speaker. If the meter indication or the audible clicks are above 10 counts per minute (CPM) contact the Supervisor or RSO.

5.1.6 Verify that the acceptance data has been established on PIKA Form 1-1. If so, proceed to 5.1.7. If not, perform following actions:

5.1.6.1. Enter the required information regarding the instrument and the check source in the top section of the form.

5.1.6.2. Place the detector in the appropriate test jig to determine the ambient background count rate. Allow the instrument to stabilize for approximately one minute then perform a ten-minute count or observe and note the background CPM.

5.1.6.3. Place the check source in the test jig and reposition the detector in the test jig. Allow the instrument to stabilize for approximately one minute then perform a five-minute count or observe and note the CPM.

5.1.6.4. Determine the average net count rate in CPM by subtracting the background CPM from the source CPM. Enter this value in the "Avg Net CPM" space on PIKA Form 1-1. If net counts are less than 10,000, count for longer times.

5.1.6.5. Determine the acceptance range by multiplying the "Avg Net CPM" by 0.8 for the –20% and 1.2 for the +20%.

5.1.7 Perform the instrument source check by positioning the detector in the appropriate test jig to determine the ambient background count rate. Allow the instrument to stabilize for approximately one minute then perform a one-minute count or observe and note the background CPM. Enter this value in the "BKG CPM" space on PIKA Form 1-1.

5.1.8 Place the check source in the test jig and reposition the detector in the test jig. Allow the instrument to stabilize for approximately one minute then perform a one-minute count or observe and note the CPM. Enter this value in the “Source CPM” space on PIKA Form 1-1.

5.1.9 Determine the average net count rate in CPM by subtracting BKG CPM from the Source CPM. Enter this value in the “Source Net CPM” space on PIKA Form 1-1.

5.1.10 If the source net CPM falls within the acceptance range enter "pass" in the "Pass/Fail" space. If the source net CPM does not fall within the acceptance range, enter "fail" in the "Pass/Fail" space, then remove the instrument from service and contact health physics supervision.

5.1.11 Complete the daily entry by entering your initials, the date and time.

5.2 Interpretation of Results

After performing the survey, the meter reading on the alpha and beta survey meters must be corrected for detector efficiency and detector surface area before comparing results with the contamination limits in Section 3.6 of the Radiation Safety Manual. The conversion from CPM to DPM/100 cm^2 is performed using the following equation:

$$(DPM / 100\, cm^2) = \frac{A}{(B \times C)}$$

Where:

A = Alpha or Beta survey meter indication in net CPM (α or β) (i.e. Gross Alpha or Beta Survey Counts minus background counts = Net CPM).

B = The detector surface area (in cm^2) divided by 100 cm^2.

C = Detector efficiency (expressed as decimal).

Examples of B

Ludlum Model	*B*
44-9	0.15
43-5	0.76
43-68	1.26
43-37	5.8

6.0 ATTACHMENTS

PIKA Form 1-1, Survey Meter Source Check

ATTACHMENTS

Survey Meter Source Check

Instrument Information				Source Information			
Inst Model		Detector Model		Nuclide		Activity (dpm)	
Inst ID		Detector ID		PIKA #		Activity (uCi)	
Cal Due		Cal Due		Mfg. ID		Cert Date	

Acceptance Data	Avg Net CPM		-20%		+20%	

Visual Inspection					Source Counts				Performed		
[1]Battery Voltage	[2]High Voltage	Cable	[2]Speaker	Display	Source CPM	BKG CPM	Source Net CPM	Pass / Fail	By	Date	Time

Comments:	Reviewed by:
	Date:

Note 1: if available, record the actual battery voltage. Otherwise record SAT or UNSAT.
Note 2: record NA if the instrument does not have this feature.

PIKAP-003

PIKA
INTERNATIONAL, INC.

PROCEDURE

Operation of Micro-R Survey Meters

PIKA International, Inc.
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Stafford, TX 77477

PIKA

PROCEDURE

APPROVAL PAGE

Procedure Number/Title: PIKAP-003, ***Operation of Micro-R Survey Meters,*** has been reviewed and approved by the following:

APPROVAL SIGNATURES

Shahrukh Kanga Principal, QA/QC PIKA International, Inc.	Date
Joel Cehn, CHP Radiation Safety Officer PIKA International, Inc.	Date
Terry Kasnavia President PIKA International, Inc.	Date

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1.0 PURPOSE AND SCOPE

This procedure provides the methods PIKA International, Inc. (PIKA) will utilize in operation of the micro-R-meter for gamma radiation surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

This procedure will be used by PIKA personnel and subcontractors to operate the micro-R-meter during gamma radiation surveys.

2.0 GENERAL

2.1 Definitions

2.1.1 Restricted Area - Also referred to as a Radiological Controlled Area (RCA), is an area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Gamma radiation survey - A survey technique to determine gamma radiation levels from radioactive materials in facilities, materials or landmasses.

2.1.3 Acceptance Range - A range of values that describe an acceptable daily instrument source check result.

2.2 Precautions

2.2.1 If any instrument inconsistencies are observed (e.g., unusually high or low background readings, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the site supervisor.

2.2.2 A battery check and general observation of instrument condition shall be performed daily.

2.2.3 Survey instrument calibrations shall be performed by an NRC or Agreement State approved calibration facility with NIST traceable sources.

2.3 Quality Control

2.3.1 The micro-R-meter will be source checked with an appropriate source daily.

2.3.2 Contamination survey meters will have current/valid calibration documentation, not more than 12 month old, attached to the meter or in the storage case.

3.0 REFERENCES, RECORDS AND EQUIPMENT

3.1 References

- RSM, Radiation Safety Manual

- Manufacturer's Technical Manual(s)
- PIKAP-008, Radiation and Contamination Surveys
- PIKAP-018, Radioactive Check Sources
- ANSI N323-1997, American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments

3.2 Records

Administrative forms included in this procedure shall not be modified without the written authorization of the Project Manager and the documented concurrence of the RSO. In no case shall modifications reduce the content required by the original form.

- PIKA Form 3-1, Micro-R Meter Source Check

3.3 Equipment

- Ludlum Model 19 or equivalent detector

4.0 RESPONSIBILITIES

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of operating micro-R survey meters are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the micro-R survey meters. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM) - The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Health Physics Technicians - Technicians using Micro-R meters are responsible for knowing and complying with this procedure.

5.0 PROCEDURE

5.1 Initial Preparations

5.1.1 Select the Micro-R meter to be used in the survey, observe the physical appearance (i.e., no broken parts and instrument is complete) and verify that the instrument has a currently valid calibration.

5.1.2 Depress the BATTERY TEST button and verify the meter indication falls within the shaded region of the dial indicating the batteries have proper voltage to operate the instrument. Replace the batteries if the indication is below the shaded region.

5.1.3 Turn the instrument selector switch to the lowest scale position (usually 25 uR/hour) and let the instrument warm up for one minute. With the selector switch in this position, use the 0 to 25 uR/hr scale on the dial for obtaining instrument readings.

5.1.4 Switch the audio toggle switch to "ON" and the response toggle switch to "SLOW".

5.1.5 Verify that the acceptance data has been established on PIKA Form 3-1. If so, proceed to Step 5.1.6. If not, perform following actions:

5.1.5.1 Enter the required information regarding the instrument and the check source in the top section of the form.

5.1.5.2 Place the detector in the appropriate test jig to determine the ambient background count rate. Allow the instrument to stabilize for approximately one minute then perform a one-minute count or observe and note the background exposure rate (uR/hr).

5.1.5.3 Place the check source in the test jig and reposition the detector in the test jig. Allow the instrument to stabilize for approximately one minute then perform a one-minute count or observe and note the exposure rate (uR/hr).

5.1.5.4 Determine the average net exposure rate in (uR/hr) by subtracting the background uR/hr from the source uR/hr. Enter this value in the “Avg Net uR/hr” space on PIKA Form 3-1.

5.1.5.5 Determine the acceptance range by multiplying the “Avg Net uR/hr” by 0.8 for the –20% and 1.2 for the +20%.

5.1.6 Perform the instrument source check by positioning the detector in the appropriate test jig to determine the ambient background count rate. Allow the instrument to stabilize for approximately one minute then perform a one-minute count or observe and note the background exposure rate (uR/hr). Enter this value in the “BKG uR/hr” space on PIKA Form 3-1.

5.1.7 Place the check source in the test jig and reposition the detector in the test jig. Allow the instrument to stabilize for approximately one minute then perform a one-minute count or observe and note the exposure rate (uR/hr). Enter this value in the “Source uR/hr” space on PIKA Form 3-1.

5.1.8 Determine the average net exposure rate by subtracting BKG uR/hr from the Source uR/hr. Enter this value in the “Source Net uR/hr” space on PIKA Form 3-1.

5.1.9 If the source net uR/hr falls within the acceptance range enter "pass" in the "Pass/Fail" space. If the source net uR/hr does not fall within the acceptance range enter "fail" in the "Pass/Fail" space, then remove the instrument from service and contact health physics supervision.

5.1.10 Complete the daily entry by entering your initials, the date and time.

NOTE: Do not use malfunctioning or out of tolerance instruments.

5.2 Survey Technique

General survey techniques are provided in PIKAP-008, Radiation and Contamination Surveys. Additional survey guidance for use in specific situations will be provided in work plans or radiation work permits.

5.3 Interpretation of Results

5.3.1 In a uniform background radiation field (without interfering sources of radiation), methods such as; selectively shielding the detector, soil sample analysis, etc., can be used to differentiate between extraneous radioactive sources (e.g., skyshine or radioactive waste shipment containers), naturally occurring radioactive material and/or radioactive contamination.

5.3.2 Note the location of installed devices that contain radioactive material and could cause elevated radiation survey levels in localized areas.

5.3.3 Land mass surveys might contain areas with naturally occurring radioactive materials that will elevate background radiation levels.

6.0 ATTACHMENTS

PIKA Form 3-1, Micro-R Meter Source Check

ATTACHMENTS

MICRO-R METER SOURCE CHECK

Instrument Information				Source Information			
Inst Model		**Detector Model**		**Nuclide**		**Activity (dpm)**	
Inst ID		**Detector ID**		**PIKA #**		**Activity (uCi)**	
Cal Due		**Cal Due**		**Mfg. ID**		**Cert Date**	

Acceptance Data	**Avg Net uR/hr**		**-20%**		**+20%**	

Visual Inspection					Source Counts				Performed		
[1]Battery Voltage	[2]High Voltage	Cable	[2]Speaker	Display	Source uR/hr	BKG uR/hr	Source Net uR/hr	Pass / Fail	By	Date	Time

Comments:	**Reviewed by:**
	Date:

Note 1: if available, record the actual battery voltage. Otherwise record SAT or UNSAT.
Note 2: record NA if the instrument does not have this feature.

PIKAP-008

PROCEDURE

Radiation and Contamination Surveys

PIKA International, Inc.
12919 Southwest Freeway, #190
Stafford, TX 77477

PIKA

PROCEDURE

APPROVAL PAGE

Procedure Number/Title: PIKAP-008, ***Radiation and Contamination Surveys,*** has been reviewed and approved by the following:

APPROVAL SIGNATURES

Shahrukh Kanga Principal, QA/QC PIKA International, Inc.	Date
: Joel Cehn, CHP Radiation Safety Officer PIKA International, Inc.	Date
Terry Kasnavia President PIKA International, Inc.	Date

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1.0 PURPOSE AND SCOPE

This procedure provides the methods PIKA will use to perform and document radiation and contamination surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results. Adherence to this procedure also provides adequate control of radiation exposures which meets PIKA's goal of maintaining radiation exposures As Low As Reasonably Achievable (ALARA).

This procedure will be used by PIKA personnel to perform radiation and contamination surveys at customer facilities.

2.0 GENERAL

2.1 Definitions

2.1.1 Restricted Area - Also referred to as a Radiological Controlled Area (RCA), is an area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Contamination Survey - A survey technique to determine fixed and removable radioactive contamination on components and facilities.

2.1.3 Radiation Survey - A survey technique to determine radiation exposure rates in areas containing radioactive materials.

2.1.4 ALARA – (As Low As Reasonably Achievable) An approach to radiation exposure control to maintain personnel exposures as far below the federal limits as technical, economical and practical considerations permit.

2.2 Quality Control

2.2.1 Instrumentation used to perform surveys will be physically inspected and response checked with standards daily and verified to have current valid calibration.

2.2.2 All radiation and contamination survey instruments will be calibrated annually.

2.2.3 All radiation and contamination surveys will be reviewed by the Radiation Protection Supervisor or designee to verify accuracy and completeness.

3.0 REFERENCES, RECORDS AND EQUIPMENT

3.1 References

- 10 CFR 20, Subpart F, Surveys and Monitoring
- 10 CFR 20.2103, Records of Surveys
- RSM, Radiation Safety Manual
- PIKAP-001, Operation of Contamination Survey Meters
- PIKAP-002, Alpha-Beta Sample Counting Instrumentation
- PIKAP-003, Operation of Micro-R Survey Meters

- PIKAP-004, Operation of Ionization Chambers
- PIKAP-015, Personnel Protective Equipment, Monitoring and Decontamination

3.2 Records

Administrative forms included in this procedure shall not be modified without the written authorization of the Project Manager and the documented concurrence of the RSO or designee. In no case shall modifications reduce the content required by the original form.

- PIKA Form 8-1, Radiological Survey Report
- PIKA Forms 8-2, 8-2A & 8-2B, Radiation/Contamination Survey
- PIKA Form 8-3, Radiation/Contamination Survey Supplement

3.3 Equipment

- Radiation and Contamination Survey Meters will be selected based on job-specific requirements and, when appropriate, will be identified in the Site Specific Work Plan.

4.0 RESPONSIBILITIES

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of performing radiation and contamination surveys are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in performing radiation and contamination surveys. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM) - The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Health Physics Technicians - Technicians performing radiation and contamination surveys are responsible for knowing and complying with this procedure.

5.0 PROCEDURE

5.1 Discussion

5.1.1 Radiation surveys are performed to detect and assess radiation that may be encountered during a decontamination or decommissioning project.

5.1.2 Contamination surveys are conducted to detect loose surface contamination and fixed contamination. Loose surface contamination is normally detected indirectly by a smear sample or wipe performed on the item or surface of interest. Fixed contamination levels are measured directly. Contaminants may emit alpha or beta particles, gamma radiation, or any combination of these.

5.2 Prerequisites

5.2.1 Obtain and review any site-specific survey plans, and any previous surveys performed in the area.

5.2.2 Obtain appropriate survey instruments and prepare the instruments for use.

5.2.3 Obtain the necessary forms, smears, and protective clothing that will be used during the survey.

5.2.4 Plan the strategy for performing the survey before entering the area to reduce exposure time in the area.

5.2.5 If removable contamination is expected to be above allowable limits, establish access controls to the area that will prevent the spread of contamination from the area.

5.3 Radiation Surveys

5.3.1 Gamma Radiation Surveys

The following guidance shall be used unless an approved site-specific survey/ work instruction directs otherwise.

5.3.1.1 When entering Radiation and High Radiation Areas, select the appropriate scale based on anticipated exposure rates.

5.3.1.2 Observe the meter reading as you enter the area. If necessary, change scales to maintain on-scale reading.

5.3.1.3 If the observed exposure rates are greater than anticipated as the area is entered:

1. Exit the area immediately.
2. Check personnel dosimetry for exposure.
3. Verify proper operation of the instrument.
    a. If the instrument is operating properly, do not re-enter the area.
    b. Contact health physics supervision for guidance.
    c. If the instrument is NOT operating properly, perform the following actions:
        i. Complete and attach an "Out of Service" tag to the faulty instrument.
        ii. Remove the instrument from service.
        iii. Obtain a different instrument that is functioning properly and re-perform the survey.

5.3.1.4 Always survey a sufficient number of locations to determine average and maximum general area and contact radiation levels.

5.3.1.5 Perform General Area gamma exposure rate surveys.

1. Rotate body 360 degrees while performing General Area exposure rates so source of radiation is not shielded.
2. Attempt to determine the source of radiation fields.
3. Monitor exposure rates from the lower thigh to head level on contact and 12 inches (30 cm) from significant radiation sources.
4. Record the highest level as the General Area exposure rate.
5. If exposure rate sources are predominantly from overhead or below lower thigh, denote this on the survey form.

NOTE: The true contact exposure rate may be several times the contact exposure rate indicated by the survey instrument. Determination of the true contact exposure rate will be made by a radiological engineer as necessary when the maximum dimension of the item or hot spot is less than the detector dimensions.

6. Perform contact gamma exposure rate measurements with the detector within ½ inch of the surface to be surveyed.
7. Perform survey at arms length or with an extendable probe instrument.
8. Avoid touching or direct handling of equipment or hot spots until an evaluation of the true contact exposure rate has been performed.
9. Verify the exposure rates of known hot spots only if worker activities are expected in the immediate vicinity of the hot spot.

5.3.2 Beta Radiation Surveys

5.3.2.1 Measure beta exposure rates using an ion chamber with a beta shield. When using a beta shield, a higher reading is obtained with the beta shield open compared with the beta shield closed; this indicates the presence of beta radiation.

5.3.2.2 Measure beta exposure rates at the point of interest. This exposure rate is normally obtained within 4 cm of the surface for extremity exposure rate or at 30 cm for a skin of the whole body or lens of the eye exposure rate.

CAUTION: The window area of the detector is covered with a 7 mg/cm2 aluminized Mylar covering and can be easily punctured. Avoid protruding fragments that might puncture the detector face.

5.3.2.3 To obtain the beta exposure, first obtain a reading with the beta shield closed (CW).) as described in Section 5.3.1. Open the beta shield and obtain a reading (OW) at the same location holding the meter in the same configuration.

5.3.2.4 Determine the beta exposure using the following formula:

Estimated True Beta Exposure = (OW - CW) x BCF

Where OW = Window reading (beta shield open)

CW = Closed Window reading (beta shield closed)

BCF = Beta Correction Factor

BCF = 2 for reading taken at 30 centimeters

BCF = 5 for reading taken at 4 centimeters

NOTE: Beta correction factors presented are for estimation purposes only. Due to the nature of beta radiation, it is incredibly challenging to determine true beta exposure rates in the field and requires extensive sampling, laboratory analysis, and precisely modeled geometries.

5.3.2.5 Beta exposure rates to the skin of the whole body or lens of the eye are obtained in the area where workers will be located during work activities. If only a portion of the workers body will be exposed to the field, the highest exposure rate will be used to determine working time.

5.3.2.6 Beta exposure rates to the extremities are obtained by obtaining measurements at 4 centimeters from the surface contacted by the worker.

5.3.2.7 Document on PIKA Forms 8-1, 8-2 and/or 8-3.

5.4 Removable Contamination Surveys

The following guidance shall be used unless an approved site-specific survey/work instruction directs otherwise. Specific survey instructions will be prepared for radioisotopes requiring unusual sampling techniques, such as tritium.

5.4.1 Removable Contamination Surveys Using Disc Smears

5.4.1.1 Label or number smears, as necessary, to identify each smear.

5.4.1.2 Wipe the smear over approximately 100 cm2 (16 square inches) of the surface to be sampled.

5.4.1.3 Apply moderate pressure.

5.4.1.4 Exercise care on rough surfaces so as not to tear the smear.

5.4.1.5 Exercise care on wet surfaces so as not to degrade the smear. Ensure that surfaces are not submerged in water and that cloth smears or similar are used on wet/damp surfaces.

5.4.1.6 When surveying an area:

1. Obtain smears from sample points which are representative of the average and maximum contamination levels in the area, such as:
   a. Areas of high traffic
   b. On and under benches or tables
   c. Beneath piping and components
   d. On accessible wall surfaces
   e. On piping and significant components
   f. Near drains, sumps and low spots
2. Smear floor and component surfaces which display evidence of (potentially) contaminated water leakage.
3. Pay attention to boundaries between contaminated and clean areas.

5.4.1.7 When surveying equipment:

1. Obtain smears on large surfaces.
2. Obtain smears in cracks or crevices where contamination may have settled.
3. Obtain smears on openings to internal surfaces.

5.4.1.8 Handle smears in a manner that will prevent cross-contamination (e.g., place each smear in a separate envelope).

5.4.2 Field Counting Smears for Beta-Gamma Activity Using a Hand Held Detector

5.4.2.1 Field counting of smears is appropriate for smears taken in known contamination areas. Examples of such surveys include:

1. Routine surveys in contaminated areas
2. Job coverage or pre-job surveys in contaminated areas
3. RWP surveys in contaminated areas
4. Contaminated equipment and materials surveys

5.4.2.2 Areas or equipment may not be released based on field counting results.

5.4.2.3 Allow wet smears to dry prior to counting.

5.4.2.4 Survey the group of smears with a survey meter prior to removal from the envelope or bag.

5.4.2.5 If the radiation level exceeds 50,000 cpm, or greater than 5 mrem/hr, survey each smear separately until the high activity smears have been segregated.

5.4.2.6 Count smears greater than 50,000 cpm or 1 mrem/hr as described in Section 5.3.2 of this procedure.

5.4.2.7 Count the smears in an area with a background of less than 300 cpm.

5.4.2.8 Hold the detector within ½ inch of the smear.

5.4.2.9 Allow the meter reading to stabilize.

5.4.2.10 If the smear sample is less than 50,000 cpm, calculate the sample activity as follows:

$$Sample\ Activity\ {}^{dpm}\!/_{100cm^2} = \frac{Sample\ CPM - BKG\ CPM}{Instrument\ Efficiency\ {}^{CPM}\!/_{dpm}}$$

5.4.2.11 If the smear sample exceeds 50,000 cpm or 1 mrem/hr, evaluate the smear using an Ion Chamber with a beta window.

5.4.2.12 For beta exposure rate, obtain Open Window and Closed Window readings and calculate sample activity as follows:

$$Beta\ Activity\ {}^{mrad}\!/_{hr^2} = (Open\ Window - Closed\ Window) \times Instrument\ BCF$$

Where: BCF = Beta Correction Factor

1. Record beta activity result as mrad/hr.
2. Record closed window reading as mrem/hr.

5.4.2.13 Dispose of contaminated smears as radioactive waste.

5.4.3 Counting smears for alpha or beta-gamma activity using fixed geometry portable counters.

5.4.3.1 The use of fixed geometry portable counters, such as a Ludlum 2929, is appropriate for smears taken in non-contaminated areas of RCAs or outside RCAs. Fixed geometry counters may also be used to count smears taken to release equipment.

5.4.3.2 Scan the group of smears with an RM-14/HP-210 or equivalent prior to removal from the envelope or bag.

1. If the group of smears is greater than 5000 cpm, scan each smear separately until smears greater than 5000 cpm are segregated.
2. Count smears greater than 5000 cpm as described in Section 5.4.2 of this procedure.

5.4.3.3 Count the remaining low-level smears in accordance with the operating procedure for the instrument.

5.4.3.4 Record smear results in dpm/100 cm^2.

5.4.3.5 Dispose of all smears as radioactive waste.

5.4.4 Removable Contamination Surveys Using Large Area Wipes

5.4.4.1 Large area contamination surveys (LAW) are appropriate for monitoring the radiological cleanliness of non-contaminated areas or equipment, to track area decontamination progress, or for initially verifying surfaces are free from contamination.

5.4.4.2 There are no specific requirements concerning the amount of area to be wiped when performing large area smears. The area wiped should be determined based on the use of the survey data.

5.4.4.3 Performing LAWs

1. Use masslinn, oil impregnated cloths, or equivalent to perform large area wipes. Select an appropriate collection material and method based upon the survey conditions such as wet surfaces, rough surfaces, heavily soiled area and oily and greasy surfaces.
2. Label or number the cloths, as necessary, to assist in determining the location of the sample.
3. Determine the size of the area to be sampled based on the use of the results of the survey.
4. Wipe the collection media over the surface using moderate pressure by hand, with a masslinn mop, or other approved techniques.

5.4.5 Evaluating LAWs

5.4.5.1 Allow wet LAW to dry prior to counting.

5.4.5.2 Scan the LAW with an appropriate field instrument, in an area with a low background.

5.4.5.3 Hold the detector within ½ inch of the LAW and move the detector over the LAW at a maximum rate of one detector width per second.

5.4.5.4 If any indication of an increased count rate is noted, pause to allow the meter reading to stabilize.

5.4.5.5 If the LAW reading is indistinguishable from background, consider the surveyed surface to be free from contamination.

5.4.5.6 If the LAW reading is greater, conduct further surveys to isolate the boundaries of the contamination.

5.4.5.7 Dispose of all LAS as contaminated waste.

5.5 Fixed Contamination Surveys

5.5.1 When available, use an instrument with an audible response.

5.5.2 During alpha radiation scanning or frisking, keep the detector within 1/4" of the surface being measured. During beta radiation scanning or frisking, keep the detector within 1/2" of the surface being measured. Scan at a rate not to exceed one detector width per second.

5.5.3 Hold the probe stationary over areas that give an increase in the audible or visual count rates.

5.5.4 Allow the meter to stabilize.

5.5.5 Document results on PIKA Forms 8-1, 8-2 and/or 8-3.

5.5.6 Use one or a combination of the attached survey forms, as appropriate, to document the survey.

5.5.7 If the reading is greater than 50,000 cpm, evaluate the area for beta and gamma exposure rate using an ion chamber as described in Section 5.3.2.

6.0 ATTACHMENTS

PIKA Form 8-1, Radiological Survey Report

PIKA Form 8-2, Radiation/Contamination Survey

PIKA Form 8-2A, Radiation/Contamination Survey (B25 Box)

PIKA Form 8-2B, Radiation/Contamination Survey (Drum)

PIKA Form 8-3, Radiation/Contamination Survey Supplement

ATTACHMENTS

DATE: TIME:	INSTRUMENTATION USED				
SURVEY NUMBER:	**MODEL**	**S/N**	**% EFF.**	**CAL DUE**	**BKGD**
LOCATION:					
SURVEYOR:					
REVIEWED BY:					
RSO/HP:					

Description of drawing:

LOCATIONS AND FIXED / SMEARABLE RESULTS
RESULTS = DPM/100 cm² SMEARABLE
Or DPM/Probe Area FIXED
Circle FIXED (F) or SMEARABLE (S) on each

#	Alpha	Beta/Gamma
1	F S	F S
2	F S	F S
3	F S	F S
4	F S	F S
5	F S	F S
6	F S	F S
7	F S	F S
8	F S	F S
9	F S	F S
10	F S	F S
11	F S	F S
12	F S	F S
13	F S	F S
14	F S	F S
15	F S	F S
16	F S	F S
17	F S	F S
18	F S	F S

Routine ☐ (Daily / Weekly / Monthly) Non-routine ☐

Comments: ______________________________

All radiation readings in μr/hr unless otherwise noted.
(#)….denotes smear location or fixed α/β readings.
#…….denotes G/A radiation readings.
/ #…denotes contact / 1 meter radiation readings.
*………denotes highest radiation reading on contact.
Δ……..denotes A/S location.

DATE: TIME:	INSTRUMENTATION USED				
SURVEY NUMBER:	**MODEL**	**S/N**	**% EFF.**	**CAL DUE**	**BKGD**
LOCATION:					
SURVEYOR:					
REVIEWED BY:					
RSO/HP:					

Description of drawing:

Routine ☐ (Daily / Weekly / Monthly) Non-routine ☐

Comments: ______________________________

All radiation readings in μr/hr unless otherwise noted.
(#)….denotes smear location or fixed α/β readings.
#…….denotes G/A radiation readings.
/ #…denotes contact / 1 meter radiation readings.
*………denotes highest radiation reading on contact.
Δ……..denotes A/S location.

SURVEY NUMBER:								
SURVEYOR:				LOCATION:				
Location	**Exposure Rate (mR/hr)**			**Fixed + Removable**		**Removable**		**Comments**
	Contact	**30 cm**	**1 Meter**	**Alpha dpm/probe**	**Beta/Gamma dpm/probe**	**Alpha dpm/100cm^2**	**Beta/Gamma dpm/100cm^2**	
1								
2								
3								
4								
5								
6								
7								
8								
9								
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PIKAP-018

PROCEDURE

Radioactive Check Sources

PIKA International, Inc.
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PIKA

PROCEDURE

APPROVAL PAGE

Procedure Number/Title: PIKAP-018, ***Radioactive Check Sources,*** has been reviewed and approved by the following:

APPROVAL SIGNATURES

______________________________	________________
Shahrukh Kanga Principal, QA/QC PIKA International, Inc.	Date
______________________________	________________
Joel Cehn, CHP Radiation Safety Officer PIKA International, Inc.	Date
______________________________	________________
Terry Kasnavia President PIKA International, Inc.	Date

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1.0 PURPOSE AND SCOPE

This procedure describes methods PIKA International, Inc. (PIKA) will utilize for control of instrument check sources used on jobs involving radioactive material. These sources are used to ensure proper radiation detection instrument operation. Adherence to this procedure will provide reasonable assurance that personnel exposures will be below specified limits, sources will not be lost or misplaced, personnel will remain free of contamination and contamination will not be spread beyond any designated contaminated area.

This procedure will be used by PIKA personnel and subcontractors to ensure proper control, use, and storage of radioactive check sources used for portable radiation detectors.

2.0 GENERAL

2.1 Precautions

2.1.1 Individual source quantities shall not exceed exempt quantity limits without permission of the Radiation Safety Officer.

2.1.2 If non-exempt quantity sources are used, the RSO will determine any additional precautions (i.e., finger rings, etc.).

2.1.3 Sealed sources of high activity may exhibit very high dose rates, ensure that a thorough dose rate survey has been performed and documented prior to beginning any leak test evaluation of non-exempt sources.

2.1.4 If dose rates warrant, generate a Radiation Work Permit for leak testing of non-exempt sources.

2.1.5 Radioactive sources shall be controlled by PIKA Radiation Protection personnel.

2.1.6 The storage location will be approved by the Radiation Safety Officer for protection against loss, leakage, or dispersion by the effect of fire or by water.

2.2 Quality Control

Leak tests will be performed at intervals not to exceed six months on all beta and/or gamma emitting sealed sources with an activity greater than 100 microcuries, and at intervals not to exceed three months on all alpha emitting sealed sources with an activity greater than 10 micro curies.

The methods specified in this procedure will be audited annually to ensure compliance with the requirements to control and inventory radioactive sources.

3.0 REFERENCES, RECORDS, AND EQUIPMENT

3.1 References

- PIKA International, Inc. Radioactive Materials License # 42-27787-01
- RSM, Radiation Safety Program Manual
- PIKAP-001, Operation of Contamination Survey Meters
- PIKAP-002, Alpha-Beta Sample Counting Instrumentation
- PIKAP-003, Operation of Micro-R Survey Meters
- PIKAP-004, Operation of Ionization Chambers
- PIKAP-008, Radiation and Contamination Surveys

3.2 Records

Administrative forms included in this procedure shall not be modified without the written authorization of the Project Manager and the documented concurrence of the RSO or designee. In no case shall modifications reduce the content required by the original form.

- PIKA Form 18-1, Sealed Source Inventory and Leak Test Form
- PIKA Form 18-2, Non Exempt Source Leak Test Data Sheet

3.3 Equipment

- Remote smear handing assembly
- Liquid cleaner (if recommended by source manufacturer)
- Smears
- Portable radiation detection equipment
- Radioactivity counting equipment
- Calibration sources

4.0 RESPONSIBILITIES

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the tasks of control and leak testing of sealed sources of radioactive material, are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

4.2 Radiation Safety Officer - The Radiation Safety Officer (RSO) is responsible for training of personnel working with radioactive sources and for ensuring that leak tests are conducted at the required frequency. The RSO ensures the Health Physics Technicians are qualified by training and experience to perform the requirements of this procedure.

4.3 Project Manager - The Project Manager is responsible for ensuring the conditions of this procedure are complied with during all project operations.

4.4 Health Physics Technicians - Health Physics Technicians are responsible for control and use of radioactive check sources.

5.0 PROCEDURE

5.1 Possession

Only qualified Radiation Protection personnel may use or possess PIKA radioactive check sources.

5.2 Source File Maintenance

The Radiation Safety Officer (RSO) prepares and maintains a source file which shall, at a minimum, consist of the following:

5.2.1 Procurement history of each source including copies of seller certification;

5.2.2 Status change - damage, sale or transfer, or disposal, or recalibration;

5.2.3 A completed PIKA Form 18-1, Sealed Source Inventory and Leak Test, and

5.2.4 Any other correspondence related to the sources.

5.3 Physical Inventory

A physical inventory of all instrument check sources will be conducted by the RSO or designee at least once each quarter and whenever a new check source is received or an old check source is disposed. The results shall be recorded on PIKA Form 18-1 and shall be retained in the source file for a period of not less than three years.

5.4 Leak Tests of Exempt Quantity Sources

Although leak tests are not required for exempt quantity sealed sources, in the event a source is suspected of having a loss of encapsulation or other possible leakage, the following procedure shall be followed, wearing gloves or using tongs:

5.4.1 A visual inspection of the source shall be made for physical damage;

5.4.2 One of the following tests shall be used to determine source leakage when it is required:

5.4.3 NOTE: Any evaluation of the leakage of radioactive material from sources shall not cause violation of the source container in any way.

5.4.3.1 Dry Wipe Test - This test will be performed on encapsulated sources or adjacent surfaces of plated or foil sources. The sources shall be wiped with dry disc smear with the application of moderate pressure. Removal of any radioactive material from the source or adjacent surfaces will be determined by counting the filter paper with appropriate instrumentation.

5.4.3.2 Wet Wipe Test - This test will be performed on encapsulated sources only. The entire surface of the source shall be wiped with disc smear moistened with water, with the application of moderate pressure. Removal of any radioactive material from the source will be determined by counting the filter paper with an appropriate detection instrument after the filter paper has dried out.

5.4.4 When any contamination or leak test reveals the presence of 0.005 µCi or more of removable contamination, or activity removed is above the minimum sensitivity of the detecting instrument the source shall be retested. The source will be either repaired, if possible, or disposed of as radioactive waste if the second test is unsatisfactory. The results of the leak test for the sources are recorded on PIKA Form 18-1 and shall be retained for a minimum of three years.

5.5 Leak Tests of Non Exempt Quantity Sources

5.5.1 Precautions and Initial Preparations

5.5.1.1 Select an area to conduct the leak test that is free of radioactive contamination.

5.5.1.2 Select instruments that are capable of measuring activity associated with the source of interest and capable of detecting at least 0.005 microcuries of the radionuclide of concern.

5.5.1.3 Prepare ethanol, propanol, or DI water in a nearby container as appropriate for the equipment being tested. Specific solutions may be mentioned in vendor documentation. If they are, use the solutions required by the vendor.

5.5.1.4 Inform the RSO or designee of the source leak test to be done. The RSO or designee will evaluate the test and provide precautionary measures to ensure protection of people and equipment in the work area.

5.5.1.5 Be aware of other counting equipment in the area of the source. Inform counting room personnel that they may experience increased count rates during source exposure for the leak test.

Sealed sources of high activity may cause extremely high dose rates that may result in physical damage to your body. The leak testing of high activity sources will be controlled by a specific RWP. Methods used to minimize the risk of exposure to personnel such as the use of remote operating devices will be detailed in the RWP.

5.5.1.6 Use a cloth smear to contact the outside surface of the source. This smear will be the leak test sample that must be analyzed for activity associated with a potentially leaking source. **If the source certificate contains a precautionary statement that directs users of the source not to touch the source surface, then the wipe sample should be obtained from other accessible surfaces of the source and the accessible interior surfaces of the source container**.

5.5.1.7 Exercise caution when handling the leak test sample to prevent the spread of contamination should the sample have loose surface activity from a leaking source.

5.5.1.8 If the source emits particulate radiation, the radioactive material will typically be covered by a very thin material for protection of the source surface. Take special precautions to prevent damage to the material during the leak test.

5.5.1.9 Be sure to wear laboratory gloves when handing equipment associated with the test or the leak test samples.

5.5.2 Analysis

The leak test sample shall be analyzed using PIKA instrument procedures in a manner that will ensure detection of at least 0.005 microcuries of the radionuclide of interest. The results of the leak test are documented on PIKA Form 18-2, Non Exempt Source Leak Test Data Sheet.

If the activity of the leak test sample exceeds the leak test limit of 0.005 microcuries, then properly remove the source from service to prevent further spread of contamination. Notify the RSO and Project Manager. Conduct a detailed survey of the leak test work area and other areas where the source was used or stored to ensure proper identification and control of any contamination.

5.6 Storage Locker

The on-contact radiation level exterior to the source storage locker shall be maintained at less than 2 millirem per hour on any accessible surface. A radiation survey of the storage locker shall be performed at least quarterly and immediately after the receipt of any additional check sources.

5.7 Action Levels

5.7.1 Inventory

The Radiation Safety Officer shall be notified immediately if it has been determined that a source is missing. An immediate search shall be conducted and the Project Manager notified.

5.7.2 Leakage

When any contamination or leak test reveals the presence of 0.005 µCi or more, the Radiation Safety Officer shall be notified immediately. Corrective action shall be taken to repair the source or dispose of the source as radioactive waste.

5.7.3 Radiation Levels

Radiation levels shall be maintained at less than 2 millirem per hour on contact with the source storage area.

6.0 ATTACHMENTS

PIKA Form 18-1, Sealed Source Inventory and Leak Test

PIKA Form 18-2, Non Exempt Source Leak Test Data Sheet

ATTACHMENTS

PIKA International, Inc.

SEALED SOURCE INVENTORY AND LEAK TEST

Inventory Period: First Qtr. ☐ Second Qtr. ☐ Third Qtr. ☐ Fourth Qtr. ☐

Date Performed: ________ By: ______________________________
Print / Sign

Reviewed/Approved By: ______________________________ Date: ____________
Print / Sign

Isotope	Source (Type / Form)	Serial Number	Location	Initial Activity	Corrected Activity	Leak Test dpm/smear	Leak Test µCi/smear

Note and provide discussion for any problems that are encountered.

____

____

____

PIKA International, Inc.

NON-EXEMPT SOURCE LEAK TEST DATA SHEET

Applicability: This form shall be used for recording all information regarding the leak testing of non-exempt sources of radioactive material.

SOURCE INFORMATION

Source ID Number: ______________________

Source Manufacturer: ______________________

Date of Source Assay: ______ / _____ / ______

Source Model Number: ______________________

Source Serial Number: ______________________

Activity of Source at Assay Date: ________ Ci

Radionuclide name: ____________________

Half-life of radionuclide: ______________________

Activity of source Today: _______________ Ci

LEAK TEST SAMPLE INFORMATION ________________ **Date** ________________

Location of Leak Test work Area: ____

Describe the method of leak testing: ____

____

Sample Geometry: __________________________

Detector: ______________________________

Detection Efficiency: ________________________ c/d

Background count time: ______ minutes

Background count rate: ___________ count/minutes

MDA: ________________ microcuries

Sample net count rate: __________________________

Sample count time: ______ minutes

Leak test sample activity: __________________________ microcuries

LEAK TEST RESULT – *Check all boxes that apply*

- ☐ The leak test sample is in excess of the 0.005 microcurie unit.
- ☐ The leak test sample is below the 0.005 microcurie limit.
- ☐ The source has been controlled to prevent spread of activity from the shield.
- ☐ The source has been released to the operators for continued use.

Source Leak Test Performed By: ___________________________ Date: ______ / _____ / ______

Leak Test Analysis Conducted By: ___________________________ Date: ______ / _____ / ______

Radiation Safety Officer: ___________________________ Date: ______ / _____ / ______

PIKAP-020

PROCEDURE

Unconditional Release of Materials from Radiological Controls

PIKA International, Inc.
12919 Southwest Freeway, #190
Stafford, TX 77477

PIKA

PROCEDURE

APPROVAL PAGE

Procedure Number/Title: PIKAP-020, ***Unconditional Release of Materials from Radiological Controls,*** has been reviewed and approved by the following:

APPROVAL SIGNATURES

Shahrukh Kanga Principal, QA/QC PIKA International, Inc.	Date
Joel Cehn, CHP Radiation Safety Officer PIKA International, Inc.	Date
Terry Kasnavia President PIKA International, Inc.	Date

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1.0 PURPOSE AND SCOPE

The purpose of this procedure is to specify requirements for releasing material from controlled areas and to minimize the potential for unintentionally releasing contaminated items to uncontrolled areas in accordance with the provisions of references in section 3.

This procedure provides instructions for performing release surveys of items controlled as contaminated or potentially contaminated with radioactive materials.

This procedure will be used to ensure by survey that all materials released from contaminated or potentially contaminated areas will meet the release criteria applicable to the license conditions, facility requirements, or as specified in regulations or guidance provided by applicable regulatory agencies of the federal or state government.

2.0 GENERAL

2.1 Definitions

2.1.1 Activity – The rate of disintegration (transformation) or decay of radioactive materials. The units of activity for the purpose of this procedure are disintegrations per minute (dpm), Becquerel (Bq), or micro-Curies.

2.1.2 Contamination – Deposition of radioactive material in any place where it is not desired particularly where its presence may be harmful. The harm may be actual exposure to individuals or release of the material to the environment or general public. Contamination may be due to the presence of alpha particle, beta particle or gamma ray emitting radionuclides.

2.1.3 Restricted Area – also referred to as a Radiological Control Area (RCA), is an area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials and/or to prevent the release of radioactive materials to the uncontrolled areas.

2.1.4 Fixed Contamination – radioactive contamination that is not readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk smear, or masslin.

2.1.5 Minimum Detectable Activity (MDA) – for purposes of this procedure, MDA for removable radioactive contamination is defined as the smallest amount of sample activity that will yield a net count with a 95% confidence level based upon the background count rate of the counting instrument used.

2.1.6 Senior Health Physics Technician – An individual designated by the Radiation Safety Officer to evaluate materials or items in accordance with Sections 5.2 and 5.3.

2.1.7 Release for Unconditional Use – A level of radioactive material that is acceptable for use of property without restrictions. Under normal circumstances, authorized limits for residual radioactive material are set equal to, or below, the values specified in Regulatory guide 1.86, Termination of Operating Licenses for Nuclear reactors, Table 1.

2.1.8 Survey Exempt Materials – the contents of sealed containers that remain unopened while in a controlled area are exempt; the outside surfaces are not exempt.

2.2 Precautions

2.2.1 Instruments used to perform release surveys shall be operated in accordance with their respective operating procedure:

2.2.2 Large area smears may be used to augment (but not replace) the 100 cm2 smear survey.

2.2.3 Radiation/contamination surveys shall be performed in accordance with PIKAP-008, Radiation and Contamination Surveys.

2.2.4 Audible response instruments must be used during direct scan surveys.

2.2.5 Items presented for unconditional release shall be direct scanned in an area of low background.

2.3 Quality Control

Instrumentation used in the surveys will be checked with standards daily and verified to have current valid calibration.

When releasing large amounts of materials, a program shall be established to ensure by second check that no radioactive material is released to the public or the environment.

2.4 Limitations

2.4.1 The maximum probe speed during direct scan surveys of surfaces shall be 3 cm/sec.

2.4.2 A response check shall be performed at the completion of the workday for instruments used for direct scan surveys in accordance with the instrument's operating procedure.

2.4.3 The probe face shall be held within ¼ inch of the surface being surveyed for alpha radiation, and within ½ inch of the surface being surveyed for beta-gamma radiation.

2.4.4 If an instrument used to perform release surveys fails any operational check, it shall be removed from service. All datum collected during the period of instrument failure must be evaluated by the Health Physics supervisor.

3.0 REFERENCES, RECORDS AND EQUIPMENT

3.1 References

- 10 CFR 20, Standards for Protection Against Radiation
- Reg Guide 1.86, Termination of Operating Licenses for Nuclear Reactors
- RSM, Radiation Safety Manual
- PIKAP-001, Operation of Contamination Survey Meters
- PIKAP-002, Alpha-Beta Sample Counting Instrumentation
- PIKAP-003, Operation of Micro-R Survey Meters
- PIKAP-008, Radiation and Contamination Surveys
- PIKAP-012, Radiological Controlled Areas

3.2 Records

Administrative forms included in this procedure shall not be modified without the written authorization of the Project Manager and the documented concurrence of the RSO or designee. In no case shall modifications reduce the content required by the original form.

- PIKA Form 20-1, Unconditional Release Log

3.3 Equipment

- Radiation detection instruments,
- Survey supplies such as disc smears and large area wipes.

4.0 RESPONSIBILITIES

4.1 Program Manager - The program Manager is responsible for ensuring that all personnel assigned the task of unconditionally releasing materials from controlled areas are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

4.2 Radiation Safety Officer - The Radiation Safety Officer (RSO) is responsible for training personnel performing surveys described in this procedure. The RSO ensures the Health Physics Technicians are qualified by training and experience to perform the requirements of this procedure.

4.3 Project Manager - The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Health Physics Technician - Health Physics Technicians are responsible for performing the surveys described in this procedure.

5.0 PROCEDURE

5.1 Release Limits For Gross Activity (Unknown Isotopes)

EMISSION	REMOVABLE dpm/100 cm^2	TOTAL (Fixed and Removable) dpm/100 cm^2
Alpha	20	100
Beta-Gamma	200	1000
NOTE: If all of the project isotopes are known and documented, the release limits of Table 1 of Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors or the most current regulatory guidance, shall apply.		

5.2 Protocols for Inaccessible Surfaces

5.2.1 Items with inaccessible surfaces should be disassembled as completely as possible to facilitate release surveys. Items with inaccessible surfaces will not be unconditionally released unless evaluated and documented by the RSO or designee.

5.2.2 The following guidance will be used when performing evaluations:

- A history of the item should be reviewed.
- The release survey shall be reviewed.
- Determination of the radiological conditions in the area the item has been used or stored shall be reviewed.
- Use of gamma radiation sensitive detectors such as NaI(T1) or equivalent should be considered. (These detectors may indicate internal contamination that a beta sensitive detector may not detect due to the beta detector's lack of sensitivity to photon emissions).

5.2.3 Hazardous or Fragile Materials

Materials considered hazardous due to their physical or chemical nature and fragile items shall not be unconditionally released unless evaluated. For example, gases, pyrophoric materials, easily damaged electronic devices, or other easily damaged materials cannot be directly or indirectly surveyed. These materials will be evaluated on a case by case basis for release in a manner consistent with Section 5.2.2.

5.3 Survey Exempt Materials

5.3.1 Items such as briefcases, pens, papers, personal clothing, etc., are exempt from the Health Physics release survey requirements of this procedure if they are not casually used in a contaminated area.

5.3.2 Individuals shall survey the exempt items in the same manner as a whole body frisk when leaving a controlled area or have a Health Physics Technician perform the survey.

5.4 Survey Procedure

5.4.1 Upon receipt of an item presented for unconditional release, attempt to determine the history:

- Purpose of item.
- The current and past use of the item.
- The location(s) in which the item was used or stored.
- If the item was ever used for work with radioactive material or used in an area where radioactive material was used or stored.

NOTE: This knowledge of the item history should provide the surveyor with information helpful in performing the release survey.

5.4.2 Using protective clothing such as gloves, perform a survey for removable contamination on all accessible surfaces of the item using large area wipes (e.g. masslinn).

If the presence of radioactive material is indicated on the large area wipe by a count rate above background, the item shall be treated as contaminated until the contamination is properly quantified.

5.4.3 Perform a direct scan survey on all accessible surfaces of the item.

NOTE: Items presented for release shall be direct scanned in an area of low background. Preferably < 100 CPM. The Health Physics Technician performing the release survey shall determine if the background is acceptable for direct scan of the item.

5.4.3.1 If the scan indicates radioactive material on the surface of the item is less than the limits for release for total activity, proceed to c.

5.4.3.2 If the scan indicates radioactive material on the surface of the item is greater than regulatory limits for total activity the item cannot be released.

5.4.3.3 During the direct scan of the accessible surfaces of the item, a static measurement shall be taken If an increase in the audible count rate is detected. During the static measurement, the meter probe shall be held at the proper distance from the surface being surveyed for the proper response period to allow the meter reading to stabilize.

5.4.4 Perform disc smears on the accessible surfaces of the item.

5.4.5 Count the smears and documents the results in accordance with PIKAP-008 and /or PIKAP-002, as appropriate.

5.4.5.1 If the smear results indicate removable activity below the release limits, proceed to Step 5.4.6.

5.4.5.2 If the smear results indicate removable activity above the release limits, the item cannot be released.

5.4.6 If the item has internal or inaccessible surfaces, PIKA personnel will disassemble the item and repeat steps 5.4.2 through 5.4.5 or have the item evaluated for release by the RSO or designee.

5.4.7 Items identified as radioactive during the release survey shall be controlled in accordance with PIKAP-012, Radiological Controlled Areas.

5.4.8 If the item meets the unconditional release criteria, complete PIKA Form 20-1. Health Physics Supervision must review the survey record and the unconditional release log, and approve the release before the item is allowed to leave the radiologically controlled area.

