

**LUDLUM MODEL 193**

**SURVEY METER**

**May 2000**

**Serial No. 136337 and Succeeding  
Serial Numbers**



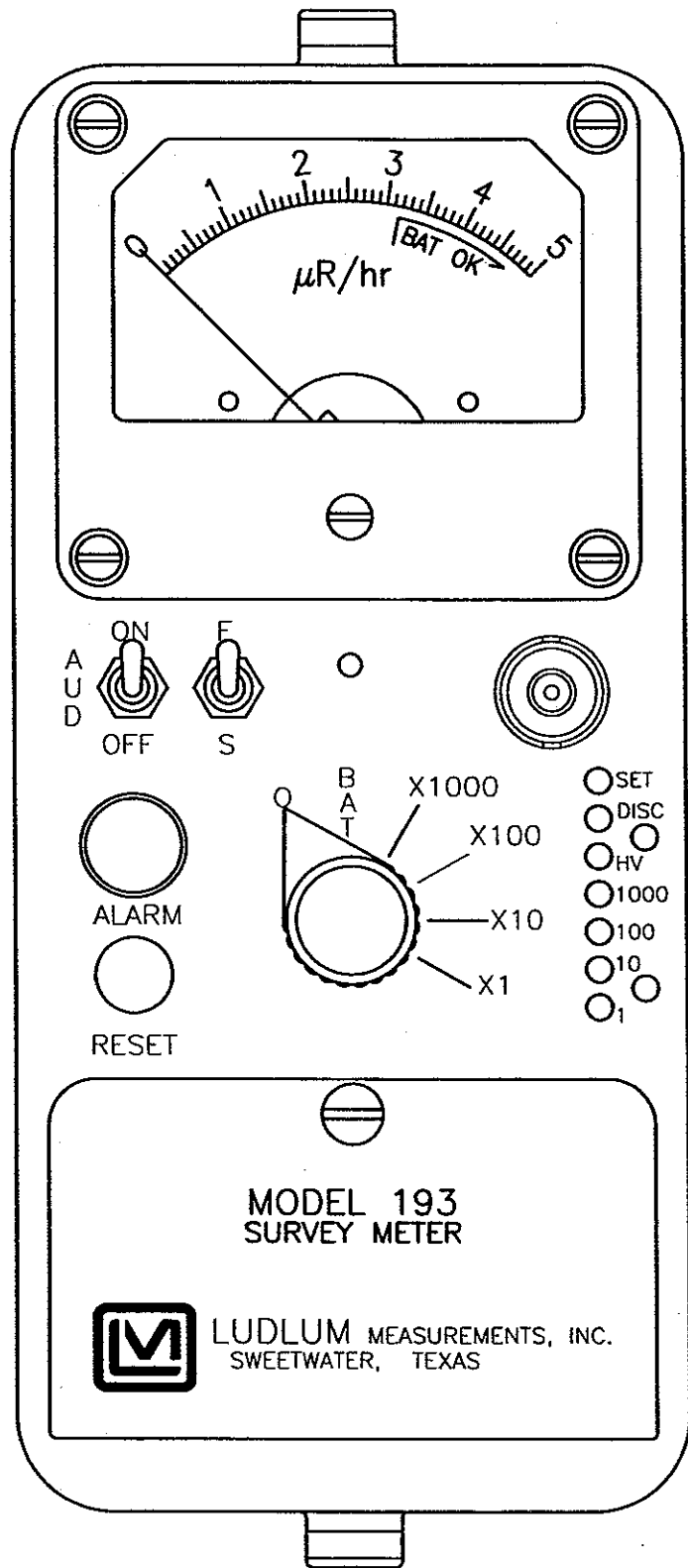
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REV #	ALTERATIONS	DATE	BY
	VALID	5-13-97	JGW



DWN	DATE	CHECKED	APPROVED
JGW	5-13-97	<i>BS 5-13-97</i>	<i>BLH 5-13-97</i>

TITLE: M 193 FRONT PANEL DRAWING

LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556	SERIES	SHEET
	363	772

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**1. GENERAL**

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The Model 193 Survey Meter is a portable gamma survey instrument with an adjustable audible and visual alarm. The Model 193 is designed to use external scintillation detectors. Range multipliers of X1, X10, X100 and X1000 provide an operating range from 0-5000 microroentgens per hour ( $\mu\text{R/hr}$ ) (0-50  $\mu\text{Sv/h}$ ) used in conjunction with the 0-5  $\mu\text{R/hr}$  (0-0.05 $\mu\text{Sv/h}$ ) meter dial.

The Model 193 offers two types of alarms:

(1) a user-adjustable, meter-driven alarm. For example, an alarm point can be set at 25  $\mu\text{R/hr}$  (0-0.25 $\mu\text{Sv/h}$ ), activating a steady tone and alarm light.

(2) A deviation beep alarm which "beeps" and flashes the alarm light when the radiation level rises above background. The background level is determined by an 8-second interval following power-up or following a reset. During these 8 seconds, beeps from the speaker and flashes of the ALARM lamp will occur every half-second. After the background update period, the instrument is ready to survey.

This instrument is the choice for rapid surveys of very low level radiation. The deviation beep alarm allows inexperienced users to easily use the Model 193. The user does not have to watch the meter closely to find "hot" items.

If the detector uses a sodium iodide (NaI) crystal, low energy gamma radiation will cause the meter to over-respond.

The over-response is characteristic of the NaI scintillation material. A typical response curve shows an over-response of 5-8 times at about 120 KeV. See detector response curves in the specific detector manuals.

**CAUTION**

The instrument, depending upon the detector used, will respond to radiation from X-ray machines and pulsed radiation sources, but non-linearity may occur due to the integration time of the M193.

Other features include a 2-position meter response time selection; adjustable detector operating voltage (HV) from 200-1500 volts; and an alarm audible tone with "AUD ON/OFF" switch.

The instrument is capable of using either standard "D" cell alkaline or the nickel cadmium rechargeable batteries. However, the Model 193 does not include circuitry for recharging batteries; thus, the rechargeable batteries must be removed for recharging. A battery test scale is provided to check the status of the batteries when the range selector switch is moved from "OFF" to "BAT" position.

