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Final Technical Progress Report
Differential Collision Cross-Sections for Atomic Oxygen

"Analysis of Space Flight Instruments for Solar Terrestrial Physics"

Contract NAS8-36955
Delivery Order 59

George C. Marshall Space Flight Center
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by

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Final Report on Delivery Order 59 of NAS8-36955

1. Studies of Fundamental Parameters Relevant to the Space Station Environment

During February, June, July, September and October 1990, the work on the Cross-section Facility at MSFC was supported under D.O. 59 (NAS8-36955). A summary of the status is given below. A more detailed report on previous activities is given under the final report for D.O. 48. Table 1 shows the sources of funding for this activity since 12/16/88.

A facility has been designed, fabricated, assembled, tested and operated for measurement of differential scattering cross sections important to understanding the induced environment for a vehicle in low earth orbit.

The cryo pump for the compressor broke during May and work continued on software improvements. All problems were resolved during June and by the end of June, the system was fully operational. Additional progress was made in isolating noise sources. Work was also done on reducing long term drift and on improving the reliability and stability of the measured signals.

As part of the deliverables on this contract a user's manual and a report on the performance of the system was written.

A user's manual for the facility is attached as Appendix A. It contains instructions for assembly of the system, procedures for performance of initial tests to check-out and to calibrate the system, alignment procedures, and operating instructions. The performance of the facility was evaluated and found to be satisfactory in all the essential areas. First, the vacuum system was checked for leak tightness and cleanliness. The two pulsed beam valves were tested to determine the temporal and spatial profiles of the gas pulses. The alignment of the critical parts verified using HeNe lasers and the pulsed valves. Finally, differential scattering cross sections were measured. Results for the scattering measurements are contained in Appendix B.

2. Input to the Development of the Ultraviolet Imager Optical System

2.1 Support for Changes to Perkin Elmer Subcontract

Under this contract modifications to a subcontract to Perkin Elmer (now Hughes Danbury) for the design and fabrication of a prototype/engineering model of the UVI imager for the ISTP program were carried out. Further details of how these modifications interface with the overall UVI design and development subcontract to Perkin Elmer are given in the final report on NAS8-37586. Here we report only on the specific tasks affected by the change request.

These tasks included:

1. A re-analysis of the straylight study conducted under NAS8-37586 due to a change in the front end baffle design.

2. Re-design of the baffle system

TABLE 1

FUNDING FLOW FOR CROSS-SECTION FACILITY

CONTRACT	NAS8-36955 D.O. 48	NAS8-36955 D.O. 59	(ISTP) NAS8-37586	NAG8-834 (KEFFER-P.I.)
MONTH	7/9/89 - 7/10/90	11/5/89 - 11/6/90	12/16/88 - 8/30/90	6/90 -
1989	PERCENT	CHARGED	(DR. KEFFER)	
6	0	0	100	0
7	0	0	100	0
8	0	0	100	0
9	0	0	100	0
10	100	0	0	0
11	100	0	0	0
12	100	0	0	0
1990				
1	100	0	0	0
2	0	100	0	0
3	100	0	0	0
4	100	0	0	0
5	0	100	0	0
6	0	100	0	0
7	30	0	0	70
8	0	0	0	100
9	0	100	0	0
10	0	100	0	0
11	0	0	0	100

3. Assessment of the impact of these design changes on the optical bench and associated thermal analysis.

The reason for the design change arose as a result of the filter design activity that was being carried out in parallel at UAH. A need to include a second reflective filter component in the optical train was identified as essential to meet the UVI/ISTP science spectral purity requirements. To incorporate this filter requirement, Perkin Elmer was requested to insert a 45° reflective surface at the entrance aperture to the system. This required folding the optical beam through 90°, which impacted the baffle design, with associated straylight, mechanical and thermal re-design.

The straylight section of the report received from Hughes Danbury is attached as Appendix C which includes the sketch showing the design change requested.

The statement of work also included an assessment of the impact of incorporating a folding mirror to switch between channels. The R.O.M. cost estimate received from Perkin Elmer for the baffle re-design alone exceeded available resources in the budget and the folding mirror task was rejected as a viable option under this contract. A cost reduction was negotiated with Perkin Elmer to bring the total cost within budget whereby it was agreed that MSFC would machine the set of aluminum aspheric mirrors. Perkin Elmer provided final engineering drawings to MSFC for this purpose. After machining at MSFC final assembly was carried out at Perkin Elmer.

2.2 Design, Fabrication and Evaluation of UV Filters Using a Four-Layer Aluminum Base

As part of the filter design and development program, UAH studied the option of using aluminum layered filters. The advantage of using aluminum instead of all-dielectric filters, is that the latter have a long wavelength window, which must be blocked by including a second set of reflective filters in the optical train as discussed in Section 2.1. Figure 2.2-1 shows a filter designed at 1356 Å using pure aluminum. However, the required purity of aluminum film deposited can only be achieved in two ways:

- by using an ultra-high vacuum water (10^{-10} torr)

- by using a very high deposition rate, namely 100 nm thickness of Al per second, with very precise control of the deposition rate.

Attempts to locate a company with a UHV coater failed, because rental costs were prohibitively high. Acton Research Corporation was approached who believed they could achieve the high deposition rate. However, as mentioned above, rapid deposition must be made at very high accuracy (3%).

After a few depositions, Acton Research found that they could not control the aluminum deposition rate to our specifications. A detailed error analysis was carried out to assess the impact of errors on the filter performance. Appendix D1 shows the predicted filter performances achievable with the UAH coater as a function of errors. Appendix D2 shows the effect of upgrading the quality of the aluminum deposited, and Appendix D3 shows a realistic projection of the best that could be done with no budgetary constraints.

