UNIVERSITY OF WISCONSIN

SPACE SCIENCE AND ENGINEERING CENTER

MADISON, WISCONSIN

T W E R L E

PRESSURE SENSOR

MANUFACTURING MANUAL

APRIL 1973

University of Wisconsin

Space Science and Engineering Center

T W E R L E

Pressure Sensor

Manufacturing Manual

April 1973

TWERLE PRESSURE SENSOR

GENERAL

The pressure sensor utilizes an aneroid capsule with capacitive coupling. The aneroid capacitor serves as the tuning capacitor of a Clapp oscillator. The rest of the circuitry includes a source follower buffer and a complementary output stage.

To minimize the effects of oscillator drift, the aneroid capacitor is compared to a reference capacitor. A high quality relay (gold contacts) switches between the two capacitors. The difference between the reference frequency and the aneroid frequency is a measure of pressure. The oscillator effect will be completely nullified if the two capacitors (or two frequencies) are equal. The reference capacitor is a system of three capacitors, one of them variable. The variable capacitor is adjusted for zero frequency difference at the expected flight pressure of 150mb.

The aneroid capsule was selected for its short term and long term stability, aging behavior, and small temperature coefficient. A VAISALA 150 mb mounted capsule was chosen. The capsule includes pre-mounted capacitor plates. The temperature coefficient of the capsule capacitors is approximately - 10 ppm/°C, hence zero temperature coefficient capacitors (NPO) are used in the reference capacitor system. Typical values for the sensor are: reference frequency of 1 MHz, sensitivity of 500 Hz/mb and temperature dependence less than ± .05 mb/°C. A YSI Thermistor is attached to the aneroid mount. It is connected to a separate temperature measuring circuit to yield the pressure sensor temperature within 1°C.

To allow maximum pre-flight aging at the expected pressure level, the aneroid capsule is mounted inside an evacuated bubble which has a relief valve. From the assembly stage, throughout the temperature cycling, calibration, storage, prelaunch calibration, and balloon ascent, the aneroid is never again exposed to surface pressure. (However, accidental exposure, for short periods, is not harmful.) The relief valve opens at a pressure differential of 60mb. Hence, it will only open during the balloon ascent just prior to arrival at the ceiling altitude.

The evacuated bubble allows a last minute calibration of an aged capsule, at the launching site, at a pressure of 150mb, without pressure shocks before and after the calibration.

In addition to the temperature compensation and temperature monitoring, the entire pressure sensor is enclosed in a passive temperature enclosure which was chosen after tests of various types of enclosures in actual balloon flights. The enclosure is essentially an 8" plastic foam sphere covered with aluminum foil. The upper hemisphere is covered with aluminized mylar (mylar outside) and the lower hemisphere is painted with white lead paint. Such an enclosure yielded the lowest, flatest and most stable daytime temperature curve.

Special care is devoted to the calibration. The calibration is performed after one week of temperature cycling and eight days of simulated flight conditions: pressure 150mb, temperature -55°C night, -25°C day, (expected flight temperatures: -70°C to -55°C night, -40°C to -20°C day). Frequency difference versus pressure, between 170mb and 130mb, is plotted at three temperatures: -40°C, -30°C, and -20°C (daytime range). Only after the calibration is performed at the flight temperature range are

Three more plots made at +20°C, +25°C, and +30°C. These will enable a correction to be made after the prelaunch calibration which will be performed at room temperature. It was found that after exposure to room temperature, the sensor has to pass two night-day cycles before it arrives back at the previous reading obtained at typical daytime flight temperatures.

The combination of a reference capacitor, temperature compensation and temperature monitoring, a good temperature enclosure, continuous aging and last minute calibration, the latter both being performed at the flight pressure, is expected to yield the specified accuracy of 0.5mb/6 month. A considerably better short term accuracy is expected.

TWERLE PRESSURE TEST SYSTEM

GENERAL OPERATING PROCEDURES

Pumpdown procedure:

1. Close all valves.
2. Turn on the T.I. Gauge and allow it to fully warm up. It is recommended that the T.I. Gauge remain on all the time. Turn the pressure control valve to normal.
3. Turn on the vacuum pump and allow to warm up for about 15 minutes.
4. Open valve #2.
5. Open valve #4 while observing the Wallace and Tiernan gauge and pumpdown to the desired pressure. Close valve #4.
6. Set the T.I. gauge readout dial to the desired pressure. Refer to the gauge calibration table for the proper counter dial setting.
7. Open valve #1.
8. If the null meter deflects far to the right, the pressure must be reduced back to the meter null position using pumpdown needle valve #7. If the null meter deflection is far to the left, the pressure must be increased by using the air inlet needle valve #6 until the meter is nulled.
9. The pressure control valve will maintain the chamber pressure at the T.I. gage setting by opening for short bursts upon an increase in chamber pressure. The amount of flow required thru the solenoid valve can be controlled by the pressure control needle valve #10. The exact setting will depend on the individual system's leak rate. Needle valves #6 and #7 can be used separately to compensate for pressure changes due to test chamber temperature changes. For example, should the chamber temperature be increased by resetting the chamber temperature control, the pressure will increase at a rate greater than what the pressure control valve can handle. Therefore during the temperature transition time it will be necessary to open pumpdown needle valve #7 slightly in order to maintain

the pressure within allowable control limits. After the chamber pressure has stabilized to the new temperature, the needle valve can be closed. Conversely, if the chamber temperature is lowered, it will be necessary to compensate for the decrease in pressure by bleeding air into the system with the air inlet needle valve #6.

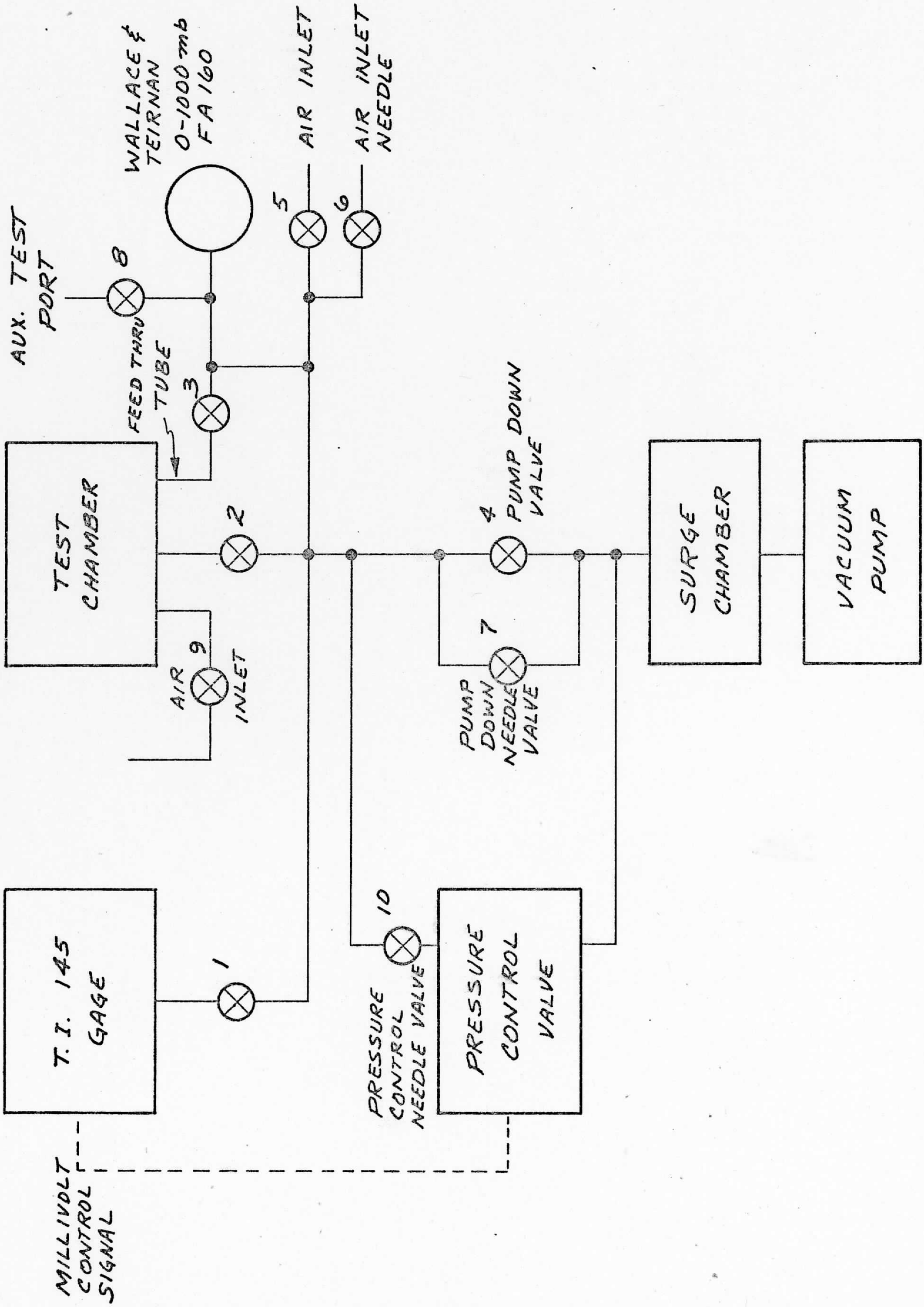
Shutdown procedure:

10. Turn the T.I. Gauge to standby and close valve #1.

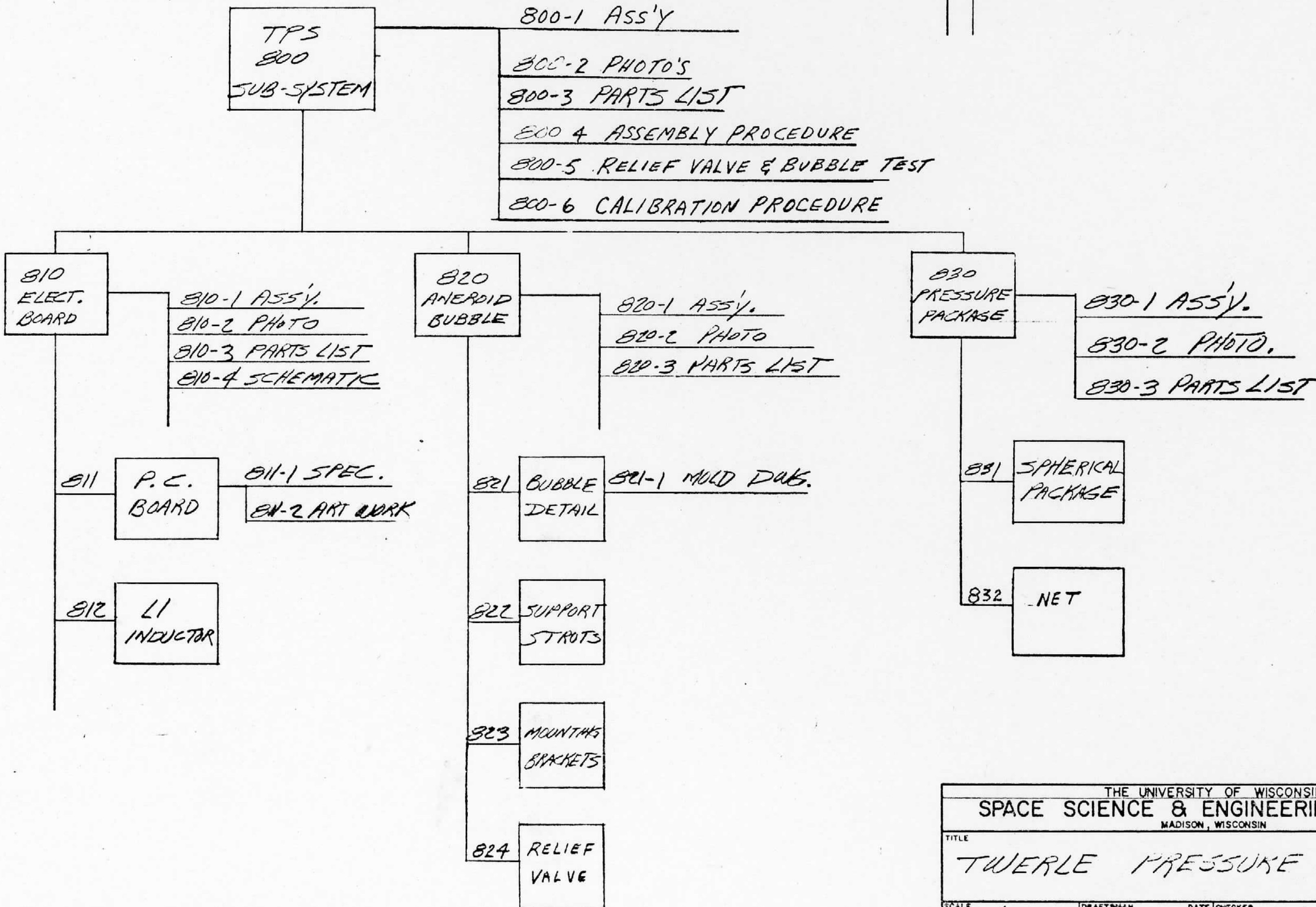
11. Open valve #4 and 5.

12. After a few seconds the roughing pump may be turned off.

13. Close all valves.



TWERLE PRESSURE TEST SYSTEM TP800



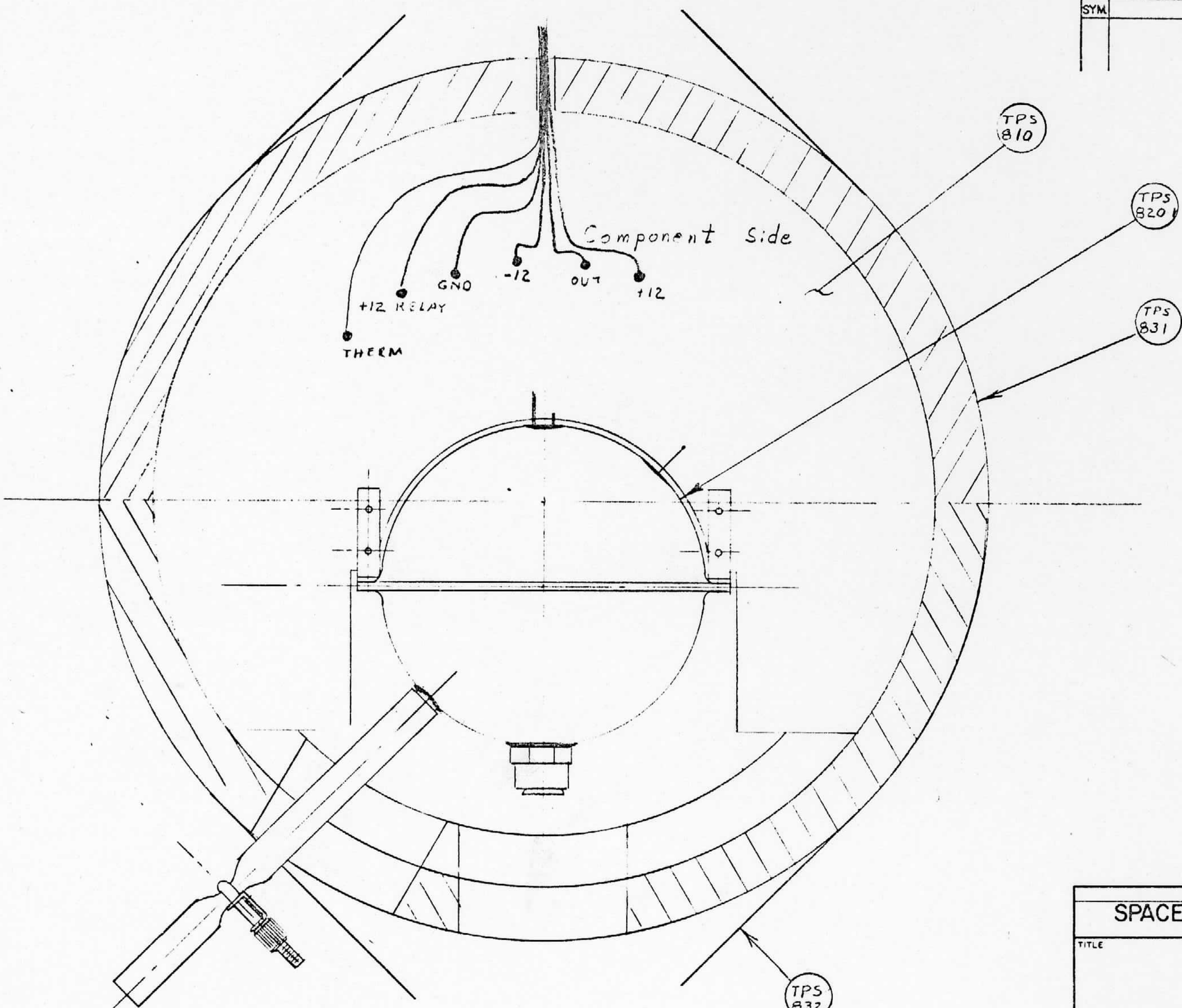
REVISIONS

SYM.	DESCRIPTION	DATE	APPROVED

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: TWERLE PRESSURE SENSOR

SCALE NONE	DRAFTSMAN [initials] DATE	CHECKER DATE	ENGINEER DATE
APPROVAL DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE	
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TPS 800