6.0 ATTACHMENTS

PIKA Form 20-1, Unconditional Release Log

ATTACHMENTS

PIKA International Inc. ***Unconditional Release Log***

Project Name: ______________________________ Project #: ________________

Date	Survey Number	Item, Component, or Equipment Description	Surveyed by (Print / initials)	Release approved by HPS (Print / sign)

Reviewed by RSO or designee____________________________________Date....______________

LUDLUM MODEL 12
SURVEY METER

June 2007

Serial Number 218039 and Succeeding

Serial Numbers

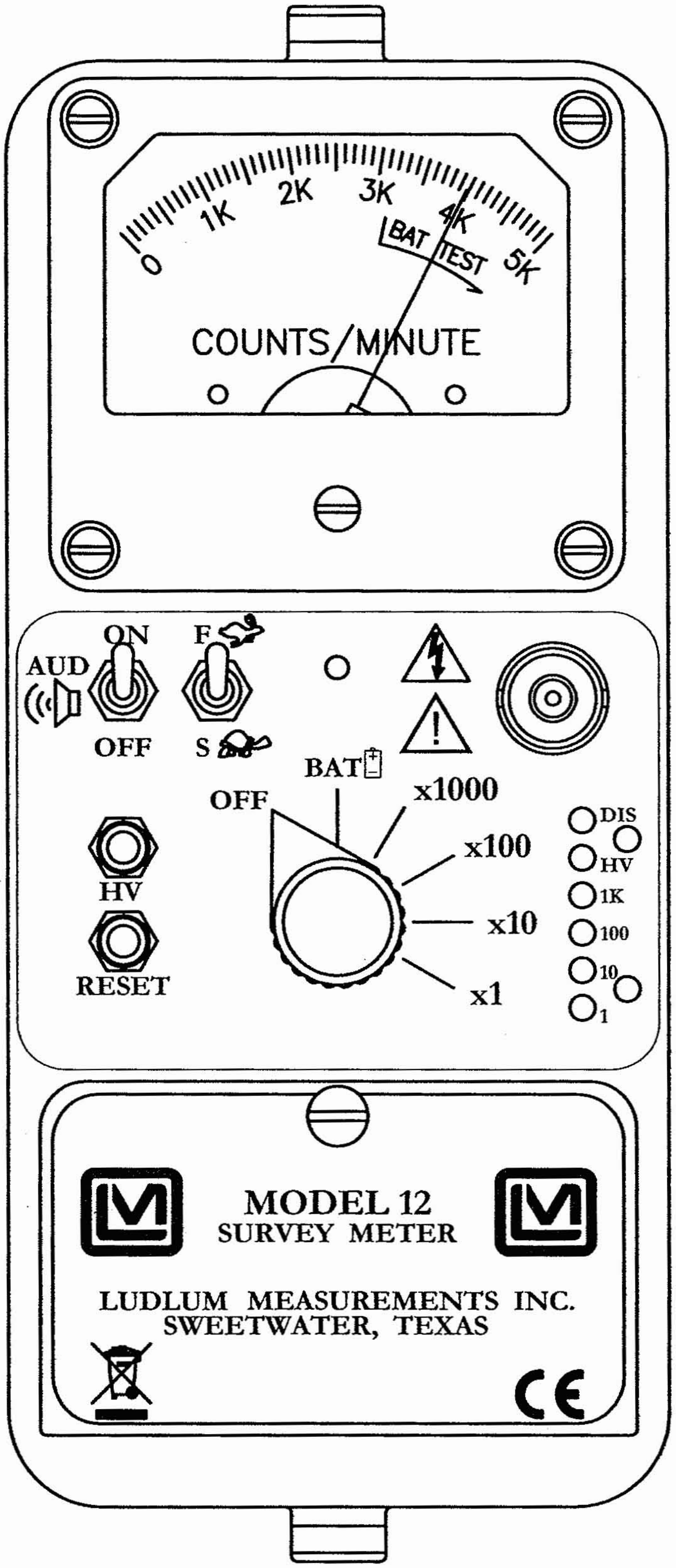
LUDLUM MODEL 12
SURVEY METER

June 2007

Serial Number 218039 and Succeeding Serial Numbers

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

REV #	ALTERATIONS	DATE	BY
1	VALID	2/15/06	PW
2	UPDATED BATTERY LID	8/12/06	CMC
3	ADDED RESET BUTTON	4/25/07	CMC



DWN	DATE	CHK	DATE	APP	DATE
CMC	4-25-07			KGO	4-26-07

PART NUM: 4464-277 | SCALE: FULL ☒ OTHER

TITLE M 12 CASTING ASSY

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 464 | SHEET 300A

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Section 1

Introduction

The Model 12 is a portable Survey Meter with four linear ranges used in combination with exposure rate or CPM meter dials. The instrument features a regulated high-voltage power supply, unimorph speaker with audio ON-OFF capability, fast-slow meter response, meter reset button and a six-position switch for selecting battery check or range multiples of ×1, ×10, ×100 and ×1000. Each range multiplier has its own calibration potentiometer. The unit body and meter housing are made of cast aluminum and the can is 0.090" thick aluminum.

The audio provides a brief "click" for every radiation event detected. It also provides a steady tone to warn the user of a low battery condition. This low battery warning overrides the position of the AUD ON-OFF switch.

With an adjustable detector voltage of 200-2500 volts and adjustable discriminator of 1-100 millivolts, this unit can be operated with most proportional, scintillation or G-M detectors. Scintillation detectors will require voltage divider circuit resistance in excess of 50 megohms.

The unit is operated with two "D" cell batteries for operation from –4°F (–20°C) to 122°F (50°C). For instrument operation below 32°F (0°C) either very fresh alkaline or rechargeable NiCd batteries should be used.

Section 2

Getting Started

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 12 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!

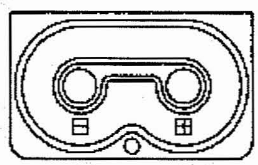
If multiple shipments are received, ensure that the detectors and instruments are not interchanged. Each instrument is calibrated to specific detectors, and therefore not interchangeable.

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 12 range selector switch is in the OFF position. Open the battery lid by pushing down and turning the quarter-turn thumbscrew counterclockwise ¼ turn. Install two "D" size batteries in the compartment.



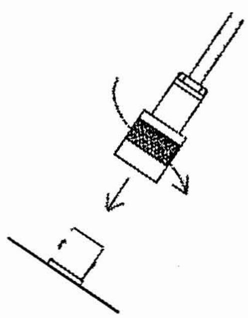
Note the (+) and (-) marks inside the battery door. Match the battery polarity to these marks. Close the battery box lid, push down and turn the quarter-turn thumb screw clockwise ¼ turn.

Note:

The center post of a "D" size battery is positive.

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 12 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 ¼ turn. Repeat the process in the same manner with the other end of the cable and the instrument.

Battery Test

Check the batteries daily or prior to use, whichever is less frequent, to assure proper operation of the instrument. Move the range multiplier 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 ×1000 position. Place the AUD ON-OFF switch in the ON 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.

The detector cable can be a source of problems. Test the detector cable by bending and flexing either end of the cable and checking for an increase in the rate of counts detected. Replace the cable if an increase in the rate of counts is detected.

Check the meter reset function by depressing the RES pushbutton switch and ensuring the meter needle drops to "0".

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

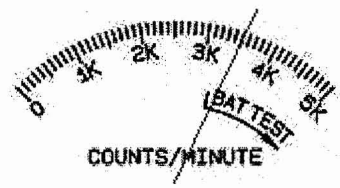
Reading the Meter Face Dial

Reading the meter face is very important for consistent measurements. There are, in general, three types of meter faces: 1) count rate (typically cpm – counts per minute) 2) exposure rate (typically mR/hr) and 3) "combo" (typically cpm and mR/hr.) The following examples are intended to help the user interpret the correct reading.

The normal procedure is to turn the range selector switch to the highest range and if no readings are seen on the meter, turn the selector switch down to the lower scales until a reading is seen. The ranges on the instrument selector switch are multipliers for the meter reading. A typical single scale (one arc) meter face with a cpm (counts per minute) dial is shown below.

The count rate scale reads 0-5K COUNTS/MINUTE (kcpm or 1000's of counts per minute) and has BAT TEST on the dial.

If the needle is pointing as indicated below and the instrument range selection switch is on the ×0.1 scale multiple, then the reading is 3.5 kcpm (multiplied by) ×0.1 = 350cpm.



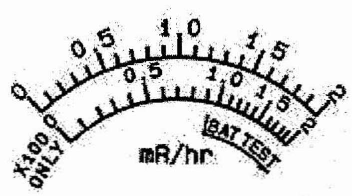
The same needle indications on successive ranges would be:

×1 = 3.5 kcpm (or 3,500 cpm)

×10 = 35 kcpm (or 35,000 cpm)

×100 = 350 kcpm (or 350,000 cpm)

A typical dual scale (two arcs) meter face is shown below. The top scale reads 0-2 mR/hr. The bottom scale also reads 0-2 mR/hr and is for ×100 only scale. The ×100 ONLY scale will work correctly when the multiplier switch is in the ×100 range. The meter face also has a BAT TEST position on the dial.



If the needle is pointing as indicated below and the range selection switch is on the ×0.1 scale, then the reading is 0.1 mR/hr.

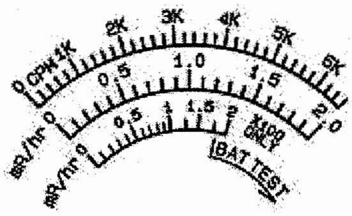
The same needle indications on successive ranges would be:

×1 = 1.0 mR/hr (or 1,000 μR/hr)

×10 = 10 mR/hr (or 10,000 μR/hr)

×100 = 70 mR/hr (or 70,000 μR/hr)

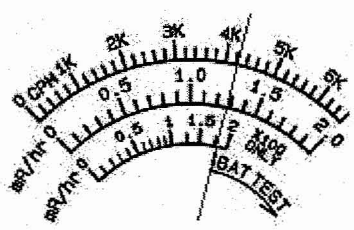
The dial shown below has three arcs: a counts per minute scale (cpm), a linear mR/hr scale, and a non-linear mR/hr scale for the ×100 range only. The meter face also has a BAT TEST position.



The top cpm scale is valid for the ×0.1, ×1, ×10 and the ×100 ranges. The linear (middle) mR/hr scale is valid for the ×0.1, ×1 and×10 ranges. The non-linear mR/hr scale is valid for the ×100 range only. This meter face is commonly referred to as a "combo" meter face, since it has both, count rate (cpm) and exposure rate (mR/hr) arcs. Simpler meter faces may only have a count rate or an exposure rate arc(s) like the previous meter faces shown.

A "combo" meter face is specifically designed for a particular detector. In the example above, the 1.0 mR/hr mark on the middle arc lines up with 3.3kcpm on the upper arc. The meter face in this example works with a detector that receives 3.3kcpm per mR/hr (the Ludlum Model 44-9 pancake detector.)

In the following picture, the needle is on the first tick mark past the 4kcpm mark. Therefore, if the instrument selector switch is on the ×0.1 range, the reading is 4.2kcpm (multiplied by) ×0.1 = 420cpm.



The same needle indications on successive ranges would be:

×1 = 4.2kcpm (or 4,200 cpm)

×10 = 42kcpm (or 42,000 cpm)

×100 = 420kcpm (or 420,000 cpm)

If you use the mR/hr scales, then the readings would be:

×0.1 = 0.13 mR/hr

×1 = 1.3 mR/hr

×10 = 13 mR/hr

×100 = 180 mR/hr*

Note:

*This reading is using the bottom (non-linear) scale.

Many different dials are available, but each can be used as described above.

Operational Check

To assure proper operation of the instrument and detector(s) between calibrations, an instrument operational check including battery test and instrument test (as described above) should be performed at least daily or prior to use, whichever is less frequent. A reference reading(s) with a check source should be obtained with the detector(s) in a constant and reproducible manner at the time of calibration or at the time the instrument is received in the field.

If at anytime the instrument fails to read within 20% of the reference reading when using the same check source, it should be sent to a calibration facility for recalibration and/or repair. If desired, multiple readings may be taken at different distances and/or with different sources so that other ranges or scales are checked.

Section 3

Specifications

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

Battery Life: typically 2000 hours with alkaline batteries (battery condition may be checked on the meter).

End-of-Battery Life Warning: At 2.1 Vdc the meter needle will drop to the edge of the BAT TEST or BAT OK area when the meter selector switch is moved to the BAT position. At 2.0 Vdc a steady audible tone will be emitted to warn the user of the low battery condition.

Multipliers: ×1, ×10, ×100 and ×1000 selected by a front panel range selector switch.

High Voltage: adjustable from 200 to 2,500 volts; can be read on the meter; electronically regulated to 1%; support of scintillation loads to 1,500 volts, proportional loads to 2,500 volts.

Sensitivity: adjustable from 1 to 100 mV.

Input Impedance: 0.1 megohm.

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

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

Range: typically 0-500,000 counts/minute (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 2 feet).

Response: toggle switch for FAST (4 seconds) or SLOW (22 seconds) from 10% to 90% of final reading

Connector: series ″C″ (other available).

Reset: pushbutton to zero the meter.

Size: 6.5"(16.5 cm) H × 3.5" (8.9 cm) W × 8.5" (21.6 cm) L.

Weight: 3.5 lbs. (1.6 kg), including batteries.

Construction: cast and drawn aluminum with beige powder-coating.

Cable: 39-inch with ″C″ connector.

Section 4

Identification of Controls and Functions

See the M 12 FRONT PANEL drawing at the beginning of this manual to reference the following controls:

(A) Meter: 2.5" (6.4cm) arc, 1 mA analog type with pivot-and-jewel suspension. Typical meter dials are 0-0.2 mR/hr, 0-2.0 μSv/h, 0-500 cpm or combination of exposure rates (0-0.2 mR/hr or 0-2.0 μSv/h) and cpm and BAT TEST.

(B) Connector: Used to connect the detector to the instrument. Typically series ″C″ but can be ″BNC″, ″MHV″, ″UHF″ or others.

(C) Range Selector Switch: A six-position switch marked OFF, BAT, ×1000, ×100, ×10, ×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 (×1000, ×100, ×10, ×1) provides the operator with four decades of an overall range. Multiply the scale reading by the multiplier to determine the actual scale reading.

(D) Discriminator Adjustment: Allows the input sensitivity to be adjusted from 1 to 100 millivolts.

(D) HV Adjustment: Provides a means of varying the high voltage from 200 to 2500 volts.

(D) Range Calibration Adjustment: 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.

(E) Battery Compartment: Sealed compartment to house two ″D″ cell batteries.

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

(G) 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.

Note:

A low battery condition results in a steady audio tone regardless of the position of the AUD ON/OFF switch.

(H) 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.

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.

(I) HV Pushbutton Switch: When depressed, displays the detector high voltage on the meter. The output resistance of the high voltage supply is 1.5 megohms with a typical scintillation voltage divider of 100 megohms. The actual detector voltage will be 98.5% of the indicated voltage.

Section

5

Safety Considerations

Environmental Conditions for Normal Use

The detector may be affected by altitude by altitude. Refer to the detector manual for more informantion.

Indoor or outdoor use

No maximum altitude

Temperature range of –20°C to 50°C (–4°F to 122°F). May be certified for operation from –40°C to 65°C (–40°F to 150°F)

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

Pollution Degree 1 (as defined by IEC 664)

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 12 Survey Meter 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 1 minute before accessing internal components.

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 on the battery compartment lid. See section 9, "Recycling" for further information.

Cleaning and Maintenance Precautions

The Model 12 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 1 minute before cleaning the exterior or accessing any internal components for maintenance.

Section

6

Calibration and Maintenance

Calibration

Calibration controls are located on the front of the instrument under the calibration cover. The controls may be adjusted with a 1/8-inch blade screwdriver.

Note:

Local procedures may supersede the following

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

Connect the input of the instrument to a negative pulse generator, such as a Ludlum Model 500 Pulser.

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 following 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 target 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.

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, calibrate each succeeding range by increasing (or decreasing) this rate by a factor of ten for each.

Internal Calibration after Overhaul

Connect instrument to a Model 500 Pulser. Adjust the front panel HV adjustment for a Pulser high voltage meter reading of 1500 volts. Depress the HV pushbutton while adjusting the main board HV SET potentiometer (R38) for a Model 12 meter reading of 1500 volts.

Establishing an Operating Point

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 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.

Adjusting either the instrument gain or the high voltage controls the total system gain. Voltage affects control in the probe; DIS (Discriminator) controls the amplifier gain.

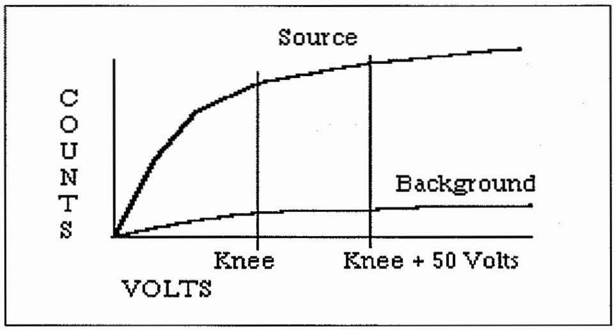
In the special case of G-M detectors, a minimum voltage must be applied to establish the Geiger-Mueller characteristic. Further changes in gain will not affect this type of probe.

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. 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 the 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, plot a HV versus count rate curve to produce a plateau graph similar to the one on the following page. Then set DIS on the low side of center. For mixed detector use, both sensitivity and high voltage may be adjusted for the other detectors as long as the high voltage setting is above the minimum required by the G-M tube.



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.

Air Proportional Alpha Detectors: Set the DIS for one-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.

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.

Maintenance

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and the calibration. The Model 12 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 1 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 manufacturer's 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 100°F.

Section 7

Troubleshooting

Occasionally, you may encounter problems with your LMI instrument or detector that may be repaired or resolved in the field, saving turnaround 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 G-M, Scintillator or Proportional Detector

SYMPTOM	POSSIBLE SOLUTION
no power (or meter does not reach BAT TEST or BAT OK mark)	1. Check batteries and replace if weak. 2. Check polarity (See marks inside batter lid). Are the batteries installed backwards?

SYMPTOM	POSSIBLE SOLUTION
no power (or meter does not reach BAT TEST or BAT OK mark) (continued)	3. Check battery contacts. Clean them with rough sandpaper or use an engraver to clean the tips.
	4. Check for loose or broken wires, especially between the main board and the calibration board.
nonlinear 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, placing the instrument on the lowest range setting, and wiggling the cable while observing the meter face for significant changes in readings.
	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 OFF. The meter should come to rest on "0".
meter goes full-scale or "pegs out"	1. Replace the detector cable to determine whether or not the cable has failed- causing excessive noise.
	2. Check the HV and, if possible, the input threshold for proper setting.

SYMPTOM	**POSSIBLE SOLUTION**
meter goes full-scale or "pegs out" (continued)	3. Check for loose wires, especially between the main board and the calibration board.
	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.
no response to radiation	1. Substitute a "known good" detector and/or cable.
	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.
no audio	1. Ensure that the AUD ON-OFF switch is in the ON position.
	2. Remove the instrument housing and check the connection between the circuit board and the speaker. Plug in the 2-pin connector if necessary.

Troubleshooting G-M 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 G-M 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 mylar window assembly will usually fix the problem.

Note:

When replacing the window, make sure to use a window made with the same thickness mylar 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 ^3He detectors typically require a 2 mV threshold and about 1700 Vdc. Neutron 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 200°F.

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

Section 8

Technical Theory of Operation

MAIN BOARD (Drawing 464 × 275 3 sheets)

Input

Detector pulses are coupled through C16 to emitter follower Q4. R42 provides 3.7 volt bias. R41 couples to detector high voltage. CR3 protects the input from high voltage transients.

Amplifier

A self-biased amplifier provides gain in proportion to R15 divided by R14 and R47. Transistor (pin 3 of U4) provides amplification. U6 is coupled as current mirror to provide a load for pin 3 of U4. The output self-biases to 2 Vbe (approximately 1.4 volts) at emitter of Q1.

Positive pulses from Q1 are coupled to the discriminator U8. Amplifier gain is controlled by R47.

Discriminator

Comparator U8 has a fixed discrimination of 15 millivolts. Any pulse above 15 millivolts causes the output of U8 to go low. This negative pulse is coupled to pin 5 of U9A for meter drive and pin 12 of U9B for audio drive. The pulse is also available at pin 3 of P2 for special applications.

Audio

U9B develops a 22 millisecond pulse for each discriminator pulse if audio switch is ON allowing pin 13 of U9B to be high. Pin 10 of U9B is normally low preventing U12 from oscillating. When pulse goes high, U12 oscillates driving the unimorph speaker. U7B is normally closed, but during low battery state, pin 5 of U7B opens, allowing R30 to pull pin 3 of U12 high causing a steady tone even though the audio is OFF.

Scale Ranging

Detector pulses from the discriminator are coupled to univibrator pin 5 of U9A. For each scale, the pulse width of pin 6 of U9A 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 C9 by one count on the ×1 range as 1,000 counts on ×1K range.

Digital Analog Converter

U5 is coupled as a current mirror. For each pulse of current through R24 and equal current is delivered to C9. This charge is drained off by R25. The voltage across C9 is proportional to the incoming count rate.

RateMeter Drive Circuit

Voltage across C9 is measured by voltage follower U10 and Q2. Q2 converts voltage input to a constant current output at Q2 collector. Current flow is controlled by R19. For slow time constant, C17 is switched from the output to parallel C9 at the input. Reset (SW2) shorts the input capacitor. R44 stabilizes U10. Meter current flows through Analog Switch U7A and U16B.

HV Meter Drive

A voltage proportional to high voltage is converted to a constant current drain by voltage follower U13 and Q3. Current flow is controlled by R49. This current is converted to a constant current source by U15, and then coupled to the meter through analog switches U3B.

Battery Test

Battery voltage is connected through R8 through Analog Switch U3A and U16B to the meter.

HV Supply Board (Drawing 464 × 243)

Switching Convertor

High voltage is developed by voltage multiplier CR1 through CR10 and associated capacitors. This multiplier is driven by switching convertor U2 and T1. The convertor is powered by regulated 6 volts from the main board.

Feedback

The high voltage output is reduced 99.9% by voltage divider R4, R5 and R6. The remaining voltage is coupled to the HV meter circuit through R7 and pin 1 of P1. Also, the voltage is coupled through R8 to the switcher feedback input pin 8 of U2.

Voltage Control

The switching convertor U2 and T1 will develop an output voltage at C3 and R4 such that the voltage at pin 8 of U2 stays at 1.24 volts. If voltage at pin 2 is zero, voltage at pin 1 of U1 must be 2.541 volts to maintain 1.24 volts at pin 8 of U2. To obtain 2.541 volts at pin 1 of U2 the output voltage must be 2.541 volts. In like manner, as the voltage at pin 2 of P1 increases to 2.181 volts, the high voltage output will be driven to zero.

Filtering

The high voltage is filtered by R2, R3, C1 and C2. R2 and R3 cause the power supply to have an output resistance of 1.5 MEG. This will cause a metering error for heavy loads. For the typical 100 MEG detector, this error will only represent 1.5%.

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 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" which 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 12 Survey Meter	UNIT	Completely Assembled Model 12 Survey Meter	48-1609
Main Board, Drawing 464 × 275	BOARD	Completely Assembled Main Circuit Board	5464-275
CAPACITORS	C1	47pF, 100V	04-5660
	C2	0.1μF, 35V-T	04-5755
	C3	0.0047μF, 100V	04-5669
	C4	NOT USED	
	C5	0.1μF, 35V-T	04-5755
	C6	2.2μF, 20V	04-5790
	C7	0.022μF, 50V	04-5667
	C8	1μF, 16V	04-5701
	C9	10μF, 10V-DT	04-5766
	C10	100pF, 100V	04-5661
	C11-C12	68μF, 10V	04-5654
	C13	2.2μF, 20V	04-5790
	C14	470pF, 100V	04-5668
	C15	0.1μF, 25V	04-5744
	C16	100pF, 3KV	04-5532
	C17	47μF, 10V	04-5666
	C18	470pF, 100V	04-5668
	C19	0.001μF, 3KV	04-5632
	C20	10μF, 10V	04-5766
	C21	0.01μF, 50V	04-5664
	C30	10μF, 10V	04-5766
	C31	1μF, 16V	04-5701
	C32	470pF, 100V	04-5668

	Reference	Description	Part Number
TRANSISTORS	Q1	MMBT3904LT1	05-5841
	Q2	MMBT4403LT1	05-5842
	Q3-Q4	MMBT3904LT1	05-5841
VOLTAGE REGULATOR	VR1	LT1460KC53-2.5	05-5867
	VR2	TPS76038	05-5912
INTEGRATED CIRCUITS	U1-U3	MAX4542ESA	06-6453
	U4-U5	CMXT3904	05-5888
	U6	CMXT3906	05-5890
	U7	MAX4541ESA	06-6452
	U8	MAX985EUK-T	06-6459
	U9	CD74HC4538M	06-6297
	U10	LMC7111BIM5X	06-6410
	U11	LT1304CS8	06-6394
	U12	MIC1557BM5	06-6457
	U13	LMC7111BIM5X	06-6410
	U14	TPS76050	05-5913
	U15	CMXT3906	05-5890
	U16	MAX4541ESA	06-6452
DIODES	CR2	CMSH1-40M	07-6411
	CR3	CMPD2005S	07-6468
SWITCHES	SW1	CENTRAL-2P6P	08-6761
	SW2	TP11LTCQE	7464-186
	SW3-SW4	7101SDCQE	08-6781
	SW5	TP11LTCQE	7464-186
POTENTIOMETERS / TRIMMERS	R33	250K, 64W254, ×100	09-6819
	R34	250K, 64W254, ×10	09-6819
	R35	500K, 64W504, ×1	09-6850
	R36	250K, 64W254, ×0.1	09-6819
	R38	100K, 64W104, HV SET	09-6813
	R47	1M, 64W105, NAME	09-6814
	R49	10K, 3266×1-103, HV METER ADJ	09-6822

	Reference	Description	Part Number
RESISTORS			
	R1-R5	200K, 1/8W, 1%	12-7992
	R6	8.25K, 1/8W, 1%	12-7838
	R7	10K, 1/8W, 1%	12-7839
	R8	2.37K, 1/8W, 1%	12-7861
	R9-R11	10K, 1/8W, 1%	12-7839
	R12	1K, 1/4W, 1%	12-7832
	R13	10K, 1/8W, 1%	12-7839
	R14	4.75K, 1/8W, 1%	12-7858
	R15	249K, 1/4W, 1%	12-7862
	R16	10K, 1/8W, 1%	12-7839
	R17	1K, 1/8W, 1%	12-7832
	R18	4.75K, 1/8W, 1%	12-7858
	R19	2K, 1/8W, 1%	12-7926
	R20	100K, 1/8W, 1%	12-7834
	R21	249K, 1/4W, 1%	12-7862
	R22	1M, 1/8W, 1%	12-7844
	R23	124K, 1/4W, 1%	12-7032
	R24	14.7K, 1/8W, 1%	12-7068
	R25	200K, 1/4W, 1%	12-7992
	R26	100K, 1/4W, 1%	12-7834
	R27	68.1K, 1/8W, 1%	12-7881
	R28	100K, 1/8W, 1%	12-7834
	R29	1K, 1/8W, 1%	12-7832
	R30	100K, 1/8W, 1%	12-7834
	R31	475K, 1/8W, 1%	12-7859
	R32	100K, 1/8W, 1%	12-7834
	R37	200K, 1/4W, 1%	12-7992
	R39	1M, 1/4W, 1%	12-7844
	R40	10K, 1/4W, 1%	12-7839
	R41-R42	100K, 1/4W, 1%	12-7834
	R43	10K, 1/4W, 1%	12-7839
	R44	1K, 1/4W, 1%	12-7832
	R45	475K, 1/4W, 1%	12-7859
	R46	10K, 1/4W, 1%	12-7839
	R48	1M, 1/4W, 1%	12-7844
	R50	1K, 1/4W, 1%	12-7832
CONNECTORS			
	P1	640456-5 - MTA100	13-8057
	P2	640456-6 - MTA100	13-8095
	P3	640456-2 - MTA100	13-8073

	Reference	Description	Part Number
	P4	640456-4 - MTA100	13-8088
	P5	DET PAD-RD120	7464-270
	P6	HV PAD-RD120	7464-270
INDUCTORS	L1	22 μH	21-9808
HV Power Supply Board, Drawing 464 × 243	BOARD	Completely Assembled HV Power Supply Board	5464-243
CAPACITORS	C1-C2	0.01µF, 3KV, 2%	04-5762
	C3-C22	0.01µF, 500V	04-5696
	C23	0.1µF, 50V	04-5663
	C24	68µF, 10V	04-5654
	C25	NOT USED	*
INTEGRATED CIRCUITS			
	U1	LMC7111BIM5X	06-6410
	U2	LT1304CS8	06-6394
DIODES			
	CR1-CR10	CMPD2005S	07-6468
	CR11	CMSH1-40M	07-6411
RESISTORS			
	R2-R3	750K, 1/4W, 1%	12-7882
	R4-R5	500M, 3KV, 2%	12-7031
	R6	1M, 1/4W, 1%	12-7844
	R7	10K, 1/4W, 1%	12-7839
	R8	1M, 1/4W, 1%	12-7844
	R9	953K, 1/8W, 1%	12-7950
	R10	10 Ohm, 1W, 1%	12-7952
	R11-R12	150K, 1/4W, 1%	12-7833
	R13	100K, 1/4W, 1%	12-7834
CONNECTOR			
	P1	640456-4 MTA100×4	13-8088
	P2	CON 1	18-9238
TRANSFORMER			
	T1	31032R, Midcom	21-9925

Wiring Diagram, Drawing 464 × 309

	Reference	Description	Part Number
CONNECTORS	J1	MTA100×5, MAIN BOARD 5464-275	13-8140
	J2	MTA100×6, OPTIONAL 5464-275	13-8095
	J3	MTA 100×2, MAIN BOARD 5464-275	13-8073
	J4	MTA100×4, MAIN BOARD 5464-275	13-8088
	J5	MAIN BOARD 5464-275	**
	J6	MAIN BOARD 5464-275	**
	*	DETECTOR CONNECTOR, (RECPT-"C" SOLDERLESS)	4478-049
AUDIO	DS1	UNIMORPH, TEC-3526-PU	21-9251
BATTERIES	B1-B2	"D" CELL BATTERY	21-9313
METER	M1	PORT BEZEL W/ MVMNT ASSY	4363-188
MISCELLANEOUS	*	RANGE KNOB	08-6613
	*	BATTERY SPRING	21-9263
	*	BATTERY CONTACT	7001-004-04
	*	CAN GASKET	22-9773

Section 11

Drawings

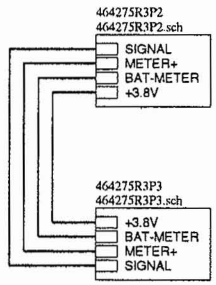
MAIN CIRCUIT BOARD, Drawing 464 × 275 (3 sheets)

MAIN CIRCUIT BOARD LAYOUT, Drawing 464 × 276 (2 sheets)

HV POWER SUPPLY BOARD, Drawing 464 × 243

HV POWER SUPPLY BOARD LAYOUT, Drawing 464 × 244

WIRING DIAGRAM, Drawing 464 × 309



LUDLUM MEASUREMENTS, INC.

PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

Drawn: JK	11-OCT-05	Title: MAIN BOARD		
Design: DL	11-OCT-05	Model: M12		
Check:		Board#: 5464-275		
Approve:	JGW 12-21-05	Sheet: 1 of 3	Series	Sheet
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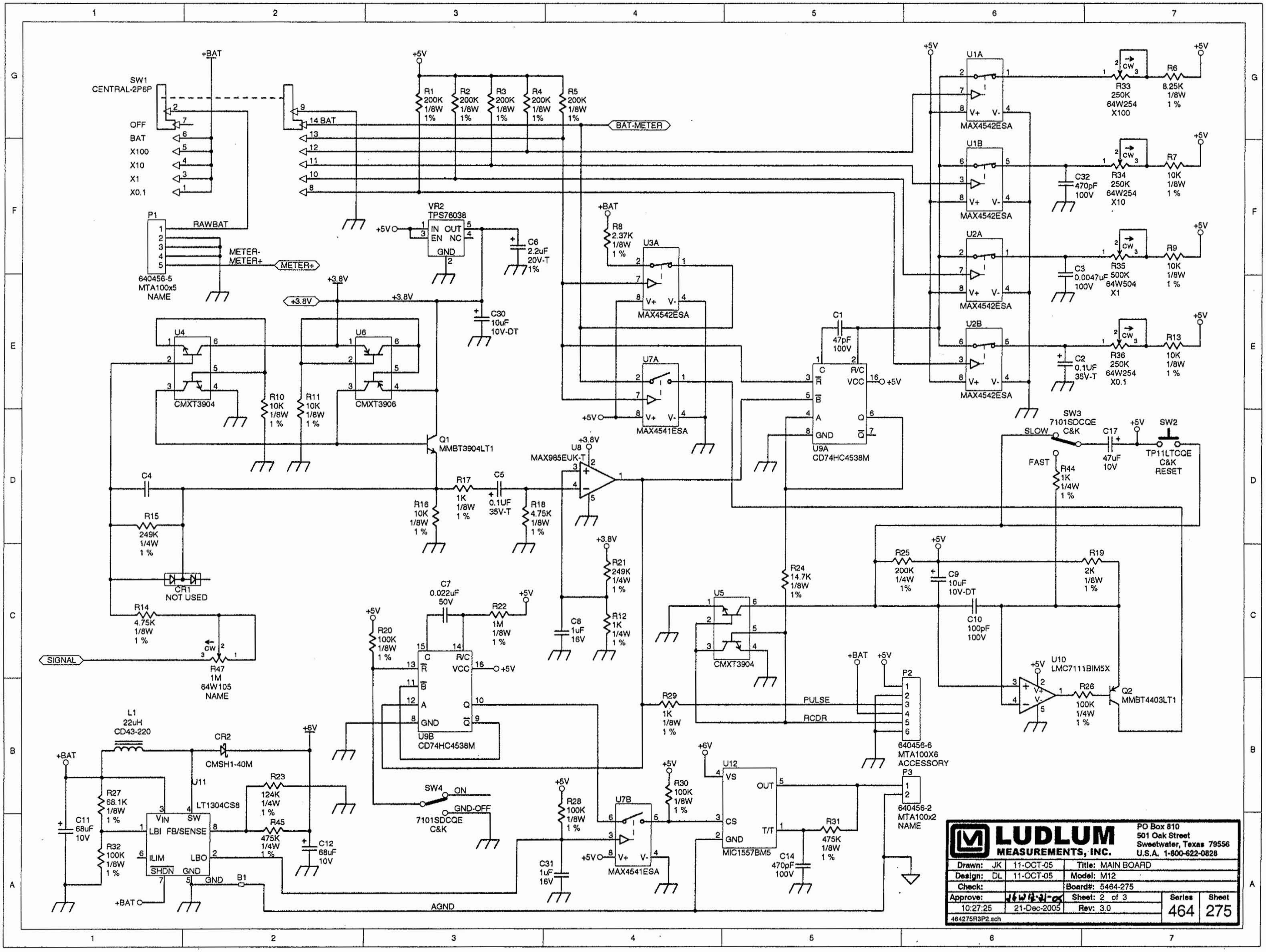
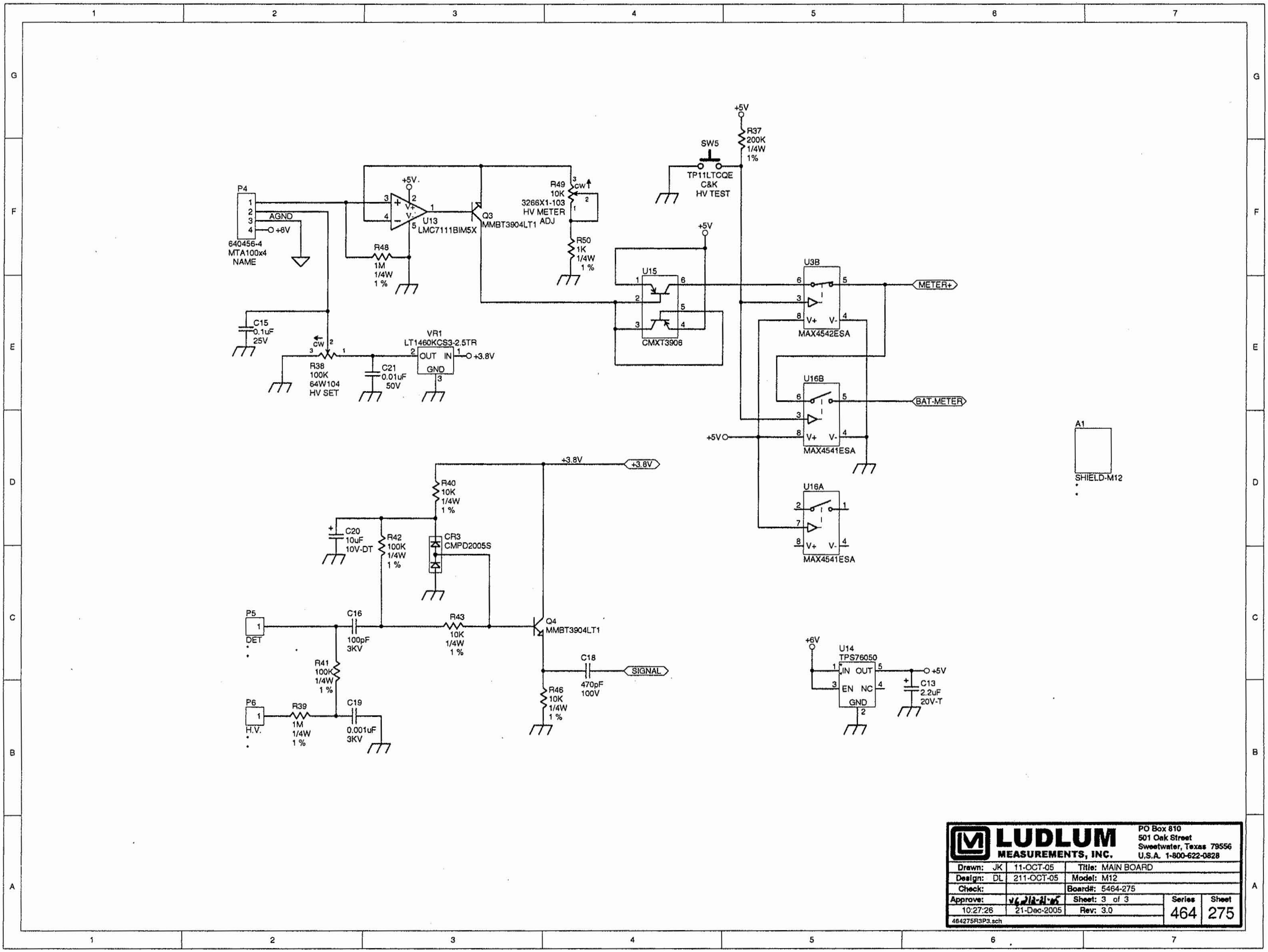
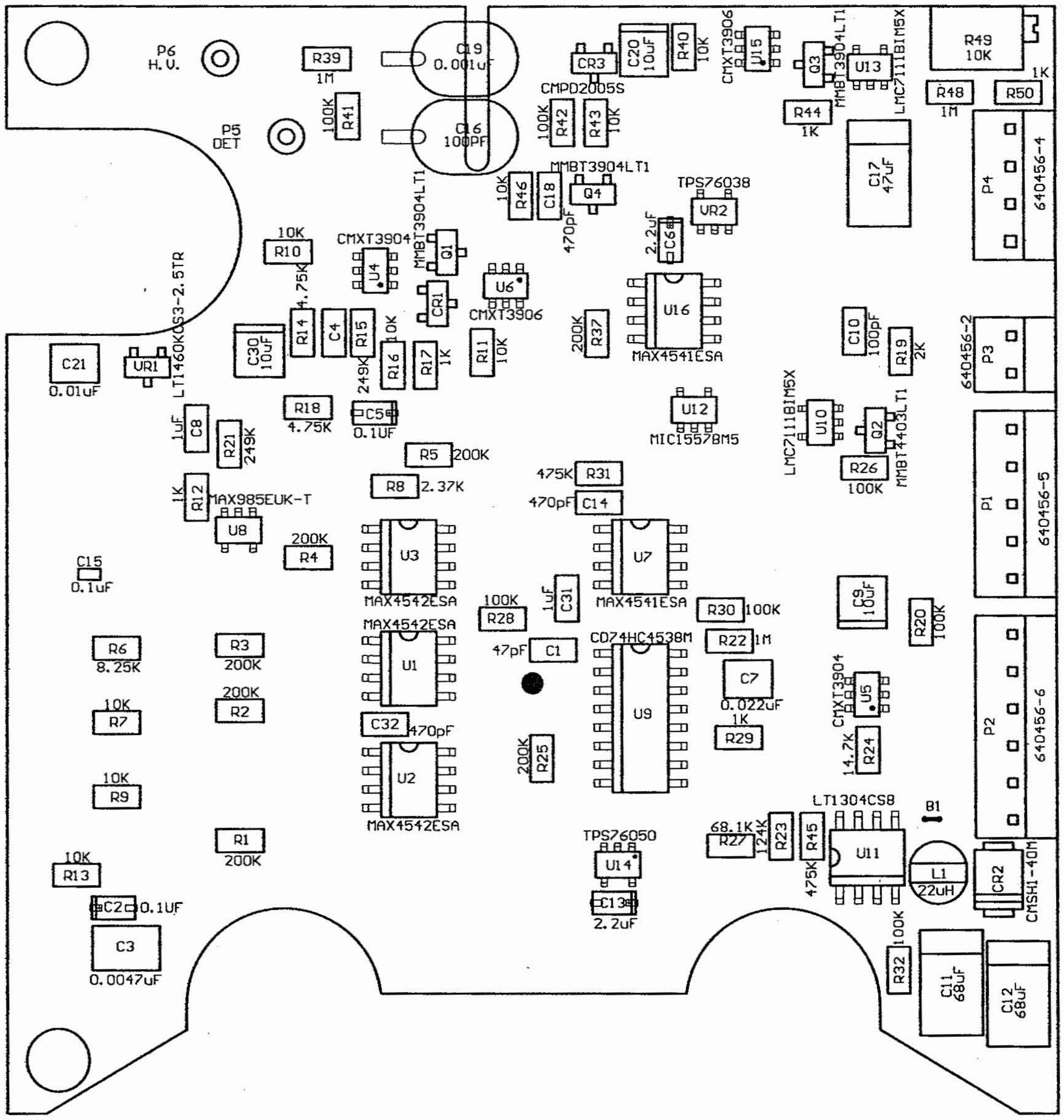


SW1
CENTRAL-2P6P
OFF
BAT
X100
X10
X1
X0.1
14 BAT
BAT-METER
P1
RAWBAT
METER-
METER+
640456-5
MTA100x5
NAME
R1 200K 1/8W 1%
R2 200K 1/8W 1%
R3 200K 1/8W 1%
R4 200K 1/8W 1%
R5 200K 1/8W 1%
VR2
TPS76038
IN OUT
EN NC
GND
C6 2.2uF 20V-T 1%
C30 10uF 10V-DT
+3.8V
U4
CMXT3904
U6
CMXT3906
R10 10K 1/8W 1 %
R11 10K 1/8W 1 %
Q1
MMBT3904LT1
C4
R15 249K 1/4W 1 %
CR1
NOT USED
R14 4.75K 1/8W 1 %
SIGNAL
R47 1M 64W105 NAME
R16 10K 1/8W 1 %
R17 1K 1/8W 1 %
C5 0.1UF 35V-T
R18 4.75K 1/8W 1 %
U8
MAX985EUK-T
R8 2.37K 1/8W 1 %
U3A
MAX4542ESA
U7A
MAX4541ESA
R21 249K 1/4W 1 %
R12 1K 1/4W 1 %
C8 1uF 16V
C7 0.022uF 50V
R22 1M 1/8W 1 %
R20 100K 1/8W 1 %
U9B
CD74HC4538M
U9A
CD74HC4538M
C1 47pF 100V
U1A
MAX4542ESA
U1B
MAX4542ESA
U2A
MAX4542ESA
U2B
MAX4542ESA
R33 250K 64W254 X100
R6 8.25K 1/8W 1 %
R34 250K 64W254 X10
R7 10K 1/8W 1 %
C32 470pF 100V
R35 500K 64W504 X1
R9 10K 1/8W 1 %
C3 0.0047uF 100V
R36 250K 64W254 X0.1
R13 10K 1/8W 1 %
C2 0.1UF 35V-T
SW3
7101SDCQE
C&K
SLOW
FAST
C17 47uF 10V
SW2
TP11LTCQE
C&K
RESET
R44 1K 1/4W 1 %
R25 200K 1/4W 1%
C9 10uF 10V-DT
R19 2K 1/8W 1 %
C10 100pF 100V
R24 14.7K 1/8W 1%
U5
CMXT3904
U10
LMC7111BIM5X
R26 100K 1/4W 1 %
Q2
MMBT4403LT1
R29 1K 1/8W 1 %
PULSE
RCDR
P2
640456-6
MTA100X6
ACCESSORY
L1
22uH
CD43-220
CR2
CMSH1-40M
U11
LT1304CS8
R27 68.1K 1/8W 1 %
R32 100K 1/8W 1 %
C11 68uF 10V
R23 124K 1/4W 1 %
R45 475K 1/4W 1 %
C12 68uF 10V
B1
AGND
SW4
ON
GND-OFF
7101SDCQE
C&K
R28 100K 1/8W 1 %
C31 1uF 16V
U7B
MAX4541ESA
R30 100K 1/8W 1 %
U12
MIC1557BM5
C14 470pF 100V
R31 475K 1/8W 1 %
P3
640456-2
MTA100x2
NAME
LUDLUM MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828
Drawn: JK 11-OCT-05
Design: DL 11-OCT-05
Check:
Approve:
10:27:25 21-Dec-2005
Title: MAIN BOARD
Model: M12
Board#: 5464-275
Sheet: 2 of 3
Rev: 3.0
Series 464
Sheet 275
464275R3P2.sch


P4
640456-4
MTA100x4
NAME
AGND
+6V
+5V
U13
LMC7111BIM5X
Q3
MMBT3904LT1
R48
1M
1/4W
1 %
R49
10K
3266X1-103
HV METER
ADJ
CW
R50
1K
1/4W
1 %
SW5
TP11LTCQE
C&K
HV TEST
R37
200K
1/4W
1%
C15
0.1uF
25V
R38
100K
64W104
HV SET
VR1
LT1460KCS3-2.5TR
OUT
IN
GND
+3.8V
C21
0.01uF
50V
U15
CMXT3906
U3B
MAX4542ESA
METER+
U16B
MAX4541ESA
BAT-METER
U16A
MAX4541ESA
V+
V-
A1
SHIELD-M12
R40
10K
1/4W
1 %
C20
10uF
10V-DT
R42
100K
1/4W
1 %
CR3
CMPD2005S
P5
DET
C16
100pF
3KV
R43
10K
1/4W
1 %
Q4
MMBT3904LT1
C18
470pF
100V
SIGNAL
R46
10K
1/4W
1 %
R41
100K
1/4W
1 %
P6
H.V.
R39
1M
1/4W
1 %
C19
0.001uF
3KV
U14
TPS76050
IN
OUT
EN
NC
GND
C13
2.2uF
20V-T
LUDLUM MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828
Drawn: JK 11-OCT-05
Design: DL 211-OCT-05
Check:
Approve:
10:27:26 21-Dec-2005
464275R3P3.sch
Title: MAIN BOARD
Model: M12
Board#: 5464-275
Sheet: 3 of 3
Rev: 3.0
Series 464
Sheet 275



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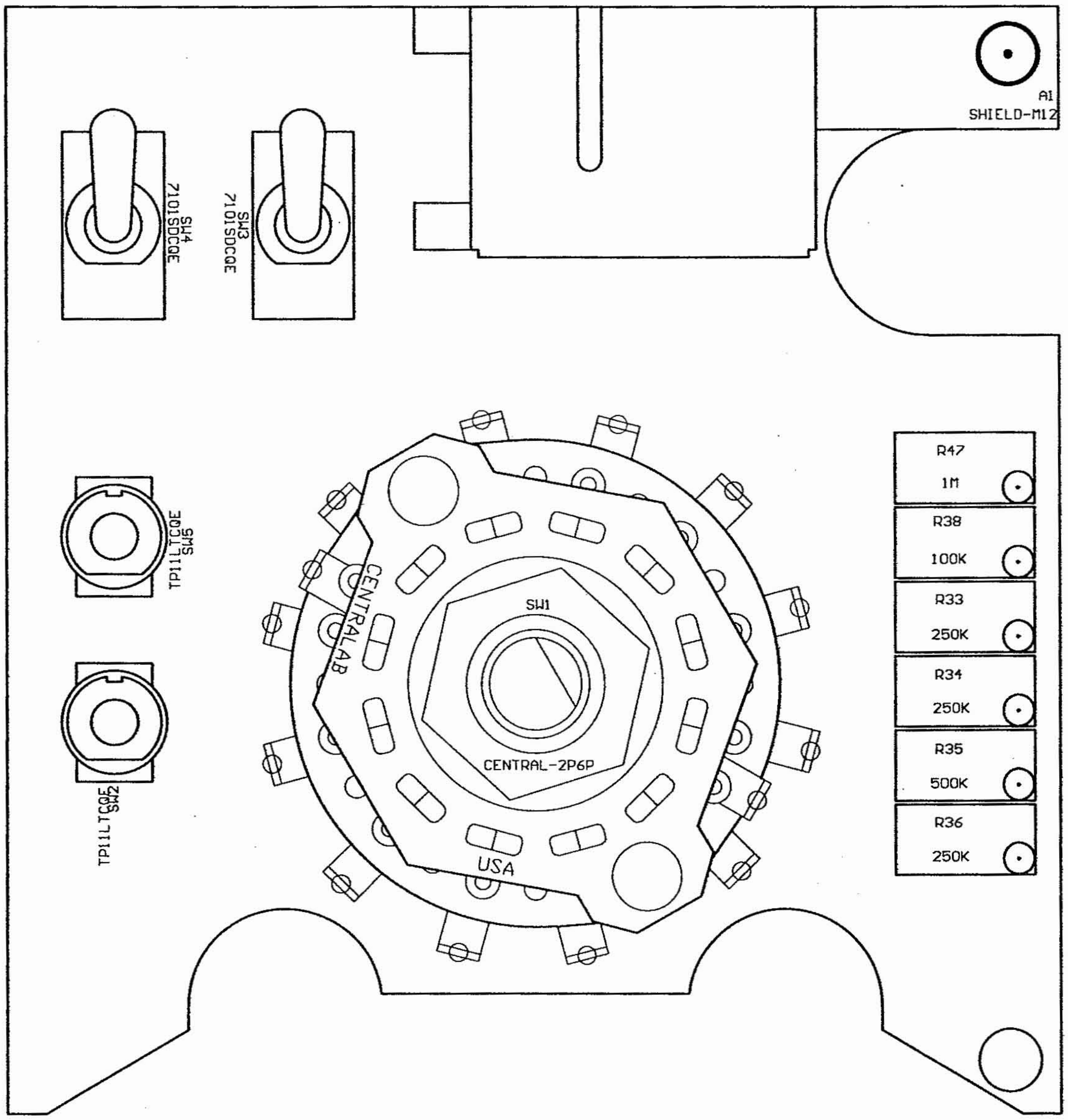
Approve: JGW	12-21-05	**Board#:** 5464–275	
Layer:		**Rev:** 3.0	**Series** 464 / **Sheet** 276
	10:26:49 21–Dec–2005	**SCALE:** 0.96	



