LUDLUM MODEL 2929
DUAL-CHANNEL SCALER

September 2020

Serial Number 248597 and Succeeding

Serial Numbers

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DUAL-CHANNEL SCALER

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Shown with a Model 43-10-1

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.

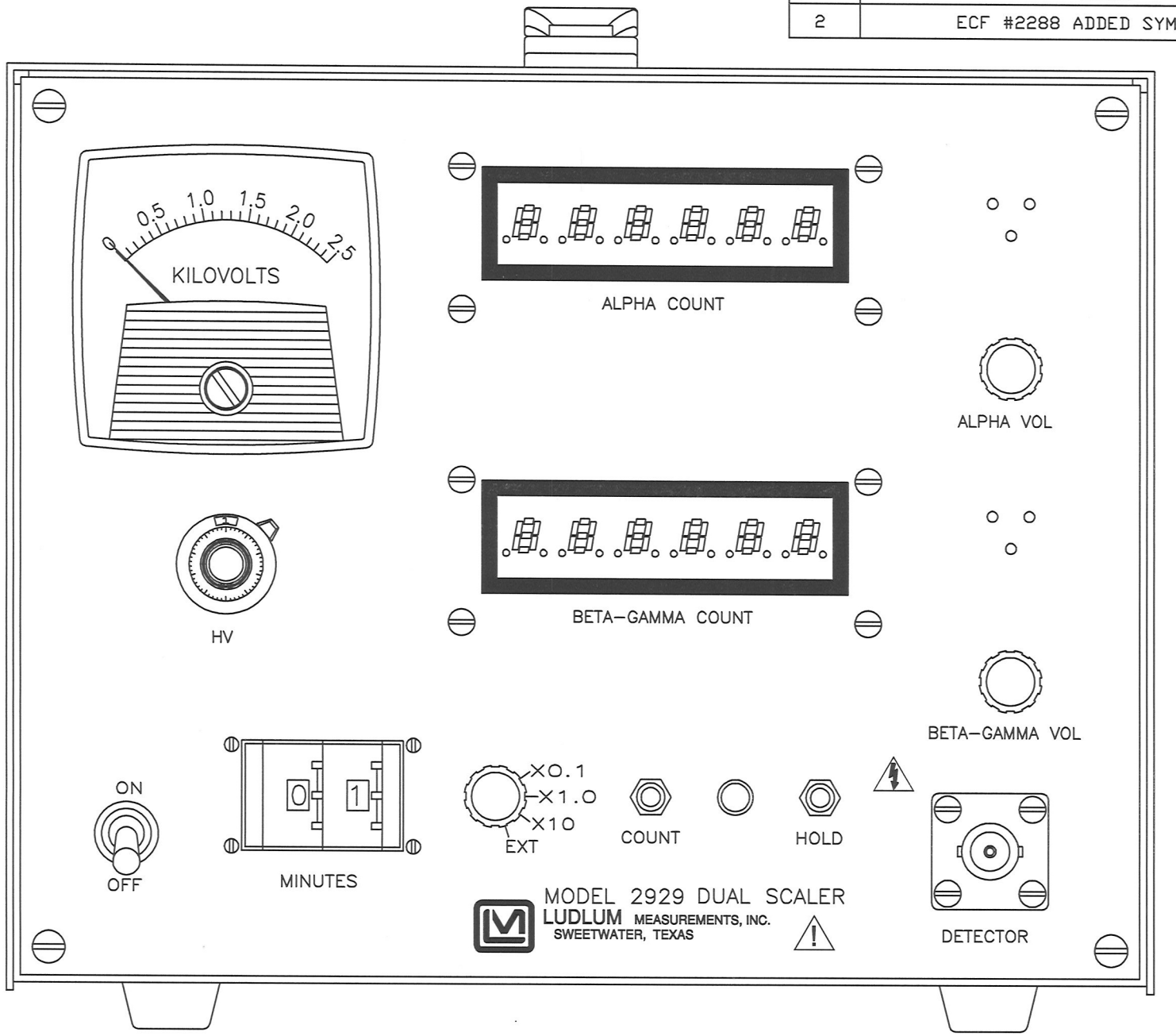
RETURN OF GOODS TO MANUFACTURER

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	12/11/98	DDW
2	ECF #2288 ADDED SYMBOLS	01/31/2008	PW



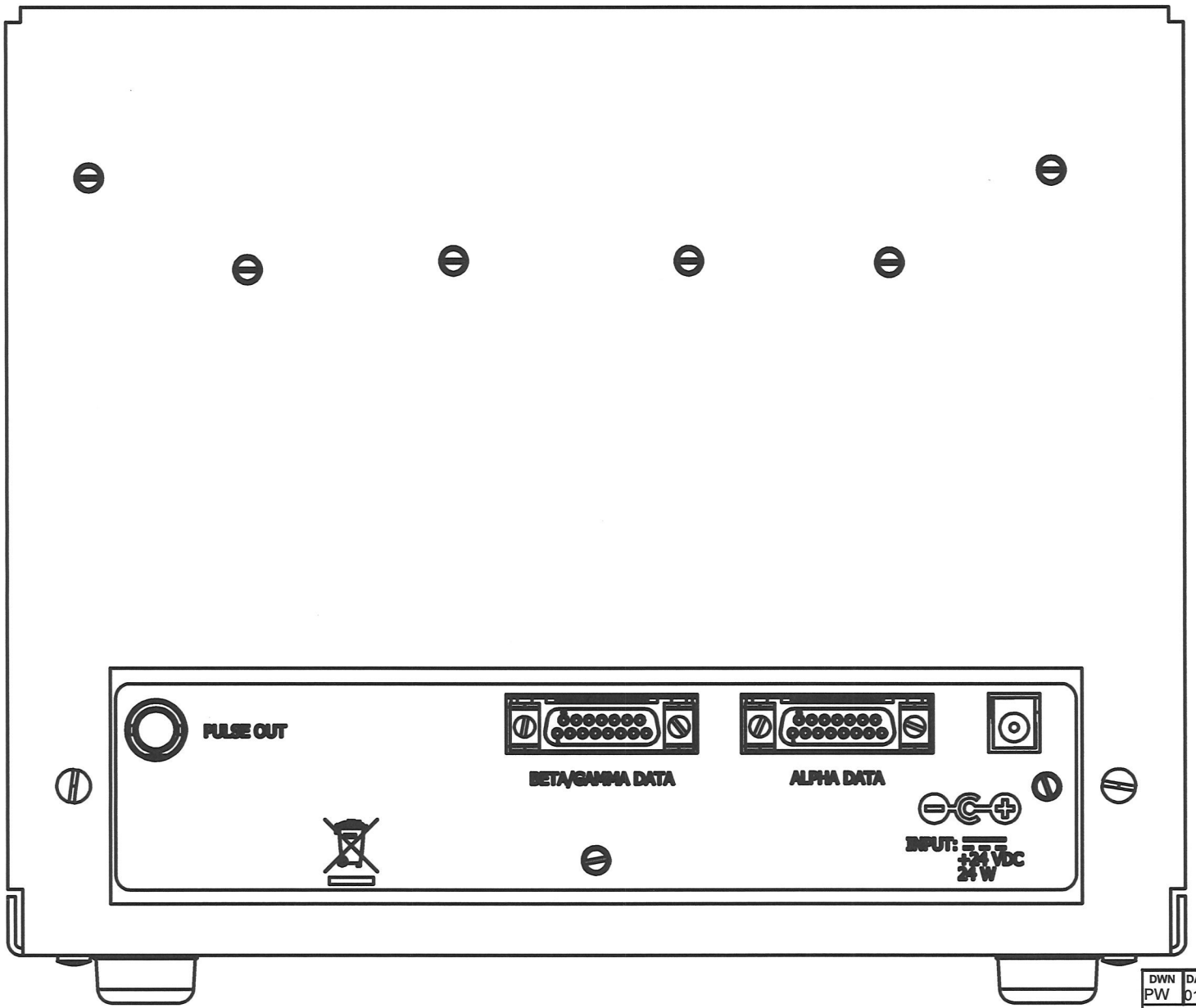
DWN	DATE	CHECKED	APPROVED
PW	01/31/08		RD 1/31/08

TITLE: M 2929 MODEL 2929 FRONT PANEL

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

SERIES	SHEET
337	1

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	1/18/2008	PW
2	ADDED DND SYMBOL	05/11/2011	PW



DWN	DATE	CHK	DATE	APP	DATE
PW	01/18/2008			PW	5-11-2011

DWG NUM: 4337-209 SCALE: 1:1

TITLE M 2929 REAR CHASSIS ASSEMBLY

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

SERIES 337 **SHEET** 209

Table of Contents

Section 1

Introduction

The Model 2929 is a dual-channel scaler designed for use with "Phoswich" and/or proportional detectors. A pulse height analyzer is employed to provide information to the two independent counters.

The Model 2929 is powered by a 95 to 250 Vac wall transformer with an output of 24 Vdc. It has a built-in detector high voltage power supply with front panel readout, as well as adjustable count time periods ranging from 0.1 to 990 minutes. It also has a click-per-event audio for each of the two channels. The unit will operate two printing calculators (Ludlum Model 264) by way of data connectors located on the rear chassis. The amplifier circuitry consists of a three-stage amplifier fed directly to the discriminator circuit. All discriminator controls are located internally and are easily accessible internally on the right-hand side of the chassis.

The Model 2929 is generally used in conjunction with a Model 43-10-1 Alpha/Beta Sample Counter.

Section

2

Specifications

Power: 95 to 250 Vac wall transformer with 24 Vdc output, 50-60 Hz single phase (typically less than 100 mA)

Input Senstivity: Beta-gamma lower threshold is adjustable from 4 mV, beta-gamma upper threshold is adjustable from 25 mV to 100 mV, and alpha threshold is adjustable from 175 mV.

High Voltage (HV): fully adjustable from 200 to 2500 V ±100 V with the capability of supporting 60-megohm scintillation loads to 1500 V

HV Meter: 6.4 cm (2.5 in.) panel analog meter readout

HV Meter Accuracy: ±10% of reference value

Audio: click-per-event type with volume control for each of the two channels

Count Time: 0-99 minutes with multiplier of 0.1, 1.0 and 10; external position for use with an external clock source

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

Scaler Readout: six-digit, light-emitting diode readout for each of the two channels

Scaler Accuracy: ±2% of reference value

Size: 24.4 x 37.1 x 25.1 cm (9.6 x 14.6 x 9.9 in.) (H x W x L)

Weight: 5.5 kg (12.1 lb), including detector

Finish: beige powder coat with anodized front panel and silk-screened nomenclature

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

Section 3

Controls and Functions

Front Panel

High Voltage: 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 60-megohm scintillation loads to 1500 V.

HV Meter: a 6.4 cm (2.5 in.) panel meter displaying the high-voltage setting continuously.

HV: a 10-turn dial used to adjust the detector high voltage.

ON/OFF: a toggle switch used to apply power to the instrument when in the "ON" position.

Count Lamp: a red light indicating that the scaler is in the count cycle.

Count Switch: resets and starts the counting cycle. This switch will also reset the two counters when depressed.

HOLD Switch: stops the count cycle without resetting the scaler display. The counters will hold the value present at the time this button is depressed.

Minutes: a two-decade thumb-wheel switch used for presetting count time. This switch is used in conjunction with the multiplier switch.

Multiplier: a rotary switch allowing selection of count time mulitpliers of 0.1, 1, 10 or an EXT position for timing using external clock sources.

Detector Input Connection: a series "C" coaxial connector used to supply the detector with its bias voltage and also to return the signal from the detector. (Other connectors are available upon request.)

Beta-Gamma Vol: a rotary control used to vary the audio output of the beta-gamma channel from off to full volume.

Alpha Vol: a rotary control used to vary the audio output of the alpha channel from off to full volume.

Alpha Count: a six-digit LED readout indicating counts received in the alpha counting channel.

Beta-Gamma Count: a six-digit LED readout indicating counts received in the beta channel.

Rear Panel

Amp Out: a BNC connector that provides access to the final amplifier stage. The pulse is positive-going with a maximum amplitude of approximately 22 V.

Alpha Out: a 15-pin D type connector used as a data output for the alpha counter. (Refer to Section 7 for a listing of pin numbers and their functions.)

Beta-Gamma Out: a 15-pin D type connector used as a data output for the beta-gamma counter. (Refer to Section 7 for a listing of pin numbers and their functions.)

Fuse: Use of a 1-Amp, fast-blowing fuse provides protection to the instrument in case of internal electrical failure.

110 Vac: a connector used to apply line power to the instrument

Section 4

Safety Considerations

Environmental Conditions for Normal Use

Indoor use only

No maximum altitude

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

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

Pollution Degree 2 (as defined by IEC 664).

Cleaning Instructions and Precautions

The Model 2929 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 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.

Electrical Safety Precautions

Warning!

Observe the following instructions to avoid a potentially hazardous situation which, if mishandled, could result in death or serious personal injury, as well as property damage.

- Do not expose the unit to rain or an environment where it may be splashed by water or other liquids, as doing so may result in fire or electric shock.
- Use the unit only with the voltage specified on the unit. Using a voltage higher than that which is specified may result in fire or electric shock.
- Do not cut, kink, or otherwise damage nor modify the power supply cord. IN addition, avoid using the power cord in close proximity to heaters, and never place heavy objects – including the unit itself – on the power cord, as doing so may result in fire or electric shock.
- Avoid installing or mounting the unit or its power supply in unstable conditions, such as a rickety table or a slanted surface. Doing so may result in the unit falling down and causing personal injury and/or property damage.