All controls and adjustments are located on the front panel. The calibration controls are covered to prevent any inadvertent adjustment to the detector operating parameters. The two "D" cell batteries are located in an isolated compartment and are easily accessible from the front panel. The meter is housed in a rugged, aluminum bezel with a gasket seal.

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2. SUGGESTED OPERATING PROCEDURES

2.1 Battery Installation

Ensure the Model 193 power switch is in the "OFF" position. Open the battery lid by turning the quarter-turn thumb screw counterclockwise. Install two "D" size batteries in the compartment. Note the (+) and (-) marks inside the battery door. Match the battery polarity to these marks. Close the battery box lid.

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

2.2 Power-On and Instrument Check

Connect detector to Model 193 instrument.

Check that both toggle switches on Model 193 are up, pointing to AUD "ON," and "F." (See note below.)

**✓ NOTE**  
Operation with toggle switches in AUD "OFF" and Slow ("S") positions is not recommended for surveys. These positions should be used for specific measurements in a radiation field or "hot" spot.

Rotate the Range selector switch to the "BAT" position. The meter pointer should deflect above the vertical mark in the "BAT OK" region.

The M193 will establish the

background level during the 8 seconds after power-up. To signify that the instrument is not yet ready to survey, the Model 193 will beep and flash the ALARM lamp every half-second during the 8-second period. When the half-second beeps are finished, the instrument is ready to survey.

**✓ NOTE**  
It is important when turning power on, or when pressing "RESET," to be in an area of normal background radiation. This will ensure the highest sensitivity of the beep deviation alarm toward small increases in background.

Select the X10 range position. If no radiation source is nearby, any meter deflection is due to background radiation. (At the LMI factory, a typical reading is 6 - 12  $\mu\text{R/hr}$  [0.06-0.12 $\mu\text{Sv/h}$ ]).

Expose the detector to a check source and confirm meter response. "Beeps" should be audible with increasing frequency as the meter deflects upscale. Position check source where the meter pointer deflects above the alarm threshold and ensure that the ALARM lamp and a constant audible tone are initiated. Remove check source.

**✓ NOTE**  
To produce consistent check source readings between functional checks, be sure to place the source on the detector in the same orientation for each test.

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### 2.3 Surveying for Radiation

#### 2.3.1 Background

When surveying for radiation, frequent mention is made of "background radiation," or just "background." Many people do not realize that radiation is everywhere and so is just considered as "background." This background radiation is due to natural materials that emit radiation and to cosmic radiation. The amount of background radiation will vary, depending upon geographical location, environmental factors, and other conditions. The important thing to remember while surveying is that we are looking for excess radiation above "background."

#### 2.3.2 Surveying Technique

Follow the procedure under section 2.2 for power-up and instrument check to verify that the instrument is working correctly.

To survey people or items, hold the detector such that its front end is within 1-6 inches of the surface of the object/person. Move the detector slowly over the surface of the object/person, while listening for **multiple** beeps. Occasionally, background will cause the instrument to beep, which indicates that the instrument is OK. But **multiple** beeps indicate an increase in the radiation level and possibly the presence of radioactive material.

Note that with the range switch in the "X1" position, 5  $\mu\text{R/hr}$  ( $0.05\mu\text{Sv/h}$ ) is the maximum measurable value. In the "X10" position, 50  $\mu\text{R/hr}$  ( $0.5\mu\text{Sv/h}$ ) is the maximum. For the "X100" and "X1000" positions, the maximum values indicated on the meter are 500  $\mu\text{R/hr}$  ( $5\mu\text{Sv/h}$ ) and 5000

$\mu\text{R/hr}$  ( $50\mu\text{Sv/h}$ ), respectively. The value of 5000  $\mu\text{R/hr}$  is equal to 5  $\text{mR/hr}$  ( $0.05\text{mSv/h}$ ) and represents the largest exposure rate that can be read by the Model 193 Survey Meter. By comparison, current United States Nuclear Regulatory Commission (USNRC) guidelines set a non-occupational limit of 100  $\text{mrem/year}$ , with no more than 2  $\text{mrem}$  in any one hour. For gamma radiation only, this limit corresponds to about 100  $\text{mR/year}$  ( $1\text{mSv/year}$ ), with no more than 2  $\text{mR}$  ( $0.02\text{mSv}$ ) in any one hour. Using this dose as an example, if the Model 193 meter reads "5" while in the "X1000" range, a non-radiation worker can spend no more than 24 minutes in that radiation field.

#### 2.3.3 False Alarms

Two situations come up frequently that may cause some concern. The first involves alarms caused by people who have just had some kind of nuclear medicine treatment. These treatments will include a radioactive substance being ingested or injected into the patient. While short-lived, this radiation will be measurable for days after the treatment.

The second situation involves materials which are naturally "hot" or radioactive. These materials, usually minerals dug from the ground, contain trace amounts of radioactive elements, distributed uniformly throughout the load.

Either situation may cause an alarm to be actuated or a reading above background levels; however, if a careful contamination survey reveals no "hot spots," one of these situations could exist.

In any case, take suitable precautions against unnecessary exposure to radiation by utilizing time, distance, and shielding factors.

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**3. SPECIFICATIONS**

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● **POWER:** two standard "D" size batteries

● **BATTERY LIFE:** exceeds 600 hours with a fresh set of alkaline "D" cell batteries

● **BATTERY DEPENDENCE:** calibration variance less than 3% to battery endpoint

● **OPERATING TEMPERATURE:** -20 to 140°F (-29 to 60°C)

● **OPERATING RANGE:** 4 linear range multipliers of X1, X10, X100 and X1000; meter scale presentation of 0-5  $\mu\text{R/hr}$  (0-0.05 $\mu\text{Sv/h}$ ) provides an overall range of 0-5000  $\mu\text{R/hr}$  (0-50 $\mu\text{Sv/h}$ )

● **LINEARITY:** within  $\pm 10\%$  of true value

● **RESPONSE:** two selections - Fast ("F") and Slow ("S"), approximately 4 and 22 seconds, respectively, for deflection of 10-90% of full meter scale.

