LUDLUM MODEL 2200
SCALER RATEMETER

November 2020

Serial No. 185785 and Succeeding

Serial Numbers

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

STATEMENT OF WARRANTY

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

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

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

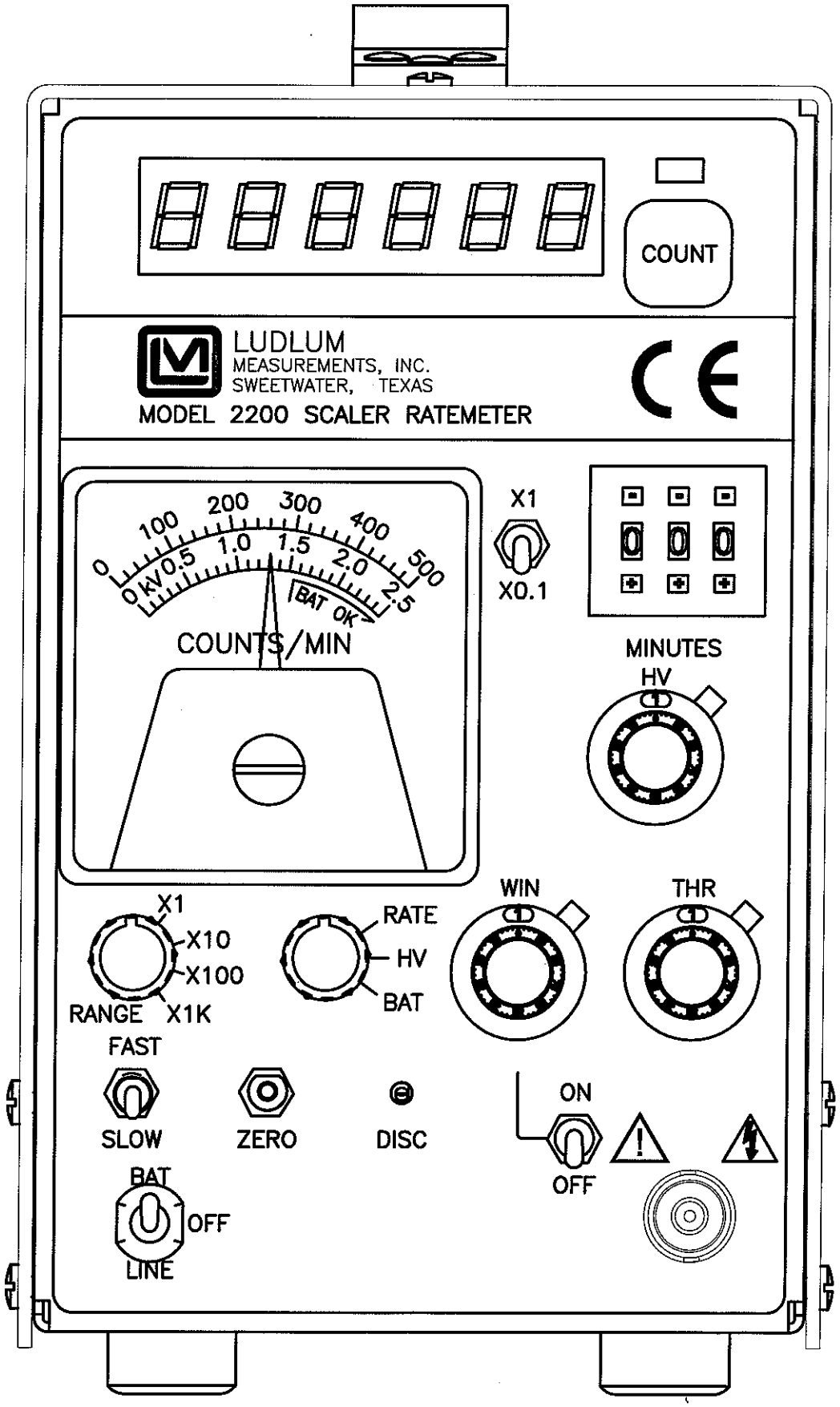
RETURN OF GOODS TO MANUFACTURER

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

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

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

REV #	ALTERATIONS	DATE	BY
1	VALID	7-3-01	BAB
2	RELOCATED 'CE' MARK	4-2-05	CMC



DWN	DATE	CHECKED	APPROVED
CMC	4-2-05		JGW 4-9-05

TITLE: MODEL 2200 FRONT PANEL

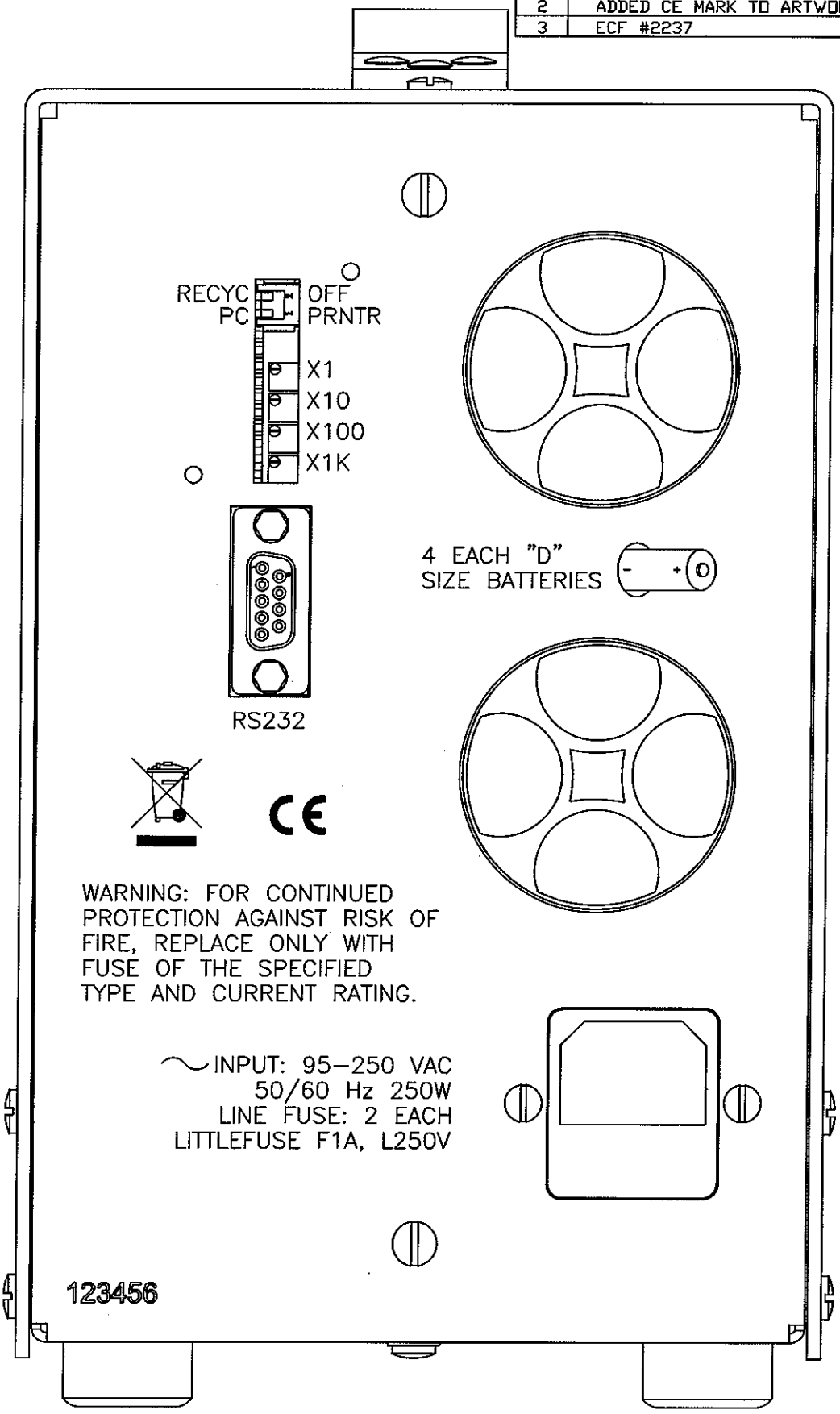
LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 167

SHEET 338

VF

REV #	ALTERATIONS	DATE	BY
1	VALID	07-16-04	CLW
2	ADDED CE MARK TO ARTWORK	3-30-05	CMC
3	ECF #2237	10/03/07	PW



DWN	DATE	CHECKED	APPROVED
PW	10/03/07		

TITLE: M 2200 REAR PANEL

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

SERIES	SHEET
167	417

Table of Contents

Section 1

Introduction

The Model 2200 Scaler Ratemeter is a self-contained counting instrument designed for operation with scintillation, proportional, or GM (Geiger Muller) detectors. Counting information is displayed both as a scaler count on the LED (light-emitting diode) display and as an averaged count rate on the analog scaler.

The instrument can be powered by 95-250 Vac, 50-60 Hz, or by four "D" cell batteries. The unit is complete with a voltage-sensitive preamplifier, linear amplifier, electronic timer, and detector high-voltage power supply. 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 window counting. Ten-turn potentiometers are supplied for threshold, window, and high-voltage controls.

An RS-232 serial port is provided, which can be attached to a computer or optional printer. A computer interface cable and software is provided to start/stop and record counts.

Section 2

Specifications

Meter: 1 mA, 6.4 cm (2.5 in.) scale, self-shielded DC mechanism

Ratemeter: four-decade, linear ratemeter with ranges of 0-500; 0-5000; 0-50,000; and 0-500,000 cpm (counts per minute); 6.4 cm (2.5 in.) scale panel meter; separate scales for battery check and high-voltage readout

Ratemeter Accuracy: within 10% of reference value

Scaler: a six-digit, LED readout

Scaler Accuracy: within 2% of reference value

Input Sensitivity: voltage-sensitive for use with all types of detectors – proportional, GM, scintillator

High Voltage: adjustable with a 10-turn control from 200-2500 V; supports 60 megohm scintillation loads to 1500 V

Time: time base is normally in minutes from 0-999 with multiples of X0.1 and X1. (Optional: Instrument can be switched to a seconds time base by switching the internal dipswitch SW1 "2" to the ON position. In this case, the count time may be set to 0-999 seconds with a multiplier switch of X1 and X10.)

Timer Accuracy: time base for the scaler is crystal-controlled and has a timer accuracy of ±0.2% of the thumbswitch setting

Response Time: in fast position, 4 seconds; in slow position, 22 seconds, for 10-90% of full-scale deflection

Input Connection: series "C" coaxial connector; other connectors are available upon request

Line Power: 95-250 Vac, 50-60 Hz single phase

Batteries: four "D" cells with typical life of 120 hours; self-contained in the instrument

Temperature Range: -20 to 50 °C (-4 to 122 °F); may be certified to operate from -40 to 65 °C (-40 to 150 °F)

Size: 21.6 x 12.7 x 21.6 cm (8.5 x 5 x 8.5 in.) (H x W x L), excluding handle

Weight: 3.4 kg (7.5 lb), including battery

Finish: beige powder coat with sub-surface printed front panel

Section 3

Description of Controls and Functions

Front Panel

COUNT LAMP: a red LED, indicating that the scaler is in the count cycle.

COUNT SWITCH: resets and starts the scaler counting. The scaler turns off at the end of the preset time.

COUNT TIME: Time base is normally in minutes from 0-999 with multiples of X0.1 and X1. It may be changed to seconds by an internal dipswitch.

MINUTES: a three-decade thumbwheel switch used for presetting count time.

Ratemeter Function Selector: a three-position switch labeled RATE, HV, and BAT. The function of this switch is to allow the operator to have ratemeter readout on the meter, HV readout on the meter, or battery check status on the meter.

THRESHOLD: A 10-turn potentiometer is used to set the basic pulse discrimination point of the scaler. This control is linear in the range of 1.00 through 10.00. If set below 1.00, in addition to non-linearities, the system noise can cause errors.

WINDOW: a 10-turn potentiometer used for adjusting the window width. It is calibrated with the THRESHOLD control so that one turn of the window control is equivalent to one turn of the THRESHOLD control.

WINDOW ON-OFF: a toggle switch allowing insertion (ON) or removal (OFF) of the window.

Detector Input Connection: a series "C" coaxial connector; other connectors are available upon request.

DISCR: a one-turn potentiometer for setting the range of the threshold potentiometer. It is a non-indicating control, allowing a wide selection of operating points without exceeding the linear ranges of the threshold/window circuits or detector voltage rating. Maximum amplifier sensitivity occurs at maximum clockwise setting.

RANGE Selector Switch: a four-position switch providing range multipliers of X1, X10, and X1K. With a scale of 0-500 cpm, the full range of the instrument is 0-500,00 cpm.

ZERO Switch: When depressed, this switch discharges the integrating capacitor, driving the meter to zero.

F-S Response: a two-position toggle switch indicating fast or slow response. In "F" position, the meter will deflect from 10 to 90% of full scale in 4 seconds. In "S" potion, the meter will deflect from 10 to 90% of full scale in 22 seconds.

HV: a 10-turn potentiometer control for adjusting HV from 200 V to 2500 V. It provides a linear adjustment of the detector voltage supply. Changing the detector voltage will cause the detector gain to change. A linear change in voltage will cause an exponential change in detector gain. The instrument will support 100 megohm scintillation loads to 1500 V.