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Check:		Model: M12			
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Layer:		Rev:		Series	Sheet
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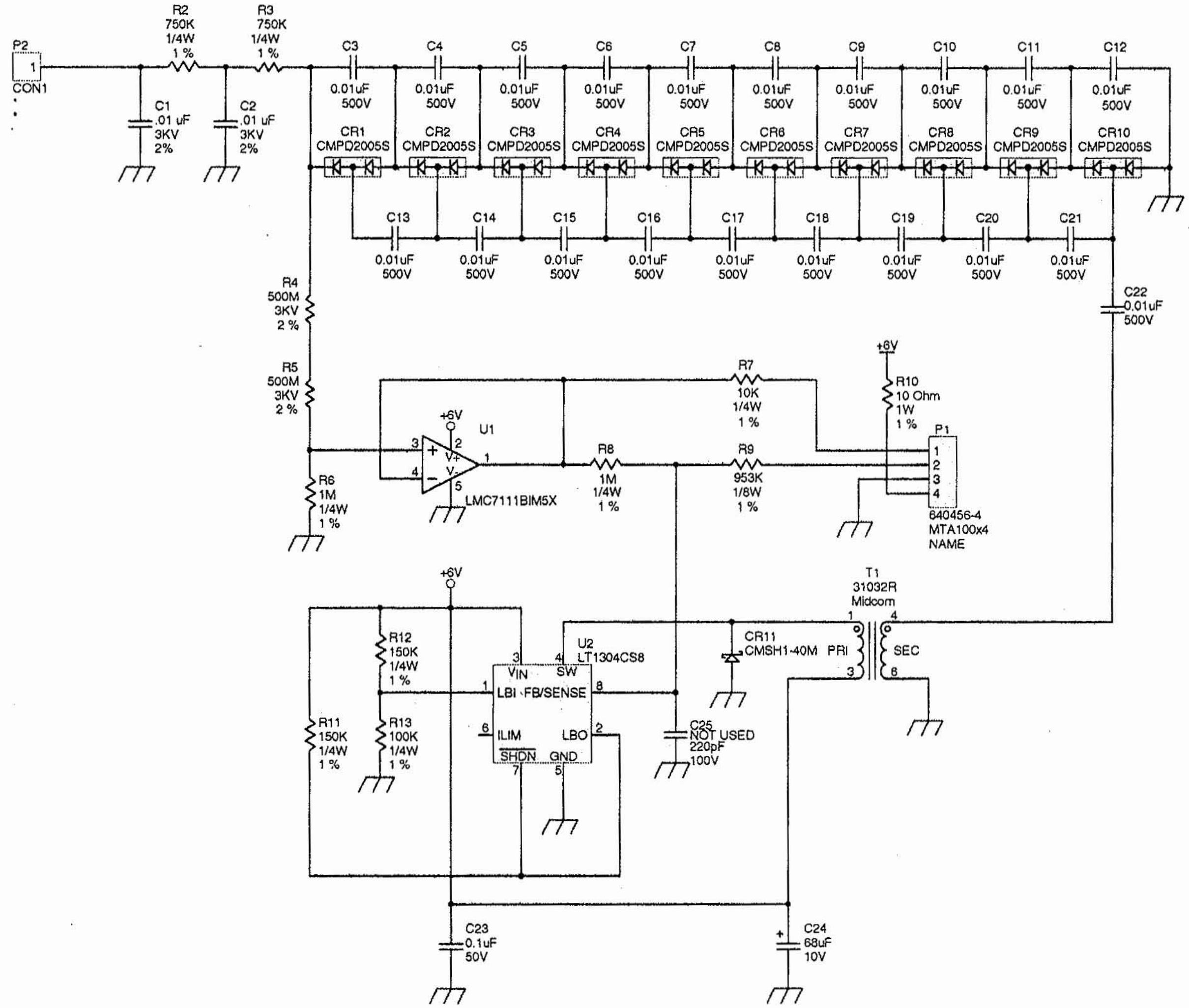

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Drawn: JK	06-DEC-04	Title: HV POWER SUPPLY BOARD
Design: DL	06-DEC-04	Model: M12/M12-4
Check:		Board#: 5464-243
Approve: DL	8/12/05	Sheet: 1 of 1
14:49:22	11-Aug-2005	Rev:

Series 464 | Sheet 243

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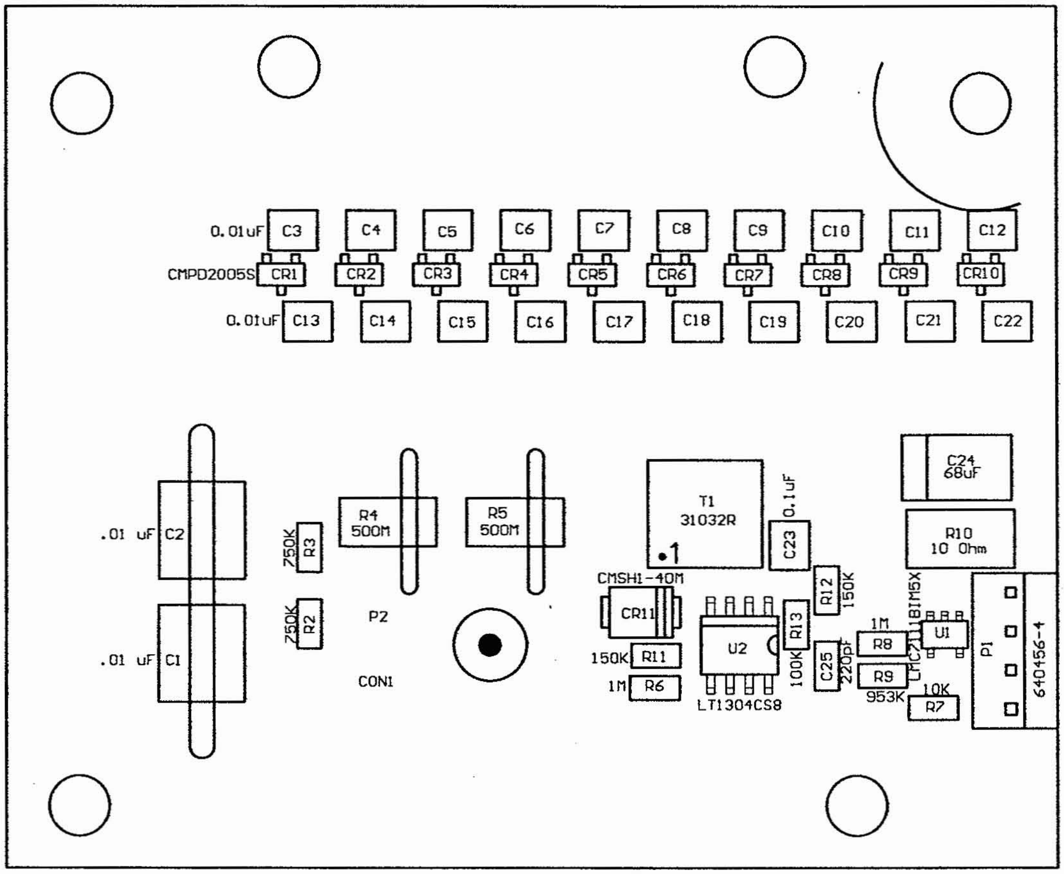

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		Rev:	Series 464	Sheet 244
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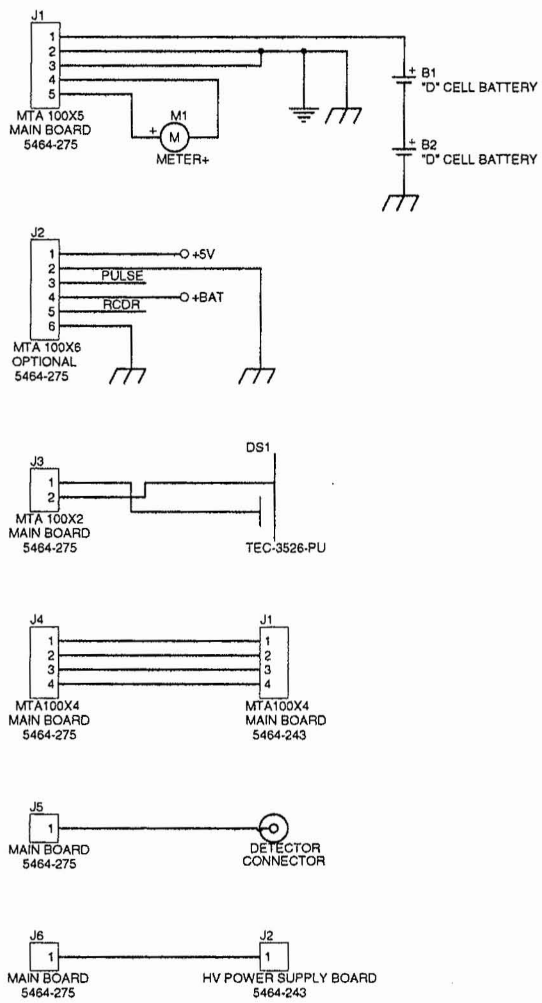

LUDLUM MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

Drawn: JK	01-JUN-04	Title: WIRING DIAGRAM
Design: DL	01-JUN-04	Model: 12
		Board#: 464-309
Approve:	20Dec05	Sheet: 1 of 1
10:58:14	28-Dec-2005	Rev: 3.0
464X309.wd		

Series	Sheet
464	309

LUDLUM MODEL 19
MICRO R METER

July 2006

Serial Number 207422 and Succeeding Serial Numbers

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

REV#	ALTERATIONS	DATE	BY
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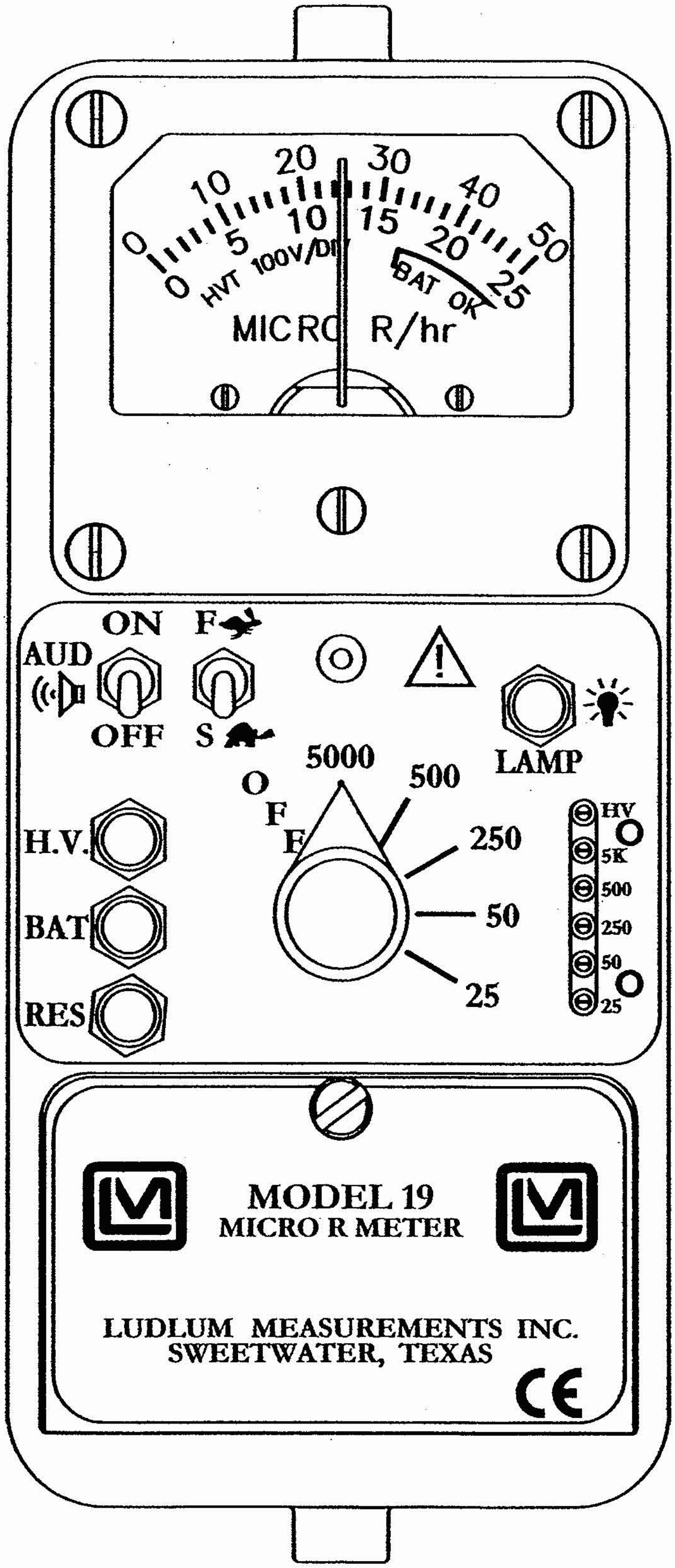

DWN	DATE	CHK	DATE	APP	DATE
DDW	3-16-04			3-18-04			3-18-04

DWG NUM: 4367-169.IAM — SCALE: FULL / OTHER ☒

TITLE: M 19 FRONT PANEL

LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556 — SERIES 367 — SHEET 169

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Section 1

Introduction

The Ludlum Model 19 Micro R Meter utilizes an internally-mounted 1" × 1" NaI(Tl) scintillator for optimum performance in locating and measuring low-level (near "background") gamma radiation.

The unit features a pushbutton lighted meter and was designed to be moisture and dust resistant. The meter is housed in a rugged aluminum bezel with waterproof seals. All controls, including a calibration potentiometer for each range, are located on the front panel. Front panel switches are rubber-booted to seal out moisture and dust. A high voltage (HV) test control is provided to allow rapid plateau testing of the detector.

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

The instrument is capable of using either standard "D" cell flashlight batteries or nickel-cadmium rechargeable batteries. However, the Model 19 does not include circuitry for recharging the batteries. The two "D" cell batteries are located in an isolated compartment, easily accessible from the front panel.

The Model 19 NaI scintillator is energy sensitive. An energy response curve is included in section 10 of this manual for further reference.

Section 2

Getting Started

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 19 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 19 power switch is in the "OFF" position. Open the battery lid by pushing down and turning the quarter-turn thumbscrew counterclockwise ¼ 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 ¼ turn.

Note:

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

Operational Check

Turn the Range Selector switch to the "25" position. Depress the "BAT" pushbutton switch and ensure that the meter needle falls within the "BAT OK" marks. Check for a proper background reading. A typical reading would be: 5-15 uR/hr

Turn the Range Selector switch to the "5000" position. Expose the instrument to a "check source" and verify that the instrument indicates within 20% of the check source reading obtained during the last calibration.

Switch the "AUD ON/OFF" switch to the "ON" position and confirm that the external unimorph speaker produces an audible click for each event 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.

Turn the Range Selector switch to the "250" position and increase the source activity for a meter reading of 10-100 uR/hr. 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 RESET and ensuring the meter needle drops to "0".

Depress the "LAMP" pushbutton switch. Ensure that the meter face illuminates when the switch is depressed. Proceed to use the instrument.

Maintenance

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and the calibration. The Model 19 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 1 minute before accessing internal components.

Recalibration

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

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 manufacturer's 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 100°F.

Section 3

Specifications

Linearity: Reading within 10% of true value.

High Voltage: Variable from 400 to 1500 Vdc; electronically regulated to within 1%.

Battery Dependence: Instrument calibration change less than 3% within the meter battery check limits.

Power: Two standard alkaline "D" cell batteries, secured in an isolated compartment.

Battery Life: Expected lifetime of approximately 2000 hours with the "AUD ON/OFF" switch in the OFF position.

Audio Output: Built-in unimorph speaker and "ON/OFF" switch provided on the front panel.

Counting Ranges: Two-scale meter face presenting 0-50 micro R/hr with full scale range positions of 5000, 500 and 50; and 0-25 micro R/hr with full scale range positions of 250 and 25.

Meter: 1 mA, 2 ½ -inch scale, pivot-and-jewel suspension.

Detector: Photomultiplier coupled to a 1" × 1" NaI(Tl) crystal, mounted inside the instrument housing.

Construction: Cast and drawn aluminum with beige powder-coat finish and printed membrane front panel.

Size: 15.75 cm (6.2") H × 8.9 cm (3.5") W × 21.6 cm (8.5") L, not including instrument handle.

Weight: 2.1 kg (4.5 lbs.), including batteries.

Section 4

Identification of Controls and Functions

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

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 is, 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. The "S" position should be used for slow response and damped, meter deviation.

BAT Pushbutton Switch: When depressed, this switch indicates the battery charge status on the meter. The range selector switch must be out of the OFF position.

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

LAMP Pushbutton Switch: When depressed, this switch lights the meter face.

HV Pushbutton Switch: When depressed, the meter reads the detector high voltage. Each meter division is equivalent to 100 volts.

HV Adjustment: Provides a means to vary the high voltage from 400 to 1500 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.

Section

5

Safety Considerations

Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude

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

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

Pollution Degree 1 (as defined by IEC 664).

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 19 Micro R Meter is marked with the following symbols:

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 1 minute before accessing internal components.

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 on the battery compartment lid. See section 8, "Recycling" for further information.

Cleaning and Maintenance Precautions

The Model 19 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 1 minute before cleaning the exterior or accessing any internal components for maintenance.

Section 6

Troubleshooting

Occasionally, you may encounter problems with your LMI instrument or detector that may be repaired or resolved in the field, saving turnaround 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) sticky meters (2) 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 Scintillation Detector

SYMPTOM	POSSIBLE SOLUTION
No power (or meter does not reach BAT TEST or BAT OK mark)	1. Check batteries and replace if weak. 2. Check polarity (See marks inside batter lid). Are the batteries installed backwards?

SYMPTOM	POSSIBLE SOLUTION
No power (or meter does not reach BAT TEST or BAT OK mark) (continued)	3. Check battery contacts. Clean them with rough sandpaper or use an engraver to clean the tips.
	4. Check for loose or broken wires, especially between the main board and the calibration board.
Nonlinear 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 "sticky" meter movement. Does the reading change when you tap the meter? Does the meter needle "stick" at any spot?
	3. Check the "meter zero." Turn the power OFF. The meter should come to rest on "0".
Meter goes full-scale or "Pegs Out"	1. Check the HV and, if possible, the input threshold for proper setting.
	2. Check for loose wires, especially between the main board and the calibration board.

Section 7

Technical Theory of Operation

Detector

The detector consists of a crystal of sodium iodide with Thallium activation (NaI Tl) that gives off light pulses when penetrated by radiation photons.

The light pulses are converted to electrical pulses by the photo cathode of the photomultiplier tube. The photomultiplier includes a 9 stage electron amplifier. This amplifier utilizes an electrostatic field for each stage, adding up to a required 500 to 1500 volt supply.

Input

Detector pulses are coupled from the detector through C6 to the amplifier. CR1 protects the amplifier from input shorts. R37 couples the detector to the high voltage supply.

Amplifier

A self-biased amplifier provides gain in proportion to R15 and C4 divided by R14. Transistor (pin 3 of U4) provides amplification. U6 is configured as a current mirror to provide a load for pin 3 of U4. The output self-biases to 2 Vbe (approximately 1.4 volts) at emitter of Q1. This provides just enough bias current through pin 3 of U4 to conduct all of the current from the current mirror.

Positive pulses at R16 are coupled to the discriminator through C5.

Discriminator

Comparator U8 provides discrimination. The discriminator is set by the voltage divider, R21 and R23, coupled to pin 3 of U8. U8 output pulses are coupled to pin 5 of U9A for meter drive and pin 12 of U9B for audio.

Audio

Discriminator pulses are coupled to univibrator pin 12 of U9B. Front panel audio ON-OFF selector controls the reset at pin 13 of U9B. When ON, pulses from pin 10 of U9B turn on oscillator U12, which drives the can-mounted unimorph. Speaker tone is set by R31, C14; duration by R22, C7.

Scale Ranging

Detector pulses from the discriminator are coupled to univibrator pin 5 of U9A. For each scale, the pulse width of pin 6 of U9A is controlled by the front panel calibration controls and their related capacitors. This arrangement allows the same current to be delivered to C9 in proportion to the meter reading.

Digital Analog Converter

U5 is configured as a current mirror. For each pulse of current through R24, an equal current is delivered to C9. This charge is drained off by R25. The voltage across C9 is proportional to the incoming count rate.

Meter Drive

The meter is driven by the collector of Q2 coupled as a voltage follower in conjunction with pin 1 of U10.

For Battery Test, the voltage follower is bypassed and the meter movement is directly coupled to the battery through R8.

Fast/Slow Time Constant

For slow time constant, C17 is switched from the output of the meter drive to parallel C9.

Low Voltage Supply

Battery voltage is coupled to U11 and associated components (a switching regulator) to provide 5 volts at pin 8 to power all circuits.

High Voltage Test

A constant current is developed by collector of Q3 in proportion to HV signal at pin 1 of U17. U16 provides a current mirror to drive the meter through analog switch logic circuit U15, U14, and U3.

High Voltage Supply

High voltage is developed by switching regulator U13 and T1. Voltage multiplier CR3 thru CR7, and associated components, develop the detector voltage. Voltage feedback is provided by R39 thru U17 to feed back pin 8 of U13 for voltage regulation. Pin 1 of U17 is proportional to the high voltage, and its output is also utilized to measure the high voltage. High voltage is adjusted by varying the feedback current with R42.

Section 8

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 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" which 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 9

Parts List

	Reference	Description	Part Number
Model 19 Micro R Meter	UNIT	Completely Assembled Model 19 Micro R Meter	48-1615
Main Board, Drawing 367 × 166	BOARD	Completely Assembled Circuit Board	5367-166
CAPACITORS	C1	47pF, 100V	04-5660
	C2	0.0022µF, 50V	04-5676
	C3	0.001µF, 100V	04-5659
	C4	10pF, 100V	04-5673
	C5	0.01µF, 50V	04-5664
	C6	100pF, 3KV	04-5735
	C7	0.022µF, 50V	04-5667
	C8	1µF, 16V	04-5701
	C9	10µF, 25V	04-5655
	C10	100pF, 100V	04-5661
	C11	68µF, 10V	04-5654
	C12	10µF, 25V	04-5728
	C14	470pF, 100V	04-5668
	C17	47µF, 10V	04-5666
	C18-C27	0.01µF, 500V	04-5696
	C28	0.001µF, 2KV	04-5703
	C29	68µF, 10V	04-5654
	C30-C31	1µF, 16V	04-5701
	C32	270pF, 100V	04-5679
	C33	0.01µF, 50V	04-5664

	Reference	Description	Part Number
TRANSISTORS	Q1	MMBT3904LT1	05-5841
	Q2	MMBT4403LT1	05-5842
	Q3	MMBT3904LT1	05-5841
VOLTAGE REGULATOR	VR1	LT1460KCS3-2.5TR	05-5867
INTEGRATED CIRCUITS	U1-U3	MAX4542ESA	06-6453
	U4-U5	CMXT3904	05-5888
	U6	CMXT3906	05-5890
	U7	MAX4541ESA	06-6452
	U8	MAX985EUK-T	06-6459
	U9	CD74HC4538M	06-6297
	U10	LMC7111BIM5X	06-6410
	U11	LT1304CS8-5	06-6434
	U12	MIC1557BM5	06-6457
	U13	LT1304CS8	06-6394
	U14-U15	MAX4542ESA	06-6453
	U16	CMXT3906	05-5890
	U17-C18	LMC7111BIM5X	06-6410
DIODES	CR1	CMPD2005S	07-6468
	CR2	CMSH1-40M	07-6411
	CR3-CR7	CMPD2005S	07-6468
	CR9	CMSH1-40M	07-6411
SWITCHES	SW1	RANGE SELECTOR	08-6761
	SW2	H.V. PUSHBUTTON	08-6770
	SW3	F-S TOGGLE	08-6781
	SW4	AUD ON-OFF TOGGLE	08-6781
	SW5	RES PUSHBUTTON	08-6770
	SW6	LAMP PUSHBUTTON	08-6770
	SW7	BAT PUSHBUTTON	08-6770
POTENTIOMETERS / TRIMMERS	R33	1M, 64W105 NAME	09-6814
	R34	1M, 64W105 X10	09-6814
	R35	1M, 64W105 X1	09-6814
	R36	1M, 64W105 X0.1	09-6814
	R41	100K, 64W104 X100	09-6813

	Reference	Description	Part Number
	R42	100K, 64W104 HV ADJ	09-6813
	R52	10K, 3266X1-103 NAME	09-6822
RESISTORS			
	R1-R5	200K, 1/8W, 1%	12-7992
	R6	8.25K, 1/8W, 1%	12-7838
	R7	10K, 1/8W, 1%	12-7839
	R8	2.37K, 1/8W, 1%	12-7861
	R9-R11	10K, 1/8W, 1%	12-7839
	R12	200 Ohm, 1/8W, 1%	12-7846
	R13	10K, 1/8W, 1%	12-7839
	R14	4.75K, 1/8W, 1%	12-7858
	R15	200K, 1/8W, 1%	12-7992
	R16	10K, 1/8W, 1%	12-7839
	R17	1K, 1/8W, 1%	12-7832
	R18	4.75K, 1/8W, 1%	12-7858
	R19	2K, 1/8W, 1%	12-7926
	R20-R21	100K, 1/4W, 1%	12-7834
	R22	1M, 1/8W, 1%	12-7844
	R23	2.49K, 1/8W, 1%	12-7999
	R24	14.7K, 1/8W, 1%	12-7068
	R25	200K, 1/4W, 1%	12-7992
	R26	100K, 1/4W, 1%	12-7834
	R27	68.1K, 1/8W, 1%	12-7881
	R28	100K, 1/8W, 1%	12-7834
	R29	1K, 1/8W, 1%	12-7832
	R30	100K, 1/8W, 1%	12-7834
	R31	475K, 1/8W, 1%	12-7859
	R32	100K, 1/8W, 1%	12-7834
	R37	100K, 1/8W, 1%	12-7834
	R38	4.75M, 1/8W, 1%	12-7995
	R39	500M, 3KV, 2%	12-7031
	R40	1M, 1/4W, 1%	12-7844
	R44	1K, 1/4W, 1%	12-7832
	R45	8.25K, 1/8W, 1%	12-7838
	R46-R48	200K, 1/4W, 1%	12-7992
	R49	825K, 1/8W, 1%	12-7005
	R50	953K, 1/8W, 1%	12-7950
	R53	1K, 1/4W, 1%	12-7832
CONNECTORS			
	P1	CONN-640456-4 MTA100x4 NAME	13-8088

	Reference	Description	Part Number
	P2	CONN-640456-3	
		MTA100x3 NAME	13-8081
	P3	CONN-640456-2	
		MTA100x2 NAME	13-8073
	P4	CONTACT #1434 NAME	18-9124
INDUCTOR			
	L1	22μH, CD43-220	21-9808
TRANSFORMER			
	T1	31032R	21-9925
Wiring Diagram, Drawing 367 × 174			
AUDIO	DS1	M19 LAMP BOARD 5367-113	5367-113
	DS2	UNIMORPH TEC-3526-PU	21-9251
CONNECTOR			
	P1	MTA100x4 MAIN BOARD	
		5367-166	13-8170
	P2	MTA 100x3 MAIN BOARD	
		5367-166	13-8135
	P3	MTA 100x2 MAIN BOARD	
		5367-166	13-8178
BATTERY			
	B1-B2	DURACELL "D"	21-9313
MISCELLANEOUS			
	*	M19 INTERNAL DETECTOR	47-3426
	*	TUBE/XTAL ASSY	2004-061
	M1	MODEL 19 METER	
		ASSY 987010-001 1mA	4367-024
	*	M19 METERFACE	
		(202-016)	7367-023
	*	METER BEZEL W/ GLASS	
		W/ SCREWS	4363-352-00
	*	METER MOVEMENT (1mA)	15-8030
	*	M19 BATTERY BOX	
		LID W/CNTCT	2363-191
	*	DEEP PORTABLE	
		CAN ASSY	4363-615
	*	M19 CASTING	7367-171
	*	M19 MAIN HARNESS	8367-170

Reference	Description	Part Number
*	PORTABLE KNOB	08-6613
*	SWITCH SEAL (P/B)	08-6611
*	UNIMORPH W/WIRES, O'RING	40-0034
*	CAL COVER W/SCREWS	4363-200
*	HANDLE- PORTABLE (GRIP)	7363-139

Section 10

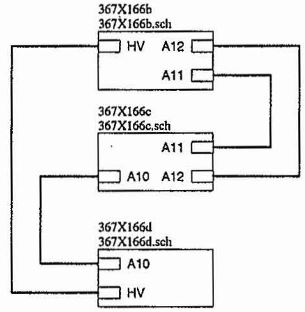
Drawings

Model Board Circuit, Drawing 367 × 166 (4 sheets)

Model Board Component Layouts, Drawings 367 × 167 (2 sheets)

Wiring Diagram, Drawing 367 × 174

Energy Response for Ludlum Model 19



LUDLUM MEASUREMENTS, INC.

PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

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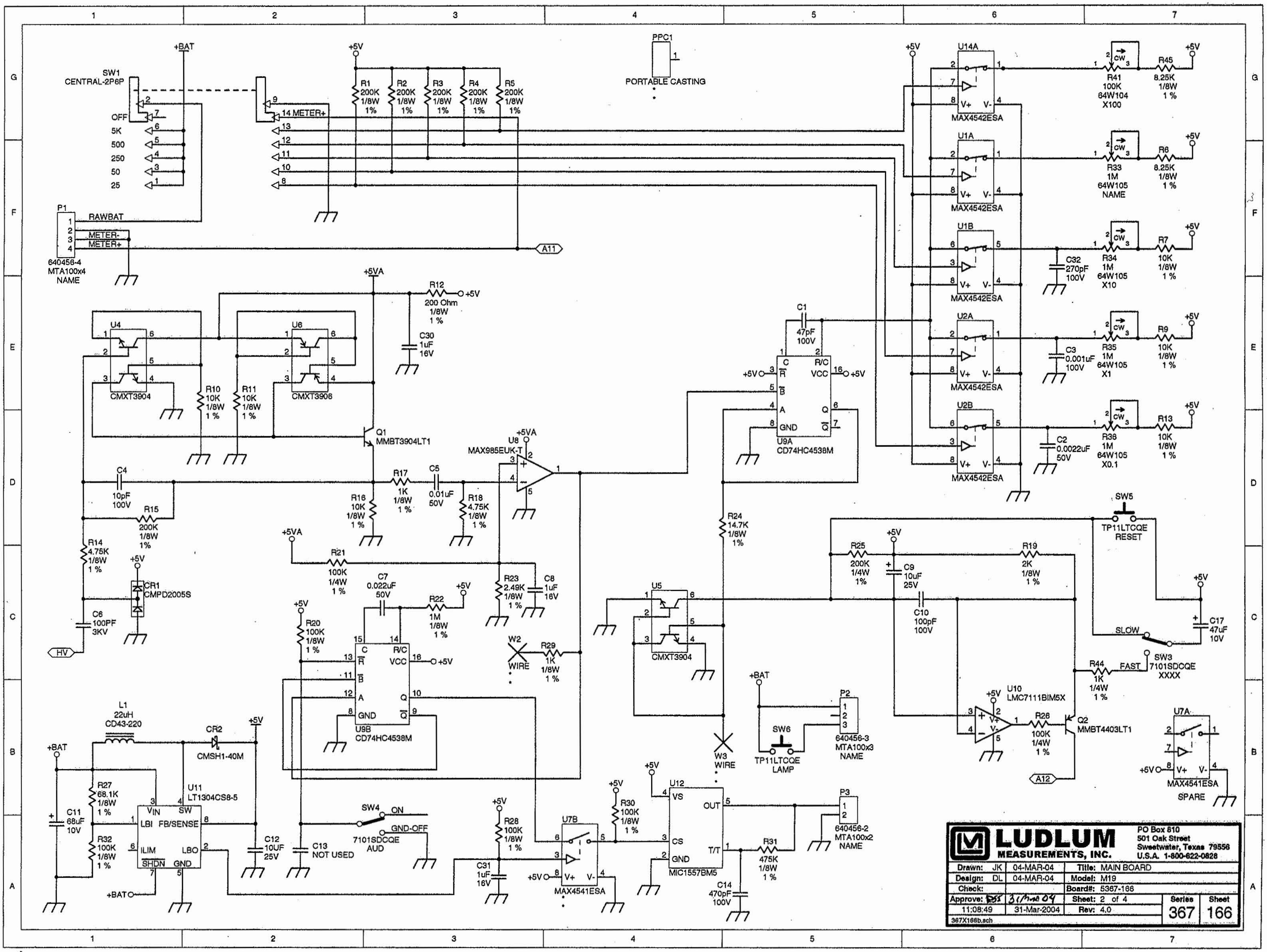
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CENTRAL-2P6P
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5K
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250
50
25
14 METER+
P1
RAWBAT
METER-
METER+
640456-4
MTA100x4
NAME
A11
+BAT
+5V
R1 200K 1/8W 1%
R2 200K 1/8W 1%
R3 200K 1/8W 1%
R4 200K 1/8W 1%
R5 200K 1/8W 1%
PPC1
PORTABLE CASTING
U14A
MAX4542ESA
R41 100K 64W104 X100
R45 8.25K 1/8W 1 %
U1A
MAX4542ESA
R33 1M 64W105 NAME
R6 8.25K 1/8W 1 %
U1B
MAX4542ESA
C32 270pF 100V
R34 1M 64W105 X10
R7 10K 1/8W 1 %
U2A
MAX4542ESA
C3 0.001uF 100V
R35 1M 64W105 X1
R9 10K 1/8W 1 %
U2B
MAX4542ESA
C2 0.0022uF 50V
R36 1M 64W105 X0.1
R13 10K 1/8W 1 %
+5VA
R12 200 Ohm 1/8W 1 %
C30 1uF 16V
U4
CMXT3904
U6
CMXT3906
R10 10K 1/8W 1 %
R11 10K 1/8W 1 %
Q1
MMBT3904LT1
C1 47pF 100V
U9A
CD74HC4538M
U8
MAX985EUK-T
C4 10pF 100V
R15 200K 1/8W 1%
R17 1K 1/8W 1 %
C5 0.01uF 50V
R16 10K 1/8W 1 %
R18 4.75K 1/8W 1 %
R14 4.75K 1/8W 1 %
CR1
CMPD2005S
C6 100PF 3KV
HV
R21 100K 1/4W 1 %
R23 2.49K 1/8W 1 %
C8 1uF 16V
C7 0.022uF 50V
R22 1M 1/8W 1 %
R20 100K 1/8W 1 %
U9B
CD74HC4538M
W2
WIRE
R29 1K 1/8W 1 %
R24 14.7K 1/8W 1%
U5
CMXT3904
SW5
TP11LTCQE
RESET
R25 200K 1/4W 1%
C9 10uF 25V
R19 2K 1/8W 1 %
C10 100pF 100V
C17 47uF 10V
SLOW
FAST
SW3
7101SDCQE
XXXX
R44 1K 1/4W 1 %
U10
LMC7111BIM5X
R26 100K 1/4W 1 %
Q2
MMBT4403LT1
A12
U7A
MAX4541ESA
SPARE
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MTA100x3
NAME
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LAMP
W3
WIRE
L1
22uH
CD43-220
CR2
CMSH1-40M
U11
LT1304CS8-5
R27 68.1K 1/8W 1 %
R32 100K 1/8W 1 %
C11 68uF 10V
C12 10UF 25V
C13 NOT USED
SW4
ON
GND-OFF
7101SDCQE
AUD
R28 100K 1/8W 1 %
C31 1uF 16V
U7B
MAX4541ESA
R30 100K 1/8W 1 %
U12
MIC1557BM5
R31 475K 1/8W 1 %
C14 470pF 100V
P3
640456-2
MTA100x2
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LUDLUM
MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828
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Approve: 31 Mar 04
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Model: M19
Board#: 5367-166
Sheet: 2 of 4
Rev: 4.0
Series 367
Sheet 166
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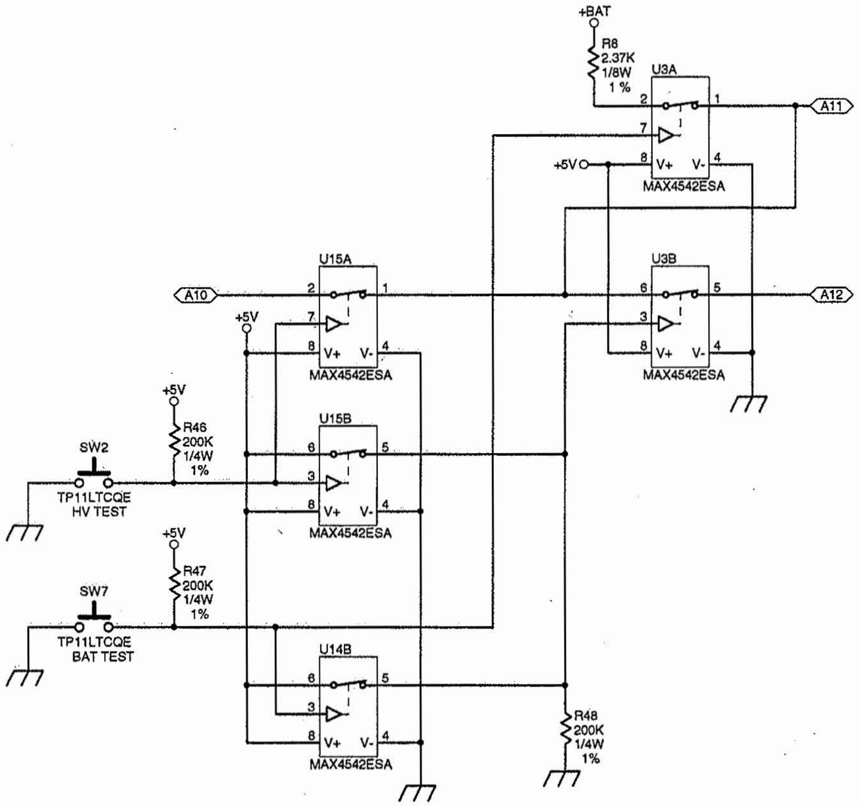

LUDLUM MEASUREMENTS, INC.

PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

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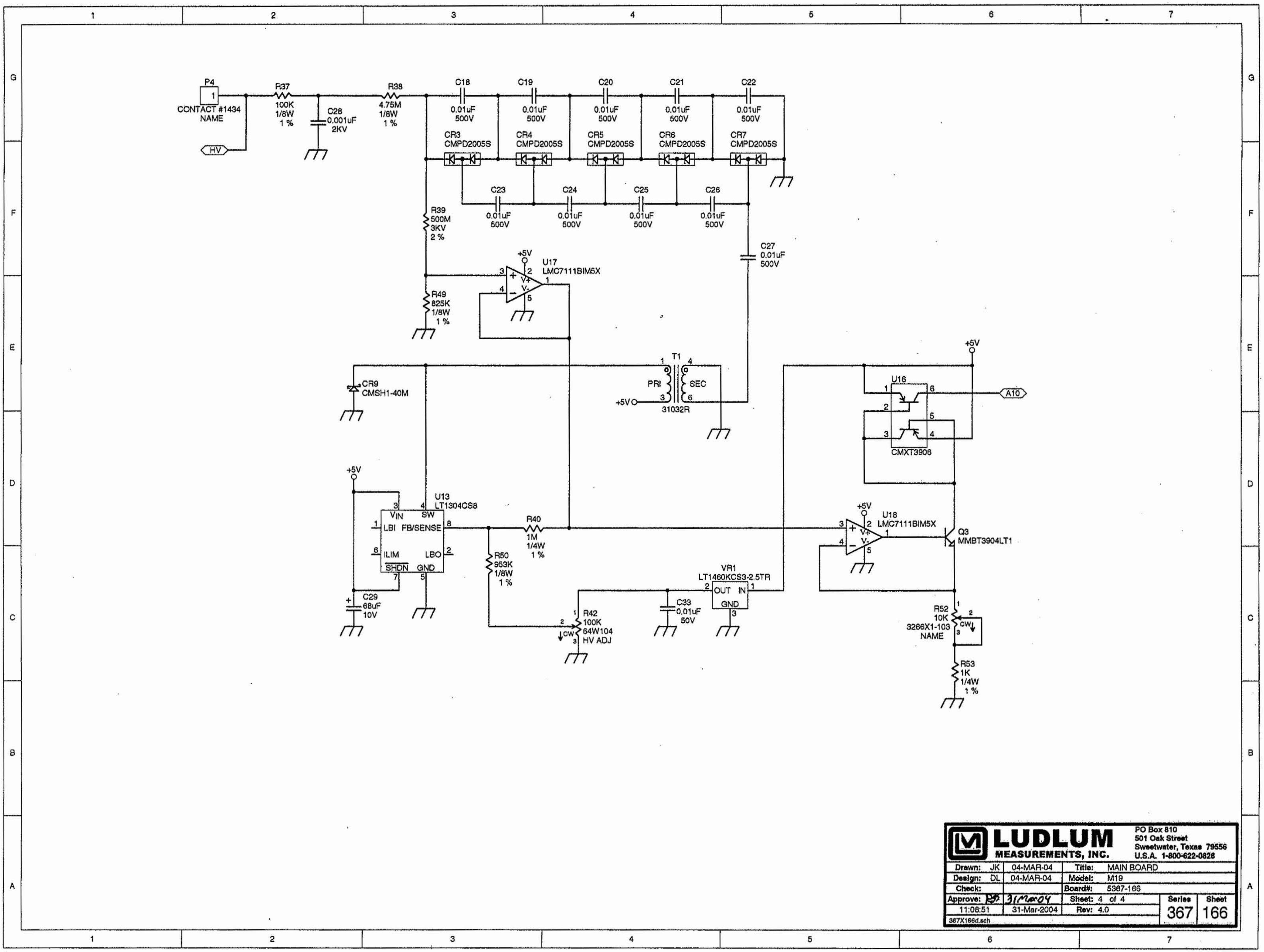
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R37
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C28
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2KV
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1/8W
1 %
C18 C19 C20 C21 C22
0.01uF
500V
CR3 CR4 CR5 CR6 CR7
CMPD2005S
C23 C24 C25 C26
C27
0.01uF
500V
R39
500M
3KV
2 %
U17
LMC7111BIM5X
R49
825K
1/8W
1 %
T1
PRI
SEC
31032R
CR9
CMSH1-40M
U16
CMXT3906
A10
U13
LT1304CS8
VIN
SW
LBI
FB/SENSE
ILIM
LBO
SHDN
GND
C29
68uF
10V
R40
1M
1/4W
1 %
R50
953K
1/8W
1 %
VR1
LT1460KCS3-2.5TR
OUT
IN
C33
0.01uF
50V
R42
100K
64W104
HV ADJ
U18
LMC7111BIM5X
Q3
MMBT3904LT1
R52
10K
3266X1-103
NAME
R53
1K
1/4W
1 %
+5V
LUDLUM
MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828
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Approve: 31 Mar 04
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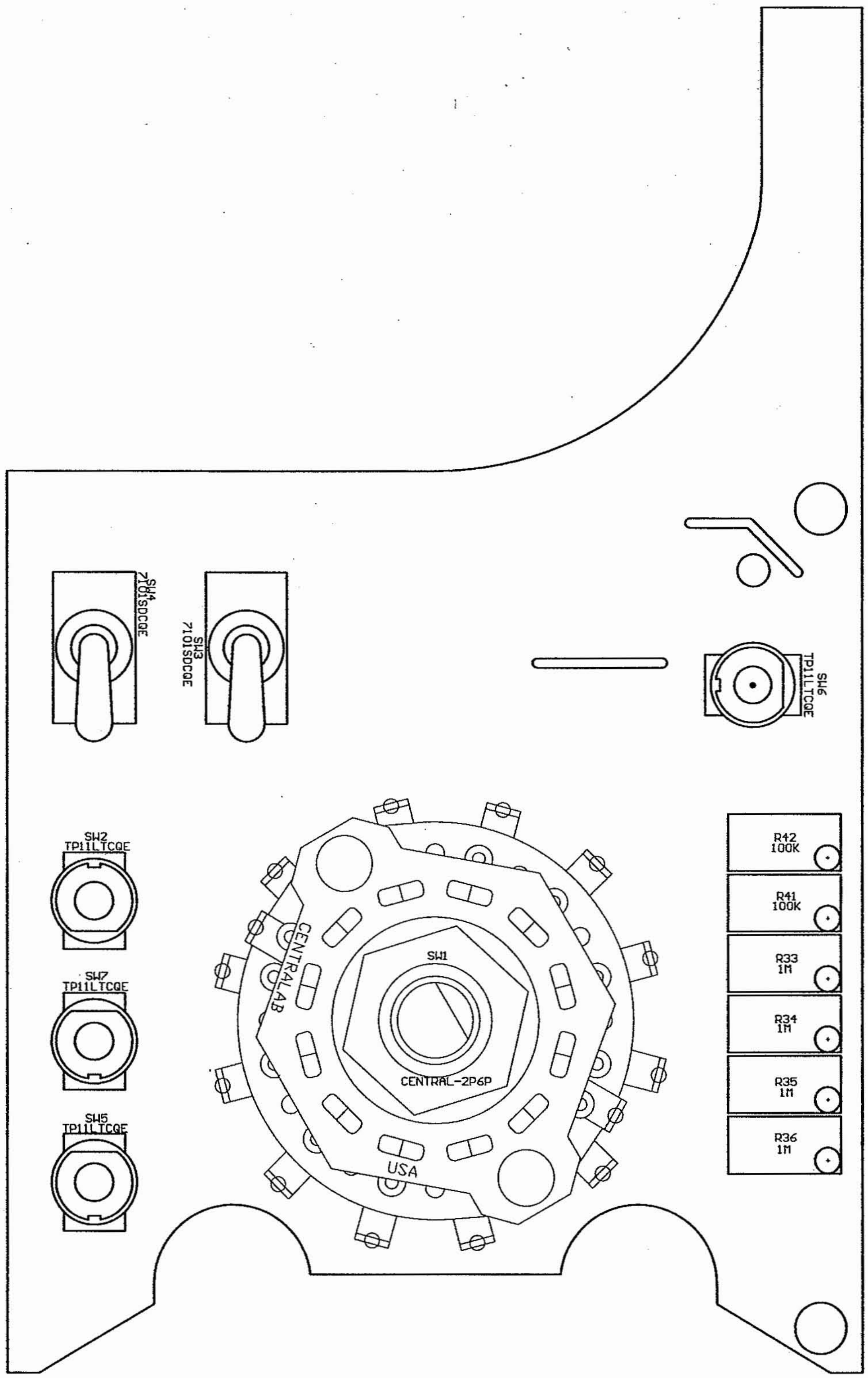
Sheet: 4 of 4
Rev: 4.0
Series 367
Sheet 166



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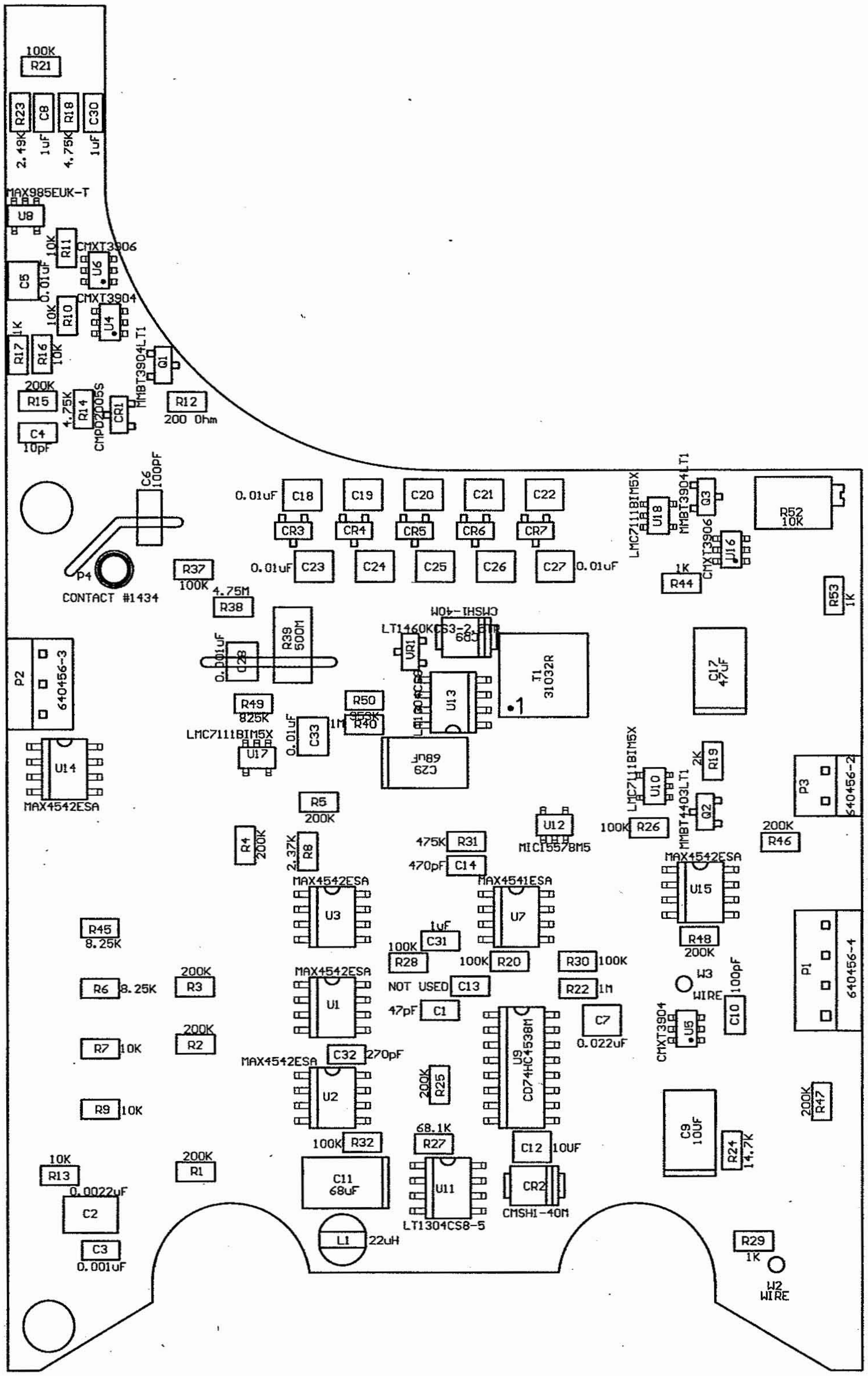

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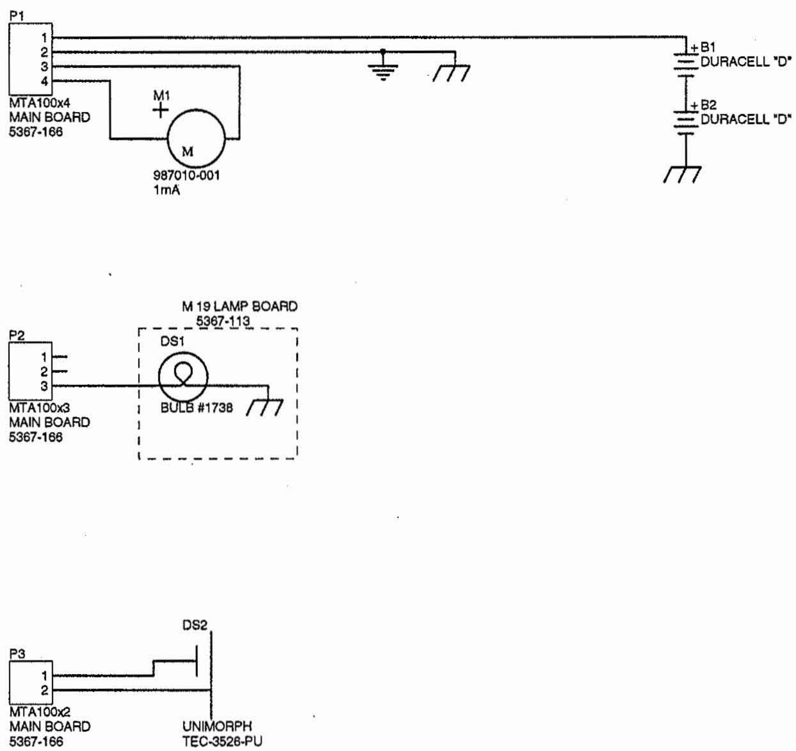

LUDLUM MEASUREMENTS, INC.

PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828

Drawn: MEB	02-APR-04	Title: WIRING DIAGRAM
Design: DL	02-APR-04	Model: 19
		Board#: 367-174
Approve: RJS	12 APR 04	Sheet: 1 of 1
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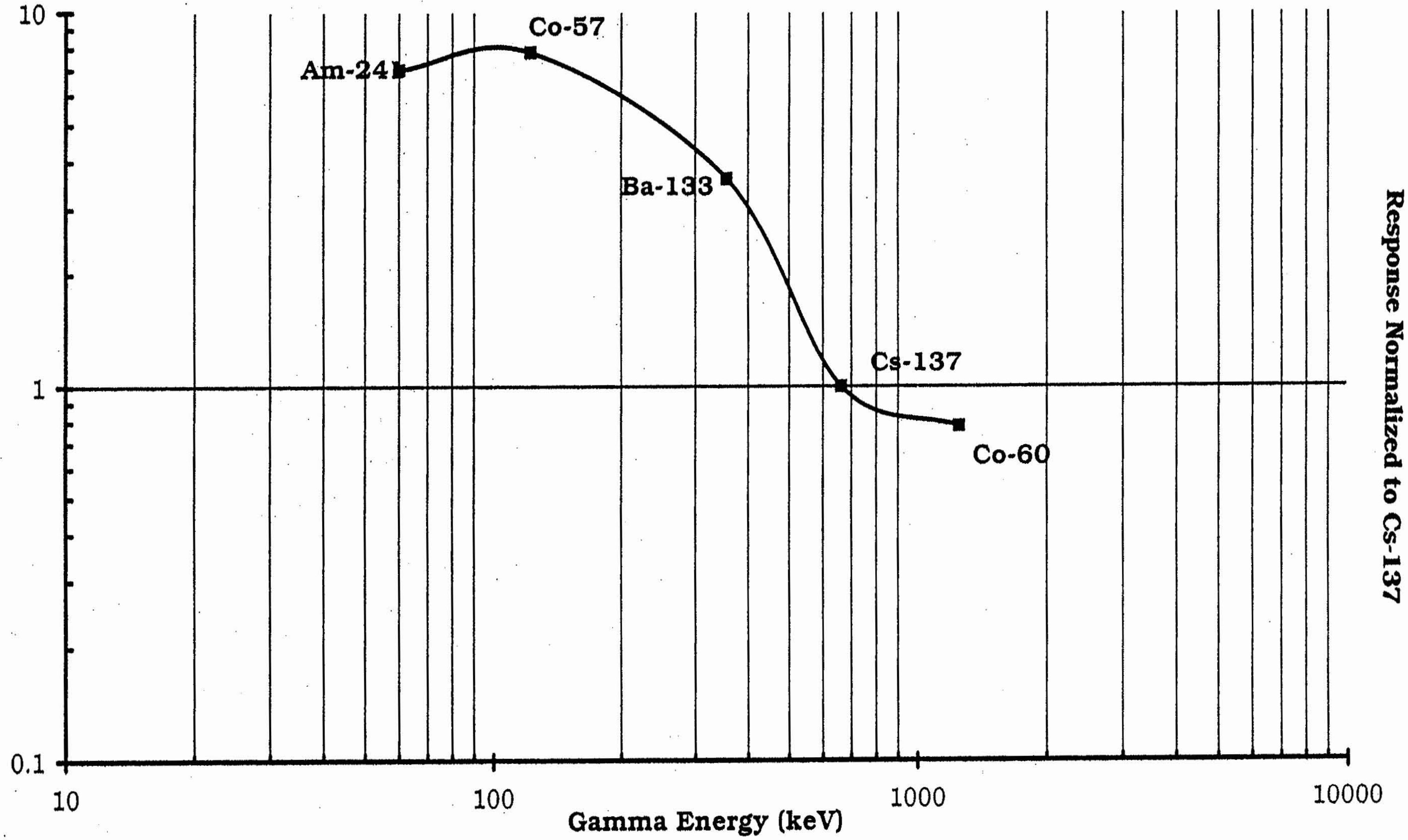
367x174		

Series	Sheet
367	174

Energy Response for Ludlum Model 19



LUDLUM MODEL 43-93 AND MODEL 43-93-2 ALPHA/BETA SCINTILLATORS

December 2006

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

Table of Contents

Introduction **1**

Specifications **2**

Safety Considerations **3**

Environmental Conditions for Normal Use **3-1**

Cleaning Instructions and Precautions **3-1**

Parts List **4**

Assembly View, Drawing 393 × 140 **4-1**

Assembly View, Drawing 393 × 119 **4-2**

1 1/8" Voltage Divider, Drawing 435 × 435 **4-3**

Drawings and Diagrams **5**

Section 1

Introduction

The Model 43-93 and 43-93-2 detectors are designed for alpha-beta surveying when coupled with compatible instruments. Functionally, these two detectors are very similar but differ in the type of protective window screen and the size of the active and open window areas.

Discriminating between alpha and beta radiation simultaneously requires the counting instrument to have either separate power supplies or window/threshold controls for each channel. The Ludlum Model 2929 Scaler, Model 2223, Model 2224 or Model 2360 instruments provide the necessary circuitry for simultaneous alpha-beta discrimination.

A Zinc Sulfide [ZnS (Ag)] scintillator is used for detecting alpha particles, and a thin plastic scintillator is employed for detecting beta radiation. The scintillation material is covered by metalized Mylar to reduce light response, limiting excessive background counts. The Model 43-93 window is protected by an 88% open square-hole screen, where the Model 43-93-2 window is protected by a 79% open hexagonal-hole screen.

The photomultiplier tube (PMT) and crystal assembly may easily be removed for repair. Refer to the assembly view drawing in section 5 of this manual for details on construction and parts. The photomultiplier tube typically operates between 500-1100 volts with a recommended maximum of 1500 volts.

Section 2

Specifications

Photomultiplier Tube: 1.125" (2.9 cm) diameter; magnetically shielded

Scintillator Material: Zinc Sulfide [ZnS (Ag)] deposited on a 0.01" (0.25 mm) rectangular plastic scintillator

Window: 1.2 mg/cm^2 Mylar

Window Area (Model 43-93):

Active area: approximately 100 cm^2

Open area: approximately 88 cm^2

Window Area (Model 43-93-2):

Active area: approximately 126 cm^2

Open area: approximately 100 cm^2

Efficiency (4π):

Model 43-93: Typically 15% for ^{99}Tc, 20% for ^{90}Sr ^{90}Y, and 20% for ^{239}Pu

Model 43-93-2: Typically 10% for ^{99}Tc, 17% for ^{90}Sr ^{90}Y, and 15% for ^{239}Pu

Typical Background (in a 10uR/hr field):

Alpha: 3 cpm or less

Beta: 300 cpm or less

Response Uniformity: 10% or less from average reading

Operating Voltage: Typically 500-1100 Vdc (1500 Vdc max.)

Dynode String Resistance: 60 megohm

Gamma Sensitivity: 15-20 cpm/µR/hr (^{137}Cs)

Dead Time: Typically 5 µsec or less

Connector: Series "C" unless otherwise specified

Temperature Range: –4°F (–20°C) to +122°F (50°C)

Size:

Model 43-93: 11.4" (29 cm) L × 3.6" (9.1 cm) W × 3.5" (8.9 cm) H

Model 43-93-2: 13.3" (33.8 cm) L × 4" (10 cm) W × 4" (10 cm) H

Weight: approximately 1 lb (0.45 kg)

Construction: Aluminum housing with beige powder-coat finish

Section 3

Safety Considerations

Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude

Temperature range of -20°C to 50°C

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

Cleaning Instructions and Precautions

The detectors specified in this manual may be cleaned externally with a damp cloth, using only water as the wetting agent. Do not immerse the detector in any liquid. Do not attempt to clean a detector that is attached to an instrument providing high voltage: disconnect the detector cable before cleaning.

Section 4

Parts List

Assembly View, Drawing 393 × 140

Reference	Description	Part Number
UNIT	Completely Assembled Model 43-93 Alpha /Beta Scintillator	47-3475

Quantity	Description	Part Number
1 ea	Welded Body Assembly	2393-141
1 ea	Mirror	2310698
1 ea	Connector Cap	7393-102
1 ea	Mylar Window Assembly	4393-149
1 ea	Window Frame	7393-148
1 ea	Face Ring	7393-137
1 ea	Square Screen (external snap-on screen)	7393-171
1 ea	Backup w/Plastic Scintillator and ZnS	4393-153
1 ea	Plastic Scintillator-EJ212-3.12 x 6.67 x 0.010	01-5692
1 ea	Photomultiplier Tube	01-5238
1 ea	Voltage Divider Board	5435-182
*	Foil-NETIC	01-5019
*	Foil-CO-NETIC	01-5026
9 ea	Sponge	7002-065-04
1 ea	Tube Holder Assembly	2393-117
1 ea	Gasket	7393-139
1 ea	O-Ring	16-8366
1 ea	Series "C" Connector RECPT-UG706/U	4478-011
1 ea	M 43-93 Vinyl Cover	7393-162

Assembly View, Drawing 393 × 119

Reference	Description	Part Number
UNIT	Completely Assembled Model 43-93-2 Alpha /Beta Scintillator	47-3227

Quantity	Description	Part Number
1 ea	Welded Body Assembly	2393-105
1 ea	Mirror	2310654
1 ea	Connector Cap	7393-102
1 ea	Mylar Window Assembly	4393-126
1 ea	Window Frame	7393-109
1 ea	Face Ring	7393-120
1 ea	Hex Screen (external snap-on screen)	7393-116
1 ea	Backup w/Plastic Scintillator and ZnS	4393-127
1 ea	Plastic Scintillator- EJ212-3.12 x 6.67 x 0.010	01-5685
1 ea	Photomultiplier Tube	01-5238
1 ea	Voltage Divider Board	5435-182
*	Foil-NETIC	01-5019
*	Foil-CO-NETIC	01-5026
9 ea	Sponge	7002-065-04
1 ea	Tube Holder Assembly	2393-117
1 ea	Gasket	7393-110
1 ea	O-Ring	16-8366
1 ea	Series "C" Connector RECPT-UG706/U	4478-011
1 ea	M 43-93-2 Vinyl Cover	7393-169

1 1/8" Voltage Divider Board, Drawing 435 × 435

	Reference	Description	Part Number
	BOARD	Completely Assembled 1 1/8" Voltage Divider Board (Models 43-93 & 43-93-2)	5435-182
CAPACITORS	C1- C3	0.01uF, 200V	04-5725
	C4	0.0047uF, 3KV	04-5547
RESISTORS	R1	10M, 1/8W, 1%	12-7996
	R2	7.5M, 1/8W, 5%	12-7971
	R3-R10	10M, 1/8W, 1%	12-7996

	Reference	Description	Part Number
	R11	2.21M, 1/8W, 1%	12-7002
	R12-R13	6.04M, 1/8W, 1%	12-7071
MISCELLANEOUS	*	SOCKET 1 1/8" PCB MOUNT	4435-103
	W1	TEFLON WHITE EE22 6" HV	21-9759
	W4	#22 BLACK UL1430 GND 6"	21-9154

Section

5

Drawings and Diagrams

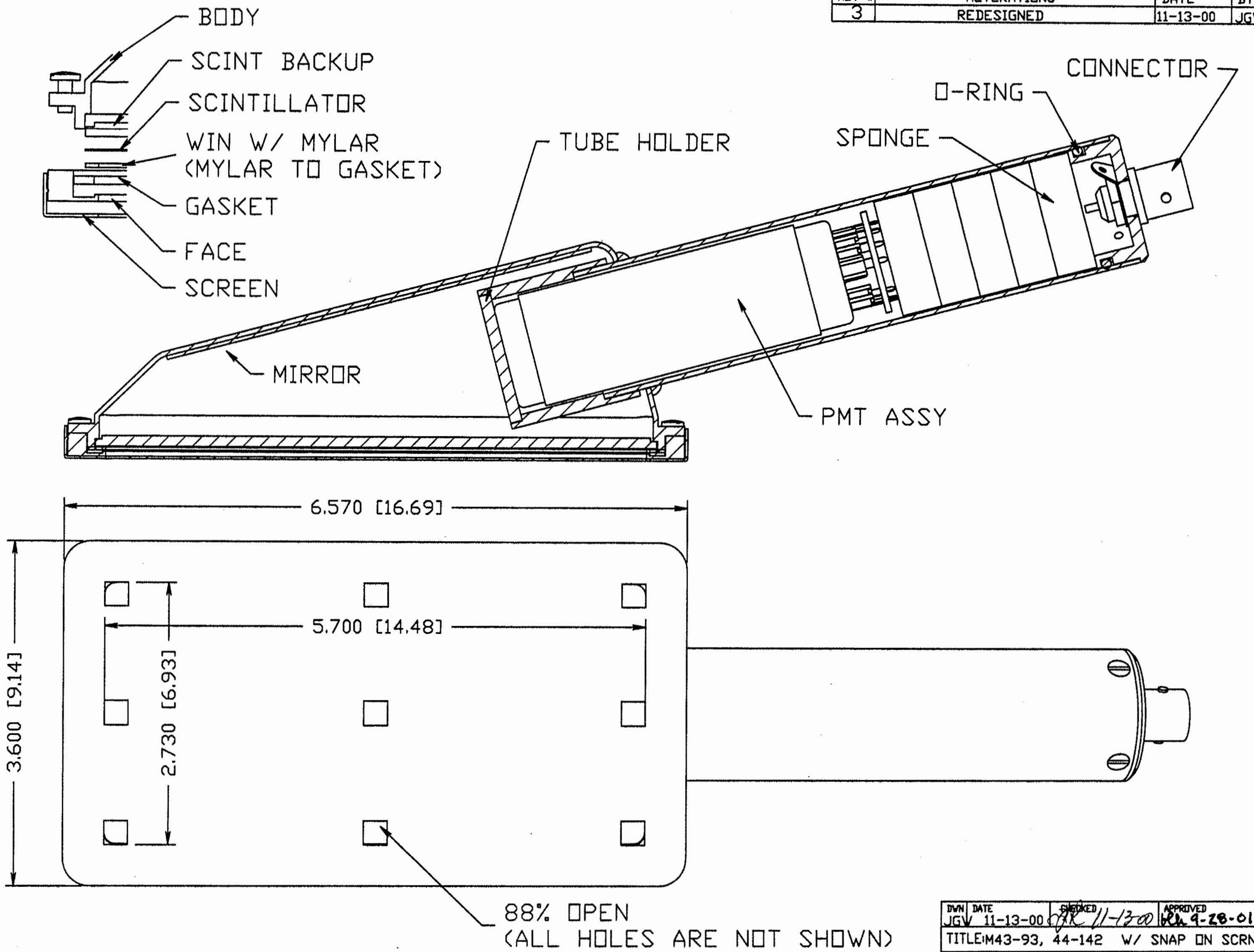
M 43-93 Assembly View, Drawing 393 × 140

M 43-93-2 Assembly View, Drawing 393 × 119

1 1/8" Voltage Divider Circuit Board, Drawing 435 × 435

1 1/8" Voltage Divider Component Layout, Drawing 435 × 436
(2 sheets)

REV #	ALTERATIONS	DATE	BY
3	REDESIGNED	11-13-00	JGW

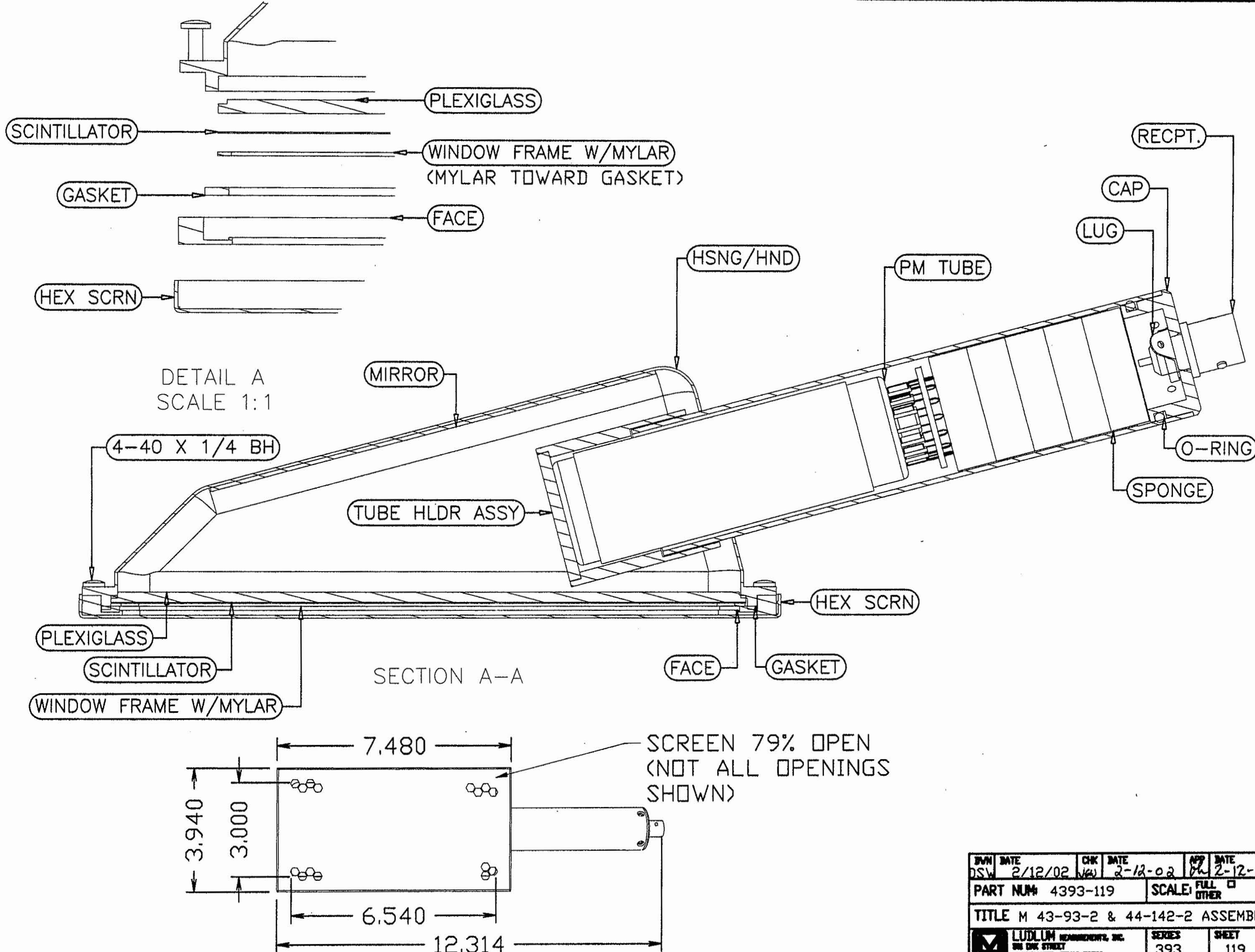


DWN	DATE	CHECKED	APPROVED
JGW	11-13-00	JK 11-13-00	Rh 9-28-01

TITLE: M43-93, 44-142 W/ SNAP ON SCRN

LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556	SERIES	SHEET
	393	140

REV #	ALTERATIONS	DATE	BY
1	VALID	2/12/02	DSW



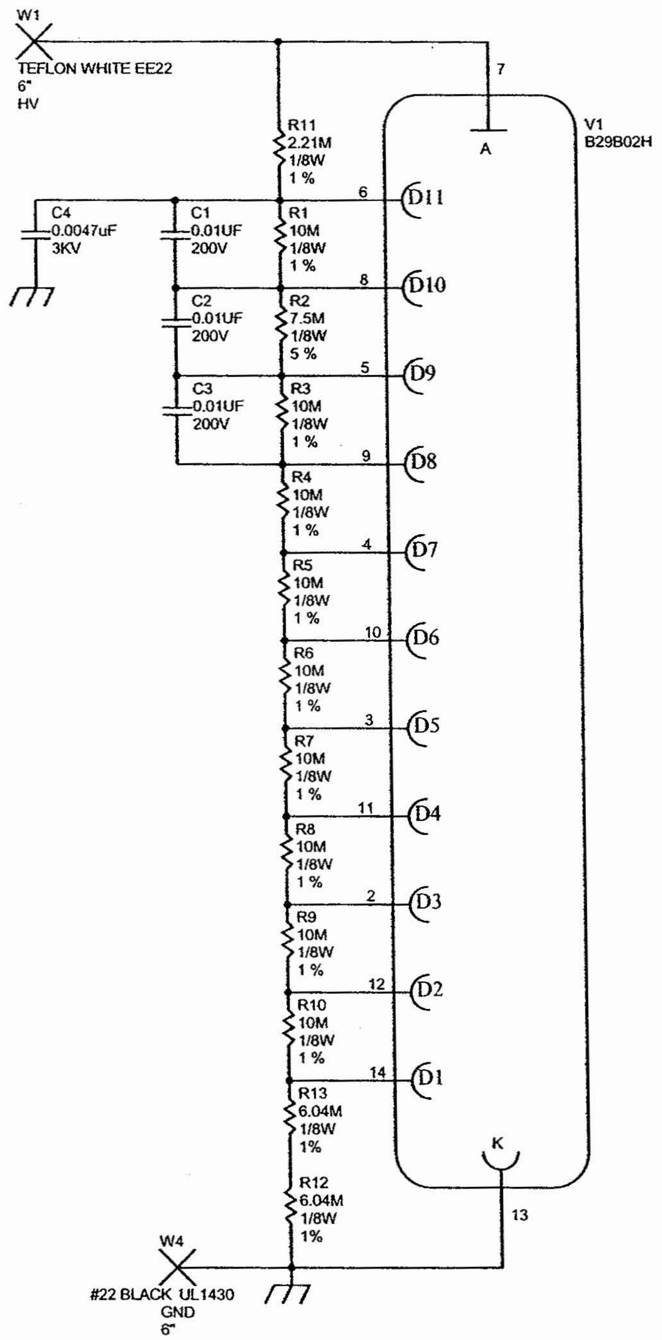
DWN	DATE	CHK	DATE	APP	DATE
DSW	2/12/02	[illegible]	2-12-02	[illegible]	2-12-02

PART NUM: 4393-119 | SCALE: FULL □ OTHER

TITLE M 43-93-2 & 44-142-2 ASSEMBLY

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

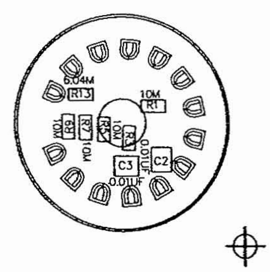
SERIES	SHEET
393	119



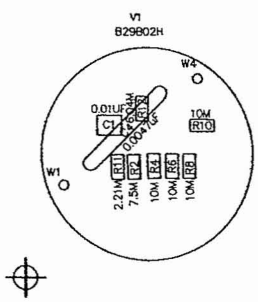
ADIT

PO Box 870
300 Crane Street
Sweetwater, Texas 79556
U.S.A. 1-800-399-4557

Drawn: KKH	08-JAN-03	**Title:** 1 1/8" Voltage Divider		
Design: LL	08-JAN-03	**Company:** Alpha Spectra		
Check:		**Tube:** B29B10		
Approve: RSS	5Jun03	**Board#:** 5435-182	**Sheet:** 1 of 1	
08:15:47	5-Jun-2003	**Rev:** 1.0	**Series** 435	**Sheet** 435



Drawn: KKH	24-MAR-03	Title: 1 1/8" VOLTAGE DIVIDER		
Design: LL	08-JAN-03	Company: LMI		
		Tube: B29B10H		
Approve: RSS	5 JUN 03	Board#: 5435-182		
Layer: Top; Mech.1 Mech.2 Bottom, Bottom Overlay; Mech.3 Mech.4 MID:		Rev: 1.0	Series	Sheet
		BS435182	435	436



Drawn: KKH	24-MAR-03	Title: 1 1/8" VOLTAGE DIVIDER			
Design: LL	08-JAN-03	Company: LMI			
		Tube: B29B10H			
Approve: BSS	5 Jun 03	Board#: 5435-182			
Layer: Mech.1 Mech.2 Mech.3 Mech.4	Top Overlay	Rev: 1.0		Series	Sheet
MID:		BS435182		435	436

LUDLUM MODEL 44-10
GAMMA SCINTILLATOR

July 2009
Serial Number PR107232 and Succeeding Serial Numbers

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

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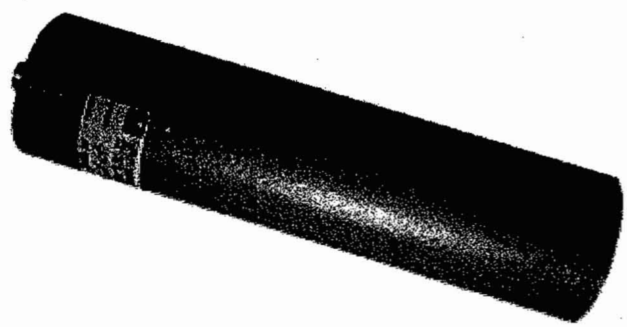
Introduction

The Model 44-10 sodium iodide (NaI) gamma scintillator is primarily used for detecting high energy gamma radiation in the range of 60 keV - 2 MeV. It consists of a 2"(5.1cm) diameter X 2"(5.1cm) thick NaI crystal coupled to a photomultiplier tube and is housed in a 0.062" thick aluminum housing. The detector is energy dependent, over responding by a factor of five in the 100 keV range and underresponding by a factor of 0.5 above 1 MeV when normalized to ^{137}Cs.

The Model 44-10 will operate with any Ludlum instrument or equivalent instrument that provides 500 - 1200 volts. The recommended instrument input sensitivity is approximately 10 mV or higher.

Some common applications for this detector include background radiation monitoring, high-sensitivity surveying, and spectrum analysis when used in conjunction with a single or multi channel analyzer.



Model 44-10

Note:

The detector does not contain any consumable materials.

Note:

If the detector is used in a manner not intended by the manufacturer, the detector may not function properly.

Unpacking and Repacking

Remove the calibration certificate or detector functional check certificate and place it in a secure location. Remove the detector and accessories (cable, etc.) and ensure that all of the items listed on the packing list are in the carton. If more than one detector is in the carton, refer to the calibration certificate(s) for serial number(S/N) match. The Model 44-10 S/N is located on the side of the detector near the connector.

To return the instrument or detector for repair or calibration, provide sufficient packing material to prevent damage during shipment and appropriate warning labels to ensure careful handling. The following items and information should also be included to insure a quick turnaround time on your repair/calibration:

- instrument(s) and related cable(s)
- brief description as to the reason for return
- description of service requested
- return shipping address
- customer name and telephone number

Specifications

SCINTILLATOR: 2" (5.1 cm) diameter X 2" (5.1 cm) thick NaI (Tl) crystal

SENSITIVITY: Typically 900 cpm/μR/hr (*^{137}Cs gamma*)

ENERGY RESPONSE: Energy dependent

COMPATIBLE INSTRUMENTS: General purpose survey meters, ratemeters, and scalers

TUBE: 2" (5.1 cm) diameter magnetically shielded photomultiplier

OPERATING VOLTAGE: 500 - 1200 volts

DYNODE STRING RESISTANCE: 60 megohm

CONNECTOR: Series "C" (*others available*)

CONSTRUCTION: Aluminum housing with beige polyurethane enamel paint

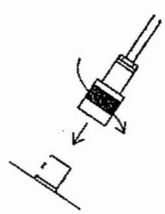
TEMPERATURE RANGE: -4°F(-20°C) to 122°F(50°C) May be certified to operate from -40°F(-40°C) to 150°F(65°C)

SIZE: 2.6" (6.6 cm) diameter X 11" (27.94 cm) L

WEIGHT: 2.3 lb (1.04kg)

Operating Procedures

Connecting to an Instrument



Connect one end of the cable provided to the detector by firmly pushing the connector together while twisting clockwise ¼ turn until latched. Repeat the process in the same manner with the other end of the cable and the instrument.

Testing the Detector

1. Insure that the instrument high voltage (HV) is at the proper setting for the detector (900 volts).
2. Connect the detector to the instrument and check for a proper background reading (typically 4,000- 10,000 cpm at 8-15 μR/hr).
3. Expose the detector to a check source and verify that the instrument indicates within 20% of the check source reading from the last calibration. Alternatively, expose the detector to a source of known value and verify that the detector detects greater than or equal to the efficiency listed in the specification section of this manual.
4. Instruments and detectors which meet these criteria are ready for use. Failure to meet these criteria may indicate a malfunction in the detector.

Safety Considerations

Environmental Conditions for Normal Use

1. Indoor or outdoor use (in a dry environment)
2. No maximum altitude
3. Temperature range of – 20°C to 50°C (5°F to 122°F); May be certified for operation from – 40°F to 150°F).
4. Maximum relative humidity of less than 95% (non-condensing)

Pollution Degree 3 (as defined by IEC 664)

Cleaning Instructions and Precautions

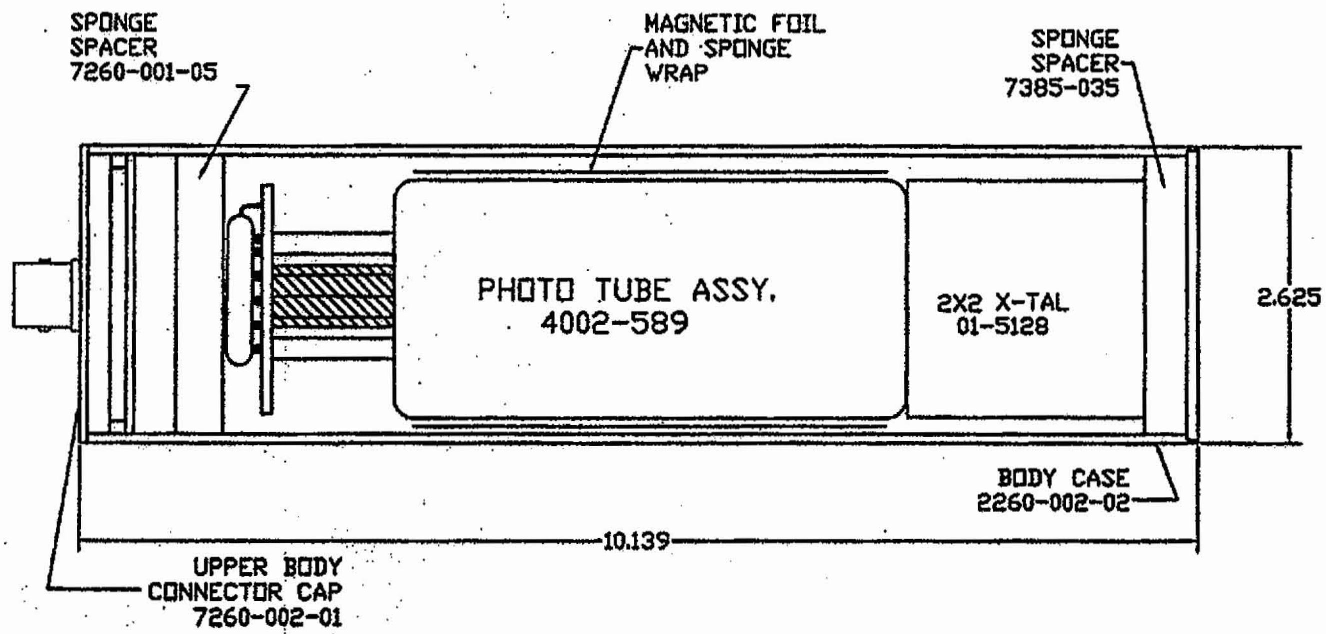
The detector may be cleaned externally with a damp cloth, using only water as the wetting agent. Do not immerse the instrument in any liquid. Observe the following precautions when cleaning:

1. Turn the instrument electronics OFF.
2. Allow the instrument to sit for 1 minute.
3. Disconnect the detector cable before cleaning the detector.

Parts List, Drawings and Diagrams

Model 44-10 Gamma Scintillator

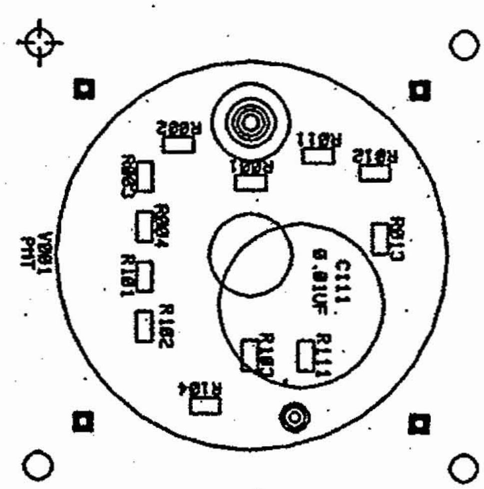
Reference	Description	Part Number
UNIT	Completely Assembled Model 44-10 Gamma Scintillator	47-1540
1 EA	BODY CASE W/ CAP	2260-002-02
1 EA	CONNECTOR CAP	7260-002-01
1 EA	2" x 2" NaI CRYSTAL	01-5128
1 EA	2" PHOTO TUBE ASSY	4002-589
1 EA	2" PM TUBE	01-5640
1 EA	CONNECTOR, UG706/U	4478-011
1 EA	O-RING	16-8289
8 EA	SPONGE SPACER	7260-001-05
1 EA	END SPONGE SPACER	7385-035
*	MAGNETIC FOIL	01-5019/5026
1 EA	SPONGE WRAP	21-9267


SPONGE
SPACER
7260-001-05
MAGNETIC FOIL
AND SPONGE
WRAP
SPONGE
SPACER
7385-035
PHOTO TUBE ASSY.
4002-589
2X2 X-TAL
01-5128
2.625
BODY CASE
2260-002-02
10.139
UPPER BODY
CONNECTOR CAP
7260-002-01

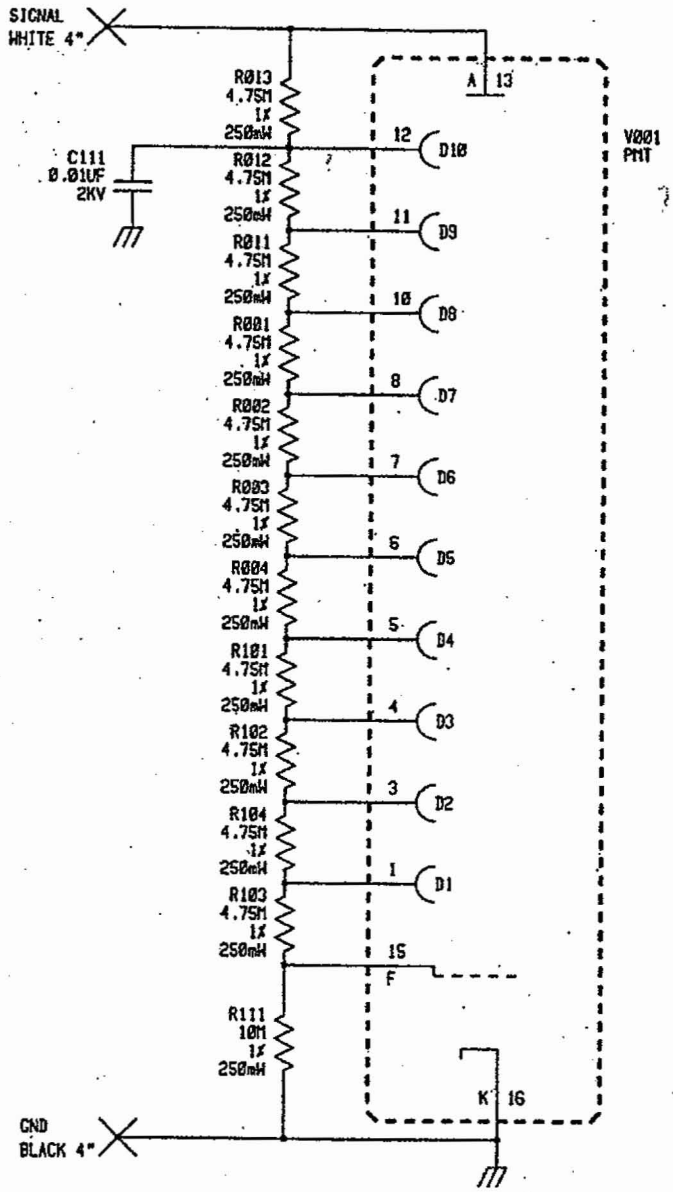
Reference	Description	Part Number

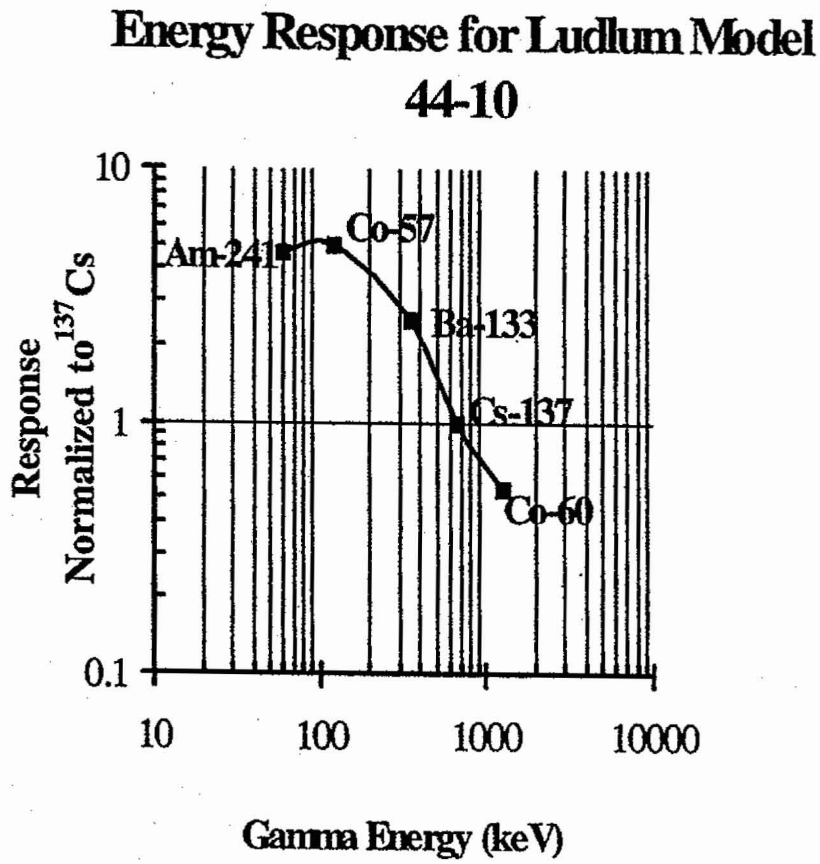
2" Voltage Divider Board

1EA	VOLTAGE DIVIDER	2002-357
1EA	CAP 0.01 µF 2kv	04-5525
11 EA	RES 4.75 meg 1/8 W, 1%	12-7995
1 EA	RES 10 meg 1/8 W, 1%	12-7996



2" Voltage Divider Board - Schematic




Energy Response for Ludlum Model 44-10
10
1
0.1
Response Normalized to 137 Cs
Am-241
Co-57
Ba-133
Cs-137
Co-60
10
100
1000
10000
Gamma Energy (keV)

LUDLUM MODEL 44-9
ALPHA, BETA, GAMMA DETECTOR

May 2007
Serial Number PR090405 and Succeeding
Serial Numbers

LUDLUM MODEL 44-9
ALPHA, BETA, GAMMA DETECTOR

May 2007
Serial Number PR090405 and Succeeding Serial Numbers

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

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M44-9 Pancake Probe, Drawing 2 × 206 6

Gamma Energy Response 7

Beta Efficiencies 7

Introduction

The Ludlum Model 44-9 G-M (Geiger-Mueller) Detector detects alpha, beta and gamma radiation. Its size and shape (pancake) provide easy handling for surveying or personnel monitoring. The detector is energy dependant, over-responding by a factor of six in the 60 keV to 100 keV range when normalized to ^{137}Cs.

The thin mica window is protected by a 79% open stainless steel screen. The G-M tube can be easily removed for replacement if necessary.

This detector operates between 850-1000 volts, with a recommendation from the tube manufacturer of approximately 900 Vdc. Recommended instrument input sensitivity is approximately 30 mV or higher to prevent the detector from double pulsing (where the detector "counts" a single pulse from the instrument multiple times.)

Caution!

The G-M tube face can rupture above 8000 feet in altitude. When transporting this detector by air, use an airtight container in order to avoid sudden atmospheric changes resulting in tube failure.

The Ludlum Model 44-9 will operate with any Ludlum instruments or equivalent instruments that provide 900 VDC and an input sensitivity of approximately 30mV or higher.

Unpacking and Repacking

Remove the calibration certificate or detector functional check certificate and place it in a secure location. Remove the detector(s) and accessories (if applicable) and ensure that all items listed on the packing list are in the carton. If multiple detectors are included, refer to the calibration certificates for serial number (SN) matches. The Model 44-9 serial number is located on the detectors' bottom plate.

To return an instrument or detector for repair or calibration, provide sufficient packing material to prevent damage during shipment (see "Caution!" in Introduction section) and affix appropriate warning labels to promote careful handling. The following items and information should also be included to insure quick turnaround time of your equipment.

- instrument(s) and related cable(s)
- brief description as to the reason for return
- description of service requested
- return shipping address
- customer name and telephone number

Specifications

Detector: pancake-type halogen quenched G-M

Window: 1.7 ± 0.3 mg/cm^2 mica

Window Area: Active – 15 cm^2; Open – 12 cm^2

Efficiency (4π geometry): typically 5% for ^{14}C; 22% for ^{90}Sr/^{90}Y; 19% for ^{99}Tc; 32% for ^{32}P; 15% for ^{239}Pu

Sensitivity: typically 3300 cpm per mR/hr (^{137} Cs gamma)

Energy Response: energy dependant (please see graphs on page 7)

Dead Time: typically 80 µs

Compatible Instruments: general-purpose survey meters, ratemeters and scalers.

Connector: series "C" (others available)

Construction: aluminum housing with beige powder-coat finish; stainless steel protective screen (79% open)

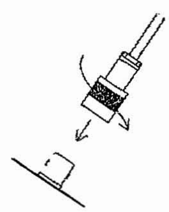
Temperature Range: 5°F (–15°C) to 122°F (50°C); may be certified for –40°F (–40°C) to 150°F (65°C)

Size: 1.8" (4.6 cm) H × 2.7" (6.9 cm) W × 10.7" (27.2 cm) L

Weight: 1 lb (0.5 kg)

Operating Procedures

CONNECTING TO AN INSTRUMENT



Connect one end of the cable provided to the detector by firmly pushing the connector together while twisting clockwise ¼ turn until latched. Repeat the process in the same manner with the other end of the cable and the instrument.

TESTING THE DETECTOR

1. Insure that the instrument high voltage (HV) is at the proper setting for the detector (900 volts).
2. Connect the detector to the instrument and check for a proper background reading (typically 25-50 cpm at 8-15 μR/hr).
3. Expose the detector to a check source and verify that the instrument indicates within 20% of the check source reading from the last calibration. Alternatively, expose the detector to a source of known value and verify that the

detector detects greater than or equal to the efficiency listed in the specification section of this manual.

4. Instruments and detectors that meet these criteria are ready for use. Failure to meet these criteria may indicate a malfunction in the detector.

Tube Replacement

Refer to drawing 2 × 206 located on page 6 of this manual to assist with replacement.

1. Remove the back plate by removing the three screws.
2. Loosen the three set screws on the side of the tube housing.
3. Remove the old tube from the detector housing.
4. Remove the anode clip from the old tube.
5. Push the clip onto the anode housing.

Note:

Do not over-flex the wire when installing the clip, as damage may occur.

Caution!

The mica window of this tube is extremely thin and fragile. There is also a thin layer of material to prevent UV interference. This material may come off if touched, causing the detector to malfunction. DO NOT TOUCH!

6. Carefully install the tube with the window facing down in the housing.
7. Ensure the tube is flush against the screen and tighten the set screws.

