HIGH-VOLTAGE INTERLOCK SYSTEM FOR THE TAGGER HODOSCOPE

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1. INTRODUCTION

The 384 E-counters and 61 T-counters in the Tagger hodoscope are not individually light-tight. The light seal is provided by the hodoscope box, whose 24 side panels can be removed for access to the detectors. Before removing any of the side panels, it is essential to be sure that all counter high voltages are off. In addition to the damage to the photomultipliers which can be caused by exposure to excessive light, there is also a human safety hazard due to exposed high voltage on the photomultiplier bases.

The LeCroy 1458 High Voltage Mainframe has an input (the rightmost BNC on the bottom of the front panel, labeled "INTERLOCK" in the 1458 manual and the schematic drawings) which must be grounded (TTL low state) in order for the high voltage to be turned on. We have designed, constructed, installed and tested a system which disables the high voltage whenever one or more of the hodoscope side panels is not tightly installed. The system consists of (1) 24 interlock switch boxes, one installed on each side panel, and (2) an interlock panel, which receives the information from the switch boxes, generates the interlock to the LeCroy 1458 inputs, displays the system status using panel lights, and indicates which of the 24 side panels is responsible for a failure of the interlock.

2. INTERLOCK SWITCH BOXES

On the upper edge of each hodoscope side panel, an interlock box has been installed. The lever of a lever-type microswitch extends down from the box and is captured between the hodoscope box and the light-sealing foam on the inner surface of the side panel. When the panel is even slightly loosened, the microswitch lever jumps to the "panel open" position and disables the high voltage.

Figure 1 shows the construction of the interlock box and the schematic circuit diagram of the 24-box circuit. Each interlock box is connected to the preceding box by a 2-conductor cable attached to terminals A and B, and to the following box by a 2-conductor cable attached to terminals C and D. The 24 boxes are wired into a ring configuration, with terminals A1 and B1 (from the first box) and C24 and D24 (from the last box) connected to the interlock processing panel.

If the cables are not connected to the interlock panel, or if the interlock panel is in "H.V. ENABLE" mode, the inter-terminal resistances are given by:

	All panels closed	Panel *N* open	
A1-C24	24 kΩ	24 kΩ	(not used)
A1-D24	∞	*N* kΩ	(not used)
B1-C24	∞	∞	(not used)
B1-D24	0	∞	interlock
All terminals to chassis ground	∞	∞	

If the interlock panel is in "H.V. OFF/TEST" mode (in which the A1 and B1 terminals are connected internally), the inter-terminal resistances are

	All panels closed	Panel *N* open	
A1-C24	24 kΩ	24 kΩ	(not used)
A1-D24	0	*N* kΩ	panel readout
B1-C24	24 kΩ	24 kΩ	(not used)
B1-D24	0	*N* kΩ	(not used)
All terminals to chassis ground	∞	∞	

The last column of each table indicates that the B1-D24 resistance is used to establish the high voltage interlock, while the A1-D24 resistance can be used to determine which panel is open when the interlock is not satisfied. If more than one panel is open, the A1-D24 resistance indicates the lowest-numbered panel.

3. INTERLOCK PANEL

The front face of the interlock panel is shown in Figure 2. The four inputs from the interlock box chain, A1, B1, C24 and D24, are connected to a terminal block on the rear of the panel, and are wired through to the front-panel banana jacks labeled "Input Monitor Points". No connection is normally made to these banana jacks.

The three isolated-ground BNC jacks labeled "INTERLOCK OUT" are wired in parallel, and are meant to be connected to the INTERLOCK inputs of the LeCroy 1458 high voltage mainframes.

- When the center switch is in the "H.V. ENABLE" position, the INTERLOCK OUT jacks are shorted when the interlock is satisfied (all panels closed), and open otherwise.
- When the center switch is in the "H.V. OFF/TEST" position, the INTERLOCK OUT jacks are open-circuited and the high voltage can not be turned on.

THE FUNCTIONING OF THE "INTERLOCK OUT" JACKS IS INDEPENDENT OF WHETHER THE AC POWER ON THE INTERLOCK PANEL IS TURNED ON.