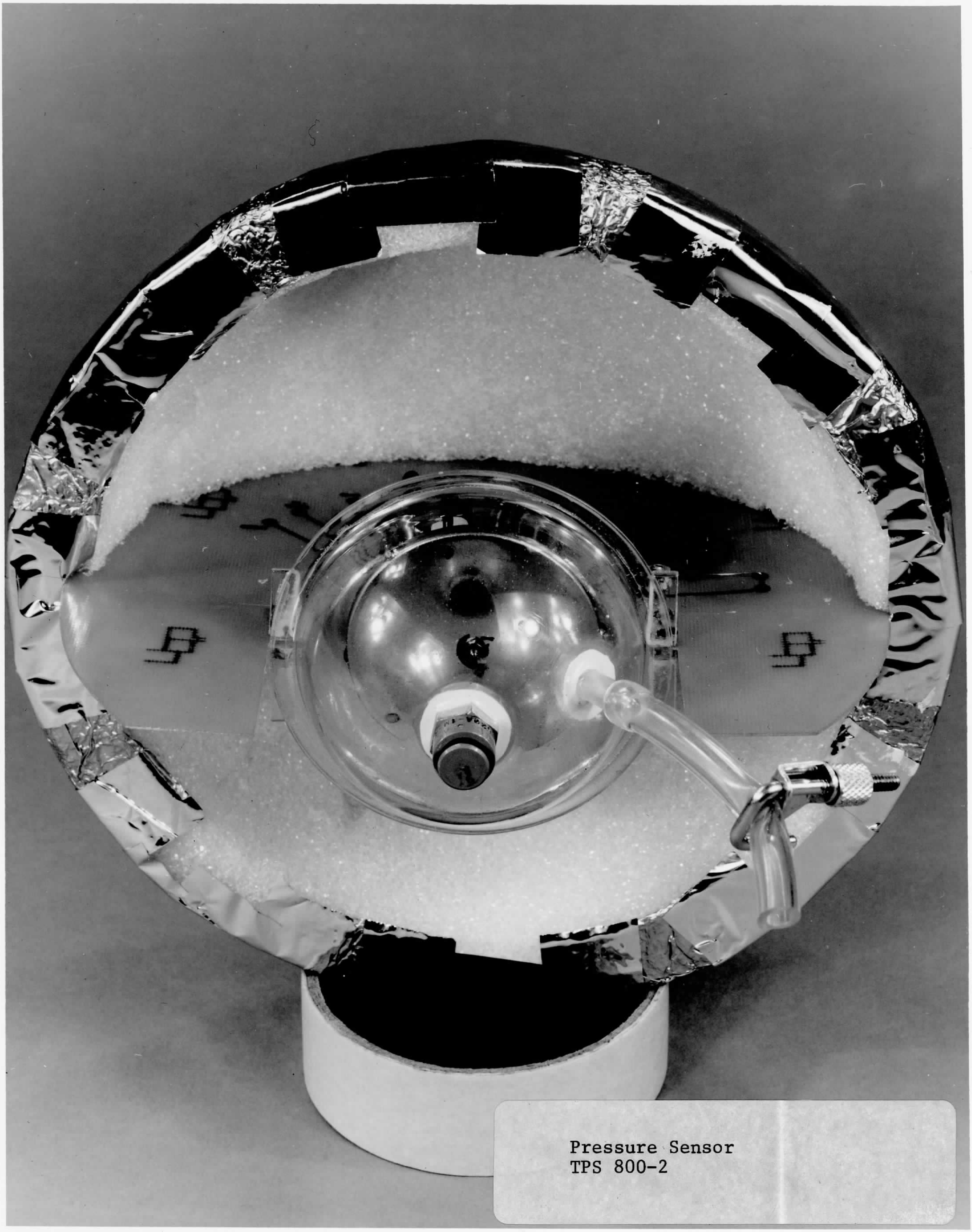


REVISIONS

SYM.	DESCRIPTION	DATE	APPROVED

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: PRESSURE SENSOR ASSEMBLY			
SCALE: FULL	DRAFTSMAN: J.G.M DATE: 4/2/73	CHECKER: J.G.M DATE: 4/2/73	ENGINEER: J.G.M DATE: 4/2/73
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE
PROJECT NO. G310	SIZE A	SHEET 1 OF 1	DRAWING NO. TPS 800-1



Pressure Sensor
TPS 800-2

TPS 800-3 T W E R L E Pressure Sensor Date April 27, 1973 Page 1 of 1

REFERENCE		DESCRIPTION		SOURCE	QUAN. ASSY.	
wg. No	SCHEM.					
810-1		Electronic Board	Sub Assembly		1	
820-1		Aneroid Bubble	Sub Assembly		1	
830-1		Pressure Package	Sub Assembly		1	

TWERLE PRESSURE PACKAGE

ASSEMBLY PROCEDURE and LEAK TEST

1. Epoxy bead thermistor to Vaisala capsule mounting plate as per Dwg. TPS820-1 detail B using Hysol 907 epoxy.

2. Solder one thermistor lead to capsule mounting plate next to thermistor. Use SN60 solder.

3. Clean red paint off center screw on aneroid capsule assembly and solder a 3" length of #24 gage tinned solid wire to screw end. Refer to Dwg. #TPS 820-1.

4. Solder three aneroid mounting struts as per Dwg. #TPS 822 to capsule mounting plate edge as per Dwg. #TPS 820-1 equally spaced 120° approximately 60° from ceramic web legs. Use SN60 solder.

5. Solder 4" length of #24 gage tinned solid copper wire to the second thermistor lead approximately 1" from bead. Cut off excess thermistor lead at splice.

6. Clean and roughen with steel wool or sandpaper the two indent wells on the two Lexan bubble halves. Refer to Dwg. TPS 821.

7. Clean and roughen with steel wool or sandpaper the mating flange area to be joined on the bubble halves.

8. Clean with iso-prop. alcohol or suitable non-residue cleaner, and carefully inspect the aneroid capsule assembly. The space between the capacitor plates must be dust free and clean.

9. Insert aneroid capsule assembly in top Lexan bubble half, Dwg TPS 821 sheet 1 of 2. Make certain that the aneroid and thermistor leads have a small amount of strain relief and do not contact mounting struts or other areas on the aneroid capsule.

10. Set the top bubble half with capsule assembly inserted on a flat surface and fill indents at wire exits with Hysol 907 epoxy. Refer to Dwg. TPS 820-1.

11. Install Circle Seal valve (Item 4) and the pump out tube (Item 3) on bottom half of the Lexan bubble. Refer to Dwg. TPS 820-1. Fill indents with Hysol 907 epoxy and let cure.

12. Prior to joining of the two bubble halves, inspect the inside areas, aneroid capsule assembly and relief valve for cleanliness.

13. Wet the two bubble flange surfaces to be joined with ethylene-dichloride. Join the two halves together. Clamp the flanges together in a suitable jig for one hour. Refer to Dwg. TPS 820-1.

14. Wet the outside of the pressure line tube (Item 3) with ethylene dichloride. Slip the 4" Tygon tube (Item 2) over the wetted pressure line tube and allow to stand for one hour. Refer to Dwg. TPS 820-1.

15. Mount the four Lexan angle brackets to the bubble flange as per Dwg. TPS 820-1 using ethylene dichloride as solvent glue. Clamp and allow to dry for one hour.

16. Install bubble assembly on completed printed circuit board as per Dwg. TPS 830-1.

17. Solder a #24 gage solid wire from the P.C. board com. pad to any one of the three aneroid mounting struts extending outside of the bubble. Solder the thermistor lead to the thermistor P.C. pad. Solder the lead extending from the aneroid to the aneroid pad.

18. Electrical checkout:
Wire up power and ground. Observe output on an oscilloscope and frequency counter. Measure input current on both the +12 and -12 volt supply. -12 volt current should be between 1 and 2 ma. +12 volt current should be between 2 and 3 ma. Output signal on oscilloscope should be a square wave from ground (OV) to +12 volts (11 volt min.).

19. Attach pressure line to vacuum system and gauge. Hold relief valve closed and begin pumpdown. Evacuate bubble to 150 mb $\pm$ .1 mb. Maintain this pressure throughout the following adjustment.

20. Energize the relay by connecting between +12 volts and the relay pad. Measure and record the output frequency.

21. Adjust capacitor C10 with the relay de-energized so that the output frequency is within 1 KHz of the output frequency with the relay energized. Both frequencies should be between 0.8 to 1.2 MHz.

22. Repeat steps 20 and 21 and readjust C10 if necessary. Note that the full adjustment range of C10 is a 180° rotation from the point where the black dot on the rotating portion matches the arrow point on the capacitors side. Record the two frequencies.
(Relay de-energized = f ref, relay energized = f aneroid) and the difference frequency Δf = f ref - f aneroid.

23. Change the pressure to 160 $\pm$ .1 mb and record the new Δf @ 160 mb. Establish from this data the sensitivity = $\frac{\Delta f\ 160 - \Delta f\ 150}{10\ \text{mb}}$ [Hz/mb].
The sensitivity should be between 350 and 700 Hz/mb.

24. Install the pinch-off clamp on the Tygon tubing while the system is connected to the vacuum system at 150 mb $\pm$ .1 mb pressure. Refer to Dwg. #TPS 830-1.

25. Disconnect from power and store for one week. After one week, connect to power and read Δf. Convert the change in mb using the sensitivity calculated in Step 23. Leak rate should not exceed 15 mb/week. If leak rate is greater than 15 mb/week, bubble assembly must be leak checked and repaired. If bubble assembly is replaced, Steps 18 thru 25 must be repeated.

26. Install flight train wiring harness to P.C. board. Refer to Dwg. #TPS 830-1.

27. Install P.C. board and bubble assembly into top half of pressure package. (Styrofoam ball, mylar covered).

28. Install the bottom half of pressure package (styrofoam ball, white paint coating) to the top half of the pressure package leaving both bottom plugs out. Tape the separation point with 2" wide aluminized mylar tape. The package is now ready for relief valve and bubble correction factor measurement and calibration. After the calibration is complete the clamped pressure line will be stuffed inside the package being careful not to interfere with the relief valve. The two styrofoam plugs can now be installed.

Measurement of Relief Valve Release Differential and Bubble Correction Factor

Differential Pressure Test and Relief Valve Test:

The object of the following tests is to evaluate the pressure system behavior to changes in atmospheric pressure as the bubble pressure remains constant at 150 mb, and to determine the atmospheric pressure required to open the relief valve while the bubble pressure is maintained @ 150 mb. Refer to the pressure test system functional block diagram.

1. Install complete pressure package assembly with plugs removed in vacuum test chamber including electrical connections. Attach clamped off Tygon pressure line to the chamber pressure line feed-thru. Be sure that the package is aligned in the fixture such that the pushrod feed-thru can be used to close the relief valve. Leave the bell jar open.

2. For this test the pressure test system should be started in the following manner:

   Turn T.I. gage to standby and allow gage to fully warm up. This gage should normally be left in standby with power on and valved off at 150 mb. Pressure control box switched to normal.

3. With all valves closed, start the vacuum pump and allow to warm up for 15 minutes. Open valve #3.

4. Slowly open valve #4 while observing the Wallace and Tiernan gage and evacuate the lines to 150 mb. Close valve #4. Line should stay at 150 mb.

5. Remove the pressure line pinch-off clamp. If necessary, bring the line pressure back to 150 mb using needle valve #7. Close valve #7 with bubble and line at 150 mb.

6. Open valve #1 and turn the T.I. gage to manual operate position and make sure that the T.I. gage is set to read 150 mb. Allow the pressure control valve to maintain 150 mb.

7. Close the bell jar.

8. Measure and record f ref (output frequency with relay de-energized) and f aneroid (output frequency with relay energized).
Record Δf = (f ref - f aneroid).

9. Close valve #1 and #3.

10. Turn T.I. gage to standby.

11. Open valve #2 and #4 while observing the Wallace and Tiernan gage and evacuate the bell jar to 300 mb ± 5 mb. Close valve #4 and make sure that the bell jar will hold at 300 mb.

12. Close valve #2.

13. Open valve #4 and evacuate line to 150 mb. Close valve #4 at 150 mb.

14. Turn T.I. gage to manual and open valve #1.

15. Open valve #3 and allow pressure control valve to maintain 150 mb bubble pressure.

16. Repeat step #8 and record as Δf at 150 mb with 300 mb outside.

17. Close valve #1 and turn T.I. gage to standby.

18. Close valve #3.

19. Energize the relay and observe the output frequency. Keep the relay energized.

20. Open valve #2.

21. Slowly open pumpdown needle valve #7 while observing the Wallace and Tiernan gage and output frequency. Allow the bell jar pressure to decrease slowly and record the exact pressure on the Wallace and Tiernan gage when the output frequency suddenly jumps to a higher valve. This occurs when the relief valve opens. Relief valve opening pressure range is 190-250 mb. Record the valve opening pressure. Close valve #7.

22. Close valve #2.

23. Push and hold relief valve closed with the push rod feed-thru.

24. Open air inlet valve #9 and allow bell jar pressure to return to atmospheric. Retract the pushrod feed-thru.

25. Slowly open valve #7 and evacuate the line to 150 mb as indicated on the Wallace and Tiernan gage.

26. Open valve #3 and reset the bubble pressure to 150 mb as indicated on the Wallace and Tiernan gage with valve #7. Close valve #7.

27. Turn the T.I. gage to manual and open valve #1. Allow the pressure control valve to reset bubble pressure to 150 mb.

28. Close valve #3.

29. Close valve #1 and turn the T.I. gage to standby.

30. Remove or open the bell jar.

31. Install the pressure line pinch-off clamp.

32. Pressure package can now be removed from the test system.

33. Test system shut-down procedure. If the mechanical vacuum pump is to be turned off the following procedure should be followed in order to prevent roughing pump oil from being drawn into the test sytem: With all other valves closed, open valve #4 and air inlet valve #5 wide open. Shut off the vacuum pump after a gurgling sound is heard or when it is apparently pumping at atmospheric pressure.

CALIBRATION PROCEDURE

1. Evacuate the pressure sensor aneroid bubble to 150mb with the relief valve closed. (NOTE: This will be the last time that the aneroid will be exposed to surface pressure.) Read f ref and f aneroid.