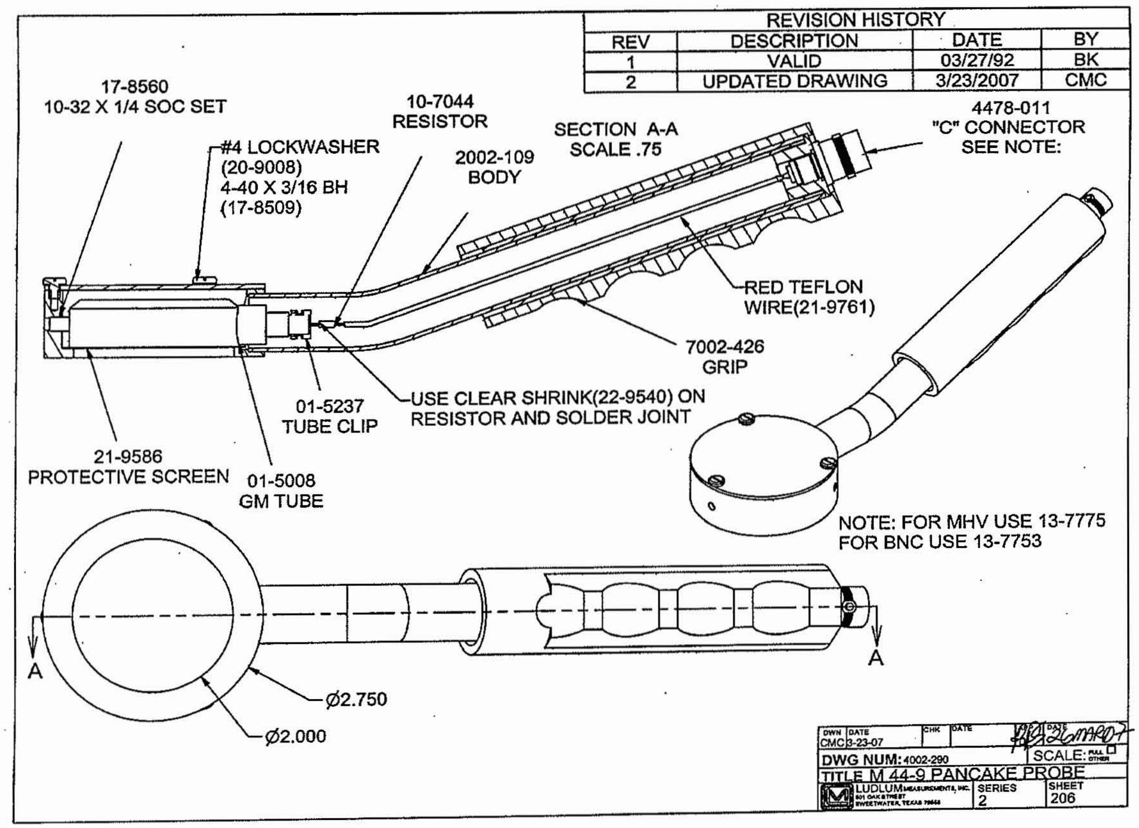
8. Replace the back plate and retaining screws.
9. Recalibrate the instrument and detector before use.

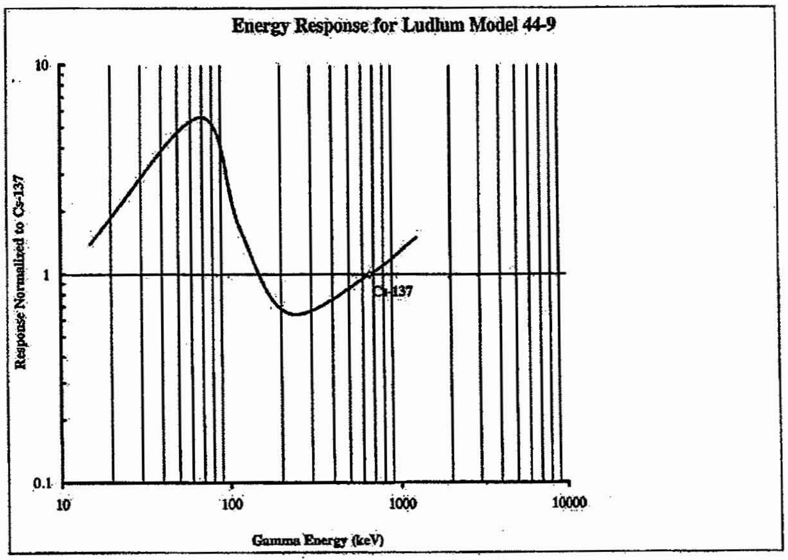
Parts List

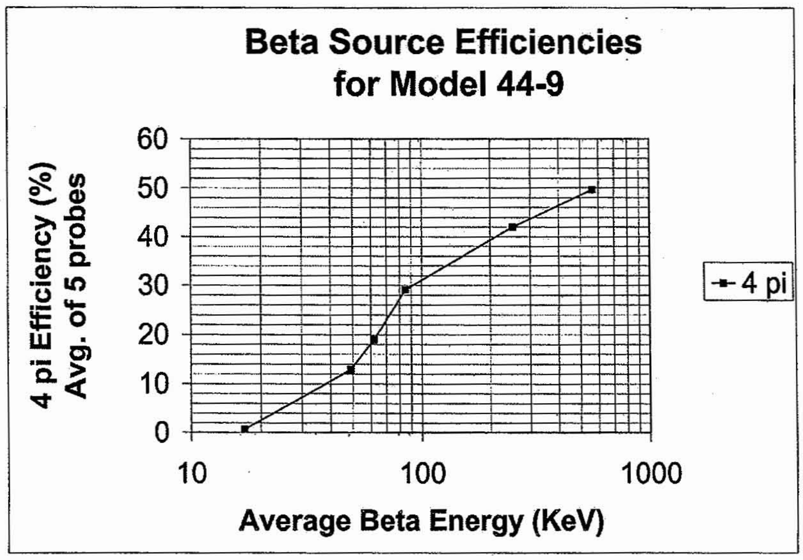
Model 44-9 Alpha-Beta-Gamma Detector

Reference	Description	Part Number
UNIT	Completely Assembled Model 44-9 Alpha-Beta-Gamma Detector	47-1539
*	DETECTOR BODY	2002-109
*	HANDLE GRIP	7002-426
*	G-M TUBE (LND 7311, TGM N1002)	01-5008
3 EA	SOCKET SET SCREWS (10-34 × ¼)	17-8560
*	PENCIL CLIP	01-5237
*	RESISTOR 3.3M	10-7044
*	CONNECTOR, UG706/U	4478-011
*	HV RED TEFLON WIRE	21-9761
*	PROTECTIVE SCREEN	21-9586
*	RED PROTECTIVE CAP	03-5476

Drawings and Diagrams




Energy Response for Ludlum Model 44-9
Response Normalized to Cs-137
10
1
0.1
Cs-137
10
100
1000
10000
Gamma Energy (keV)

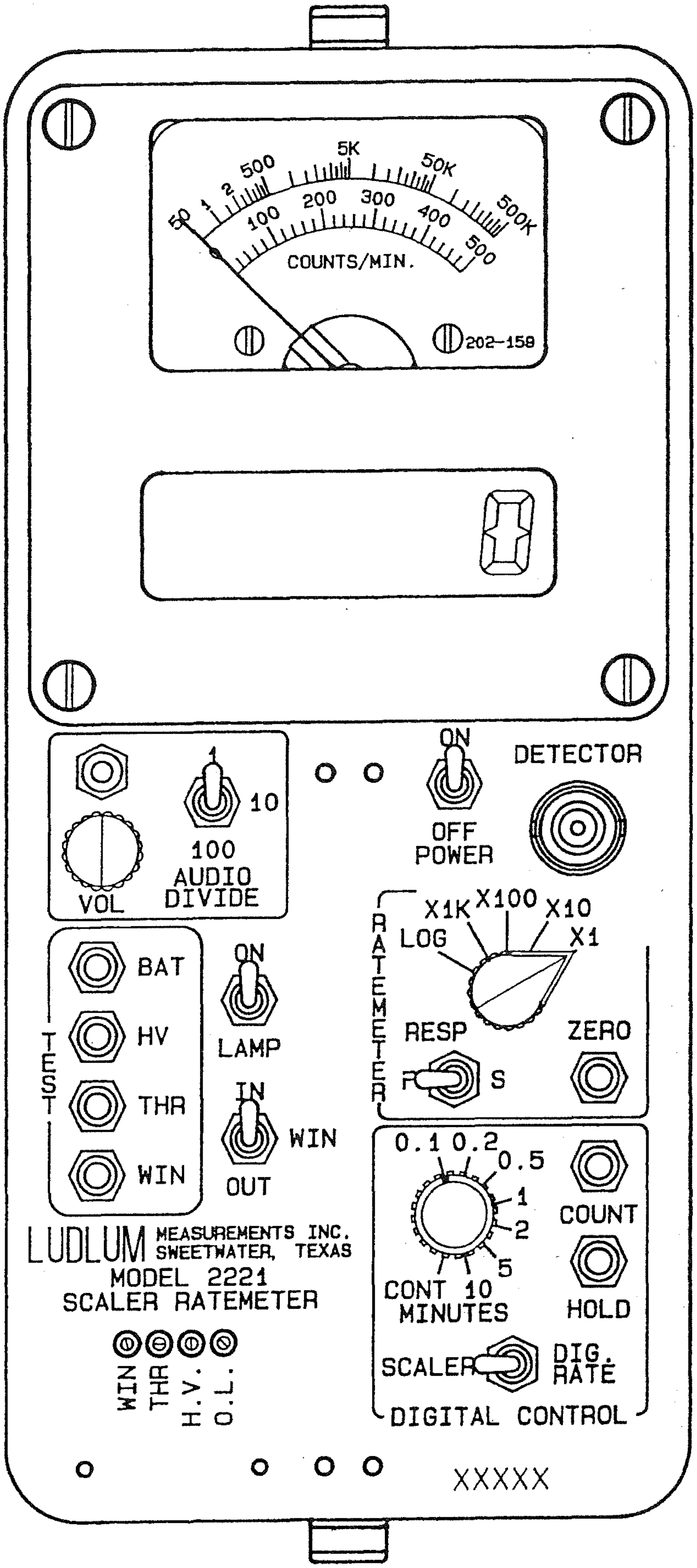

Beta Source Efficiencies
for Model 44-9
4 pi Efficiency (%)
Avg. of 5 probes
60
50
40
30
20
10
0
10
100
1000
Average Beta Energy (KeV)
4 pi

LUDLUM MODEL 2221
PORTABLE SCALER RATEMETER

Revised January 2002

Serial Number 161568 and
Succeeding Serial Numbers

LUDLUM MEASUREMENTS, INC.
501 OAK ST., P.O. BOX 810
SWEETWATER, TX 79556
915/235-5494 FAX: 915/235-4672



CHG	NO.		DWN	CHK	APP
DWN PW	DATE 5/31/89	CHK	DATE	APP	DATE

TOL: SHOP STD ☐ OTHER

SCALE: FULL ☐ OTHER

TITLE MODEL 2221 PORTABLE SCALER

LUDLUM MEASUREMENTS, INC. — SERIES 281 — SHEET 74

M2221 Portable Scaler Ratemeter
January 2002

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1. GENERAL

The Ludlum Model 2221 Portable Scaler Ratemeter is a self-contained counting instrument designed for operation with scintillation, proportional or G-M detectors. Power is derived from four flashlight batteries.

The unit is complete with a voltage-sensitive preamplifier, linear amplifier, electronic timer, detector high-voltage power supply and detector overload detection circuitry.

A single channel analyzer is also featured in this unit for use in gamma spectrum analysis. The analyzer may be switched on or off, allowing gross or window counting.

The unit has a combination four-decade linear and log ratemeter and a six-digit LCD readout for the scaler and digital ratemeter. Potentiometers are supplied for threshold, window and high-voltage controls.

2. SPECIFICATIONS

- **HIGH VOLTAGE**: 200 to 2400 volts with digital readout

- **BATTERY COMPLEMENT**: four each "D" cell flashlight batteries

- **BATTERY LIFE**: approximately 250 hours with size D, alkaline batteries

- **CALIBRATION STABILITY**: less than 3% variance to battery endpoint

- **SENSITIVITY**: voltage-sensitive and adjustable from 1.5 mV to 100 mV; typically factory-calibrated to 10 mV = 100 on the THR display

- **INPUT IMPEDANCE**: 22k

- **READOUT**: 6 digit liquid crystal display, 0.5" (1.3cm) characters with backlight selection

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

- **SCALES/RANGE**: four decade log ratemeter ranging from 50 to 500k CPM; four decade linear ratemeter - 0-500 CPM meter dial with range multipliers of X1K, X100, X10, X1 producing an overall range of 0-500k CPM

- **OPERATING TEMPERATURE**: 5-122°F (-15 to 50°C)

- **LINEARITY**: ±10% of the true value for the analog and digital ratemeter; ±2% of the true value for the digital Scaler, HV, THR, and WIN digital voltmeter readings; ±4% of the true value for the BAT voltmeter reading

- **RESPONSE**: 2 positions - Fast response = 4 ±1 second, Slow response = 22 ± 2 second; all response times are measured from 10-90% of final reading

- **CALIBRATION CONTROLS**: recessed screwdriver adjustments with calibration cover

- **AUDIO**: built-in unimorph speaker with click-per-event and switch selectable divide by 1, 10, and 100.

- **CONNECTOR**: Series "C"

- **SIZE**: 4.25" (10.8 cm)W X 10" (25.4cm) L X 9" (22.9cm) H including handle

3. DESCRIPTION OF CONTROLS AND FUNCTIONS

- **POWER**: Two-position switch to turn power to instrument on or off

- **DETECTOR**: series "C" connector for detector

  Input Impedance: 22k

  Ballast Resistor: 1M

- <u>RATEMETER</u>:

  - **F-S RESP Switch**: Two-position switch for selecting ratemeter response: F position 4 ±1 second; S position 22 ±2 seconds.

  - **ZERO**: when pressed, resets the ratemeter

  - **RANGE SELECTOR**: Five-position switch labeled LOG, X1K, X100, X10, X1 used to select the analog ratemeter range. The LOG position selects the upper meter scale to provide a four decade logarithmic reading from 50-500k CPM. The X1, X10, X100, and X1K range multipliers used with the lower 0-500 CPM meter scale providing and overall measuring range from 0-500k CPM. Multiply the meter reading by the respective range position.

- <u>DIGITAL CONTROL</u>:

  - **COUNT Pushbutton**: When pressed, resets and starts the counter. While the counter is counting, two colons on the display are turned on.
  - **HOLD Pushbutton**: When pressed, stops the counter and leaves the count in the display.

  - **SCALER/DIG RATE Toggle Switch**: Two-position toggle switch for selecting scaler or digital ratemeter

    SCALER Position: The display shows the counter contents.

    DIG. RATE Position: The display shows the ratemeter count rate.

    ✓ Note: The scaler and digital ratemeter are active even when not selected. This allows the user to start a timed count, switch to the Digital Ratemeter and then switch back to Scaler without having to restart the counter.

  - **MINUTES Selector Switch**: Eight-position switch used for selecting the count times for the Scaler:

POSITION	COUNT TIME IN MINUTES
0.1	0.1
0.2	0.2
0.5	0.5
1	1
2	2
5	5
10	10
CONT	
COUNTER COUNTS UNTIL HOLD IS PRESSED	

- <u>CALIBRATION CONTROLS</u>:

  - **WIN**: 20-turn potentiometer used to adjust window width when the window toggle switch, WIN, is in the "IN" position

  - **THR**: 20-turn potentiometer used to adjust the Threshold

- **HV**: 20-turn potentiometer used to adjust detector voltage

- **O.L.**: 20-turn potentiometer used to adjust detector overload current

- <u>**TEST**</u>:

- **BAT Pushbutton Switch**: When pressed, displays the battery voltage in the digital display.

- **HV Pushbutton Switch**: When pressed, displays the detector high voltage in the digital display.

- **THR Pushbutton Switch**: When pressed, displays the Threshold setting in the digital display.

- **WIN Pushbutton Switch**: When pressed, displays the window setting in the digital display.

- **LAMP Toggle Switch**: Two-position switch to turn on the display lights.

- **WIN Toggle Switch**: Two- position switch for switching the window IN or OUT

IN position: The SCA is set up as a window counter.
OUT position: The SCA is set up as a gross counter.

- <u>**AUDIO**</u>:

- **VOL Control**: One-turn potentiometer used to adjust the volume of the speaker or headset.

- **AUDIO DIVIDE**:

"1" Position: provides 1 click per event
"10" Position: provides 1 click per 10 events
"100" Position: provides 1 click per 100 events

- **1/8" PHONE JACK**: Used for headset. When headset is plugged in, the unimorph on the can is disabled.

- **LIQUID CRYSTAL DISPLAY**: Six-1/2" high digits, displaying counter contents or digital count rate

- <u>**STATUS INDICATORS:**</u>

Counter Overflow: When in SCALER mode, the left digit alternates between the correct digit and an "H".

Detector Overload: The display flashes all dashes.

Battery: When the battery voltage is 4.4 volts or less, all decimal points are turned on.

Scaler Counting: The two colons are turned on when MINUTES selector switch is in CONT position.

4. OPERATING PROCEDURES

4.1 Initial Preparation

- Unscrew battery door latch.

- Install for "D" size batteries in the battery holder. The correct position of the batteries is indicated on the bottom of the battery door.

- Switch the POWER ON/OFF switch to the ON position. A random number will first be observed in the display, then 8.8:8.8:8.8. The third displayed number will be the program version. (At the time of this printing, program version is #261010.)

- Press COUNT pushbutton. The display should zero. Two colons should appear on the display.

- Press HOLD pushbutton. The colons should disappear.

- Switch LAMP toggle switch to the ON position. LCD display backlighting and two lamps at the bottom of the analog meter should be illuminated.

✓ NOTE: If the Lamp switch is left in the ON position for extended periods of time, battery life will decrease rapidly.

- Check TEST pushbutton functions for proper operation.

4.2 Operating Point

Instrument and detector operating point is established by setting the probe voltage (HV) and instrument sensitivity (THR). For a given detector system, efficiency, background and noise are fixed by the physical makeup of the 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 the singular case of the G-M detector, a minimum operating voltage is required to establish the G-M operating region. (At lower voltages, the detector operates as a very insensitive proportional counter.) This detector is not capable of energy discrimination (pulse-height discrimination). The Threshold (THR) is typically adjusted to 550, with a THR reading of 100 = 10 mV input pulse, for G-M detectors.

For gain sensitive detectors (proportional or scintillation), the most straightforward method of selecting the operating point is to develop a graph, relating count rate to system gain. This relationship is commonly referred to as a plateau or instrument plateau curve. System gain may be changed by adjusting detector high voltage or THR control. The threshold is typically adjusted for 100 = 10 mV for scintillation detectors and 50 (5mV equivalent) on the THR readout for proportional detectors.

4.3 Limitation of Controls

HV Control provides a linear adjustment of the detector voltage supply. The range is approximately 0 to 2400 volts. Changing the detector voltage will cause the detector gain to change. It should be remembered that a linear change in voltage will cause an exponential change in detector gain. THR Control sets the basic pulse discrimination point of the scaler.

WIN Control is calibrated with the THR control so that the reading of the WIN control is equivalent to the reading of the THR control. As an example, 100 on the THR is equal to 100 on the WIN.

5. DETERMINING INSTRUMENT PLATEAU AND SELECTING OPERATING POINT

☐ Set WIN ON/OFF to OFF.

☐ Set MINUTES switch to 0.1 minutes.

☐ Set THR control at 100.

☐ With detector shielded from source, turn up high voltage control and take a plot of HV versus background count rate until the detector maximum voltage rating is reached. (Maximum voltage on most scintillation detectors is 1500-1600 Vdc; maximum voltage on proportional detectors is reached at the continuous discharge point. Return HV control to minimum.

☐ Expose the detector to a source and again make a plot of voltage versus count.

☐ Plot both sets of data and select the operating point to correspond with maximum source count and minimum background count. Avoid areas of very fast count rate changes with small changes in detector voltage. The optimum operating point for low background detectors is just above the inflection point (or break-over point) of the plateau curve. If background count is irrelevant, shift operating point to the plateau center for greater stability.

6. WINDOW OPERATION AND ENERGY CALIBRATION PROCEDURES

■ The following procedure calibrates threshold directly in keV.

☐ Place RATEMETER multiplier switch to LOG position.

☐ Unscrew and remove CAL cover.

☐ Press HV pushbutton. The HV should read out on the display directly in volts. While depressing the HV pushbutton, turn HV potentiometer maximum counterclockwise. The HV should be less than 50 volts.

☐ Depress the THR pushbutton. Turn the THR potentiometer clockwise until 652 displays.

☐ With WIN IN/OUT switch IN, depress the WIN pushbutton. Turn the WIN potentiometer until 20 appears on the display.

☐ Switch WIN IN/OUT to OUT.

☐ Connect the probe and expose to Cs137 source.

☐ Increase HV (if HV potentiometer is at minimum, it will take approximately 3 turns before any change is indicated). While increasing the HV, observe the log scale of the ratemeter. Increase HV until ratemeter indication occurs.

☐ Switch WIN IN/OUT switch to IN.

☐ Turn the HV control until maximum reading occurs on the log scale. Increase HV until reading starts to drop off, then decrease the HV for maximum reading.

☐ Turn RATEMETER selector switch to the X1K position.

☐ Press ZERO pushbutton and release. If meter does not read, switch to a lower range until a reading occurs.

□ Carefully adjust HV potentiometer until maximum reading is achieved on the range scale. The instrument is now peaked for Cs137 on both the LOG and Linear scales.

✓ NOTE: When the THR control is adjusted, the effective window width remains constant. As an example, if the THR is set at 612, the WIN at 100, a 662 keV peak 612 + (100 divided by 2) will be centered in the window. Then the threshold point is equivalent to 612 keV with a 100 keV window and calibrated for 100 keV per turn. Now if the threshold is reduced to 250, the threshold is equivalent to 250 keV, but the window (100) is still equal to 100 keV. Proportionally, this represents a broader window.

7. OVERLOAD DETECTION CALIBRATION

■ Detector Count Saturation is detected in this instrument and is indicated by the LCD display flashing all dashes and the analog ratemeter deflecting full scale. The count saturation or "overload" point is calibrated by the O.L. front panel control.

□ Adjust the O.L. control to fully clockwise position.

□ Connect detector and set HV for correct detector operating voltage.

□ Expose detector to radiation field and while observing ratemeter, increase field intensity until a decrease in count rate is noticed. For alpha scintillators, the detector photomultiplier tube (PMT) should be exposed to a small light leak through the probe face to establish the detector saturation point.

□ With the detector in the count saturation field, adjust the O.L. control counterclockwise until the overload alarm point is reached (flashing dashes in LCD display).

□ Position detector in a lower field intensity just below the saturation point and confirm overload is defeated.

Example: Ludlum Model 44-9 GM pancake detector saturates at approximately 500 mR/hr (5mS/h).

□ Full scale instrument analog meter reading=200 mR/hr (2 mS/h). Set the Model 2221 to overload at 500 mR/hr (5 mS/h) field, then position detector in a 300 mR/hr (3 mS/h) field and confirm that overload alarm is defeated. The O.L. control will have to be "fine adjusted" to perform the above procedure.

8. CALIBRATION

■ Refer to schematic and component layout for the following calibration.

8.1 Ratemeter Calibration

□ Connect Frequency counter to pin 18 of U22 (80C51FA) on Processor board, #5261-073. Confirm crystal frequency is 6 MHz ±0.1% (6,006 khz-5,994 kHz).

□ Set THR control to 100 and Window IN/OUT switch to the OUT position.

□ Connect Ludlum Model 500 Pulser or equivalent and adjust count rate for 40,000 CPM.

□ Switch Ratemeter Multiplier switch to the X100 position and the Response switch to "F."

□ Adjust pulse amplitude above threshold until a steady count rate is observed on ratemeter.

□ Adjust R40 Meter Cal (labeled MCAL) on Processor board, for 40,000 CPM on meter.

□ Switch SCALER/DIG RATE switch to the SCALER position.

□ Confirm counter time operation by taking 0.1 minute count. Colons should be observed during count cycle.

8.2 TEST Pushbutton/Display Calibration

□ Adjust THR control to fully clockwise position.

□ Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) on the Amp./P.S. board. Connect negative lead to ground near U3.

□ Press the THR test pushbutton and adjust R171 Volt Cal (labeled "V"), so that the front panel display reading corresponds to the voltmeter reading at pin 7 of U3.

8.3 High Voltage Calibration

□ Connect HV meter (2500 Megohm input impedance or greater) to the junction of R32 (4.7 Meg) and R33 (1 Meg) on Amp/P.S. board.

□ While pressing the HV Test pushbutton, adjust the HV front panel control until the display reads 1500.

□ Adjust R175 HV Cal on Amp/P.S. board for 1500 ±5 volts on external HV meter.

□ Confirm HV will adjust from 50 to 2400-2500 volts. Insure HV displayed reading tracks within 2% of HV output.

8.4 Threshold/Gain Calibration

□ Set pulser pulse amplitude to 10mV.

□ With THR set at 100, on display, fine adjust R174 Gain control (on P.S. board) until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.

□ Adjust THR control for readings of 200, 300, 400, and 500 to insure the pulser input is 20, 30, 40 and 50mV respectively. Use the 3/4 CPM input setting to discriminate turn on points as in procedure above.

□ Adjust THR control back to 100.

□ Switch Window IN/OUT switch to the IN position. Adjust WIN control for 100, 200, 300, 400 and 500 to confirm 20, 30, 40 and 50mV window cut off points.

□ Set WIN back to 100 and OUT position.

□ Check the rest of the front panel functions for proper operation.

9. OVERHAUL PROCEDURE

■ The checkout below can be performed with boards in instrument. An extender board (part no. 5261-098) is available if better access to board components is necessary.

9.1 Amplifier/Power Supply Board

□ Connect L.V. power supply to Model 2221 and plug in Amp/P.S. board. (component side to back of instrument).

□ Adjust the WIN, THR and O.L. front panel controls to maximum clockwise position. Turn HV control to maximum counterclockwise position. Switch the lamp switch to the OFF position. Window IN/ OUT switch to the OUT position.

□ Adjust input voltage for approximately +4 Vdc and turn instrument to the ON position. Battery current should be approximately 30 mA or less.

□ Confirm pin 8 of U7 (CA3290A) is equal to or greater than +6.4 Vdc.

□ Increase supply voltage to approximately +5 Vdc and pin 8 of U7 should increase to +9 ±1 Vdc.

□ Check for +5 ±0.15 Vdc at pin 8 of any of the TLC27M7IP's.

□ Check for -6.5 ±0.5 Vdc at pin 4 of any of the same TLC27M7IP's.

□ Connect subminax wire from detector input to Amp/P.S. board.

□ Connect HV meter to detector input and adjust front panel HV control to fully clockwise position.

□ Adjust the HV front panel control to the fully clockwise position. Then adjust R175 HV CAL for approximately 2400-2450 Vdc. Decrease front panel HV control to the fully counterclockwise position and confirm that HV output is 50 volts or less. Then set HV for approximately 1000 Vdc.

□ Connect voltmeter to pin 1 of U3 (TLC27M7IP).

□ With HV output set at approximately 1000 volts adjust R176 Current Cal (labeled "O") for approximately 0.1 Vdc at pin 1 of U3.

□ Connect Overrange Simulator (needs to have a 1000 meg resistor) to detector input and confirm pin 1 of U3 increases to approximately 0.15 ±0.01 Vdc.

□ Connect voltmeter to pin 1 of U2 (LM358) and with Overrange Simulator connected, adjust O.L. control on the front panel counterclockwise until the voltmeter reads approx +0.5 Vdc. Disconnect Simulator and confirm pin 1 of U2 goes above +3 volts.

□ Turn O.L. control to its maximum clockwise position.

□ Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) and connect negative lead to ground close to U3.

□ Press the WIN test pushbutton and confirm pin 7 of U3 is approximately 2.7 to 3.8 volts.

□ Press THR test and confirm pin 7 is 1.23 ±0.02 Vdc.

□ Press BAT test pushbutton and confirm pin 7 is approximately 0.5 with supply voltage at +5 Vdc.

□ With the HV still set at 1000 Vdc, pin 7 of U3 should be approximately 1 ±0.1 Vdc while pressing the HV test pushbutton.

□ Connect oscilloscope to pin 3 of U5 (LM331) and adjust R171 Volt Cal (labeled "V") for approximately 2 khz (0.5 millisecond period) with the HV pushbutton pressed.

□ Connect voltmeter to pin 7 of U3 and while pressing the THR test pushbutton, adjust THR control for approximately +0.1 Vdc.

□ Switch the Window IN/OUT switch to the IN position. While pressing the WIN test pushbutton, adjust the WIN control for approximately +0.1 Vdc at pin 7 of U3 also. Then switch the Window to the OUT position.

□ Connect oscilloscope to pin 2 of U8 (CA3096).

□ Connect pulser and set pulse amplitude for approximately 10 millivolts. Set CPM to 40,000.

□ Adjust R174 Gain (labeled "G") to maximum clockwise position and confirm positive pulses at pin 2 of U8 are approximately 1 ± 0.1 volt in amplitude.

□ Connect oscilloscope to pin 10 of U105 (CD4098).

□ Adjust R174 Gain until pulses just start to appear at pin 10 of U105. Then adjust pulser amplitude until pulses are clearly visible.

□ Adjust R173 T Pulse (labeled "T") for a 2.5 microsecond positive pulse width at pin 10 of U105.

□ Connect oscilloscope to pin 7 of U105 and adjust R172 Width (labeled "W") for a 3 microsecond negative pulse width.

□ Switch the Window IN/OUT switch to the IN position and verify that the pulses are present at pin 7 of U105 from 10 to 20 mV input pulse amplitude and off above approximately above 20 mV.

□ Switch Window IN/OUT switch to the OUT position and verify the pulses appear above the window limit as in the above step.

□ Battery current should be less than 30 mA with +5 Vdc supply input.

9.2 Processor Board Checkout

■ The procedure below is to be used without the Amp/P.S. board. If the Amp/P.S. board is used, delete the steps containing the signal generator use. Use the pulser for the standard count rate inputs. Window, Threshold, HV and Bat test will display the control setting.

□ Plug in Amp/P.S. Simulator board and connect Signal Generator to jumper wires (black= probe ground).

□ Plug in Processor board, component side toward back of instrument. Connect display ribbon cable.

□ c. Set Signal Generator to square wave function.

Range= 10k and all other switches to the OUT position.

□ Adjust the Freq. Symmetry, Amplitude and D.C. Offset controls to achieve a 5 volt negative pulse with a pulse width of approximately 50 microseconds and a period of approximately 1.2 milliseconds.

□ With supply voltage set at +5 ±0.15 Vdc, turn instrument ON and observe display= 8.8:8.8:8.8 for approximately 2 seconds, then 261010 indicating the program number.

☐ Connect Frequency Counter to pin 18 of U22 (80C51FA) and confirm crystal frequency is 6 Mhz ±0.1% (6,006 khz-5,994 khz).

☐ Switch the Scaler/Dig. Rate Switch to the Dig Rate position.

☐ Counts should start accumulating every 2 seconds until approximately 50,000 CPM is observed. (The symmetry control can be fine adjusted until 50,000 CPM is achieved). At this displayed count rate, the low BAT Test indication should be observed, indicated by 5 decimal points across the bottom of the display.

☐ Press BAT Test and display should be 4.1 ±0.2.

☐ Press HV and WINDOW= 410 ±20. Threshold pushbutton has no effect without Amp/P.S. plugged in.

☐ Switch Ratemeter Response time to F.

☐ Switch Ratemeter multiply to X100.

☐ Adjust R40 Meter Cal, (labeled MCAL), until Ratemeter matches displayed accumulated count (approximately 50,000 CPM).

☐ Decade the Multiplier range on the Signal Generator to correspond to each decade on Rate Multiplier to confirm range switch operation.

☐ Connect Voltmeter to recorder output and confirm R41 RCDR CAL, (labeled RCAL), will adjust from 0 to approximately 3.7 Vdc, with full scale CPM on display and ratemeter. Then set for 1 Vdc to equal full scale meter deflection.

☐ Connect Oscilloscope to pin 9 of U10 (ICM7556) and decade Sweep Generator down to the 1k range.

☐ Switch the Audio Divide switch between the 1, 10, and 100 positions to confirm Audio frequency divides or multiplies by 10, between each position.

☐ Connect Headset or unimorph and confirm volume control operation.

☐ With full scale meter deflection (500), check F/S response time (90% full scale) for 4.5 ±0.5 seconds and 22 ±2 seconds respectively.

☐ Check Count, Hold, and Zero pushbutton functions.

☐ Switch Scaler/Dig. Rate switch to the Scaler position and check the 0.1, 0.2 and 2 minute time multipliers for correct time operation.

☐ With +5 volts supply input, battery current should be less than approximately 15 mA, with full scale meter deflection.

9.3 Functional/Chassis Checkout

☐ This procedure requires a checked-out Amp/P.S. board and Processor board.

☐ Connect one lead of an ohmmeter to chassis ground.

☐ Connect other lead of ohmmeter to the Processor board cinch connector pins below to check count time switch operation. Boards are not plugged in yet.
1= open
0= shorted

COUNT TIME POSITION	PROCESSOR BOARD CINCH CONNECTOR PIN 8	30	31
0.1	0	0	0
0.2	0	0	1
0.5	1	0	0
1	1	0	1
2	0	1	0
5	0	1	1
10	1	1	0
CONT	1	1	1

Connect external power supply and set input voltage for approximately +5 Vdc.

☐ Turn Lamp switch to the OFF position. THR and O.L. controls to maximum clockwise position and HV to maximum counterclockwise position.

☐ Plug in Processor and Amp/P.S. boards and related cable connections.

☐ Turn instrument ON. Current draw should be less than 45 mA.

☐ Confirm display reads 8.8:8.8:8.8 for approximately 2 seconds, then 261010 indicating the program version.

☐ Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) on the Amp./P.S. board. Connect negative lead to ground near U3.

☐ With the THR control full clockwise, press the THR test pushbutton and adjust R171 Volt Cal (labeled "V"), so that the front panel display reading corresponds to the voltmeter reading at pin 7 of U3.

☐ Connect HV meter (2500 Megohm input impedance or greater) to the junction of R32 (4.7 Meg) and R33 (1 Meg) on P.S. board.

☐ While pressing the HV Test pushbutton, adjust HV control until the display reads 1500. R176 Current Cal may have to be adjusted counterclockwise to defeat the Overrange function.

☐ Adjust R175 HV Cal on Amp/P.S. board for 1500 ±5 on external HV meter.

☐ Confirm HV will adjust from 50 to 2400-2500 volts. Insure HV displayed reading tracks within 2% of HV output.

☐ Adjust HV for approximately 1000 volts.

☐ Adjust R176 Current Cal (labeled "0") for approximately 0.1 volt at pin 1 of U3 (TLC27M7IP) on Amp/P.S. board.

☐ Connect Overrange Simulator (1000 megohm) to the detector input.

☐ Adjust the O.L. control counterclockwise until hyphens start flashing across display every other count interval. Disconnect Overrange Simulator and confirm overrange function is defeated. Then adjust to fully clockwise position.

☐ Set THR control to 100 and Window IN/OUT switch to the OUT position.

☐ Connect pulser and adjust count rate for 40,000 CPM.

☐ Switch Ratemeter Multiplier switch to the X100 position and the Response switch to "F."

☐ Adjust pulse amplitude above threshold until a steady count rate is observed on ratemeter.

☐ Adjust R40 Meter Cal (labeled MCAL) on Processor board, for 400 CPM on meter.

☐ Adjust pulser for 10,000 CPM and check meter for ±10% linearity of reading. Adjust pulser and rate Multiplier switch to confirm linear readings on all ranges.

☐ Switch SCALER/DIG. RATE switch to the SCALER position.

☐ Confirm count time switch operation by taking a 0.1 minute and 0.5 minute count. Colons should be observed during count cycle.

☐ Check HOLD and ZERO pushbutton functions.

☐ Switch SCALER/DIG. RATE switch to the DIG. RATE position and confirm update count display operation approximately every 2 seconds.

☐ Connect unimorph and headset to the audio outputs and confirm audio divide and volume control functions. NOTE: Unimorph should shut off when headset is connected.

☐ With the THR control adjusted for 100, adjust R174 Gain (labeled G) for 1.5 millivolt input sensitivity. Insure instrument functions at low input sensitivity without "noise".

☐ Instrument may have to be placed in can to permit "noise free" operation.

☐ Set pulser pulse amplitude to 10mV.

☐ With THR still set at 100, fine adjust R174 Gain control until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.

☐ Adjust THR control for readings of 200, 300, 400, and 500 to insure the pulser input is 20, 30, 40 and 50mV respectively. Use the 3/4 CPM input setting to discriminate turn on points as in procedure above.

☐ Adjust THR control back to 100.

☐ Switch Window IN/OUT switch to the IN position. Adjust WIN control for 100, 200, 300, 400 and 500 to confirm 20, 30, 40 and 50mV window cut off points.

☐ Set WIN back to 100 and OUT position for instrument shipment.

☐ Input a full-scale ratemeter count rate (500 CPM) and connect voltmeter to the recorder output. Adjust R41 (labeled RCAL) on Processor board for 1 volt.

☐ Check F/S ratemeter response time for 4.5 ±0.5 and 22 ±2 seconds at 90% of full scale.

☐ Decrease input supply voltage until periods are observed at bottom of display. Press BAT Test pushbutton and confirm low BAT Test is 4.4 ± 0.1 Vdc. Adjust supply voltage back to 5 volts and confirm BAT test and actual supply input is 5 ±0.05 Vdc.

☐ Switch SCALER/DIG. RATE switch to the SCALER position. Count Time Multiplier to CONT. Press count pushbutton and start with low enough count rate to observe each digit number count sequence from Least significant digit to MSD. Decade pulser count rate to speed up digit segment display check.

☐ Increase count rate enough to overflow counter. An "H" should be observed in the MSD flashing every count interval.

☐ Turn Lamp switch to the ON position and confirm 2 lamps in the display and 2 lamps below the meter are illuminated.

☐ Current draw with lamps on should be 210 ±20 mA.

☐ Turn lamp OFF and current should be approximately 40 ±5 mA.

PARTS LIST

Ref. No.	Description	Part No.
	Model 2221 Portable Scaler Ratemeter	
UNIT	Completely Assembled Model 2221 Portable Scaler Ratemeter	48-2065
	Amplifier/Power Supply Board, Drawing 261 X 56	
BOARD	Assembled Board	5261-072
•	**CAPACITORS**	
C107	1µF, 35V, DT	04-5575
C108	2.2µF, 25V, DT	04-5559
C109	4.7µF, 10V, DT	04-5578
C110	4.7µF, 10V, DT	04-5578
C111	100µF, 10V, DT	04-5576
C112	4.7µF, 10V, DT	04-5578
C114	10pF, 100V, C	04-5573
C115	0.1µF, 100V, C	04-5521
C116	0.1µF, 100V, C	04-5521
C117	0.1µF, 100V, C	04-5521
C118	0.1µF, 100V, C	04-5521
C120	0.0022µF, 100V, P	04-5580
C121	0.001µF, 100V, C	04-5519
C122	0.1µF, 100V, C	04-5521
C123	100pF, 100V, C	04-5527
C124	0.1µF, 100V, C	04-5521
C125	0.01µF, 100V, C	04-5523
C126	47pF, 100V, C	04-5533
C127	0.1µF, 100V, C	04-5521
C128	47pF, 100V, C	04-5533
C129	100pF, 100V, C	04-5527
C130	10pF, 100V, C	04-5573
C131	0.1µF, 100V, C	04-5521
C132	10pF, 100V, C	04-5573
C133	0.0015µF, 3kV, C	04-5518
C135	0.0015µF, 3kV, C	04-5518
C136	0.0015µF, 3kV, C	04-5518
C137	100pF, 3kV, C	04-5532
C138	100pF, 3kV, C	04-5532
C139	0.0056µF, 3kV, C	04-5522
C140	0.0056µF, 3kV, C	04-5522
C141	0.0056µF, 3kV, C	04-5522
C145	1µF, 35V, DT	04-5575
C146	100µF, 10V, DT	04-5576
C147	100µF, 10V, DT	04-5576
C148	10µF, 20V, DT	04-5592
C154	0.0015µF, 3kV, C	04-5518
C164	0.1µF, 100V, C	04-5521
C165	0.1µF, 100V, C	04-5521
•	**TRANSISTORS**	
Q142	2N3904	05-5755
Q143	MPSU51	05-5765
•	**INTEGRATED CIRCUITS**	
U1	TLC27M7	06-6248
U2	LM358	06-6024
U3	TLC27M7	06-6248
U4	TLC27M7	06-6248
U5	LM331	06-6156
U6	LM2578	06-6223
U7	CA3290AE	06-6140
U8	CA3096	06-6023
U9	CA3096	06-6023
U105	CD4098	06-6066
U106	CA3096	06-6023
U144	CD4052	06-6141
•	**DIODES**	
CR10	IN5819	07-6306
CR12	MR-250-2	07-6266
CR13	MR-250-2	07-6266
CR14	MR-250-2	07-6266
CR15	MR-250-2	07-6266
CR16	1N4148	07-6272
CR17	1N4148	07-6272
CR18	1N4148	07-6272
CR19	1N4148	07-6272
CR20	1N4148	07-6272
CR21	1N4148	07-6272
CR22	1N4148	07-6272
CR24	1N5819	07-6306
CR25	1N5819	07-6306
CR151	MR-250-2	07-6266
CR177	1N5252	07-6265
•	**RESISTORS**	
R32	4.7M	10-7030
R33	1M	10-7028
R34	1M	10-7028
R35	1G	12-7686
R36	1G	12-7686
R37	0.1 OHM, 1%	12-7647

Ref. No.	Description	Part No.
R38	10k	12-7748
R39	1M, 1%	12-7763
R40	10k	12-7748
R41	10k	12-7748
R42	10k	12-7748
R43	10k	12-7748
R44	47k	12-7758
R45	4.7k	12-7755
R46	10k	12-7748
R47	10k	12-7748
R48	10k	12-7748
R49	1k	12-7750
R50	220 OHM	12-7753
R51	220 OHM	12-7753
R52	470k	12-7757
R53	47k	12-7758
R54	1k	12-7750
R55	10k	12-7748
R56	4.7k	12-7755
R57	10k	12-7748
R58	10k	12-7748
R59	10k	12-7748
R60	1k	12-7750
R61	178k, 1%	12-7769
R62	4.7k	12-7755
R63	100k	12-7747
R64	10k	12-7748
R65	10k, 1%	12-7764
R66	220 OHM	12-7753
R68	10k	12-7748
R69	1.5k	12-7773
R70	100k, 1%	12-7765
R71	200k	12-7752
R72	200k	12-7752
R73	100k	12-7747
R74	100k	12-7747
R78	22k	12-7754
R79	10k	12-7748
R80	10k	12-7748
R81	100k	12-7557
R82	200k	12-7752
R83	22k	12-7754
R84	10k	12-7748
R85	1M	12-7763
R86	4.42k	12-7760
R87	47 OHM	12-7756
R88	100k, 1%	12-7765
R89	17.8k	12-7759
R90	10k,1%	12-7764
R91	1M, 1%	12-7763
R92	1M, 1%	12-7763
R93	40.2k, 1%	12-7761
R94	100 OHM	12-7746
R95	10k	12-7748

Ref. No.	Description	Part No.
R96	1M, 1%	12-7763
R97	10M	12-7749
R98	1M	12-7751
R99	470k	12-7757
R100	470k	12-7757
R101	100k	12-7747
R102	1M, 1%	12-7763
R171	10k TRIMMER	09-6822
R172	100k TRIMMER	09-6823
R173	100k TRIMMER	09-6823
R174	10k TRIMMER	09-6822
R175	1M TRIMMER	09-6828
R176	1M TRIMMER	09-6828

- **TRANSFORMERS**

T103	M2300 HVPS	4275-037
T104	M2221 LVPS	4275-094

- **MISCELLANEOUS**

9 EA.	CLOVERLEAF RECEPTACLES	
	011-6809-00	18-8771
3 EA.	SPACERS	18-8933
*	TRANSISTOR SPACER	18-8992
*	AMPLIFIER SHIELD	7261-100

Processor Board, Drawing 261 X 91

BOARD	Assembled Board	5261-136

- **CAPACITORS**

C1	47pF, 100V, C	04-5533
C2	0.047µF, 100V, C	04-5565
C3	0.001µF, 100V, C	04-5519
C4	27pF, 100V, C	04-5614
C5	27pF, 100V, C	04-5614
C6	22µF, 15V, DT	04-5579
C7	10µF, 20V, DT	04-5592
C8	100µF, 10V, DT	04-5576
C9	100µF, 10V, DT	04-5576

- **TRANSISTOR**

Q36	2N3904	05-5755

- **INTEGRATED CIRCUITS**

U10	ICM7556	06-6244
U11	CD74HCO8	06-6222
U13	CD4054	06-6245
U14	CD4056	06-6095
U15	CD4056	06-6095
U16	CD4056	06-6095

Ref. No.	Description	Part No.
U17	CD4056	06-6095
U18	CD4056	06-6095
U19	CD4056	06-6095
U20	CD74HC573	06-6093
U21	87C257	06-6278
U22	80C51FA	06-6236
U25	RDD104	06-6060
U26	LM358	06-6024
U43	CD74HC238	06-6246

- **DIODE**

CR45	1N4148	07-6272

- **RESISTORS**

R27	3.3k	10-7013
R28	220k	10-7066
R29	130k	10-7067
R30	470k	10-7026
R31	220k	10-7066
R32	1.2k	10-7058
R33	5.6k	10-7042
R40	1M TRIMMER	09-6828
R41	1M TRIMMER	09-6828

- **RESISTOR NETWORKS**

R34-R35	NETWORK-22k SIP 10 PIN	12-7566

- **TRANSFORMER**

T37	M300-9	4275-074

- **CRYSTAL**

Y39	6.000 MHZ	01-5209

- **CONNECTOR**

P3/1-50	RIBBON-1-102159-0	13-7834

- **MISCELLANEOUS**

*	28P SOCKET	06-6096
7 EA.	SPACER-816-045 16P	18-8990
*	SPACER-470-015	18-8991
2 EA.	RIBBON-102312-2 LATCH	13-7805

Calibration Board, Drawing 261 X 59

Ref. No.	Description	Part No.
BOARD	Assembled Board	5261-075

- **VOLTAGE REFERENCES**

U1	LM385Z-1.2	05-5808
U2	LM385Z-1.2	05-5808
U3	LM385Z-1.2	05-5808

- **RESISTORS**

R4	22k	12-7754
R10	22k	12-7754
R11	100k TRIMMER	09-6813
R12	100k TRIMMER	09-6813
R13	100k TRIMMER	09-6813
R14	100k TRIMMER	09-6813

- **CONNECTOR**

P6/1-7	640457-7 MTA100	13-8183

LCD Display Board, Drawing 261 X 58

BOARD	Assembled Board	5261-074

- **INTEGRATED CIRCUIT**

U7	3918	07-6252

- **RESISTORS**

R4	22 OHM	10-7072
R14	22 OHM	10-7072

- **CONNECTORS**

P4	RIBBON-RD67 50BRN EDGE 50P	13-7816
P5	640456-2 MTA100	13-8073

- **MISCELLANEOUS**

DS10-DS13	BULB-#6833	22-9613

Backplane Board, Drawing 261 X 60

Ref. No.	Description	Part No.
BOARD	Assembled Backplane Board	5261-076
	• **DIODE**	
CR6	1N5819	07-6306
	• **CONNECTORS**	
J1-J2	EZA22DRSN	13-8181
P7	640456-7 MTA100	13-8115
P8	1-640456-4 MTA100	13-8141
P9	640456-5 MTA100	13-8057
P10	640456-2 MTA100	13-8073
P11	1-640456-4 MTA100	13-8141

Chassis Wiring Diagram, Drawing 261 X 61

Ref. No.	Description	Part No.
	• **AUDIO**	
DS1	UNIMORPH 60690	21-9251
	• **CONNECTORS**	
J1	CONN-640456-2 MTA100	13-8073
J2	UG706/U SERIES C	13-7751
J5	PHONE JACK TINI #42A	21-9333
J6-J7	(ON CAL HARNESS)	8261-088
J8	(ON MAIN HARNESS)	8261-087
J9	(ON BATTERY HARNESS)	8261-089
J10	NOT USED	
J11	(ON MAIN HARNESS)	8261-087
	• **SWITCHES**	
S1-S7	30-1-PB GRAYHILL	08-6517
S8-S12	7101-SYZ-QE TOGGLE	08-6511
SW1	513381	08-6656
SW2	513381	08-6656
SW3	MTA-206PA	08-6657
	• **BATTERY**	
B1-B4	1.5 VOLT "D" DURACELL	21-9313
	• **RESISTORS**	
R1	10k NON-LOCKING	09-6753
	• **MISCELLANEOUS**	
M1	M2221 METER ASSY.	4261-091

DRAWINGS AND DIAGRAMS

Amplifier/Power Supply Board Schematic, Drawing 261 x 56
Amplifier/Power Supply Board Component Layout, Drawing BS261072

Processor Board Schematic, Drawing 261 x 91
Processor Board Component Layout, Drawing 261 x 103

Calibration Board Schematic, Drawing 261 x 59
Calibration Board Component Layout, Drawing BS261075

LED Display Board Schematic, Drawing 261 x 58
LED Display Board Component Layout, Drawing BS261074

Backplane Board Schematic, Drawing 261 x 60
Backplane Board Component Layout, Drawing BS261076

RS-232 Board Schematic, Drawing 261 x 179
RS-232 Board Component Layout, Drawing 261 x 180

Wiring Diagram, Drawing 261 x 61

Model 2221 RS-232 Port Addition (LMI Part Number 4261-148)

The Model 2221 RS-232 port addition allows the M2221 data to be read as output to a computer or serial printer, by dumping either the ratemeter or scaler reading, as desired. The desired reading is selected with a toggle switch located in the digital control section of the front panel, labeled with two positions: "SCALER" and "DIG. RATE." The port addition kit (LMI Part Number 4261-148) includes the internal board, a cable that will connect directly to a 9-pin PC port and software routines to log the readings.