RATEMETER: a four-decade linear meter with ranges of 0-500, 0-5000, 0-50,000, and 0-500,000 cpm. Readout is on a 6.4 cm (2.5 in.) scale panel meter. Separate scales are for battery check and high-voltage readout in conjunction with the Rate, HV, and Bat Switch.

Count Readout: a six-decade, LED readout indicating the count.

Rear Panel

RS-232 Connector: a 9-pin "D" connector, allowing computer or printer output.

RS-232 Data Dipswitch: two-pole dipswitch located on the rear chassis underneath the calibration cover; controls the RS-232 data. The top switch, labeled "PC" and "PRNTR," controls the type of data. In PC mode, data is bi-directional, allowing the computer to start/stop counting. If the dipswitch is set to PC, and the pushwheels are set to all zeroes, the instrument count time can also be changed by the computer through the RS-232 port. In the PRNTR mode, the scaler count is output at the end of each count only. If the dipswitch is set to PRNTR, setting the pushwheels to 000 sets the count time to infinity, allowing for very long count times. The bottom dipswitch, marked "RECYCLE" and "OFF," allows counting to recycle instead of requiring a manual count for each cycle.

Input Power: a receptacle for 95-250 Vac, 50-60 Hz line cord.

Battery Compartment: holds four "D" cell batteries.

Internal Controls

Ratemeter Calibration Controls: four potentiometers used to calibrate the ratemeter. Each range control is labeled respectively to the ratemeter range switch on the front panel.

Time base Dipswitch: two-pole dipswitch located on the main circuit board. It allows for selection of a seconds time base, variable from 0 to 999 seconds, with a multiplier switch of X1 and X10.

Section 4

Safety Considerations and Warning Markings

Environmental Conditions for Normal Use

Indoor use only

No maximum altitude

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

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

Mains supply voltage range 95-250 Vac

Maximum transient voltage of 1500 Vac

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

Pollution Degree 2 (as defined by IEC 644)

Cleaning Instructions and Precautions

The Model 2200 may be cleaned externally with a damp cloth, using only water as the wetting agent. Do not immerse the instrument in any liquid. Observe the following precautions when cleaning:

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

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

Warning Markings and Symbols

Caution!

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

Caution!

Verify instrument voltage input rating before connecting to a power converter. If the wrong power converter is used, the instrument and/or power converter could be damaged.

The Model 2200 is marked with the following symbols:

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

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

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

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

Warning!

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

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

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. See section 8, "Recycling" for further information. Also displayed on the side panel.

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

Replacement of Fuses

Warning!

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

Return for Repair or Calibration

To return an instrument for repair or calibration, provide sufficient packing material to prevent damage during shipment.

Every returned instrument must be accompanied by an **Instrument Return Form**, which can be downloaded from the Ludlum website at www.ludlums.com. Find the form by clicking the "Support" tab and selecting "Repair and Calibration" from the drop-down menu. Then choose the appropriate Repair and Calibration division where you will find a link to the form.

Note:

Ludlum Measurements, Inc. recommends recalibration at intervals no greater than one year, assuming that regular operational checks are performed. Check the appropriate local, state, and federal regulations to determine required recalibration intervals.

Section 5

Operating Procedures

Power

Select either line or battery operation with the power switch.

Line Operation: Connect the instrument to line power of 95-250 Vac, 50-60 Hz. Turn the power switch to LINE and proceed to use the instrument.

Battery Operation: The battery lids are located at the rear of the instrument. Use a coin or screwdriver to open the lids. Place 4 "D" cells in the instrument with the terminal "buttons" (positive ends) facing out. Turn the power switch to BAT to operate. Check the battery condition by placing the RATE-HV-BAT selector to BAT. (A downscale reading indicates battery reversal.)

Operational Check: Determine that the instrument is operational by pressing COUNT. The count lamp should illuminate. (This action starts the scaler count.)

DISCR and THRESHOLD Settings

The instrument DISCR control is calibrated at the factory so that 1.00 on the threshold dial is equal to a 10 mV input sensitivity. The DISCR control should not be changed unless a pulser is available to determine the threshold-versus-millivolt relationship.

The threshold control should not be set below 1.00. Excessive counting may occur at lower threshold settings.

Set DISCR and THRESHOLD for appropriate detector.

For scintillation detectors:

- Set THRESHOLD on 1.00.
- Connect scaler to pulser.
- Set pulser pulse height at 10 mV.

- Adjust DISCR until scaler meter reaches 75% of generated, incoming count rate. The input sensitivity is now set for 10 mV with THRESHOLD set for 1.00.

- Proceed to use instrument with THRESHOLD setting at 1.00 or more.

For Geiger Mueller (GM) detectors:

- Set the THRESHOLD and the pulser as in the first three steps for scintillation detectors.

- Disconnect pulser and set the THRESHOLD on 3.00 and proceed to use the instrument. The input sensitivity is approximately 30 mV. At settings less than this, double-pulsing may occur. Some GM tubes may require even higher settings of 7.00 or 8.00.

For proportional detectors:

- Set the THRESHOLD on 1.00.

- Connect the scaler to the pulser.

- Set the pulser pulse height at 2 mV.

- Adjust the DISCR until the scaler meter reaches 75% of the generated incoming count rate. The input sensitivity is now set for 2 mV with the THRESHOLD SET ON 1.00.

- Proceed to use instrument with THRESHOLD setting at 1.00 or more.

Operating Point

The instrument and detector operating point is established by setting the probe voltage (HV) and instrument sensitivity (DISCR and THRESHOLD). Efficiency, background, and noise for a given detector system 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 GM detector, a minimum operating voltage is required to establish the GM 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).

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 (HV), THRESHOLD control or DISCR (amplifier gain).

Determining Instrument Plateau

- Set window ON-OFF at OFF.
- Set the time multiplier toggle switch to X0.1 and the MINUTES thumbwheel switch to 001. This gives a 0.1 minute count.
- Set THRESHOLD control at 1.0.
- With the detector shielded from the source, adjust the high-voltage control by 100-volt increments and take a plot of HV-versus-background coutn rate until the detector voltage rating is reached. Return the HV control to zero.

  Note: If the detector voltage is reached before any background counts are detected, turn the DISCR clockwise to increase the sensitivity.
- Expose the detector to a source and again make a plot of count-versus-voltage.
- Plot both sets of data and select the operating point to correspond with the 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 the background count is irrelevant, shift the operating point to the plateau center for greater stability.

Operating the Instrument

Ensure that all settings and adjustments have been properly made. Proceed to use the instrument.

Section 6

Window Operation and Energy Calibration Procedures

General

The Model 2200 is calibrated at the factory so that one turn on the THRESHOLD controls is equal to one turn on the window dial.

Equipment Required

- Detectors capable of energy discrimination. Examples used are the Ludlum Models 44-3 and 44-2.
- Known gamma radiation sources. Typical sources are ^{137}Cs (662 keV) and ^{241}Am (60 keV).

Procedures to Calibrate Threshold to 10 keV/Turn

Initial Model 2200 control settings

- Window ON-OFF switch at OFF
- Ratemeter RANGE selector switch at X10
- THRESHOLD dial at 5.50
- WINDOW dial at 1.00
- HV dial at 0.00

Turn-on

- Connect the Model 44-3 detector to the instrument.
- Turn the power switch to the appropriate power supply.

Operation and Calibration

- Expose ^{241}Am to the detector.
- Increase the HV setting until the count from the source just starts to count.

- Switch the window ON-OFF to ON.
- Increase the HV until the source peaks on the ratemeter. Increase the range switch as needed to prevent the meter from exceeding full scale.
- The THRESHOLD dial is now calibrated to 10 keV/turn. The WINDOW control may be widened or narrowed without affecting the THRESHOLD setting. (As now calibrated, the instrument will respond only to radiation energies between 55 keV and 65 keV. Adjust the THRESHOLD dial for other energies of interest.

Procedures to Calibrate Threshold to 100 keV/Turn

Initial Model 2200 control settings:

- Switch the window ON-OFF to OFF.
- Ratemeter RANGE selector switch at X10.
- THRESHOLD dial is at 6.42.
- WINDOW dial is at 0.40.
- HV dial is at 0.00.
- Connect the Model 44-2 detector to the instrument.
- Turn the power switch to the appropriate power supply.

Operation and Calibration

- Expose ^{137}Cs to detector.
- Increase HV setting until count from source just starts to count.
- Switch window ON-OFF to ON.
- Increase HV until source peaks on ratemeter. Increase RANGE switch as needed to prevent meter from exceeding full scale.
- THRESHOLD dial is now calibrated to 100 keV/Turn. The WINDOW control may be widened or narrowed without affecting the threshold setting. (As now calibrated, the instrument will respond only to radiation energies between 642 keV and 682 keV. Adjust THRESHOLD dial for other energies of interest.)

Section 7

Data Output

General

The Model 2200 RS-232 serial port can be connected to a computer or printer for data-logging of the scaler count information. Windows™-based software and cable are supplied with the instrument. The computer software can control the count time, start and stop counting, time/data stamp data, and print or save data. An optional printer may also be purchased to print each scaler reading.

The two-pole dipswitch on the rear chassis underneath the calibration cover controls the RS-232 data. The top switch, labeled "PC" and "PRNTR," controls the type of data. In PC mode, data is bi-directional, allowing the computer to start/stop counting. In the PC mode, the count time can also be changed by the computer, but only if the count time push-wheels are set to 000. In the PRNTR mode, the scaler count is output at the end of each count only. The bottom dipswitch, marked "RECYCLE" and "OFF," allows counting to recycle instead of requiring a manual push of the COUNT button for each cycle. This mode is useful with the optional printer for taking many separate counts.

Software

Prior to Installation of Software:
Ensure both the computer and the Model 2200 are turned off.

Connect one end of the supplied RS-232 cable to the Model 2200 and connect the other end of the cable to any unused serial port on the back of the computer. (This unused port should be labeled COM1, COM2, COM3, or COM4.)

To Install Software:

1. Insert LMI Model 2200 software CD into the CDROM drive. Setup will automatically start. If it does not, double-click on the "setup.exe" file located on the CD.

2. The program will be installed to "C:\Program Files\m2200." An icon in the start menu is created under Start/Programs/Ludlum Measurements, Inc./Model 2200.

3. Prior to running the program, ensure that the Model 2200 is in the PC mode, and the count time push-wheels are set to 000.

Button Functions

Start/Stop Count: Click on this button to start a count. Clicking on it again will hold the count. The Model 2200 automatically sends the final count to the computer when the count time expires.

Read Count: Click on this button to read the current count as displayed on the Model 2200 display.

Set Count Time: Click on this button to set the count time. The count tiem push-wheels must be set to 000 for this to work.

Read Count Time Left: Click on this button to read the remaining count time left during a timed count. If a count is not in progress, this returns "0."

Start Logging/Stop Logging: Click on this button to start taking a series of time counts. The number of counts taken can be adjusted to continuous, 10 counts, 100 counts, 200 counts or a user-defined value. After the logging has been stopped, the data may be saved to a comma-delimited file or printed to a printer. A temporary file called "grid.dat" is created when logging is started. The format for the file is a comma-delimited text file.

If the program is closed before the Save of Print button is used, the data can be retrieved from this file.

Log 1 Count: logs only one count.

Save: Click on this button to save the logged data to a comma delimited file for import into a spreadsheet or database program.

Print: Click on this button to print the logged data to printer.

Append Data: When checked, data is appended to the table, and when unchecked, the table is cleared when the "Start Logging" or "Log 1 Count" buttons are pressed.

Comment 1/Comment 2: two user-defined fields that can be used to store comments. These fields are 20 characters in length.

RS-232 Parameters

Baud Rate: 2400
Data Bits: 8
Parity: N
Stop Bit: 1

All set commands must be terminated with a linefeed character. Commands will also work with a carriage return and line feed. Commands that require parameters must be padded with zeros so the command will be the correct length. Commands must be in upper-case.

Set commands return OK [CR][LF] if the command was received correctly by the Model 2200. If the command is not recognized, the Model 2200 will return ERROR-XX[CR][LF]. "XX" indicates the first two characters of the command have been received.

Set Commands

CMD SC: Set Count Time. The Model 2200 must be in PC mode, and the count time push-wheel switches must be set to "000" for this count time to be used. The count time can be adjusted from 0 to 65535, which corresponds to 0 (infinite) to 6553.5 minutes. The multiplier switch has no effect on the count time set with the SC command.

Format: SCnnnnnn[CR][LF]

CMD SO: Start a scaler count that will automatically output the results when the count time expires. Sending the **SO** command while a count is in progress will stop the current count. The returned format is the same as the **RS** command. The **RS** command can be sent while the Model 2200 is counting to read the current scaler count without having to wait for the count to complete.

Format: SO[CR][LF]
Return: nnnnnn[CR][LF]

CMD SS: Start a normal scaler count. Count result must be returned with **RS** command. Sending the **SS** command while a count is in progress will stop the current count. The **RS** command can be sent while the Model 2200 is counting to read the current scaler count without having to wait for the count to complete.

Format: SS[CR][LF]

Read Commands

CMD RC: Read Count Time. If the push-wheels are set to "001," the **RC** command will return 00010 with a multiplier of X1. If the multiplier is X0.1, then the return value would be 00001 minutes. If the push-wheels are set to "000" and the count time is set to 65535, the count time would be 6553.5 minutes.

Format: RC[CR][LF]
Return: nnnnn[CR][LF]

CMD RL: Read remaining count time. The output is the same as the **RC** command.