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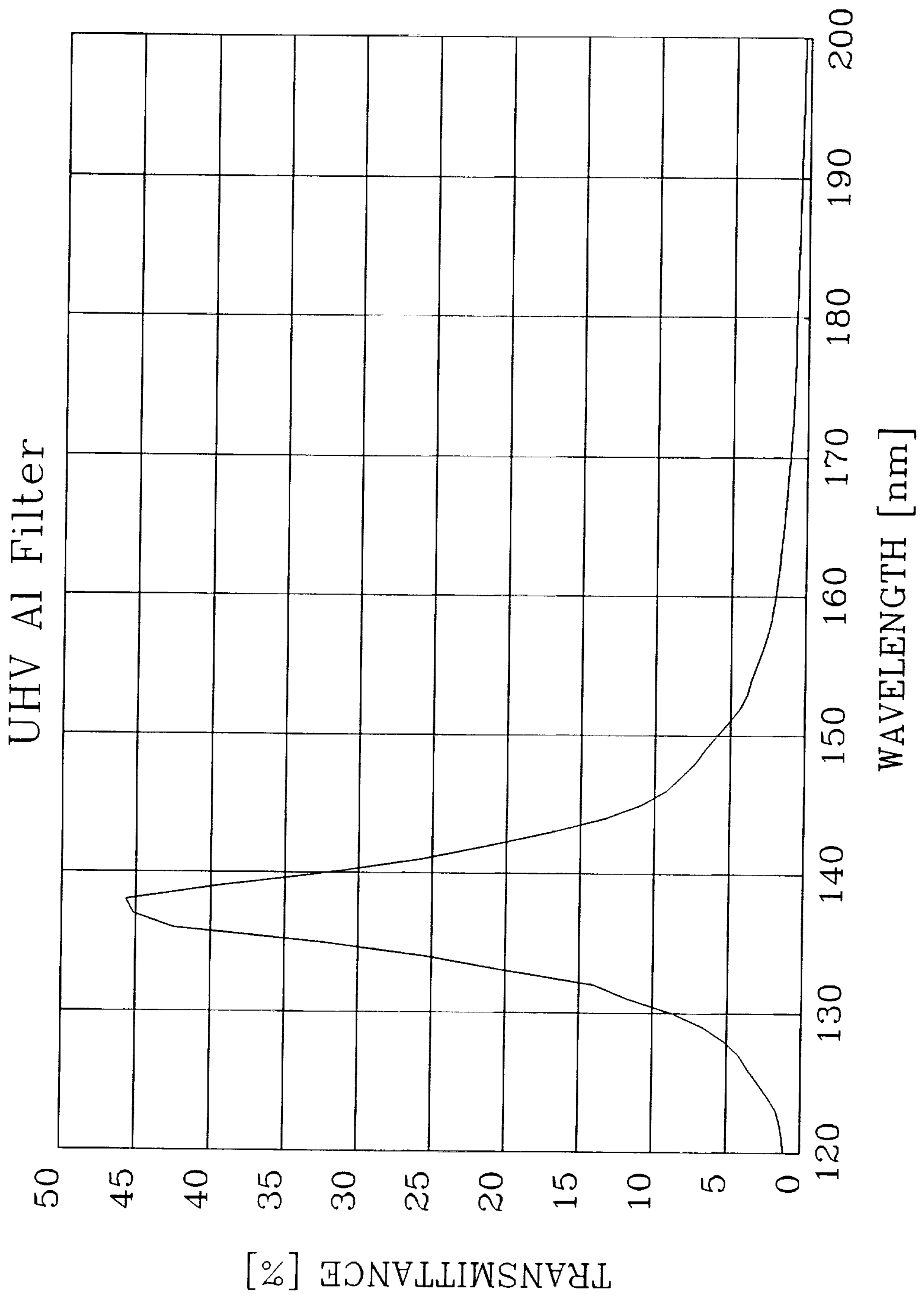

Figure 2.2-1

After analysis of the performance of the filter fabricated by Acton, the approach was rejected as too costly. The two-element alternative employing one dielectric and one reflective filter with long wavelength blocking was finally selected for ISTP.

Appendix A

CROSS SECTION VACUUM CHAMBER

ASSEMBLY PROCEDURE

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- I. Initial Inspection
  - A. Verify that all parts have been received.
  - B. Visually inspect all bagged parts.
  - C. Visually inspect vacuum chamber exterior.
  - D. Remove ***Top Flange (F/N 2)*** and set it on the alignment table. Visually inspect vacuum chamber interior.
  - E. Remove ***Mounting Base No. 2 (F/N 11)*** for skimmer installation.
  - F. Replace ***Top Flange (F/N 2).***

- II. Skimmer, Mirror, and Window Installation
  - A. Epoxy ***Beam Skimmer No. 1 (F/N 37)*** to ***Beam Skimmer Mounting Plate No. 1 (F/N 13).***
  - B. Epoxy ***Beam Skimmer No. 2 (F/N 37)*** to ***Beam Skimmer Mounting Plate No. 2 (F/N 14).***
  - C. Epoxy ***Laser Mirror (F/N 81)*** to ***Mounting Base No. 1 (F/N 10).***
  - D. Epoxy ***Laser Window (F/N 80)*** to ***Pulsed Valve Cover No. 1 (F/N 6).***
  - E. Bolt ***Beam Skimmer Mounting Plate No. 1 (F/N 13)*** to ***Mounting Base No. 1 (F/N 10).***

- III. Bellows and Adjusting Assembly Installation
  - A. Bolt ***Adjusting Subassembly No. 1*** to ***Support Stand (F/N 4).***
  - B. Install vertical motion ***Adjustment Brackets (F/N's 21 and 22)*** and ***Threaded Rod (F/N 26).***
  - C. Bolt ***Lower Support Bracket (F/N 19)*** to ***Adjusting Subassembly No.1.***
  - D. Bolt ***Adjusting Subassembly No. 2*** to ***Lower Support Bracket (F/N 19).***
  - E. Install horizontal motion ***Adjustment Brackets (F/N's 21 and 22)*** and ***Threaded Rod (F/N 26).***
  - F. Remove ***Top Flange (F/N 2)*** and set it on the alignment table.
  - G. Position and support ***Pulsed Valve Cover No. 1 (F/N 6)*** in its place.
  - H. Bolt ***Pulsed Valve Cover No. 1 (F/N 6)*** loosely to ***Bottom Head (F/N 3).***
  - I. Install ***Pulsed Valve Cover No. 3 (F/N 9)*** bolting loosely in place at both ends.
  - J. Bolt ***Upper Support Bracket (F/N 20)*** to ***Adjusting Subassembly No. 2*** and ***Pulsed Valve Cover No. 3 (F/N 9)*** using ***Shims (F/N's 27,28,29 and 30)*** as required.
  - K. Tighten bolts holding ***Pulsed Valve Cover No. 1 (F/N 6)*** and ***Pulsed Valve Cover No. 3 (F/N 9).***
  - L. Verify functionality of adjusting assemblies.
  - M. Bolt ***Mounting Base No. 1 (F/N 10)*** with ***Beam Skimmer (F/N 37)*** in place to ***Pulsed Valve Cover No. 1 (F/N 6).*** Insure proper positioning of ***Laser Mirror (F/N 81).***
  - N. Bolt ***Mounting Base No. 2 (F/N 11)*** with ***Beam Skimmer (F/N 37)*** in place to ***Pulsed Valve Cover No. 2 (F/N 7).***
  - O. Cover ***Chamber Shell Assembly (F/N 5)*** top port with plastic while continuing with the assembly procedure.

- IV. Pulsed Valve Installation
  - A. Bolt ***Gas Expansion Nozzle (F/N 15)*** to ***Beam Valve No. 1 (F/N 38).***
  - B. Install ***Beam Valve No. 1 (F/N 38)/Gas Expansion Nozzle (F/N 15)*** assembly in ***Quick Disconnect No. 1.***
  - C. Install ***Beam Valve No. 2 (F/N 38)*** in ***Quick Disconnect No. 2.***

D. Make electrical connections between ***Beam Valves (F/N 38)*** and ***Beam Valve Drivers.***

E. Connect ultra high purity oxygen to ***Beam Valve No. 1 (F/N 38).*** Connect ultra high purity nitrogen to ***Beam Valve No. 2 (F/N 38).*** Install a ***Leak Valve*** and a ***Pressure Gauge (0 to 200 psi)*** in each compressed gas line. See ***Pulsed Molecular Beam Valve Instruction Manual*** for details.

