Helicycle Crew Alerting System (CAS)

June 10, 2018 – I am almost out of the Master Warning Annunciators that I was selling with the CAS Logic Boards. That annunciator was very high-quality and was a major component. I purchased the entire lot as new/surplus. Now that they ae almost gone I cannot find any others that are comparable. As a result, I stopped making the logic boards. But if there is enough interest in purchasing the boards without the annunciator I can always make more. If I do, I'll add another input for the new fuel pressure indicator I'm now adding to the Uma custom indicators I sell.

INTRODUCTION

If you view my Monterey Bay Shoreline video on YouTube, you may notice that my low rotor warning light comes on as I start to climb out after passing a sunken ship towards the end of the video. The alarm worked flawlessly and was indicating that my belts were slipping. But unfortunately I was too busy navigating my way back across a mountain range to notice it. The alarm indicator is bright, and located right under my dual tachometer near the middle of the upper panel, but I never noticed that it was illuminated. It was only after viewing the video that I realized that I had experienced an in-flight problem on that flight. This is not good!

In the Helicycle we spend a lot more time looking outside than when flying a fixed wing aircraft. For one thing, we are often flying close to the ground or other obstructions. It's the nature of helicopters and one of the capabilities that attracted me to them. But that presents a potential problem – what good are your instruments and warning lights if you don't look at them? Even assuming that you have a good scan going and check your instruments on a regular basis, it can be very difficult to catch a transient fault condition such as a fluctuating oil pressure.

My lack of situational awareness on that flight caused me serious concern. It was unrealistic to think that I would improve my instrument scan to the point where that could never happen again. To make matters worse, most of my indicator lights are lower on my panel and even further out of my field of view when looking outside the aircraft. Clearly, something needed to be done.

Figure 1 - Upper Instrument Panel

All of the military and commercial passenger aircraft that I have ever worked on have a Crew Alerting System and a sunlight-readable Master Warning Annunciator which is usually located in the center of the glare shield or at the top of the instrument panel. Its purpose is to call attention to any out-of-tolerance condition. The crew can then determine the nature of the problem and deal with it. If this works for these aircraft, it will also work on the Helicycle.

In the picture to the left you see my annunciator at the top of the Helicycle upper panel. Since it is higher up on the panel, many times brighter than the individual indicator lights, and substantially larger, it is much easier to see with your peripheral vision while looking outside the aircraft.

The Crew Alerting System (CAS) is designed around a group of eight high-quality UMA aircraft instruments that I have customized for the Helicycle. Five are shown in the center of the panel in Figure 1. A total of nine alarm inputs come from those indicators, three from my Rotor RPM Alarm, and one from my 55-Amp alternator, one from the chip detectors, and one from the clutch switch, for a total of fifteen alarms (Figure-2).

The CAS logic module is flexible, however, and it can take inputs from many other devices.