Format: RL[CR][LF]
Return: nnnnn[CR][LF]

CMD RM: Read count time base. 0=minutes, 1=seconds. The time base is normally in minutes from 0 to 999. Instrument can be switched to a seconds time base by switching the internal dip-switch SW1 "2" to the "ON" position. In this case, the count time is adjustable from 0 to 999 seconds with a multiplier switch of X1 and X10.

Format: RM[CR][LF]
Return: nnnnn[CR][LF]

CMD RS: Read current scaler count. The number returned is the same number displayed on the LED display.

Format: RS[CR][LF]
Return: nnnnnn[CR][LF]

HyperTerminal

HyperTerminal, which is usually installed in Windows 2000 XP, can be used to communicate with the Model 2200. The ASCII Setup under the connection properties must be changed to "Send line ends with line feeds" and "Echo typed characters locally."

Set PC count time to 1 minute:
SC00010
OK
RC
00010

Start count and automatically return count when time expires:
SO
OK
060000

Start count and monitor progress:
SO
OK
RS
000125
RL
00010
RS
001101
RL
0009
RS
004125
RL
0003
060000

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." This notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol will be placed near the AC receptacle, except for portable equipment where it will be placed on the battery lid.

Section 9 Parts List

	Reference	Description	Part Number
Model 2200 Scaler Ratemeter	UNIT	Completely Assembled Model 2200 Scaler Ratemeter	48-1651
Main Board, Drawing 167 x 413	BOARD	Assembled Board	5167-413
CRYSTAL	Y1	MICRO 6.144 MHZ	01-5262
CAPACITORS	C1-C3	100pf, 100V	04-5661
	C4	0.1µF, 50V	04-5663
	C5	100pf, 100V	04-5661
	C6-C7	0.01µF, 500V	04-5696
	C8	68µF, 10V	04-5654
	C9	1µF, 35V	04-5755
	C10-C11	0.02µF, 3kV	04-5704
	C12-C18	0.01µF, 500V	04-5696
	C19	10µF, 25V	04-5728
	C20	0.01µF, 500V	04-5696
	C21	0.001µF, 2kV	04-5703
	C22	0.0047µF, 100V	04-5669
	C23-C26	0.1µF, 50V	04-5663
	C27	0.0015µF, 100V	04-5680
	C28	22µF, 20V	04-5672
	C29	10µF, 25V	04-5728
	C31	10µF, 25V	04-5728
	C33	10µF, 25V	04-5728
	C34	68µF, 10V	04-5654
	C36	0.1µF, 50V	04-5663
	C37	10µF, 25V	04-5728
	C39-C40	37pF, 100V	04-5658
	C41-C44	1µF, 16V	04-5701
	C45	47µF, 10V	04-5666
	C46-C47	10µF, 25V	04-5728

	C48-C60	0.001µF, 2kV	04-5703
	C61	68µF, 10V	04-5654
	C63	10µF, 25V	04-5728
	C64-C65	0.1µF, 50V	04-5663

	Reference	Description	Part Number
TRANSISTORS	Q2	REG-LT1406KCS3	05-5867
	Q4	MAX810LEUR	06-6424
INTEGRATED CIRCUITS	U1-U2	LM358D	06-6312
	U3	CA3096M	06-6288
	U4	LT1304CS8-5	06-6434
	U5	CD74HC4538M	06-6297
	U6	LM828M5	06-6518
	U8	N87C51PA1	06-6286
	U9	MAX232D	06-6382
	U10	LT1304CS8	06-6394
DIODES	CR1-CR5	CMPD2004S	07-6402
	CR6-CR7	CMSH1-40M	07-6411
	CR8	MMBD914LT1	07-6353
	CR9	CMSH1-40M	07-6411
	CR12-CR17	CMPD2004S	07-6402
	CR18	CMSH1-40M	07-6411
	CR19-CR20	MMBD914LT1	07-6353
SWITCHES	SW1	90HBW08	08-6712
	SW2	A6ER-2101RA	08-6782
RESISTORS	R1-R2	800 MEG, 2%	12-7009
	R3	562k, 1/8W, 1%	12-7929
	R4-R5	100k, 1/8W, 1%	12-7834
	R6	1MEB, 1/8W, 1%	12-7844
	R7	22.1k, 1/8W, 1%	12-7843
	R9	100k, 1/8W, 1%	12-7834
	R10	365k, 1/8W, 1%	12-7049
	R11-R19	1k, 1/8W, 1%	12-7832
	R20	10k, 1/8W, 1%	12-7839
	R22	100k, 1/8W, 1%	12-7834
	R23	33.2k, 1/8W, 1%	12-7842
	R24	12.1k, 1/8W, 1%	12-7879
	R25	100OHM, 1/4W, 1%	12-7904
	R26	5K TRIMMER	09-6918
	R27	1MEG, 1/8W, 1%	12-7844
	R28	100k TRIMMER	09-6930
	R29	1k, 1/8W, 1%	12-7832

	R31	10k, 1/8W, 1%	12-7839
	Reference	Description	Part Number
	R32	100k TRIMMER	09-6823
	R33-R35	1MEG TRIMMER	09-6828
	R36	4.75k, 1/8W, 1%	12-7858
	R37	10OHM, 1W, 1%	12-7952
	R39-R40	33.2k, 1/8W, 1%	12-7842
	R45-R46	22.1k, 1/8W, 1%	12-7843
	R47	82.5k, 1/8W, 1%	12-7849
	R50-R51	4.75OHM, 1/8W, 1%	12-7980
INDUCTORS	L1-L2	22µH	21-9808
	L3	220µH	21-9678
TRANSFORMERS	T1	31032R	21-9925
CONNECTORS	P1	640445-3 MTA156	13-8125
	P2	640456-5 MTA100	13-8057
	P3	1-640456-1 MTA100	13-8059
	P4	640456-3 MTA100	13-8081
	P5	640456-6 MTA100	13-8095
	P6	1-640456-0 MTA100	13-8066
	P7	747020-2	13-8555
	P9	640456-6 MTA100	13-8095
MISCELLANEOUS	W1	TEFLON WIRE	21-9759

Amplifier Board, Drawing 167 x 392

	BOARD	Assembled Board	5167-382
CAPACITORS	C1	68µF, 6.3V	04-5654
	C2	10µF, 25V	04-5728
	C3	0.001µF, 3kV	04-5727
	C4	100pF, 100V	04-5661
	C5-C7	0.01µF, 50V	04-5664
	C8	10µF, 25V	04-5728
	C9-C10	0.01µF, 50V	04-5664
	C11-C12	47pF, 100V	04-5660
	C13	10µF, 25V	04-5728
	C14	0.1µF, 50V	04-5663
	C15-C17	27pF, 100V	04-5658

	Reference	Description	Part Number
	C18	0.1µF, 50V	04-5663
	C19-C20	10µF, 25V	04-5728
	C21	100pf, 100V	04-5661
	C22-C23	0.1µF, 50V	04-5663
TRANSISTORS	Q1	MMBT3904LT1	05-5841
	Q2	2N7002L	05-5840
RESISTORS	R2	100OHM, 1/8W, 1%	12-7840
	R3-R5	1k, 1/8W, 1%	12-7832
	R6-R8	100k, 1/8W, 1%	12-7834
	R9	5.62k, 1/8W, 1%	12-7871
	R10-R11	10k, 18W, 1%	12-7839
	R12-R13	22.1k, 1/8W, 1%	12-7843
	R14	12.1k, 1/8W, 1%	12-7879
	R15-R16	5.62k, 1/8W, 1%	12-7871
	R17	3.32k, 1/8W, 1%	12-7870
	R18	47.5k, 1/8W, 1%	12-7872
	R19-R25	10k, 1/8W, 1%	12-7839
	R26	100OHM, 1/8W, 1%	12-7840
	R27-R28	4.75k, 1/8W, 1%	12-7858
	R29	3.32k, 1/8W, 1%	12-7870
	R30-R31	500k TRIMMER	09-6904
	R32	15k, 1/8W, 1%	12-7998
	R33	10k TRIMMER	09-6822
	R34	5.62 1/8W, 1%	12-7871
INTEGRATED CIRCUITS	U1-U3	CA3096M	06-6288
	U5	TLC372ID	06-6290
	U6	CD74HC4538M	06-6297
	U7	TLC27M7ID	06-6292
DIODES	CR1-C2	MMBD914LT1	07-6353
	CR3	REG-LM385M3-2.5	05-5878
INDUCTORS	L1-L3	470µH	21-9699
CONNECTORS	P16	640456-6 MTA100	13-8095
	P17	640456-3 MTA100	13-8081
	P18	640456-7 MTA100	13-8115
MISCELLANEOUS	W1-W2	Coax Pigtail	8167-511
	W3	Wire	*

	Reference	Description	Part Number
Switch Board, Drawing 167 x 273	BOARD	Assembled Board	5167-336
CAPACITORS	C1	100µF, 10V, C	04-5576
RESISTORS	R1	10k TRIMMER	09-6787
SWITCHES	SW1	TT11DGPC9T	08-6769
	SW2	TP11LTCQE	08-6770
	SW3-SW4	56DP36-01-2-AJN	08-6766
CONNECTORS	P12	1-640456-1 MTA100	13-8059
	P13	640456-2 MTA100	13-8073
	P14	640456-3 MTA100	13-8081
Pushwheel Board, Drawing 167 x 264	BOARD	Assembled W/T/R Board	5167-333
CAPACITORS	C1-C3	0.001µF, 100V	04-5519
SWITCHES	SW1-SW3	SWITCH-3P3210P00	4167-504
CONNECTORS	P11	640456-8 MTA100	13-8039
Display Board, Drawing 167 x 276	BOARD	Assembled Display Board	5167-337
CAPACITORS	C1	47µF, 16V, C	04-5550
	C2-C5	0.001µF, 16V, C	04-5519
LED DISPLAYS	U1-U6	HDSP-E103	07-6342
	U7	MAX7219ENG	06-6443
DIODES	CR1	LED DISPLAY	07-6377
RESISTORS	R1-R4	22k, 1/4W, 5%	10-7070
	R5	47k, 1/3W, 5%	12-7758
SWITCHES	SW1	SCHURTER	08-6783
CONNECTORS	P15	640456-6 MTA100	13-8095

Wiring Diagram, Drawing 167 x 418

	Reference	Description	Part Number
SWITCHES	SW1	MTF206P	08-6780
	SW2-SW3	7101-SYZ-QE	08-6511
RESISTORS	R1-R3	10k, 10-TURN POT	09-6761
CONNECTORS	P7	747020-2 RS232	13-8555
	P20	UG706/U "C" LMI	4478-011
	J1	640428-3 MTA156	13-8124
	J2	640442-5 MTA100	13-8140
	J3	1-640442-1 MTA100	13-8137
	J4	640442-3 MTA100	13-8135
	J5	640442-6 MTA100	13-8171
	J6	1-640442-0 MTA100	13-8136
	J8	WIRE	*
	J9	640442-6 MTA100	13-8171
	J11	640442-8 MTA100	13-8184
	J12	1-640442-1 MTA100	13-8137
	J13	640442-2 MTA100	13-8178
	J14	640442-3 MTA100	13-8135
	J15-J16	640442-6 MTA100	13-8171
	J17	640442-3 MTA100	13-8135
	J18	640442-7 MTA100	13-8178
	J19	AC RECPTACLE W/ CORCOM FILTER	21-9830
MISCELLANEOUS	PS1	POWER SUPPLY	22-9321
	F1	3AG 1A FUSE	21-9704
	*	METER ASSY	4167-302
	M1	MODEL 2200 METER	15-8048
	B1-B4	BATTERY	21-9313
	W2	WIRE JUMPER	*
	W3	COAX CABLE	*
	2 EA.	BATTERY HOLDER	22-9388
	*	MAIN HARNESS	8167-376
	*	POWER HARNESS	8167-416
	*	METER HARNESS	8167-348
	*	PREAMP HARNESS	8167-419
	*	READOUT HARNESS	8167-374
	*	CALIBRATION COVER	9167-380
	*	HANDLE	21-9346
	*	*Belden* POWER CORD	21-9394
	*	CABLE "C"	40-1004

Appendix A – Calibration Procedure

WORKING COPY

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

CALIBRATION PROCEDURES

MODEL: 2200 **DIAL: 202-026** **DETECTOR: None**

Revision 6
Revised by: Julie Smith **Date:** 7-9-04
Approved by: [signature] **Date:** 9 Jul 04
Q/A Approval: [signature] **Date:** 12 JUL 04

Equipment Required

■ All instruments used in calibrating the M2200 must be calibrated by standards traceable to the National Institute of Standards and Technology and must have a current calibration label attached.

■ A Ludlum Model 500 Pulser or equivalent is required. If the Pulser does not have a high voltage readout, use a high impedance voltmeter with at least 1000 Megohm meter input resistance to adjust the detector voltage. (Instrument used to measure voltage must be capable of a range up to 2500 volts.)

Initial Calibration Procedures

■ If any calibration procedure cannot be completed satisfactorily, the instrument shall be tagged and removed for proper disposition.

☐ Perform mechanical checks on all knobs, dials, switches, and buttons. Ensure that the analog meter movement has proper mechanical zero. The adjustment is on the front of the meter bezel. It must be adjusted to "zero" with the Power Switch in the OFF position.

☐ Place Power Switch to LINE.

HV Meter Calibration

☐ Connect M2200 to the Pulser or a certified high impedance voltmeter.

☐ Place M2200 WINDOW OFF-ON switch to OFF.

☐ Rotate M2200 Ratemeter Function Selector Switch to HV.