V. Mass Spectrometer Installation

- A. Select optimal orientation for ***Rotary Platform (F/N 31).***
- B. With ***Top Flange (F/N 2)*** on the alignment table, bolt ***Rotary Platform (F/N 31)*** to the 13.25" conflat flange on the ***Top Flange (F/N 2).***
- C. Bolt ***Flange Reducer (F/N 12)*** to ***Rotary Platform (F/N 31).***
- D. Bolt ***Mass Spectrometer Mount (F/N 8)*** to ***Flange Reducer (F/N 12).***
- E. Carefully insert ***Mass Spectrometer (F/N 33)*** into ***Mass Spectrometer Mount (F/N 8)*** and bolt in place. Tighten the bolts only by hand.
- F. Check all ***Mass Spectrometer Feedthrough Pins*** to insure that there are no short circuits to the ***Mass Spectrometer Mount (F/N 8).***
- G. Tighten the bolts holding the ***Mass Spectrometer (F/N 33).***
- H. Recheck all ***Mass Spectrometer Feedthrough Pins*** to insure that there are no short circuits to the ***Mass Spectrometer Mount (F/N 8).***
- I. Bolt ***Seal Plate No. 3 (F/N 18)*** to front of ***Mass Spectrometer Mount (F/N 8).***
- J. Bolt ***Mass Spectrometer Feedthrough Flange*** to ***Chamber Shell Assembly (F/N 5)*** 6" conflat flange port.
- K. Make electrical connections to ***Mass Spectrometer Feedthrough Flange.***
- L. Decide if it is easier to complete steps M, N and O now or after installation of the ***StarCell Ion Pump.***
- M. Replace ***Top Flange (F/N 2)*** with mass spectrometer assembly in place.
- N. Make electrical connections to the ***Mass Spectrometer (F/N 33).*** Access must be through an open port in the ***Chamber Shell Assembly (F/N 5)*** or with the ***Top Flange (F/N 2)*** suspended above the ***Chamber Shell Assembly (F/N 5).***
- O. Make electrical connections to ***C50 Mass Spectrometer Electronics.***

VI. Vacuum Pumps Installation

- A. StarCell Ion Pump
  - 1. Bolt ***Mass Spectrometer Roughing Port Adapter*** to ***Flange Reducer (F/N 12).***
  - 2. Select optimal orientation for ***StarCell Ion Pump (F/N 32).***
  - 3. Bolt ***StarCell Ion Pump (F/N 32)*** to ***Mass Spectrometer Roughing Port Adapter.***
  - 4. Bolt ***Ion Gauge Tube*** and ***All Metal Valve*** to ***Mass Spectrometer Roughing Port Adapter.***
  - 5. Make electrical connections to the ***StarCell Ion Pump Power Unit*** and the ***Ion Gauge Controller.***
- B. Rotary Platform Differential Pumping
  - 1. First Stage
    - a. Blank off the ***First Stage Differential Pumping Port.*** If

initial vacuum testing indicates a need for further differential pumping of the ***Rotary Platform***, then install the ***SD-90 Mechanical Pump*** as indicated in steps b and c below.

b. Connect the ***SD-90 Mechanical Pump*** with a ***Roughing Trap*** to the ***Rotary Platform (F/N 31)*** at the ***First Stage Differential Pumping Port.***

c. Make exhaust connection for the ***SD-90 Mechanical Pump.***

2. Second Stage
   a. Bolt the ***VacIon Appendage Pump*** to the ***Rotary Platform (F/N 31)*** at the ***Second Stage Differential Pumping Port.***
   b. Make electrical connections to the ***VacIon Pump Control Unit.***

C. Cryopump
   1. Choose a convenient orientation for ***Gate Valve (F/N 36).***
   2. Bolt ***Gate Valve (F/N 36)*** to 14" conflat flange on ***Bottom Flange (F/N 3).***
   3. Make electrical and compressed air connections to the ***Gate Valve (F/N 36).***
   4. Determine and set correct air pressure for ***Gate Valve (F/N 36).*** Refer to ***Gate Valve Installation, Operation and Maintenance Instructions.***
   5. Bolt ***Cryopump (F/N 34)*** to ***Gate Valve (F/N 36).***
   6. Connect ***Cryopump (F/N 34)*** to ***Cryopump Compressor*** using ***Flexible Compressed Helium Lines*** (See ***Cryopump Operator's Manual).***
   7. Make electrical connections to ***Cryopump Compressor.***
   8. Make cooling water connections for ***Cryopump Compressor.***
   9. Install ***Cryopump Roughing Valve*** on ***Cryopump (F/N 34)*** roughing port.
   10. Install ***Cryopump Purge Valve Valve*** on ***Cryopump (F/N 34)*** purge port.

D. Turbomolecular Pumps
   1. Bolt ***Turbomolecular Pumps No. 1 and No. 2 (F/N 35)*** to 10" conflat flanges on ***Bottom Flange (F/N 3).***
   2. Connect the ***Turbomolecular Pump Vent Valves*** to ***Turbomolecular Pumps No. 1 and No. 2 (F/N 35).***
   3. Make electrical connections between the ***Turbomolecular Pump Vent Valves***, the ***Turbomolecular Pump Controllers*** and ***Turbomolecular Pumps No. 1 and No. 2 (F/N 35).***
   4. Make cooling water connections to ***Turbomolecular Pump Controllers.***
   5. Connect ***SD-450 Mechanical Pumps*** to ***Turbomolecular Pumps No. 1 and No. 2 (F/N 35)*** using ***Flexible Bellows.*** Include a ***Thermocouple Gauge*** and a ***Vent Valve*** in each foreline.
   6. Make exhaust connections for ***SD-450 Mechanical Pumps.***
   7. Connect ***Thermocouple Gauges*** in each foreline to ***Gauge Controller.***

E. Roughing Pumps
   1. Bolt the ***Main Chamber Roughing Valve*** to one of the 2.75" conflat flange ports on the ***Chamber Shell Assembly (F/N 5).***

2. Bolt a ***Four Way Cross*** to ***Main Chamber Roughing Valve.***
3. Bolt the ***Dual Sorption Pump Assembly*** to the ***Four Way Cross.***
4. Install a ***Thermocouple Gauge Tube*** with the ***Sorption Pumps*** and make electrical connection to the ***Gauge Controller.***
5. Bolt ***Venturi Pump*** to one of the 2.75" conflat flange ports on the ***Dual Sorption Pump Assembly (F/N 5).***
6. Connect compressed air at > 60 psig to ***Venturi Pump.*** Include a shut off valve between the compressed air and the ***Venturi Pump.***
7. Install a ***Convectron Gauge Tube*** with the ***Venturi Pump*** and make the connection to the ***Gauge Controller.***
8. Make ***Flexible Bellows*** connections to the ***All Metal Valve*** on the ***Mass Spectrometer Roughing Port Adapter*** and to the ***Cryopump Roughing Valve.***

VII. Final Assembly

A. Install ***Bakeout Lamps*** in the two off-axis 2.75" conflat flanges on the ***Top Flange (F/N 2).***

B. Make electrical connections for ***Bakeout Lamps.***

C. Blank off the remaining 2.75" conflat flanges on the ***Top Flange (F/N 2).***

D. Install an ***Ion Gauge Tube*** on one of the 2.75" conflat flanges around the circumference of the ***Chamber Shell Assembly (F/N 5).***

E. Make electrical connections between the ***Ion Gauge Tube*** and the ***Ion Gauge Controller.***

F. Blank off the 13.25" conflat flange, the 10" conflat flange and all remaining 2.75" conflat flanges on the ***Chamber Shell Assembly (F/N 5).*** Use 2.75" ***Viewports*** if desired.