The POWER ON switch turns on AC power to a 5 volt DC power supply which drives the front panel displays.

•The POWER ON light is on whenever the 5V DC supply is on.
•The SHUTTER IN light is on whenever the adjacent isolated-ground BNC input jack is short-circuited. This jack is normally cabled to the microswitch at the top of the shutter track, and the short circuit indicates that the shutter is fully in.
•The unlabeled light and BNC above the SHUTTER IN input are available for future use (light on = input shorted.)

The other displays depend on the position of the center switch:

•Switch in "H.V. ENABLE" position:

If all panels are closed (B1-D24 shorted), the PANELS CLOSED and the H.V. ENABLED lights are both on, and the "INTERLOCK OUT" BNC jacks are shorted.

If one or more panels are open (B1-D24 open), the PANELS CLOSED and the H.V. ENABLED lights are both off, and the "INTERLOCK OUT" BNC jacks are open.

The PANEL OPEN meter is not powered.

•Switch in "H.V. OFF/TEST" position:

The "INTERLOCK OUT" BNC jacks are open.

The PANELS CLOSED and the H.V. ENABLED lights are both off, independent of the state of the panels. (Note: These two lights are currently wired identically; we may eventually add circuitry to allow the PANELS CLOSED light to function in this switch position.)

The PANEL OPEN meter is powered:

- If a panel is open, it reads the number of kilohms and tenths of kilohms corresponding to the open panel (1.0 kΩ to 24.0 kΩ). The reading should be rounded to the nearest kilohm, and compared with the table (see below) to determine which panel is open. The calibration of the panel meter can be adjusted using the 50 kΩ trim potentiometer on the back of the panel.

- If all panels are closed, the meter reads approximately 0 ohms. (In this switch position, the A1 and B1 inputs are tied together.)

Table I. Relation between kilohms read on panel meter and the number of the open panel. The panel numbering system is:
N1-N12 = north side, numbered from high (east) to low (west) end
S1-S12 = south side, numbered from high (east) to low (west) end

Resistance vs. Panel Number
(Switch must be in TEST position)

R (kΩ)	Panel	R (kΩ)	Panel
1	S12	13	N1
2	S11	14	N2
3	S10	15	N3
4	S9	16	N4
5	S8	17	N5
6	S7	18	N6
7	S6	19	N7
8	S5	20	N8
9	S4	21	N9
10	S3	22	N10
11	S3	23	N11
12	S1	24	N12

4. TECHNICAL INFORMATION

The back panel wiring diagram is shown in Figure 3, and the equivalent schematic diagrams in the two switch positions are shown in Figure 4.

The panel meter reads 0 - 2000 mV. The decimal point has been wired to display at the 10 mV ("DP1") position. In the "H.V. OFF / TEST" mode, a current source of approximately 10 μA is produced by connecting a fixed 430 kΩ and variable 0-50 kΩ resistor in series with the A1-D24 resistance (0-24 kΩ). Thus a 10 mV reading (which appears as "1.0" on the meter) corresponds to approximately 1.0 kΩ resistance between A1 and D24, and in general the meter indicates the A1-D24 resistance in kilohms. (When all panels are closed, the meter indicates the B1-D24 resistance of 0, since A1 and B1 are tied together in this mode.) The variable resistor should be adjusted to make the maximum reading slightly greater than 24.0 "kΩ". This will assure that all readings can be "rounded down" (rather than "rounded up") to the nearest kilohm.

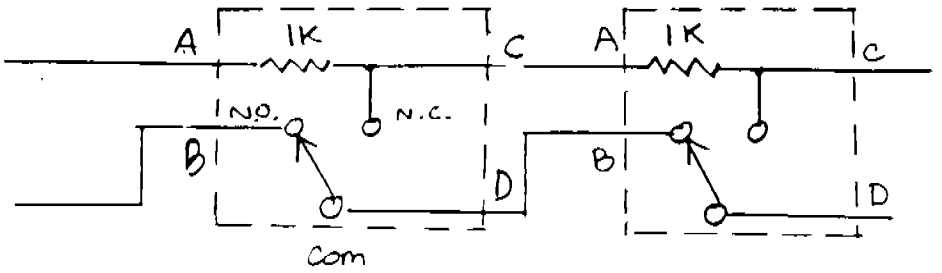
Major components:

Power supply:	SOLA 5V, 500 mA, model 85-05-150.
Panel meter:	Acculex DP35-200N, 2.00 V full scale, +5V power
LED indicators:	CMLW 6081-900-304R, 5.0 V, 16 mA

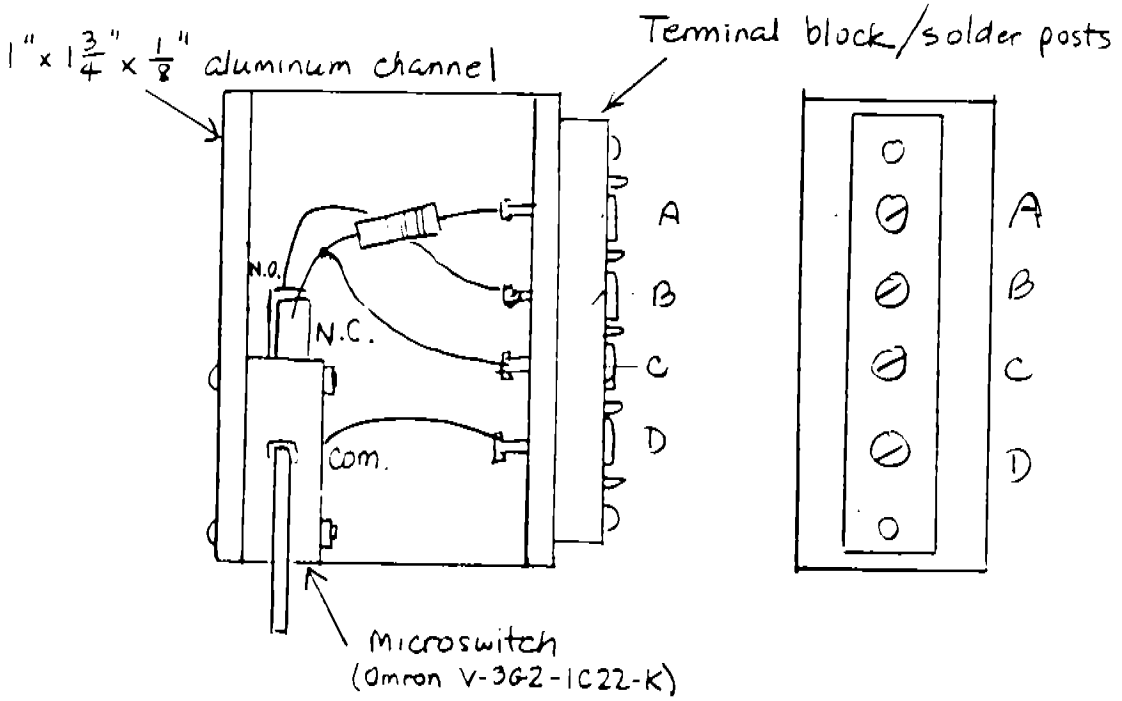
5. TROUBLE-SHOOTING HINT

During the initial installation, the panel and interlocks appeared to pass all tests until the BNC cable was connected from the panel to the LeCroy 1458 interlock input, at which time no effect was produced by opening a panel. The cause was an inadvertent short of one of the interlock cable lugs to the hodoscope box, resulting in a short from terminal B1 to the chassis ground of the LeCroy 1458. The lesson: check first that all of the interlock lines A1, B1, C24 and D24 show infinite resistance to chassis ground.

LIST OF FIGURES



Door closed → N.O.