2. Install the pressure line pinch off clamp and remove the bubble from the vacuum system.

3. Temperature cycle the entire assembly between -55°C and +55°C for one week. Each temperature cycle consists of a 12 hour soak at -55°C and a 12 hour soak at +55°C.

4. Install the package in the pressure test system chamber. Connect the electrical leads and record f ref and f aneroid. Energize the relay and observe f aneroid as the following steps are carried out. Find the approximate inside pressure from Δf. If the inside pressure is outside the range 100 to 200mb, check for leakage.

5. Turn on the vacuum pump and open valve #2 with all other valves closed.

6. Slowly begin pumpdown by opening valve #4 while observing the Wallace and Tiernan gauge and the output frequency.

7. Observe and record the gauge pressure at the time of relief valve opening as evidenced by a step change in output frequency. This pressure differential should be within ±50mb of the differential recorded in step #21 of the measurement of relief valve release differential and bubble correction factor, TPS 800-5. This test will confirm the presence of a bubble leak or a change in the relief valve opening point during thermal cycle. The bubble temperature during this test should be the same as in step #21 of document TPS 800-5.

8. Adaptation phase:
With the package installed in the test chamber, pumpdown to 150mb ± .1mb. Record the pressure sensor temperature by measuring the resistance of the aneroid temperature thermistor. Data will be recorded during the thermal cycle of -55°C to -25°C. One thermal cycle consists of 8 hours at -55°C ± 5°C and 16 hours at -25°C ±2°C. A minimum of 8 cycles will be required. Pressure at -55°C is 150mb ± 25mb and at -25°C it is 150mb ± .02mb. Begin by soaking at -55°C for 8 hours, at the specified

pressure, and then reset to -25°C. After the first 8 hours of soak at -25°C at 150mb ± .1mb, record the reference frequency and the aneroid frequency every 2 hours until the end of the 16 hour soak at -25°C at 150mb ± .02mb. Do this for all 8 cycles. Plot the Δf = (f ref - f aneroid) as a function of time (days) during the test. Refer back to the data recorded in step #23 of the TWERLE Pressure Package Assembly Procedure and Leak Test, TPS 800-4, to establish the sensitivity in Hz/mb for the particular unit being calibrated. The change in Δf during the last 4 thermal cycles taken at -25°C should not represent a pressure change of greater than .2mb. For example, if the sensitivity of the unit is 500 Hz/mb, the plotted data (Δf) during the last 4 days of the test should indicate a change in Δf(f ref - f aneroid) of less than 100Hz.

Calibration phase:

(NOTE: Under no circumstances can the sensor temperature be allowed to increase above -10°C between steps #8 and 11.)

9. Soak at -40°C at 150mb ±.1mb for 8 hours. Record the thermistor resistance. Record Δf(f ref - f aneroid) at 170mb ±.02mb, 160mb ±.02mb, 150mb ±.02mb, 140mb ±.02mb, and 130mb ±.02mb. Record the data after 10 minutes at each pressure setting.

10. Soak at -30°C at 150mb ±.1mb for 8 hours and repeat the remainder of step #9.

11. Soak at -20°C at 150mb ±.1mb for 8 hours and repeat the remainder of step #9.

12. Soak at +20°C at 150mb ±.1mb for 8 hours and repeat the remainder of step #9.

13. Soak at +30°C at 150mb ±.1mb for 8 hours and repeat the remainder of step #9.

14. Soak at +25°C at 150mb ±.1mb for 8 hours and repeat the remainder of step #9.

15. While at +25°C and 150 ±.1mb, depress the relief valve shut with valve #2 closed. Start bleeding the chamber pressure back to atmospheric by opening valve #9 while maintaining pressure on the relief valve to assure that it is closed.

16. With the chamber at ambient pressure, attach the pinched off pressure line to the test system feedthru. Open valve #3. Evacuate the lines to 150mb as indicated on the Wallace and Tiernan gauge. Open the pinch off clamp. Set the bubble pressure to 150 $\pm$.02mb using the T.I. Gauge. The bubble pressure should be near 150mb already. Record the thermistor resistance and Δf(f ref - f aneroid). Install the pressure line pinch off clamp. Turn the T.I. gauge to standby and close valve #1.

17. Remove power from the pressure package. The package may now be removed from the test system, the styrofoam plugs installed, and the assembly stored away.

TWERLE PRESSURE SENSOR TEST DATA

Test	f ref	f aneroid	(f ref-f an)	Pressure	Therm. Resistance	Therm. Temp.	Date	Notes
Ref.cap. adjust TPS 800-4 #21								
Sensitivity TPS 800-4 #23								
Leak Test TPS 800-4 #25 Repeat Leak Test data after one week								
Bubble Factor Test TPS 800-5 #8 1000 mb outside								
TPS 800-5 #16 300 mb outside								
Valve opening TPS 800-5 #21								
Δf prior to Thermal Cycle TPS 800-6 #1								
Δf after Thermal Cycle TPS 800-6 #4								
Valve opening TPS 800-6 #7								

ADAPTION PHASE DATE

Test	f ref	f aneroid	Δf f ref-f an	Pressure	Therm. Resistance	Therm. Temp.	Date	Notes
Adaption Data TPS 800-6 #8								

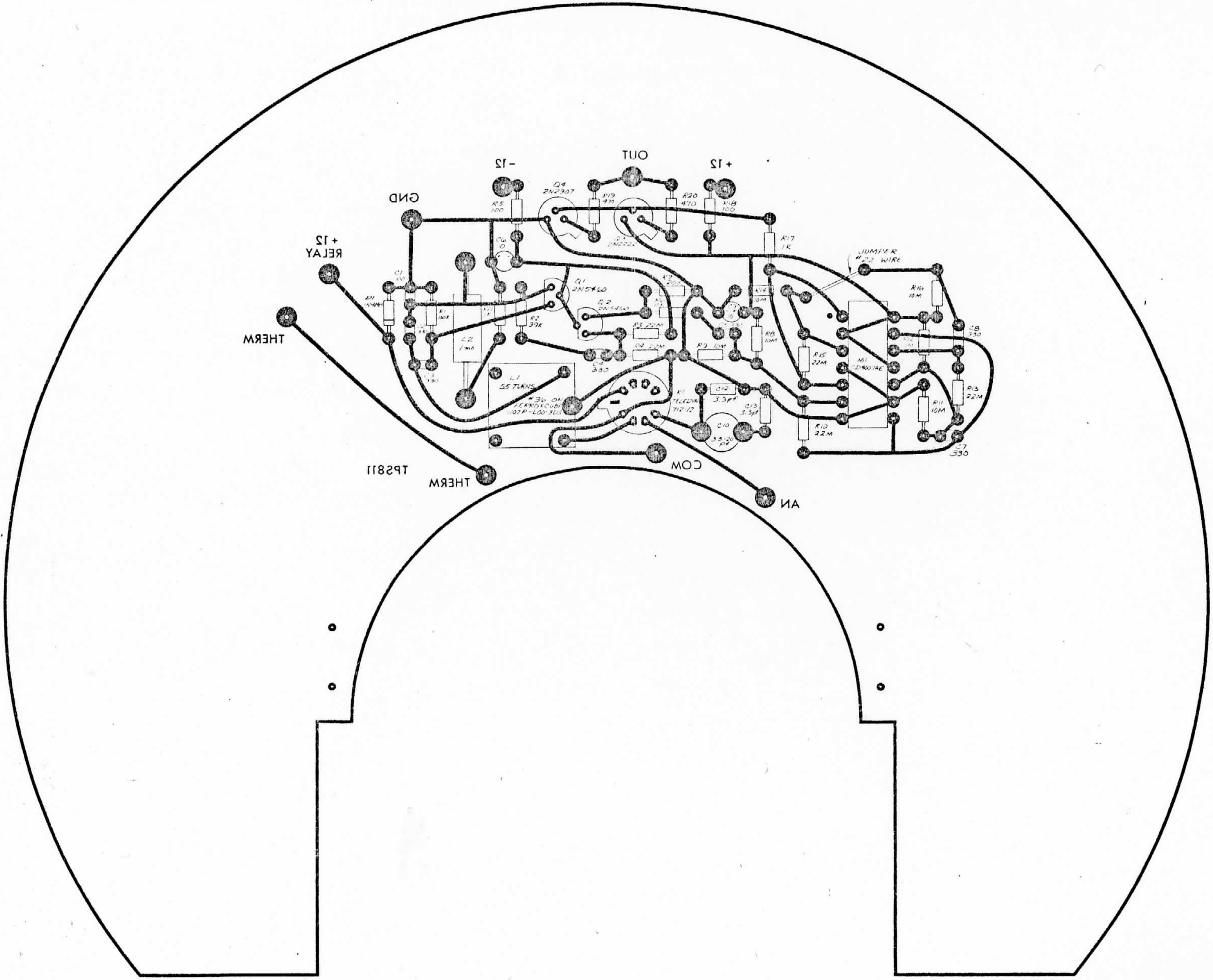
ADAPTION PHASE DATE

Test	f ref	f aneroid	Δf f ref-f an	Pressure	Therm. Resistance	Therm. Temp.	Date	Notes
Adaption Data TPS 800-6 #8								

CALIBRATION

Test	f ref	f aneroid	Δf (f ref-f an)	Pressure	Therm. Resistance	Therm. Temp.	Date	Notes
TPS 800-6 #9 @ -40°C				170				
				160				
				150				
				140				
				130				
TPS 800-6 #10 @ -30°C				170				
				160				
				150				
				140				
				130				
TPS 800-6 #11 @ -20°C				170				
				160				
				150				
				140				
				130				
TPS 800-6 #12 @ +20°C				170				
				160				
				150				
				140				
				130				
TPS 800-6 #13 @ +30°C				170				
				160				
				150				
				140				
				130				
TPS 800-6 #14 @ +25°C				170				
				160				
				150				
				140				
				130				
TPS 800-6 #16				150				

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



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TITLE: ELECTRONICS BOARD ASSEMBLY			
SCALE: 4/1	DRAFTSMAN: [illegible] DATE: 5/1/73	CHECKER / DATE	ENGINEER / DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE / DATE	PROJECT APPROVAL / DATE	
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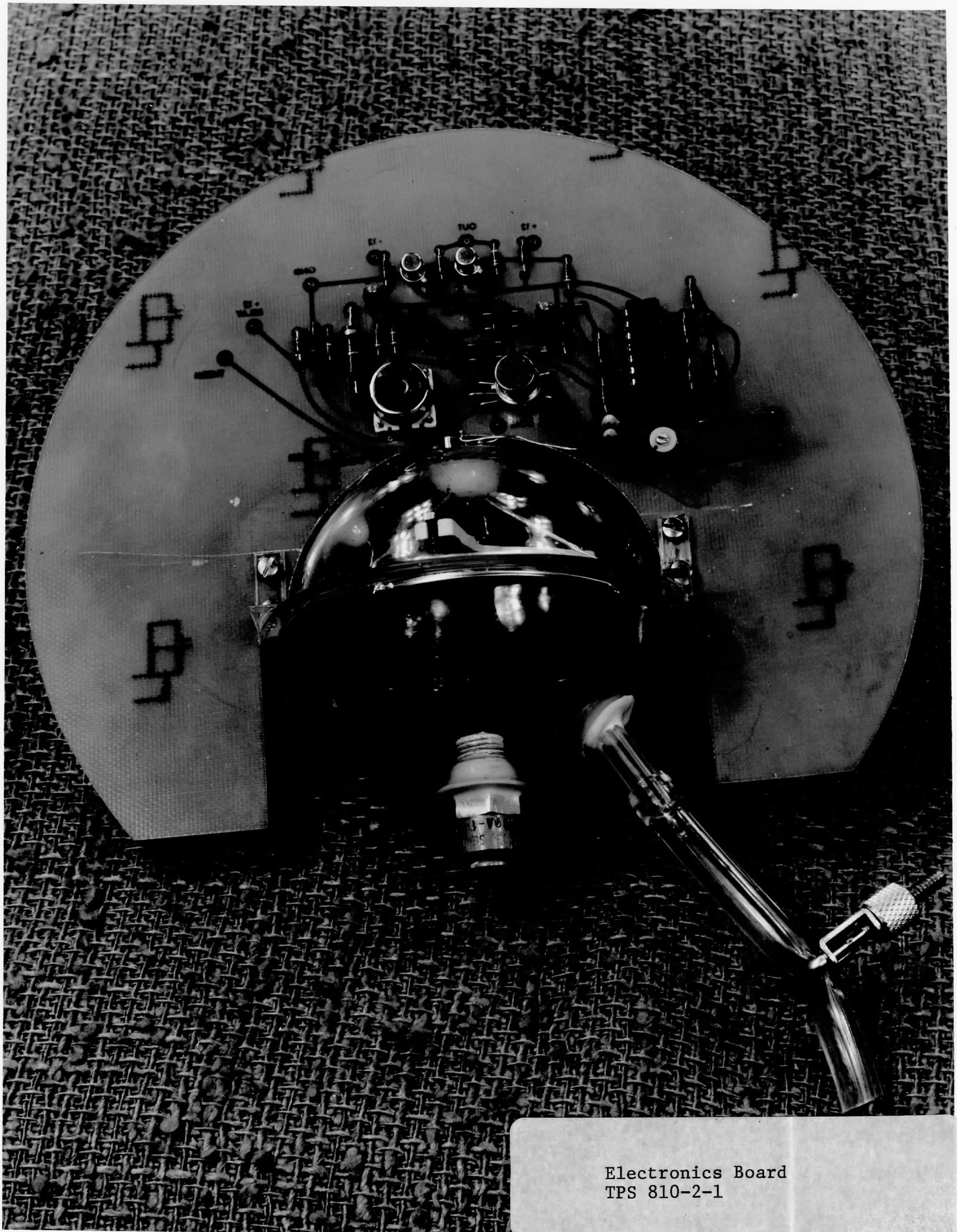
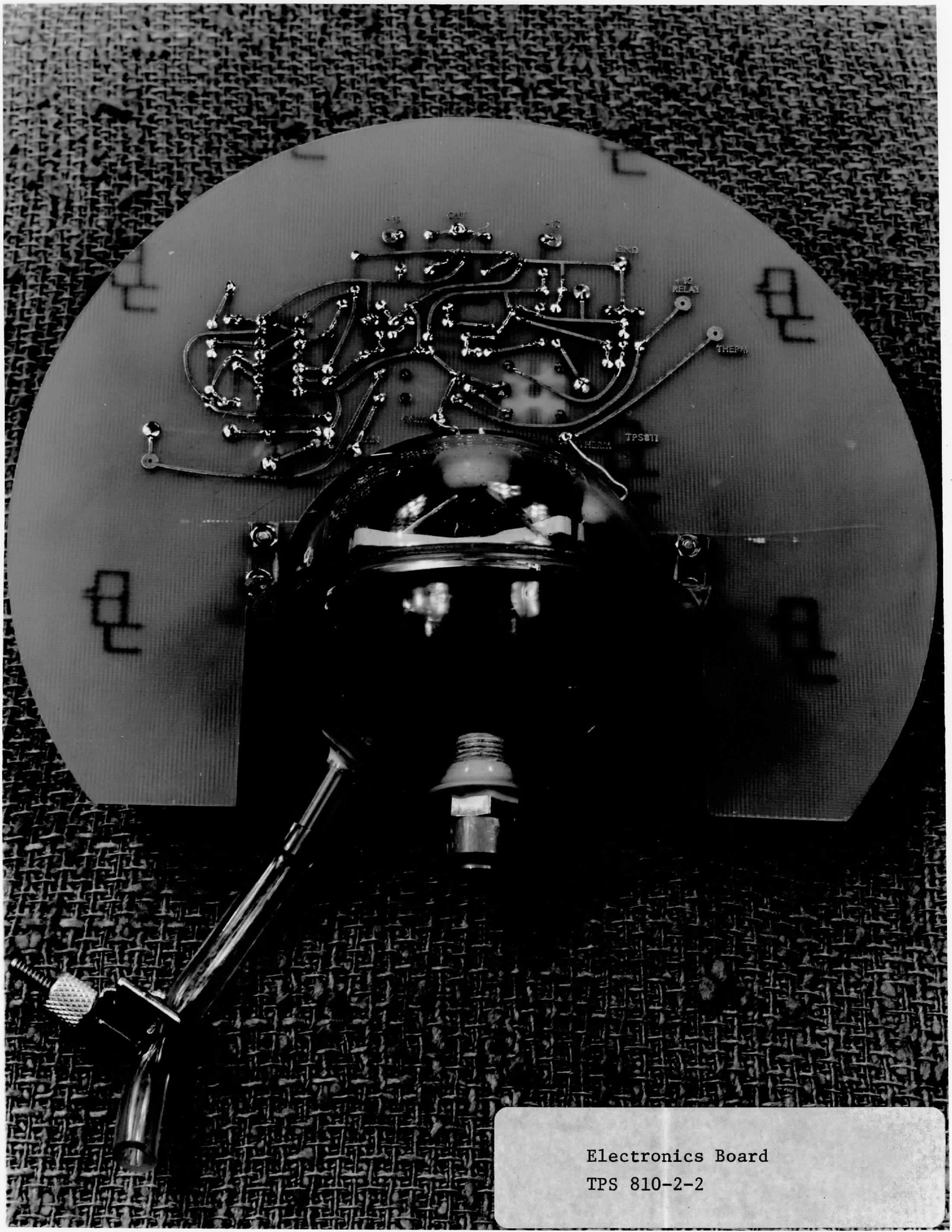