The Model 2929 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 symbols appears on the back panel.

CAUTION, RISK OF ELECTRICAL 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 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. The symbol is placed near the DC receptacle. See section 5, "**Recycling**" for further information.

Section

5

Recycling

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

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

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

Ludlum Measurements, Inc. products that have been placed on the market after August 13, 2005 have been labeled with a symbol recognized internationally as the "crossed-out wheelie bin." This notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. On the Model 2929, the symbol will be placed on the rear panel.

The symbol appears as such: 

Section 6

Operating Procedures

Once the Model 2929 is calibrated for use with a specific detector, the high-voltage operating point must be determined. See HV adjustment procedures below for details on selecting the proper operating voltage.

Count time: Selection should be based on the count rates being observed and the desired statistical accuracy.

Volume Controls: Adjust to desired levels. Note that audio is operating whether a count cycle is in process or not.

Detector: Connect the detector to the instrument using the cable supplied with the instrument. Note that a cable length change can cause a shift in calibration.

Printer: When operating two Model 264 printers and a recycle is required, be sure that only one printer has its recycle switch "ON."

Calibration Procedures

The following procedures apply to the Model 2929 when used in conjunction with the Model 43-10-1 scintillator

NOTE: The following settings are normally:

Beta Threshold (B-G THS) = 4 mV
Beta Window (B-G WIN) = 50 mV
Alpha Threshold (ALPHA THS) = 175 mV

Amp/Disc Board

- Apply a negative pulse of 10 mV amplitude to the DETECTOR input of the Model 2929. A count rate greater than 25,000 cpm should be used.

- Adjust the GAIN control located internally and to the right-hand side of the instrument for a positive pulse amplitude of 200 mV (at the AMP OUT connector).

This completes the amplifier gain calibration. The optimum amplifier gain should be approximately 20.

- Apply a negative pulse of 200 mV amplitude.
- Attach an oscilloscope probe to pin 7 of U5 ad adjust **B-G THS** WIDTH (R6) for a five-microsecond wide negative 5 V pulse.
- Move the oscilloscope to pin 9 of U5 and adjust B-G WIN WIDTH (R5) for a 10-microsecond wide negative 5-volt pulse.
- Move the oscilloscope to pin 9 of U6 and apply a negative pulse of 4 mV amplitude.
- Adjust **B-G THS** (R3) until negative 5-volt pulses appear.
- Apply a negative pulse of 50 mV amplitude and adjust B-G WIN (R2) until negative 5-volt pulses just disapper.
- Apply a negative pulse of 175 mV amplitude and adjust **ALPHA THS** (R4) until a 5-volt positive pulse appears at pin 6 of U6.

High Voltage Power Supply

- With a high-voltage meter of at least 1000 megohm input impedance, adjust the front-panel HV control for 1000 Vdc at the detector connector.
- Adjust R6 for a front-panel meter reading of 1 kV.

NOTE: If adjustment is necessary, a 10-pin extender board will be required.

- With no detector attached, turn the HV dial to maximum (fully clockwise) and adjust R13 for 1500 V. (Higher limits may be necessary, depending upon the type of detector being used.

High Voltage Adjustment Procedures

High Voltage: Selection of an operating voltage is determined by the plateau method. With this method, a graph of high-voltage settings versus counts

received from each channel is generated (source counts and background counts). LMI uses ^{239}Pu as the alpha source; and ^{99}Tc or ^{14}C as beta sources.

The following procedures describes the determination of the operating voltage for a Model 43-10-1 detector, which is commonly used with the Model 2929 dual channel scaler. Note that certain criteria must be met for the background counts, source efficiencies, and crosstalk.

1. Connect the Model 43-10-1 to the counting instrument with proper cable.

2. Place a calibrated ^{99}Tc source in the sample holder. Close and lock the sample drawer.

3. Adjust the counting instrument HV until it receives at least 27% 4π efficiency

4. Decrease HV by 25 volts.

5. Record the HV.

6. Record the ^{99}Tc source count and beta crosstalk in the alpha channel.

7. Remove the ^{99}Tc source and record the background count in the alpha and beta channels.

8. Place a calibrated ^{239}Pu source in the sample holder. Close and lock the sample drawer.

9. Record the ^{239}Pu source count and the alpha crosstalk in the beta channel.

10. Increase the HV by 25 volts.

11. Repeat Steps 5-10 until one or more of the following conditions happen:

    a. Beta background exceeds 80 cpm
    b. Alpha background d exceeds 3 cpm
    c. Alpha crosstalk in the beta channel ^{exc14eeds} 10%
    d. Beta crosstalk in the alpha channel exceeds 1%.

12. The operating voltage should be selected at a point where:

a. ^{99}Tc efficiency greater than or equal to 27%.
b. ^{239}Pu efficiency greater than or equal to 37%
c. Alpha crosstalk in beta channel less than or equal to 10%
d. Beta crosstalk in alpha channel is less than or equal to 1%
e. Beta background is less than or equal to 80 cpm
f. Alpha background is less than or equal to 3 cpm.

Section 7

Data Output

Function Identification

PIN	FUNCTION
1	Count Complete
2	Printer Ready
3	Load Printer
4	Printer Clock
5	Ground
6	Count
7	Hold
8	+5 Vdc
9	Alpha Pulse Out
10	Beta/Gamma Pulse Out
11	Blanking
12	Bit 1
13	Bit 2
14	Bit 3
15	Bit 4

Function Source

All functions are from Model 2929 to accessory except:

PIN 2 Printer Ready
PIN 6 Count
PIN 7 Hold

Output Signals

Output signals are CMOS with LO = GROUND and HI = VOLTAGE on Pin 8.

Pin 2 Printer Ready: Signal should be of the same voltage swing as the signals from the Model 2929.

6 Count: Signal should be pulled low to start counting.

Pin 7 Hold: Signal should be pulled low to stop counting.

Removing Data from the Model 2929

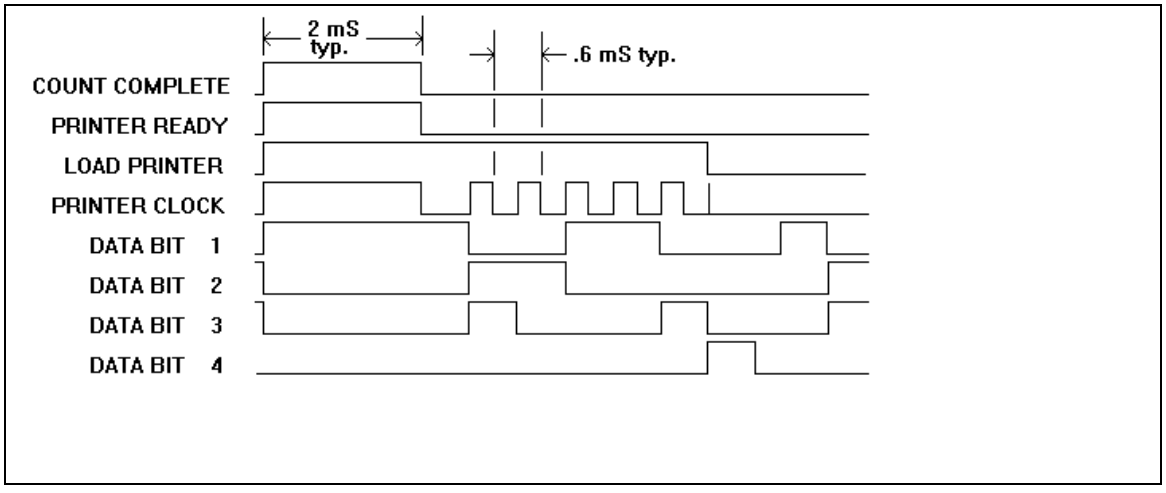
When the Model 2929 has timed out and counting stops, a HI pulse appears on pin 1 (count complete). This pulse is approximately 2 milliseconds wide and is used to signal the accessory unit that data is ready to be transmitted. When the accessory unit is ready to accept the data, Pin 2 (printer ready) is pulsed HI for a minimum of 2 milliseconds. When this Pin goes LO, data is unloaded from the Model 2929 as follows:

The most significant digit appears first. This is valid at the negative eduge of the first clock pulse and position continues until all digits have been read out.

At this time, Pin 3 (load printer) goes LO, signaling completion of data transfer.

NOTE: Count Complete (Pin 1) and Printer Ready (Pin 2) are tied together. The data is presented as BCD data on Pins 12 (BIT 1), 13 (BIT 2), 14 (BIT 3), and (BIT 4).

Figure 1



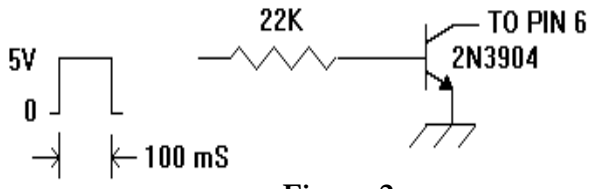


Figure 2

To start the Model 2929 again, Pin 6 (count) may be brought LO for a minimum of 100 milliseconds. The suggested circuit for this is shown in Figure 2.

Pins 9 and 10 are +5 V pulses and are present even if the Model 2929 is not in a count cycle.

Section

8

Optional Equipment

Model 264 Printer

The LMI Model 264 accessory printer is offered as an option for the Model 2929 Scaler.

A recycle switch on the Model 264 is provided for continuous cycling, if desired. \When the counting time has reached the preset selection, the count is printed, and the scaler and timer are reset to 0 to begin again. The preset time is variable from 6 seconds up to 990 minutes.

The calculator may be used for any normal calculation function as long as the keys are not activated at the same time the scaler is feeding its information to the printer.

NOTE: When operating two Model 264 printers and a recycle is required, be sure that only one printer has its recycle switch ON.

Model 464 RS-232 Interface

The LMI Model 464 RS-232 interface connects to the Model 2929, allowing communication between the scaler and a device with an RS-232c I/O (Input/Output), such as a personal computer (PC).

A command input through the RS-232 port to the interface is interpreted and action is taken accordingly. The scaler can be started, stopped and have data extracted by way of commands sent to the interface. The timed count may be controlled by the scaler front panel, interface internal timer or by a timer in the controlling device. The interface internal timer is programmable to 4.5 days.

Other commands allow the user to read the interface timer, read the current count, start a timed count using the interface internal timer, and ask the interface if the timer has timed out.

The interface is powered by the scaler and is reset when the scaler is turned off.

Model 464-2 Two-Channel Counter

The Model 2929 with modified data output connector may be connected to a Model 464-2 two-channel counter with a single cable for display on a PC by way of a serial port.

Every 0.5 seconds, the counts are collected from the counter boards and sent to the RS-232 port. The supplied software allows the user to specify count time, alarms, and to log counts to disk.

NOTE: The Model 464-2 accumulates counts independently from the Model 2929 and its internal timer. Pulses are sent to the Model 464-2 counters, regardless of the status of the Model 2929 control board. This allows the user to take timed counts at the Model 2929 without affecting the serial port operation.

Section 9

Parts List

	Reference	Description	Part Number
Model 2929 Dual-Channel Scaler	UNIT	Completely Assembled Model 2929	48-1426
Power Supply Board, Drawing 337 x 27	BOARD	Assembled Power Supply	5337-031
CAPACITORS	C1	100pF, 3kV	04-5532
	C2	2.2µF, 20V, DT	04-5508
	C3	100µF, 10V, DT	04-5576
	C4	0.1µF, 35V, DT	04-5574
	C5	1µF, 35V, DT	04-5575
	C6-C7	0.0056µF, 3kV, C	04-5522
	C8-C9	0.01µF, 2kV, C	04-5525
	C10	0.0056µF, 3kV, C	04-5522
	C11	0.1µF, 100V, C	04-5521
	C12	0.0056µF, 3kV, C	04-5522
	C13	0.1µF, 100V, C	04-5521
TRANSISTORS	Q1	MPSW51	05-5765
	Q2	2N3904	05-5755
INTEGRATED CIRCUITS	U1	LM358	06-6024
	U2	LM385z-1.2	05-5808

	Reference	Description	Part Number
DIODE			
	CR1	1N4148	07-6272
	CR2-CR5	GI250-2	07-6266
		THERM-RL 1006	07-6322
		THERM-RL 1006	07-6322
RESISTORS			
	R1	220K, 1/4W, 5%	10-7066
	R2-R3	1G, FHV-1, 2%	12-7686
	R4	1M, 1/4W, 5%	10-7028
	R5	301 OHM, 1/8W, 1%	12-7677
	R6	2K TRIMMER	09-6798
	R7	820K, 1/4W, 5%	10-7063
	R8-R9	10K, 1/4W, 5%	10-7016
	R10	1.5K, 1/4W, 5%	10-7065
	R11	200 OHM, 1/4W, 5%	10-7006
	R12	10M, 1/4W, 5%	10-7031
	R13	500K TRIMMER	09-6792
	R14	1M, 1/4W, 5%	10-7028
TRANSFORMERS	T1	L8050 X 50	40-0902
Amplifer/ Discriminator, Drawing 337 x 19	BOARD	Assembled Discriminator	5337-026
	C1	10µF, 20V, DT	04-5592
CAPACITORS	C2-C3	1µF, 35V, DT	04-5575
	C5	0.1µF, 100V, C	04-5521
	C10	47pF, 100V, C	04-5533
	C11	0.1µF, 100V, C	04-5521
	C12	1µF, 35V, DT	04-5575
	C13	0.01µF, 100V	04-5523
	C16	22µF, 35V, DT	04-5594
	C18-C19	100pf, 100V, C	04-5527
	C20-C21	0.01µF, 100V	04-5523
	C22-C23	100pf, 100V, C	04-5527
	C24	0.01µF, 100V	04-5523
	C25	100pf, 100V, C	04-5527
	C26	22µF, 35V, DT	04-5594