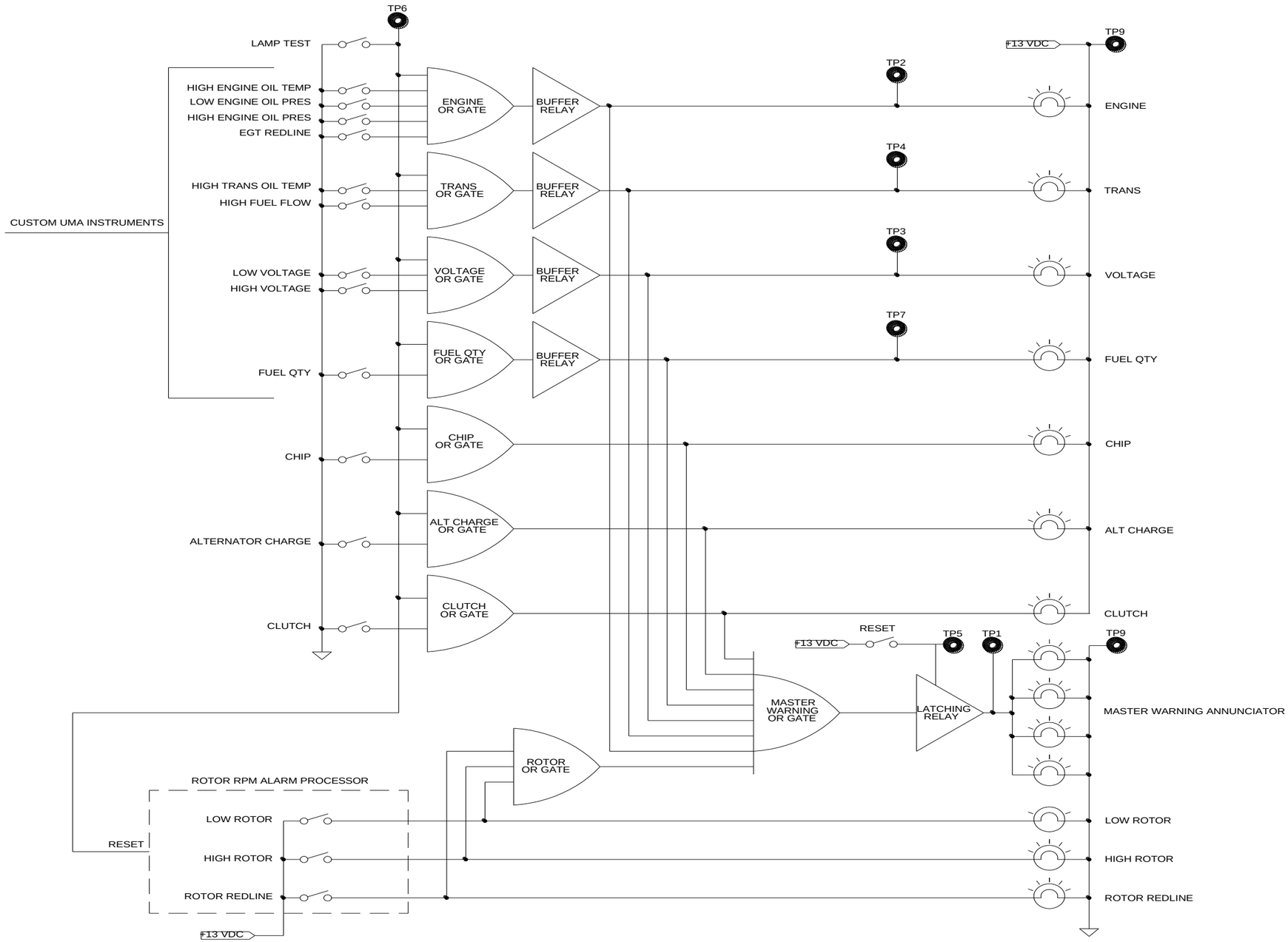

Figure 2 - Simplified CAS Logic Board

MAJOR COMPONENTS IN THE CREW ALERTING SYSTEM

Table-2 and Figure-3 show all the interconnections to and from the CAS logic board. As mentioned, this board was designed as one components in an integrated Crew Alerting System. The major components in the CAS are as follows:

- Customized UMA Engine Oil Pressure indicator (2 alarm outputs)
- Customized UMA Engine Oil Temperature indicator (1 alarm output)
- Customized UMA Transmission Oil Temperature indicator (1 alarm output)
- Standard UMA Fuel Quantity indicator (1 alarm output)
- Customized Fuel Pressure indicator (1 alarm output) ← New
- Customized UMA Fuel Flow indicator (1 alarm output)
- Customized Exhaust Gas Temperature indicator (EGT) (1 alarm output)
- Customized UMA Voltmeter (2 alarm outputs)
- Helicycle.Org Rotor RPM Alarm processor board (3 alarm outputs)
- Chip Detectors (1 alarm output – MR and TR detectors are wired in parallel)
- 55-Amp automotive Alternator (1 alarm output)
- Clutch Engaged Switch (1 alarm output)
- Master Warning Annunciator Assembly with a normally open DPST momentary push button switch (lamp test) and illuminated warning indicator
- Normally open SPST momentary push button reset switch

CAS LOGIC BOARD THEORY OF OPEERATION

LOGICAL OR GATES – An OR Gate is a circuit with multiple inputs and one output. An OR Gate will produce an output if any one or more of its inputs are active. OR gates are widely used in my circuit and are implemented using silicon diodes. Starting at the top of figure-2, notice that eight of the alarm outputs from the custom UMA indicators are grouped into three alarm outputs using OR gates. This reduce clutter on the instrument panel.

SPST REED RELAYS – These relays act as buffers for all of the UMA indicator alarms. The UMA instrument alarms are only capable of driving a maximum load of 40 milliamps, so those outputs are buffered to allow them to drive much heavier loads.

REMAINING ALARMS – The remaining alarms are capable of driving larger loads directly and do not need to be buffered.

LAMP TEST SWITCH – Each of the alarm inputs drives an OR gate, and one input to each OR gate comes from the Lamp Test switch. The gates isolate each alarm circuit from that common switch. This switch also triggers a reboot of the Rotor RPM Alarm processor board, which will test not only the three alarm indicators, but the processor itself. This switch is located in the Master Warning Annunciator assembly.

LATCHING RELAY – Each alarm circuit drives one common OR gate which sets a latching reed relay when activated. This relay provides drive to the Master Warning Annunciator.