Electronics Board
TPS 810-2-1



Electronics Board
TPS 810-2-2

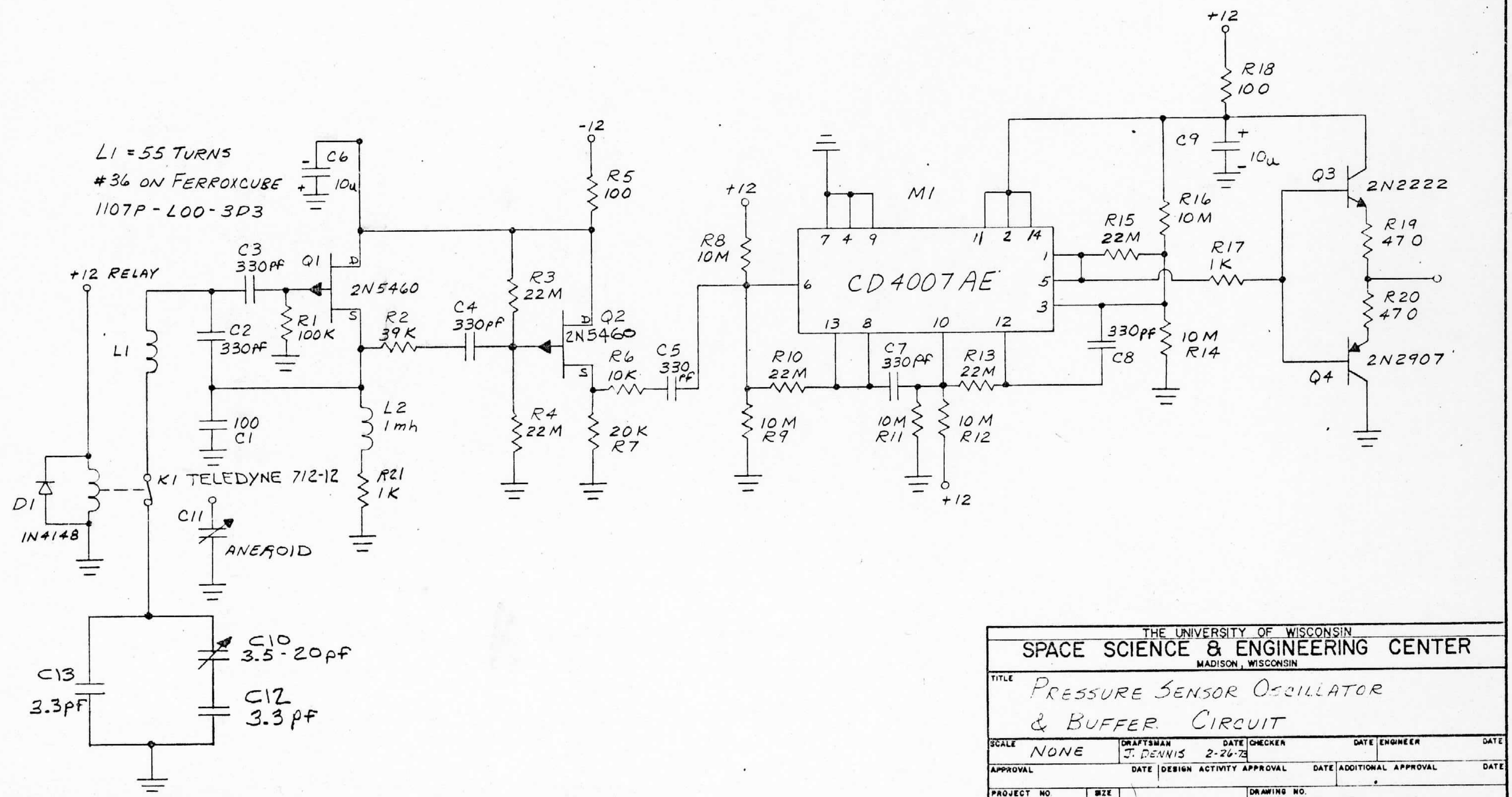
810-3 T W E R L E Pressure Electronics Parts List 810-3 Date 18 April 73 Page 1 of 2

REFERENCE Dwg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
810-4	D1	Diode 1N4148	ITT	1	
810-4	Q1	FET Transistor 2N5460	Motorola	2	
810-4	Q2	Same as Q1			
810-4	Q3	Transistor NPN 2N2222	Motorola	1	
810-4	Q4	Transistor PNP 2N2907	Motorola	1	
810-4	M1	COS/MOS Integrated Circuit CD4007AE	RCA	1	
810-4	C1	Capacitor, Ceramic 100pf 8101-A200-W5R-101K	Erie	1	
810-4	C2	Capacitor, Ceramic 330pf 8111-A100-W5R-331K	Erie	6	
810-4	C3	Same as C2			
810-4	C4	Same as C2			
810-4	C5	Same as C2			
810-4	C6	Capacitor, Tantalum, 10µ-25v 196D106 x 9025KA1	Sprague	2	
810-4	C7	Same as C2			
810-4	C8	Same as C2			
810-4	C9	Same as C6			
810-4	C10	Capacitor, Trimmer 518-000A 3.5-20	Erie	1	
810-4	C11	Aneroid Capacitor 150mb cap. = 6pf	Vaisala	2	
810-4	C12	Capacitor, Ceramic 3.3pf 8101-A200-COG-339	Erie	2	
810-4	C13	Same as C12			
810-4	R1	Resistor, Comp. 100K RC05GF104J	Allen Bradley	1	
810-4	R2	Resistor, Comp. 39K RC05GF393J	Allen Bradley	1	
810-4	R3	Resistor, Comp. 22M RC05GF226J	Allen Bradley	5	
810-4	R4	Same as R3			
810-4	R5	Resistor, Comp. 100 Ohm RC05GF101J	Allen Bradley	2	
810-4	R6	Resistor, Comp. 10K RC05GF103J	Allen Bradley	1	
810-4	R7	Resistor, Comp. 20K RC05GF203J	Allen Bradley	1	

810-3 T W E R L E Pressure Electronics Parts List — Date 18 April 73 — Page 2 of 2

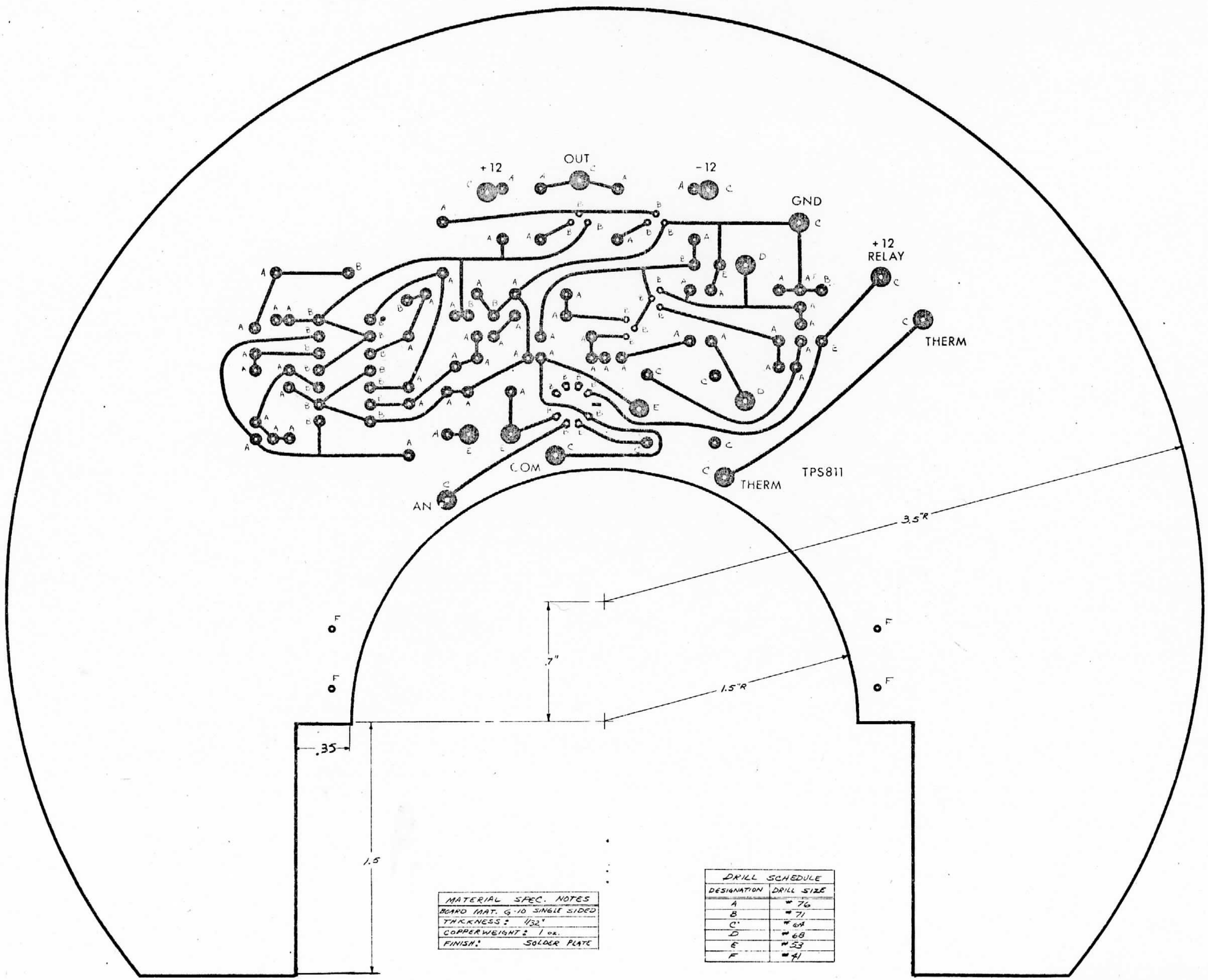
Reference Dwg. No	Reference Schem.	Description	Source	Quan. Assy.	
810-4	R8	Resistor, Comp. 10M RC05GF106J	Allen Bradley	6	
810-4	R9	Same as R8			
810-4	R10	Same as R3			
810-4	R11	Same as R8			
810-4	R12	Same as R8			
810-4	R13	Same as R3			
810-4	R14	Same as R8			
810-4	R15	Same as R3			
810-4	R16	Same as R8			
810-4	R17	Resistor Comp. 1K RC05GF102J	Allen Bradley		
810-4	R18	Same as R5			
810-4	R19	Resistor Comp. 470 Ohm RC05GF471J	Allen Bradley		
810-4	R20	Same as R19			
810-4	R21	Same as R17			
810-4	L1	Ferrite Core 1107P-L00-3D3	Ferroxcube		
810-4	L1	Bobbin (Part of L1) 1107-F1D	Ferroxcube		
810-4	L1	Hardware (Part of L1) 1107-HD	Ferroxcube		
810-4	L2	Inductor, 1000yh SWD-1000	Nytronics		
810-4	L				
810-4	K1	Relay, DPDT 712-12	Teledyne		

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED



THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN				
TITLE: PRESSURE SENSOR OSCILLATOR & BUFFER CIRCUIT				
SCALE: NONE	DRAFTSMAN: J. DENNIS, DATE: 2-26-73	CHECKER, DATE	ENGINEER	DATE
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL	DATE ADDITIONAL APPROVAL	DATE
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TPS 810-4	

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



MATERIAL SPEC. NOTES	
BOARD MAT.	G-10 SINGLE SIDED
THICKNESS:	1/32"
COPPERWEIGHT:	1 oz.
FINISH:	SOLDER PLATE

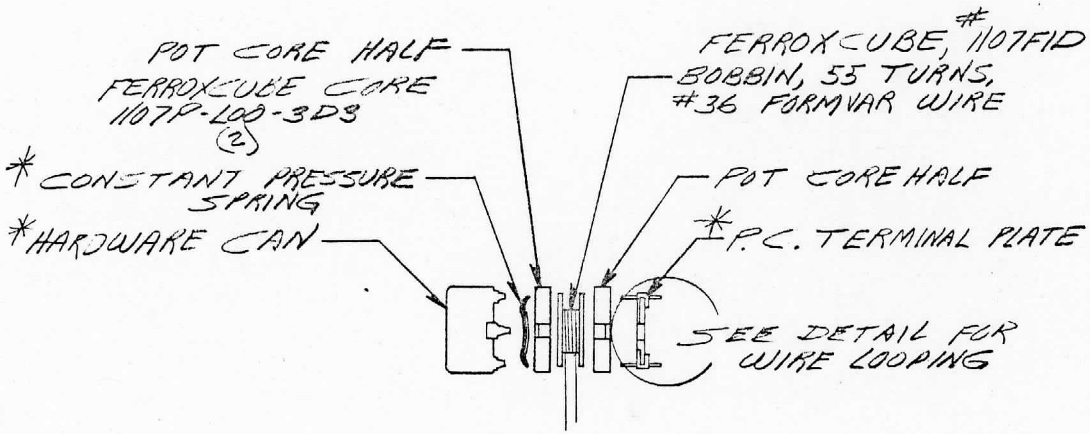
DRILL SCHEDULE	
DESIGNATION	DRILL SIZE
A	#76
B	#71
C	#69
D	#68
E	#53
F	#41

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER

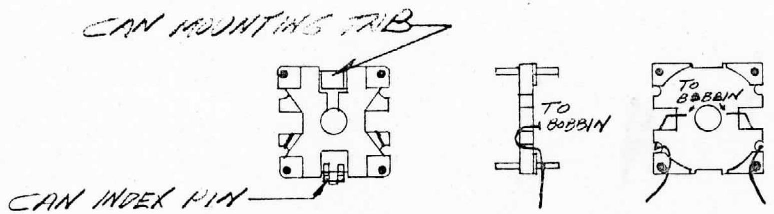
TITLE: ELECTRONICS BOARD P.C. SPECIFICATION

SCALE 4/1 | DATE 5/1/73 | PROJECT NO 6300 | SIZE D | SHEET 1 OF 1 | DRAWING NO TPS 811-1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