	Reference	Description	Part Number
TRANSISTORS	Q1	2N3904	05-5755
INTEGRATED CIRCUITS	U1-U2	CA3096	06-6023
	U3-U4	LM293P	06-6890
	U5-U7	CD4098	06-6066
DIODE	CR1	1N4148	07-6272
VOLTAGE REGULATORS	VR1	LM78L05	05-5815
	R1-R4	10K TRIMMER	09-6794
	R5	200K TRIMMER	09-6791
	R6	50K TRIMMER	09-6790
	R9	12K, 1/4W, 5%	10-7048
	R10	10K, 1/4W, 5%	10-7016
	R11	4.7K, 1/4W, 5%	10-7014
	R12	22K, 1/4W, 5%	10-7070
	R13-R14	10K, 1/4W, 5%	10-7016
	R15	820K, 1/4W, 5%	10-7063
	R16	330 OHMS, 1/4W, 5%	10-7053
	R17	1K, 1/4W, 5%	10-7009
	R18	10K, 1/4W, 5%	10-7016
	R19	5.6K, 1/2W	11-7275
	R20	1K, 1/4W, 5%	10-7009
	R21	56K, 1/4W, 5%	10-7021
	R23	5.6K, 1/4W, 5%	10-7042
	R24	100K, 1/4W, 5%	10-7023
	R26	10K, 1/4W, 5%	10-7016
	R28	18K, 1/4W, 5%	10-7018
	R29	2.7K, 1/4W, 5%	10-7055
	R31	150K, 1/4W, 5%	10-7024
	R33	820 Ohm, 1/4W, 5%	10-7060
	R35	10K, 1/4W, 5%	10-7016
	R37	1M, 1/4W, 5%	10-7028
	R38-R39	5.6K, 1/4W, 5%	10-7042
	R40	10K, 1/4W, 5%	10-7016
	R41	56K, 1/4W, 5%	10-7021
	R42	5.6K, 1/4W, 5%	10-7042
	R43	100K, 1/4W, 5%	10-7023
	R45	10K, 1/4W, 5%	10-7016
	R47	24K, 1/4W, 5%	10-7059
	R49	2.2K, 1/4W, 5%	10-7012

	R59	330 OHMS, 1/4W, 5%	10-7053
	R66	1K, 1/4W, 5%	10-7009
	R72	22K, 1/4W, 1%	10-7070
	R74-R75	56K, 1/4W, 5%	10-7021
	R76	10K, 1/4W, 5%	10-7016
	R78	330 OHMS, 1/4W, 5%	10-7053
Scaler Board, Drawing 167 x 170	BOARD	Completely Assembled Scaler	5167-235
CAPACITORS			
	C1	100µF, 10V, DT	04-5576
	C2	0.001µF, 100V, C	04-5519
	C3	0.01µF, 10V	04-5523
	C4	0.001µF, 100V, C	04-5519
INTEGRATED CIRCUITS			
	U1	CD4001BE	06-6064
	U2	CD4093BE	06-6030
	U3	LS7031	06-6114
	U4	CD4001BE	06-6064
	U5	CD4098BE	06-6066
	U6	CD4511BE	06-6065
	U7	ULN2003A	06-6073
	U8	CA3082	06-6004
RESISTORS			
	R7	560K, 1/4W, 5%	10-7027
	R9-R10	560K, 1/4W, 5%	10-7027
	R18	4.7K, 1/4W, 5%	10-7014
	R19	100K, 1/4W, 5%	10-7023
	R20	4.7K, 1/4W, 5%	10-7014
RESISTOR NETWORK	RN1	33 OHM 14P DIP	12-7771
	RN2	10K 14P DIP	12-7772

	Reference	Description	Part Number
Clock/Logic Board, Drawing 167 x 363	BOARD	Completely Assembled Clock/Logic	5167-362
CRYSTAL	Y1	Micro Xtal X0-43B-1.0	01-5356
CAPACITORS			
	C1	0.01µF, 100V	04-5523
TRANSISTORS			
	Q1	2N3904	05-5755
INTEGRATED CIRCUITS			
	U1	CD4093	06-6030
	U2	CD4001	06-6064
	U5-U7	CD4017	06-6001
	U8	CD40102	06-6062
	U138-U139	RDD104	06-6060
DIODES			
	CR142	1N4001	07-6268
RESISTORS			
	R1	22K, 1/4W, 5%	10-7070
	R2	220K, 1/4W, 5%	10-7066
	R3-R4	22K, 1/4W, 5%	10-7070
	R8	560K, 1/4W, 5%	10-7027
	R9	1K, 1/4W, 5%	10-7009
	R10	560K, 1/4W, 5%	10-7027
	R11-R18	56K, 1/4W, 5%	10-7021
CONNECTORS			
	JP141	531220-22P	13-8099
		103186-1 HEADER	13-8471

	Reference	Description	Part Number
Dual Audio Board, Drawing 337 x 58			
	BOARD	Assembled Dual Audio	5337-066
CAPACITORS	C2-C5	0.01µF	04-5523
	C6	100µF, 10V, DT	04-5576
TRANSISTORS	Q1-Q2	VN2222LL	05-5816
INTEGRATED CIRCUITS	U1-U2	ICM7555IPA	06-6136
	U3	CD4098BE	06-6066
RESISTORS			
	R1	10K, 1/4W, 5%	10-7016
	R2	2.2MEG 1/4W, 5%	10-7052
	R3	33K, 1/4W, 5%	10-7019
	R4-R5	1 OHM, 1%	12-7555
	R7	56K, 1/4W, 5%	10-7021
	R8-R9	10K, 1/4W, 5%	10-7016
	R11	10K, 1/4W, 5%	10-7016
	R12	2.2MEG, 1/4W, 5%	10-7052
	R13-R14	33 OHM, 1/4W, 5%	10-7001
TRANSFORMERS	T1-T2	M177-1 AUDIO	40-0948
6-Digit Readout Board, Drawing 167 x 29	BOARD	6-Digit Readout	5167-030-00
INTEGRATED CIRCUITS	U1-U6	LED-HP5082-7653	07-6283
Mother Board, Drawing 337 x 219	BOARD	Assembled Mother Board	5337-219
CAPACITORS	C1	100µF, 35V	04-5595
	C2-C3	10µF, 20V	04-5592
	C4	100µF, 35V	04-5595
	C5	0.1µF, 100V	04-5521
	C6	100µF, 10V	04-5576
	C7-C9	10µF, 20V	04-5592

	Reference	Description	Part Number
RESISTORS			
	R1	560 OHM, 1/4W, 5%	10-7054
	R3	10K, 1/4W, 1%	12-7540
	R5	560 OHM, 1/4W, 5%	10-7054
DIODES			
	CR1	1N5819	07-6306
	CR2	1N4001	07-6268
VOLTAGE REGULATORS			
	VR1	LM2597-5.0	06-6723
	VR2	LM78L12ACZ	05-5812
CONNECTORS	P1	CJ50-20A-30	13-8050
	P2-P3	1-640456-4 MTA 100X14	13-8141
	P4	CJ50-44A-30	13-8083
	P5	CJ50-20A-30	13-8050
	P6-P7	CJ50-30A-30 5167-021-00	13-8052
	P9-P10	DB15RA/F-P	13-8576
	P11	640456-5 MTA 100X5	13-8057
	P12	CJ50-44A-30 5167-362	13-8083
	P15	640456-8 MTA 100X8	13-8039
	P17	640456-9 MTA 100X9	13-8094
	P18	MTA100X11	13-8059
	P19-P20	640456-4 MTA 100X4	13-8088
	J1	RAPC712	13-8445
	J2	BNC-RA-50 OHM	21-8976
INDUCTOR	L1	DO3308P-154	22-9301
FUSES	F1	DO3308 THERMAL FUSE	21-9031
Preamp Board, Drawing 337 x 22C	BOARD	Assembled Preamp	5170-027
CAPACITORS	C1	100pF, 3kV, C	04-5532
	C3	1µf, 35V, DT	04-5575
INTEGRATED CIRCUITS	U1	CA3096E	06-6023

	Reference	Description	Part Number
RESISTORS			
	R3	22K, 1/4W, 5%	10-7070
	R5	22K, 1/4W, 5%	10-7070
	R6	10K, 1/4W, 5%	10-7016
	R7	33K, 1/4W, 5%	10-7019
	R10	330 OHMS, 1/4W, 5%	10-7053
	R12	10K, 1/4W, 5%	10-7016
	R13	1K, 1/4W, 5%	10-7009
MISCELLANEOUS	2 EA.	RECPT-CLOVERLEAF	
		011-6809	18-8771

Wiring Diagram, Drawing 337 x 66

	C2	0.0015µf, 3KV, C	04-5518
CAPACITORS	C3	10,000µF, 50V	04-5577
	C4	1600µF, 50V	04-5535
	C5-C6	0.1µF, 35V, T	04-5501
CONNECTORS	J1	RECPT-EAC 309	13-7982
	P1	EDGE-CJ50-20A-30 10 PIN	13-7852
	P2-P3	EDGE-CJ50-30A-30 15 PIN	13-7853
	P4	EDGE-CJ50-44A-30 22 PIN	13-7866
	P5	EDGE-CJ50-20A-30 10 PIN	13-7852
	P6-P7	EDGE-CJ50-30A-30 15 PIN	13-7853
	P8	RECPT-UG931/U PANEL MHV	13-7757
	P9-P10	"D" RECPT RD15F000V30	
		15 PIN	13-7789
	P11	Hard-Wired	
	P12	EDGE-CJ50-44A-30 22 PIN	13-7866
	P13	RECPT-UG568/U PANEL C	13-7752
	P14	CONN-RECPT-UG1094/U	
		SCREW BNC	13-7753
SWTICHES			
	S1	30-1-PB GRAYHILL	08-6517
	S2	TOGGLE 7952-K6	08-6525
	S3	30-1-PB GRAYHILL	08-6517
	S4	GRAYHILL	
		55D36-01-2-AJN	08-6514
	2 EA.	177602G-ECCO	08-6521
DIODES	CR1	1N5242	07-6264
	CR2-CR3	1N4001	07-6268
	CR4	PILOT RED LAMP	21-9299

	Reference	Description	Part Number
RESISTORS	R1	10K, 10-TURN	09-6761
	R2	1 MEG, 1/4W, 5%	10-7028
	R3	10K TRIMMER	09-6753
	R9	10K, 1/4W, 5%	10-7016
	R11	10K TRIMMER	09-6753
	R13	2.2K, 1/4W, 5%	10-7012
TRANSFORMER			
	T1	M2929 X5	4275-023
VOLTAGE REGULATORS	VR1	LM323K	05-5773
	VR2	LM340K-24	05-5774
MISCELLANEOUS			
	F1	FUSE - #312001 3-AGC-1	21-9277
		FUSE HOLDER 341001	21-9269
	DS1	UNIMORPH	21-9251
	DS2	UNIMORPH	21-9251
	DS3	LAMP-IDI 2110A1	21-9296
		LAMP-IDI 2110A1	21-9296
	M1	METER ASSEMBLY	4167-302
		LAMP-CLIP 515-0051	21-9300
		LAMP-PLUG 515-0074	21-9301
	2 EA.	BRIDGE RECT-250JB1L	07-6281