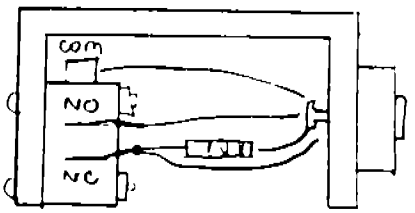


Figure 1. Interlock box. (a) Schematic (b) Construction

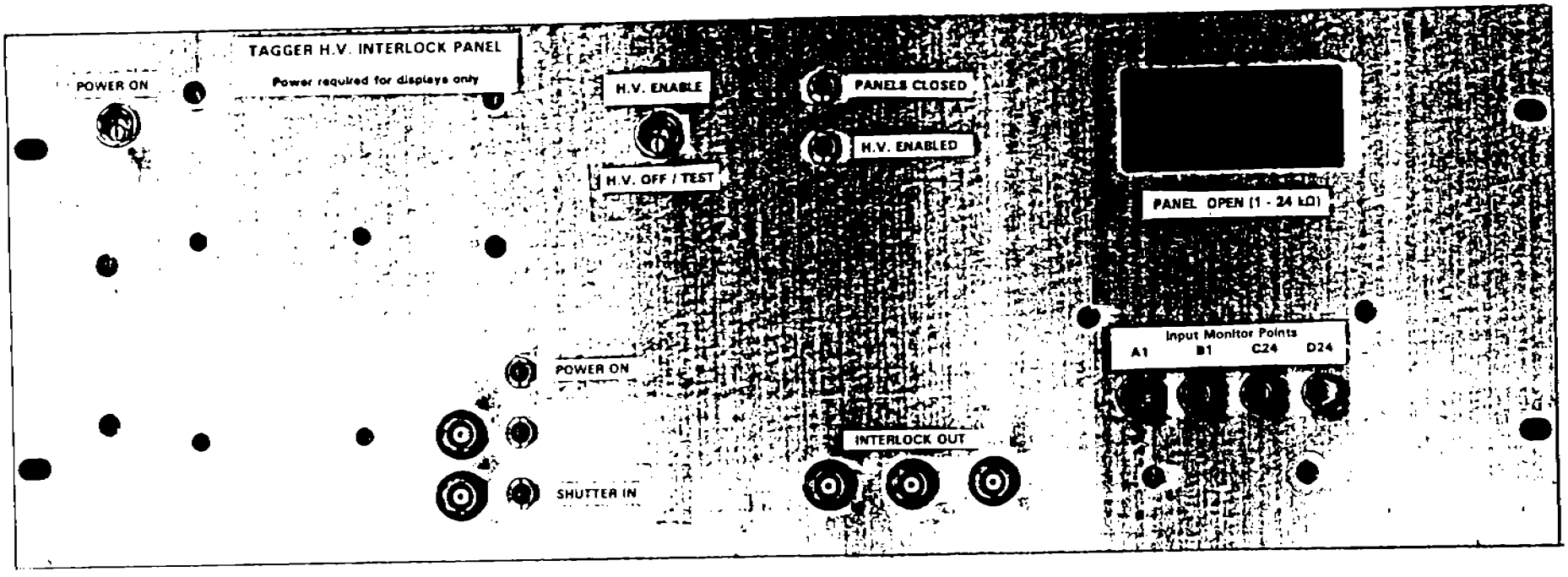


Figure 2. Front panel layout of Tagger High Voltage Interlock Panel