MASTER WARNING ANNUNCIATOR – The job of the Master Warning Annunciator is to call attention to a fault condition in a way that is very difficult to miss. It is a large and very bright indicator that is located as close to the top of the upper panel as possible.

RESET SWITCH – Pressing this momentary push button will reset the latching relay and extinguish the Master Warning Annunciator (if all the faults have been cleared). If a fault condition still exists this button will have no effect.

ALARM INPUTS

The alarm inputs can be grouped into three categories:

- UMA Indicator alarms – These alarm outputs pull a load low during an alarm condition and they are limited to a maximum load of 40 milliamps. These alarms drive small sealed reed relays located on the logic board. No additional loads may be connected directly to the UMA indicator alarm outputs (pins 6 and 7).
- +13 VDC Inputs – A number of the remaining alarm inputs such as the Rotor RPM Alarm output +13 volts to indicate an alarm condition. These lines are capable of driving higher current loads and they are not buffered with reed relays. As a result, they directly drive indicator lights.
- Grounding Inputs – The remaining alarm inputs pull the load to ground to indicate an alarm condition. These inputs are also capable of driving larger loads and they are not buffered with reed relays. They also drive their indicators directly. One example is a chip detector. It shorts the alarm line to ground to indicate an alarm condition.

ALARM OUTPUTS

Alarm outputs can also be divided into several groups:

- Indicator Lights illuminated by applying a ground
- Indicator Lights illuminated by applying +13 VDC
- The Master Warning Annunciator which is illuminated by applying +13 VDC

Note that any suitable alarm can be used in place of an indicator light. I use an aural alarm in place of an indicator light for my rotor redline alarm. Alarm indicators should be limited to a maximum load of 200 milliamps or less. All of my indicator bulbs are T-1 ¾ 14V (Digikey CM330-ND).

WIRING

All wiring to the CAS logic board terminates in a 37-pin D-Subminiature connector that is supplied with the logic board. See Table-2 and Figure-3 for details. The assumption is made that all wiring is connected directly from the alarm sources and the alarm indicators. If you have any additional connectors in your wiring they will need to be taken into account.

For lines that are long such as the ones to the clutch switch and chip detectors, you should use shielded wiring and ground the shield at the CAS logic board. The far end of the shield should float. All remaining wiring will probably be confined to the upper instrument panel and can probably be left unshielded. NOTE: *Pins 24 through 30 are set aside for shield grounds as needed.*

CAS POWER-UP AND ENGINE START – ALARM SEQUENCE

POWER FIRST APPLIED TO INSTRUMENT BUS – When power is first applied to the instrument bus the CAS Master Warning Annunciator will illuminate, indicating that one or more alarm conditions exist. At this time the Rotor RPM Alarm processor board will boot up and initiate a self-test by sequencing through its three alarms in order. You would expect to see the following:

- The Rotor RPM Alarm will complete a self-test and light the low rotor, high rotor, and rotor redline indicators one at a time
- The ENGINE alarm indicator will be illuminated indicating that the engine oil pressure is low
- The ALT light will illuminate (if you are using my 55-Amp alternator modification) indicating that there is no charge current
- The Low Rotor alarm will illuminate after the self-test is complete, indicating a low rotor condition
- The CLUTCH alarm indicator will illuminate indicating that the clutch is not fully engaged
- The MASTER WARNING ANNUNCIATOR will illuminate

ENGINE RUNNING AT IDLE:

- The ENGINE alarm indicator should extinguish indicating that the engine oil pressure is now within limits.

CLUTCH ENGAGED – BLADES TURNING – STILL AT ENGINE IDLE:

- The CLUTCH alarm indicator should extinguish indicating that the clutch is fully engaged.
- The ATL alarm indicator should extinguish showing that the alternator is charging the batteries

ENGINE RUNNING AT FULL SPEED:

- Low Rotor Alarm extinguishes indicating that the main rotor rpm is now in the green
- All alarm indicators should be extinguished except the MASTER WARNING ANNUNCIATOR – It can now be extinguished by pressing the RESET button (on my cyclic grip).

Depending on how you have wired your ship, the CAS will now be monitoring up to fifteen separate parameters for you during your flight.

NOTE: *The simplified diagram on Figure-3 shows the UMA and Rotor RPM Alarm outputs as mechanical switches for simplicity. They are actually solid state and not mechanical.*

ALARM TEST

When you press the Master Warning Annunciator it will activate all of the alarm indicators including the annunciator itself and also initiate a reboot of the Rotor RPM Alarm processor board. This action tests a large portion of the alarm circuitry and wiring and will give you confidence that the CAS is fully functional. Once the Rotor RPM Alarm has completed its self-test you can extinguish the CAS Master Warning Annunciator by pressing your reset button. During this test the CAS will draw maximum current of slightly more than 1.0 Amps.