FIND NO.	SHEET NO.	CODE LTR	NO. REQD	PART NO.	DESCRIPTION	VENDOR NO.	REMARKS
				-			
				-			
				-			
				-			
				-			
				-			
84		S	8	-	SCREW, 1/2-13UNC X 1.50 LG HEX HD		
83		S	48	-	SCREW, 5/16-24UNF X 2.50 LG HEX HD		
82	4-5-6	S	A/R	953-000-1	TORR SEAL EPOXY RESIN	2	
81	4	S	1	2200-1000-CT-EQ	GOLD COATED MIRROR	10	GFE
80	3-6	S	1	0205-1000-120	ZINC SELENIDE WINDOW	10	GFE
79	6	F	2	90M09126-5	O-RING		
78	6	S	2	2-450 V747-75	O-RING	9	
77	3	S	2	2-450 V747-75	O-RING	9	
76	4	S	2	2-439 V747-75	O-RING	9	
75	4	S	2	2-362 V747-75	O-RING	9	
74	5	S	1	2-023 V747-75	O-RING	9	
73	4	S	1	2-016 V747-75	O-RING	9	
72	5	S		2-011 V747-75	O-RING	9	
71		S	4	-	WASHER, FLAT 5/8 DIA		
70		S	4	-	SCREW, 3/4-10UNC X 2.50 LG HEX HD		
69		S	8	-	SCREW, 3/8-16UNC X 1.25 LG HEX HD		
68		S	16	-	SCREW, 1/2-20UNF X 2.00 LG HEX HD		
67		S	20	-	SCREW, 1/2-20UNF X 2.50 LG HEX HD		
66		S	5	-	WASHER, FLAT #2		
65		S	6	-	SCREW, #2-56UNC X .38 LG SOCKET HD		
64		S	14	-	WASHER, FLAT #4		
63		S	14	-	SCREW, #4-40UNC X .25 LG SOCKET HD		
62		S	16	-	WASHER, FLAT #10		
61		S	16	-	SCREW, #10-32UNF X .75 LG SOCKET HD		
60		S	36	-	NUT, 3/8-24UNF HEX		
59		S	12	-	SCREW, 3/8-24UNF X 1.50 LG HEX HD		
58		S	8	-	SCREW, 3/8-16UNC X 1.00 LG HEX HD		
57		S	32	-	WASHER, FLAT 1/4 DIA		
56		S	32	-	SCREW, 1/4-20UNC X .75 LG HEX HD		
55		S	32	-	SCREW, 5/16-18UNC X .75 LG HEX HD		
54		S	6	-	SCREW, 1/2-13UNC X 1.25 LG HEX HD		
53		S	48	-	NUT, 1/2-20UNF HEX		
52		S	84	-	WASHER, FLAT 1/2 DIA		
51		S	24	-	SCREW, 1/2-20UNF X 1.50 LG HEX HD		
50		S	96	-	NUT, 5/16-24UNF HEX		
49		S	16	-	SCREW, 5/16-24UNF X 2.00 LG HEX HD		
48		S	204	-	WASHER, FLAT 3/8 DIA		
47		S	144	-	SCREW, 3/8-24UNF X 2.00 LG HEX HD		
46		S	136	-	WASHER, FLAT 5/16 DIA		
45		S	40	-	SCREW, 5/16-24UNF X 1.75 LG HEX HD		
44	6	S	16	CL-9-HK-9	HAND KNOB	8	
43	6	S	16	CL-2A-58	SWING BOLT	8	
42	3	S	8		CLASS L 1.500 DIA SHAFT X 14.00 LG	7	
41	3	S	8	TWN-24-ADJ	ADJ DIA TWIN PILLOW BLOCK	7	
40	3	S	16	SB-24	SHAFT SUPPORT BLOCK	7	
39					NOT USED		
38	4-5	S	2	BV-100	BEAM VALVE	6	GFE
37	4-5	S	2	MODEL 1	BEAM SKIMMER	5	GFE
36	2	S	1	155009	VACUUM GATE VALVE	3	GFE
35	1	S	2	V1000	TURBOMOLECULAR PUMP	2	GFE
34	1	S	1	HV-12	CRYO-PUMP	2	GFE
33	2	S	1	EX 200	MASS SPECTROMETER	4	GFE
32	1	S	1	230 L/S	STARCELL VACUUM PUMP	2	GFE
31	1	S	1	RHM-1000	ROTATING PLATFORM	1	GFE
30	4-5	F	A/R	90M09126-4	SHIM		
29	4-5	F	A/R	90M09126-3	SHIM		
28	4-5	F	A/R	90M09126-2	SHIM		
27	4-5	F	A/R	90M09126-1	SHIM		
26	2-3	F	4	90M09116-2	THREADED ROD		
25	3	F	2	90M09116-1	MOUNTING BRACKET		
24	2-3	F	2	90M09115-2	MOUNTING PLATE		
23	2-3	F	2	90M09115-1	MOUNTING PLATE		
22	2-3	F	4	90M09114-2	ADJUSTMENT BRACKET		
21	2-3	F	4	90M09114-1	ADJUSTMENT BRACKET		
20	2-3	F	2	90M09113-1	UPPER SUPPORT BRACKET		
19	2-3	F	2	90M09112-1	LOWER SUPPORT BRACKET		
18	5	F		90M09111--3	SEAL PLATE		
17	5	F		90M09111-2	SEAL PLATE		
16	5	F	1	90M09111-1	SEAL PLATE		
15	4	F	1	90M09110-1	GAS EXPANSION NOZZLE		
14	5	F	1	90M09087-2	BEAM SKIMMER MOUNTING PLATE NO. 2		
13	4	F	1	90M09087-1	BEAM SKIMMER MOUNTING PLATE NO. 1		
12	2	F	1	90M09086-1	FLANGE REDUCER		
11	5	F	1	90M09085-2	MOUNTING BASE NO. 2		
10	4	F	1	90M09085-1	MOUNTING BASE NO. 1		
9	2	F	2	90M09084-1	PULSE VALVE COVER NO. 3		
8	2	F	1	90M09083-1	MASS SPECTROMETER MOUNT		
7	2	F	1	90M09082-2	PULSE VALVE COVER NO. 2		
6	2	F	1	90M09082-1	PULSE VALVE COVER NO. 1		
5	1	F	1	90M09081-1	CHAMBER SHELL ASSEMBLY		
4	1	F	1	90M09080-1	SUPPORT STAND		
3	1	F	1	90M09079-2	BOTTOM HEAD		
2	1	F	1	90M09079-1	TOP HEAD		
1	1	A	1	90M09089-1	VACUUM CHAMBER ASSEMBLY		

LEGEND: A=ASSEMBLY/ALIGNMENT ; S=STOCK ITEM ; F=FABRICATED ITEM ; M=MODIFIED ITEM ; E=EXISTING ITEM/FACILITY

Table 1. Cross section vacuum chamber parts list.