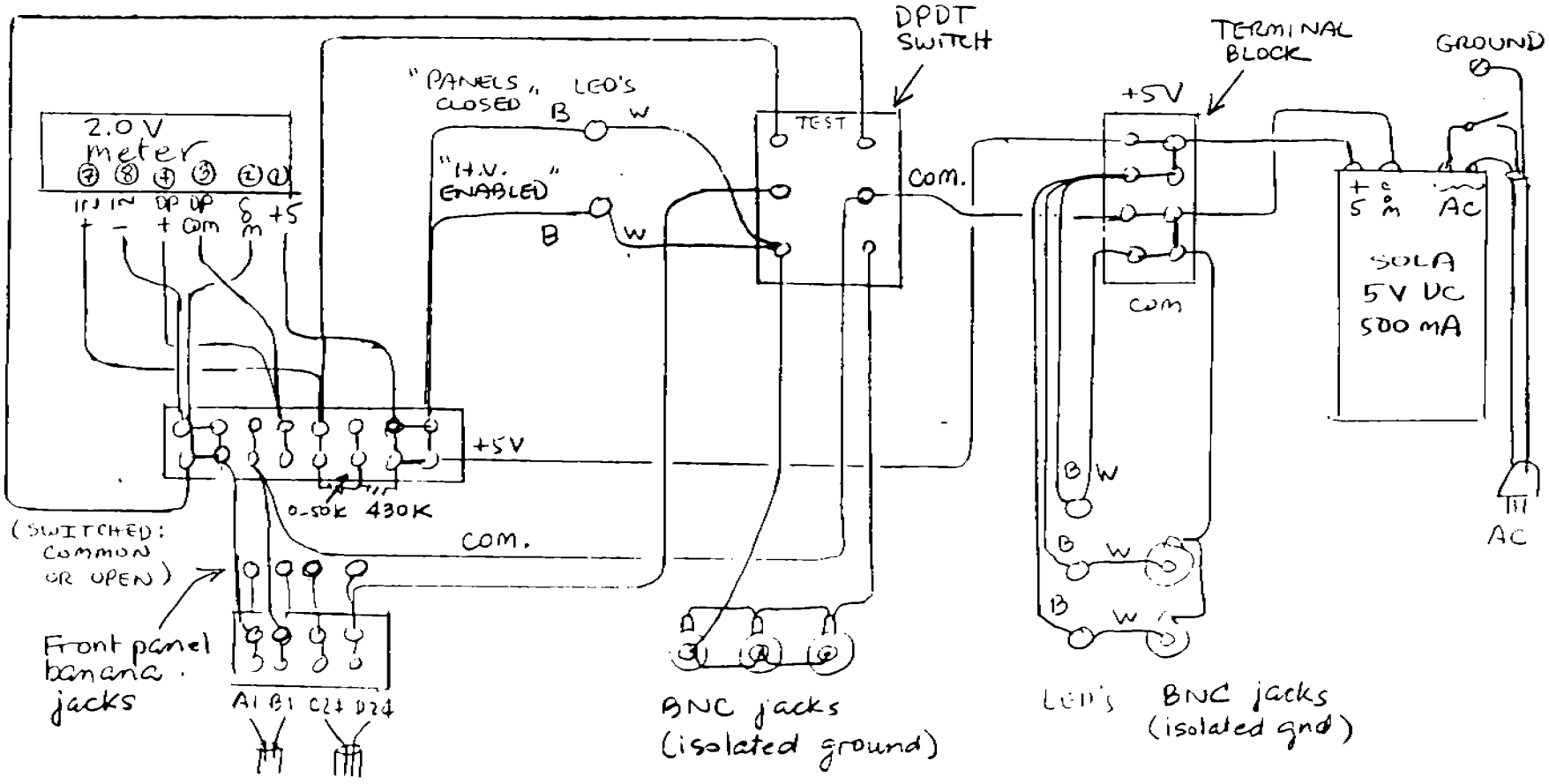
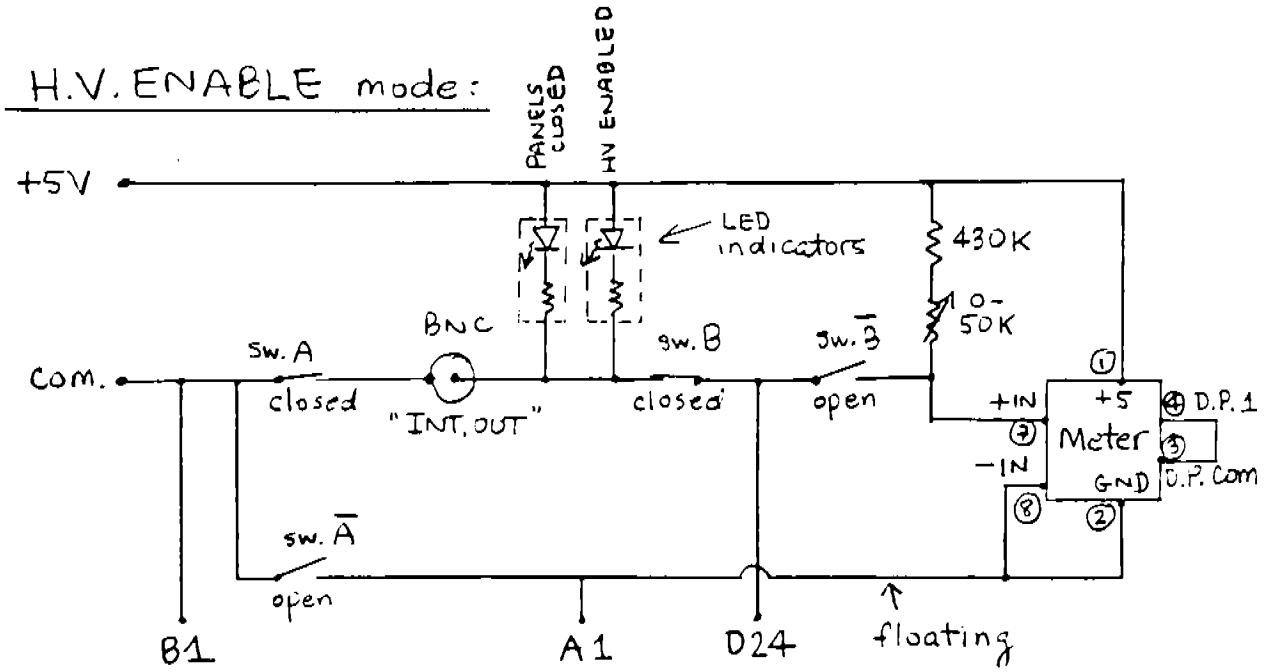
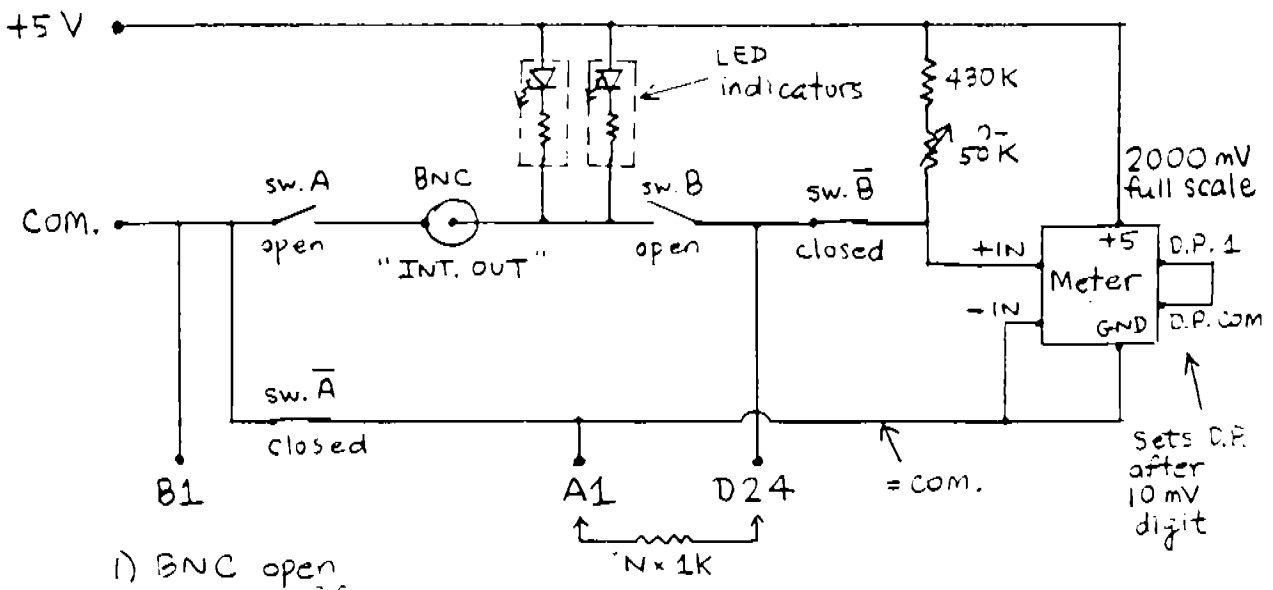