CREW ALERTING SYSEM - LOGIC BOARD WIRING					
CAS P1	DESCRIPTION	STATE WHEN ACTIVATED	FROM	PIN	COMMENTS
19	+13 VDC In		Battery Bus		To +13 VDC Battery Bus (Fused Internally)
37	Low Engine Oil Pressure Alarm In	Low	UMA Engine Oil Pressure Gauge	6	
18	Low Voltage Alarm In	Low	UMA Voltmeter	6	
36	High Engine Oil Temperature Alarm In	Low	UMA Engine Oil Temperature Gauge	7	
17	High Voltage Alarm In	Low	UMA Voltmeter	7	
35	EGT Redline Alarm In	Low	UMA EGT Gauge	7	
16	High Transmission Oil Temperature Alarm In	Low	UMA Transmission Oil Temperature Gauge	7	
34	High Engine Oil Pressure Alarm In	Low	UMA Engine Oil Pressure Gauge	7	
15	Fuel Flow Redline Alarm In	Low	UMA Fuel Flow Indicator	7	
33	Shield Ground				Use as needed to ground shields
14	Master Warning Output	High	Master Warning Annunciator	1,2,3,4	Pin C to Battery Return
32	Shield Ground				Use as needed to ground shields
13	Engine Alarm Out	Low	ENGINE Indicator Lamp	1	Pin2 to +13 VDC
31	Shield Ground				Use as needed to ground shields
12	Voltage Alarm Out	Low	VOLTAGE Indicator Lamp	1	Pin2 to +13 VDC
30	Shield Ground				Use as needed to ground shields
11	Transmission Alarm Out	Low	TRANSMISSION Indicator Lamp	1	Pin2 to +13 VDC
29	Shield Ground				Use as needed to ground shields
10	Master Warning Reset	High	RESET Momentary Push Button	1	Pin2 to +13 VDC
28	Shield Ground				Use as needed to ground shields
9	Lamp Test Input	Low	Master Warning Annunciator	5	Pins C, 7 and 8 to battery return
27	Shield Ground				Use as needed to ground shields
8	Chip Alarm In	Low	Chip Detectors		Depends on sneak path through frame for return
26	Chip Alarm Out	Low	CHIP Indicator Lamp	1	Pin2 to +13 VDC
7	Low Fuel Quantity Alarm In	Low	UMA Fuel Quantity Gauge	6	
25	Low Fuel Quantity Alarm Out	Low	FUEL Indicator Lamp	1	Pin2 to +13 VDC
6	Alternator Charge Alarm In (Automotive Only)	Low	Automotive Alternator	L	
24	Alternator Charge Alarm Out (Automotive Only)	Low	CHARGE Indicator Lamp	1	Pin2 to +13 VDC
5	Low Rotor Alarm In	High	Rotor Alarm Processor Board	2	
23	Low Rotor Alarm Out	High	LOW ROTOR Indicator Lamp	1	Pin2 to battery return
4	High Rotor Alarm In	High	Rotor Alarm Processor Board	3	
22	High Rotor Alarm Out	High	HIGH ROTOR Indicator Lamp	1	Pin2 to battery return
3	Rotor Redline Alarm In	High	Rotor Alarm Processor Board	4	
21	Rotor Redline Alarm Out	High	Sonalert Aural Alarm	+	- to battery return
2	Loose Clutch Alarm In	Low	Clutch Switch		
20	Loose Clutch Alarm Out	Low	CLUTCH Indicator Lamp	1	Pin2 to +13 VDC
1	Battery Return		Battery Bus		To Battery Bus Negative