Section

10

Drawings

Power Supply Board, Drawing 337 x 27

Power Supply Board Component Layout, Drawing 377 x 35

Amplifier/Discriminator Board, Drawing 337x 19

Amplifier/Discriminator Board Component Layout, 337 x 4-42A

Scaler/Ratemeter Board, Drawing 167 x 170

Scaler/Ratemeter Board Component Layout, Drawing 167 x 176

Clock/Logic Board, Drawing 167 x 363

Clock/Logic Component Layout, Drawing 167 x 364

Dual Audio Board, Drawing 337 x 58

Dual Audio Component Layout, Drawing 337 x 59

6-Digit Readout Board, Drawing 375 x 60

6-Digit Readout Board Component Layout, Drawing 375 x 60A

Mother Board, Drawing 337 x 219

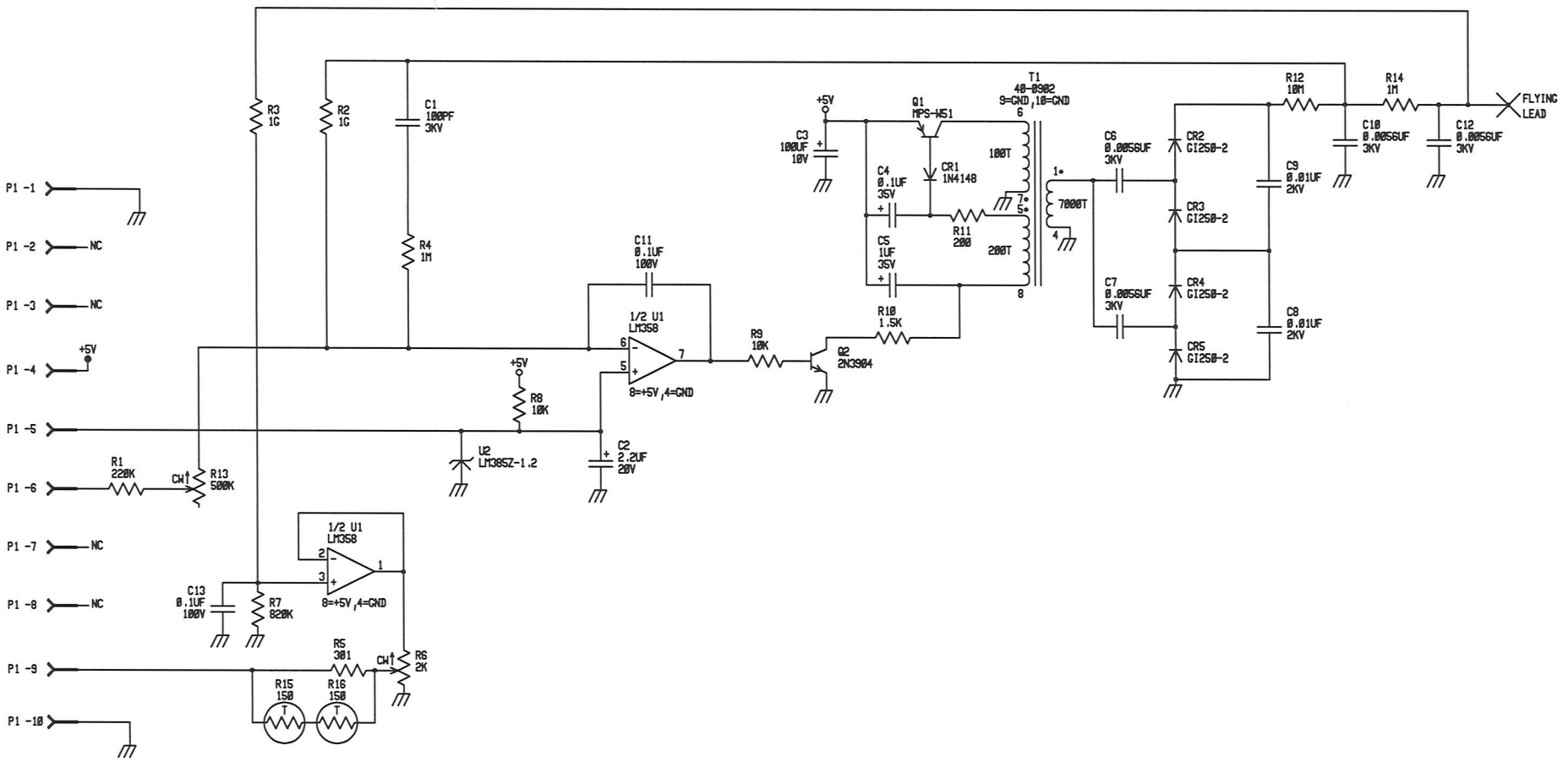
Mother Board Component Layout, Drawing 337 x 220 (2 sheets)

Preamp Board, Drawing 337 x 22

Preamp Board Component Layout, Drawing 170 x 31

Wiring Diagram, Drawing 337 x 231

REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



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DSGN	-	
APPD	RDS	20 JAN 99
NEXT HIGHER ASSY.	-	
09:52:09	19-Jan-99	S8337031

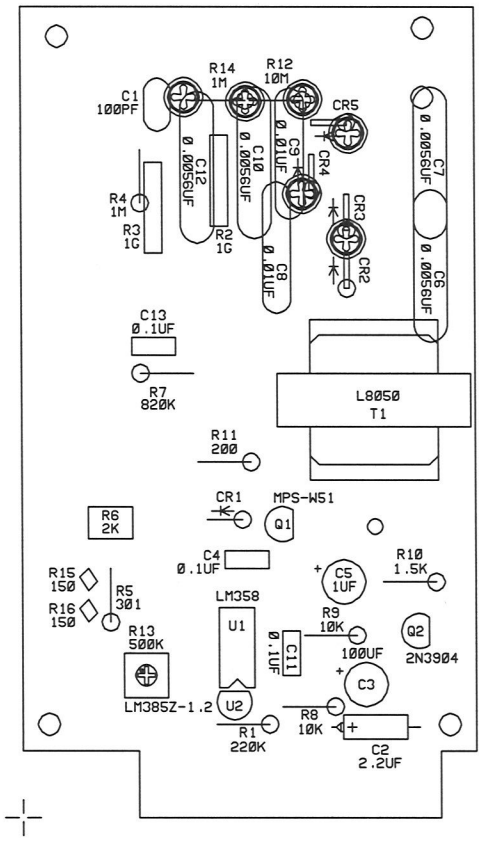
LUDLUM MEASUREMENTS INC.

TITLE: POWER SUPPLY BOARD (2500V)

BOARD# 5337-031

SIZE	MODEL	SERIES	SHEET
C	2929	337	27

SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.					
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CHK R.C.	19-Jan 99	BOARD: 5337-031			
DSGN		MODEL: 2929			
APP RDS 20JAN99		FILENAME:	BS337031		
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		REVISION	SERIES	SHEET	
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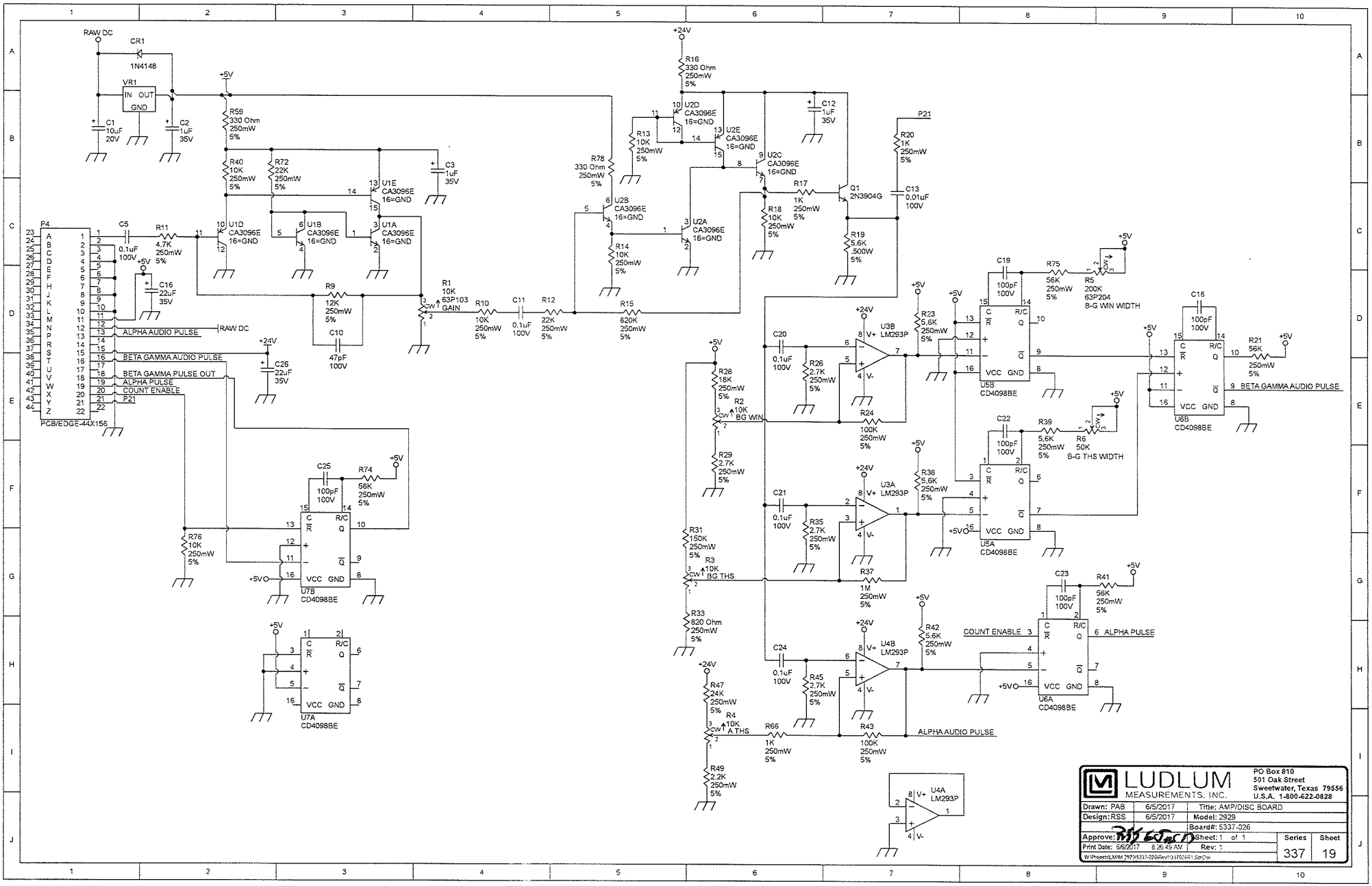
RAW DC
CR1
1N4148
VR1
IN OUT
GND
C1 10uF 20V
C2 1uF 35V
+5V
R59 330 Ohm 250mW 5%
R40 10K 250mW 5%
R72 22K 250mW 5%
C3 1uF 35V
U1E CA3096E 16=GND
U1D CA3096E 16=GND
U1B CA3096E 16=GND
U1A CA3096E 16=GND
P4
PCB/EDGE-44X156
C5 0.1uF 100V
R11 4.7K 250mW 5%
C16 22uF 35V
ALPHA AUDIO PULSE
BETA GAMMA AUDIO PULSE
BETA GAMMA PULSE OUT
ALPHA PULSE
COUNT ENABLE
P21
R9 12K 250mW 5%
C10 47pF 100V
R1 10K 63P103 GAIN
R10 10K 250mW 5%
C11 0.1uF 100V
R12 22K 250mW 5%
R15 820K 250mW 5%
C26 22uF 35V
+24V
R16 330 Ohm 250mW 5%
R78 330 Ohm 250mW 5%
U2D CA3096E 16=GND
U2E CA3096E 16=GND
U2C CA3096E 16=GND
U2B CA3096E 16=GND
U2A CA3096E 16=GND
R13 10K 250mW 5%
R14 10K 250mW 5%
R17 1K 250mW 5%
R18 10K 250mW 5%
Q1 2N3904G
R19 5.6K .500W 5%
C12 1uF 35V
C13 0.01uF 100V
P21
R20 1K 250mW 5%
C20 0.1uF 100V
R26 2.7K 250mW 5%
R24 100K 250mW 5%
U3B LM293P
R23 5.6K 250mW 5%
C19 100pF 100V
R75 56K 250mW 5%
R5 200K 63P204 B-G WIN WIDTH
U5B CD4098BE
C18 100pF 100V
R21 56K 250mW 5%
BETA GAMMA AUDIO PULSE
U6B CD4098BE
R28 18K 250mW 5%
R2 10K BG WIN
R29 2.7K 250mW 5%
C21 0.1uF 100V
R35 2.7K 250mW 5%
R37 1M 250mW 5%
U3A LM293P
R38 5.6K 250mW 5%
C22 100pF 100V
R39 5.6K 250mW 5%
R6 50K B-G THS WIDTH
U5A CD4098BE
R31 150K 250mW 5%
R3 10K BG THS
R33 820 Ohm 250mW 5%
C24 0.1uF 100V
R45 2.7K 250mW 5%
R43 100K 250mW 5%
U4B LM293P
R42 5.6K 250mW 5%
C23 100pF 100V
R41 56K 250mW 5%
COUNT ENABLE
ALPHA PULSE
U6A CD4098BE
R47 24K 250mW 5%
R4 10K A THS
R66 1K 250mW 5%
R49 2.2K 250mW 5%
ALPHA AUDIO PULSE
U4A LM293P
C25 100pF 100V
R74 56K 250mW 5%
R76 10K 250mW 5%
U7B CD4098BE
U7A CD4098BE
VCC GND
R/C
LUDLUM MEASUREMENTS, INC.
PO Box 810
501 Oak Street
Sweetwater, Texas 79556
U.S.A. 1-800-622-0828
Drawn: PAB 6/5/2017
Design: RSS 6/5/2017
Approve:
Print Date: 5/6/2017 8:26:45 AM
Title: AMP/DISC BOARD
Model: 2929
Board#: 5337-026
Sheet: 1 of 1
Rev: 1
Series 337
Sheet 19
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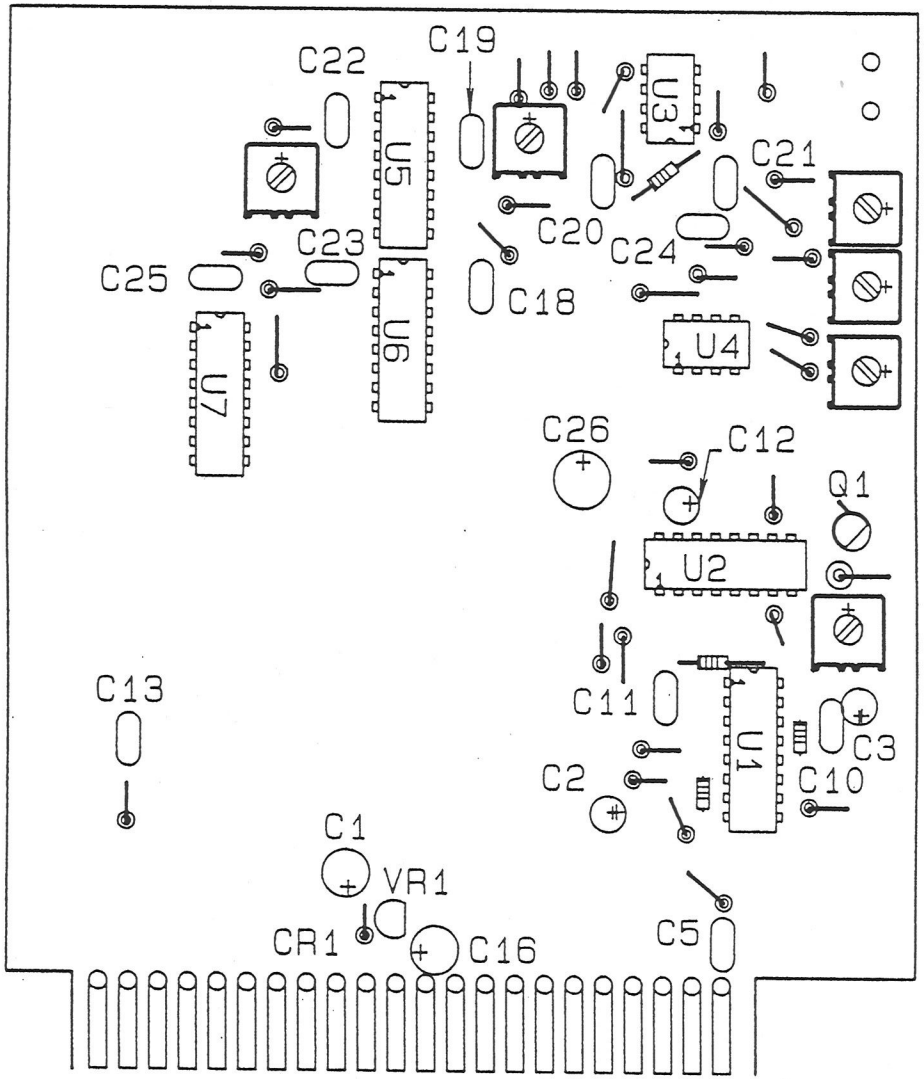