☐ Set the M2200 HV adjust potentiometer for a reading of 1500 volts on the Pulser (or voltmeter). The M2200 analog meter should indicate 1.5 kV. If it does not, remove the M2200 cover and adjust R26 on the Main circuit board for a reading of 1.5 kV on the M2200 HV meter.

☐ Vary the M2200 HV adjust potentiometer until the M2200 analog meter indicates 0.5 kilovolts.

☐ The Pulser voltmeter should read 500 volts ±10%.

☐ Vary the M2200 HV adjust potentiometer until the M2200 analog meter indicates 2.0 kilovolts.

☐ The Pulser voltmeter should read 2000 volts ±10%.

☐ **SLOWLY** increase HV adjust potentiometer toward maximum position. HV should reach the limit at approximately 2500 volts. If it does not, adjust R28 on the Main circuit board for 2500 volts (maximum).

☐ Vary the M2200 HV adjust potentiometer until the M2200 analog meter indicates 0.9 kilovolts.

Input Sensitivity

☐ Connect the M2200 to the Pulser if a voltmeter was used in the previous step.

☐ Rotate M500 Pulse Polarity switch to the -NEG position, the AMPLITUDE control to the 50MV position, and the LO-HI control to 1 (10 millivolts [mV]).

☐ Rotate M2200 Ratemeter switch to RATE and the RANGE switch to X1K.

☐ Adjust Pulser MULTIPLIER, COARSE and FINE controls for a 400k cpm output.

☐ Rotate the M2200 THRESHOLD potentiometer to the 1 position in the window of the tumbler and zero on the graduated scale (10 mV). The M2200 analog meter should read 300 cpm (300k cpm). If it does not, adjust the DISC potentiometer until the analog meter reads 300k ±10% cpm.

Window Check

☐ Place the M2200 WINDOW OFF-ON switch to ON position and rotate the WINDOW potentiometer to the 1 position (10 mV).

☐ Slowly rotate Pulser AMPLITUDE LO-HI control clockwise. The M2200 analog meter should increase to 400k cpm and then drop back to approximately 300k cpm. At this point, the Pulser AMPLITUDE meter should read "2" ±10% (20 mV ±2 mV).

☐ Rotate M2200 WINDOW potentiometer to 2 (20 mV).

☐ Slowly rotate Pulser AMPLITUDE LO-HI control clockwise. The M2200 analog meter should increase to 400k cpm and then drop back to approximately 300k cpm. At this point, the Pulser AMPLITUDE meter should read "3" ±10% (30 mV ± 3mV).

☐ Place M2200 WINDOW OFF-ON switch to OFF.

Miscellaneous Checks

☐ Rotate M2200 Ratemeter Function switch to the BAT position and the Power Switch to BAT. The analog meter pointer should remain in BAT TEST area of the meter face as long as the Ratemeter Function switch is in the BAT position.

☐ Rotate Ratemeter Function switch to the RATE position and the Power Switch to LINE. Depress the M2200 ZERO pushbutton switch. The analog meter pointer should return to zero and remain there until the pushbutton is released.

☐ Rotate Pulser MULTIPLIER switch to 1K position. Rotate M2200 RANGE switch to 1K position. Adjust Pulser COARSE and FINE controls so that M2200 analog meter

pointer is deflected full-scale.

☐ Place the F-S switch in the F position. Depress the M2200 ZERO switch and determine the time required for the M2200 analog meter pointer to reach 90% of full-scale. It should be 4 ±10% seconds.

☐ Place the F-S switch in the S position. Depress the M2200 ZERO switch and determine the time required for the M2200 analog meter pointer to reach 90% of full-scale. It should be 22 ±10% seconds.

☐ Re-position the F-S switch in the F position for the remainder of this procedure.

Analog Range Calibration

■ Analog range calibration points are selected to be at approximately 20% (lower calibration point - LCP) and 80% (upper calibration point - UCP) of full-scale deflection on the analog meter dial. Table 1 provides the Range Multipliers, Reference Calibration Points, and the Linear Dial Readings for the following procedures.

TABLE 1

	Range Multi-plier	Reference Cal. Point	Instrument Dial Reading
UCP	X1K	400k cpm	400 cpm
LCP	X1K	100k cpm	≈100 cpm
UCP	X100	40k cpm	400 cpm
LCP	X100	10k cpm	≈100 cpm
UCP	X10	4k cpm	400 cpm
LCP	X10	1k cpm	≈100 cpm
UCP	X1	400 cpm	400 cpm
LCP	X1	100 cpm	≈100 cpm

☐ Adjust Pulser for a 400k cpm output.

☐ Rotate M2200 Range switch to the X1K position.

☐ The M2200 analog meter should indicate 400 (400k cpm). If it does not, remove the M2200 from the case and adjust the X1K potentiometer on the side of the instrument.

☐ Adjust Pulser controls for an output of 100k cpm.

☐ The M2200 analog meter should indicate 100 ±10% (100k cpm).

☐ Repeat the above procedures for the X100, X10, and X1 scales using the values in Table 1.

Digital Display Calibration

■ Table 2 provides the Reference Calibration Points, and the Digital Display Readings for the following procedures.

TABLE 2

Reference Cal. Point	Digital Display Reading
400k cpm	≈40000(0)
40k cpm	≈4000(0)
4k cpm	≈400(0)
400 cpm	40(0)
40 cpm	4(0) cpm

☐ Adjust Pulser for a 400k cpm output.

☐ Set the MINUTES switches to 001 (1 minute) and the Time multiplier switch to X0.1.

☐ Depress and then release the COUNT pushbutton switch.

☐ The M2200 digital display should read 40000 ±2% (due to 0.1 minute count time).

☐ Adjust Pulser controls for an output of 40k cpm.

☐ Depress and then release the COUNT pushbutton switch.

☐ The M2200 digital display should read 4000 ±2%.

☐ Repeat the above procedures for the remaining values in Table 2.

Appendix B – Electronics Checkout Procedure

WORKING COPY

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

CHECKOUT PROCEDURES

MODEL: 2200

17 Steps

Revision 6
Revised by: Kimberly Jones Date: 3-22-16
Approved by: [signature] Date: 22 March 16
Q/A Approval: Larry Hill Date: 22 mar 16

Equipment Required:

Ludlum Model 500 Pulser
Digital Multimeter
HV Meter - input impedance ≥ 1000 megohms (Pulser HV meter may be used with appropriate cable)
Oscilloscope
Low Voltage (≥ 5.5 Vdc @ 200 mA) Power Supply

Refer to the schematic and component layout diagrams in the Model 2200 Manual for the following:

I. 5167-413 Main Board

1. Visually inspect the board for solder bridges, unsoldered pins, etc. Install the microprocessor chip programmed with the correct firmware 167-01-Nxx, where "xx" is the current firmware version. Adjust the meter mechanical zero for "0," and ensure that the power switch is set to OFF. Make sure that both switches on the dipswitch SW1 are OFF (down) and the dipswitch SW2 on the back chassis is ON (to the right).

2. Set the low-voltage power supply to 6 volts, and attach the negative lead to chassis ground. Attach the positive lead to the upper battery tube at the connection close to the back chassis.

3. Turn the power switch to the BAT position, and verify that the current drain is less than 150 mA. The amount of current will depend primarily on the number of lit

LED segments and the high voltage setting. Check for +5 V ±0.25 Vdc at pin 8 of U4 LT1304CS8-5. Also check for +8 V ±0.25 Vdc at pin 2 of P2. Turn the low-voltage supply down to 4.4 Vdc ±0.25 Vdc and turn the RATE/HV/BAT switch to the BAT position and verify that the meter needle is on the BAT TEST line. Switch the power switch to the OFF position.

4. Connect the AC power cord to the power receptacle and turn the power switch to the LINE position. Verify the same voltages as in step 3.

5. Adjust the front-panel HV control to the maximum clockwise position (10.00). Select the HV position on the RATE/HV/BAT switch. Attach a high-voltage meter to the coaxial connector on the front of the instrument. Turn instrument on and adjust R28 for a high-voltage meter reading of 2500 Vdc. Adjust R26 for a full-scale reading on the Model 2200 meter of 2.5 kV. Adjust the front-panel HV control to 0.00, and confirm that the voltage does drop below 400 Vdc.

II. Display Board (Part Number 5167-337)

1. Confirm that all the LED segments and then the firmware version are displayed upon power-up, and that the red LED above the COUNT button is illuminated.

III. Amplifier Board (Part Number 5167-382)

1. Select the RATE position of the RATE/HV/BAT switch and switch the WINDOW ON/OFF toggle switch to the OFF position. Turn the threshold dial marked THR to 1.00. Set the count time to "010" minutes and the multiplier toggle switch to "x1."

2. Connect the Model 500 Pulser (or equivalent) to the detector input connector. Adjust the pulser amplitude for a 10 mV negative pulse. Adjust the pulser frequency for 40,000 cpm. With the Model 2200 on, press the COUNT switch, and adjust the discriminator control marked DISC on the front panel until the Model 2200 just starts to count. Rotate the THR and the WIN dials to the maximum clockwise (10.00) positions.

3. Connect a DC multimeter between pins 2 and 1 of P18 on the amplifier board. Measure the voltage; it should be approximately 2.5 Vdc. Connect the multimeter between pin 4 of P18 and pin 5, and adjust R33 until the voltage equals the voltage between pins 1 and 2 of P18.

4. Adjust the WIN and THR dials to 0.00, and switch the WIN toggle switch to the ON position. Measure and note the voltage between pin 3 of U5A and chassis ground. Connect the multimeter to pin 2 of U5A, and adjust R30 so that the voltage at pin 3 equals the voltage at pin 2. Perform the same procedure for pins 5 and 6 of U5B, adjusting the trimmer R31.

5. Switch the x1/x10/x100/x1K range multiplier switch to the x100 position and the F/S response switch to the F position. Switch the WIN toggle switch to the OFF position. With the THR dial set at 1.00, adjust the DISC potentiometer until the meter reads 300 (75% of final reading). The "75% of final reading" rule will be used throughout this procedure to maintain consistent setpoints. With 40,000 cpm from the pulser, adjust the x100 ratemeter calibration potentiometer R33 on the main board until the meter dial reads 400 cpm.

6. Check threshold linearity by setting the THR dial to 4.00 and seeing that the pulser amplitude must be 40 mV ±2 mV in order for the Model 2200 to start counting.

7. Set the WIN dial to 1.00, and turn the WIN toggle switch to the ON position. Verify that the Model 2200 just starts to count as the pulser amplitude crosses the threshold voltage and stops counting at 10 mV higher than the threshold voltage.

8. Set the THR dial to 1.00 and the WIN toggle switch to the OFF position. Adjust the pulser's pulse amplitude to 20 mV and the frequency to 400 cpm. Switch the Model 2200 multiplier switch to the X1 position, and adjust the X1 potentiometer R35 for 400 COUNTS/MIN on the ratemeter. Adjust the pulser frequency to 100 cpm, and confirm the Model 2200 ratemeter reads within 10%. Calibrate the X10 thru X1K ranges, incrementing the pulser count rate respectively. Select the F position on the F/S response switch. Depress the RESET switch and confirm the

meter pointer increases from 10% to 90% of the final reading in 4.0 ±0.5 seconds. Switch to the S position and verify that the response time is 22 ±2 seconds.

9. Hold the COUNT button down while turning the instrument on to check that the microprocessor is reading the count time pushwheels and multiplier toggle switch correctly. The pushwheel reading should be displayed on the LED display as long as the COUNT button is held down. Toggle the time multiplier toggle switch to verify that the count time is multiplied by 10 in the up position.

10. Set the threshold to 2.5 mV, the HV to 2000 Vdc, and remove the detector coax cable. Count for one minute. End count should be 3 or less.

11. Connect an RS-232 cable and RS-232 device, such as a computer or serial printer, to verify that the serial port is working. When a count is finished, the RS-232 output should match the display when the dipswitch on the back chassis is on PRNTR. Also verify that with the dipswitch in the position on the back chassis marked RECYC, the counting will recycle (or repeat) after ending a count. Leave the dipswitch in the PRNTR mode, with the RECYC in the OFF position and with both switches to the right.

Appendix C – Scaler Printer Option

Ludlum Measurements, Inc. sells a small 40-column serial-input impact printer for use with our new (year 2001) scaler or scaler/ratemeters. This small printer can print the results of each scaler count. It can also be configured to print the time/date with each scaler count. LMI furnishes the printer with a cable and an adapter to fit any IBM-compatible PC computer's serial port, either 9-pin or 25-pin.

Printer Specifications

Size: 10.3 cm wide x 11.4 cm deep x 5.1 cm high (4.05 x 4.5 x 2.0 in.)

Power: comes with 9 Vac wall transformer, 2.9 A peak current

Speed: 33 lines per minute

Paper Roll: standard 5.7 cm (2.25 in.) wide calculator paper

Ribbon Life: 200,000 characters

Replacement Ribbon: Epson HX-20 cartridge

Configuration

Before use, the printer must be configured. Please see the printer manual for details on changing the printer setup. When starting from the default configuration, only one parameter must be changed – BAUD must be changed to 2400.

Optional: To configure the printer to print out the time/date with each scaler count, choose the CUSTOM selection in printer setup. Set the desired time/date format and set the AUTO T/D parameter to YES. Then the time/date must be set under the SET CLOCK menu.