Table 1- CAS Logic Board Pinouts

SIMPLIFIED CAS WIRING DIAGRAM

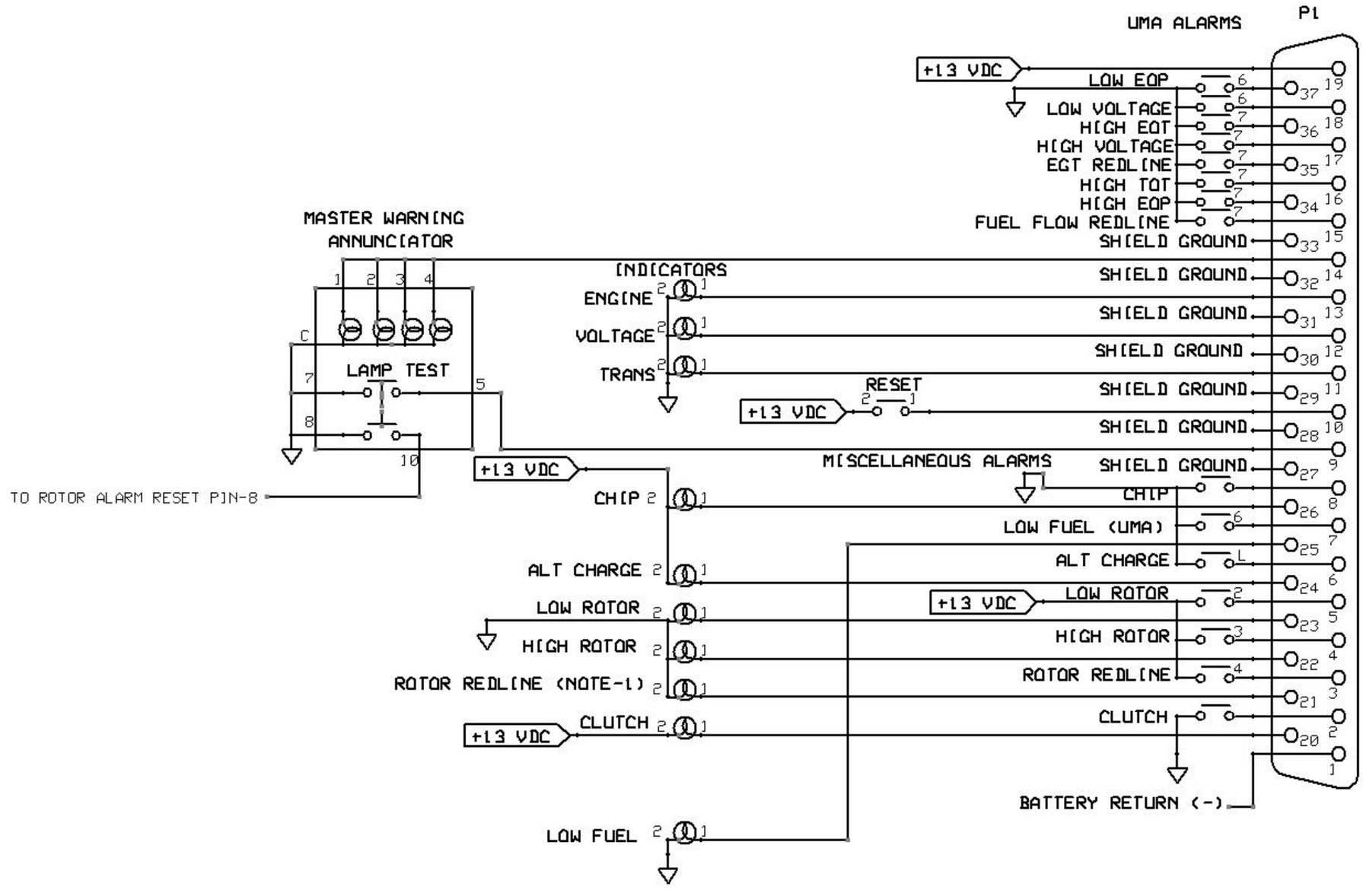

Figure 3 - Simplified CAS Wiring Diagram

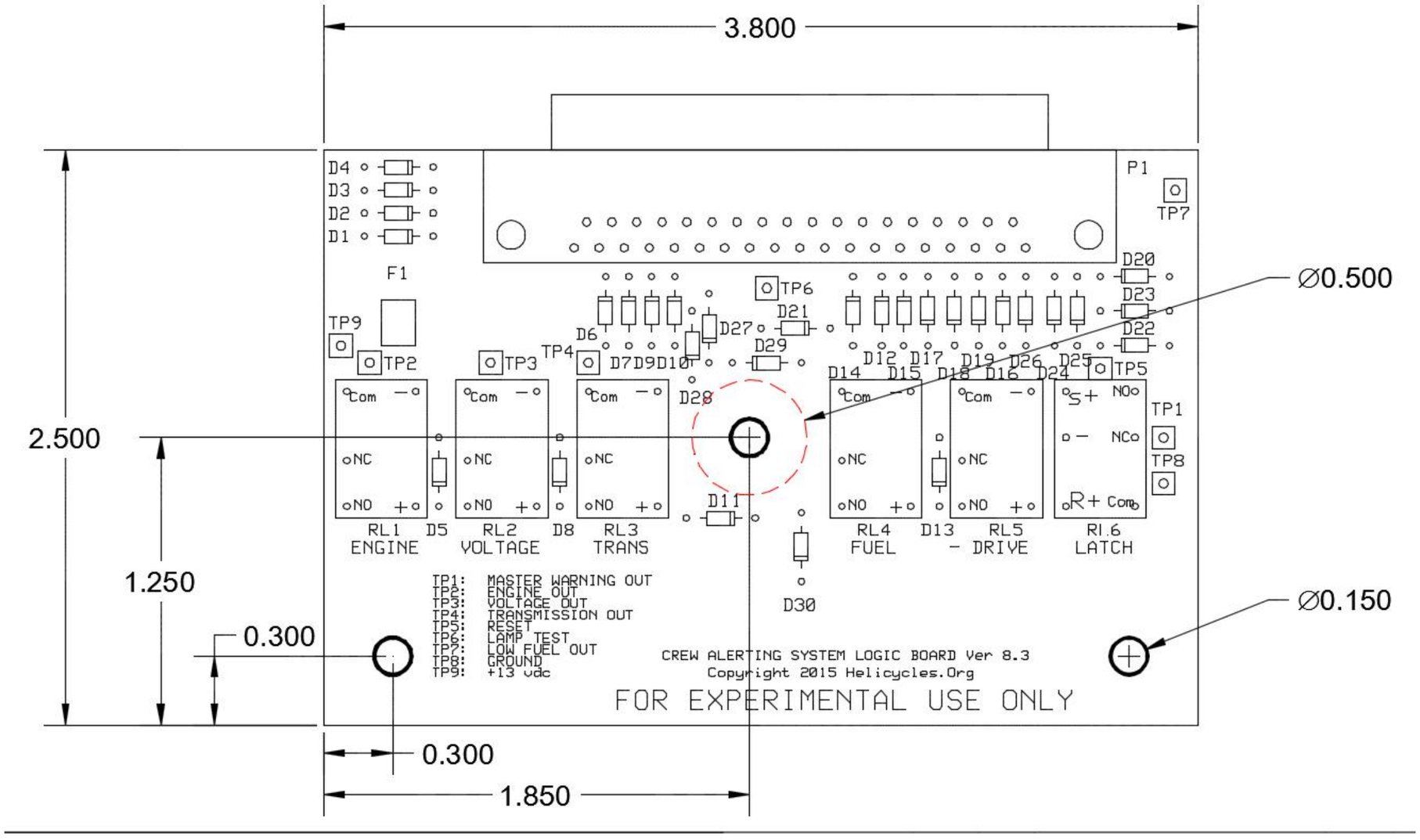

Figure 4 – Mechanical Layout of the CAS Logic Board

The CAS Logic Board mounts in three places (Figyre-4) using 4-40 standoffs. Use caution when installing the center standoff and do not damage the reed relays on either side. The maximum clearance for this center mount is 0.500 inches. Also insure that the standoffs you use do not short any of the traces on either side of the board. Use metallic standoffs as the mounting pads are used to ground the board to your ship. I suggest mounting to the radio trays as the instrument panel is not a good ground.