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MODEL: 2929	
PART #: 5337-026	
DWN: BQ	DATE: 5-24-94
DSGN:	DATE:

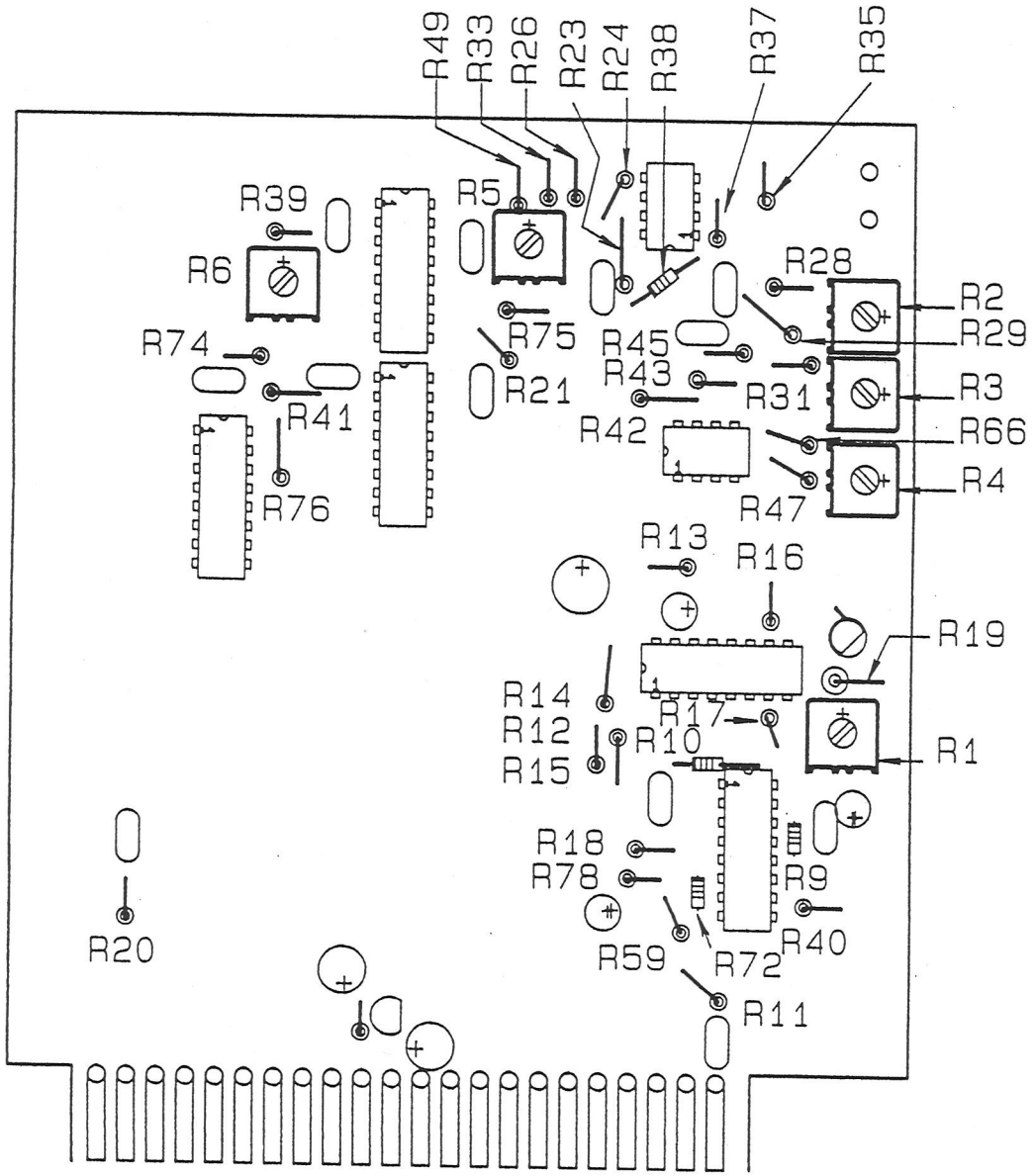
CHG	NO.					DWN	CHK	APP
DWN	DATE	CHK	DATE	APP	DATE			
BQ	5-24-94	DW	3/16/95	JW	5-26-95			

TOL: SHOP STD ☐ OTHER | SCALE: FULL ☐ OTHER

TITLE M2929 DUAL CHANNEL SCALER

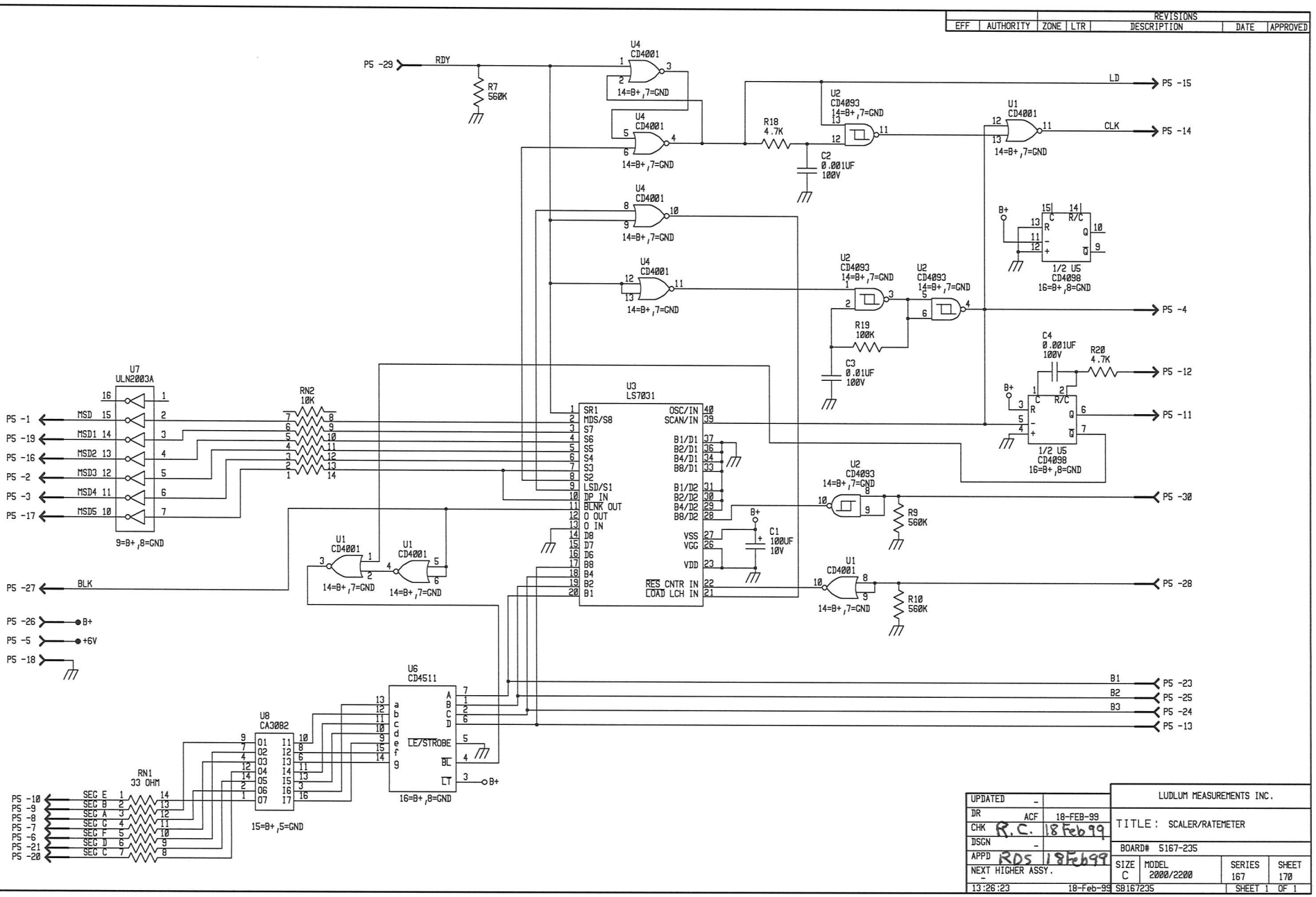
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556

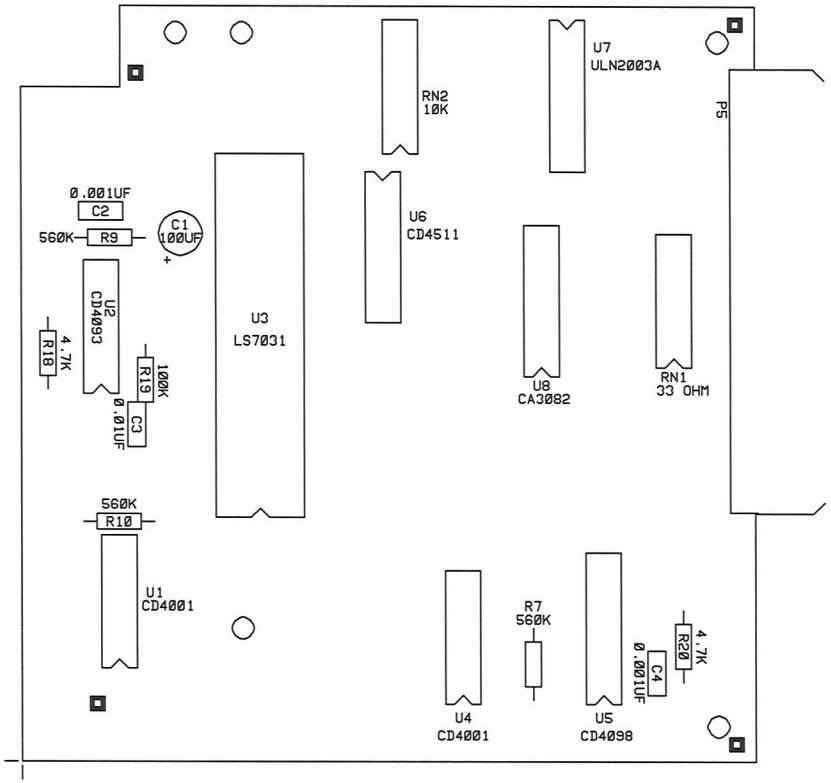
SERIES	SHEET
337	42



DESC: AMPLIFIER DISCRIMINATOR	
MODEL: 2929	
PART #: 5337-026	
DWN: BQ	DATE: 5-24-94
DSGN:	DATE:

CHG	NO.				DWN	CHK	APP
DWN	DATE	CHK	DATE	APP	DATE		
BQ	5-24-94	DCA	5/16/95	JGW	5-16-95		
TOL: SHOP STD ☐ OTHER			SCALE: FULL ☐ OTHER				
TITLE M2929 DUAL CHANNEL SCALER							
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556			SERIES 337		SHEET 42A		