● **INPUT SENSITIVITY:** adjustable

from 10-30 mV; typically set at 30 mV

● **HIGH VOLTAGE:** externally adjustable from 200 to 1500 volts

● **ALARM:** adjustable from 10% of full meter scale to greater than full meter scale; audible and visual indication

● **AUDIO:** audible click-per-deviation; beeps for every 1/8 second interval that is 2 sigma above background level, enabled/disabled by "AUD ON/OFF" toggle switch; corresponds to alarm lamp initiation

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

● **SIZE:** 6.5" (16.5 cm) H X 3.5 in (8.9 cm)W X 8.5in (21.6 cm)L, including handle

● **WEIGHT:** 3.5 lbs (1.6 kg), including batteries

● **FINISH:** drawn-and-cast aluminum, with computer-beige polyurethane enamel and silk-screened nomenclature

**4. PRELIMINARY INSTRUCTIONS**

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**4.1 Unpacking and Repacking**

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● Remove calibration certificate and place in secure location. Remove instrument and accessories (batteries, etc.) and ensure that all of the items listed on the packing list are in the carton.

● To return the instrument for repair or calibration, provide sufficient packing material to prevent damage during

shipment. Provide appropriate warning labels to ensure careful handling. Include brief information as to the reason for return and the return shipping instructions, such as:

- return shipping address
- customer name or contact
- telephone number
- description of service requested and all other necessary information

## 5. DESCRIPTION OF CONTROLS AND FUNCTIONS

- **Range Multiplier Selector Switch:** 6-position rotary switch marked "OFF, "BAT, X1000, X100, X10, X1." The "BAT" position indicates battery status. The meter pointer should deflect above the vertical mark on the "BAT OK" scale. The X1, X10, X100, and X1000 multipliers are used in conjunction with the  $\mu\text{R/hr}$  meter dial. Multiply the scale reading by the multiplier to determine the actual reading.

- **AUD ON-OFF Toggle Switch:** In the "ON" position, the switch energizes the unimorph speaker, located on the left side of the instrument.

✓NOTE

The audible fixed ALARM is independent of the "AUD ON/OFF" switch. The audible alarm can only be silenced by depressing the "RESET" button.

- **F-S Toggle Switch:** Position switch to select meter response. Selecting the fast, "F," position of the toggle switch provides 10-90% of the final meter reading in four seconds. In slow, "S", position, 90% of the final meter reading takes 22 seconds. In "F" position, there is fast response and large meter deviation. In "S" position, there is a slow response and damped meter deviation.

- **ALARM Light:** Red lamp that illuminates when the meter pointer deflects above the alarm setpoint or flashes when the radiation level rises above background radiation levels. An audible alarm tone will accompany the visual alarm. The alarm is latching and will remain in the alarm condition until the "RESET" button is depressed.

- **RESET Pushbutton:** When depressed, provides a rapid means to drive the meter to zero. "RESET" also causes an 8-second background update. During these 8 seconds, the unimorph will "beep," and the ALARM light will flash every half-second.

■ Remove "CAL" cover to access:

✓NOTE

Multi-turn potentiometers discussed below are 20-turn (approximately).

- **Alarm SET:** Multi-turn potentiometer used to adjust the alarm threshold. The threshold is set by exposing the M193 to the desired radiation field and adjusting the "SET" control until the alarm point corresponds to the meter reading. The range is adjustable from 10-100% of full scale on each range multiple.

- **DIS (Discriminator):** Multi-turn potentiometer used to vary the detector pulse counting threshold (input sensitivity) from 10-30 millivolts. The discriminator is typically set at 30 mV and requires a Model 500 Pulse Generator or equivalent to check/adjust the input sensitivity.

- **HV Adjustment:** Multi-turn potentiometer which provides a means to vary the detector operating voltage (HV) from 200 to 1500 volts. The HV setting may be checked at the detector connection (internal) with an appropriate voltmeter.

- **Range Calibration Adjustments:** Multi-turn potentiometers for the X1000, X100, X10, and X1 range multipliers. These controls allow individual calibration for each range multiplier.



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## 6. CALIBRATION

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■ A Ludlum Model 500 Pulser or equivalent is required. If the Pulser does not have a high-voltage readout, use a high voltage meter with at least 1000 megohms input resistance for HV measurements.

Ensure that the meter movement has proper mechanical zero. The adjustment is on the front of the meter bezel. It must be adjusted to "zero" with the Range selector switch in the "OFF" position.

Rotate the Range selector switch to the "BAT" position. The meter pointer should deflect above the vertical mark on the "BAT OK" indication.

Remove the "CAL" cover. Disable the alarm by adjusting the "SET" control to the maximum counterclockwise position. Rotate the Range switch to the "OFF" position.

Disconnect detector (if connected) and connect the Pulser to the M193.

Adjust the Pulser pulse amplitude to approximately 30 mV.

Rotate the M193 Range switch to the "X1000" position.

Adjust the Pulser count rate for a cpm output of approximately: [4000 $\mu$ R/hr (40 $\mu$ Sv/h)=700Kcpm] for a (1" x 1") and [4000 $\mu$ R/hr (40 $\mu$ Sv/h)=3.6Mcpm] for a (2" x 2"). The M193 meter should indicate approximately 80% of full scale; however, there will be no needle deflection at all if the M193 DIS potentiometer is set too high (too far counterclockwise). In this case, adjust the DIS potentiometer (clockwise)

for maximum needle deflection; that is, until further adjustment produces no additional needle deflection.

Adjust the Pulser MULTIPLIER, COARSE and FINE controls for approximately 80% of full-scale deflection on the M193 meter ("4").

Decrease the Pulser AMPLITUDE LO-HI control until the Pulser meter indicates 30 millivolts (mV).

Adjust the M193 DIS potentiometer (clockwise) until the M193 meter indicates approximately 60% of full scale ("3"). This should be the knee of the input sensitivity plateau or slightly above the area where a small decrease in the AMPLITUDE LO-HI control causes the M193 meter pointer to fall rapidly toward the low end of the dial. The M193 input sensitivity is the voltage indicated at this point on the Pulser meter.

Reconnect detector.