The scaler reading dumps when the scaler has completed a count. The ratemeter is dumped every 2 seconds in one of three formats, depending on the firmware installed. The three available formats are (1) counts per 2 seconds, (2) counts per 60 seconds (cpm), or (3) counts per second (cps). Data output is always in a 6-digit format with a letter prefix, corresponding to the following:

Ratemeter: "R"

Scaler: According to the table below

Letter Prefix	Time of Count (min)	Time of Count (sec)
	Format 1 or 2	Format 3 (cps version)
A	0.1	1
B	0.2	2
C	0.5	5
D	1.0	10
E	2.0	30
F	5.0	60
G	10.0	120

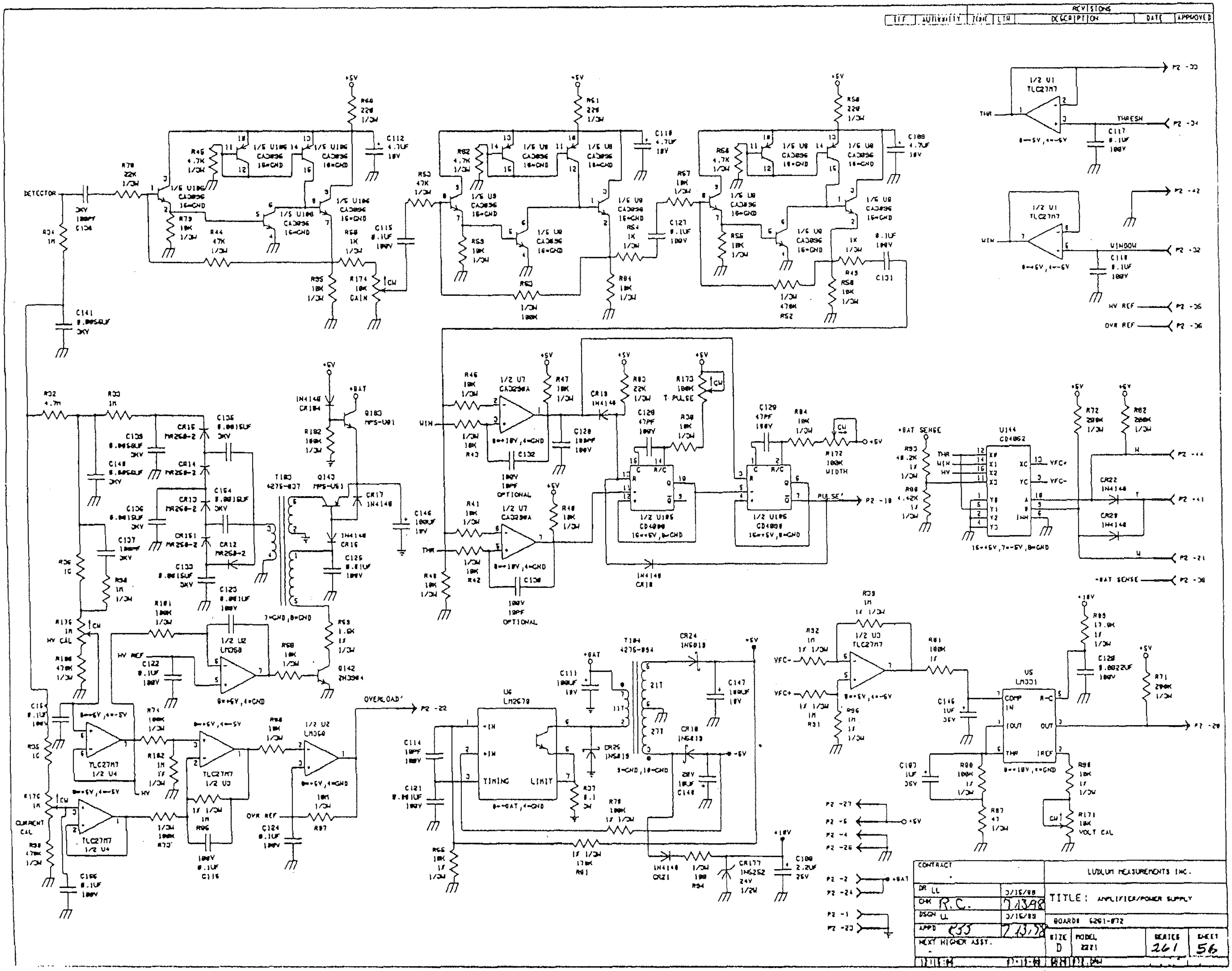
A carriage return and then a linefeed character follow the 6th digit.

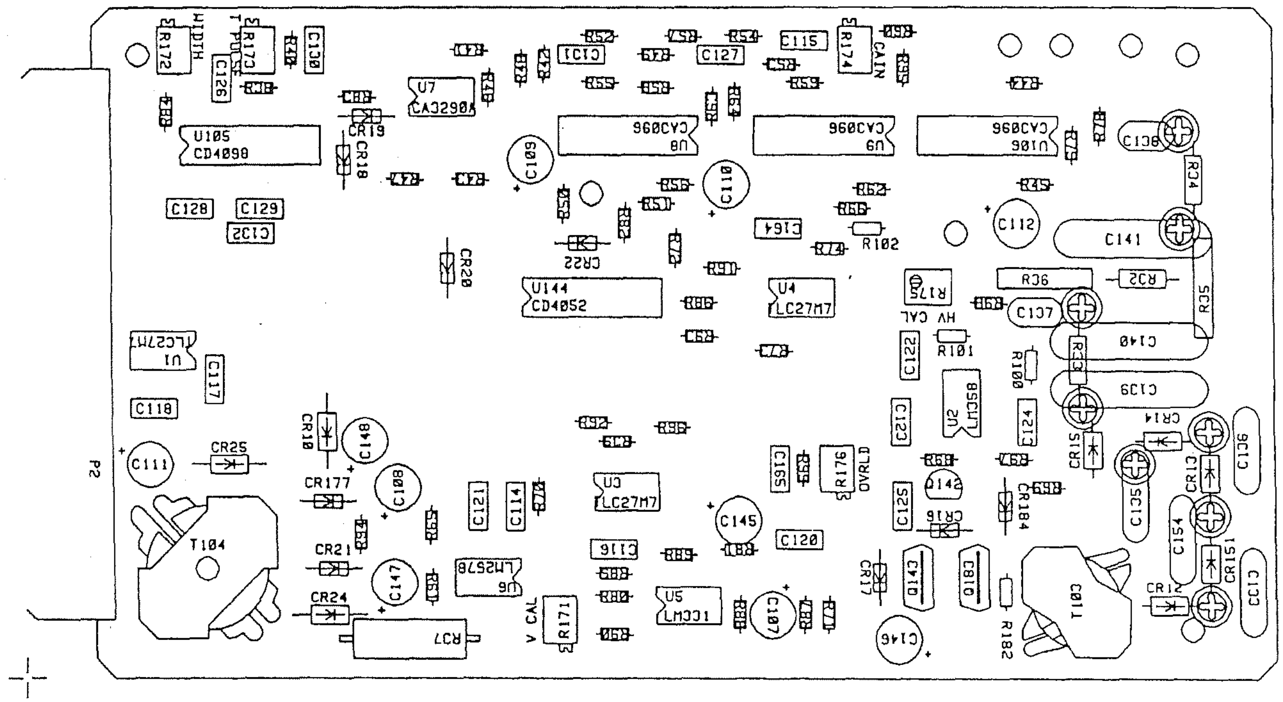
The communication protocol is 9600 baud, no parity, 1 stop bit, and 8 data bits. The RS-232 port is an output only with no handshaking available. The M2221 will dump the data, no matter what, even if the attached computer or printer is not ready. The cable provided is a coaxial cable, providing TXD and GND to a 9-pin D-connector, ready to plug into a standard PC serial port.

The Model 2221 Processor Board (Part Number 5261-136) utilizes an 87C257 EPROM with one of the following firmware numbers, depending on the desired rate:

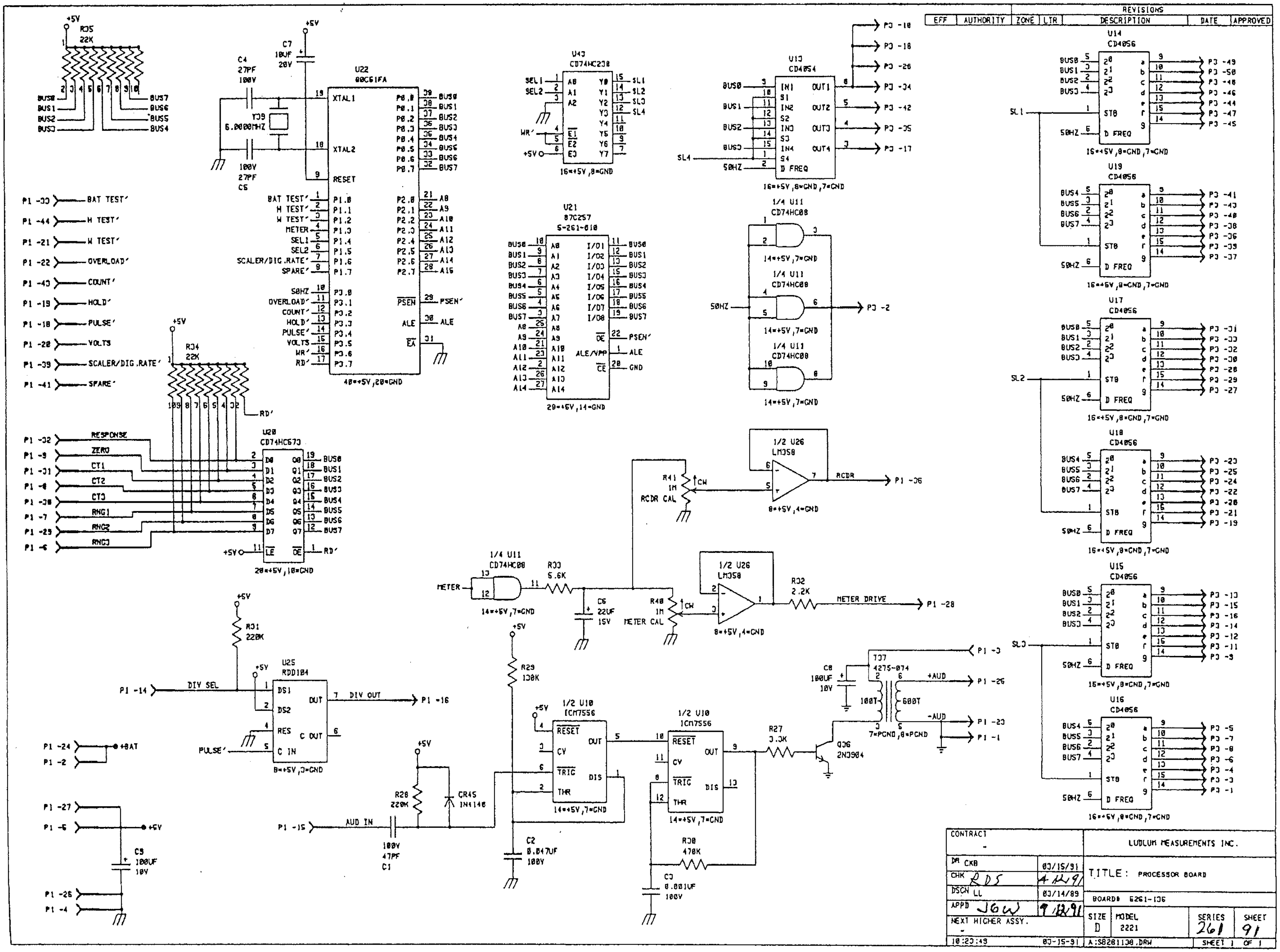
Rate Dump as counts per 2 seconds -- #261-06-N03.
Rate Dump as counts per 60 seconds -- #261-07-N02.
Rate Dump as counts per second with meterface 202-930 -- #261-02-N02

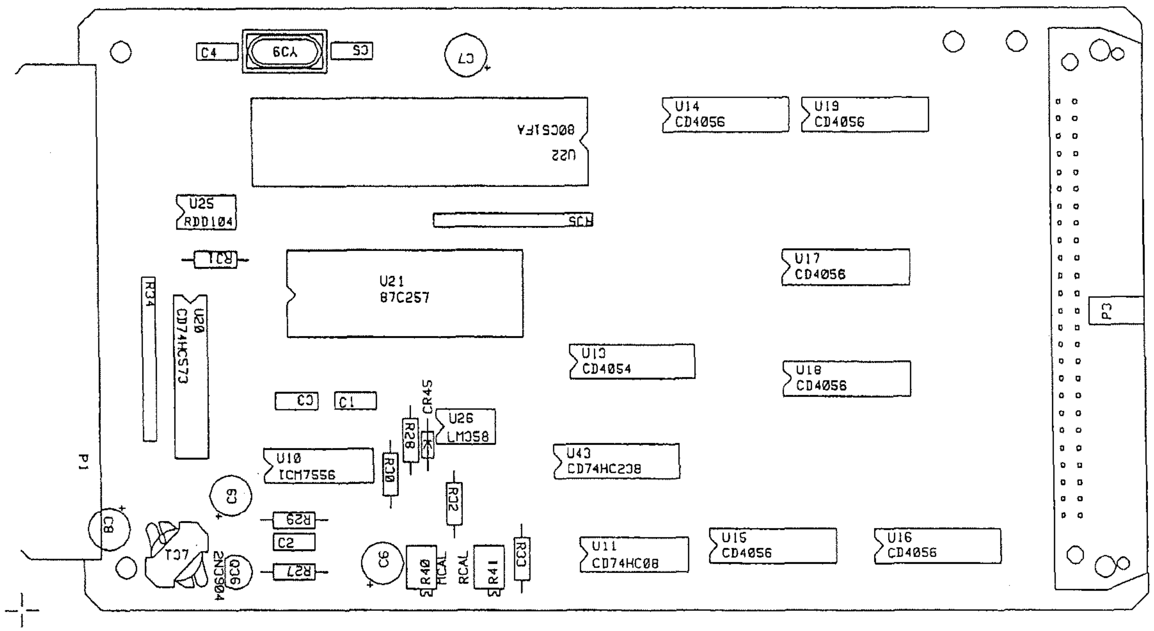
Ref. No.	Description	Part No.
	RS-232 Board, Drawing 261 X 179	
BOARD	Assembled RS-232 Board	5261-179
	• CAPACITORS	
C1	4.7µF, 20V, SMT	04-5653
C2	10µF, 20V, SMT	04-5655
C3	4.7µF, 20V, SMT	04-5653
C4	10µF, 20V, SMT	04-5655
C5-C6	68µF, 10V, SMT	04-5654
	• INTEGRATED CIRCUITS	
U001	IC-MAX220CSE, SMT	06-6329


REVISIONS
DESCRIPTION
DATE
APPROVED
DETECTOR
P2 -22
OVERLOAD'
PULSE'
+BAT SENSE
CONTRACT
LUDLUM MEASUREMENTS INC.
TITLE: AMPLIFIER/POWER SUPPLY
BOARD# 5261-072
SIZE D
MODEL 2221
SERIES 261
SHEET 56
NEXT HIGHER ASSY.



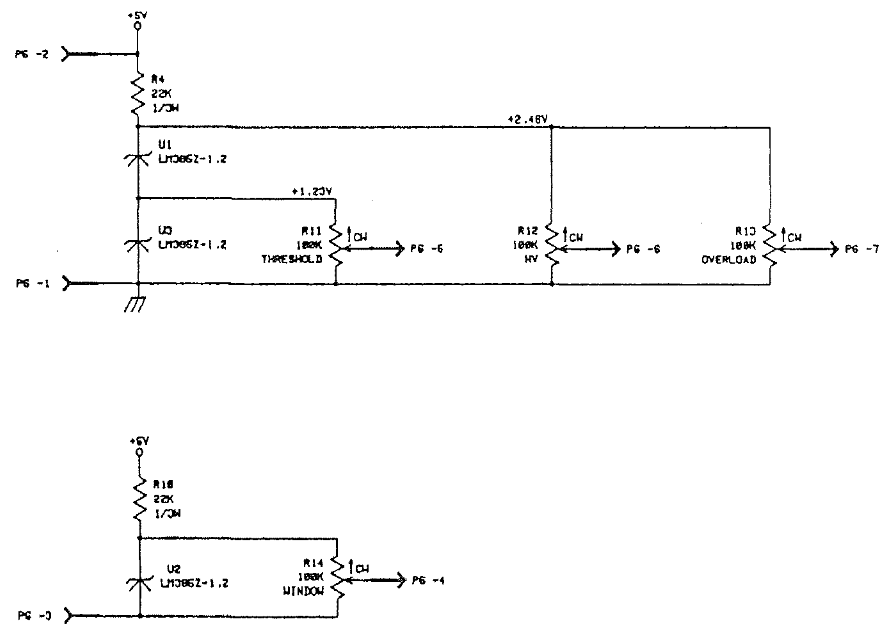
BOARD# 5261-Ø72	
TITLE AMPLIFIER/POWER SUPPLY	
MODEL 2221	
COMPONENT OUTLINES	
DR RDS	4/7/89
CHK R.C.	7/13/98
DSGN LL	3/15/89
APPD BS	7/13/98
B:BS261Ø72.DRW	
Ø7-19-89	15:32:24


REVISIONS
EFF
AUTHORITY
ZONE
LTR
DESCRIPTION
DATE
APPROVED
CONTRACT
LUDLUM MEASUREMENTS INC.
TITLE: PROCESSOR BOARD
BOARD# 5261-136
DR CKB 03/15/91
CHK RDS
DSGN LL 03/14/89
APPD JGW
NEXT HIGHER ASSY.
SIZE D
MODEL 2221
SERIES 261
SHEET 91
10:20:49 03-15-91 A:S8261136.DRW
SHEET 1 OF 1

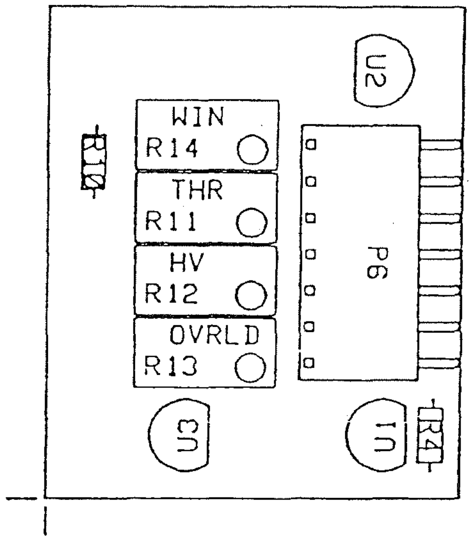


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR CKB	03/15/91	TITLE: PROCESSOR BOARD	
CHK R.C.	4/13/98	BOARD# 5261-136	BS261136
DSGN LL	03/14/91	MODEL 2221 SERIES 261	SHEET 103
APP [signature]	7-13-98	COMP ARTWORK ☐	SLDR ARTWORK ☐
09:19:04	29-Mar-94	COMP OUTLINE ☒	SLDR OUTLINE ☐
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



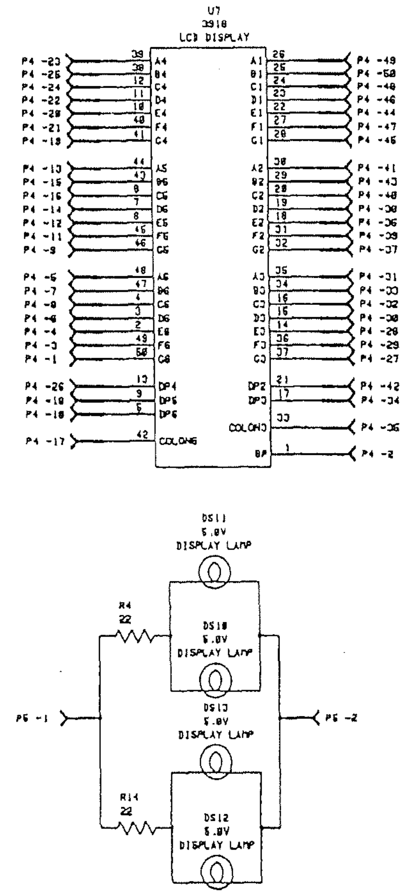
CONTRACT -		LUDLUM MEASUREMENTS INC	
DR LL	3/16/89	TITLE: CALIBRATION BOARD	
CHK R.C.	4/13/98		
DSGN LL	3/16/89	BOARD# 5261-075	
APPD BS	7/13/98	SIZE D / MODEL 2221	SERIES 261 / SHEET 59
NEXT HIGHER ASSY. -			
15:59:36	07-19-89	8:5B261075.DRW	SHEET 1 OF 1



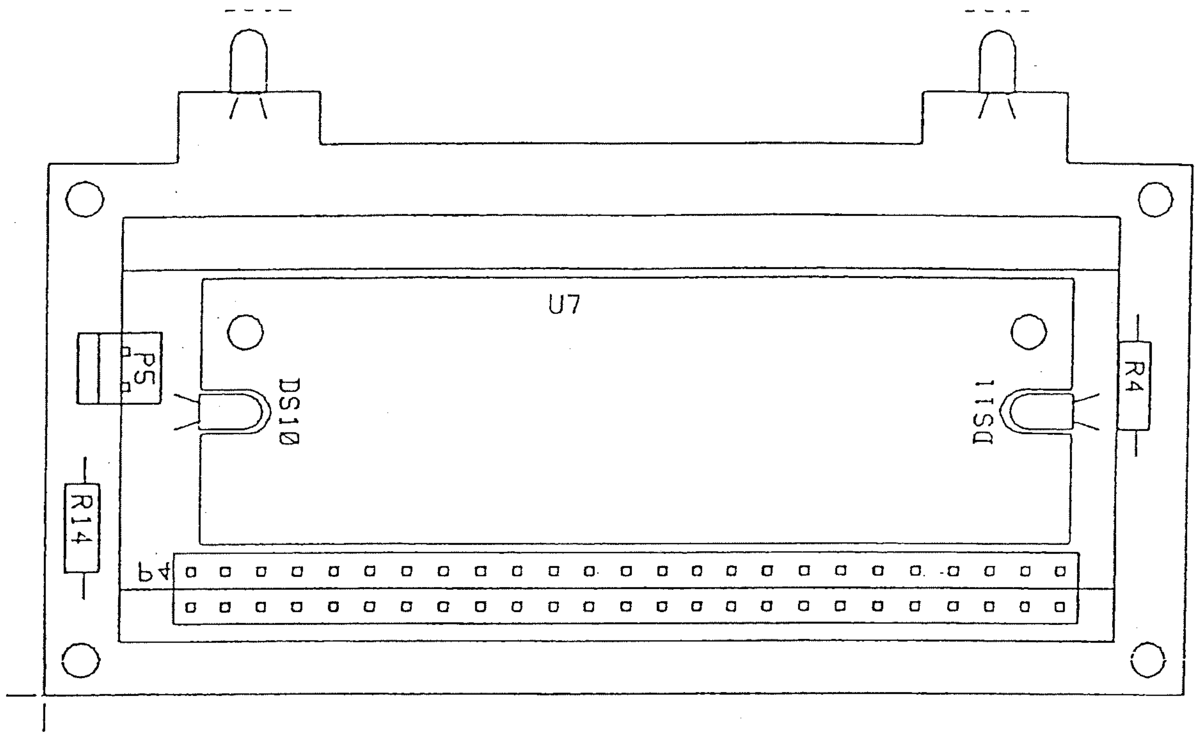
BOARD# 5261-Ø75	
TITLE CAL BOARD	
MODEL 2221	
COMPONENT OUTLINES	
DR RDS	3/28/89
CHK R.C.	7/13/98
DSGN LL	3/16/89
APPD RSS	7/13/98
BS261Ø75.DRW	
Ø5-2Ø-89	Ø7:38:12

EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED

REVISIONS



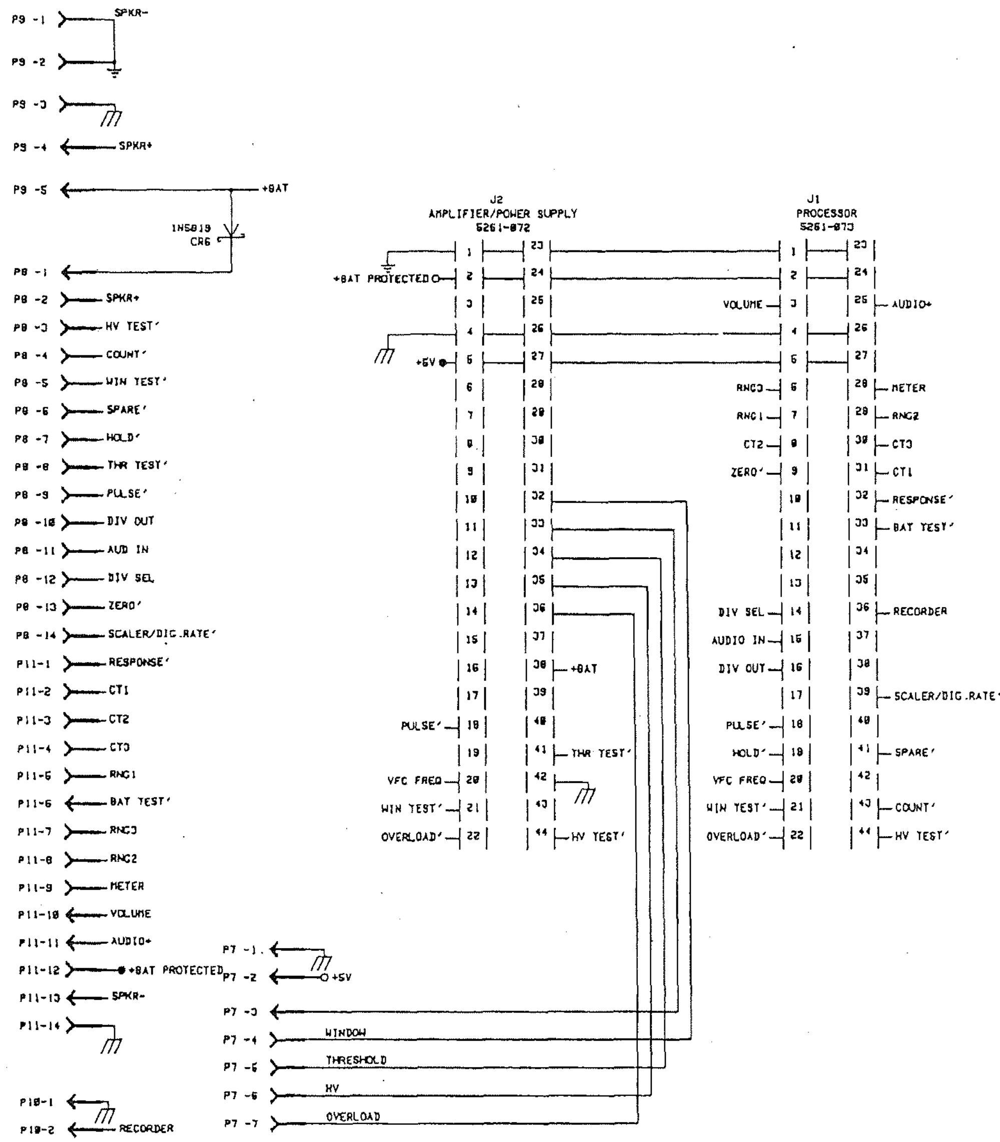
CONTRACT -		LUDLUM MEASUREMENTS INC.
DR LL	3/16/88	TITLE: LCD DISPLAY
CHK R.C.	7.13.98	
DSGN LL	3/16/88	BOARD# 5261-074
APPD	7.23.98	SIZE D / MODEL / SERIES 261 / SHEET 58
NEXT HIGHER ASSY. -		



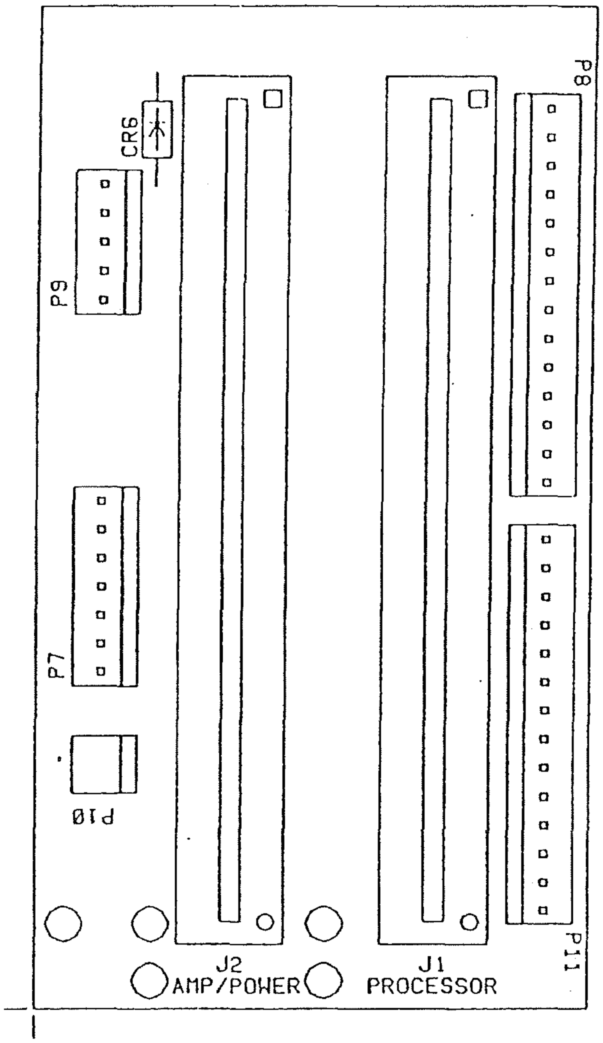
BOARD# 5261-Ø74	
TITLE DISPLAY BOARD	
MODEL 2221	
COMPONENT OUTLINES	
DR -	3/27/89
CHK R.C.	7/13/98
DSGN LL	3/16/89
APPD RSS	7/13/98
BS261Ø74.DRW	
Ø5-24-89	15:44:2Ø

REVISIONS

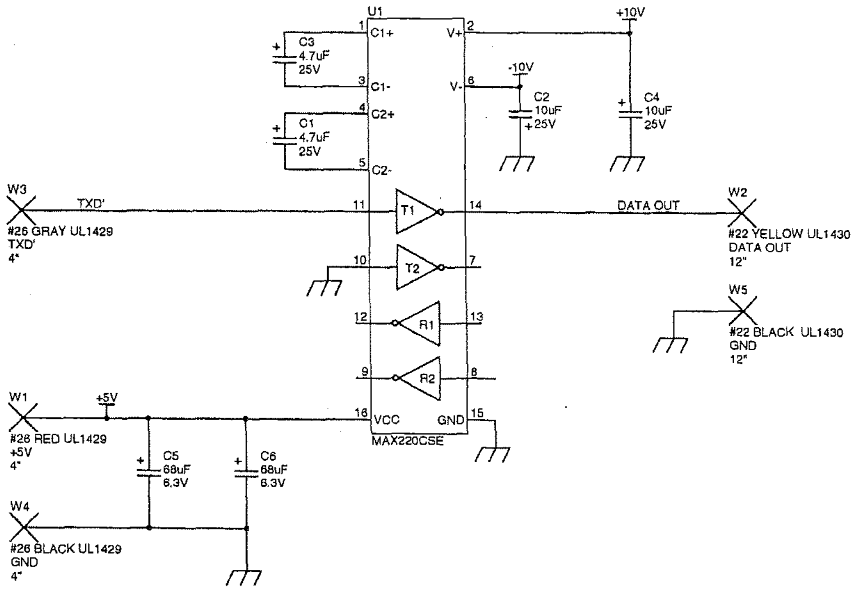
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



CONTRACT		LUDLUM MEASUREMENTS INC.			
DR LL	3/16/88	TITLE: BACKPLANE			
CHK R.C.	7/13/98				
DSGN LL	3/16/89	BOARD# 5261-076			
APPD BS	7/13/98				
NEXT HIGHER ASSY.		SIZE D	MODEL 2221	SERIES 261	SHEET 60
07:46:14	05-24-89	S8261076.DRW			SHEET 1



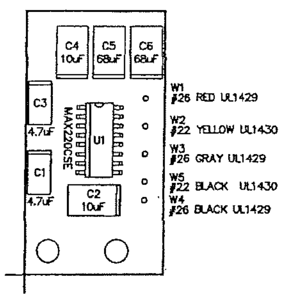
BOARD# 5261-Ø76	
TITLE BACKPLANE	
MODEL 2221	
COMPONENT OUTLINES	
DR RDS	3/28/89
CHK R.C.	7 /13 /98
DSGN LL	3/16/89
APPD RSS	7 /13 / 98
BS261Ø76.DRW	
Ø5-24-89	15:15:37



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828
Drawn: CKB	21-MAR-01	Title: RS-232 BOARD
Design: RDS	11-NOV-99	Model: 2221
Check: RC	Feb 4 02	Board#: 5261-179
Approve: RDS	4Feb02	Sheet: 1 of 1
14:13:37	4-Feb-2002	Rev: 1.0

Series 261 | Sheet 179

X:\Projects\LMI\M2221\M2221.Ddb - Documents\5261-179rev1.0\261x179.Sch



Drawn:	CKB	21-MAR-01	Title:		
Design:	RDS	11-NOV-99	RS-232 BOARD		
Check:	R.C.	Feb 4, 2002	Model: 2221		
Approve:	RDS	4Feb02	Board#: 5261-179		
Layer: Mech.1 Mech.2 Mech.3 Mech.4	Top Overlay		Rev: 1.0	Series	Sheet
	MD:				
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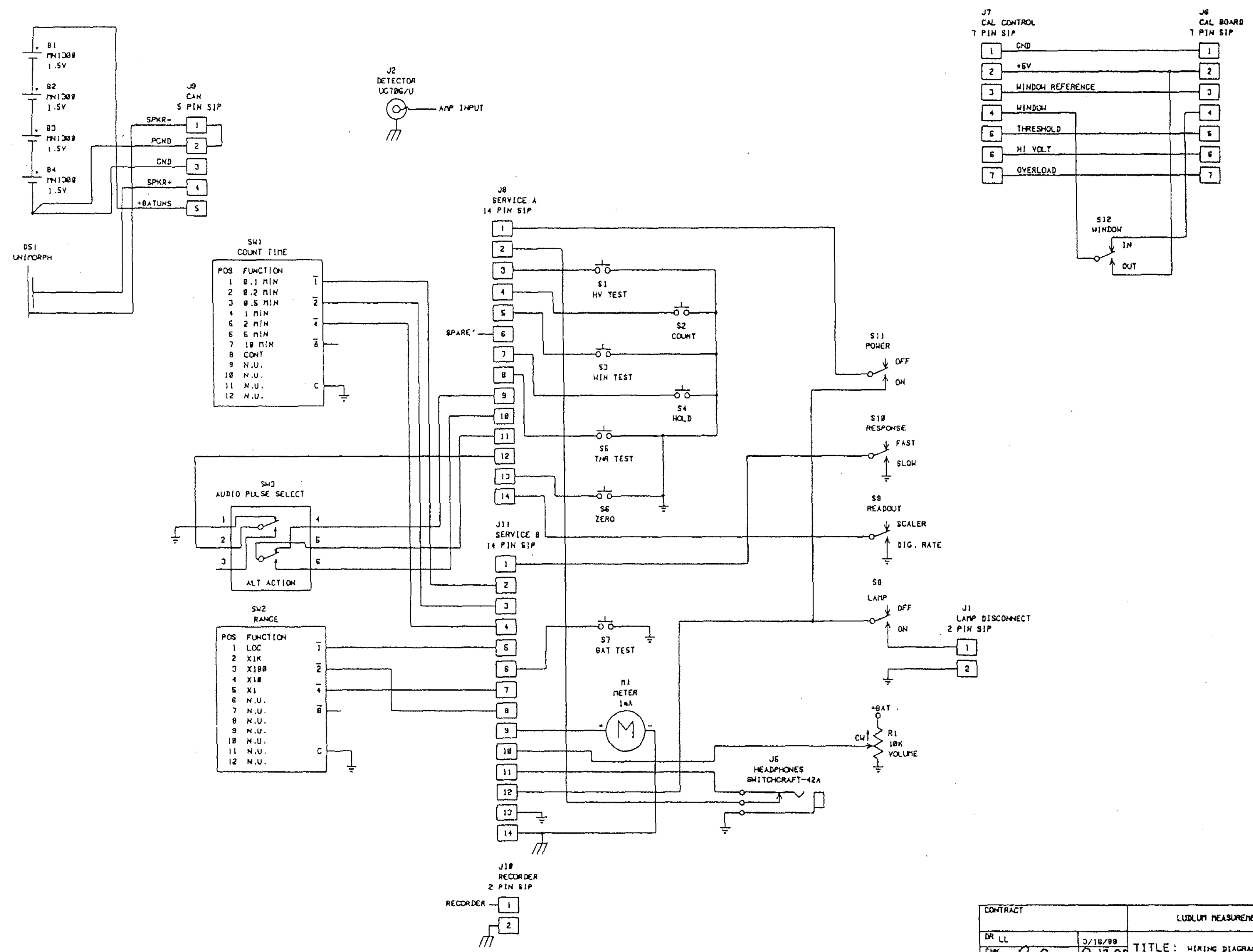
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED

REVISIONS



CONTRACT		LUDLUM MEASUREMENTS INC.
DR LL	3/16/89	TITLE: WIRING DIAGRAM
CHK R.C.	7/13/98	
DSGN LL	3/16/89	BOARD# 261-077
APPD RSS	7/13/98	SIZE D · MODEL 2221 · SERIES 261 · SHEET 61
NEXT HIGHER ASSY. -		
10:41:05	05-20-89	S0261077.DRW · SHEET 1 OF 1

LUDLUM MODEL 2360
SCALER/RATEMETER DATA LOGGER

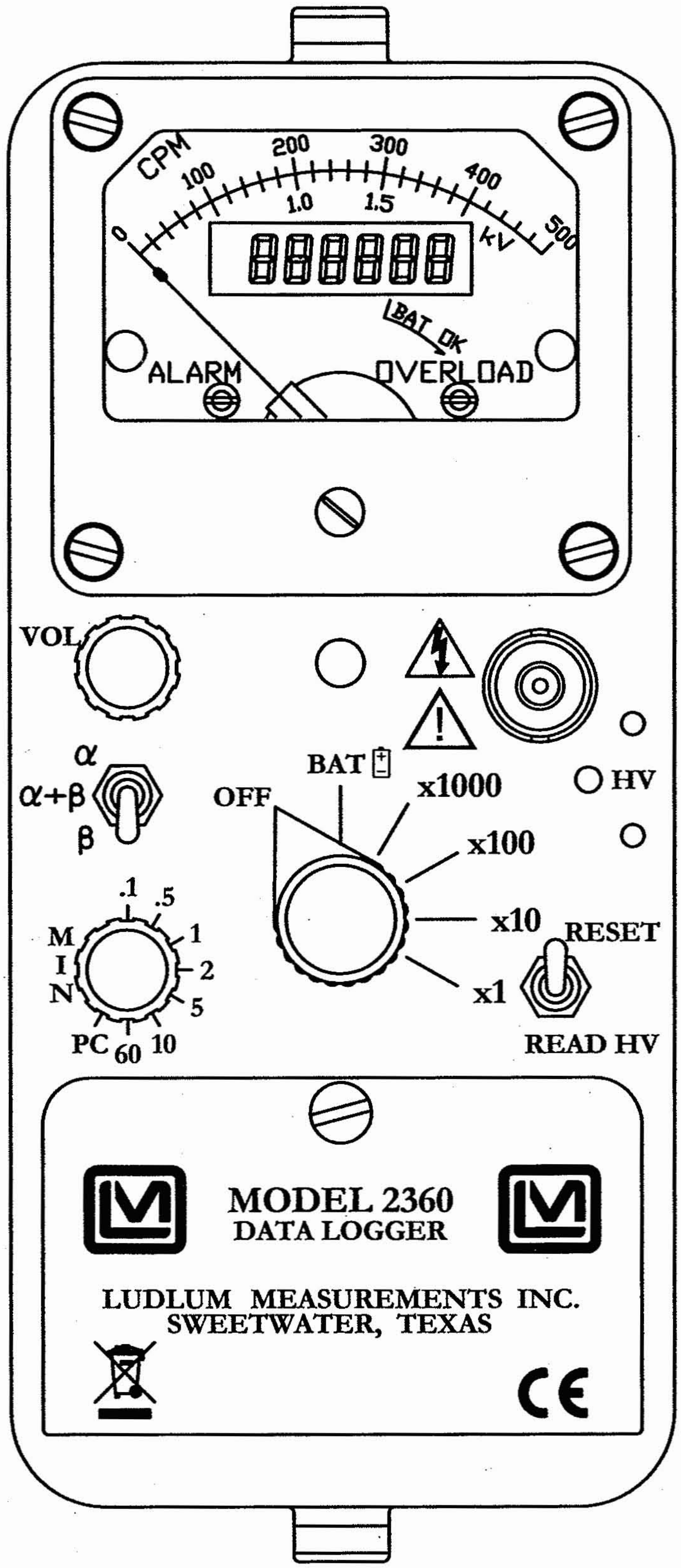
September 2006

Serial Number 133669 and Succeeding

Serial Numbers

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

REV #	ALTERATIONS	DATE	BY
1	VALID	8/1/96	RSS
2	UPDATED ARTWORK	5/15/06	CMC



DWN	DATE	CHK	DATE	APP	DATE
CMC	5-15-06			[signature]	5-15-06

PART NUM: 4390-159 | SCALE: FULL ☒ OTHER

TITLE M 2360 ALPHA/BETA DATA LOGGER

LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556 | SERIES 390 | SHEET 157

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Section 1

Introduction

The Ludlum Model 2360 Scaler/Ratemeter Data Logger is an easy-to-use survey instrument incorporating the best of the analog and digital worlds. Able to measure both alpha and beta radiation levels simultaneously, the Model 2360 presents the data in scaler (digital display) mode or ratemeter (analog meter) mode. The Model 2360 also logs up to 550 data-points consisting of: sample number, date/time stamp, sample measurements (both alpha and beta, cpm if ratemeter measurement or counts per count time if logging scaler count), scaler count time, "S" or "R," identifying whether scaler count or ratemeter was logged, and location identifier (10 characters).

Each alpha-beta data-point is logged by simply pressing the button located in the instrument handle. The appropriate scaler or ratemeter measurement is taken, and both alpha and beta readings are logged into non-volatile memory. An internal dipswitch allows for logging of the scaler reading, ratemeter reading, both scaler and ratemeter readings, and NO logging. The location identifier can be input by a PC or other RS-232 device prior to logging a sample.

There are also six lines (15 characters each) of header information that can be stored at the beginning of the non-volatile memory. The header lines can contain such information as the user name, survey name, serial numbers, etc. The "CALIBRATION DUE DATE" can also be stored in non-volatile memory, which will disable the instrument when the internal clock date reaches the stored date.

The Model 2360 has a long arc length (2.38") meter face that normally reads from 0 to 500 cpm. The main rotary switch allows for multiplication ranges of ×1, ×10, ×100, and ×1000. The Model 2360 has a three-position toggle switch on the front panel to switch between displaying alpha, beta, or alpha + beta levels.

Alpha and beta pulses have different audio tones, so that the user can discriminate between the two. A two-position momentary action switch allows either a meter reset, or displays the detector HV onto the meter. The following six alarms may be set via the RS-232 port:

Alpha Ratemeter (0-999999 cpm)

Beta Ratemeter (0-999999 cpm)

Alpha + Beta Ratemeter (0-999999 cpm)

Alpha Scaler (0-999999)

Beta Scaler (0-999999)

Alpha + Beta Scaler (0-999999)

These alarm points, when exceeded, light the meter face LED, marked ALARM, and activate the audio speaker. The ratemeter alarms are non-latching (will cease when the radiation level drops below the alarm point). The scaler alarm will continue until the RESET is pressed, or the next scaler count is started.

The digital display is a full 6-digit liquid crystal display (LCD) display, which is direct-driven for good viewing and a wide temperature response from -40°F to 140°F. The digital display displays the scaler count, and prior to each sample logging, displays the current sample number. The display also has an arrow symbol for counting overflow, and two colons that indicate that a scaler count is in progress.

The Model 2360 communicates through an RS-232 port located on the instrument can. The computer interface software is supplied on CD and includes the following functions:

downloading of header and logged data into an ASCII file

setting and reading of instrument parameters/header information

setting of the "CALIBRATION DUE DATE"

setting of the internal real-time clock/calendar

setting of the user-definable scaler time

setting of location code and alarm points

clearing of logged memory

Section 2

Getting Started

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 2360 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!

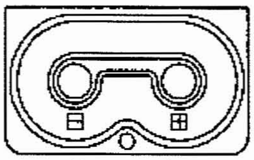
If multiple shipments are received, ensure that the detectors and instruments are not interchanged. Each instrument is calibrated to specific detectors, and is therefore not interchangeable.

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 2360 range selector switch is in the "OFF" position. Open the battery lid by pushing down and turning the quarter-turn thumbscrew



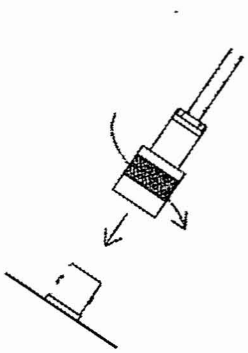
counterclockwise ¼ turn. Install two "D" size batteries in the compartment.

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 ¼ 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 2360 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 ¼ turn. Repeat the process in the same manner with the other end of the cable and the instrument.

Internal Switches

Release the can latches and remove the cover from the 2360, taking care not to damage the speaker wires. Using a ball-point pen, set the switches for the desired AUDIO division and TONE and described on Page 4-3. Replace the cover and fasten the latches.

Battery Test

The batteries should be checked each time the instrument is turned on. Move the range selector 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.

Turn the range selector switch from the off position to the ×1000 position and verify that the meter needle is driven full-scale for approximately 2-seconds and then returns to zero. Also, ensure both alarm LED's on the front panel turn on briefly. The LCD should go through an initialization sequence displaying "88:8.8:8.8", then the current sample number, and finally "0".

Operating the Instrument

Connect a detector to the instrument if you have not already done so. Obtain a meter reading from a check source or calibrated source, if available. Verify that the reading falls within the expected range. Remove the source.

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

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

Proceed with use.

Principle of Operation

The Model 2360 is to be used in combination with an alpha/beta scintillation or proportional detector. The pulse height differential between the alpha and beta pulses from the scintillation or proportional detector is discriminated by the Model 2360.

The detected alpha count is displayed by selecting the "α" position on the 3-position "α/α+β/β" toggle switch. Likewise, the sum of the alpha and beta counts or the beta counts only are displayed by selecting the appropriate "α + β" or "β" position. Multiply the cpm reading on the analog ratemeter by the range multiplier position. When using the LCD and preset count time interval, the counts are accumulated in each of the three channels during the count cycle. The count cycle is started by depressing the push-button located in the end of the carrying handle. If a scaler or ratemeter alarm is activated, the ALARM LED will light and the audio will sound a steady tone.

The RESET toggle switch position resets the meter pointer to zero and deactivates any current alarm. The detector operating voltage is displayed on the meter dial by selecting the READ HV position. The high voltage scale ranges from 0-2 kV (kilovolts). The OL (overload) lamp, located in the lower right corner of the meter dial, indicates that the detector is saturated either by a puncture in the detector face or an exposure to a radiation field above the counting capability of the instrument. The analog meter deflects full scale when the OL lamp is illuminated.

Section 3

Specifications

Power: Two standard "D" size batteries housed in an externally accessible sealed compartment

Battery Life: Typically 250 hours of operation with a fresh set of alkaline "D" cell batteries

Compatible Detectors: Proportional and dual phosphor scintillation detectors; common Models: 43-1-1, 43-2-2, 43-20, 43-68, 43-89 and 43-93

Data Logger: Capable of logging up to 550 individual data points into non-volatile memory with the following identifiers for each point:

alpha and beta sample counts
sample number
date/time stamp
scaler count time
10-character location identifier

Range: Four linear range multiples of ×1, ×10, ×100, and ×1000; used in combination with the 0-500 CPM meter dial providing an overall range of 0-500 kcpm

Thresholds: Internal control allows for adjustment from –2 to –15 mV for beta and –40 to –700 mV for alpha

Window: Internal control allows for adjustment from the beta threshold up to the alpha threshold setting (beta only)

Audio: Built-in unimorph speaker with volume control (greater than 60 dB at 2 feet – full volume); headset jack located on the instrument "can"

Audio Divide: Selectable dual or individual click-per-event for alpha and beta counts with divisions of 1, 10, 100 or 1000 events-per-click (beta only)

Alarm points: Six separate alarm points, set through the RS-232 port, activating the alarm audio tone, and lighting the ALARM LED. The six alarm points can be set from 0 to 99999. Ratemeter alarms are non-latching, while scaler alarms are not. (A latched alarm requires the RESET button be pressed in order for the alarm to clear) The six alarms are:

Alpha Ratemeter
Beta Ratemeter
Alpha + Beta Ratemeter
Alpha Scaler
Beta Scaler
Alpha + Beta Scaler

High Voltage: Recessed front-panel potentiometer; adjustable from 200 to 2000 Vdc

Linearity: Within 10% of true value for the analog CPM meter; within 2% for the LCD

Response Time: ×0.1 range multiplier = 7 seconds, ×1 = 7 sec., ×10 = 2 sec., ×100 = 2 sec.; all response times measured from 10-90% of full-scale

Analog Meter: Rugged 1 milliamp (mA), with pivot-and-jewel suspension and 2.38-inch arc length

Connector: Series "C" standard, others available

Temperature Range: –20°C to +50°C, may be certified for operation from –40°C to +65°C

Maximum Relative Humidity: less then 95% (non-condensing)

Size: 6.5" (16.5 cm) H × 3.5" (8.9 cm)W × 8.5" (21.6 cm)L

Weight: 3.5 lbs, including batteries

Finish: Drawn-and-cast aluminum, with beige powder-coating

Section 4

Description of Controls and Functions

Operator Controls

OFF/BAT/X1000/X100/X10/X1 Switch (or Range Selector Switch): A 6-position rotary switch to select the analog meter range multipliers and check the battery status. When switched to the "BAT" position, the meter pointer should deflect above the left vertical mark on the "BAT OK" line. Moving the range selector switch to one of the range multiplier positions (×01, ×10, ×100, ×1000) provides the operator with an overall range of 0-500 kcpm. Multiply the scale reading by the multiplier to determining the actual reading.