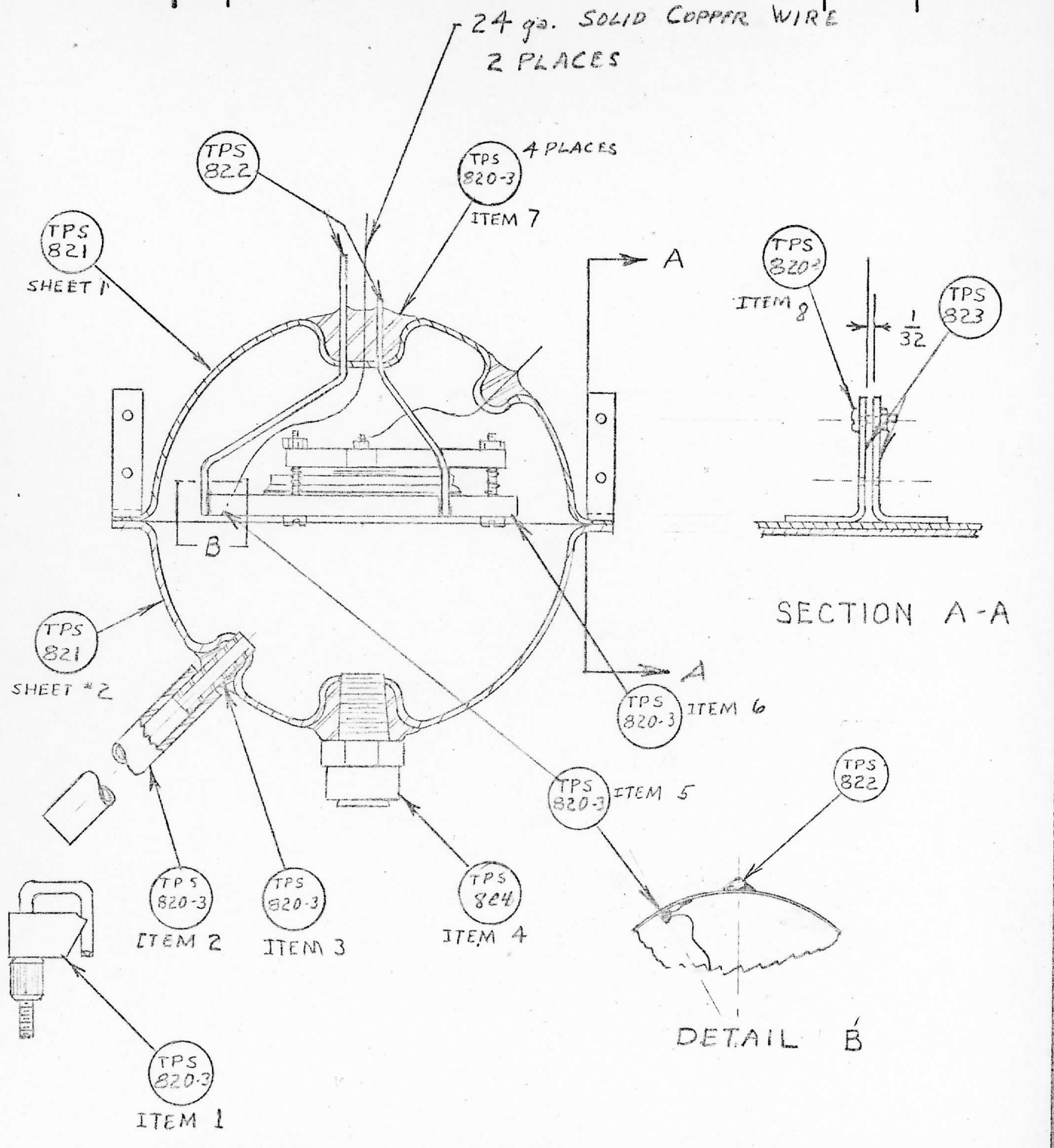
* PART OF FERROXCUBE HARDWARE KIT 1107HD



DETAIL OF DIRECTION OF WIRING LOOPING AROUND P.C. TERMINAL PLATE

THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN				
TITLE: INDUCTOR L1				
SCALE: NONE	DRAFTSMAN: JB	DATE	CHECKER / DATE	ENGINEER / DATE
APPROVAL		DATE	DESIGN ACTIVITY APPROVAL / DATE	ADDITIONAL APPROVAL / DATE
PROJECT NO: 6300	SIZE: B	SHEET 1 OF 1	DRAWING NO.: TPS 812	

LTR.	REVISIONS DESCRIPTION	DATE	APPROVED



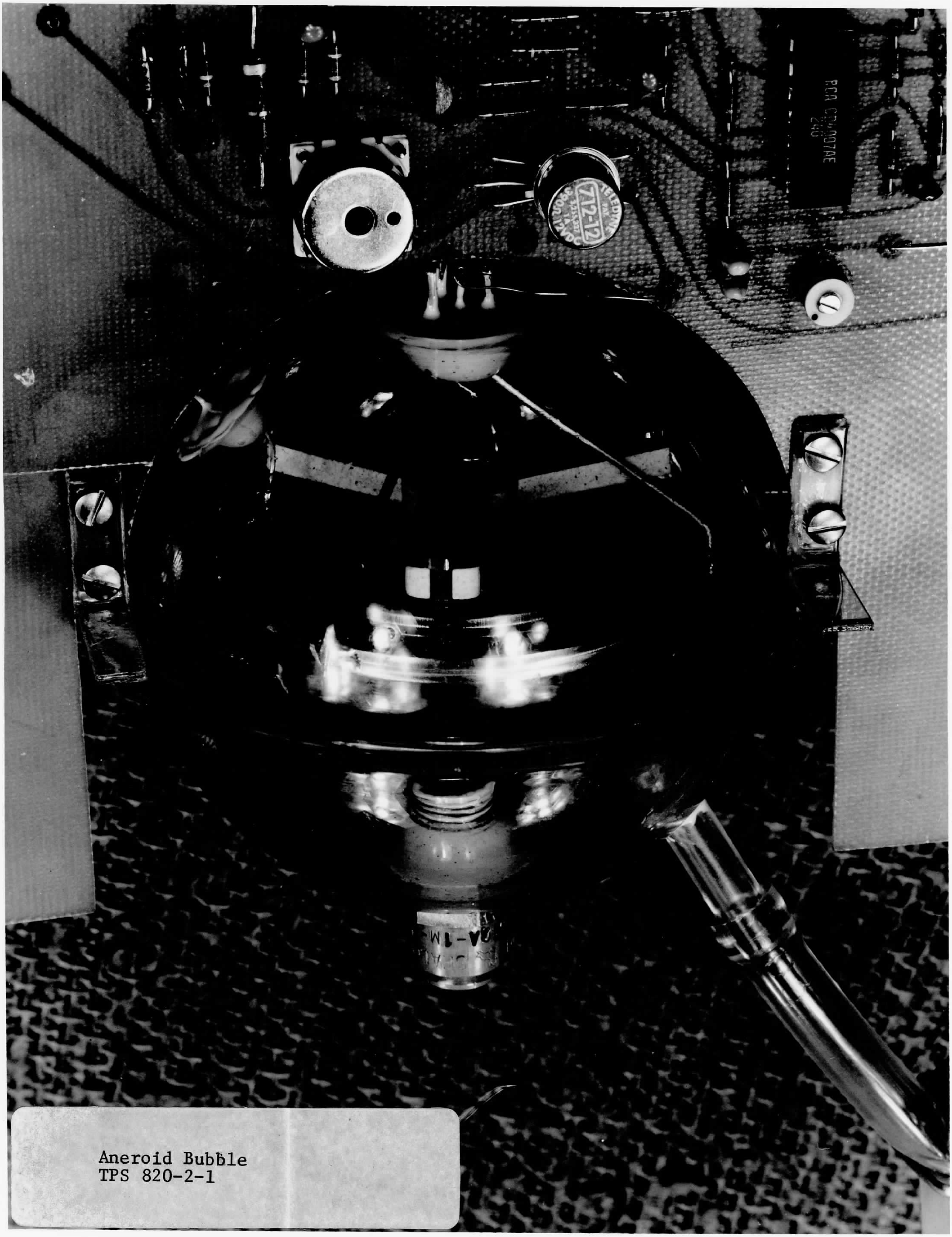
THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE
PRESSURE BUBBLE ASSEMBLY

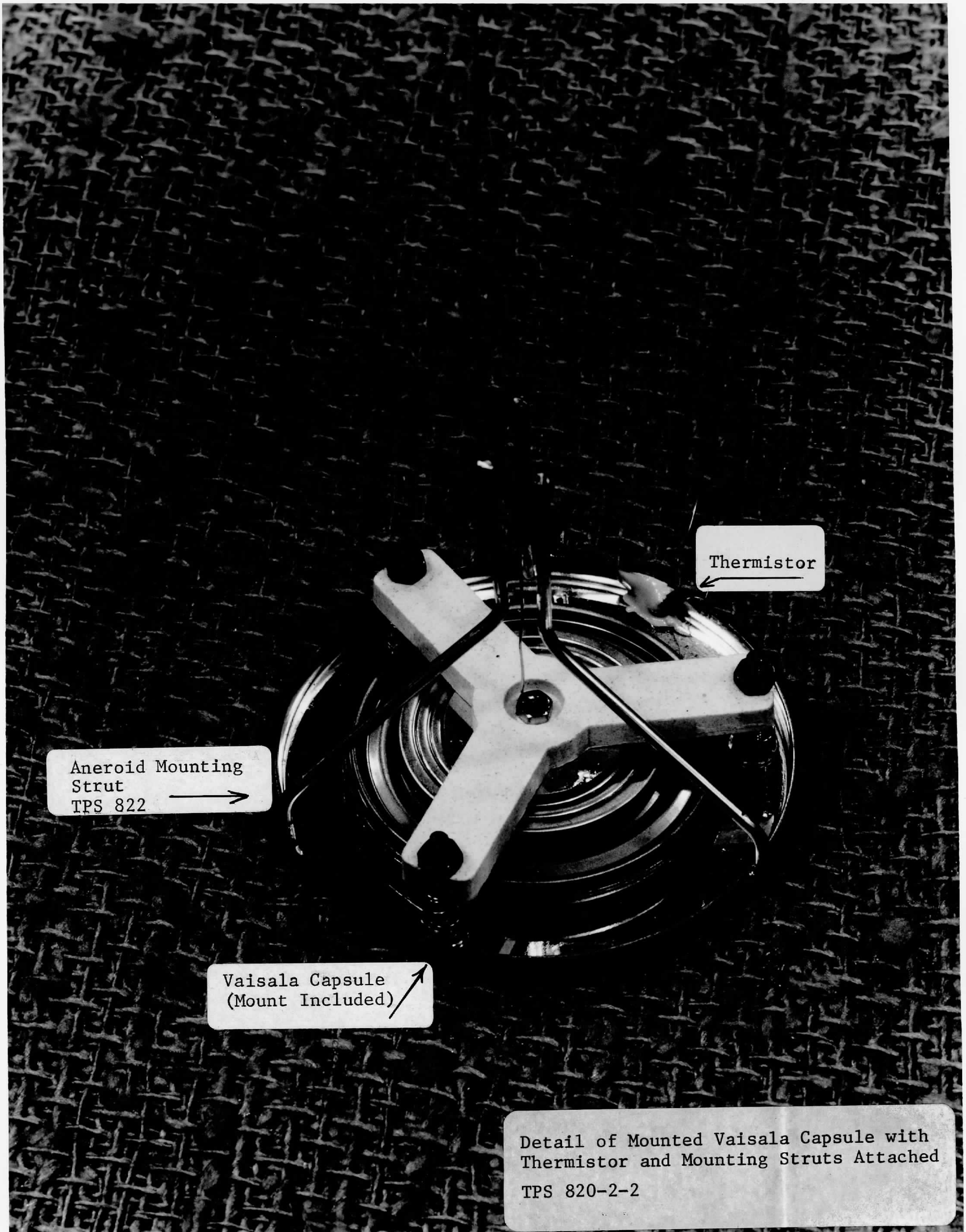
SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	J.G.M	3/30/73	J.G.M	3/30/73	J.G.M	3/30/73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TPS 800-1				

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6310	A	1 OF 1	TPS 820-1



Aneroid Bubble
TPS 820-2-1



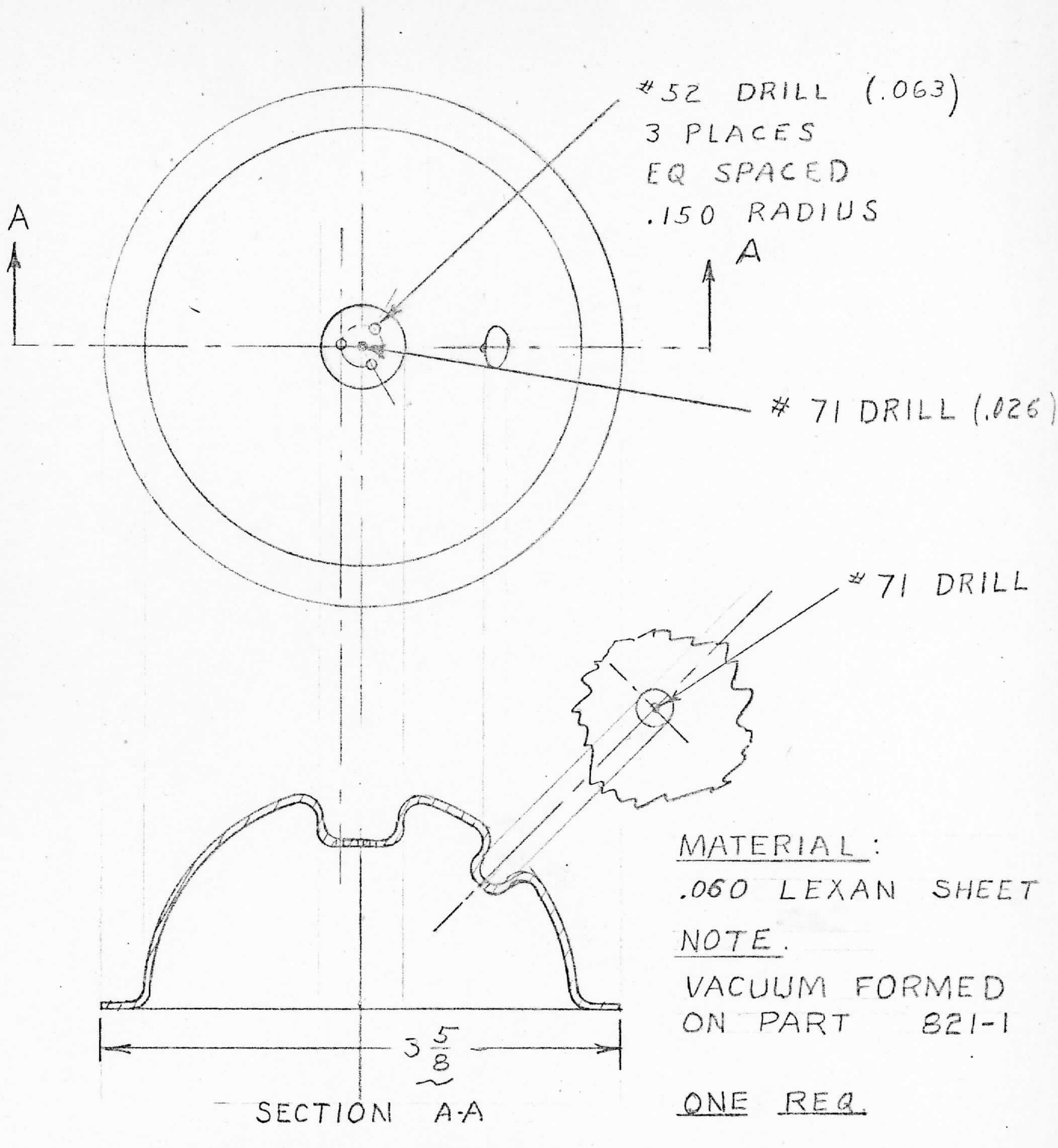
Detail of Mounted Vaisala Capsule with Thermistor and Mounting Struts Attached

TPS 820-2-2

TPS 820-3 T W E R L E Pressure Sensor Date April 27, 1973 Page 1 of 1

REFERENCE Dwg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
820-1	1	Pinchit Tube Shut-Off Clamp--Part 5330K14	Mc Master--Carr (Chicago)	1	
820-1	2	Tygon Tube 1/4 ID x 3/8" OD x 4" long		1	
820-1	3	Plexiglass Tube 1/8" I x 1/4" OD x 5/8" long	Rohm & Hass Co.	1	
820-1	4	Vacuum Relief Valve	Circle Seal Corp. p71-673 Supplied by NCAR	1	
20-1	5	Thermistor 3K @25°C	YSI 44005	1	
20-1	6	Aneroid Capsule & Mount	Vaisala, Supplied by NCAR	1	
820-1	7	Shell Epon 907 Epoxy	Hysol Corp.	--	
820-1	8	#2-56 Screw & Nut	Allmetal Screw Co.	4	
821		Bubble, Lexan	In-House Manufacture	2	
822		Strut, Aneroid Support	In-House Manufacture	3	
823		Bracket, Mounting	In-House Manufacture	4	

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



MATERIAL:

.060 LEXAN SHEET

NOTE.