Expose the detector to <sup>241</sup>Am source. Switch the Range multiplier switch to the position where the meter responds to the source. Decrease the HV (counterclockwise) until the meter indication starts to drop off. If the meter does not respond, switch to the X1 range position and slowly increase the HV (clockwise) until the meter starts to respond to the source.

Measure the detector HV.

Increment the HV in 50 volts steps and plot exposure rate (source and

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background) versus HV to produce a graph similar to the one in Figure 1. Repeat without source for measurement of background radiation.

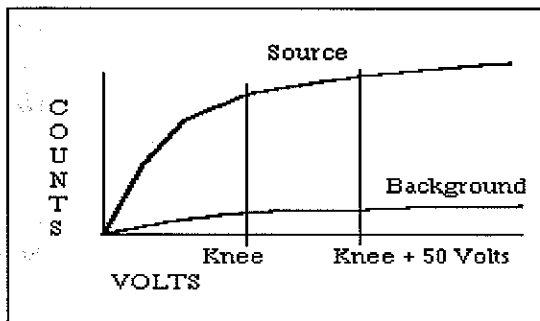


Figure 1

■ The "plateau" is that portion of the curve from the knee to the point where either the source counts or background counts start to rapidly increase with a small change in detector high voltage.

Adjust the HV to approximately 50 volts above the plateau knee. The plateau length should be at least 100 volts.

Reconnect detector.

Switch the Range multiplier to the X1000 position. Expose the instrument to a calibrated gamma field which corresponds to approximately 80% (4000 $\mu$ R/hr) (4  $\mu$ Sv/h) of full meter scale. Adjust the X1000 range calibration control for proper reading. Position detector in a field which corresponds to approximately 20% of meter scale and confirm meter indicates within  $\pm 10\%$  of the field. Repeat calibration for the X100, X10, and X1 ranges.

✓ **NOTE:** If, in the previous step, the calibration range background is too high for the lower scale(s) or if the appropriate radiation fields are not available, the lower scale(s) will have to be electronically

(Pulser) calibrated as follows:

Turn instrument off.

Disconnect the detector and connect a Ludlum Model 500 Pulser or equivalent to the Model 193. Switch to the lowest range position calibrated with radiation. Adjust Pulser negative pulse amplitude to 50 mV.

Adjust the Pulser count rate until the meter reads approximately 80% of full meter scale. Note the count rate.

Switch the Model 193 to the next lower position and decade the Pulser to the next lowest range.

Adjust the calibration potentiometer to correspond to approximately 80% of full scale reading. Check the 20% scale indication by dividing the Pulser count rate by 4. Repeat on lower scale if necessary.

Turn the M193 OFF and disconnect the Pulser. Reconnect the detector.

■ The calibrated M193 should display a value representing the background radiation. At the LMI factory, a typical background reading is 6-12  $\mu$ R/hr (0.06-0.12 $\mu$ Sv/h).

Adjust the alarm set point by exposing the instrument to a source to drive the meter pointer to the desired alarm point. Adjust the alarm "SET" potentiometer until the alarm is initiated. Remove source and depress the "RESET" button to disable alarm. Slowly increase meter reading with check source to confirm desired alarm set point. Readjust "SET" control as necessary.

## 7. MAINTENANCE

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Instrument maintenance consists of keeping the instrument clean and periodically checking the batteries and the calibration.

To assure proper operation of the instrument between calibrations, the instrument should be tested with a check source prior to each use. A reference reading should be obtained when exposed to the check source in a constant and reproducible manner at the time of calibration. If the instrument response differs from the reference reading by more than  $\pm 20\%$ , the instrument should be returned to a calibration facility for maintenance, repair or recalibration, as required.

Recalibration should be accomplished after any maintenance or adjustment of any kind has been performed on the instrument. Battery replacements are not considered to

be maintenance and do not normally require the instrument to be recalibrated.

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

The batteries should be removed and the battery contacts cleaned of any corrosion at least every 3 months. If the instrument has been exposed to a very dusty or corrosive atmosphere, more frequent battery servicing should be used.

Use a spanner wrench to unscrew the battery contact insulators, exposing the internal contacts and battery springs. Removing the handle will facilitate access to these contacts.



### NOTE

NEVER STORE THE INSTRUMENT OVER 30 DAYS WITHOUT REMOVING BATTERIES. ALTHOUGH THIS INSTRUMENT WILL OPERATE AT VERY HIGH AMBIENT TEMPERATURES, BATTERY SEAL FAILURE CAN OCCUR AT TEMPERATURES AS LOW AS 100° FAHRENHEIT.

## 8. THEORY OF OPERATION

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### 8.1 Input

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Detector pulses are coupled from the detector through C57 to emitter follower Q96. R83 and R89 provide bias. R137 protects Q96 from input shorts. R27 couples the detector to the high voltage supply.

### 8.2 Amplifier

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Self-biased amplifier U1 provides gain in proportion to R63 divided by R70. Transistor pins 4, 5, and 6 of U1, provide amplification. Pins 10-15 are coupled as a constant current source to pin 6 of U1. The output self-biases to  $2V_{be}$  (approx. 1.4 volts) at pin 7 of U1. This provides just enough bias current through pin 6 to conduct all of the current from the constant current source. Positive pulses from pin 7 are coupled to the discriminator (U2) through R64 and C109.

### 8.3 Discriminator

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Comparator U2 provides discrimination. The discriminator is set by the voltage at pin 3 of U2. These pulses are coupled to pin 5 of U3 for meter drive and pin 12 of U3 for audio.

### 8.4 Scale Ranging

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Detector pulses from the discriminator are coupled to univibrator pin 5 of U3. For each scale, the pulse width of pin 6 of U3 is increased by a factor of 10, with the actual pulse width being controlled by the front panel calibration controls and their related capacitors. This arrangement allows the same current to be delivered to C105 by 1

count on the X1 range as by 1000 counts on X1000 range.

### 8.5 Digital Analog Converter

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Pin 12 and 15 of U4 are coupled as a current mirror. For each pulse of current through R72, an equal current is delivered to C105. This charge is drained off by R74. The voltage across C105 is proportional to the incoming count rate.