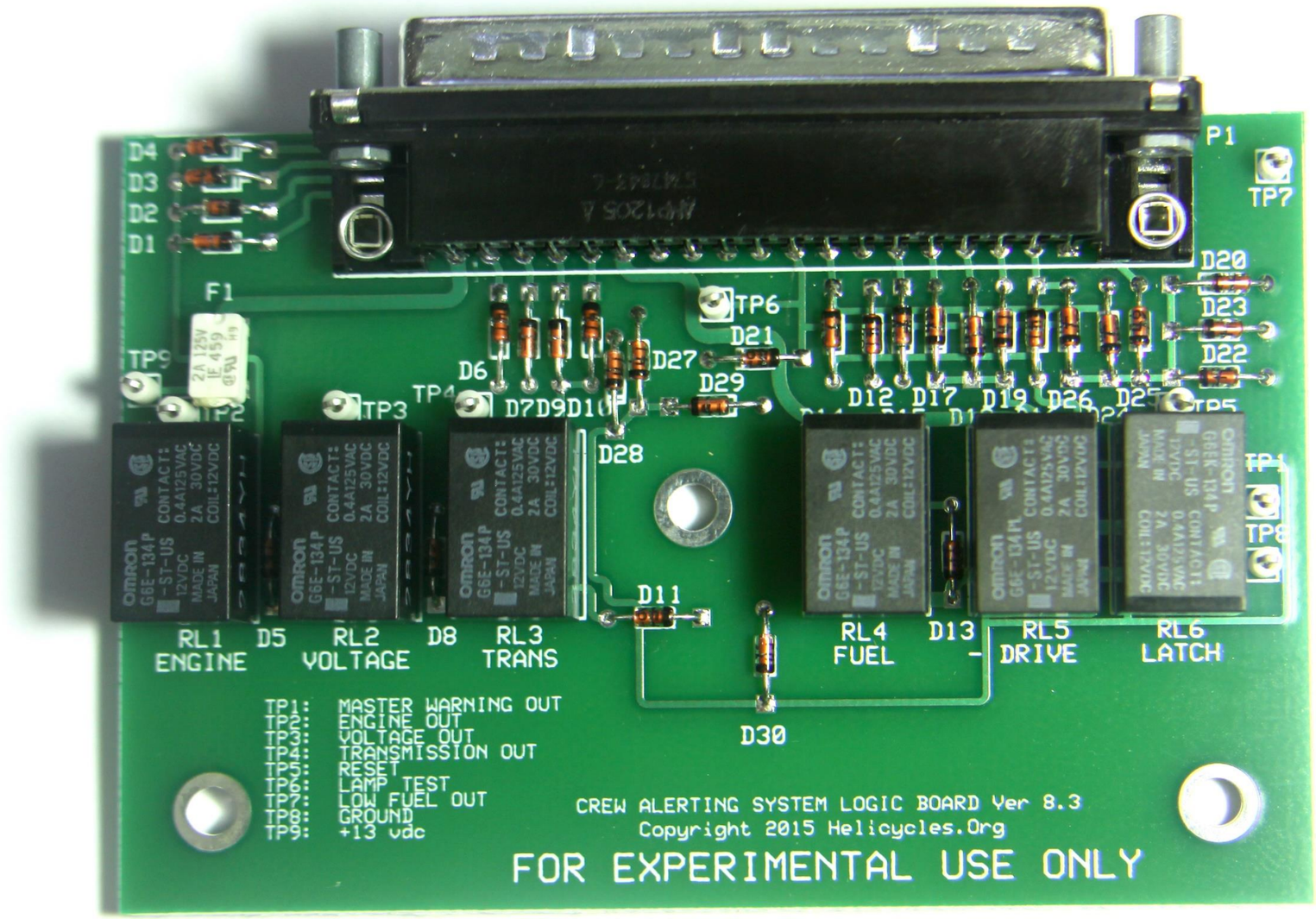

Figure 5 - PCB Layout

WIRING, TESTING, AND TROUBLESHOOTING

Notice in Figure-2 and Figure-5 that there are nine test points on the logic board. These can be very useful during wiring, testing, and troubleshooting. They are also clearly marked on the board itself.

I suggest that you wire the CAS is a methodical step-by-step process, checking for proper functionality as you go. If you run into a problem, stop and sort it out before proceeding.

I plan to install connectors on all of my sensors. I fabricated a small box with one switch and a pot. I can connect this box in place of any UMA sensor for temperature or pressure and use it to exercise the associated indicator. This will allow me to test the wiring to that indicator and also trigger an alarm condition which will then feed into the CAS Logic Board where it should illuminate the correct indicator and set the latching relay which will illuminate the Master Warning Annunciator.

WARNING: Shorting out a test point will probably destroy the board. Be careful and take your time!

CONTACT INSERTION AND EXTRACTION

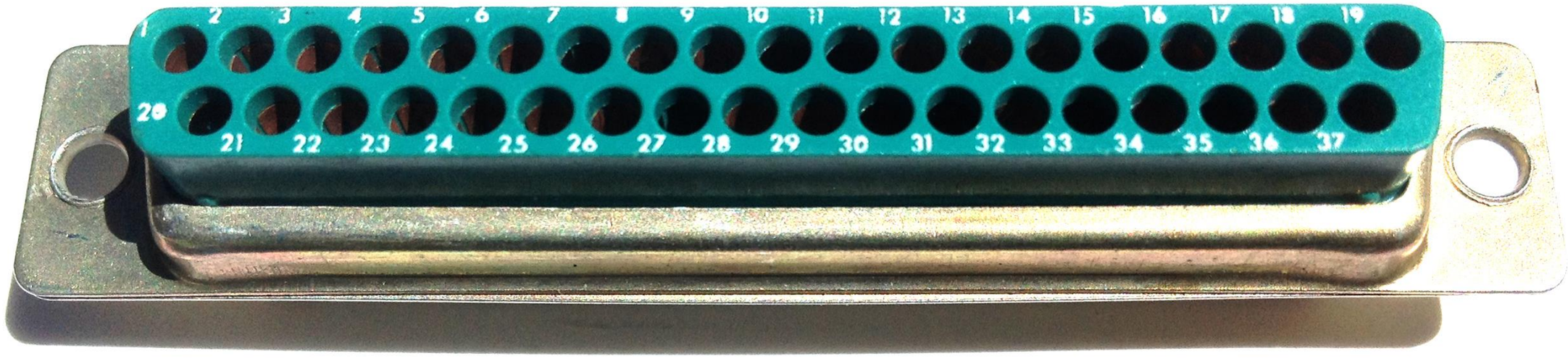

Figure 6 - Wire Side of Mating DB-37 female Connector

Figure-6 shows the wire side of the mating 37-Pin D-Subminiature connector that you will be wiring to. Observe the contact numbers when installing your wiring. You do not need an insertion tool to insert the contacts – just push the contact firmly into the hole until you hear and feel a “click”. However, if you make a mistake, you will need an extraction tool to remove that wire. Be careful!