Figure 3. Wiring diagram of Tagger H.V. Interlock Panel (rear view).



	B1-D24 shorted	B1-D24 open
1)	BNC shorted	BNC open (~+5V)
2)	LED's on	LED's off
3)	Meter is off (no GND connection).	



1) BNC open
2) LED's off
3) Meter on, reads 10 mV for each 1K resistance A1-D24, or 0 if B1-D24 shorted. (10 mV appears as "1.0")

Figure 4. High voltage interlock panel schematic diagrams, drawn separately in the two switch positions "H.V. ENABLE" and "H.V. OFF/TEST".

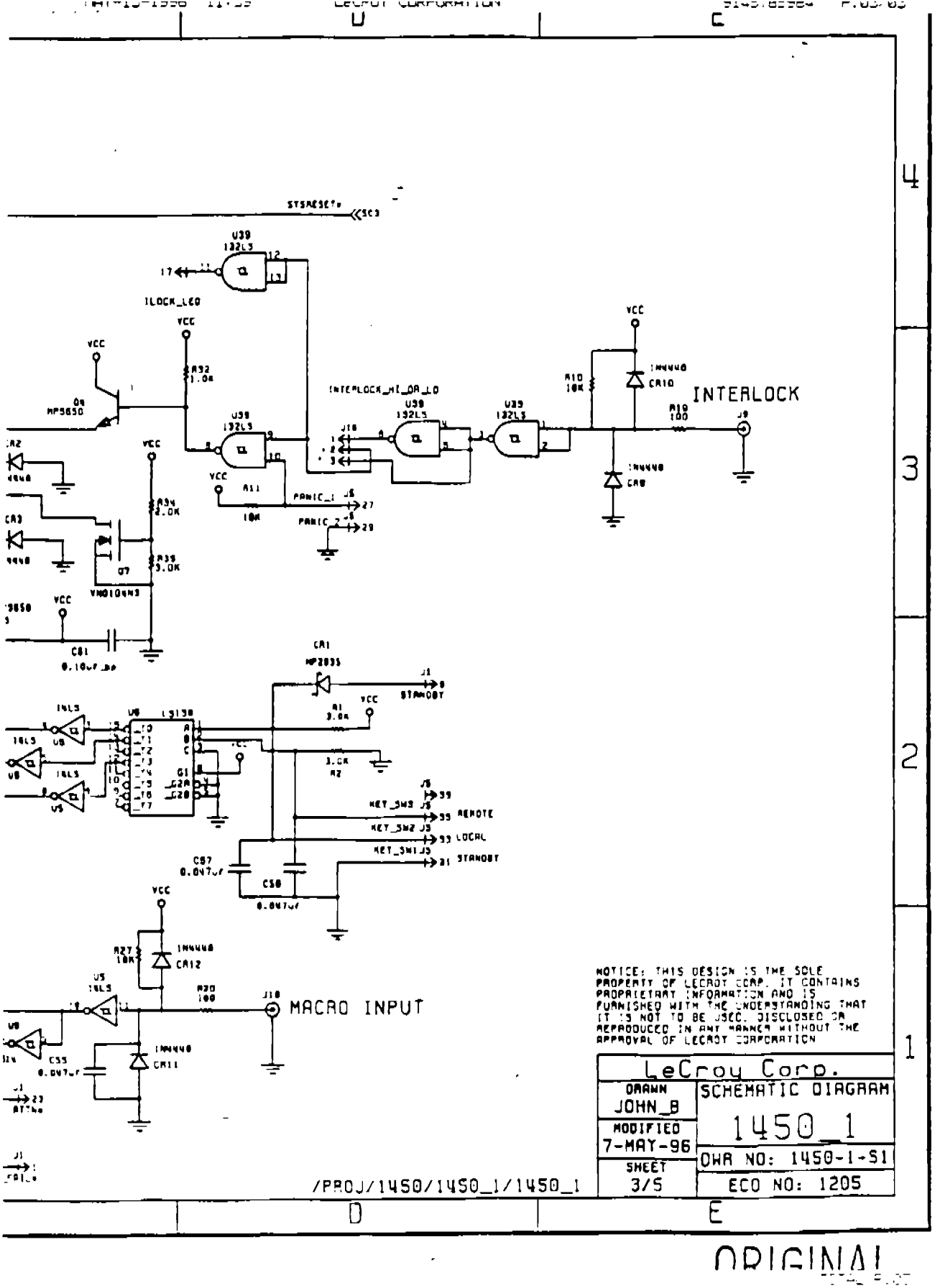


Figure 5. Interlock portion of schematic diagram for LeCroy 1458 (faxed 13 May 1996 by Keith Widmer, LeCroy Corporation, phone 914/578-6030.)