Appendix D – Drawings and Diagrams

Main Board, Drawing 167 x 413 (4 sheets)

Main Board Component Layout, Drawing 167 x 414

Amplifier Board, Drawing 167 x 392

Amplifier Board Component Layout, Drawing 167 x 393A

Switch Board, Drawing 167 x 273

Switch Board Component Layout, Drawing 167 x 274 (2 sheets)

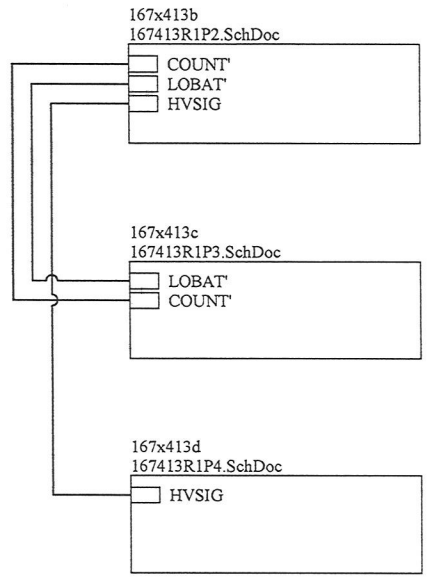
Pushwheel Board, Drawing 167 x 264

Pushwheel Component Layout, Drawing 167 x 265A (2 sheets)

Display Board, Drawing 167 x 276

Display Board Component Layout, Drawing 167 x 277 (2 sheets)

Wiring Diagram, Drawing 167 x 418



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828		
Drawn: CKB	05/13/2003	**Title:** MAIN BOARD		
Design: RSS	03/02/2002	**Model:** 2200		
		Board#: 5167-413		
Approve:		**Sheet:** 1 of 4	**Series**	**Sheet**
Print Date: 3/21/2016 1:32:46 PM		**Rev:** 1	167	413
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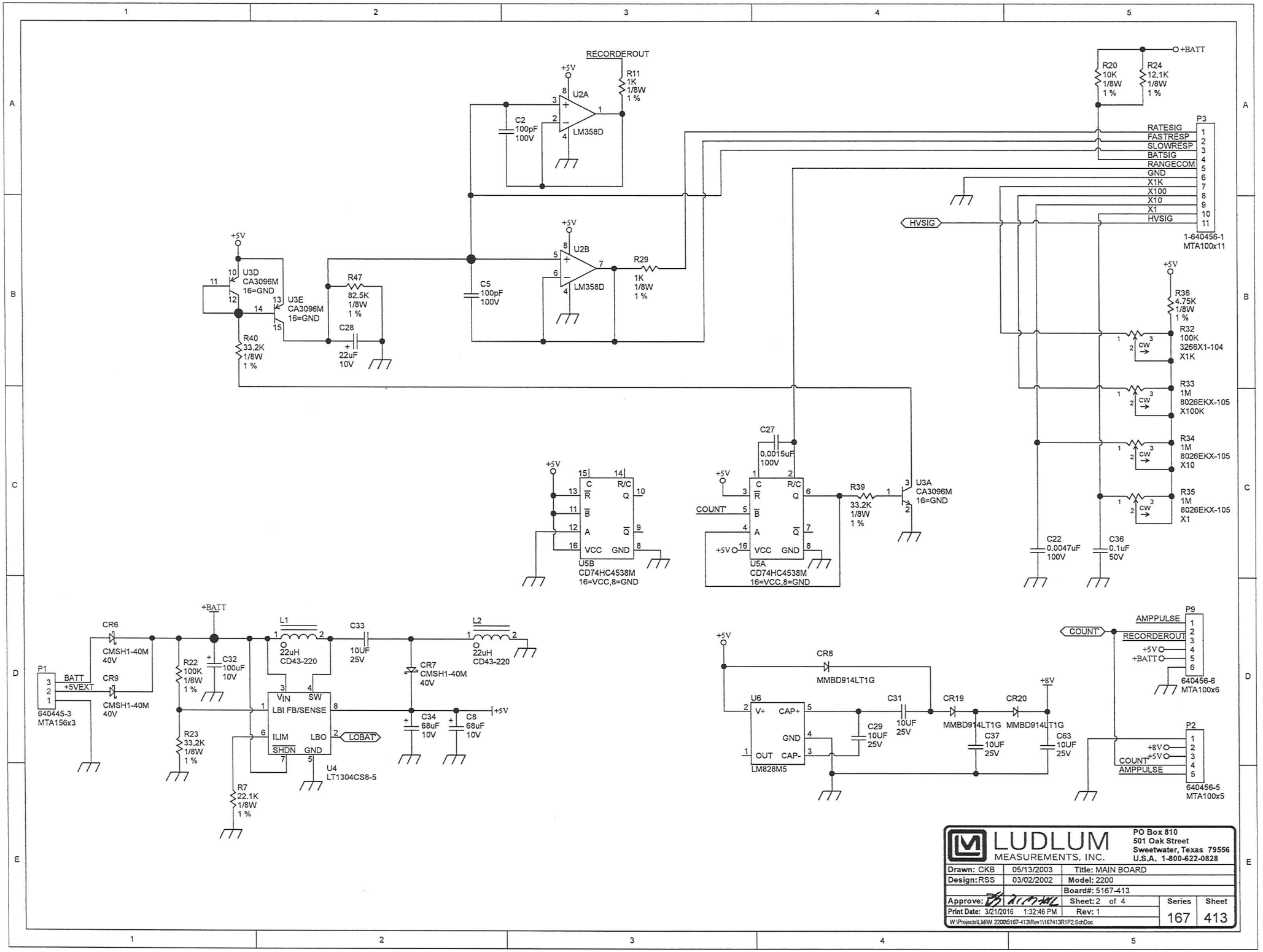

LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: CKB	05/13/2003	Title: MAIN BOARD	
Design: RSS	03/02/2002	Model: 2200	
		Board#: 5167-413	
Approve:		Sheet: 2 of 4	Series 167 / Sheet 413
Print Date: 3/21/2016 1:32:46 PM		Rev: 1	
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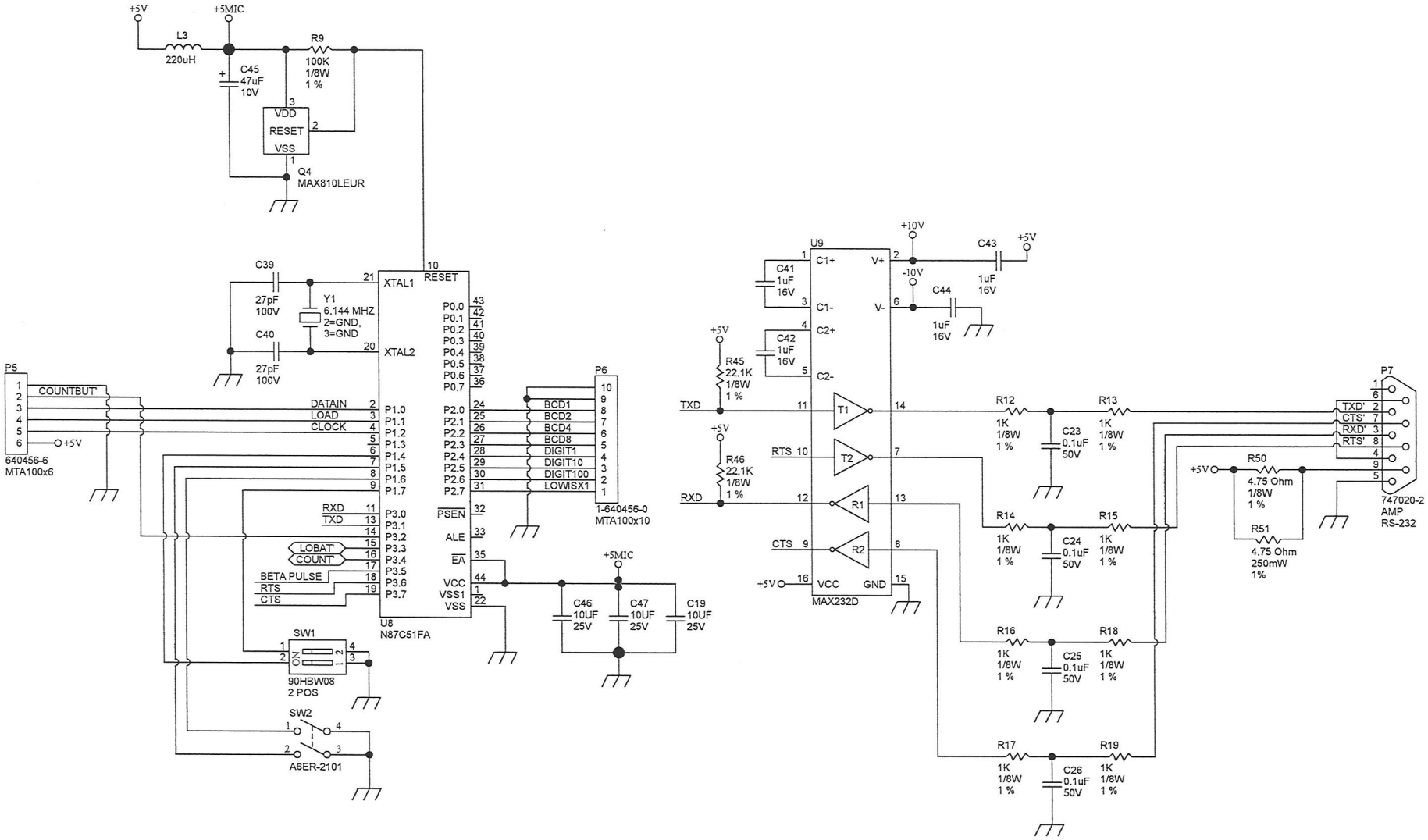

LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: CKB	05/13/2003	Title: MAIN BOARD	
Design: RSS	03/02/2002	Model: 2200	
		Board#: 5167-413	
Approve:		Sheet: 3 of 4	Series 167 / Sheet 413
Print Date: 3/21/2016 1:32:46 PM		Rev: 1	
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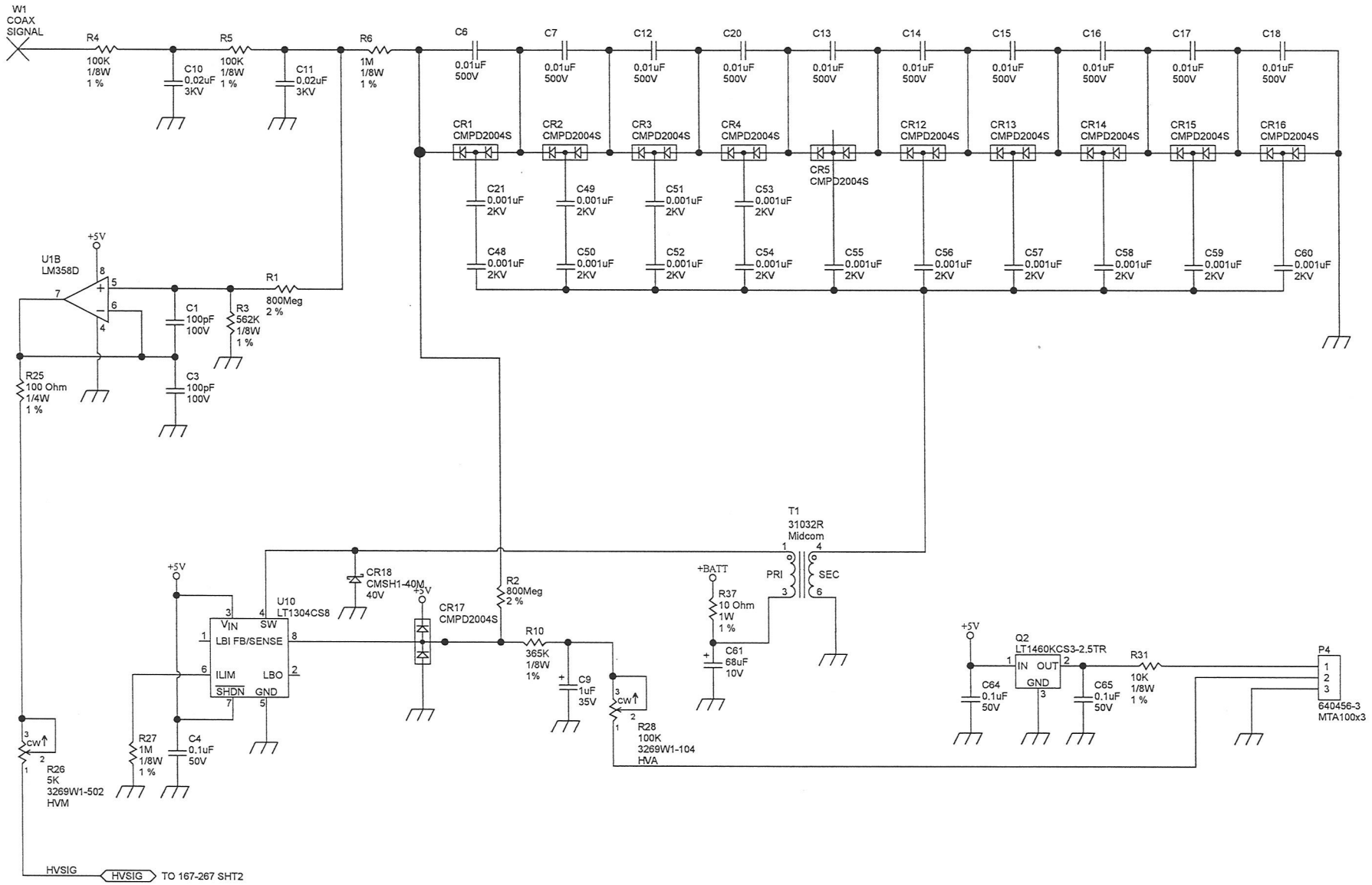

LUDLUM MEASUREMENTS, INC.