During initial instrument turn-on, the meter will be driven full-scale for about 2 seconds and then return to zero. The LCD will show "88:8.8:8.8", display the current sample number, and then "0". If the count button is pressed while the display is showing all 8's then the following numbers are shown: firmware number, date, time, PC defined scaler time, alpha ratemeter alarm, alpha + beta rate meter alarm, alpha scaler alarm, alpha + beta scaler alarm, current sample number, and then "0".

Liquid Crystal Display (LCD): 6-digit display that displays the count rate for the selected channel. Also indicates when a count is in progress by displaying two colons; the colons are turned off when the count is complete. Is the counter exceeds 999999, an arrow in the upper left corner of the display turns on in order to indicate an overflow; the counter then rolls over to zero and continues counting.

VOL: Turning this control clockwise will increase the speaker volume and counterclockwise will decrease the volume.

Note:

The volume should be turned down, when not required, to reduce battery drain.

α/α+β/β Switch: A 3-position toggle switch used to select the sum of alpha and beta count channels (α+B), alpha count only (α), or beta count only (B), for display. This switch affects both the analog meter and digital display. The rate meter channels are active regardless of the switch position and will continue to function when the channel is not selected for display. This ability allows the operator to view each channel separately or together by simply selecting the appropriate switch position.

Headphone Jack: 1/8" phone jack on instrument can for the connection of external headphones. Inserting a phone plug into the jack disconnects the external unimorph speaker from the audio circuitry. Use 1/8" mating plug- LMI part # 21-9653.

RS-232 Port: Located on the instrument can and allows for connection of the instrument to a PC for dumping data and setting-up parameters

RESET/HV: A dual-position momentary toggle switch which provides readout of the detector high voltage when the "HV" position is selected. When the RESET position is selected this switch provides a rapid means of driving the analog rate meter to zero and resetting the meter after an alarm condition. Use the 0-2 kV meter scale for high voltage readings.

MIN 0.1, 0.5, 1, 2, 5, 10, 60, PC Count Time Select Switch: An 8-position rotary switch used to select scaler count times in minutes. When set to PC, the scaler will use the user-defined count time. The count cycle is initiated by depressing the push-button switch in the carrying handle.

Log Pushbutton (located in the carrying handle): When depressed, the current sample number is displayed, the counter is reset to zero and the timer is started. If selected, the instrument will also log the current reading. The colons on the display turn on and stay on until the count has expired.

Remove the front panel calibration cover to access the following calibration potentiometer:

HV: A multi-turn potentiometer used to adjust the detector high voltage from 200 to 2000 Vdc.

Internal Controls

Remove the instrument cover (can) to access the following dipswitches on SW1.

RECYCLE: A 1-pole DIP switch (#1) used to select recycle scaler mode. When placed in the ON position the instrument will start a count cycle. If the instrument is set to log the sample it will be saved and a new count will be started again. The ratio is selected from the following table:

SWITCH 1	RECYCLE MODE
ON	ON
OFF	OFF

TONE: A 1-pole DIP switch (#2) used to select tone discrimination between alpha and beta count channels. When in the DUAL mode, alpha and beta pulse tones will be audible in all selector switch positions (i.e. if in the β-only position and beta radiation is detected, the beta tones will be heard in addition to the alpha tones).

When the SNGL tone position is selected, both alpha and beta pulse tones can be heard in the "α+β" selection, but alpha pulses are the only audible tones in the α-channel selection, and beta pulse tones are the only audible tones in the β-channel selection.

SWITCH 2	TONE MODE
ON	DUAL
OFF	SINGLE

AUDIO Divide: A 2-pole DIP switch (#3 & #4) used to select audio divisions of 1, 10, 100, and the beta audio subtract mode.

Note:

The AUDIO divide function only affects the lower-frequency beta tones. The higher-frequency alpha click-per-event will be unaffected by the divide-by selection.

The ratio is selected from the following table:

SWITCH 3	SWITCH 4	DIVIDE BY RATIO
ON	ON	1
ON	OFF	10
OFF	ON	100
OFF	OFF	Beta audio Subtract Mode

LOG SAMPLE: A 2-pole DIP switch (#5 & #6) used to select logging mode. When both switches are OFF the instrument will not log samples but will output the ratemeter readings to the RS-232 port every two seconds in ASCII format. When set to log both scaler and ratemeter, two samples are actually saved. The logging mode is selected from the following table.

SWITCH 5	SWITCH 6	LOGGING MODE
ON	ON	Log ratemeter and scaler
ON	OFF	Log ratemeter
OFF	ON	Log scaler
OFF	OFF	No sample saved. Output ratemeter every 2 seconds.

The following controls are utilized during calibration only and should only be altered by a qualified calibration technician.

MTR: A multi-turn potentiometer used to calibrate the meter to the CPM reading.

AT: A multi-turn potentiometer used to vary the alpha pulse discriminator from 40 to 700 millivolts (mV).

BW: A multi-turn potentiometer used to vary the upper beta pulse discriminator from BT setting to AT setting.

BT: A multi-turn potentiometer used to vary the lower beta pulse discriminator from 2 to 15 mV.

OL: A multi-turn potentiometer which provides a means to vary the detector current overload set point.

LIM: A multi-turn potentiometer used to set the maximum HV limit to 2000 Vdc.

HV: A multi-turn potentiometer used to adjust the high voltage test reading (0 to 2 kV scale) to correspond with the actual high voltage output. The HV switch must be depressed during adjustment.

LB: A multi-turn potentiometer used to adjust the minimum battery voltage level (2.2 Vdc) corresponding to the low battery indication on the meter dial. The BAT switch position must be selected during adjustment.

Section 5

Safety Considerations

Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude

Temperature range of –20°C to +50°C, may be certified for operation from –40°C to +65°C

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

Pollution Degree 1 (as defined by IEC 664)

Cleaning Instructions and Precautions

The Model 2360 Scaler/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 range selector switch to the OFF position.
2. Allow the instrument to sit for 1 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 2360 Scaler/Ratemeter is marked with the following symbols:

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 1 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 on the battery lid. See section 10, "Recycling" for further information.

Section 6

Calibration and Maintenance

Calibration

Note:

Local procedures may supersede the following.

ESTABLISHING AN OPERATING POINT

The detector operating parameters are established by adjusting the detector operating voltage (HV), alpha threshold, and beta window to find an optimum efficiency for the alpha/beta scintillator or proportional detector.

The threshold and window parameters can be adjusted to optimize alpha/beta count discrimination, count efficiency, and minimize "cross talk" between channels. Refer to the specific detector Operation Manual or calibration certificate for the suggested threshold and window settings. Once the thresholds and window settings are established, an operating voltage versus count rate plot should be performed for both alpha and beta count channels with alpha and beta particle emission sources.

The following procedure is example of determining the operating voltage for an alpha/beta scintillation or proportional detector:

Connect a Ludlum Model 500 Pulser or equivalent to the Model 2360.

Switch the 2360 to the β position. Adjust the beta threshold (BT) for 3.5 mV and the window (BW) for 30 mV. The Pulser counts should be detected on the 2360 ratemeter above 3.5 ± 1 mV and should shut off above 30 mV.

Switch the channel selector switch to the α position. Adjust the Pulser for a 120 mV pulse output and vary the AT control until counts are detected on the ratemeter.

Depress the HV switch and adjust the HV potentiometer for 0.4 to 0.5 kV on the 0-2.0 kV scale. Connect the scintillator and switch to the β only position. Place an alpha source on the detector face.

Slowly increase the HV potentiometer to observe an increase, then decrease, and increase again in count as the HV is increased. Decrease the HV until the ratemeter is in the "dip" of the observed count rate versus HV plot just performed. Depress the HV switch and note the HV setting.

Plot a HV versus count rate plateau in 25 volt increments, 50 volts each side of the HV reading found in the above step (i.e., HV setting for count "dip" in the above step = 675 volts, start the plot at 625 volts and increase in 25 volts steps until 725 volts is reached). Plot alpha source, beta source, and background counts for both α and β channel positions.

Find the optimum operating voltage from the plot which gives the greatest alpha and beta source efficiency while maintaining no greater than the maximum acceptable level of "cross talk" between channels.

Select the desired count channel display, and proceed to use instrument.

METER CALIBRATION

A Ludlum Model 500 Pulser or equivalent is required. If the Pulser does not have high voltage readout, use a high impedance voltmeter with at least 1000 megohm input resistance to measure the detector voltage.

Ensure that the meter movement has proper mechanical zero. The adjustment is on the front of the meter bezel. It must be adjusted to "0" with the ON/OFF selector switch in the OFF position.

Connect the Model 500 Pulser to the Model 2360 with the appropriate cable. Rotate the Model 2360 range multiplier switch to the ×100 position. Select the α+β channel position.

Adjust the Pulser for 40,000 cpm and adjust the pulse amplitude to at least twice the beta threshold level (i.e.; beta threshold = 3.5 mV, adjust the Pulser to 7-10 mV).

Remove the instrument cover and adjust the MTR potentiometer until the meter reads 400 cpm. Adjust the Pulser to 10,000 cpm and ensure ratemeter reads 100 ± 10%. Decade the Pulser and Model 2360 range multiplier switch to check meter linearity on the ×1000, ×10, and ×1 positions. Linearity should be within 10% of each reading.

Set the LCD count time for 1 minute. Adjust the Pulser count rate to 40k cpm. Depress the count button and when count cycle is complete confirm that LCD reads within 2% of the incoming count rate.

Adjust the BT, BW, and AT controls for the appropriate set points as described in the following subsection.

Connect a high impedance high voltage meter (may use the Model 500 Pulser if equipped with a HV meter) to the detector input connector and adjust the HV control for a reading of 1000 Vdc on the voltmeter.

Depress the RES/HV switch to the HV position and adjust the HV potentiometer located on the circuit board for a reading of 1.0 kV on the meter dial. Adjust the HV output from 500 to 1500 Vdc and confirm that the 2360 HV meter corresponds to the external voltmeter within 10% of each reading.

Rotate the range multiplier switch to the OFF position. Remove the batteries from the battery compartment and connect a DC power supply to the two screw terminals located at the rear of the battery compartment. The positive power supply lead should connect to the terminal with the red wire and the negative lead to the terminal with the black wire.

Adjust the power supply for 2.2 Vdc and switch the 2360 to the BAT position. Adjust the LB potentiometer to align the meter needle with the low battery mark on the meter dial (vertical line to the left of BAT OK).

Replace the instrument can and proceed with use.

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 re-adjusted, the overload adjustment must be re-adjusted.

Adjust the OL control to the maximum counterclockwise position.

Note:

Detector saturation is when the meter response no longer increases with increasing radiation field intensity.

For alpha/beta scintillators, expose the detector photomultiplier tube (PMT) to a small light leak by loosening the detector window. Some scintillation detectors incorporate a screw in the detector body which when removed will simulate a detector face puncture or light leak. The meter should start to decrease toward zero as light saturates the scintillation material.

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.

Re-seal the detector window and expose the detector to a radiation source that will drive the meter near full scale. Confirm that the LED does not turn on and the meter remains on scale.

Maintenance

Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and the calibration. The Model 2360 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 1 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, battery replacement, or cable 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 manufacturer's 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 100°F.

Section 7

RS-232 Interface

Communicating with the Model 2360

The Model 2360 has an RS-232 serial port that can be connected to a PC or other RS-232 device. The proper communication settings are (2400,8,N,1):

2400 Baud
8 data bits
No parity
1 stop bit

Commands

The following table shows all the commands used to communicate with the Model 2360. All commands must be in uppercase letters. The data can be in either upper or lower case. All set commands should return "OK" + a carriage return and line feed.

READ COMMANDS

RA	Read sample number
RC	Read cal. Date
RD	Read date
RHx	Read header
RL	Read current location
RP	Read user(PC) time
RR	Read α / β ratemeter
RS	Read samples.
R1	Read α ratemeter alarm
R2	Read β ratemeter alarm
R3	Read $\alpha+\beta$ ratemeter alarm
R4	Read α scaler alarm
R5	Read β scaler alarm
R6	Read $\alpha+\beta$ scaler alarm

SET COMMANDS

SCmmddyyyy	Set calibration date
SDmmddyyyy	Set current date
SHxyyyyyyyyyyyyyyy	Set Header
SLxxxxxxxxxx	Set current location
SMx	Sets ratemeter dumping
SPxxx.x	Set user (PC) time
SR	Send reset samples
SThhmm	Set current time
S1xxxxxx	Set α ratemeter alarm
S2xxxxxx	Set β ratemeter alarm
S3xxxxxx	Set α+β ratemeter alarm
S4xxxxxx	Set α scaler alarm
S5xxxxxx	Set β scaler alarm
S6xxxxxx	Set α+β scaler alarm

COMMAND DESCRIPTIONS

RA
This command reads the current sample number. The output is 6 characters including a [CR] and [LF]. The format is:

```
0001[CR][LF]
```

RC
This command reads the calibration date. During power up the Model 2360 checks the current date against this date. If the current date is past the calibration date, the message "OUTCAL" is displayed and the Model 2360 is disabled until the calibration date is changed ahead of the current date. The output is 10 characters including a [CR] and [LF]. The format is:

```
MMDDYYYY
12251996[CR][LF]
```

RD
This command reads the current date and time. The output is 21 characters including a [CR] and [LF]. The format is :

```
HH:MM:SS MM/DD/YYYY
16:16:29 11/20/1996[CR][LF]
```

RHx
This command reads the specified header where "x" equals a number 1 - 6. The output is 17 characters including a carriage return [CR] & line-feed [LF].

```
[15 characters]
John Smith [5 SPACES][CR][LF]
```

RL
This command reads the current location. The output is 12 characters including a [CR] and [LF]. The format is:

```
TABLE0001[SPACE][CR][LF]
```

RP
This command reads the user-defined "PC" count time. This is the scaler count time when the Model 2360 count time switch is on the "PC" position. The output is 7 characters including a [CR] and [LF]. The format is:

```
012.5[CR][LF]
```

RR
This command reads the current alpha and beta ratemeter reading. When dip-switch 5 and 6 are set to **OFF** the Model 2360 sends this message every 2 seconds. The alpha Ratemeter reading is first, followed by the beta ratemeter reading. The output is 15 characters including a [CR] and [LF]. The format is:

Alpha Beta
```
000003 002305[CR][LF]
```

RS
This command will return all logged samples from memory. A "$" signifies the end of samples. The maximum number of samples stored is 550. The format is:

```
0001 11/18/96 14:50:05 000020 000450 R 001.0 CHKSRC
0002 11/18/96 14:50:07 000015 000390 S 001.0 TABLE0001
0003 11/18/96 16:49:49 000040 001400 R 000.1 TABLE0002
$
```

R1, R2, R3, R4, R5, R6
These commands read the alarm set points.

R1 = Alpha Ratemeter.
R2 = Beta Ratemeter.
R3 = Alpha + Beta Ratemeter.
R4 = Alpha Scaler.
R5 = Beta Scaler.
R6 = Alpha + Beta Scaler.

The output is 8 characters including a [CR] and [LF]. The format is:

```
000500[CR][LF]
```

SCmmddyyyy
This command sets the calibration due date. The date is entered in Month Day Year (MMDDYYYY) format. During power up the Model 2360 checks to see if the current date is past the calibration due date. If it is, then the Model 2360 displays "OUTCAL" and is disabled until this command is issued to set the calibration date ahead of the current date. The length of the command is 12 characters including a [CR] and [LF]. The format is:

```
SC11201997[CR][LF]
```

Sdmmddyyyyz
This command sets the current date. The date is entered in Month Day Year format. The PCF8593 clock/calendar chip uses a counter from 0 to 3 to represent the year. The variable "z" must correspond to the following table. The length of the command is 13 characters including a [CR] and [LF].

Year ending in	Year Code
04	0
05	1
06	2
07	3
08	0
09	1
10	2
11	3

For example, the command to set the date to March 20, 2006 is:

```
SD032020062[CR][LF]
```

SHxyyyyyyyyyyyyyyy

This command sets the specified header. The variable "x" can be any number between 1 and 6. The variable "y" must be to 15 characters. If the value is less than 15 characters it must be padded with spaces. The length of the command is 20 characters including a [CR] and [LF]. The format is:

```
SH1JOHN SMITH[5 SPACES][CR][LF]
```

SLxxxxxxxxxx

This command sets the current location that will be saved with any subsequent logged samples. The location can be up to 10 characters in length and must be padded with spaces if less than 10 characters. The length of the command is 14 characters including a [CR] and [LF]. The format is:

```
SLTABLE0007[SPACE][CR][LF]
```

SMx

This command disables or enables the automatic dumping of the ratemeter when the Model 2360 is set not to log samples (dip-switch 5 and 6 both OFF). Specifying SM0 will disable the ratemeter dumping until the unit is turned off or the command SM1 is issued.

SPxxx.x

This command sets the user-defined count time that is selectable by setting the count time switch on the Model 2360 to "PC". The count time can be set from 000.1 minutes (6 seconds) to 546.1 minutes (32766 seconds). The length of the command is 9 characters including a [CR] and [LF]. The format is:

```
SP001.0[CR][LF]
```

SR

This command resets the sample number to one and clears all samples stored in memory. Use this command with caution. The length of the command is 4 characters including a [CR] and [LF]. The format is:

WARNING!

This command will erase all logged samples from memory.

```
SR[CR][LF]
```

SThhmm

This command sets the current time in 24-hour format. 24-hour time is as follows:

12:00 AM	0000	12:00 PM	1200
01:00 AM	0100	01:00 PM	1300
02:00 AM	0200	02:00 PM	1400
03:00 AM	0300	03:00 PM	1500
04:00 AM	0400	04:00 PM	1600
05:00 AM	0500	05:00 PM	1700
06:00 AM	0600	06:00 PM	1800
07:00 AM	0700	07:00 PM	1900
08:00 AM	0800	08:00 PM	2000
09:00 AM	0900	09:00 PM	2100
10:00 AM	1000	10:00 PM	2200
11:00 AM	1100	11:00 PM	2300

The length of the command is 8 characters including a [CR] and [LF]. For example, the command to set the time to 1:00pm is:

ST1300[CR][LF]

S1, S2, S3, S4, S5, S6

These commands set the alarms for the alpha, beta, and alpha + beta ratemeter and also the alpha, beta, and alpha + beta scaler. If the alarm is set to 0, then the alarm is disabled. S1 = Alpha Ratemeter.

S2 = Beta Ratemeter.
S3 = Alpha + Beta Ratemeter.
S4 = Alpha Scaler.
S5 = Beta Scaler.
S6 = Alpha + Beta Scaler.

The length of the command is 10 characters including a [CR] and [LF]. For example, to set the alpha ratemeter alarm to 500 the command is:

```
S1000500[CR][LF]
```

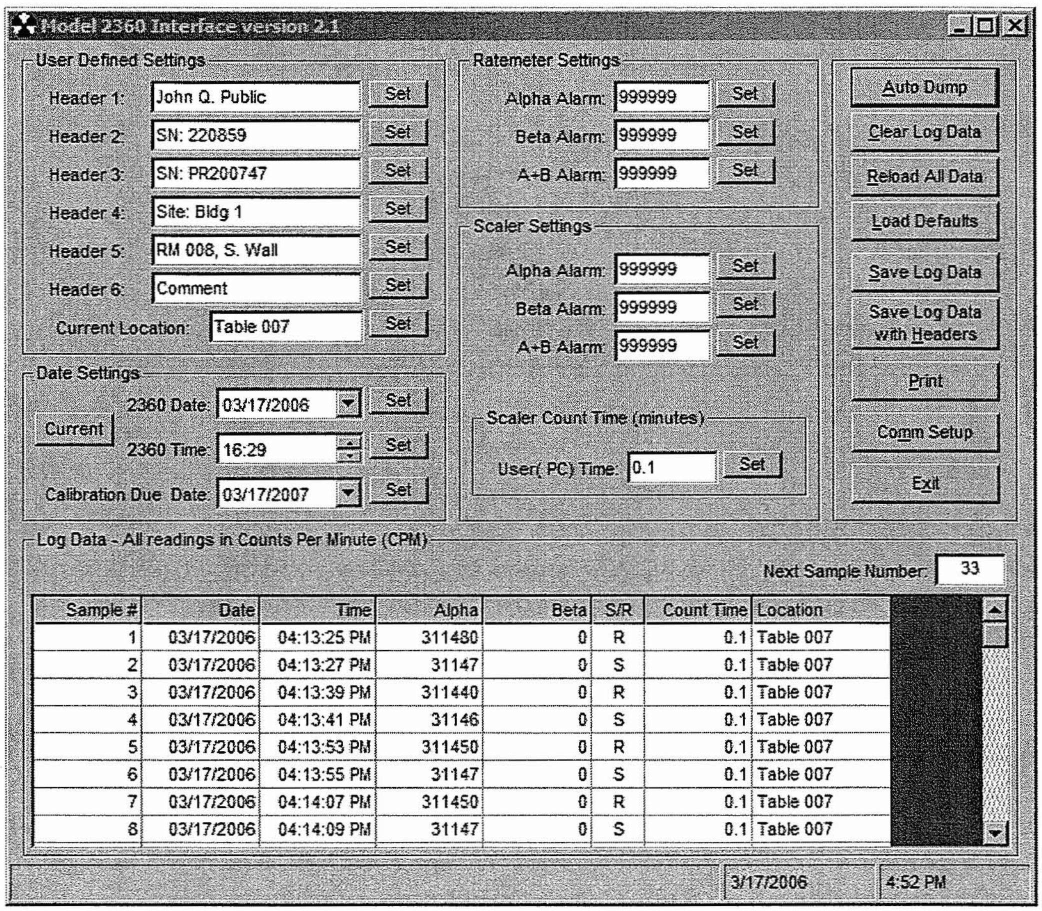
Model 2360 Interface Software

The Model 2360 Interface (LMI Part #:1370-039) is Windows-based and has a user-friendly interface which allows the user to communicate with the Model 2360. The Model 2360 Interface features automatically loading default values, and a Auto Dump Mode Display. When the program is started, the user is prompted to either allow the software to find the Model 2360 or to manually specify a serial port. Once connected, the software will download all data from the Model 2360, which includes Headers and Logged Data. The user is able to change any information and update the Model 2360, print hard copies, or save data to an ASCII file for later import into word processors, spreadsheets, or other applications.

FUNCTIONS

The Model 2360 Interface software has three main functions:

1. Read or update the parameters stored in the Model 2360
2. Read, save or delete the logged data stored in the Model 2360
3. Collect and save real-time data at specified intervals of time.



MAIN SCREEN

[**Set**]—Clicking the **Set** button will save the parameter to the Model 2360. Each parameter has its own **Set** button.

[**Auto Dump**]—Displays the Auto Dump Data screen which allows for real time logging of data.

[**Clear Log Data**]—Erases the logged sample data in the Model 2360.

Caution:

Data will be lost if this button is pressed and the data has not previously been saved.

[**Reload All Data**]—Downloads all information from the Model 2360.

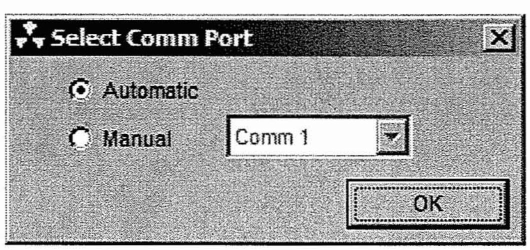
[**Load Defaults**]—Reloads all header data to the original state as shipped from Ludlum Measurements, Inc.

[**Save Log Data**]—Displays the "save file" prompt to allow the user to specify which drive and directory to save the Log File.

[**Save Log Data**]—Displays the "save file" prompt to allow the user to specify which drive and directory to save the Log File. This option also saves the six header fields to the file.

[**Print**]—Prints all parameters as well as logged data to the default printer. If there is no logged data, only the parameters will printed.

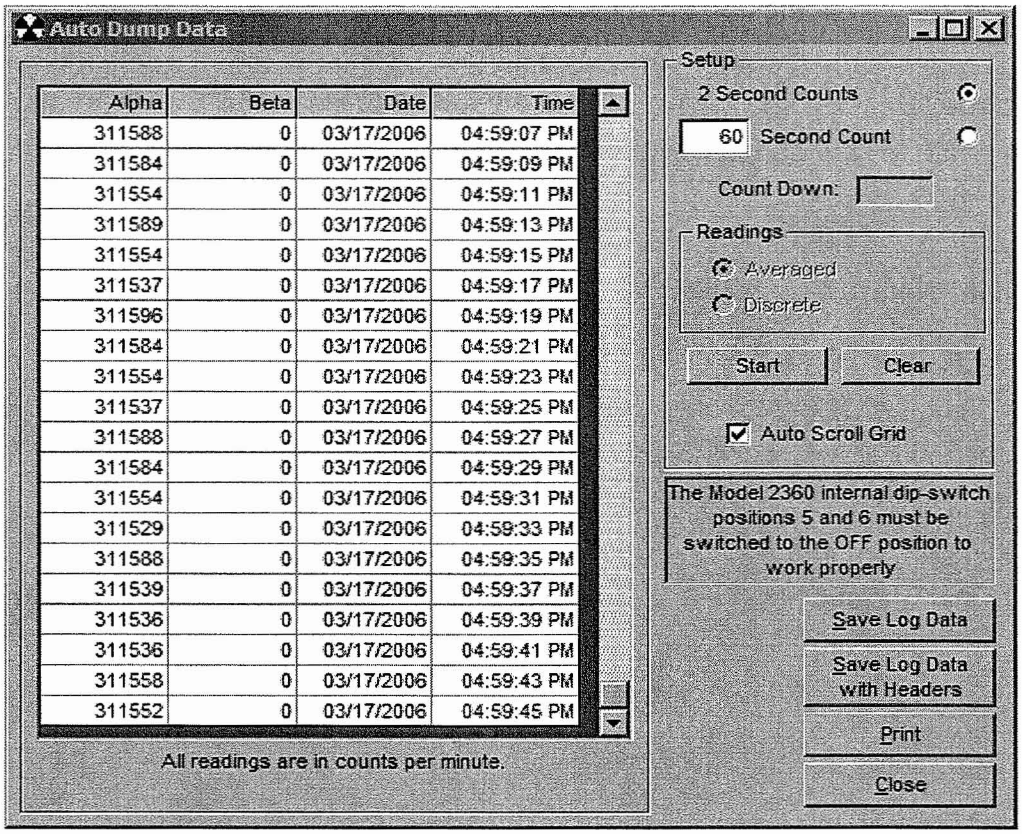
[**Comm Setup**]—Displays the Select Comm Port screen. Select "Automatic" to allow the software to scan all available serial ports to find the Model 2360. Select "Manual" and choose a specific serial port.



AUTO DUMP DATA (SETUP)

Note:

For Auto Dumping to work properly, the Model 2360 Internal Dip Switches 5 and 6 must be set to the OFF position.



Alpha	Beta	Date	Time
311588	0	03/17/2006	04:59:07 PM
311584	0	03/17/2006	04:59:09 PM
311554	0	03/17/2006	04:59:11 PM
311589	0	03/17/2006	04:59:13 PM
311554	0	03/17/2006	04:59:15 PM
311537	0	03/17/2006	04:59:17 PM
311596	0	03/17/2006	04:59:19 PM
311584	0	03/17/2006	04:59:21 PM
311554	0	03/17/2006	04:59:23 PM
311537	0	03/17/2006	04:59:25 PM
311588	0	03/17/2006	04:59:27 PM
311584	0	03/17/2006	04:59:29 PM
311554	0	03/17/2006	04:59:31 PM
311529	0	03/17/2006	04:59:33 PM
311588	0	03/17/2006	04:59:35 PM
311539	0	03/17/2006	04:59:37 PM
311536	0	03/17/2006	04:59:39 PM
311536	0	03/17/2006	04:59:41 PM
311558	0	03/17/2006	04:59:43 PM
311552	0	03/17/2006	04:59:45 PM

[Two-Second Counts]—The Model 2360 outputs the Ratemeter reading every 2 seconds. This option will capture each 2 second reading.

[User Defined Count]—This option will log the data based on a user-defined count time which is adjustable from 2 to 9998 seconds. The count time specified here must be evenly divided by 2. The count time may be changed while a count is in progress and will take effect when the current count time is finished. When a user-defined count is in progress, the "Count Down" box will display the remaining count time.

[Readings]--When counting with a user-defined count time, the saved readings can be averaged or discrete. When the "Averaged" option is selected, the readings accumulated every 2 seconds during the count time are averaged. When the "Discrete" option is selected, the last 2 second reading at the end of the count time is used. This option is only available when the user-defined count time option is selected.

[Start] **[Stop]**—Toggle from Start/Stop to start or stop the dumping of counts.

[Clear]—Clears data from the display box. This only clears the grid and does not affect the samples stored in the memory of the Model 2360.

[Auto Scroll Grid]—When checked the grid automatically scrolls to keep the newest record visible.

[Save Log Data]—Save the data to a user-specified file and location. The data is saved in standard ASCII and is readable in almost any program.

[Save Log Data with Headers]—This button performs the same function as above, but also saves the six header fields.

[Print]—Send Data including the displayed readings to the default printer. If there is no data displayed, only the Header information will printed.

[Close]—Return to the main menu area.

MODEL 2360 INTERFACE SOFTWARE SAMPLE PRINTOUTS (following pages)

Table 1: Logged Data downloaded from the Model 2360 and saved to an ASCII file

Table 2: Auto Dump Data saved to an ASCII file

Table 3: Printout of Logged Data

Table 1:

Header 1: John Q. Public
Header 2: SN: 220859
Header 3: SN: PR200747
Header 4: Site: Bldg 1
Header 5: RM 008, S. Wall
Header 6: Comment

S=Scaler, R=Ratemeter

Sample #	Date	Time	Alpha	Beta	S/R	Count Time	Location
1	03/17/2006	11:48:37 AM	311092	0	R	0.1	Table 007
2	03/17/2006	11:48:39 AM	31112	0	S	0.1	Table 007
3	03/17/2006	11:48:51 AM	311144	0	R	0.1	Table 007
4	03/17/2006	11:48:53 AM	31113	0	S	0.1	Table 007
5	03/17/2006	11:49:05 AM	311127	0	R	0.1	Table 007
6	03/17/2006	11:49:07 AM	31113	0	S	0.1	Table 007
7	03/17/2006	11:49:19 AM	311143	0	R	0.1	Table 007
8	03/17/2006	11:49:21 AM	31113	0	S	0.1	Table 007
9	03/17/2006	11:49:33 AM	311129	0	R	0.1	Table 007
10	03/17/2006	11:49:35 AM	31113	0	S	0.1	Table 007

Table 2:

Header 1: John Q. Public
Header 2: SN: 220859
Header 3: SN: PR200747
Header 4: Site: Bldg 1
Header 5: RM 008, S. Wall
Header 6: Comment

Alpha	Beta	Date	Time
311348	0	03/17/2006	01:49:44 PM
311344	0	03/17/2006	01:49:46 PM
311299	0	03/17/2006	01:49:48 PM
311348	0	03/17/2006	01:49:50 PM
311314	0	03/17/2006	01:49:52 PM
311312	0	03/17/2006	01:49:54 PM
311297	0	03/17/2006	01:49:56 PM
311296	0	03/17/2006	01:49:58 PM
311348	0	03/17/2006	01:50:00 PM
311314	0	03/17/2006	01:50:02 PM

Table 3:

```
Model 2360 Log Data    Date: 03/17/2006    Time: 01:44:49 PM       Page 1
---------------------------------------------------------------------------
Header 1: John Q. Public
Header 2: SN: 220859
Header 3: SN: PR200747
Header 4: Site: Bldg 1
Header 5: RM 008, S. Wall
Header 6: Comment

Calibration Due Date: 03/15/2007
     Model 2360 Date: 03/17/2006
     Model 2360 Time: 01:37:21 PM

Logged Samples:  10

User PC Scaler Count Time:  0.1 minutes

        Alpha Ratemeter Alarm Setpoint:  999999
        Beta Ratemeter Alarm Setpoint:  999999
Alpha + Beta Ratemeter Alarm Setpoint:  999999

        Alpha Scaler Alarm Setpoint:  999999
        Beta Scaler Alarm Setpoint:  999999
Alpha + Beta Scaler Alarm Setpoint:  999999

S=Scaler, R=Ratemeter
Sample #  Date        Time         Alpha    Beta     S/R  Count Time  Location
--------  ----------  -----------  -------  -------  ---  ----------  ---------
       1  03/17/2006  11:48:37 AM   311092        0   R          0.1  Table 007
       2  03/17/2006  11:48:39 AM    31112        0   S          0.1  Table 007
       3  03/17/2006  11:48:51 AM   311144        0   R          0.1  Table 007
       4  03/17/2006  11:48:53 AM    31113        0   S          0.1  Table 007
       5  03/17/2006  11:49:05 AM   311127        0   R          0.1  Table 007
       6  03/17/2006  11:49:07 AM    31113        0   S          0.1  Table 007
       7  03/17/2006  11:49:19 AM   311143        0   R          0.1  Table 007
       8  03/17/2006  11:49:21 AM    31113        0   S          0.1  Table 007
       9  03/17/2006  11:49:33 AM   311129        0   R          0.1  Table 007
      10  03/17/2006  11:49:35 AM    31113        0   S          0.1  Table 007
```

Installation of the 2360 Interface Software

User must comply with the software license agreement located at the end of this section (pages 7-14 thru 7-16). By installing this software you are consenting to be bound by this agreement. If you do not agree to all the terms of this agreement, do not install the product!

Insert the Model 2360 Interface software CD into the computer. The installation routine should start automatically. If it does not, click on the Start button, select "Run" and type in the following: "d:\setup.exe".

Replace the drive letter with the correct drive letter of the CD-ROM drive. Follow the onscreen prompts to install the software. When complete the software should be installed in C:\Program Files\2360Win. A shortcut is created in the Start Menu under "Ludlum Measurements, Inc".

REMOVAL OF MODEL 2360 INTERFACE SOFTWARE

To remove the program, start from the Windows Desktop. Click on Start Button, Settings, Control Panel, and then Add/Remove Programs. Find LMI 2360 Interface from the list and highlight, then click on the add/remove button to start uninstall.

Setup will prompt to make sure removal of program LMI 2360 Interface is ok.

Setup installed shared files and will prompt if you wish to keep, remove, remove none, or remove all. Files can be removed since they are installed in C:\Program Files\Model 2360 and should not cause any problems.

Uninstall screen appears and the program removal will be complete.

CONNECTING TO A COMPUTER

Using the supplied cable, connect the end with the female connector to the Model 2360 and the other end to a free COM port on your computer. The pin-outs of the cables are as follows:

9-pin cable

Model 2360	Computer
2	2
3	3
5	5
7	7
8	8

25-pin cable

Model 2360	Computer
2	3
3	2
5	7
7	4
8	5

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

Software License Agreement

Rev. (number) 1.0
Written by (or Revised by): Rich Smola **Date:** 20Jan06
Approved by: Ed Ene **Date:** 20JAN06

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Section 8

Technical Theory of Operation

Refer to Amplifier/Power Supply Board Drawing 390 × 180 for the following:

Detector Input/Amplifier

Negative-going detector pulses are coupled from the detector through C022 to Amplifier U021. R023 and CR021 protect the input of U021 from inadvertent shorts. Self-biased amplifier U021 provides gain in proportion to R021 divided by R022. Transistor pins 4, 5, and 6 of U021, provide amplification. Pins 12 and 15 of U021 are coupled as a constant current source to pin 6 of U021. The output self-biases to 2Vbe (approximately 1.4 volts) at pin 7 of U021. This provides just enough bias current through pin 6 of U021 to conduct all of the current for the constant current source. Positive pulses from pin 7 of U021 are coupled to the discriminators through R011 and C011.

Alpha/Beta Discriminator

Positive pulses from amplifier U021 are coupled to comparator U012, pin 6, for alpha discrimination and pins 6 and 2 of U011 for beta discrimination. R201, Alpha Threshold, provides the reference voltage for alpha comparator U012. R102, Beta Threshold (defined as the lower threshold limit of the beta counting window) provides the reference voltage for beta threshold comparator pins 1, 2, and 3 of U011. R104, Beta Window (defined as the upper threshold limit of the beta counting window) provides the reference voltage for the beta window comparator pins 5, 6, and 7 of U011.

Alpha/Beta Discriminator Logic Circuit

Alpha pulses from U012 are coupled to univibrator U111. Pulses at pin 6 of U111 are inverted by Q111 for connection to reset (R) pins 3, 13 of U101. Pin 9 of U111 provides the pulses to be counted by the microprocessor (μP). Pulses from pin 9 of U111 are connected to pin 3 of U111 to provide a time delay for the μP clock cycle to complete before the next alpha pulse can be recognized by the μP.

Beta pulses from pin 1 of U011 are coupled to univibrator U101. Pulses are coupled to the µP from pin 7 of U101 as long as pins 3 and 13 of U011 remain high (+5V). When an alpha and/or a beta window pulse is present, the reset (pins 3 and 13 of U101) function is enabled, and 7 of U101 remains high. Pin 7 of U101 is connected to pin 13 of U101 to provide a time delay for the µP clock cycle to complete before the next beta pulse can be recognized by the µP.

Low Voltage Supply

Battery Voltage is coupled to switching regulator U201 and associated components to provide +5V to power op-amps and logic circuitry. The charge pump (cp) output C202, CR211, CR212, and C201 form a voltage doubler circuit to provide +9V for U201 amplifier supply. U001 and related components provide +2.5V reference for HV SET and Alpha/Beta discriminator controls. R201 (LO BAT) is adjusted so that the meter pointer is aligned with the left vertical mark on the BAT OK line with 2.2 volt battery input.

High Voltage Supply

High Voltage is developed by blocking oscillator Q421, T321, C412, and rectified by voltage multiplier CR221-CR224, C221-C223, C211, and C114. High voltage increases as current through Q421 increases, with maximum output voltage with Q421 saturated.

High voltage is coupled back through R123 to op-amp pin 2 of U311. Resistor network R211-214 completes the HV division circuit to ground. R214 provides HV limit at 2.0kV when the HV SET control on the calibration bd. is at maximum. The regulated HV output is controlled by HV potentiometer located under the CAL cover on the front panel. This control provides the reference for comparator pin 3, U311. During stable operation, the voltage at pin 2 of U311 will equal the voltage at pin 3 of U311. Pin 1 of U311 will cause conduction of Q312 to increase or decrease until the HV finds a level of stability. R115 (HV TEST) calibrates the analog meter to the HV output when the HV test push-button switch is depressed.

Detector Overload

A voltage drop is developed across R121 and sensed by comparator U012 as detector current increases. When the voltage at pin 3 of U012 goes below pin 2, pin 1 goes low, illuminating the OL LED and driving the meter to full scale. R211, Overload, provides adjustment for the overload set point.

Meter Drive

Pulses are coupled from the µP bd. to the gate of Q302. Q302 inverts the pulses CR403 and C401 provides integration. Integrated meter drive voltage is coupled from P1-13 via the battery (BAT) and HV test switch to pin 5 of U311. The meter is driven by the emitter of Q111, coupled as a voltage follower in conjunction with pin 6 and 7 of U311. R406, "Meter Cal," is adjusted to calibrate the ratemeter reading corresponding to the incoming count rate. R407 and R408 provide temperature compensation for changes in the meter resistance due to temperature variations.

Refer to Processor Board Drawing 390 × 173 for the following:

Power supply

Battery voltage is coupled to switching regulator U321 and associated components to provide +5V to power the µP and display drivers U211, 212. R101, C101, Q101, and Q201 form a delay switch which allows U321 to stabilize before the load current is connected to the +5V supply.

Microprocessor (µP)

U111, Intel N87C51FC, controls all of the data, control inputs, and display information. The clock frequency is crystal controlled by Y111 and related components at 6.144 MHz. The µP incorporates internal memory (ROM) storing the program information. C211 resets the µP at power-up to initiate the start of the program routine. During the program loop the µP looks at all of the input switches for initiation or status changes and responds accordingly.

The µP uses Pulse-width Modulation to control the analog ratemeter. The analog output, RATE (P1-3) is divided into 255 increments in a 166 µs period. At full meter deflection the low pulse period, leading edge to leading edge, will be 166 µs, 500 cpm = 163 µs, 400 cpm = 130 µs, 200 cpm = 65 µs, 100 cpm = 33 µs, and 0 = no pulse or +5V. The pulses are inverted by Q302 on the Amp/Power Supply Board and then integrated by R403, C401.

LCD Drive

U101 and U001 make up the liquid crystal display drive circuitry. The display information is sent from the µP to U101 and U001 via DATA 0-1 lines. Each bit is latched into the drivers when the CLOCK line is brought high, then low by the µP. When 32 bits have been clocked to the drivers, the

LOAD line is brought high, and then low. The corresponding digits and segments are illuminated, corresponding to the stored-count information from the μP.

Audio

Alpha and/or beta audio pulse frequency is generated by the μP and coupled to Q211. Q211 then inverts the pulses and drives the low side of the audio transformer T321. Front panel VOL control provides the bias voltage to the top of T321. Secondary winding of T321 is coupled to unimorph speaker via front panel audio jack.

Section 9

Troubleshooting

Occasionally, you may encounter problems with your LMI instrument or detector that may be repaired or resolved in the field, saving turnaround 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: (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 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 Proportional and Scintillator Type Detectors

SYMPTOM	POSSIBLE SOLUTION
No power (or meter does not reach BAT TEST or BAT OK mark)	1. Check batteries and replace if weak. 2. Check polarity (See marks inside batter lid). Are the batteries installed backwards?

SYMPTOM	POSSIBLE SOLUTION
No power (or meter does not reach BAT TEST or BAT OK mark) (continued)	3. Check battery contacts. Clean them with rough sandpaper or use an engraver to clean the tips.
	4. Check for loose or broken wires, especially between the main board and the calibration board.
Nonlinear Readings	1. Check the high voltage (HV) by using a Ludlum Model 500 Pulser (or equivalent). 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, placing the instrument on the lowest range setting, and wiggling the cable while observing the meter face for significant changes in readings.
	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 OFF. The meter should come to rest on "0".
Meter goes full-scale or "Pegs Out"	1. Replace the detector cable to determine whether or not the cable has failed- causing excessive noise.
	2. Check the HV and, if possible, the input threshold for proper setting.

SYMPTOM		POSSIBLE SOLUTION
Meter goes full-scale or "Pegs Out" (continued)	3.	Open the instrument "can" and check for loose wires.
	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.