### 8.6 Audio

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Discriminator pulses are coupled to univibrator pin 12 of U3. The front panel AUD "ON-OFF" selector controls the reset at pin 13 of U4. When ON, pulses from pin 10 of U3 turns on oscillator U5, which drives the can-mounted unimorph. Speaker tone is set by R84 and C112; with the duration by R86.

### 8.7 Meter Drive

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The meter is driven by the emitter to Q6, coupled as a voltage follower in conjunction with pin 1 of U6. For ratemeter drive, the meter is coupled to C105 at P1-15.

For battery test, the voltage follower is bypassed and the meter movement is directly coupled to the battery through R150.

### 8.8 Meter Compensation

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When the unit is provided with a high torque meter movement, with 1.2 volt drive, a temperature compensation circuit is provided on the main circuit board; components R181, R189 and R190.

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**8.9 Fast/Slow Time Constant**

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For slow time constant, C104 is switched from the output of the meter drive to parallel C105.

**8.10 Low Voltage Supply**

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Battery voltage is coupled to U7 and associated components (a switching regulator) to provide 5 volts at pin 5 to power all logic circuits. Unregulated battery voltage is used to power the meter drive (Q6) and the high voltage blocking oscillator (Q145).

**8.11 Low Voltage Reference**

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U101 provides a 1.22-volt precision reference for HV supply. This unit also biases Q96.

**8.12 High Voltage Supply**

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High voltage is developed by blocking oscillator Q145-T165 and rectified by voltage multiplier CR166,167,169 and 175. Output voltage increases as current through Q44 increases, with maximum output

voltage with Q44 saturated.

High voltage is coupled back through R47 to opamp pin 6 of U6. R147 completes the high voltage circuit to ground. High voltage output is set by front panel control HV, which sets bias of pin 5 of U6. During stable operation, the voltage at pin 6 of U6 will equal the voltage at pin 5 of U6. Pin 7 of U6 will cause conduction of Q44 to increase or decrease until the high voltage seeks a level of stability.

**8.13 Alarm**

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U2 is configured as a voltage comparator. The alarm "SET" potentiometer "wiper arm" is connected to pin 5 of U2. As the meter drive voltage, coupled to pin 6 of U2, increases above the alarm SET reference, pin 7 of U2 goes low. This causes Q200 to conduct, driving the drain of Q201 low and illuminating the alarm lamp. Audio is generated from Q200 conduction through CR202 to RESET line of U5. R210 and Q213 provide the latching alarm circuitry. Pins 7, 8, and 9 of transistor U4 provide alarm reset by way of the front panel "RESET" switch.

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**PARTS LIST**

Ref. No.	Description	Part No.	Ref. No.	Description	Part No.
<b>Model 193 Survey Meter</b>			<b>● INTEGRATED CIRCUITS</b>		
UNIT	Completely Assembled Model 193 Survey Meter	48-2959	U1	CA3096	06-6023
<b>Circuit Board, Drawing 363 X 756</b>			U2	TLC372	06-6265
BOARD	Assembled Circuit Board	5363-950	U3	CD4098	06-6066
<b>● CAPACITORS</b>			U4	CA3096	06-6023
C38	0.0015 $\mu$ F, 3kV, C	04-5518	U5	ICM7555	06-6136
C40-C41	0.0015 $\mu$ F, 3kV, C	04-5518	U6	TLC27M7IP	06-6248
C42	0.0027 $\mu$ F, 3kV, C	04-5520	U7	MAX631	06-6249
C50	100pF, 3kV, C	04-5532	U101	LM385Z-1.2	05-5808
C56	100 $\mu$ F, 10V, DT	04-5576	U224	PIC12C509	06-6420
C57	100pF, 3kV, C	04-5532	<b>● DIODES</b>		
C102	100 $\mu$ F, 10V, DT	04-5576	CR94	1N4148	07-6272
C103	10 $\mu$ F, 20V, DT	04-5592	CR166-CR167	1N4007	07-6274
C104	47 $\mu$ F, 16V, DT	04-5550	CR169	1N4007	07-6274
C105	10 $\mu$ F, 20V, DT	04-5592	CR175	1N4007	07-6274
C106	0.001 $\mu$ F, 100V, C	04-5519	CR207	1N4148	07-6272
C109	0.01 $\mu$ F, 100V, C	04-5523	<b>● RESISTORS</b>		
C112	470pF, 100V, C	04-5555	R18	1k, 1/4W, 5%	10-7009
C115	100 $\mu$ F, 10V, DT	04-5576	R27	33k, 1/4 W, 5%	10-7019
C119	0.001 $\mu$ F, 100V, C	04-5519	R36	10M, 1/4W, 5%	10-7031
C121	330pF, 100V, C	04-5531	R46	10k, 1/4W, 5%	10-7016
C126	10 $\mu$ F, 20V, DT	04-5592	R47	1G, FHV-1, 2%	12-7686
C134	100 $\mu$ F, 10V, DT	04-5576	R63	82k, 1/4W, 5%	10-7022
C163	0.01 $\mu$ F, 100V, C	04-5523	R64	1k, 1/4W, 5%	10-7009
C170	0.1 $\mu$ F, 100V, C	04-5521	R65	10k, 1/4W, 5%	10-7016
C171	1 $\mu$ F, 35V, DT	04-5575	R66	1k, 1/4W, 5%	10-7009
C191	0.0015 $\mu$ F, 3kV, C	04-5518	R68	8.2k, 1/4W, 5%	10-7015
C199	0.01 $\mu$ F, 100V	04-5523	R70	4.7k, 1/4W, 5%	10-7014
C2181	22pF, 100V, C	04-5552	R74	180k, 1/4W, 5%	10-7068
C219	0.1 $\mu$ F, 100V, C	04-5521	R75	33k, 1/4W, 5%	10-7019
C230-C231	15pF, 100V, C	04-5626	R76	10 OHM, 1/4W, 5%	10-7004
<b>● TRANSISTORS</b>			R77	2.2k, 1/4W, 5%	10-7012
Q6	2N3904	05-5755	R81	10k, 1/4W, 5%	10-7016
Q15	MPSW51	05-5765	R83	100k, 1/4W, 5%	10-7023
Q44	2N3904	05-5755	R84	470k, 1/4W, 5%	10-7026
Q96	2N3904	05-5755	R86	2.7M, 1/4W, 5%	10-7029
Q145	MPS6534	05-5763	R87	10k, 1/4W, 5%	10-7016
Q200	MPS6534	05-5763	R89	100k, 1/4W, 5%	10-7023
Q201	2N7000	05-5820	R91	4.7k, 1/4W, 5%	10-7014
Q233	MPS6534	05-5763	R137	10k, 1/4W, 5%	10-7016
			R138	1M, 1/4W, 5%	10-7028
			R150	2.37k, 1/8W, 1%	12-7648
			R159	10k, 1/4W, 5%	10-7016
			R172	47k, 1/4W, 5%	10-7020
			R177	200 OHM, 1/4W, 5%	10-7006