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

Drawn: CKB	05/13/2003	Title: MAIN BOARD	
Design: RSS	03/02/2002	Model: 2200	
		Board#: 5167-413	
Approve:		Sheet: 4 of 4	Series 167 / Sheet 413
Print Date: 3/21/2016 1:32:46 PM		Rev: 1	
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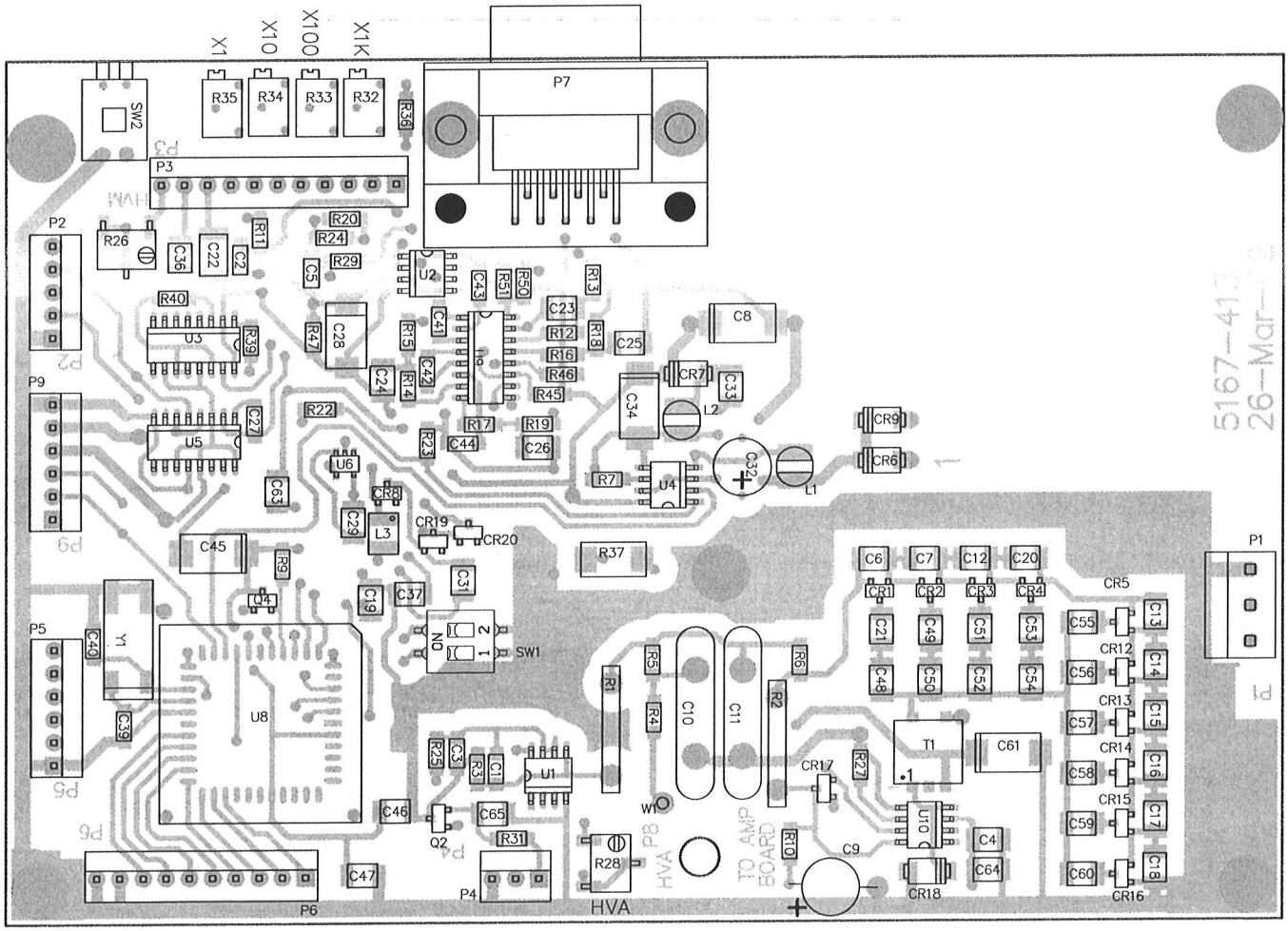

LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828	
Title: MAIN BOARD			
Drawn: CKB	05/13/2003	**Model:** 2200	
Design: RSS	03/02/2002	**Board#:** 5167-413	
Approve: DJS	4/1/2016	**Rev:** 1	
PCBA Drawing		**SCALE: 0.95**	**Series** 167 / **Sheet** 414
Print Date: 3/21/2016 1:51:08 PM		Top Overlay	
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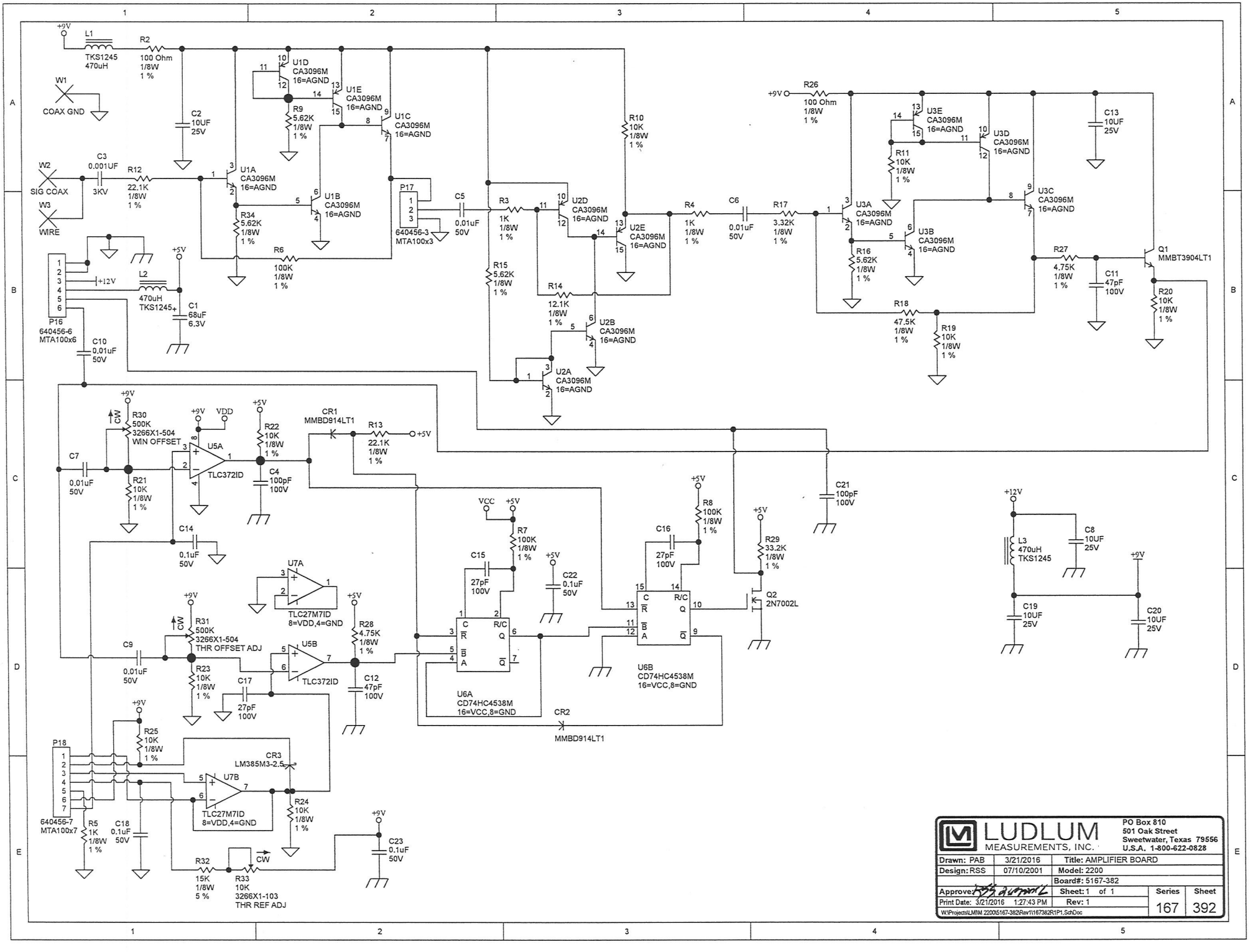
+9V
L1
TKS1245
470uH
R2
100 Ohm
1/8W
1 %
W1
COAX GND
C2
10UF
25V
U1D
CA3096M
16=AGND
U1E
CA3096M
16=AGND
U1C
CA3096M
16=AGND
R9
5.62K
1/8W
1 %
R10
10K
1/8W
1 %
W2
SIG COAX
C3
0.001UF
3KV
R12
22.1K
1/8W
1 %
U1A
CA3096M
16=AGND
U1B
CA3096M
16=AGND
R34
5.62K
1/8W
1 %
W3
WIRE
R6
100K
1/8W
1 %
P17
640456-3
MTA100x3
C5
0.01uF
50V
R3
1K
1/8W
1 %
U2D
CA3096M
16=AGND
U2E
CA3096M
16=AGND
R4
1K
1/8W
1 %
C6
0.01uF
50V
R17
3.32K
1/8W
1 %
R26
100 Ohm
1/8W
1 %
U3E
CA3096M
16=AGND
U3D
CA3096M
16=AGND
C13
10UF
25V
R11
10K
1/8W
1 %
U3A
CA3096M
16=AGND
U3C
CA3096M
16=AGND
U3B
CA3096M
16=AGND
R16
5.62K
1/8W
1 %
R27
4.75K
1/8W
1 %
C11
47pF
100V
Q1
MMBT3904LT1
R20
10K
1/8W
1 %
R18
47.5K
1/8W
1 %
R19
10K
1/8W
1 %
R15
5.62K
1/8W
1 %
R14
12.1K
1/8W
1 %
U2B
CA3096M
16=AGND
U2A
CA3096M
16=AGND
P16
640456-6
MTA100x6
+12V
L2
470uH
TKS1245
+5V
C1
68uF
6.3V
C10
0.01uF
50V
R30
500K
3266X1-504
WIN OFFSET
U5A
TLC372ID
R22
10K
1/8W
1 %
CR1
MMBD914LT1
R13
22.1K
1/8W
1 %
C7
0.01uF
50V
R21
10K
1/8W
1 %
C4
100pF
100V
C21
100pF
100V
C14
0.1uF
50V
U7A
TLC27M7ID
8=VDD,4=GND
R31
500K
3266X1-504
THR OFFSET ADJ
U5B
TLC372ID
R28
4.75K
1/8W
1 %
C9
0.01uF
50V
R23
10K
1/8W
1 %
C17
27pF
100V
C12
47pF
100V
R7
100K
1/8W
1 %
C15
27pF
100V
C22
0.1uF
50V
R8
100K
1/8W
1 %
C16
27pF
100V
R29
33.2K
1/8W
1 %
Q2
2N7002L
U6A
CD74HC4538M
16=VCC,8=GND
U6B
CD74HC4538M
16=VCC,8=GND
CR2
MMBD914LT1
L3
470uH
TKS1245
C8
10UF
25V
C19
10UF
25V
C20
10UF
25V
P18
640456-7
MTA100x7
R25
10K
1/8W
1 %
CR3
LM385M3-2.5
U7B
TLC27M7ID
8=VDD,4=GND
R24
10K
1/8W
1 %
R5
1K
1/8W
1 %
C18
0.1uF
50V
R32
15K
1/8W
5 %
R33
10K
3266X1-103
THR REF ADJ
C23
0.1uF
50V
LUDLUM
MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828
Drawn: PAB
3/21/2016
Title: AMPLIFIER BOARD
Design: RSS
07/10/2001
Model: 2200
Board#: 5167-382
Approved:
Sheet: 1 of 1
Print Date: 3/21/2016 1:27:43 PM
Rev: 1
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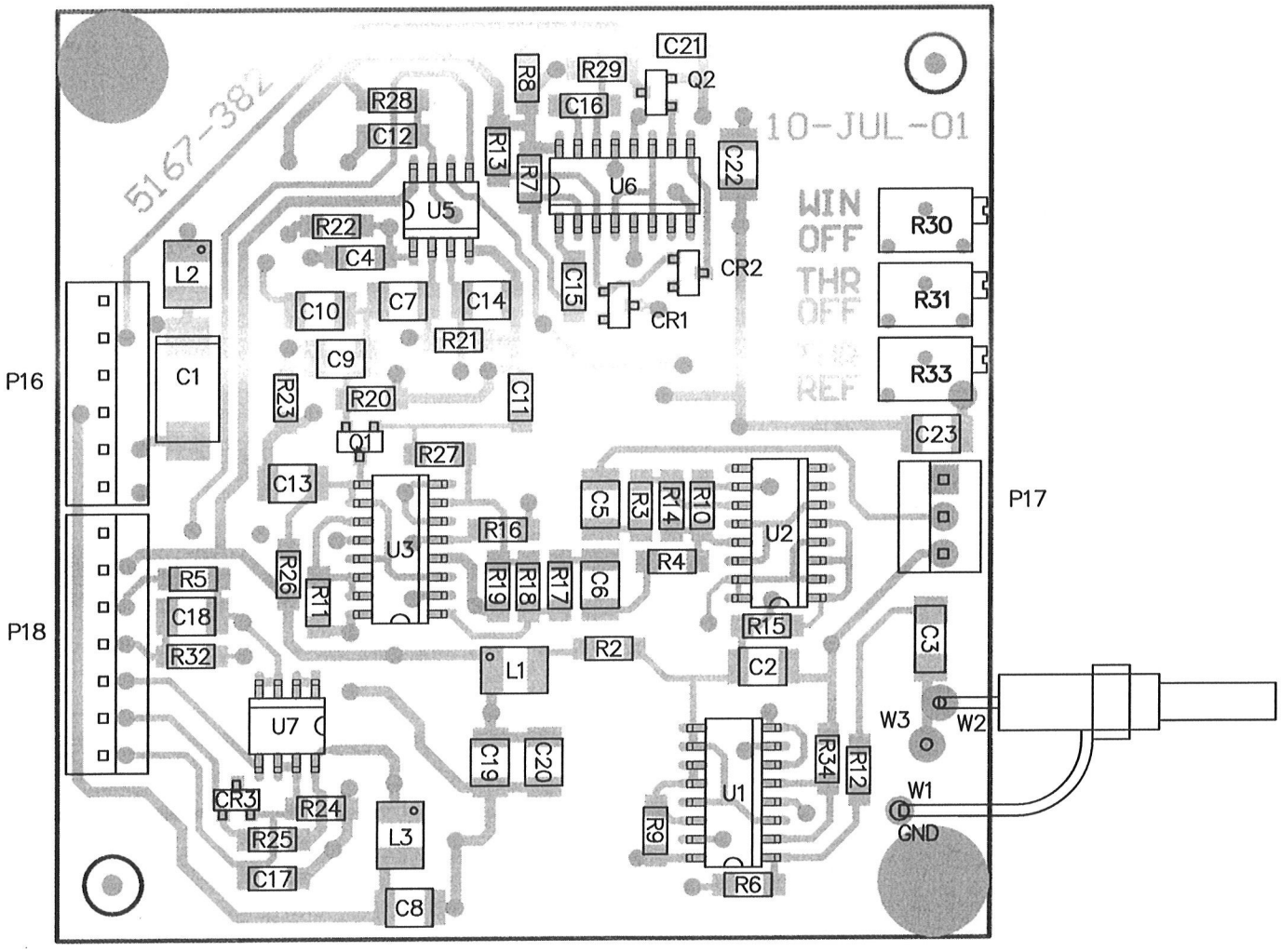
Series
167
Sheet
392