NO LONGER AVAILABLE

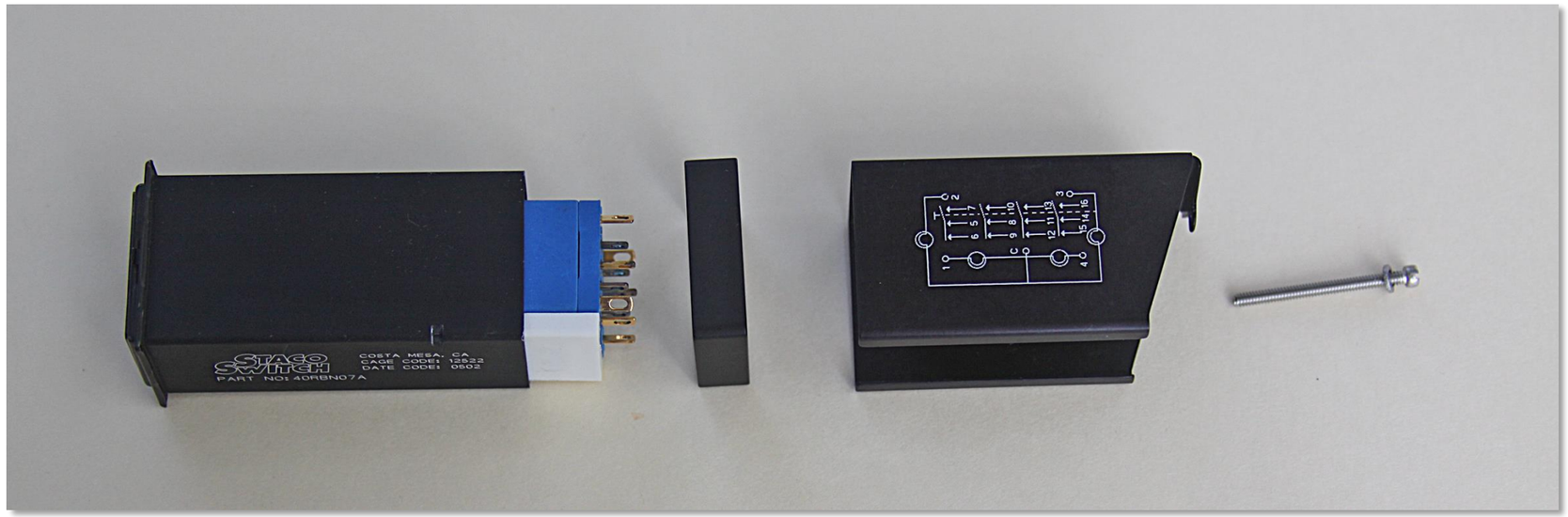

Figure 7 - Master Warning Annunciator

The sunlight-readable Master Caution Annunciator is at the heart of the CAS. I was lucky enough to purchase nine of these illuminated push buttons as new/unused military surplus. They originally sold for about $900 a piece. Needless to say, the quality is very high!

The assembly mounts from the front through a rectangular hole in the panel and is clamped into position and held by sliding these pieces over the unit and pulling them tight with the screw as you see.

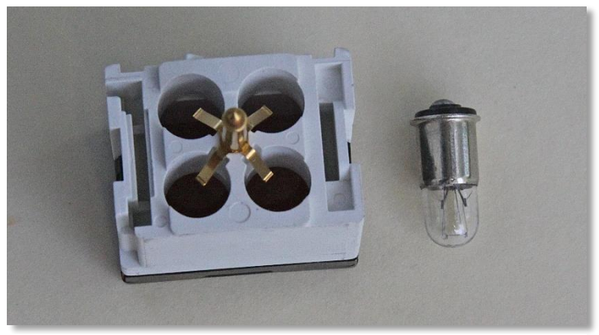

Figure 8 - Lamp Assembly

The unit uses four T-1 ¾ flanged bulbs in parallel and re-lamps from the front. This is a view of the back of the lamp assembly. It then clicks into position in the front.

My intention is to make eight CAS circuit boards which will be mated to eight of these units. Four or five are already spoken for. If you would like one of the remaining three drop me a note at this address: juan(at)helicycles(dot)org.

View YouTube video here → https://www.youtube.com/watch?v=YEh-0gWMIuw