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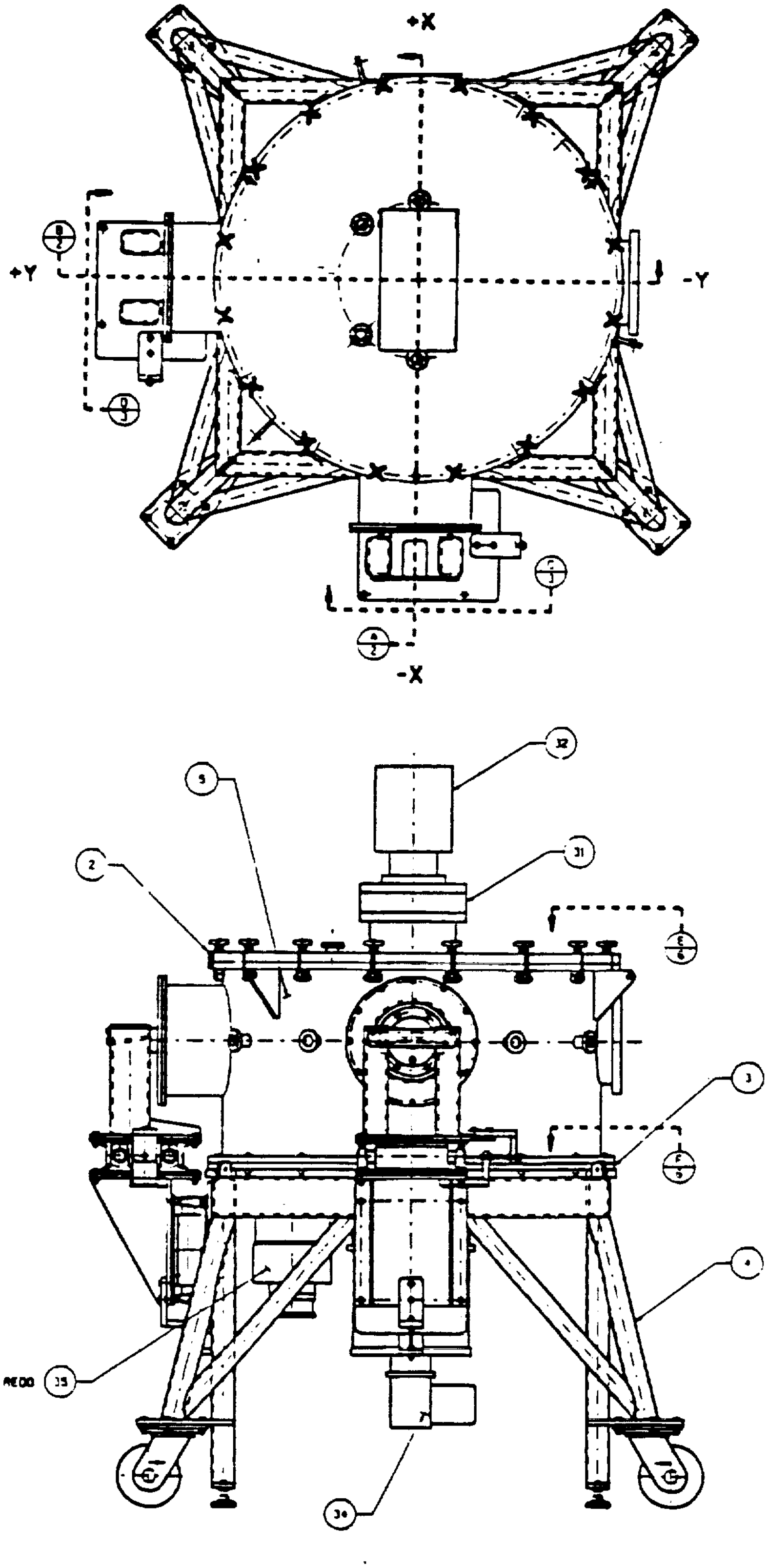

Figure 1. Top and side views of assembled cross section vacuum chamber.

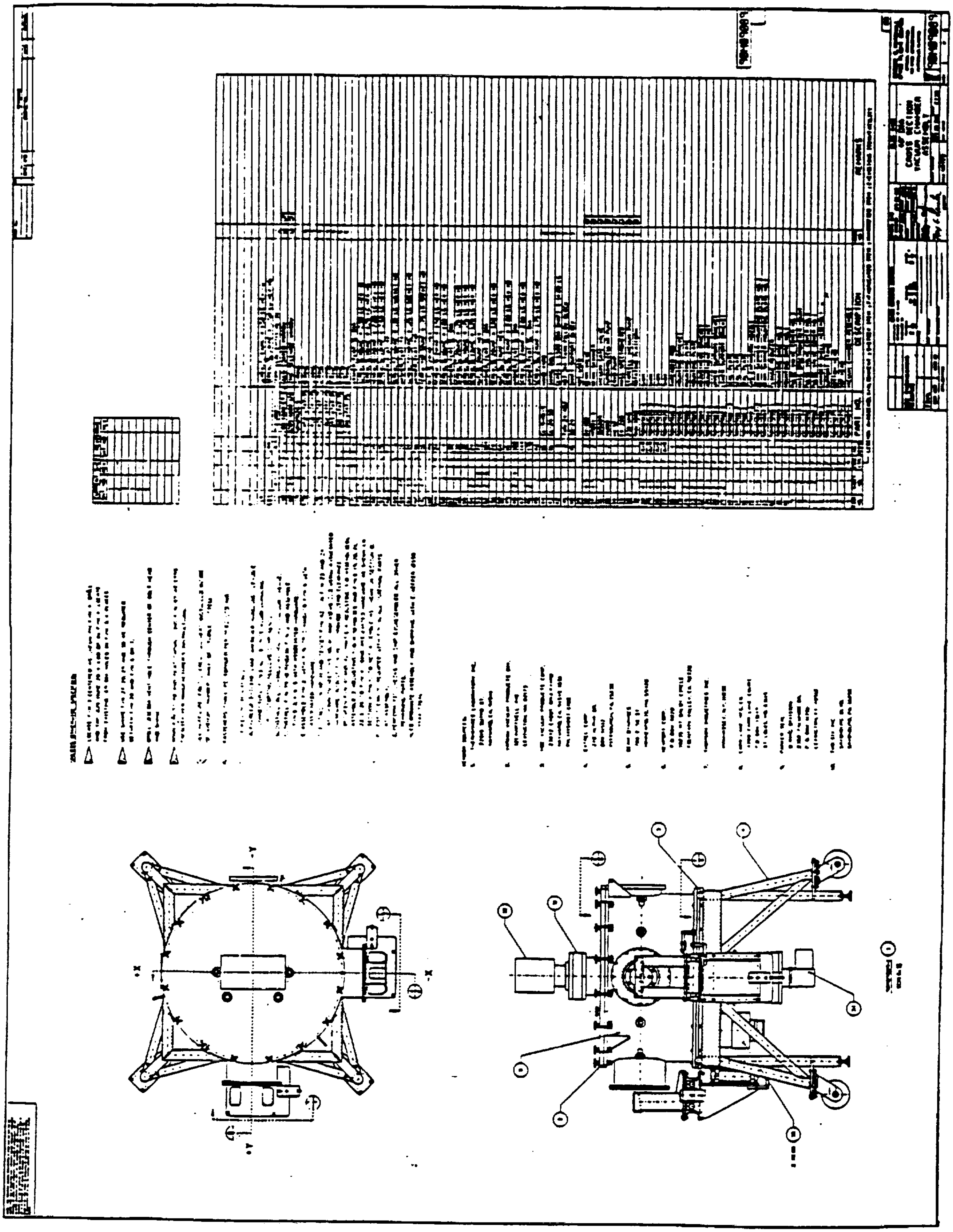

Figure 2. Cross section facility vacuum chamber assembly drawing. Sheet 1 of 6.