Section 10

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 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" which 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 11

Parts List

	Reference	Description	Part Number
Model 2360 Scaler/Ratemeter	UNIT	Completely Assembled Model 2360 Scaler/Ratemeter	48-2872
Amplifier/Power Supply Board, Drawing 390 × 180	BOARD	Completely Assembled Amplifier/ Power Supply Board	5390-174
CAPACITORS	C001	100PF, 100V	04-5661
	C002	47PF, 100V	04-5660
	C011	0.1UF, 50V	04-5663
	C012	0.001UF, 100V	04-5659
	C013	0.001UF, 100V	04-5659
	C014	0.01UF, 50V	04-5664
	C015	0.1UF, 50V	04-5663
	C016	0.001UF, 100V	04-5659
	C017	10UF, 20V	04-5655
	C021	10PF, 100V	04-5673
	C022	100PF, 3KV	04-5532
	C101	47PF, 100V	04-5660
	C102	47PF, 100V	04-5660
	C111	47PF, 100V	04-5660
	C112	47PF, 100V	04-5660
	C113	47PF, 100V	04-5660
	C114	0.0047UF, 3KV	04-5547
	C121	0.0047UF, 3KV	04-5547
	C122	0.0047UF, 3KV	04-5547
	C201	10UF, 20V	04-5655
	C202	10UF, 20V	04-5655
	C203	330PF, 100V	04-5657
	C211	0.0047UF, 3KV	04-5547
	C212	68UF, 6.3V	04-5654
	C213	1UF, 35V	04-5656

	Reference	Description	Part Number
	C214	0.01UF, 50V	04-5664
	C221	0.0047UF, 3KV	04-5547
	C222	0.0047UF, 3KV	04-5547
	C223	0.0047UF, 3KV	04-5547
	C301	68UF, 6.3V	04-5654
	C311	01UF, 50V	04-5664
	C401	1UF, 50V	04-5663
	C411	1UF, 50V	04-5663
	C412	1UF, 35V	04-5656
	C421	68UF, 6.3V	04-5654
TRANSISTORS	Q111	2N7002L	05-5840
	Q301	MMBT4403LT1	05-5842
	Q302	2N7002L	05-5840
	Q311	MMBT3904T	05-5841
	Q312	MMBT3904T	05-5841
	Q421	MJD210	05-5843
INTEGRATED CIRCUITS	U001	LM285M-2.5	06-6291
	U011	TLC372ID	06-6290
	U012	TLC372ID	06-6290
	U021	CA3096M	06-6288
	U101	CD74HC4538M	06-6297
	U111	CD74HC4538M	06-6297
	U201	MAX631AESA	06-6285
	U301	CD74HC4066M	06-6323
	U311	TLC27M7ID	06-6292
DIODES	CR021	MMBD7000LT1	07-6355
	CR111	MMBD914L	07-6353
	CR112	MMBD914L	07-6353
	CR211	BAT54	07-6354
	CR212	BAT54	07-6354
	CR221	GI250-2	07-6266
	CR222	GI250-2	07-6266
	CR223	GI250-2	07-6266
	CR224	GI250-2	07-6266
	CR225	GI250-2	07-6266
	CR411	MMBD914L	07-6353
THERMISTOR	R407	250, 03006-165.9-55-G100	07-6366

	Reference	Description	Part Number
POTENTIOMETERS	R102	10K, BETA THRESH	09-6921
	R103	1M, BETA WIN	09-6906
	R115	1M, (HV) HV READOUT	09-6906
	R406	5K, METER CAL (MTR)	09-6907
	R214	1M, HV LIMIT	09-6906
	R201	1M, ALPHA THRESH	09-6906
	R202	200K, LO BAT (LB)	09-6908
	R211	1M, OVERLOAD	09-6906
RESISTORS	R001	22.1K, 125mW, 1%	12-7843
	R002	249K, 125mW, 1%	12-7862
	R003	22.1K, 125mW, 1%	12-7843
	R004	1.5K, 125mW, 1%	12-7878
	R011	100, 125mW, 1%	12-7840
	R012	22.1K, 125mW, 1%	12-7843
	R013	33.2K, 125mW, 1%	12-7842
	R014	10.0K, 125mW, 1%	12-7839
	R015	22.1K, 125mW, 1%	12-7843
	R016	10.0K, 125mW, 1%	12-7839
	R021	392K, 125mW, 1%	12-7841
	R022	10.0K, 125mW, 1%	12-7839
	R023	10.0K, 125mW, 1%	12-7839
	R024	33.2K, 125mW, 1%	12-7842
	R025	22.1K, 125mW, 1%	12-7843
	R026	1.00M, 250mW, 5%	10-7028
	R101	100K, 125mW, 1%	12-7834
	R104	22.1K, 125mW, 1%	12-7843
	R105	100K, 125mW, 1%	12-7834
	R111	100, 125mW, 1%	12-7840
	R112	1G	12-7686
	R113	100K, 125mW, 1%	12-7834
	R114	100K, 125mW, 1%	12-7834
	R116	249K, 125mW, 1%	12-7862
	R121	4.7M, 250mW, 5%	10-7030
	R122	1.00M, 250mW, 5%	10-7028
	R123	1G	12-7686
	R212	1.00M, 125mW, 1%	12-7844
	R213	1.00M, 125mW, 1%	12-7844
	R215	1.00M, 125mW, 1%	12-7844
	R301	2.21K, 125mW, 1%	12-7835
	R302	22.1K, 125mW, 1%	12-7843

	Reference	Description	Part Number
	R303	22.1K, 125mW, 1%	12-7843
	R311	10.0K, 125mW, 1%	12-7839
	R312	22.1K, 125mW, 1%	12-7843
	R313	2.21K, 125mW, 1%	12-7835
	R314	10.0K, 125mW, 1%	12-7839
	R401	200, 1/8W, 1%	12-7846
	R402	221K, 125mW, 1%	12-7845
	R403	7.5K, 125mW, 1%	12-7847
	R404	2.21K, 125mW, 1%	12-7835
	R405	1.00M, 125mW, 1%	12-7844
	R408	301, 125mW, 1%	12-7863
	R411	200, 125mW, 1%	12-7846
	R412	10.0K, 125mW, 1%	12-7839
CONNECTORS	P1	1-640456-5	13-8355
	P2	640456-3 MTA100	13-8081
INDUCTOR	L301	220UH	21-9678
TRANSFORMER	T321	7000T/100T, 200T	40-0902
Processor Board, Drawing 390 × 173	BOARD	Completely Assembled Processor Board	5390-171
CRYSTALS	Y111	MICRO XTAL-6.144 MHZ	01-5262
	Y401	MICRO XTAL-32.768 KHZ	01-5305
CAPACITORS	C111	27PF, 100V	04-5658
	C112	27PF, 100V	04-5658
	C211	4.7UF, 20V	04-5653
	C221	47UF, 10V	04-5666
	C311	68UF, 6.3V	04-5654
	C312	68UF, 6.3V	04-5654
	C313	68UF, 6.3V	04-5654
	C314	68UF, 6.3V	04-5654
	C315	68UF, 6.3V	04-5654
	C316	68UF, 6.3V	04-5654
	C401	10PF, 100V	04-5673
	C411	10UF, 20V	04-5655
	C421	4.7UF, 20V	04-5653
	C422	10UF, 20V	04-5655

	Reference	Description	Part Number
	C423	4.7UF, 20V	04-5653
TRANSISTORS	Q101	TRANS-2N7002L	05-5840
	Q102	TRANS-2N7002L	05-5840
	Q211	TRANS-2N7002L	05-5840
INTEGRATED CIRCUITS	U101	IC-24C65ISM	06-6401
	U111	IC-N87C51FC	06-6331
	*	SOCKET-822276-1 44P	06-6293
	U201	IC-24C65ISM	06-6401
	U202	IC-PCF8574TD	06-6402
	U311	IC-LT1304CS8	06-6394
	U401	IC-PCF8593TD	06-6403
	U421	IC-MAX220CSE	06-6329
DIODES	CR211	CXSH-4 EB33	07-6358
	CR212	CXSH-4 EB33	07-6358
	CR401	MMBD914L	07-6353
	CR402	MMBD914L	07-6353
SWITCH	S301	CONFIGURE SWITCH	08-6710
RESISTORS	R101	200, 125mW, 1%	12-7846
	R102	200, 125mW, 1%	12-7846
	R103	22.1K, 125mW, 1%	12-7843
	R104	100K, 125mW, 1%	12-7834
	R170	1.00M, 125mW, 1%	12-7844
	R201	22.1K, 125mW, 1%	12-7843
	R202	100K, 125mW, 1%	12-7834
	R211	100K, 125mW, 1%	12-7834
	R311	150K, 125mW, 1%	12-7833
	R312	22.1K, 125mW, 1%	12-7843
	R313	68.1K, 125mW, 1%	12-7881
	R321	1.00K, 125mW, 1%	12-7832
	R401	1.00K, 125mW, 1%	12-7832
RESISTOR NETWORKS	RN201	NETWORK-220K	12-7923
	RN211	NETWORK-220K	12-7923
CONNECTORS	P3	1-640456-7 MTA100	13-8121
	P4	1-640456-1 MTA100	13-8059
	P12	640456-6 MTA100	13-8095

	Reference	Description	Part Number
	P13	640456-2 MTA100	13-8073
INDUCTOR	L211	22UH	21-9808
BATTERY	B411	DL2450 LITHIUM	22-9786
TRANSFORMER	T321	XFMR- M 177 AUDIO	4275-083
LCD Display Board, Drawing 390 × 170	BOARD	Completely Assembled LCD Display Board	5390-170
CAPACITOR	C201	27PF, 100V	04-5658
INTEGRATED CIRCUITS	U001	AY0438-I/L	06-6358
	U101	AY0438-I/L	06-6358
LED'S	DS001	E118, RED	07-6308
	DS201	E118, RED	07-6308
LCD	DSP101	LCD-8849-365-487 A/W	07-6406
RESISTORS	R011	10K, 125mW, 1%	12-7839
	R012	10K, 125mW, 1%	12-7839
	R111	10K, 125mW, 1%	12-7839
	R112	10K, 125mW, 1%	12-7839
Calibration Board, Drawing 390 × 176	BOARD	Completely Assembled Calibration Board	5390-172
POTENTIOMETER	R3	250K, HV SET	09-6819
CONNECTOR	P7	640456-5 MTA100	13-8057
BCD Board, Drawing 261 × 107	BOARD	Completely Assembled BCD Board	5261-154
SWITCH	S111	513384	08-6656
CONNECTOR	P5	640456-5 MTA100	13-8057

Chassis Wiring Diagram, Drawing 390 × 179

	Reference	Description	Part Number
SWITCHES	S1	SWITCH-PA-600-210	08-6501
	S3	SWITCH-MPS-103F	08-6699
	S4	PHONE JACK TINI #42A	21-9333
	S5	SWITCH-7103SYZQE TOGGLE	08-6720
	S6	SWITCH-7205SYZQE TOGGLE	08-6750
POTENTIOMETER	R1	10K, VOLUME	09-6753
CONNECTORS	J1	CONN-1-640442-5 MTA100	13-8383
	J2	CONN-640442-3 MTA100	13-8135
	J3	CONN-1-640442-7 MTA100	13-8505
	J4	CONN-640442-3 MTA100	13-8135
	J5	CONN-640442-6 MTA100	13-8171
	J6	D RECPT-RD9F000V3 9 PIN	13-8003
	J7	JACK-09-9011-1-0419	18-9080
	J8	CONN-640442-6 MTA100	13-8171
	J9	CONN-640442-2 MTA100	13-8178
	J12	CONN-640442-6 MTA100	13-8171
	J13	CONN-640442-2 MTA100	13-8178
	J14	Series "C"-UG706/U	13-7751
BATTERIES	B1-B2	"D" DURACELL BATTERY	21-9313
AUDIO	DS1	S100RL-M, UNIMORPH	21-9676
MISCELLANEOUS	M1	METER ASSEMBLY	4390-160
	*	METER-PORT BZL W/GLS	4363-352
	*	M2360 METERFACE	7390-157
	*	METER-MVT #919492 1 MA	15-8030
	*	O RING-BEZEL	16-8334
	*	SPACER-#2 X .187 NYL	18-9143
	*	BD(C)-M2360 LCD DISPLAY	5390-144
	*	BATTERY CONTACT SET	40-1707
	*	MAIN HARNESS	8390-162
	*	LCD HARNESS	8390-163
	*	CAN-RS232 HARNESS	8390-166

Section 12

Drawings and Diagrams

MAIN BOARD, Drawing 390 × 180

MAIN BOARD COMPONENT LAYOUT, Drawing 390 × 181

PROCESSOR BOARD, Drawing 390 × 173

PROCESSOR BOARD COMPONENT LAYOUT, Drawing 390 × 174

LCD DISPLAY BOARD, Drawing 390 × 170

LCD DISPLAY BOARD COMPONENT LAYOUT, Drawing 390 × 171 (2 sheets)

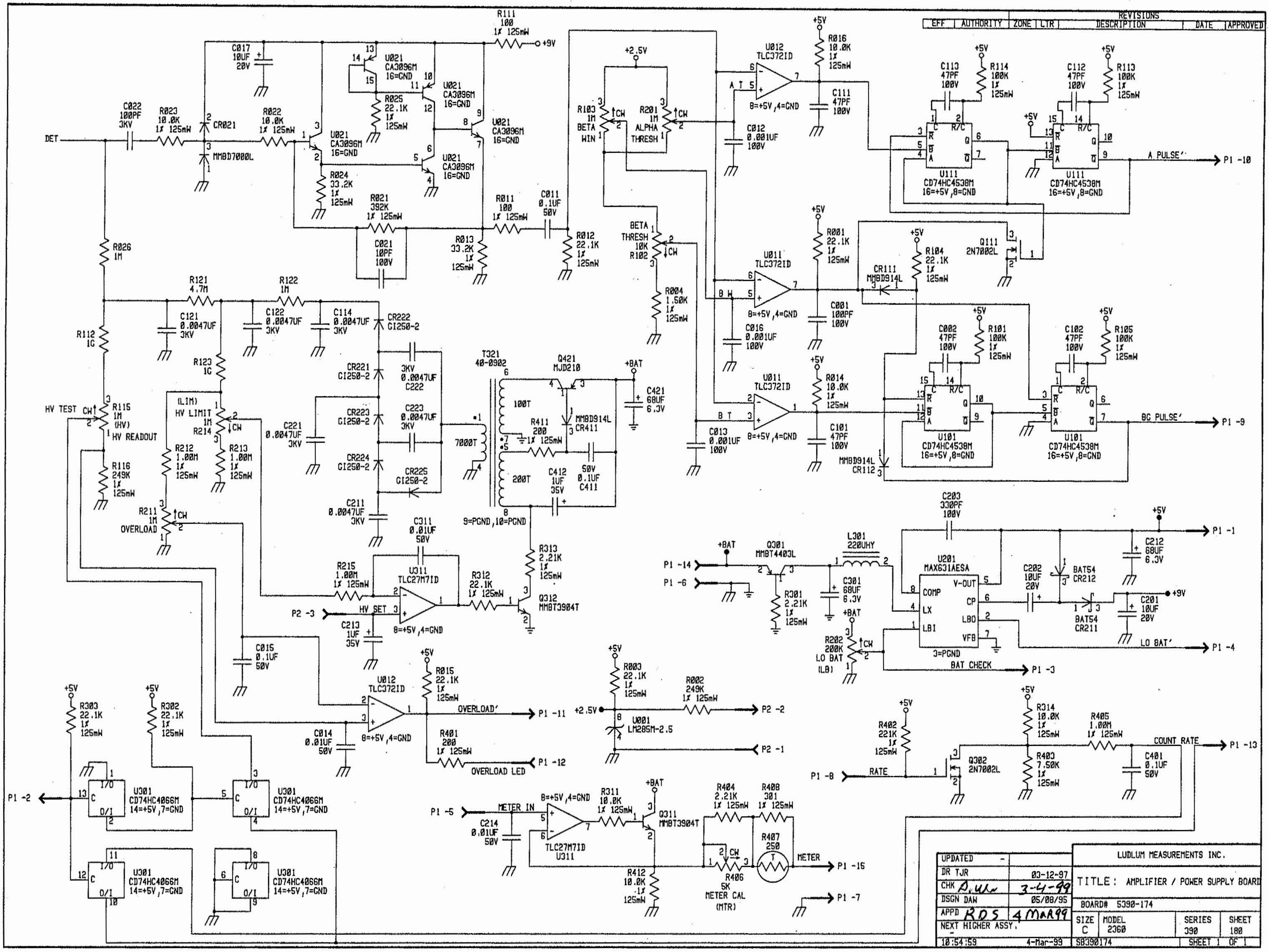
CALIBRATION BOARD, Drawing 390 × 176

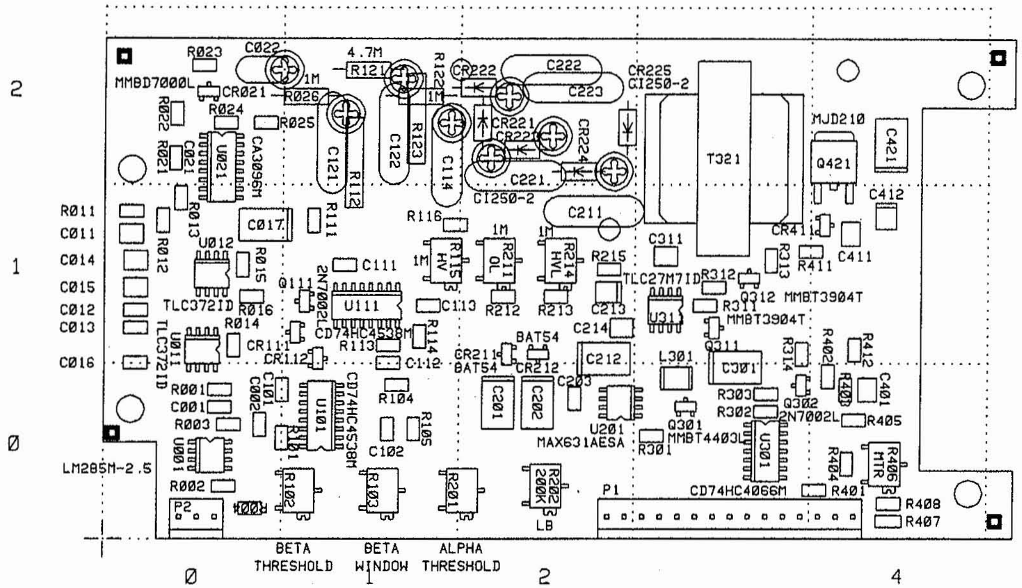
CALIBRATION BOARD COMPONENT LAYOUT, Drawing 390 × 177 (2 sheets)

BCD BOARD, Drawing 261 × 107

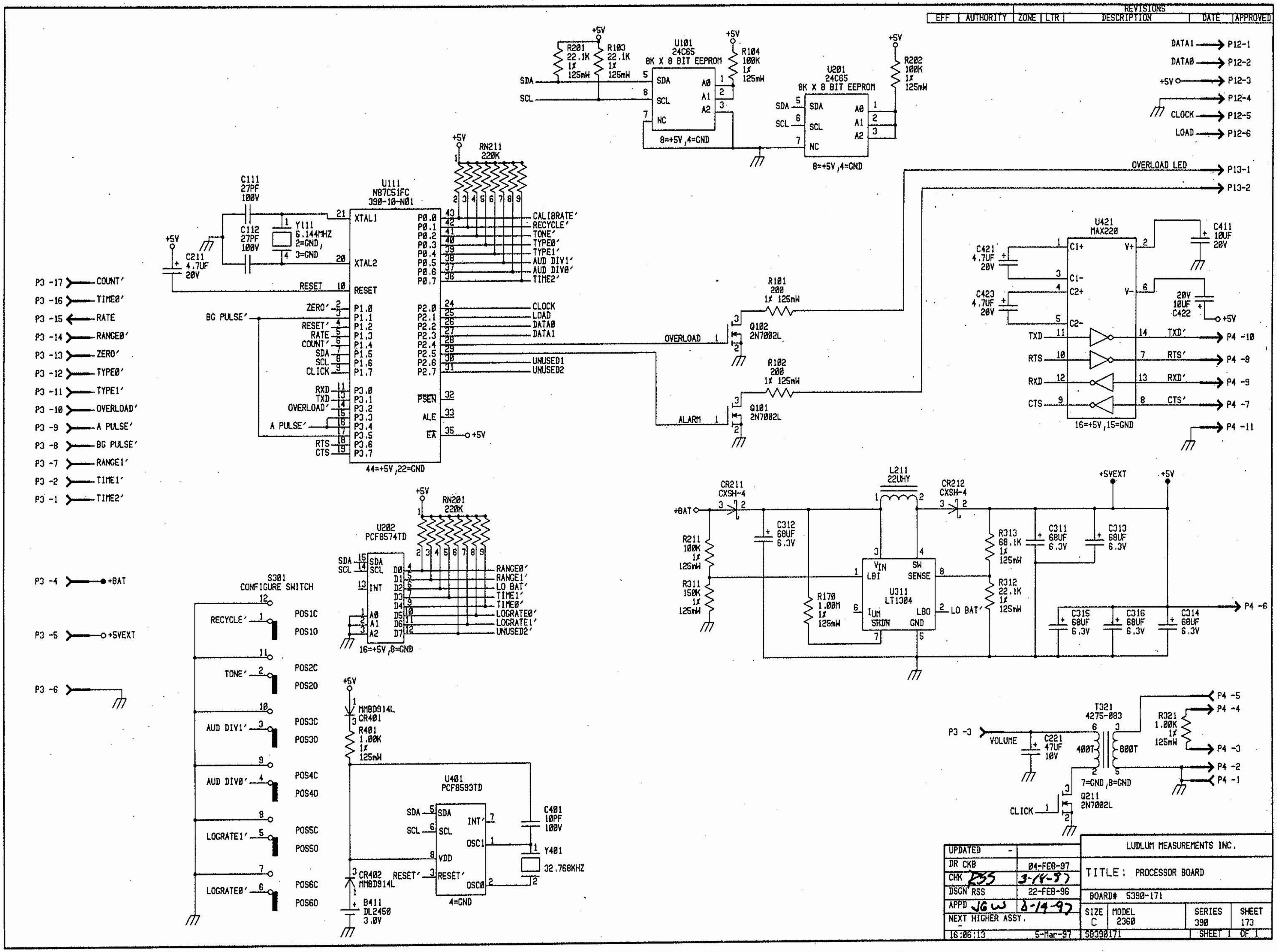
BCD BOARD COMPONENT LAYOUT, Drawing 261 × 105 (2 sheets)

WIRING DIAGRAM, Drawing 390 × 179

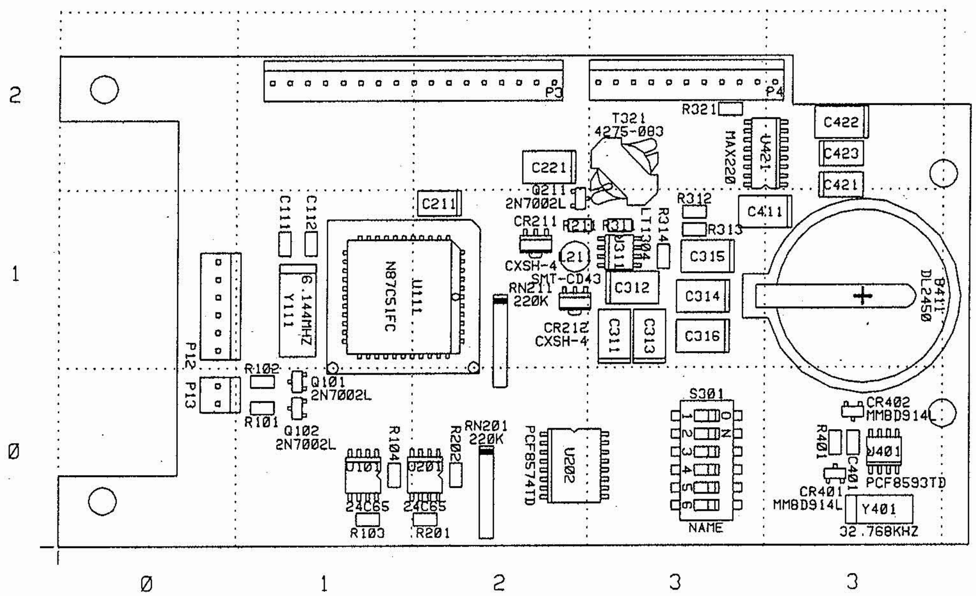

REVISIONS
EFF | AUTHORITY | ZONE | LTR | DESCRIPTION | DATE | APPROVED
DET
C022 100PF 3KV
R023 10.0K 1% 125mW
CR021 MMBD7000L
R022 10.0K 1% 125mW
C017 10UF 20V
U021 CA3096M 16=GND
R025 22.1K 1% 125mW
R024 33.2K 1% 125mW
R021 392K 1% 125mW
C021 10PF 100V
R111 100 1% 125mW +9V
R011 100 1% 125mW
C011 0.1UF 50V
R013 33.2K 1% 125mW
R012 22.1K 1% 125mW
+2.5V
R103 1M BETA WIN
R201 1M ALPHA THRESH
BETA THRESH 10K R102
R004 1.50K 1% 125mW
U012 TLC372ID 8=+5V,4=GND
A T
C012 0.001UF 100V
R016 10.0K 1% 125mW
C111 47PF 100V
C113 47PF 100V
R114 100K 1% 125mW
C112 47PF 100V
R113 100K 1% 125mW
U111 CD74HC4538M 16=+5V,8=GND
A PULSE' P1 -10
R001 22.1K 1% 125mW
U011 TLC372ID 8=+5V,4=GND
B W
C016 0.001UF 100V
C001 100PF 100V
R104 22.1K 1% 125mW
CR111 MMBD914L
Q111 2N7002L
C002 47PF 100V
R101 100K 1% 125mW
C102 47PF 100V
R105 100K 1% 125mW
B T
C013 0.001UF 100V
R014 10.0K 1% 125mW
C101 47PF 100V
U101 CD74HC4538M 16=+5V,8=GND
MMBD914L CR112
BG PULSE' P1 -9
R026 1M
R121 4.7M
R122 1M
C121 0.0047UF 3KV
C122 0.0047UF 3KV
C114 0.0047UF 3KV
R112 1G
R123 1G
HV TEST
R115 1M (HV) HV READOUT
R116 249K 1% 125mW
(LIM) HV LIMIT 1M R214
R212 1.00M 1% 125mW
R213 1.00M 1% 125mW
R211 1M OVERLOAD
CR222 GI250-2
CR221 GI250-2
CR223 GI250-2
CR224 GI250-2
CR225 GI250-2
3KV 0.0047UF C222
C223 0.0047UF 3KV
C221 0.0047UF 3KV
C211 0.0047UF 3KV
T321 40-0902
7000T
100T
200T
9=PGND,10=PGND
Q421 MJD210
+BAT
C421 68UF 6.3V
R411 200 1% 125mW
MMBD914L CR411
C412 1UF 35V
50V 0.1UF C411
R313 2.21K 1% 125mW
Q312 MMBT3904T
C311 0.01UF 50V
R215 1.00M 1% 125mW
U311 TLC27M7ID
R312 22.1K 1% 125mW
P2 -3
HV SET
C213 1UF 35V
8=+5V,4=GND
C015 0.1UF 50V
U012 TLC372ID
R015 22.1K 1% 125mW
OVERLOAD' P1 -11
C014 0.01UF 50V
R401 200 1% 125mW
OVERLOAD LED P1 -12
R303 22.1K 1% 125mW
R302 22.1K 1% 125mW
P1 -2
U301 CD74HC4066M 14=+5V,7=GND
C203 330PF 100V
P1 -14
P1 -6
Q301 MMBT4403L
R301 2.21K 1% 125mW
L301 220UHY
C301 68UF 6.3V
U201 MAX631AESA
COMP LX LBI V-OUT CP LBO VFB
3=PGND
C202 10UF 20V
BAT54 CR212
BAT54 CR211
C212 68UF 6.3V
C201 10UF 20V
P1 -1
+9V
R202 200K LO BAT (LB)
BAT CHECK P1 -3
LO BAT' P1 -4
R003 22.1K 1% 125mW
R002 249K 1% 125mW
+2.5V
P2 -2
U001 LM285M-2.5
P2 -1
R402 221K 1% 125mW
P1 -8 RATE
Q302 2N7002L
R314 10.0K 1% 125mW
R403 7.50K 1% 125mW
R405 1.00M 1% 125mW
C401 0.1UF 50V
COUNT RATE P1 -13
P1 -5 METER IN
C214 0.01UF 50V
TLC27M7ID U311
R311 10.0K 1% 125mW
Q311 MMBT3904T
R412 10.0K 1% 125mW
R404 2.21K 1% 125mW
R408 301 1% 125mW
R407 250
R406 5K METER CAL (MTR)
METER P1 -15
P1 -7
UPDATED -
DR TJR 03-12-97
CHK 3-4-99
DSGN DAW 05/08/95
APPD RDS 4 MAR 99
NEXT HIGHER ASSY.
10:54:59 4-Mar-99
LUDLUM MEASUREMENTS INC.
TITLE: AMPLIFIER / POWER SUPPLY BOARD
BOARD# 5390-174
SIZE C MODEL 2360 SERIES 390 SHEET 180
SB390174 SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.				
DR TJR	03-12-97	TITLE: AMPLIFIER / POWER SUPPLY BOARD		
CHK	3 20 97			
DSGN DAW	05/08/95	BOARD# 5390-174		BS390174
APP	3-20-97	MODEL 2360	SERIES 390	SHEET 181
14:55:49	18-Mar-97	COMP SIDE ☐	SLDR SIDE ☐	OUTLINE ☒
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐	

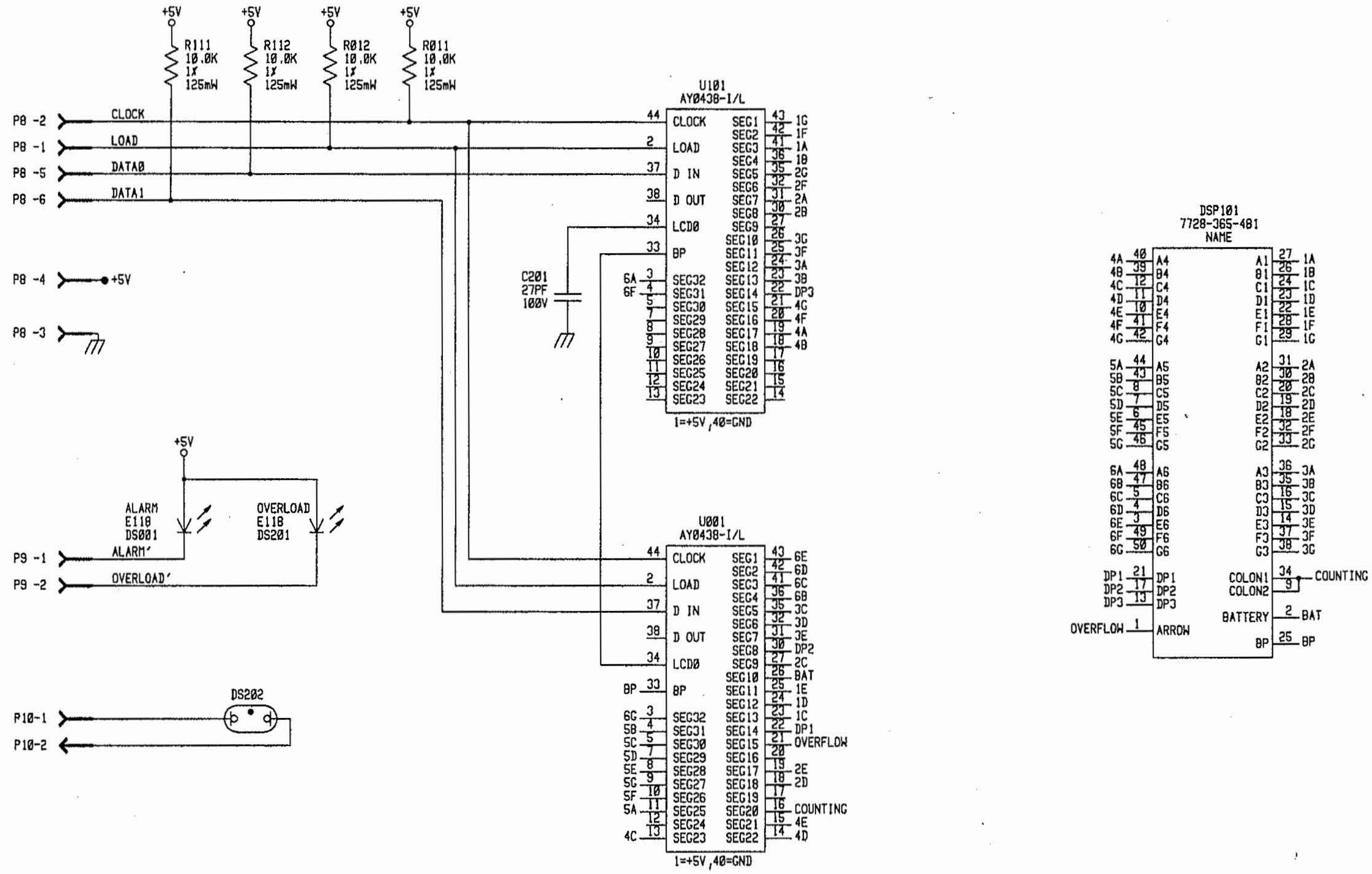


REVISIONS
EFF | AUTHORITY | ZONE | LTR | DESCRIPTION | DATE | APPROVED
U101 24C65 8K X 8 BIT EEPROM
U201 24C65 8K X 8 BIT EEPROM
8=+5V,4=GND
R201 22.1K 1% 125mW
R103 22.1K 1% 125mW
R104 100K 1% 125mW
R202 100K 1% 125mW
RN211 220K
U111 N87C51FC 390-10-N01
44=+5V,22=GND
C111 27PF 100V
C112 27PF 100V
Y111 6.144MHZ 2=GND, 3=GND
C211 4.7UF 20V
XTAL1 XTAL2 RESET
CALIBRATE' RECYCLE' TONE' TYPE0' TYPE1' AUD DIV1' AUD DIV0' TIME2'
CLOCK LOAD DATA0 DATA1 UNUSED1 UNUSED2
PSEN ALE EA
BG PULSE' A PULSE' OVERLOAD' RXD TXD RTS CTS ZERO' RESET' RATE COUNT' SDA SCL CLICK
DATA1 → P12-1
DATA0 → P12-2
+5V → P12-3
P12-4
CLOCK → P12-5
LOAD → P12-6
OVERLOAD LED → P13-1
P13-2
R101 200 1% 125mW
Q102 2N7002L
OVERLOAD
R102 200 1% 125mW
Q101 2N7002L
ALARM
U421 MAX220
16=+5V,15=GND
C421 4.7UF 20V
C423 4.7UF 20V
C411 10UF 20V
C422 10UF 20V
TXD' → P4 -10
RTS' → P4 -8
RXD' → P4 -9
CTS' → P4 -7
P4 -11
P3 -17 COUNT'
P3 -16 TIME0'
P3 -15 RATE
P3 -14 RANGE0'
P3 -13 ZERO'
P3 -12 TYPE0'
P3 -11 TYPE1'
P3 -10 OVERLOAD'
P3 -9 A PULSE'
P3 -8 BG PULSE'
P3 -7 RANGE1'
P3 -2 TIME1'
P3 -1 TIME2'
P3 -4 +BAT
P3 -5 +5VEXT
P3 -6
U202 PCF8574TD
16=+5V,8=GND
RN201 220K
RANGE0' RANGE1' LO BAT' TIME1' TIME0' LOGRATE0' LOGRATE1' UNUSED2'
S301 CONFIGURE SWITCH
RECYCLE' POS1C POS1O
TONE' POS2C POS2O
AUD DIV1' POS3C POS3O
AUD DIV0' POS4C POS4O
LOGRATE1' POS5C POS5O
LOGRATE0' POS6C POS6O
CR401 MMBD914L
R401 1.00K 1% 125mW
U401 PCF8593TD
4=GND
C401 10PF 100V
Y401 32.768KHZ
CR402 MMBD914L
B411 DL2450 3.0V
L211 22UHY
CR211 CXSH-4
CR212 CXSH-4
+BAT +5VEXT +5V
R211 100K 1% 125mW
R311 150K 1% 125mW
C312 68UF 6.3V
R170 1.00M 1% 125mW
U311 LT1304
VIN SW LBI SENSE IUM SHDN LBO GND
LO BAT'
R313 68.1K 1% 125mW
R312 22.1K 1% 125mW
C311 68UF 6.3V
C313 68UF 6.3V
C315 68UF 6.3V
C316 68UF 6.3V
C314 68UF 6.3V
P4 -6
T321 4275-083
7=GND,8=GND
400T 800T
P3 -3 VOLUME
C221 47UF 10V
R321 1.00K 1% 125mW
P4 -5 P4 -4 P4 -3 P4 -2 P4 -1
CLICK
Q211 2N7002L
UPDATED
DR CKB 04-FEB-97
CHK 3-14-97
DSGN RSS 22-FEB-96
APPD JGW 3-14-97
NEXT HIGHER ASSY.
16:06:13 5-Mar-97
LUDLUM MEASUREMENTS INC.
TITLE: PROCESSOR BOARD
BOARD# 5390-171
SIZE C MODEL 2360 SERIES 390 SHEET 173
SB390171 SHEET 1 OF 1

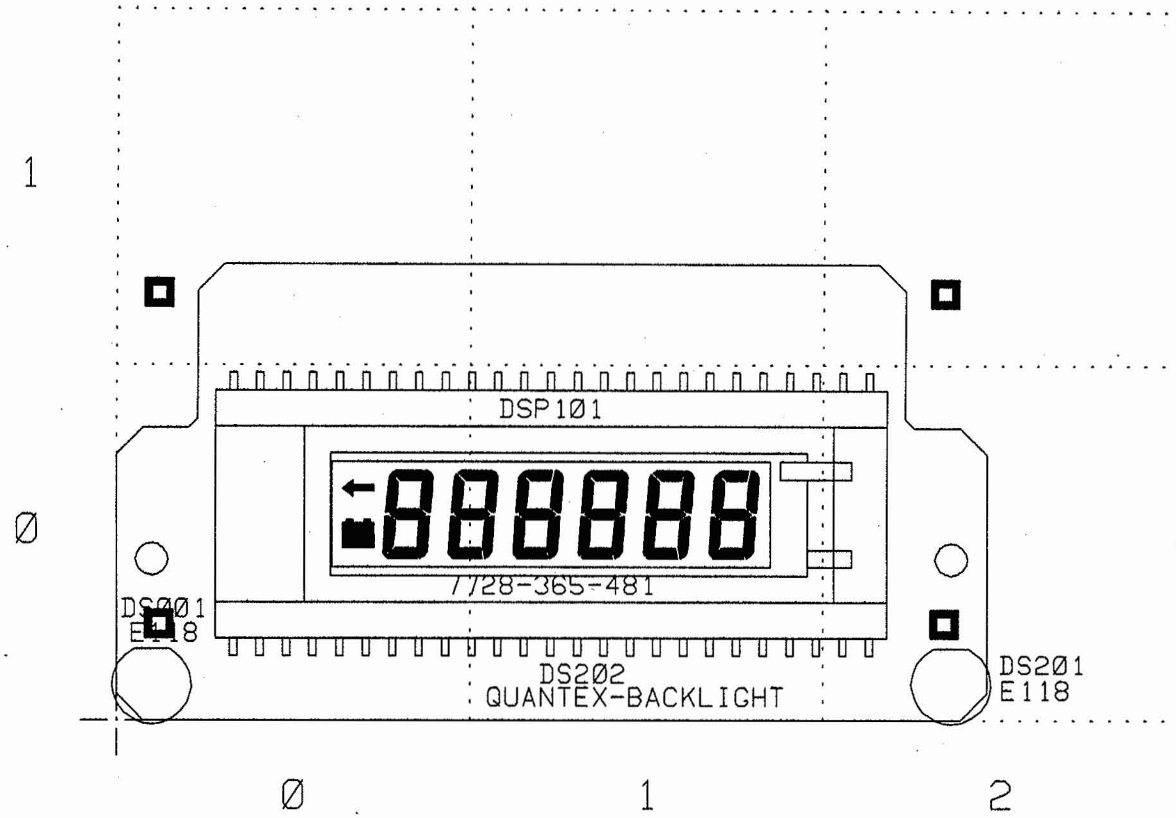


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR CKB	04-FEB-97	TITLE: PROCESSOR BOARD	
CHK BSS	3-14-97	BOARD# 5390-171	BS390171
DSGN RSS	22-FEB-96	MODEL 2360	SERIES 390 SHEET 174
APP JGW	3-14-97	COMP ARTWORK ☐	SLDR ARTWORK ☐
16:50:03	5-Mar-97	COMP OUTLINE ☒	SLDR OUTLINE ☐
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



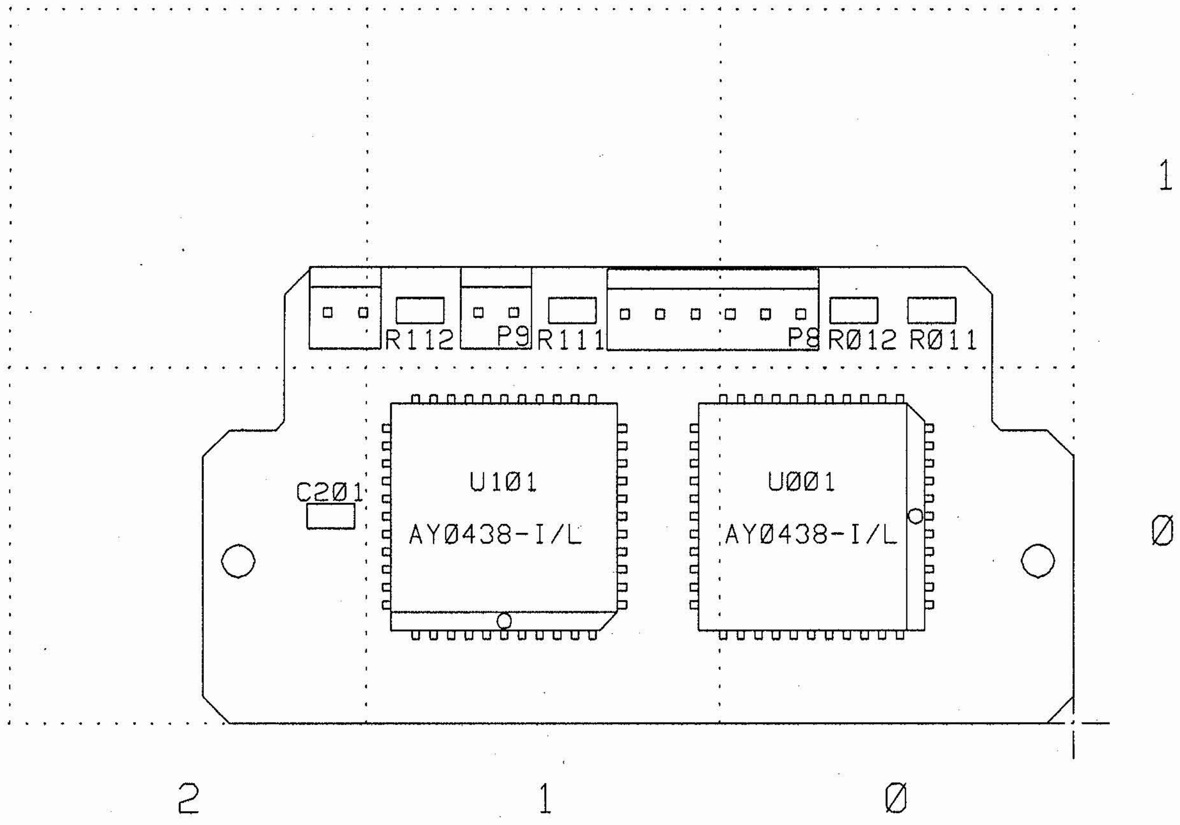
UPDATED	-	LUDLUM MEASUREMENTS INC.
DR CKB	11-APR-00	TITLE: LCD DISPLAY BOARD
CHK P.W.	4-27-00	
DSGN RSS	03-05-96	BOARD# 5390-170
APPD RS	4-28-00	SIZE C · MODEL 2360 · SERIES 390 · SHEET 170
NEXT HIGHER ASSY.		
16:27:09	11-Apr-00	SB390170 · SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.

DR	CKB	12/12/96	TITLE: LCD DISPLAY BOARDS
CHK	*[signature]*	*4-28-00*	BOARD: 539Ø-17Ø
DSGN	RSS	Ø5/31/96	MODEL: 236Ø
APP	*RSS*	*4-28-00*	FILENAME: BS39Ø17Ø
			1Ø:53:32 28-Apr-ØØ

COMPONENT		SOLDER		REVISION	SERIES	SHEET
OUTLINE		OUTLINE		1.Ø	39Ø	171

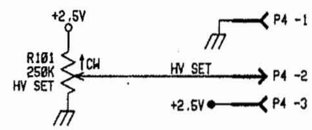


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.

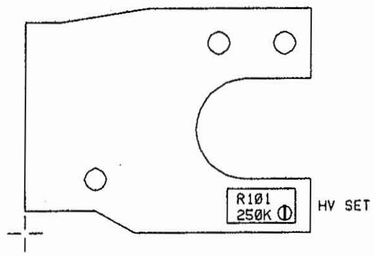
DR CKB	12/12/96	TITLE: LCD DISPLAY BOARD		
CHK P.W.	4-27-00	BOARD# 539Ø-170		
DSGN RSS	Ø5/31/96	MODEL 236Ø	SERIES 39Ø	SHEET 171
APP BS	4-28-00	COMP ARTWORK ☐	SLDR ARTWORK ☐	
		COMP OUTLINE ☐	SLDR OUTLINE ☒	

COMP PASTE ☐ COMP MASK ☐ SLDR PASTE ☐ SLDR MASK ☐

				REVISIONS		
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED

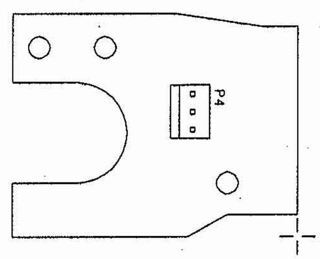


UPDATED -	/ /	LUDLUM MEASUREMENTS INC.
DR CKB	12/14/96	TITLE: CALIBRATION BOARD
CHK RSS	3/14/97	
DSGN RSS	12/14/96	BOARD# 5390-172
APPD JGW	3/14/97	SIZE D · MODEL 2360 · SERIES 390 · SHEET 176
NEXT HIGHER ASSY. -		
13:49:27	16-Dec-96	S8390172 · SHEET 1 OF 1



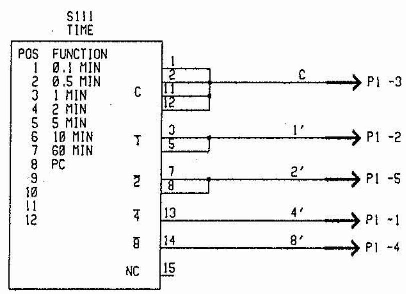
X

LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR CKB	12/14/96	TITLE: CALIBRATION BOARD	
CHK RSS	3-14-97	BOARD# 5390-172	BS390172
DSGN RSS	12/14/96	MODEL 2360	SERIES 390 SHEET 177
APP JGW	3-14-97	COMP ARTWORK ☐	SLDR ARTWORK ☐
08:58:22	5-Mar-97	COMP OUTLINE ☒	SLDR OUTLINE ☐
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐

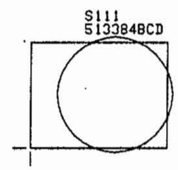


LUDLUM MEASUREMENTS INC. SWEETWATER, TX.					
DR CKB	12/14/96	TITLE: CALIBRATION BOARD			
CHK TS	3-14-97	BOARD# 5390-172		BS390104	
DSGN RSS	12/14/96	MODEL 2224-1	SERIES 390	SHEET 177	
APP JGN	3-14-97	COMP ARTWORK ☐		SLDR ARTWORK ☐	
09:38:12	20-Nov-96	COMP OUTLINE ☐		SLDR OUTLINE ☐	
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐		

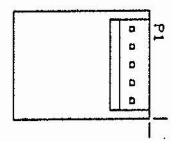
REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



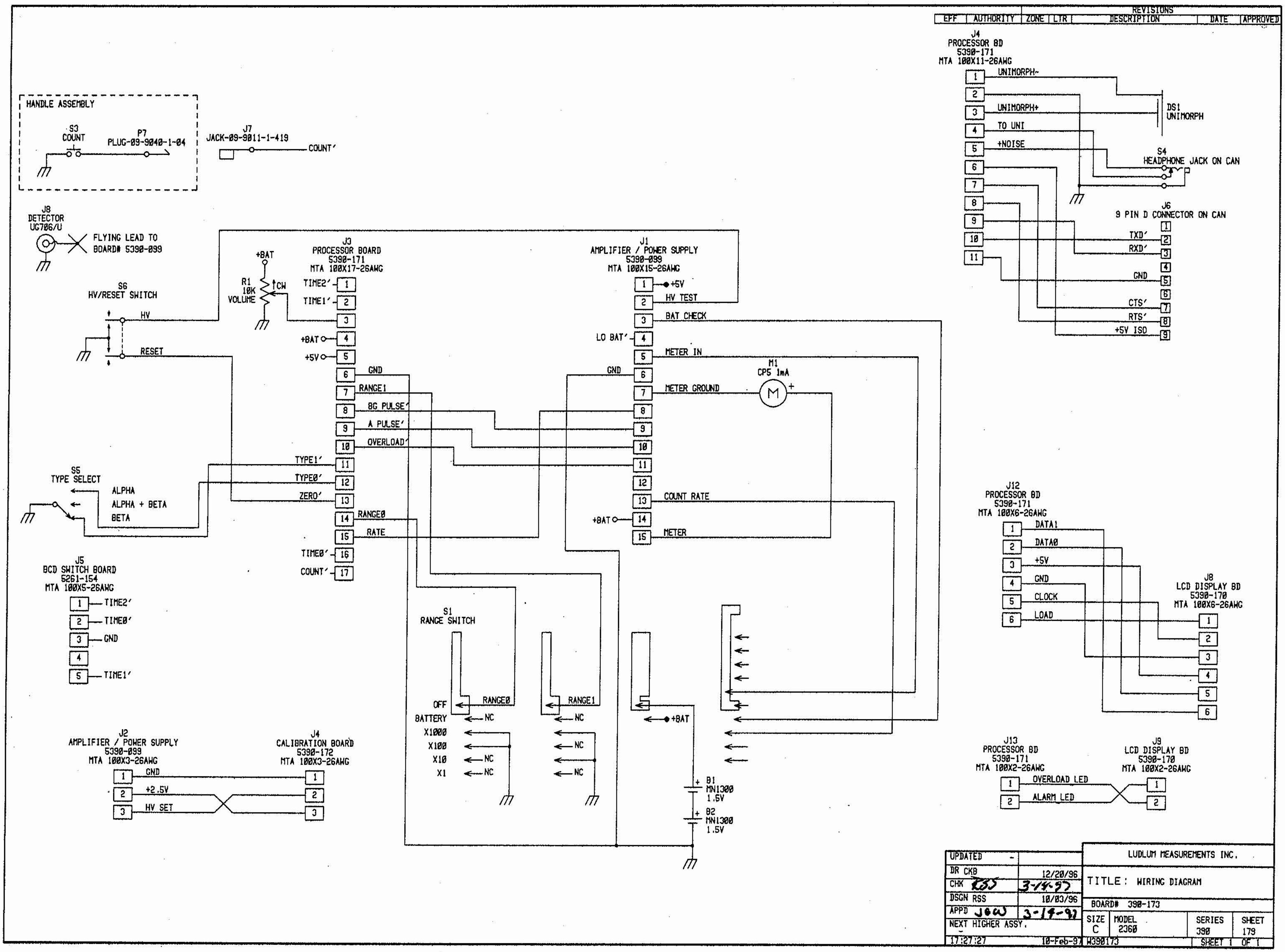
UPDATED -	/ /	LUDLUM MEASUREMENTS INC.
DR PW	10/30/96	TITLE: BCD BOARD
CHK R.C.	11/27/96	
DSGN PW	10/30/96	BOARD# 5261-154
APPD [illegible]	27 [illegible] 96	SIZE C · MODEL 2360 · SERIES 261 · SHEET 107
NEXT HIGHER ASSY.		
13:50:47	20-Nov-96	S8261154 · SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.				
DR PW	10/30/96	TITLE: BCD BOARD		
CHK R.C.	11 27 96	BOARD# 5261-154		BS261154
DSGN PW	10/30/96	MODEL 2360	SERIES 261	SHEET 105
APP	27Nov96	COMP ARTWORK ☐	SLDR ARTWORK ☐	
10:48:12	20-Nov-96	COMP OUTLINE ☒	SLDR OUTLINE ☐	
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐	



LUDLUM MEASUREMENTS INC.		SWEETWATER, TX.		
DR PW	10/30/96	TITLE: BCD BOARD		
CHK R.C.	11 27 96	BOARD# 5261-154	FILE	
DSCN PW	10/30/96	MODEL 2360	SERIES 261	SHEET 105
APP [illegible]	[illegible]	COMP ARTWORK ☐	SLDR ARTWORK ☐	
00/00/00	00/00/00	COMP OUTLINE ☐	SLDR OUTLINE ☒	
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐	


REVISIONS
EFF | AUTHORITY | ZONE | LTR | DESCRIPTION | DATE | APPROVED
HANDLE ASSEMBLY
S3 COUNT
P7 PLUG-09-9040-1-04
J7 JACK-09-9011-1-419
COUNT'
J8 DETECTOR UG706/U
FLYING LEAD TO BOARD# 5390-099
S6 HV/RESET SWITCH
HV
RESET
+BAT
R1 10K VOLUME
CW
J3 PROCESSOR BOARD 5390-171 MTA 100X17-26AWG
TIME2'
TIME1'
+BAT
+5V
GND
RANGE1
BG PULSE'
A PULSE'
OVERLOAD'
TYPE1'
TYPE0'
ZERO'
RANGE0
RATE
TIME0'
COUNT'
S5 TYPE SELECT
ALPHA
ALPHA + BETA
BETA
J1 AMPLIFIER / POWER SUPPLY 5390-099 MTA 100X15-26AWG
+5V
HV TEST
BAT CHECK
LO BAT'
METER IN
GND
METER GROUND
COUNT RATE
+BAT
METER
M1 CP5 1mA
J4 PROCESSOR BD 5390-171 MTA 100X11-26AWG
UNIMORPH-
UNIMORPH+
TO UNI
+NOISE
DS1 UNIMORPH
S4 HEADPHONE JACK ON CAN
J6 9 PIN D CONNECTOR ON CAN
TXD'
RXD'
GND
CTS'
RTS'
+5V ISO
J12 PROCESSOR BD 5390-171 MTA 100X6-26AWG
DATA1
DATA0
+5V
GND
CLOCK
LOAD
J8 LCD DISPLAY BD 5390-170 MTA 100X6-26AWG
J5 BCD SWITCH BOARD 5261-154 MTA 100X5-26AWG
TIME2'
TIME0'
GND
TIME1'
S1 RANGE SWITCH
OFF
BATTERY
X1000
X100
X10
X1
RANGE0
RANGE1
NC
+BAT
B1 MN1300 1.5V
B2 MN1300 1.5V
J2 AMPLIFIER / POWER SUPPLY 5390-099 MTA 100X3-26AWG
GND
+2.5V
HV SET
J4 CALIBRATION BOARD 5390-172 MTA 100X3-26AWG
J13 PROCESSOR BD 5390-171 MTA 100X2-26AWG
OVERLOAD LED
ALARM LED
J9 LCD DISPLAY BD 5390-170 MTA 100X2-26AWG
UPDATED
DR CKB 12/20/96
CHK RSS 3-14-97
DSGN RSS 10/03/96
APPD JCW 3-14-97
NEXT HIGHER ASSY.
17:27:27 10-Feb-97
LUDLUM MEASUREMENTS INC.
TITLE: WIRING DIAGRAM
BOARD# 390-173
SIZE C
MODEL 2360
SERIES 390
SHEET 179
W390173
SHEET 1 OF 1