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828	
Title: AMPLIFIER BOARD			
Drawn: PAB	3/21/2016	**Model:** 2200	
Design: RSS	07/10/2001	**Board#:** 5167-382	
Approve: RSS		**Rev:** 1	
PCBA Drawing		**SCALE: 1.08**	**Series** 167 / **Sheet** 393A
Print Date: 3/21/2016 1:28:20 PM		Top Overlay	
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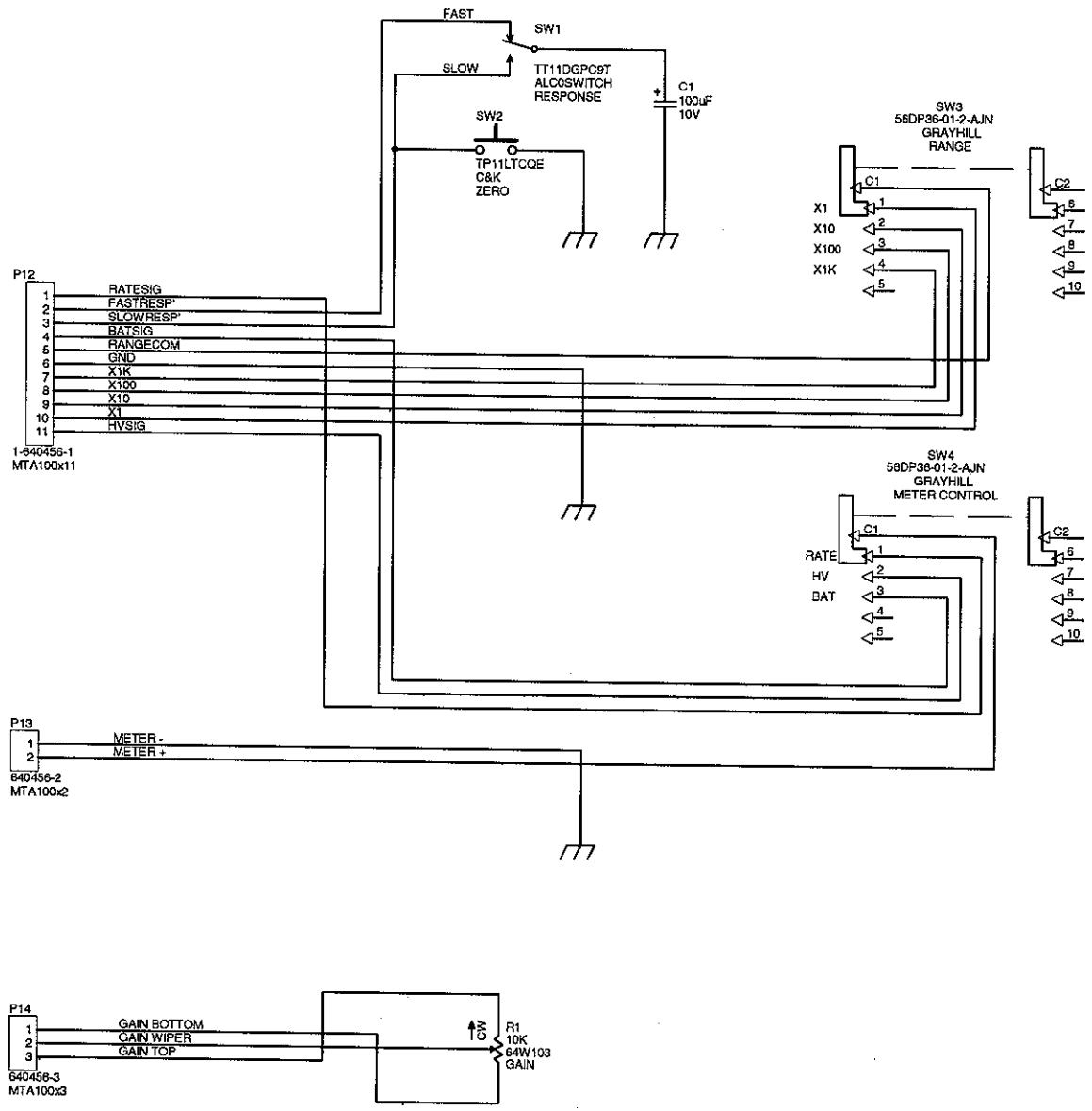
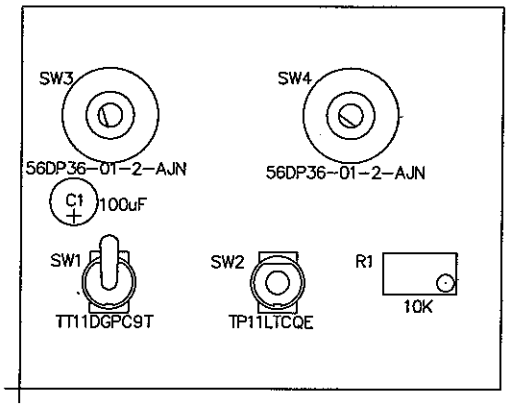
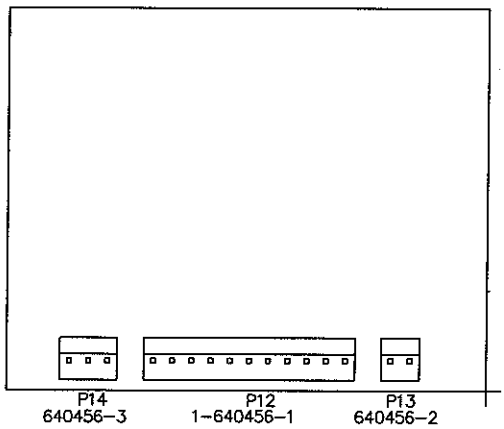


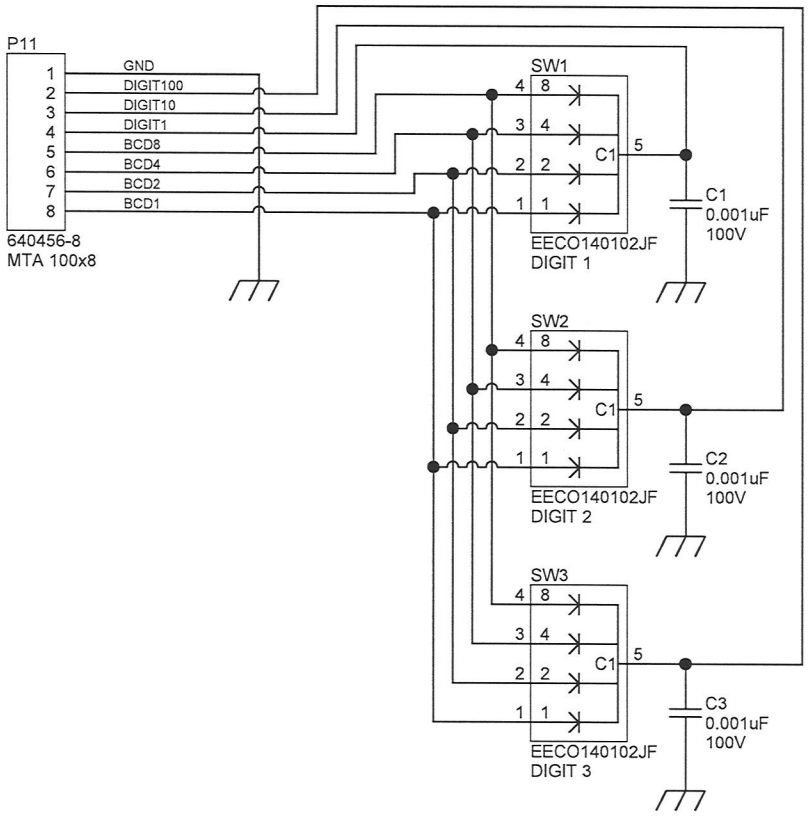
LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: JK	02-JUNE-00	Title: SWITCH BOARD	
Design: RSS	30-MAY-00	Model: 2200	
Check:	6-28-01	Board#: 5167-336	
Approve: RC	6-28-01	Sheet: 1 of 1	Series 167 / Sheet 273
16:04:49	28-Jun-2001	Rev: 1.0	
X:\Projects\LMM\2200M\2200 Dcb - Documents\5167-336\REV1.0\5167X273			



Drawn: JK	24-OCT-00	Title: SWITCH BOARD	
Design: RSS	24-OCT-00		
Check: RSS	6-28-01	Model: 2200	
Approve: R.C.	6-28-01	Board#: 5167-336	
Layer:	MID: 16:04:57 28-Jun-2001	Rev: 1.0	Series 167 / Sheet 274
		SCALE: 1.00	



Drawn: JK	24-OCT-00	Title:	
Design: RSS	24-OCT-00	SWITCH BOARD	
Check: RSS	6-28-01	Model: 2200	
Approve: R.C.	6-28-01	Board#: 5167-336	
Layer: Bottom Overlay		Rev: 1.0	Series 167 / Sheet 274
Mech.1 Mech.2 Mech.3 Mech.4 MID:		SCALE: 1.00	
16:04:57	28-Jun-2001		



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: PAB	9/3/2015	**Title:** PUSHWHEEL BOARD	
Design: RSS	04/20/2001	**Model:** 2200	
		Board#: 5167-333	
Approve: RPS 3Sep15		**Sheet:** 1 of 1	**Series** 167 / **Sheet** 264
Print Date: 9/3/2015 3:17:38 PM		**Rev:** 4	
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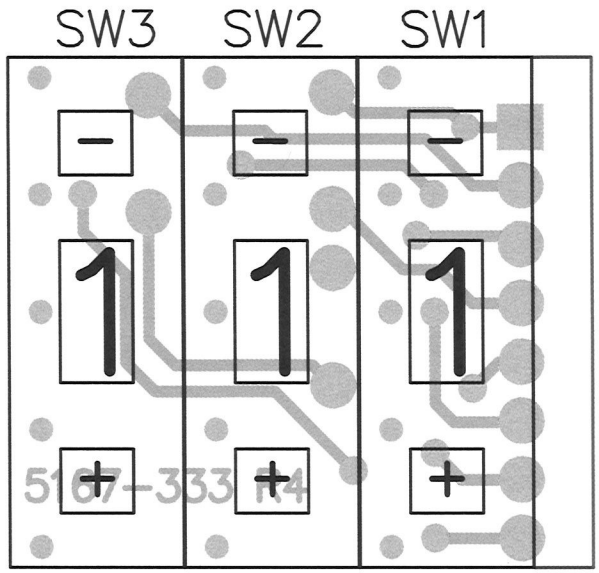

LUDLUM MEASUREMENTS, INC.	PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828		
Title: PUSHWHEEL BOARD			
Drawn: PAB	9/3/2015	**Model:** 2200	
Design: RSS	04/20/2001	**Board#:** 5167-333	
Approve: RDS	3 Sep 15	**Rev:** 4	
Print Date: 9/3/2015 3:22:36 PM		**SCALE: 1.00** Top Overlay	**Series** 167 / **Sheet** 265 A
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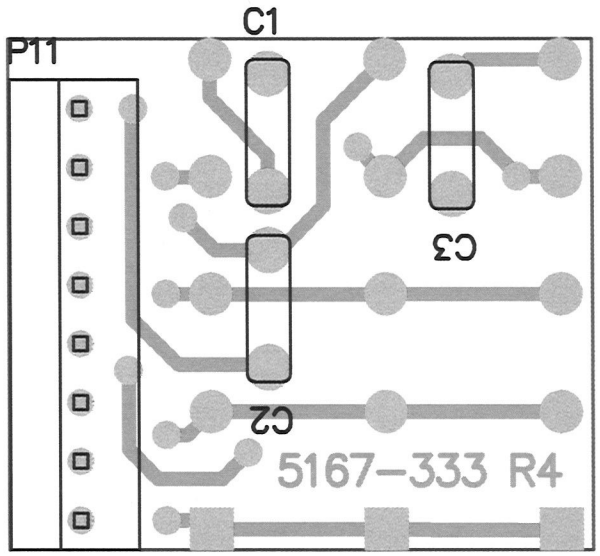

LUDLUM MEASUREMENTS, INC.