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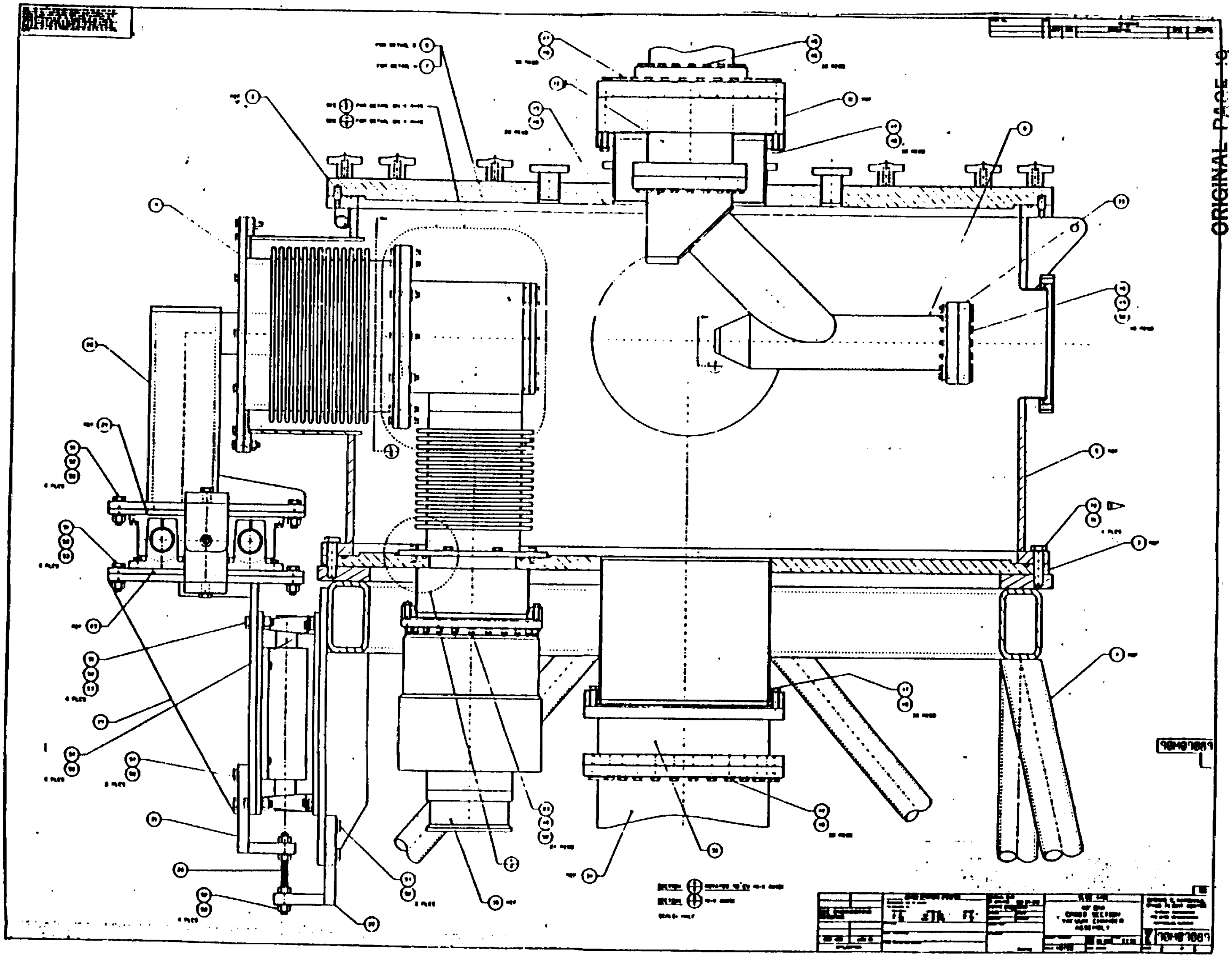

Figure 3. Cross section facility vacuum chamber assembly drawing. Sheet 2 of 6.

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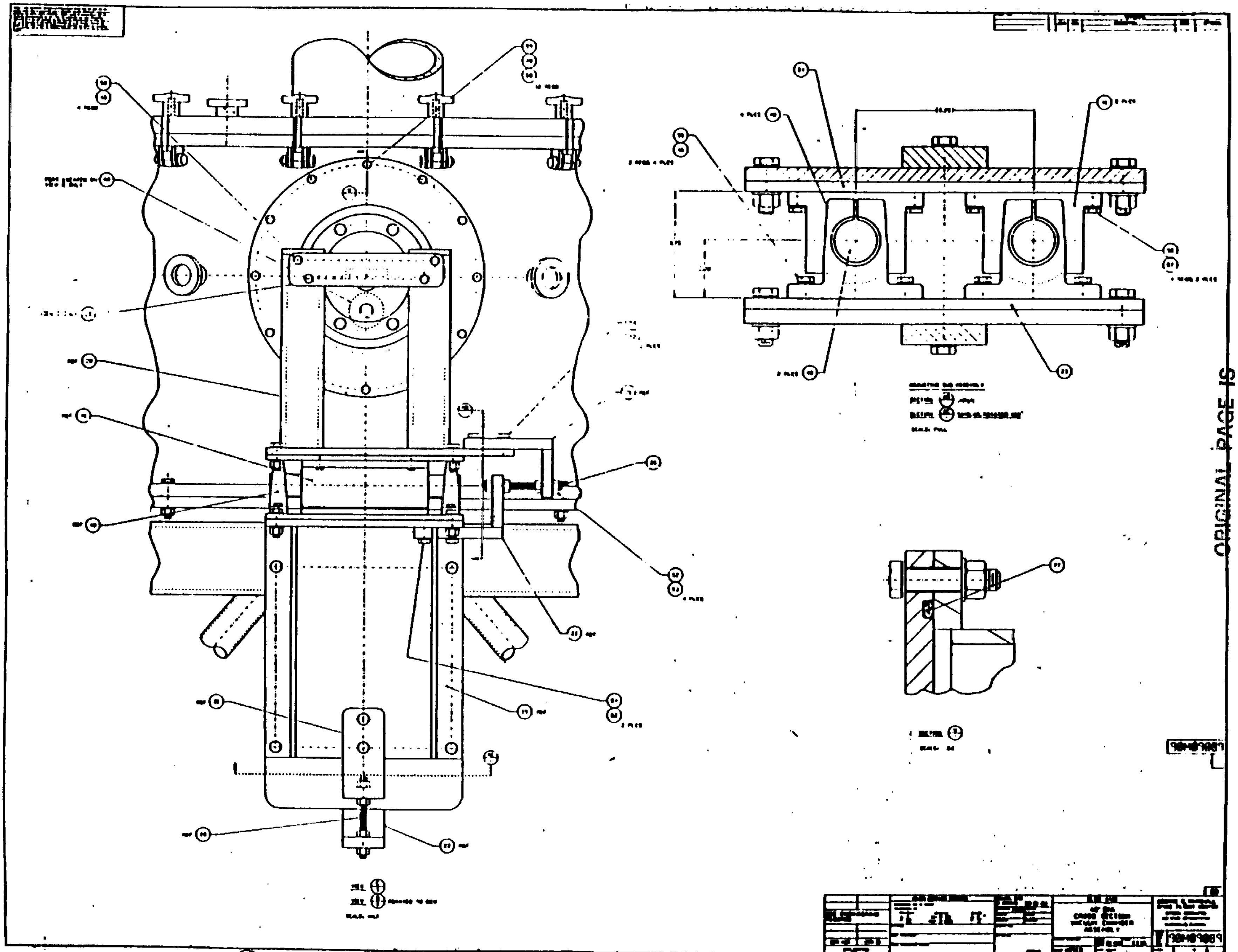

Figure 4. Cross section facility vacuum chamber assembly drawing. Sheet 3 of 6.