VACUUM FORMED ON PART 821-1

ONE REQ.

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE

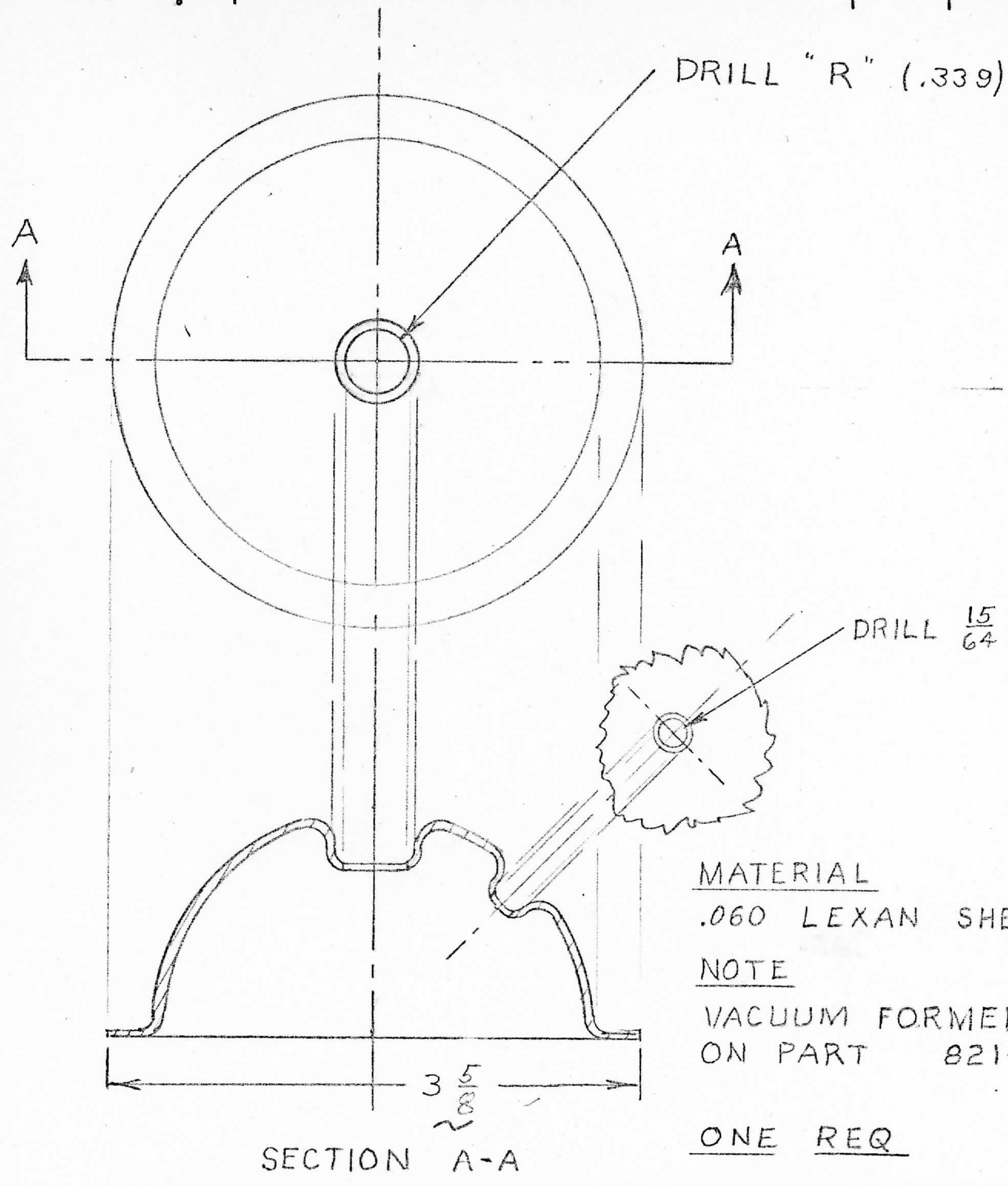
HOLE DIMENSIONS FOR THE TWO BUBBLE HALVES

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	J.G.M	4/2/73	J.G.M	4/2/73	J.G.M	4/2/73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TPS 820-1				

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6310	A	1 OF 2	TPS 821

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



MATERIAL

.060 LEXAN SHEET

NOTE

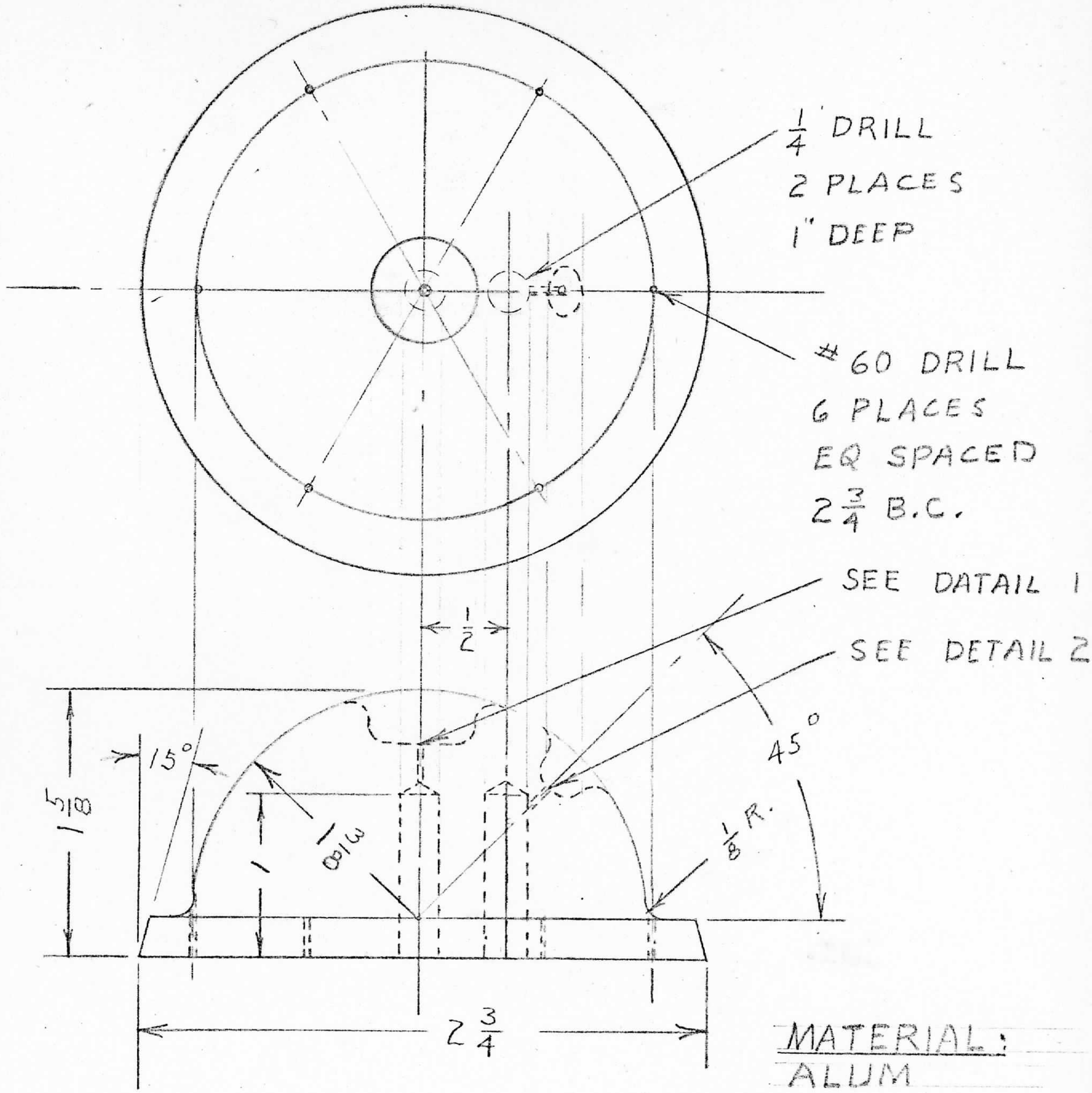
VACUUM FORMED ON PART 821-1

ONE REQ

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: HOLE DIMENSIONS FOR THE TWO BUBBLE HALVES					
SCALE: FULL	DRAFTSMAN: J.G.M	DATE: 4/2/73	CHECKER: J.G.M DATE: 4/2/73	ENGINEER: J.G.M	DATE: 4/2/73
NEXT HIGHER ASSEMBLY: TPS 820-1	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL		DATE
PROJECT NO.: 6310	SIZE: A	SHEET 2 OF 2	DRAWING NO.: TPS 821		

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



MATERIAL:
ALUM

1 REQ

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

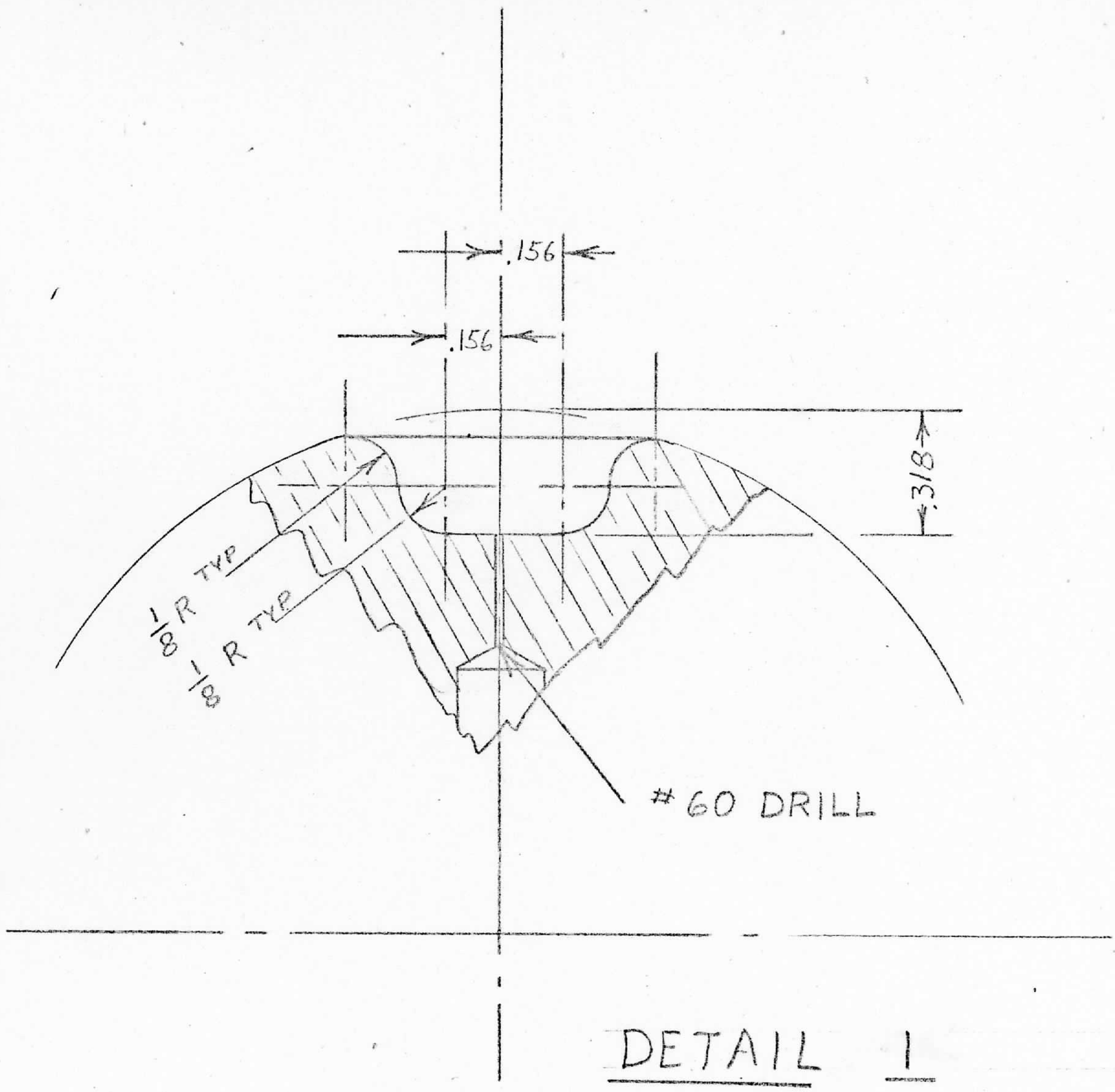
TITLE
MOLD FOR BUBBLE HALF
(TO BE SUPPLIED BY NCAR)

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	J.G.M	4/2/73	J.G.M	4/2/73	J.G.M.	4/2/73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
821				

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6310	A	1 OF 3	TPS 821-1

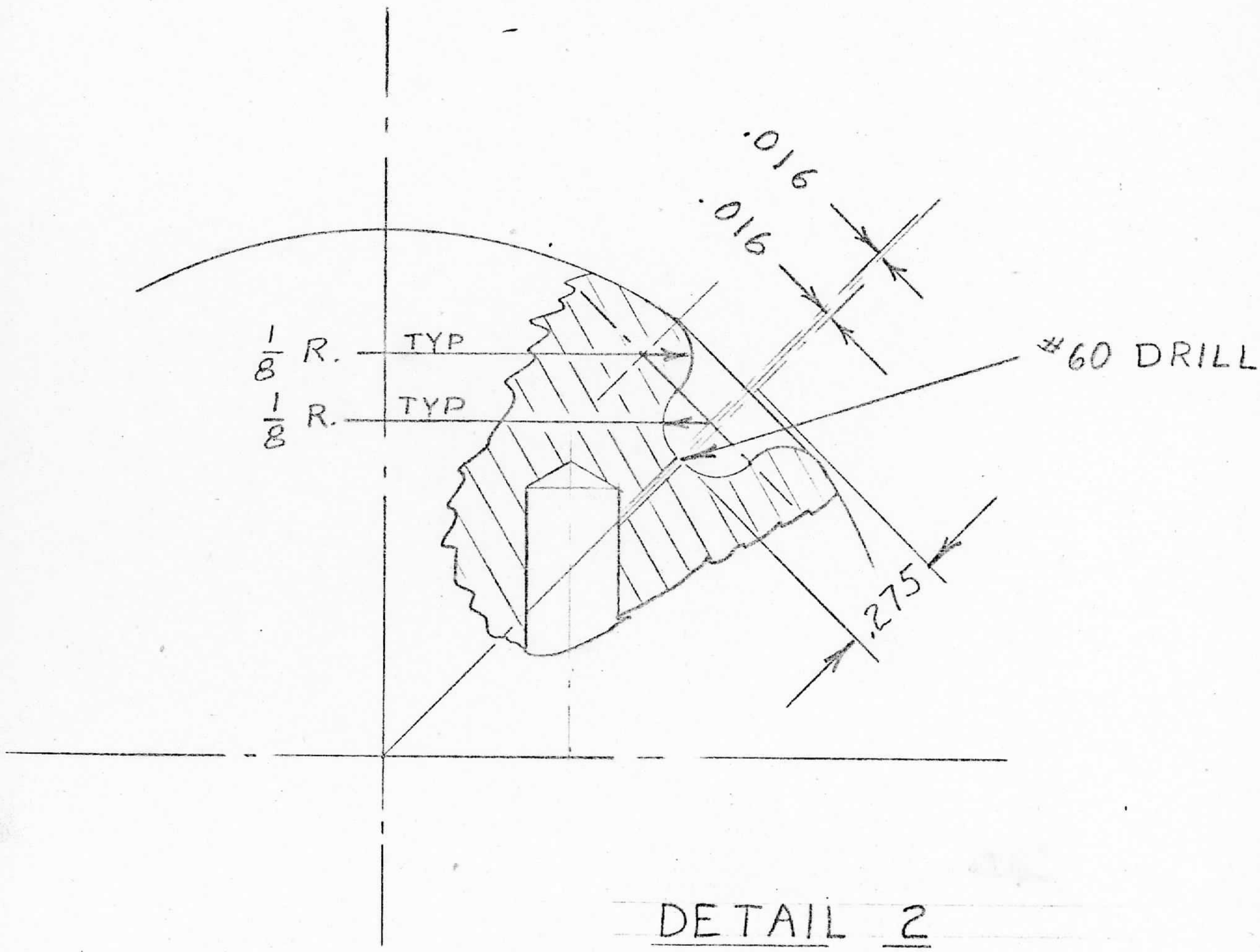
REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