**M193 SURVEY METER**  
**May 2000**

Ref. No.	Description	Part No.	Ref. No.	Description	Part No.
R147	SAT TYP. (750k, 1%)	12-7693	<u>Calibration Board, Drawing No. 363 X 665</u>		
R189	301 OHM, 1/3W, 1%	12-7855	BOARD	Completely Assembled	5363-821
R235	100 k, 1/4W, 5%	10-7023		Calibration Board	
R242	100k, 1/3W, 5%	12-7747	●	<b>CAPACITORS</b>	
R243-R245	22k, 1/3W, 5%	12-7754		C1	0.047μF 100V C X7R
R246-R249	100k, 1/3W, 5%	12-7747	C2	0.0047μF 100V C X7R	04-5570
R250	22k, 1/3W, 5%	12-7754	●	<b>RESISTORS</b>	
R251	33.2k, 1/3W, 1%	12-7793		R1-R2	1 Meg Trimmer
R252	10k, 1/3W, 5%	12-7748	R3	100k, Trimmer	09-6813
R253	47k, 1/3W, 5%	12-7758	R4	1 Meg Trimmer	09-6814
R254	33.2k, 1/3W, 1%	12-7793	R5	100k, Trimmer	09-6813
R255- R256	100k, 1/3W, 5%	12-7747	R6	100k, 1/4W, 5%	10-7023
R257	1k, 1/3W, 5%	12-7750	R7	100k, Trimmer	09-6813
●	<b>THERMISTORS</b>		R8	47k, 1/4W, 5%	10-7020
R181	R1006-98.4-59-D1	07-6332	R9	100k, Trimmer	09-6813
R190	R1006-98.4-59-D1	07-6332	R10	1k, 1/8W, 1%	12-7637
●	<b>CRYSTALS</b>		●	<b>RESISTOR NETWORKS</b>	
Y229	MICRO XTAL-4.0 MHz	01-5201	RN1	NETWORK,-10k, SIP 8PIN	12-7720
●	<b>INDUCTORS</b>		●	<b>MISCELLANEOUS</b>	
L13	470μHY	21-9600	P3-P4	CONN-640456-5 MTA100	13-8057
●	<b>TRANSFORMERS</b>				
T165	L8050	40-0902			
●	<b>MISCELLANEOUS</b>				
7 EA	CLOVERLEAF 011-6809	18-8771			
P1	CONNECTOR 1-640456-7 MTA100	13-8121			
P2	CONNECTOR 640456-2 MTA100	13-8073			
P5	CONNECTOR 640456-2 MTA100	13-8073			
1 EA	JACK,-TEST 1128-09-0319	18-8806			
1 EA	CONTACT, #1434	18-9124			

**M193 SURVEY METER**  
**May 2000**

Ref. No.	Description	Part No.	Ref. No.	Description	Part No.
<b>Chassis Wiring Diagram, Drawing No. 464 X 5</b>			●	<b>MISCELLANEOUS</b>	
	● <b>RESISTORS</b>		*	COAX PIGTAIL	8363-964
R1	56 OHM, 1/4W, 5%	10-7096	DS1	UNIMORPH 60690	21-9251
			DS2	ALARM LED	07-6409
			*	BATTERY CONTACT SET	
	● <b>CONNECTOR</b>			(Portable)	2001-042
J1	CONN-1-640442-6	13-8187	*	CASTING Model 12SA	9363-816
J2	CONN-640442-2		*	PORTABLE CAN	
	MTA100	13-8178	*	ASSY (MTA)	4363-441
J3-J4	CONN-640442-5		*	MAIN HARNESS	
	MTA100	13-8140		Model 190/193	8363-959
J5	CONN-640442-2		M1	PORTABLE KNOB	08-6613
	MTA100	13-8178		PORTABLE BEZEL	
P6	SERIES "C" UG 706/U	13-7751	*	FRONT ASSY	4363-188
			*	METER BEZEL W/GLASS,	
			*	W/O SCREWS	4363-352
	● <b>SWITCHES</b>		*	METER MOVEMENT	
S1	Centerlab PA600-210	08-6501	*	(1mA)	15-8030
S2-S3	7101-SYZ-QE	08-6511	*	PORTABLE METER	
S4	MPS-203R (PB)	08-6697	*	FACE	7363-136
			*	HARNESS-PORT	
			*	CAN WIRES	8363-462
	● <b>BATTERY</b>		*	BATTERY LID ASSY	9363-955
B1-B2	"D" Duracell Battery	21-9313	*	PORT. LATCH KIT	
			*	W/O BATT. LID	4363-349
			*	PORT. CALIB. COVER	
			*	W/SCREWS	4363-200
			*	PORT. HANDLE (ROLLED)	
			*	W/SCREWS	4363-139
			*	REPLACEMENT CABLE	
				(STD 39")	40-1004



**M193 SURVEY METER**  
**May 2000**

**DRAWINGS AND DIAGRAMS**

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Main Circuit Board, Drawing 363 x 756