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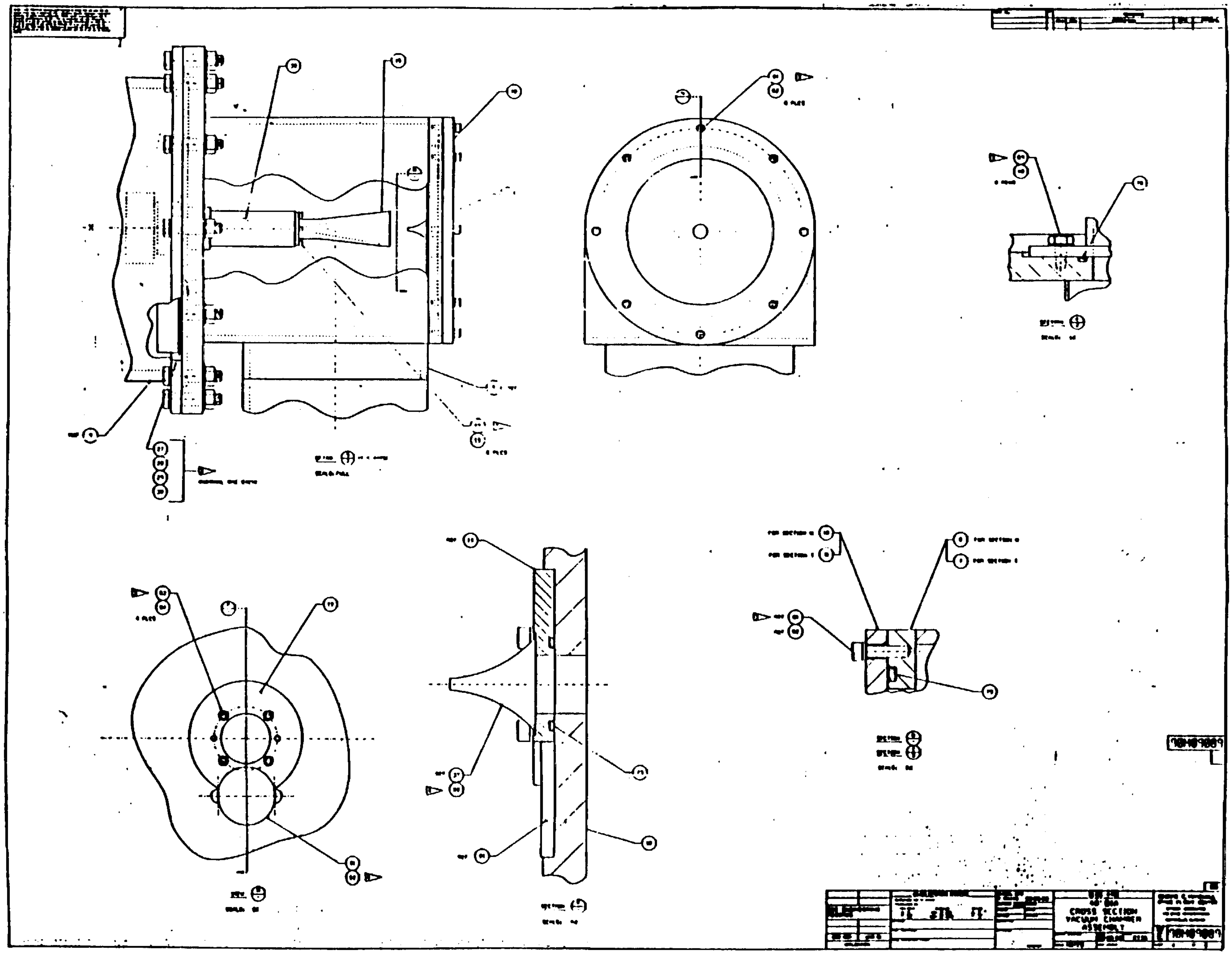

Figure 5. Cross section facility vacuum chamber assembly drawing. Sheet 4 of 6.

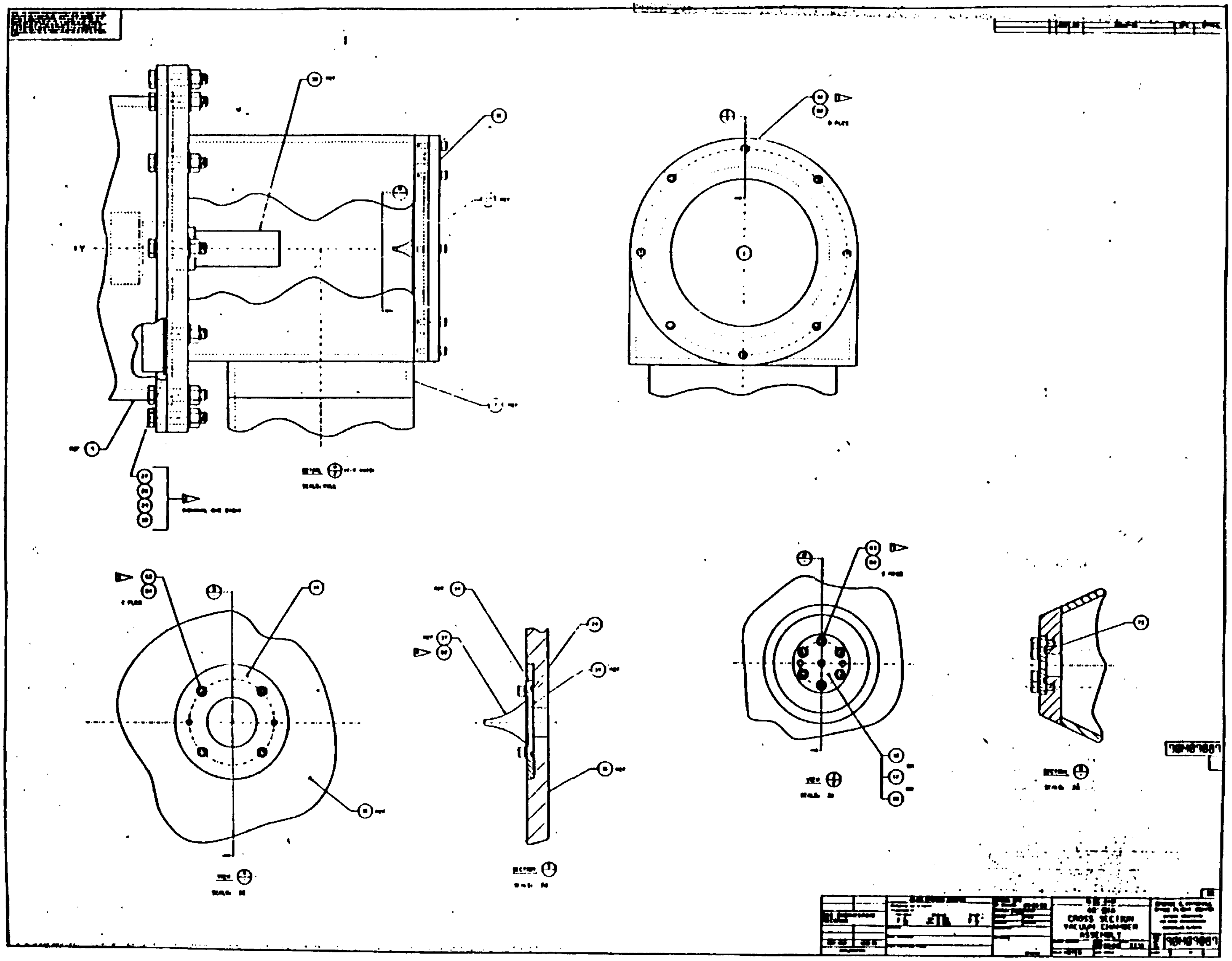

Figure 6. Cross section facility vacuum chamber assembly drawing. Sheet 5 of 6.