LED Panel Meter

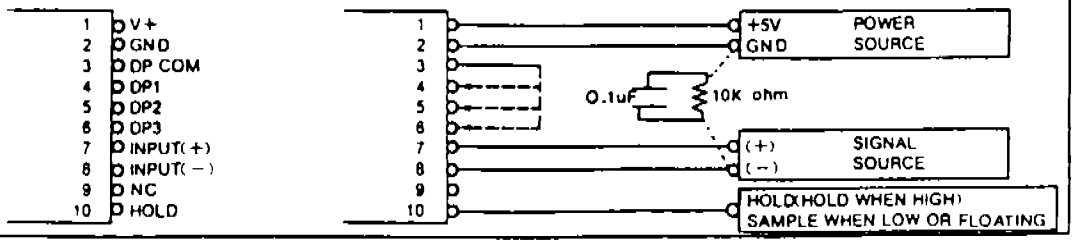
Specifications

- Dispaly:3 1/2 digit red or green LED.
- Input Ranges:+/−200mV DC,+/−2V DC,+/−20V DC.
- Large Numerals−0.56 inches.
- Accuracy:+/−0.1%, +/−2 digits.
- Power Consumption:+5V DC at 200mA rating.
- Autozero.
- Required Power:+5V DC(+/−4.9%) at 200mA.
- Overrange Indication:number "1"appears when voltage limit is exceeded.
- Overrange Protection:+/−350V DC, +/− 10V DC(200mV).
- Relative Humidity:0 to 95% non-condensing.
- Storage Temperature:−10 to 60 degrees C.
- Full Scale Differential Input.
- Common Mode Range:+/−1 V DC.
- Common Mode Rejection:86db.
- Weight:20grams/0.7oz.
- Sampling Rate:3.4/second.

Wiring Connections

When systems require both power source and signal source to be isolated please be sure to either directly wire or connect through a 10K ohm resistor pin numbers 2 and 8. By doing this errors caused by ground loops will be reduced.
The pins that are not being used Need to be left open.

Caution By exceeding the voltage limit of 6.0V DC while pins 1 and 2 are connected or by reversing the polarity permanent damage to the unit and other equipment may occur.



Decimal Point Selection

When the measurement of low level signals is required use the connection shown here. (utilizing differential input)
All diagrams OK as currently shown EXCEPT the bottom box which should read.

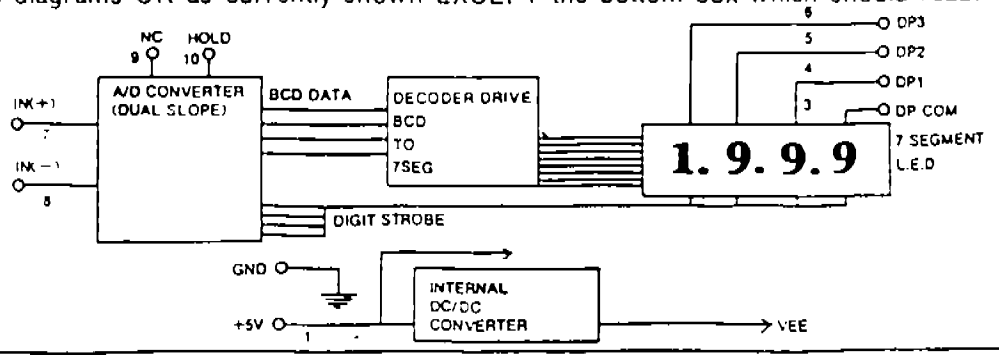


Figure 6. Specifications of panel voltmeter (Acculex DP35-200N.)