DETAIL 1

THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN					
TITLE MOLD FOR BUBBLE HALF (To BE SUPPLIED BY NCAR)					
SCALE DOUBLE	DRAFTSMAN J.G.M.	DATE 4/2/73	CHECKER J.G.M	DATE 4/2/73	ENGINEER J.G.M DATE 4/2/73
NEXT HIGHER ASSEMBLY 821		PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
PROJECT NO. 6310	SIZE A	SHEET 2 OF 3		DRAWING NO. TPE 821-1	

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



DETAIL 2

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE
MOLD FOR BUBBLE HALF
(TO BE SUPPLIED BY NCAR)

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
DOUBLE	J.G.M.	4/2/73	J.G.M.	4/2/73	J.G.M.	4/2/73

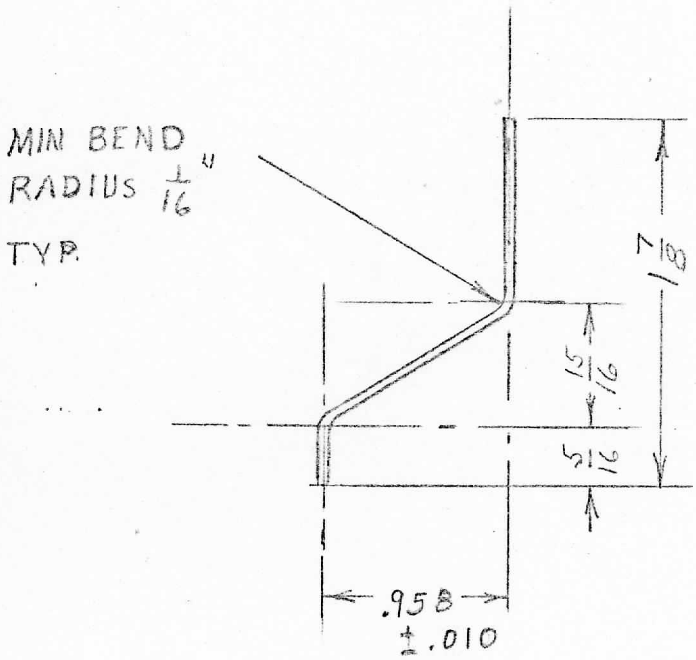
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TPS 821				

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6310	A	3 OF 3	TPS 821-1

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED

FINISH TIN WIRE

WITH SN 60 SOLDER



MATERIAL

PHOSPHOR BRONZE WIRE
SA.E STANDARD NO. 81
17 ga. (.045 DIAM.)

3 REQ

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: ANEROID MOUNTING STRUT

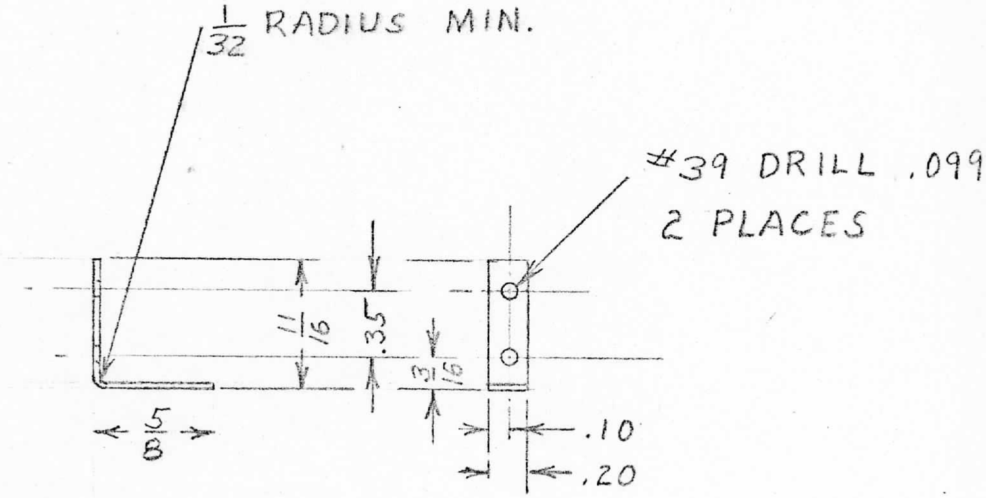
SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	J.G.M	4/2/73	J.G.M	4/2/73	J.G.M	4/2/73

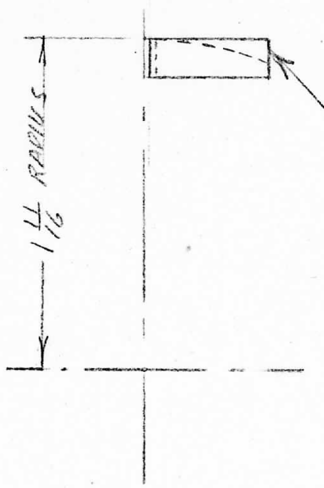
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TPS 820-1				

PROJECT NO. | SIZE | SHEET 1 OF 1 | DRAWING NO.

REVISIONS

LTR.	DESCRIPTION	DATE	APPROVED





AT ASSEMBLY SOLVENT GLUE TO PART 821 & REMOVE EXCESS MATERIAL

MATERIAL

.060 LEXAN SHEET

4 REQ

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

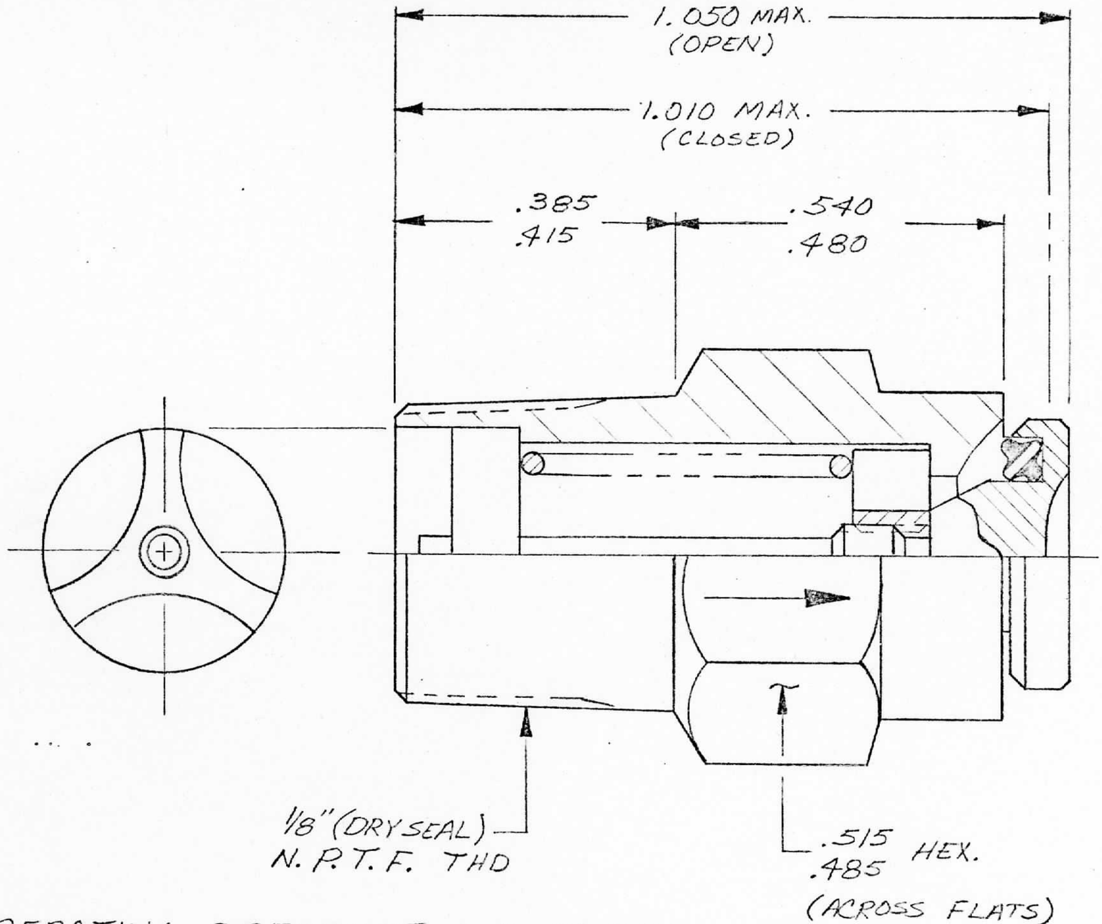
TITLE: PRESSURE BUBBLE MOUNTING BRACKETS

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	J.G.M	4/3/73	J.G.M.	4/3/73	J.G.M.	4/3/73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TPS 820-1				

PROJECT NO.	SIZE	SHEET	OF	DRAWING NO.
6310	A	1	1	TPS 823

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



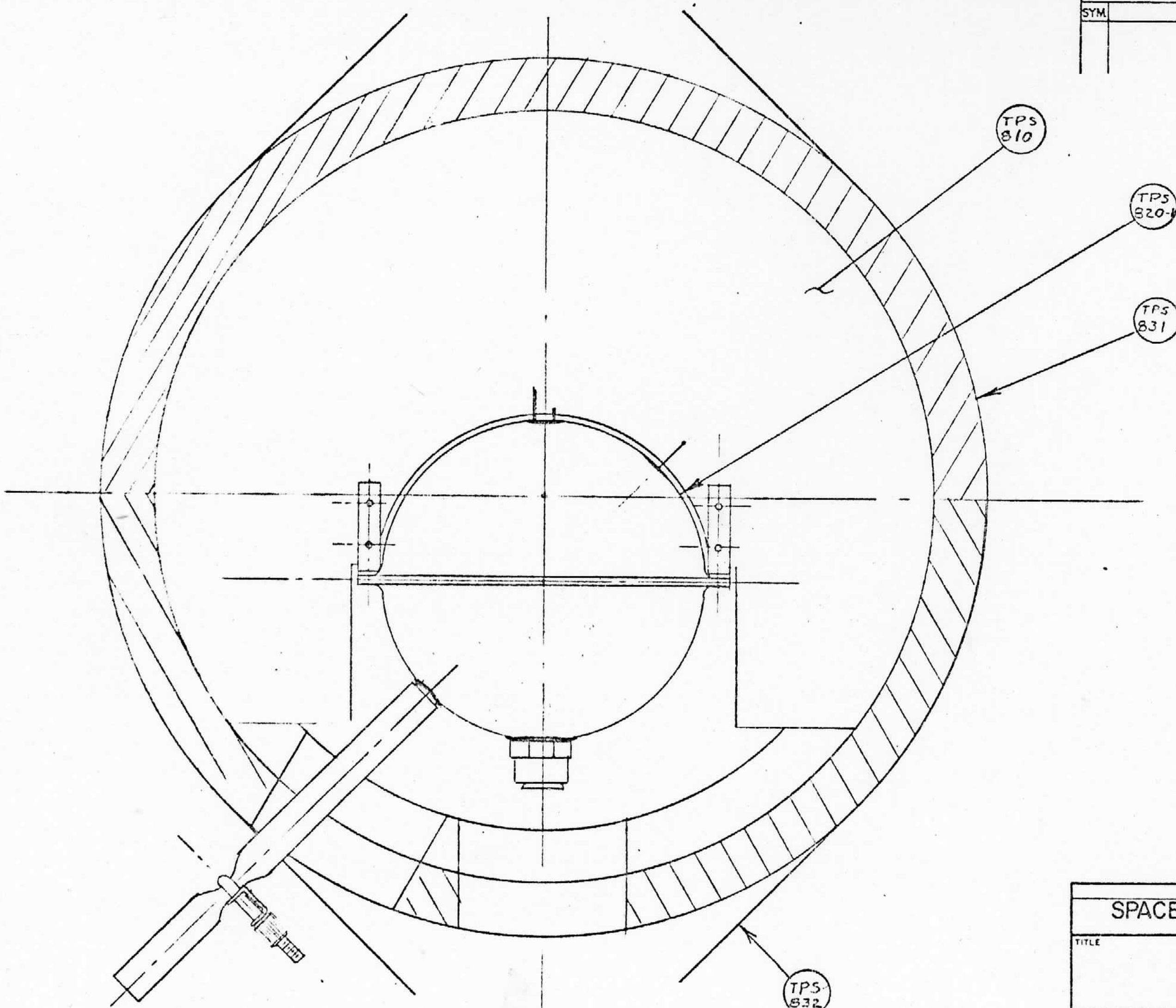
OPERATING PRESSURE : 0-50 PSI
OPERATING TEMP. : -65° TO +250°F
INTERNAL LEAKAGE : ZERO AT CLOSING PRESS.
EXTERNAL LEAKAGE : 0
MOUNT LIMITATIONS : NONE
SUITABLE FOR : AIR, N_2
CLOSING PRESSURE : 1 PSI ± 10%
VALVE MATERIAL : ALUM. 2024-T351
FINISH : CHROMIC ANODIZE
SPRING MATERIAL : CRES 302
SEALS - PART NO. : Q 5003-24
SEALS - MATERIAL : SILICONE
LUBRICANT : MIL-G-4343

PART ORDED FROM:
JAMES POND & CLARK DIV.
CIRCLE SEAL CORPORATION
ANAHEIM, CALIF.
PER THEIR DRAWING
NO. P71-673

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE
VACUUM RELIEF VALVE

SCALE	DRAFTSMAN AW DATE 5/2/73	CHECKER DATE	ENGINEER DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE DATE	PROJECT APPROVAL DATE	
PROJECT NO. 6300	SIZE A	SHEET 1 OF 1	DRAWING NO. TPS 824