REVISIONS
EFF | AUTHORITY | ZONE | LTR | DESCRIPTION | DATE | APPROVED
P5 -29
RDY
R7
560K
U4
CD4001
14=B+,7=GND
R18
4.7K
C2
0.001UF
100V
U2
CD4093
14=B+,7=GND
U1
CD4001
LD
P5 -15
CLK
P5 -14
B+
R/C
1/2 U5
CD4098
16=B+,8=GND
P5 -4
R19
100K
C3
0.01UF
100V
C4
0.001UF
100V
R20
4.7K
P5 -12
P5 -11
U7
ULN2003A
9=B+,8=GND
RN2
10K
P5 -1
MSD
P5 -19
MSD1
P5 -16
MSD2
P5 -2
MSD3
P5 -3
MSD4
P5 -17
MSD5
U3
LS7031
SR1
MDS/S8
S7
S6
S5
S4
S3
S2
LSD/S1
DP IN
BLNK OUT
O OUT
O IN
D8
D7
D6
B8
B4
B2
B1
OSC/IN
SCAN/IN
B1/D1
B2/D1
B4/D1
B8/D1
B1/D2
B2/D2
B4/D2
B8/D2
VSS
VGG
VDD
RES CNTR IN
LOAD LCH IN
C1
100UF
10V
R9
560K
P5 -30
R10
560K
P5 -28
P5 -27
BLK
P5 -26
B+
P5 -5
+6V
P5 -18
U6
CD4511
LE/STROBE
BL
LT
16=B+,8=GND
B1
B2
B3
P5 -23
P5 -25
P5 -24
P5 -13
U8
CA3082
15=B+,5=GND
RN1
33 OHM
P5 -10
SEG E
P5 -9
SEG B
P5 -8
SEG A
P5 -7
SEG C
P5 -6
SEG F
P5 -21
SEG D
P5 -20
SEG C
UPDATED -
DR ACF 18-FEB-99
CHK R.C. 18Feb99
DSGN -
APPD RDS 18Feb99
NEXT HIGHER ASSY. -
13:26:23 18-Feb-99
LUDLUM MEASUREMENTS INC.
TITLE: SCALER/RATEMETER
BOARD# 5167-235
SIZE C | MODEL 2000/2200 | SERIES 167 | SHEET 170
S0167235
SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR ACF	18-FEB-99	TITLE: SCALER/RATEMETER BOARD	
CHK CKB	12-JUL-99	BOARD: 5167-235	
DSGN		MODEL: 2000/2200	
APP RDS	12 Jul 99	FILENAME: BS167235	
COMPONENT	SOLDER	14:00:06	12-Jul-99
		REVISION	SERIES / SHEET
OUTLINE	OUTLINE	1.0	167 / 176

REVISIONS						
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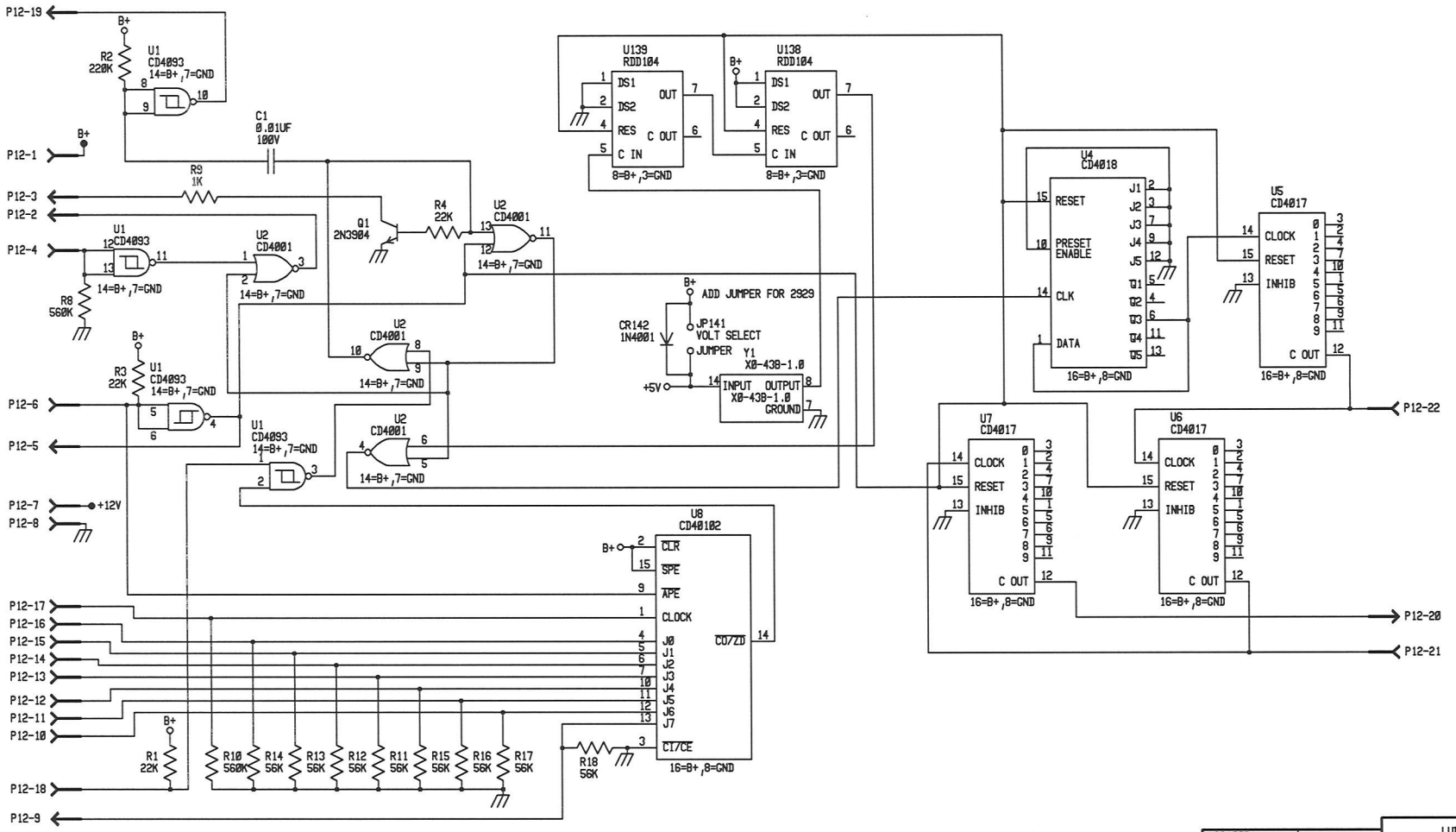

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CHK	CKB	16-NOV-98
DSGN	DL	10-NOV-97
APPD	RDS	16/Nov/98
NEXT HIGHER ASSY.	-	
13:54:36		12-Nov-98

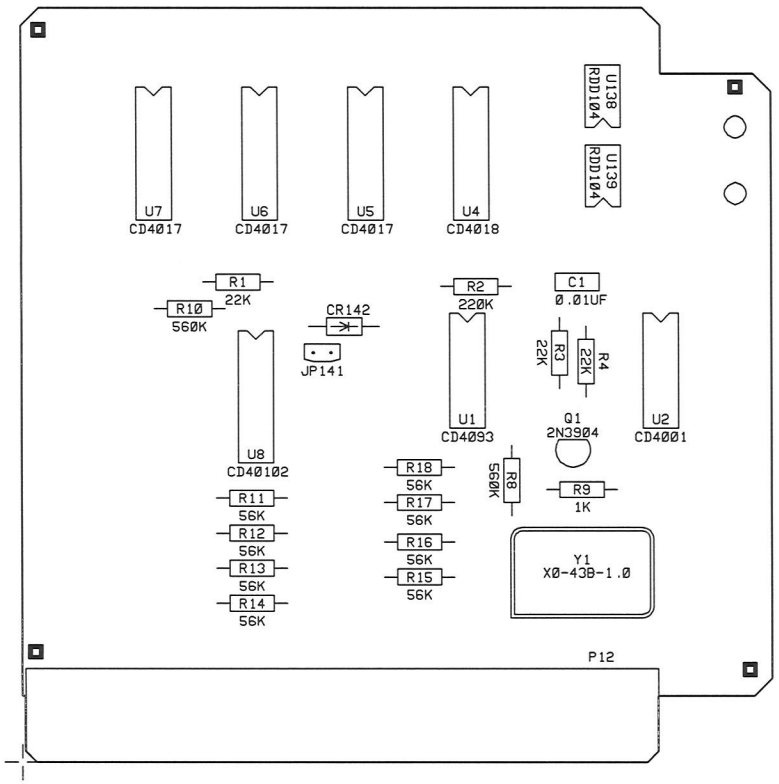
LUDLUM MEASUREMENTS INC.

TITLE: CLOCK LOGIC BOARD

BOARD# 5167-362

SIZE	MODEL	SERIES	SHEET
C	2000/2200/2929	167	363

S8167362 SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.					
DR ACF	12-NOV-98	TITLE: CLOCK/LOGIC BOARD			
CHK CKB	16-NOV-98	BOARD: 5167-362			
DSGN DL	10-NOV-97	MODEL: 2200			
APP RDS	16Nov98	FILENAME: BS167362			
COMPONENT	SOLDER	13:52:28	12-Nov-98		
		REVISION	SERIES	SHEET	
OUTLINE		1.0	167	364	

REVISIONS						
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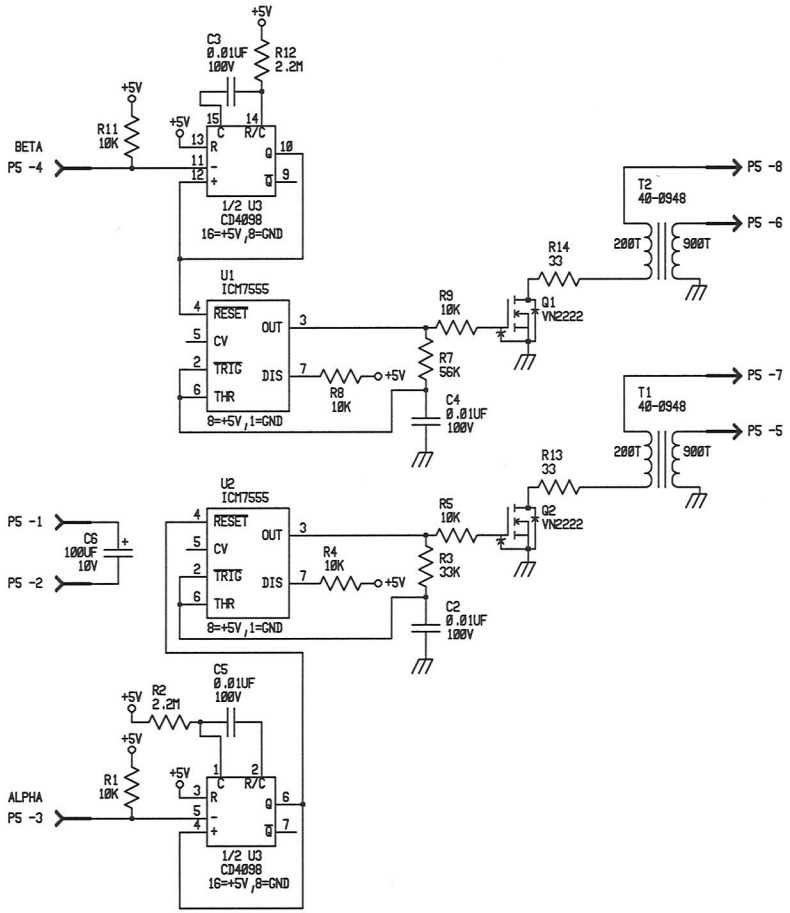