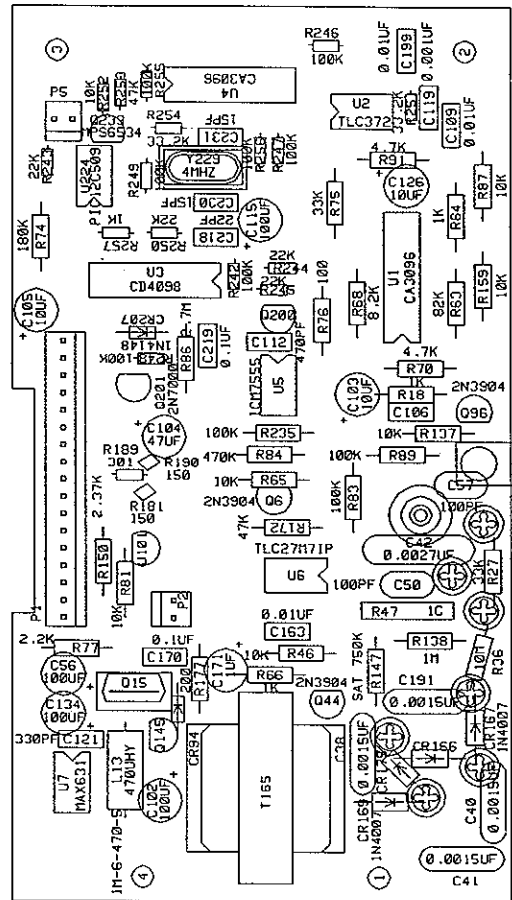
Main Circuit Board Component Layout, Drawing 363 x 757

Calibration Board, Drawing 363 x 665

Calibration Board Component Layout, Drawing 363 x 686

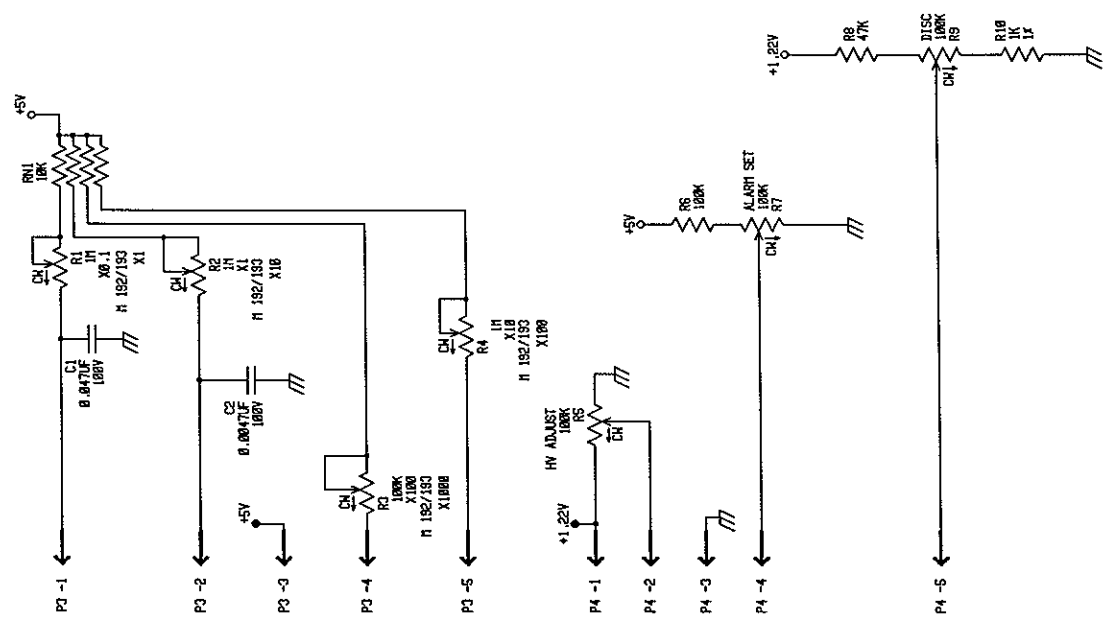
Wiring Diagram, Drawing 464 x 5





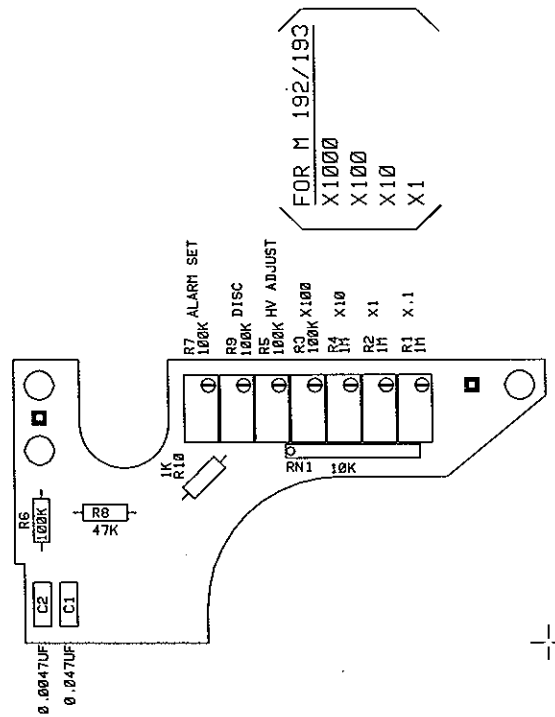
LUDLUM MEASUREMENTS INC. SHEETWATER, TX.	
DR	TJR 04-30-97
CHK	RS 5-07-97
DSON	RES 04-25-97
APP	JK 5-13-97
13-45-57	7-14-97-97
COMP PASTE	COMP TASK
SLDR PASTE	SLDR TASK
TITLE	MAIN BOARD
BOARD	5062-950
MODEL	199
SERIES	363
DATE	7/57
OUTLINE	

REV	DESCRIPTION	DATE	APPROVED
1			



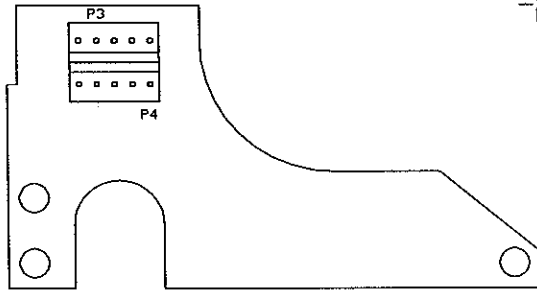
REV	DESCRIPTION	DATE	APPROVED
1			

REVISED	18-JUN-98	LUDLUM MEASUREMENTS INC.	
DR ACB	18-JUN-98	TITLE: CALIBRATION BOARD	
CHK	18-JUN-98	BOARD# 5063-021	
DESIGN RGS	12-JUN-98	SIZE	
APPD	RDS	MODEL	
NEXT HIGHER ASSY.		SERIES	
		C	
		125A \ 192 \ 193	
		SHEET	
		665	
		1 OF 1	