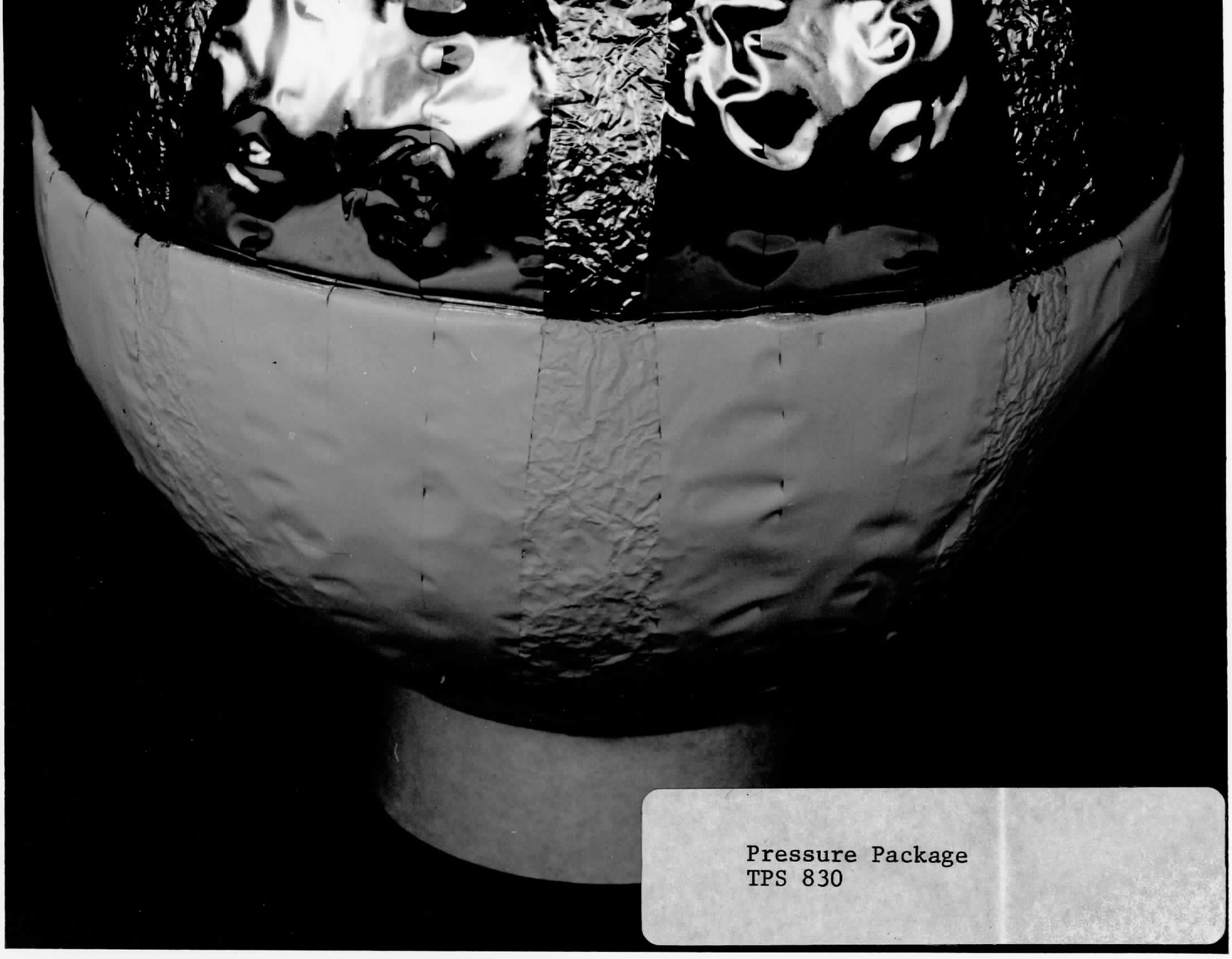


REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: PRESSURE SENSOR ASSEMBLY

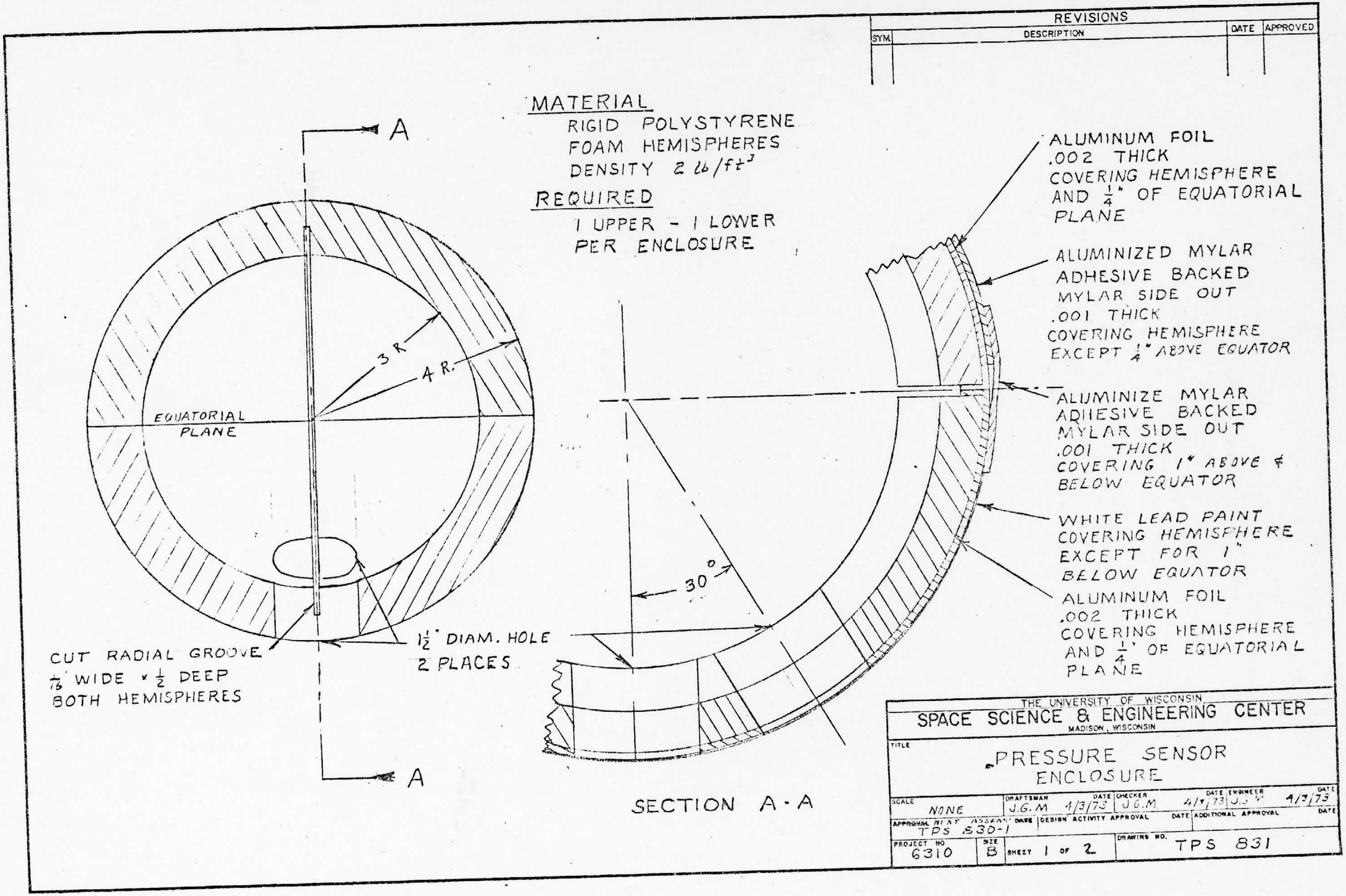
SCALE: FULL	DRAFTSMAN: J.G.M	DATE: 4/2/73	CHECKER: J.G.M	DATE: 4/2/73	ENGINEER: J.G.M	DATE: 4/2/73
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL	DATE	ADDITIONAL APPROVAL		DATE
PROJECT NO: 6310	SIZE: A	SHEET 1 OF 1	DRAWING NO. TPS 830-1			



Pressure Package
TPS 830

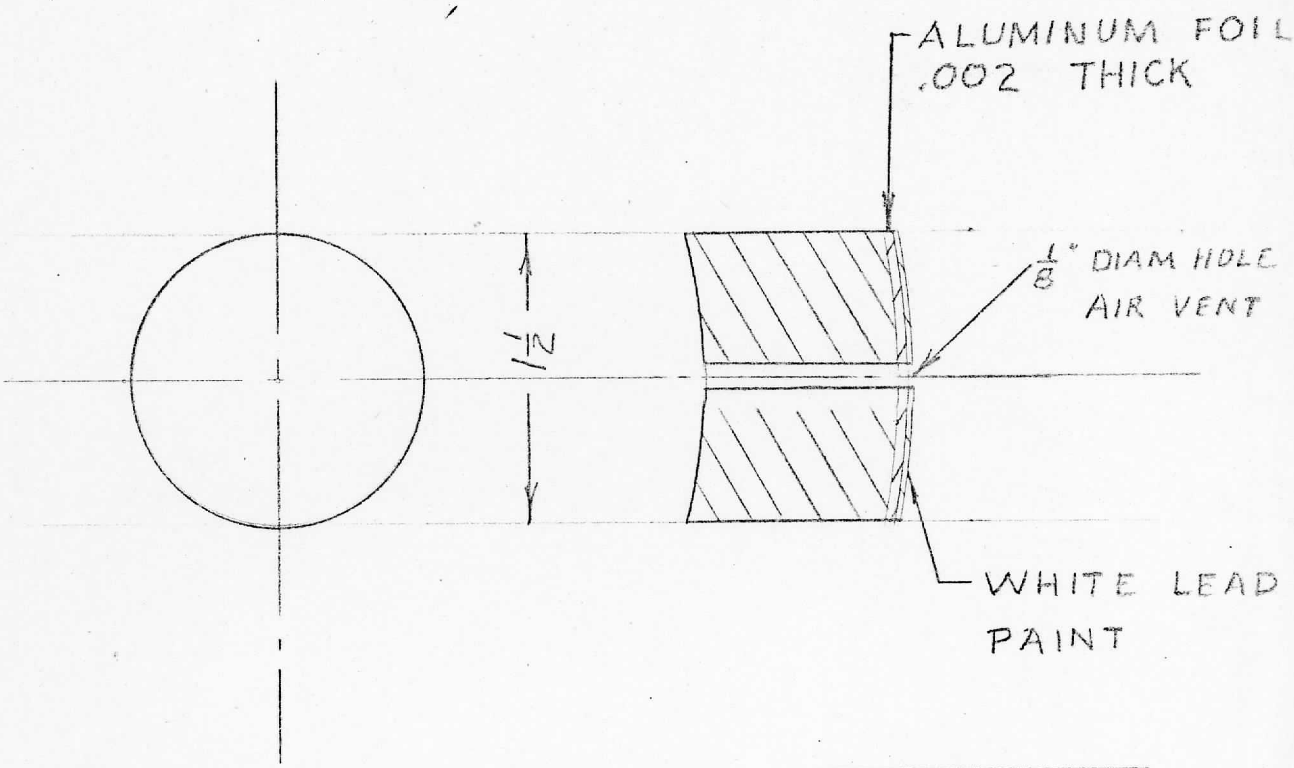
TPS 830-3 T W E R L E Pressure Sensor Date April 27, 1973 Page 1 of 1

REFERENCE		DESCRIPTION	SOURCE	QUAN. ASSY.	
Dwg. No.	SCHEM.				
831-		Sphere, 8th Enclosure		1	
832		Net, Supporting		1	


REVISIONS
SYM.
DESCRIPTION
DATE
APPROVED
MATERIAL
RIGID POLYSTYRENE
FOAM HEMISPHERES
DENSITY 2 lb/ft³
REQUIRED
1 UPPER - 1 LOWER
PER ENCLOSURE
A
A
3 R
4 R.
EQUATORIAL
PLANE
CUT RADIAL GROOVE
1/16" WIDE × 1/2 DEEP
BOTH HEMISPHERES
1 1/2" DIAM. HOLE
2 PLACES
30°
SECTION A-A
ALUMINUM FOIL
.002 THICK
COVERING HEMISPHERE
AND 1/4" OF EQUATORIAL
PLANE
ALUMINIZED MYLAR
ADHESIVE BACKED
MYLAR SIDE OUT
.001 THICK
COVERING HEMISPHERE
EXCEPT 1/4" ABOVE EQUATOR
ALUMINIZE MYLAR
ADHESIVE BACKED
MYLAR SIDE OUT
.001 THICK
COVERING 1" ABOVE &
BELOW EQUATOR
WHITE LEAD PAINT
COVERING HEMISPHERE
EXCEPT FOR 1"
BELOW EQUATOR
ALUMINUM FOIL
.002 THICK
COVERING HEMISPHERE
AND 1/4" OF EQUATORIAL
PLANE
THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN
TITLE
PRESSURE SENSOR
ENCLOSURE
SCALE NONE
DRAFTSMAN J.G.M DATE 4/3/73
CHECKER J.G.M DATE 4/4/73
ENGINEER DATE 4/3/73
APPROVAL NEXT ASSEMBLY TPS 830-1
DESIGN ACTIVITY APPROVAL DATE
ADDITIONAL APPROVAL DATE
PROJECT NO. 6310
SIZE B
SHEET 1 OF 2
DRAWING NO. TPS 831

REVISIONS

LTR.	DESCRIPTION	DATE	APPROVED



CUT FROM POLYSTYRENE
HEMISPHERE (SEE SHEET 1)
PLUGS FOR THE TWO HOLES

2 REQ.

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

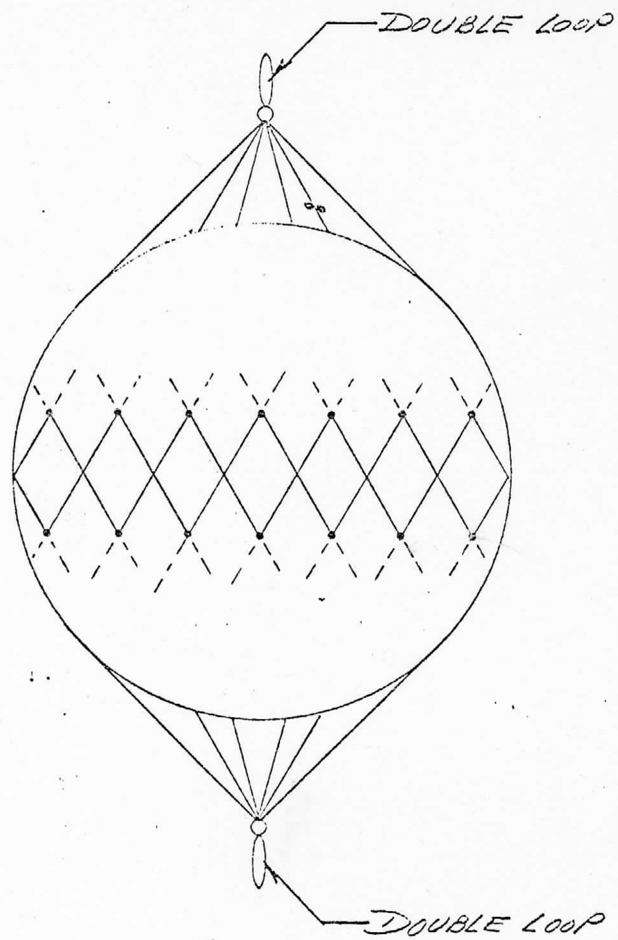
TITLE: PRESSURE SENSOR ENCLOSURE

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	JGM	4/6/73	J.G.M	4/6/73	J.G.M	4/6/73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TPS 830-1				

PROJECT NO. | SIZE | SHEET 2 OF 2 | DRAWING NO. TPS 831

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



MAT: NYLON, STRAND TEST STRENGTH 50 LBS.

THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN			
TITLE: SUPPORT NET			
SCALE: NONE	DRAWN BY	DATE CHECKER	DATE ENGINEER DATE
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL	DATE ADDITIONAL APPROVAL DATE
PROJECT NO 6300	SIZE B	SHEET 1 OF 1	DRAWING NO TPS 832