UPDATED	-		LUDLUM MEASUREMENTS INC.
DR	ACF	10-FEB-98	TITLE: DUAL AUDIO BOARD
CHK	CKB	12-FEB-98	
DSGN	RDS	19-FEB-86	BOARD# 5337-066
APPD	JGW	2-12-98	SIZE C / MODEL 2929 / SERIES 337 / SHEET 58
NEXT HIGHER ASSY.	-		
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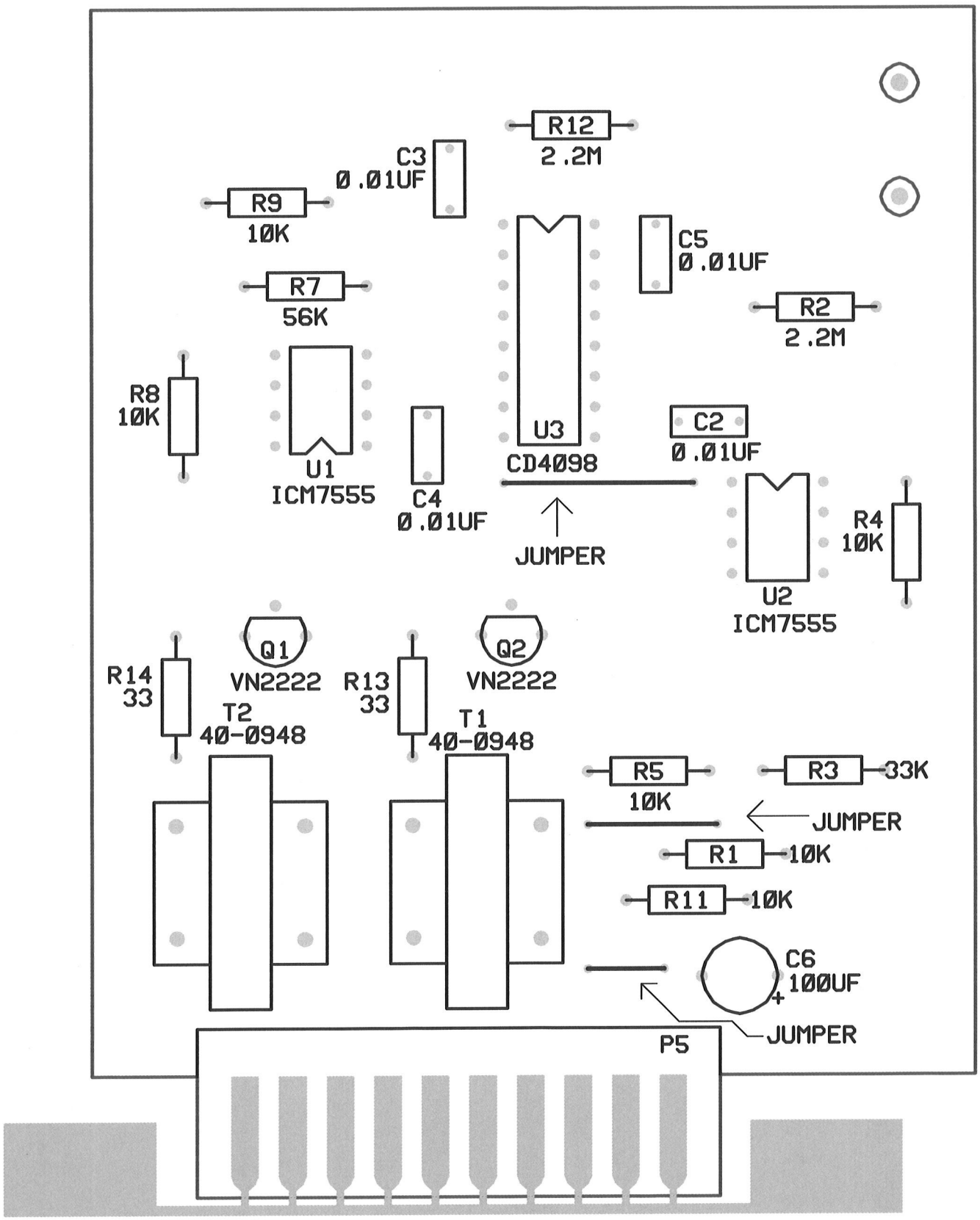
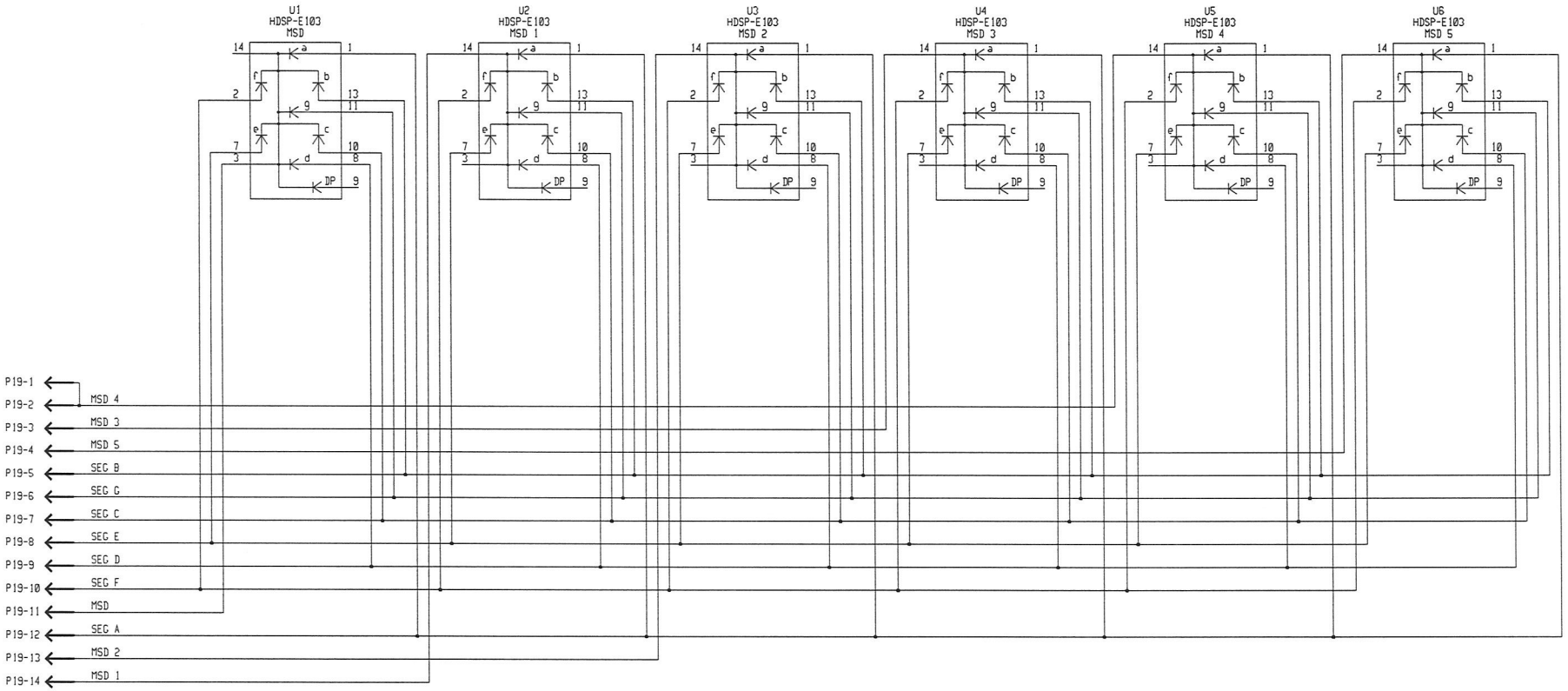
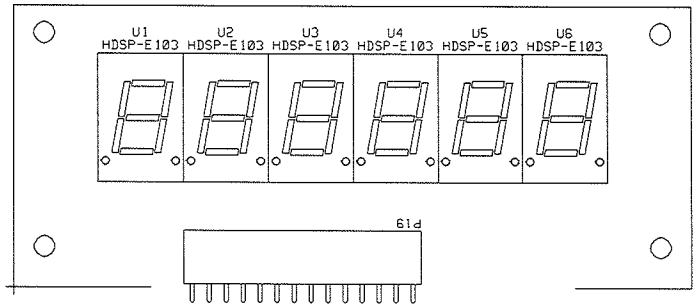


LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, TX 79556 U.S.A. 1-800-622-0828	
Title: DUAL AUDIO BOARD			
Drawn: ACF	2/11/98	**Model:** 2929	
Design: RDS	2/19/86	**Board#:** 5337-066	
Approve:		**Rev:** 1	
PCBA Drawing		**SCALE: 1.05**	**Series** 337 / **Sheet** 59
Print Date: 5/28/2015 10:26:52 AM		Top Overlay	
W:\Projects\LMIM 2929\5337-066\Rev1\337066R1_Assy.PcbDoc			

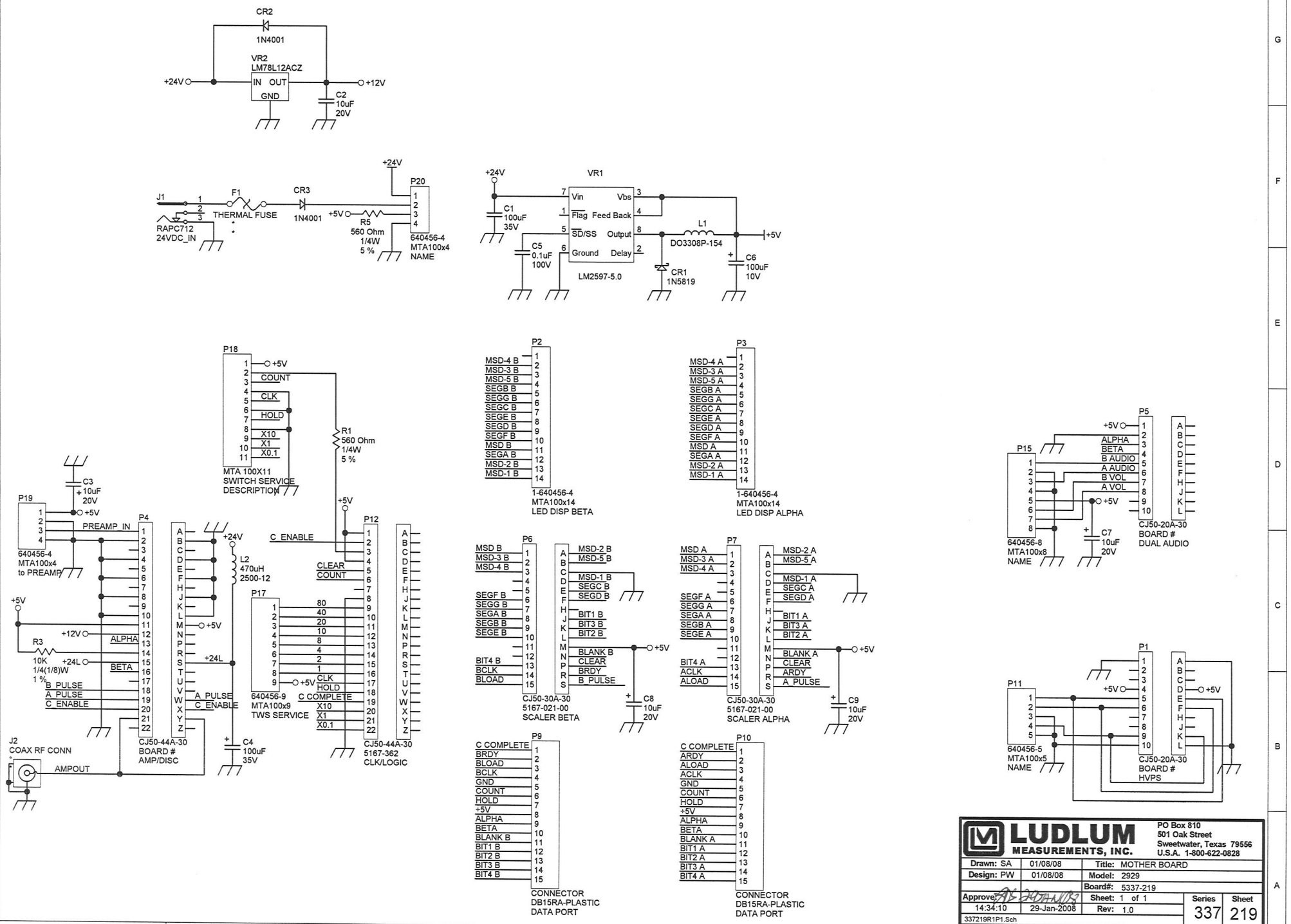
REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



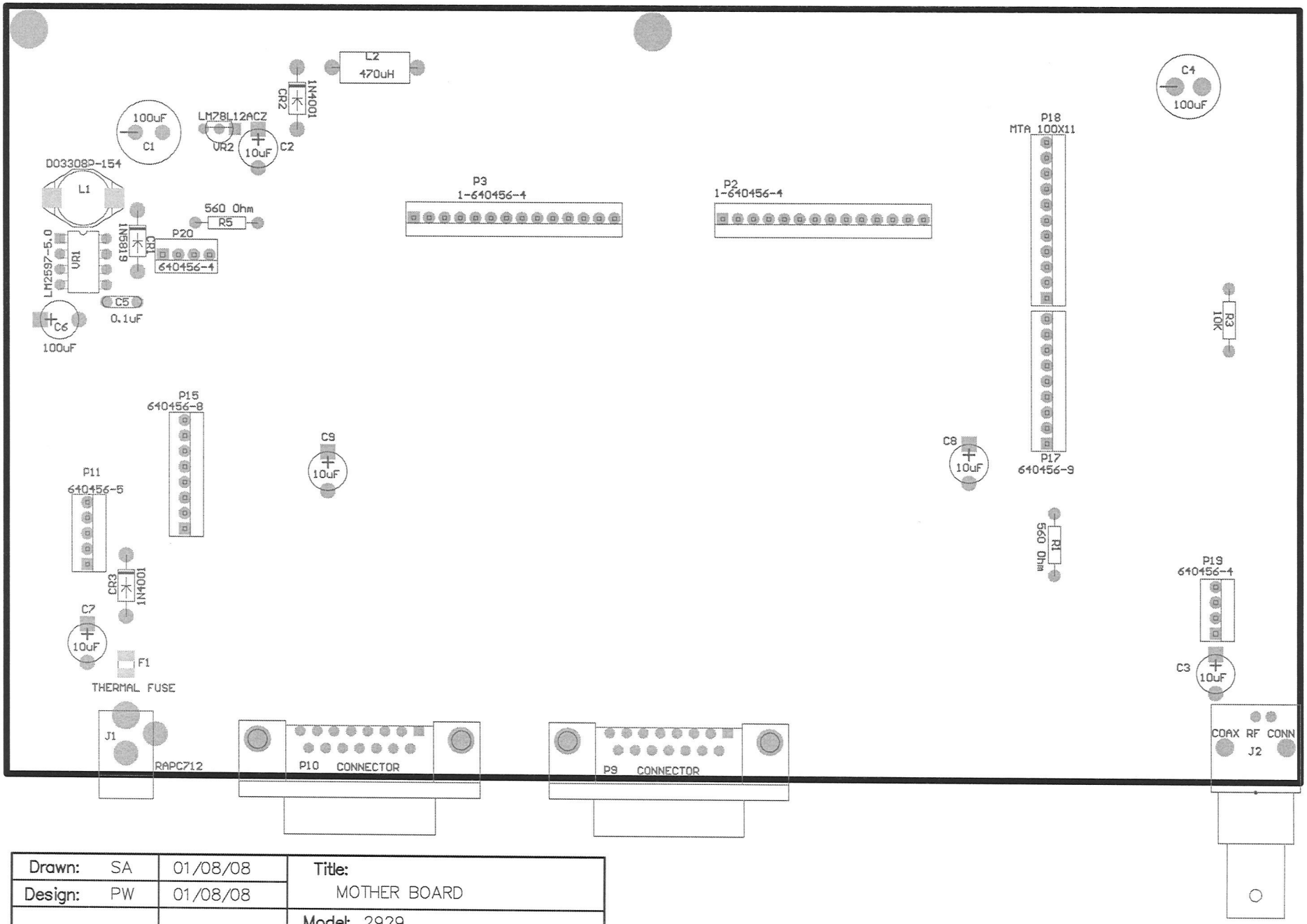
UPDATED	-		LUDLUM MEASUREMENTS INC.
DR	CKB	22-OCT-97	TITLE: 6 DIGIT DISPLAY BOARD
CHK			
DSGN	-	-	BOARD# 5375-031
APPD	RB	01Feb05	SIZE C / MODEL CW2200 / SERIES 375 / SHEET 60
NEXT HIGHER ASSY. -			11:31:19 23-Oct-97 SB375031 SHEET 1 OF 1