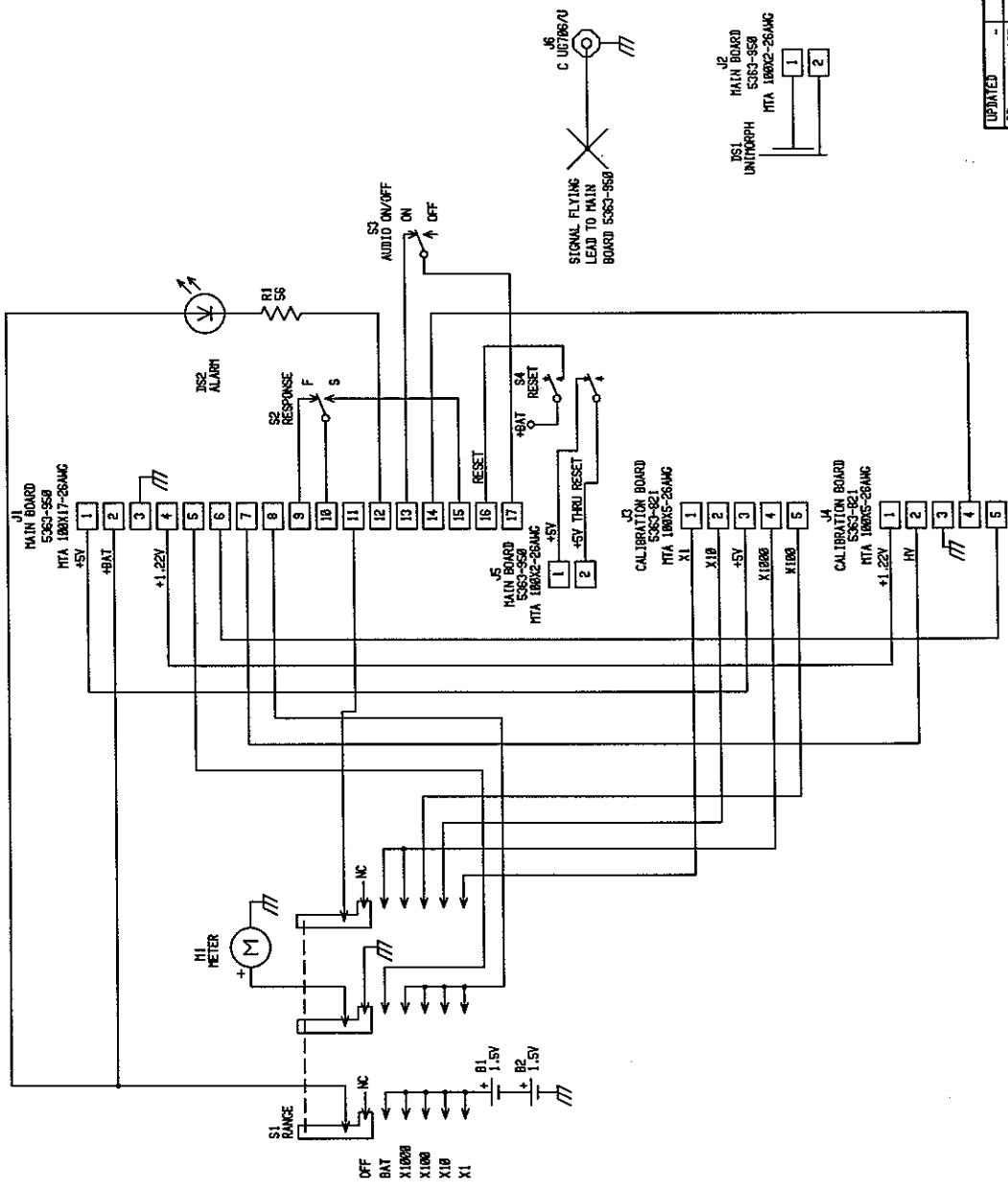
USED ON MODELS: 12SA, 192, 193

DR	ACF	13-JUN-98	TITLE	CALIBRATION BOARD	SHEETNAME	TX.
CHK	CS	15-JUN-98	BOARD#	5363-821	BS363821	
DSGN	RSE	12-JUN-98	MODEL	12SA	SERIES	363 SHEET 686
APP	20154	13-JUN-98	COMP	ARTWORK	<input type="checkbox"/>	SLDR
			COMP	OUTLINE	<input type="checkbox"/>	SLDR
			COMP	PASTE	<input type="checkbox"/>	SLDR
			COMP	TASK	<input type="checkbox"/>	SLDR
			COMP	TASK	<input type="checkbox"/>	SLDR



USED ON MODELS 12SA, 192, 193

	LUDLUM MEASUREMENTS INC.	SHEETWATER, TX.
DR	ACF	13-JUN-98
CHK	CB	17-JUN-98
DSGN	RSS	12-JUN-98
APP	MS	17-JUN-98
TITLE: CALIBRATION BOARD		BOARD# 5063-B21
MODEL 12SA		SERIES 063
COMP ARTWORK		SHEET 686
COMP OUTLINE		SILDR ARTWORK
COMP PASTE		SILDR OUTLINE
COMP MASK		SILDR PASTE
COMP MASK		SILDR MASK



UPDATED	10-JUN-98	LUDLUM MEASUREMENTS INC.
BY	ACE	
CHK	KB	TITLE: WIRING DIAGRAM
ISSN	12-JUN-98	BOARD: 464-987
APPD	RS	SIZE: MODEL C
WXT	NUMBER ASSI.	SHEET 464
14.07.98	8-AUG-98	SHEET 5