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

Title: PUSHWHEEL BOARD

Drawn: PAB	9/3/2015	**Model:** 2200	
Design: RSS	04/20/2001	**Board#:** 5167-333	
Approve: RDS	3 Sep 15	**Rev:** 4	
Print Date: 9/3/2015 3:22:39 PM		**SCALE: 1.00** Bottom Overlay	**Series** 167 / **Sheet** 265 A

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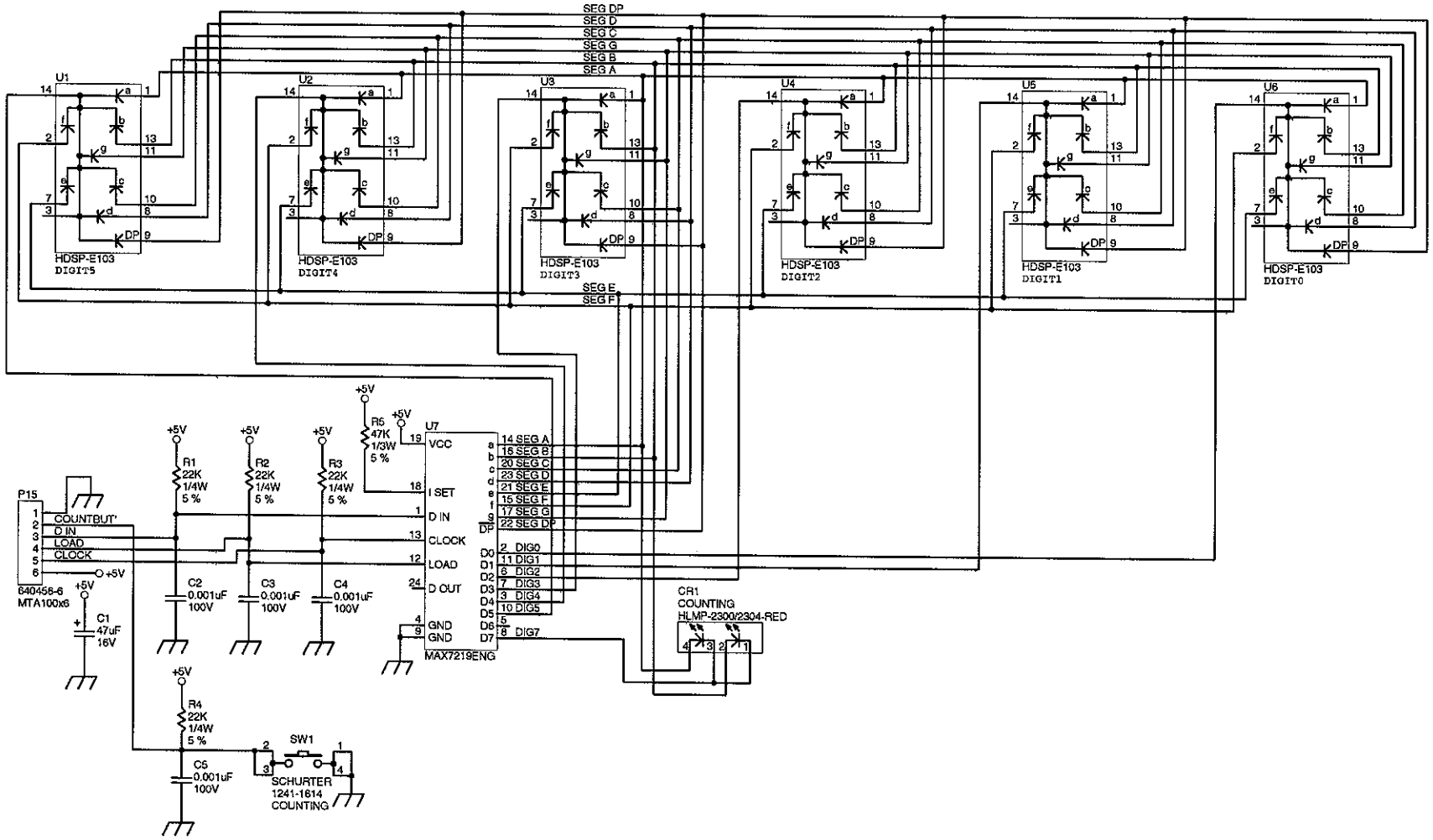

LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: JK	05-JUN-00	Title: Display Board	
Design: RSS	21-JAN-98	Model: 2200	
Check: RS	6-28-01	Board#: 5167-337	
Approve: RC	6-28-01	Sheet: 1 of 1	Series 167 / Sheet 276
16:05:32	28-Jun-2001	Rev: 1.0	
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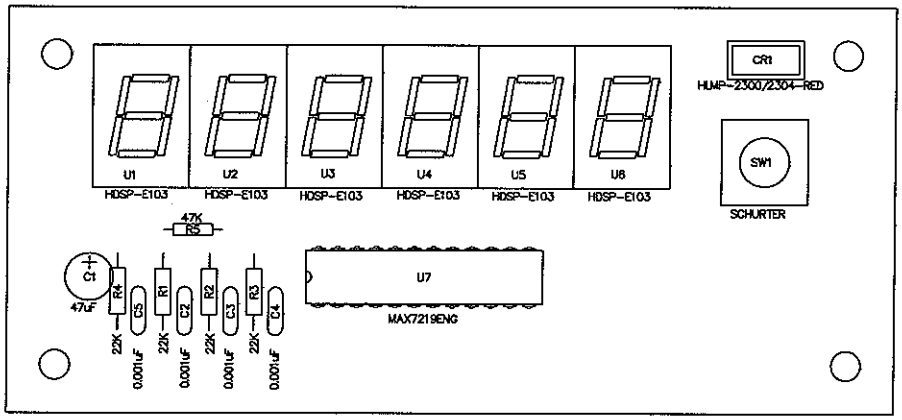
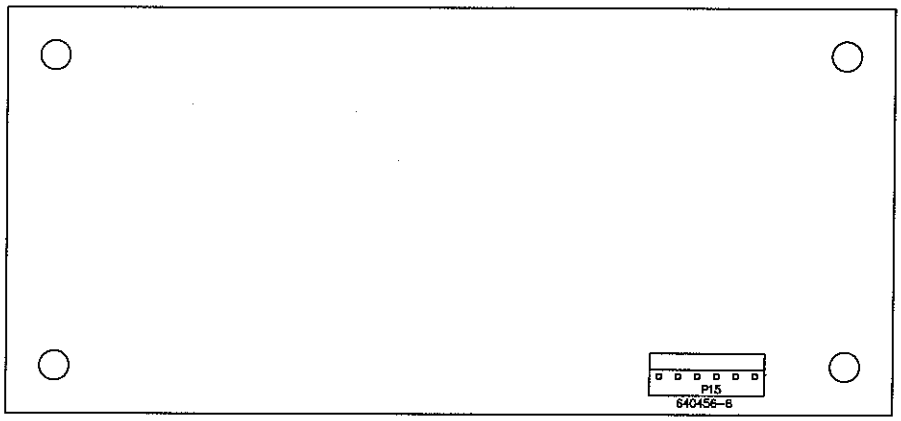
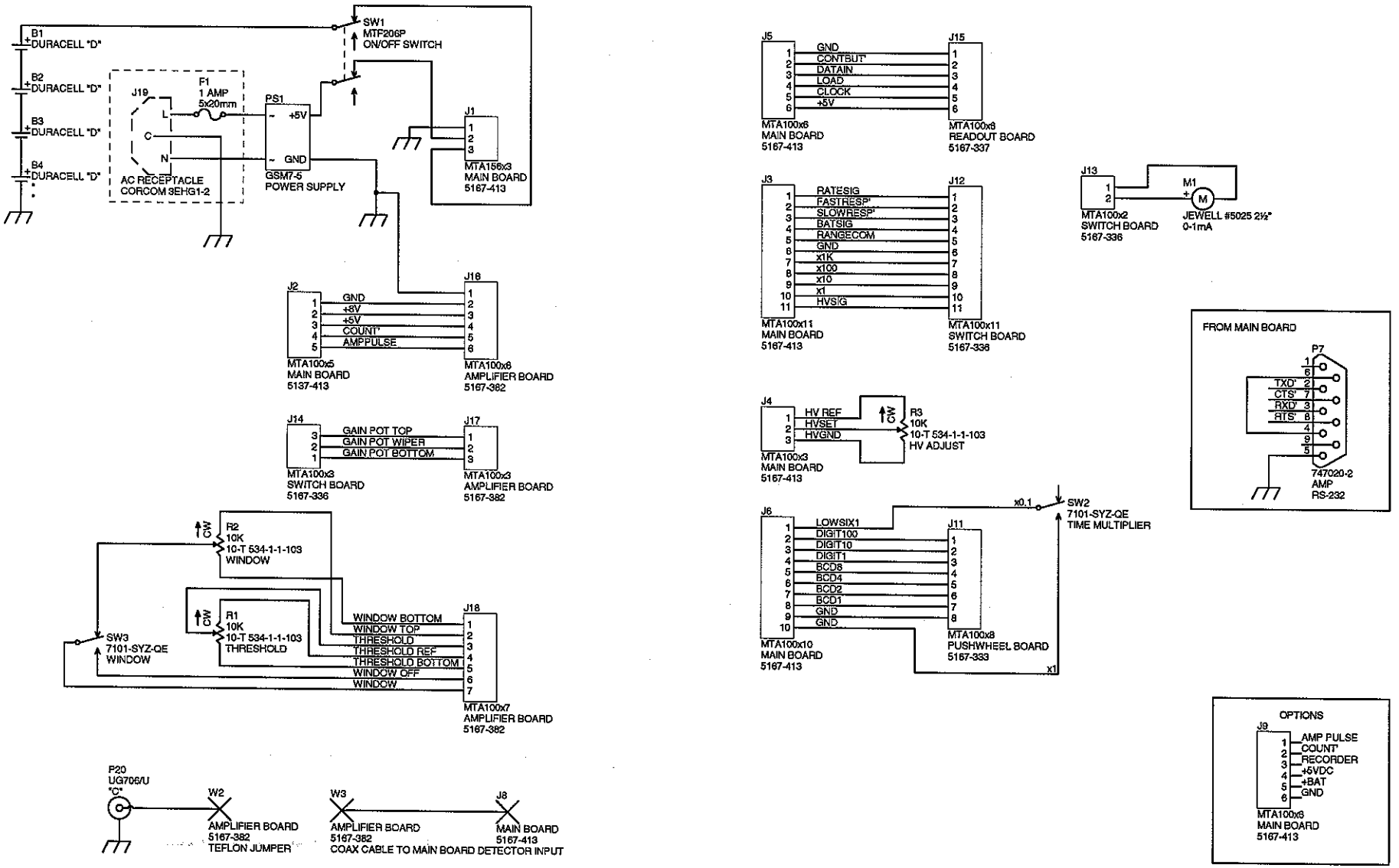


Drawn: JK	05-JUNE-00	Title: Display Board	
Design: RSS	21-JAN-98		
Check: RSS	6-28-01	Model: 2200	
Approve: R.C.	6-28-01	Board#: 5167-337	
Layer:	MD: 16:05:43 28-Jun-2001	Rev: 1.0	Series 167 / Sheet 277
		SCALE: 1.00	



Drawn: JK	05-JUNE-00	Title: Display Board	
Design: RSS	21-JAN-98		
Check: RSS	6-28-01	Model: 2200	
Approve: R.C.	6-28-01	Board#: 5167-337	
Layer: BOTTOM OVERLAY Mech.1 Mech.2 Mech.3 Mech.4 MID: 16:05:43 28-Jun-2001		Rev: 1.0 SCALE: 1.00	Series 167 / Sheet 277



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: KKH	08-JAN-04	Title: WIRING DIAGRAM	
Design: RSS	01-SEP-98	Model: 2200	
Check:		Board#: 167-418	
Approve:	8-Jan-2004	Sheet: 1 of 1	Series 167 / Sheet 418
16:28:35	8-Jan-2004	Rev: 2.0	
167X418			