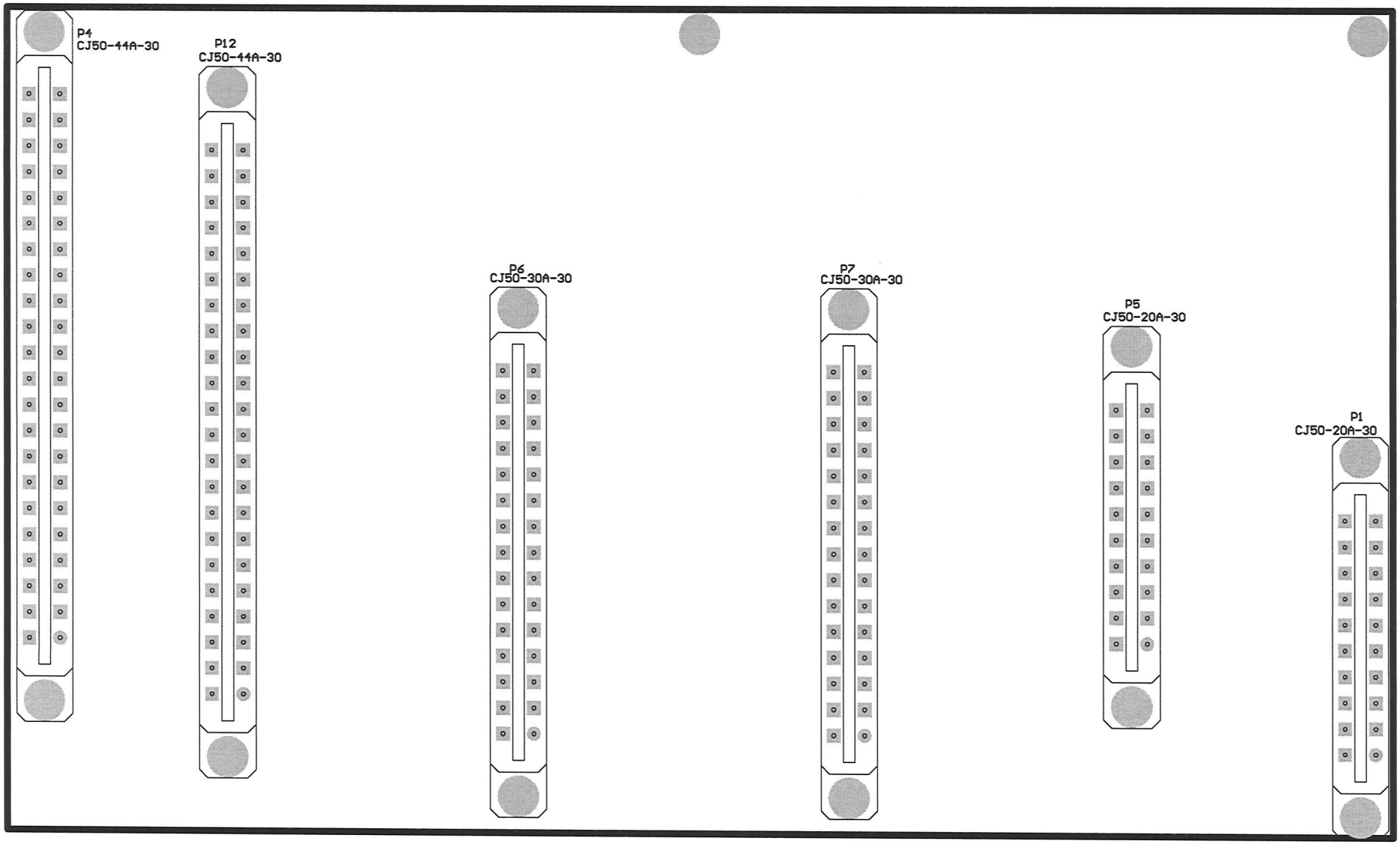
LUDLUM MEASUREMENTS INC. SWEETWATER, TX.			
DR		TITLE:	
CKB	14-NOV-97	BOARD: DISPLAY BOARD	
DSGN		MODEL: 5375-031	BS375031
APP		CUSTOMER NAME: 375	
COMPONENT	SOLDER	REVISION	SERIES / SHEET
10:28:04 12-Jan-08		1.0	375 / 60
OUTLINE	OUTLINE		



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: SA	01/08/08	Title: MOTHER BOARD	
Design: PW	01/08/08	Model: 2929	
		Board#: 5337-219	
Approved:		Sheet: 1 of 1	Series 337 / Sheet 219
14:34:10	29-Jan-2008	Rev: 1.0	
337219R1P1.Sch			

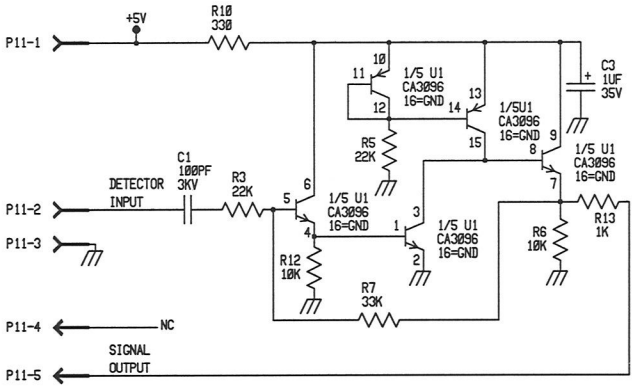


Drawn: SA	01/08/08	Title: MOTHER BOARD			
Design: PW	01/08/08				
		Model: 2929			
Approve:	01Feb08	Board#: 5337-219			
Layer:		Rev: 1.0	Series	Sheet	
MID:		SCALE: 1.15	337	220	
17:33:52	29-Jan-2008				
337219R1X1.Pcb					

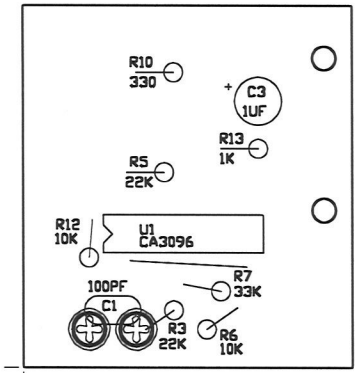


Drawn: SA	01/08/08	Title: MOTHER BOARD			
Design: PW	01/08/08				
		Model: 2929			
Approve: RBS	01Feb08	Board#: 5337-219			
Layer:		Rev: 1.0	Series	Sheet	
MID:		SCALE: 1.15	337	220	
17:21:53	29-Jan-2008				
337219R1X1.Pcb					

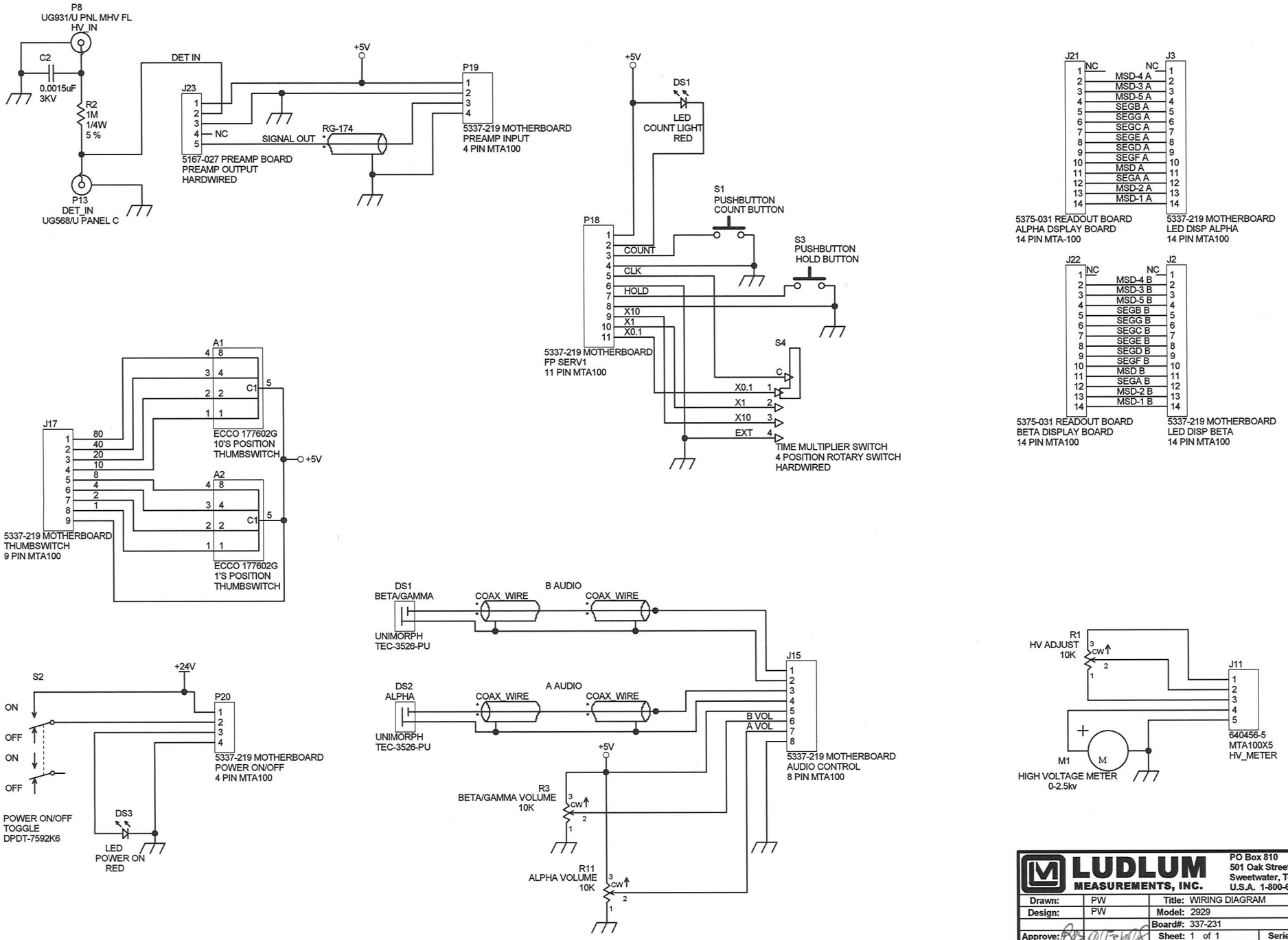
REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



UPDATED	-		LUDLUM MEASUREMENTS INC.
DR	ACF	18-FEB-98	TITLE: PREAMP
CHK	CRB	18-FEB-98	
DSGN	RDS	20-FEB-86	BOARD# 5170-027
APPD	RDS	18Feb98	SIZE C / MODEL 2929 / SERIES 337 / SHEET 22
NEXT HIGHER ASSY. -			
16:01:43	18-Feb-98	S170027	SHEET 1 OF 1



LUDLUM MEASUREMENTS INC. SWEETWATER, TX.					
DR CKB	22-JAN-99	TITLE: PREAMP BOARD			
CHK R.C.	22-Jan99	BOARD: 5170-027			
DSGN		MODEL: 2929			
APP BS	1-22-99	FILENAME: BS170027			
COMPONENT	SOLDER	22-Jan-99	13:27:59		
		REVISION	SERIES	SHEET	
OUTLINE		1.0	170	31	



LUDLUM MEASUREMENTS, INC.		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: PW		Title: WIRING DIAGRAM	
Design: PW		Model: 2929	
		Board#: 337-231	
Approve: RWS 01Feb08		Sheet: 1 of 1	Series: 337 / Sheet: 231
11:00:12	18-Jan-2008	Rev: 1	
337-231R1P1.SCH			