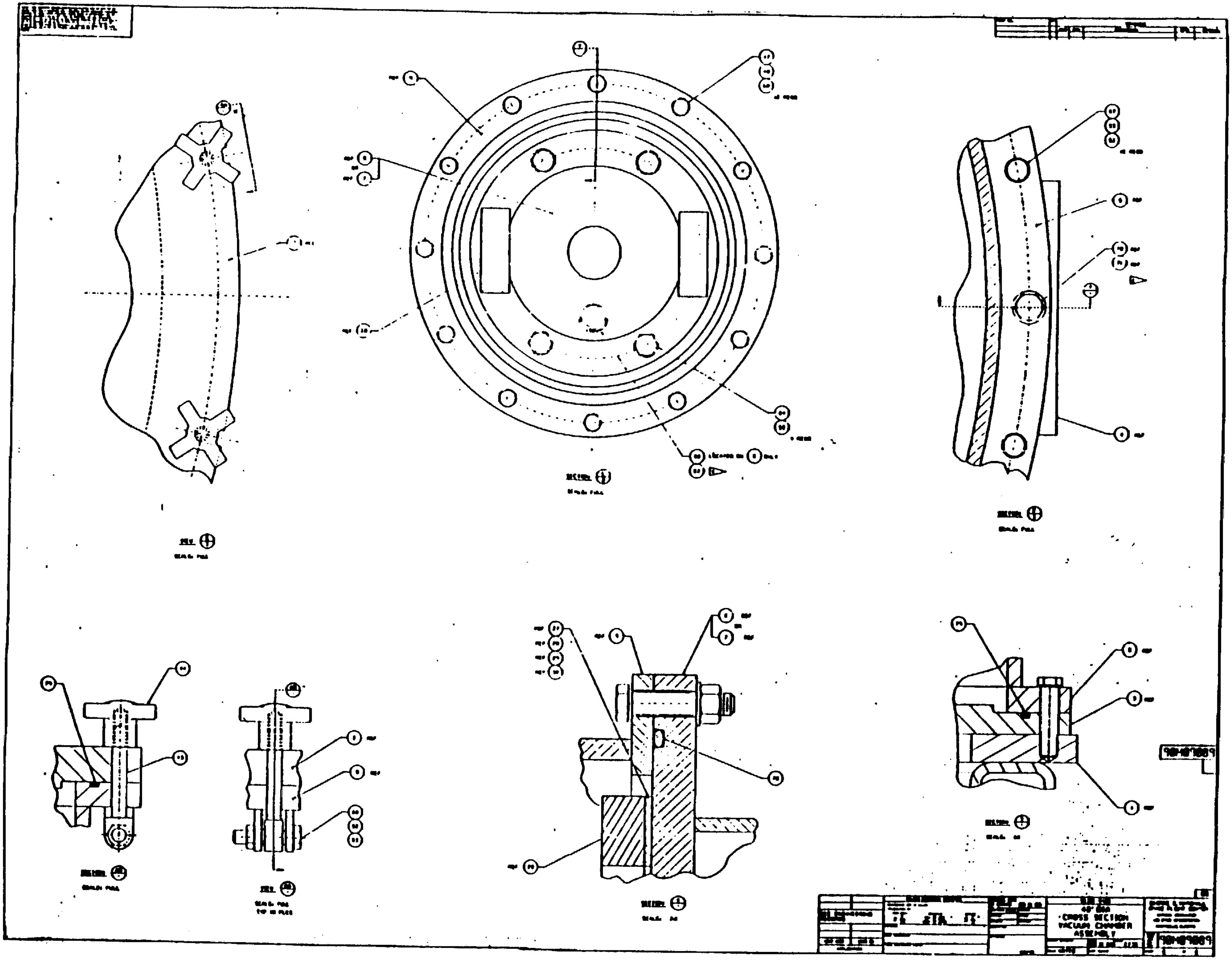

Figure 7. Cross section facility vacuum chamber assembly drawing. Sheet 6 of 6.

CROSS SECTION VACUUM CHAMBER

INITIAL TESTS

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I. Pump Down Times
  A. Record the time required for roughing out the ***Cryopump.***
  B. Record the time required for the ***Cryopump*** to cool down to ≤ 20 K.
  C. Record the time required for roughing the ***Main Chamber*** with the ***Venturi Pump.***
  D. Record the time required for roughing the ***Main Chamber*** with the ***Sorption Pumps.***
  E. Record the pressure in the ***Main Chamber*** and in the ***Mass Spectrometer Chamber*** at intervals after the ***Gate Valve*** has been opened.
  F. Record the ultimate pressure in the ***Main Chamber*** and in the ***Mass Spectrometer Chamber*** after completing all initial tests and prior to opening the chamber to begin alignment procedures.

II. Residual Gas Analysis
  A. Wait until the pressure in the ***Main Chamber*** and in the ***Mass Spectrometer Chamber*** has leveled off at a minimum value.
  B. Turn on the ***Mass Spectrometer*** and let it warm up at least 1 hour.
  C. Perform an RGA scan from mass 1 to mass 200.
  D. Perform another RGA scan from mass 1 to mass 200 after the system has been baked out.

III. Helium Leak Tests
  A. Turn on the ***Mass Spectrometer*** and let it warm up at least 1 hour.
  B. Set the ***Mass Spectrometer*** to detect only mass 4.
  C. Turn up the multiplier gain on the ***Mass Spectrometer*** to a level just below saturation.
  D. Probe all flanges and all welds with helium gas while monitoring the ***Mass Spectrometer*** for any change in signal level.

IV. Rotary Platform
  A. Record the pressure in the ***Main Chamber*** before, during, and after rotating the ***Rotary Platform.***
  B. Record the time required for the pressure to return to its baseline after a rotation of the ***Rotary Platform.***
  C. Turn on the ***Mass Spectrometer*** and let it warm up at least 1 hour.
  D. Set the ***Mass Spectrometer*** to detect only mass 4.
  E. Turn up the multiplier gain on the ***Mass Spectrometer*** to a level just below saturation.
  F. Probe the ***Rotary Platform*** with helium gas and record the signal level of the ***Mass Spectrometer.***
  G. Record the signal level of the ***Mass Spectrometer*** while rotating the ***Rotary Platform*** and probing it with helium.

V. Pulsed Valve Pre-alignment Tests
  A. Insure that ultra high purity oxygen is connected to ***Pulsed Valve No. 1*** and that ultra high purity nitrogen is connected to ***Pulsed Valve No. 2.***
  B. Set the controls on ***Beam Valve Drivers No. 1 and No. 2*** as follows:
    1. Power: On
    2. Trigger Select: Off

3. Internal Rate: CCW
4. Intensity: 00
5. Duration: 30

C. Turn on the gas supply for ***Pulsed Valve No. 1*** and set the backing pressure to 1 atmosphere.

D. Switch the ***Trigger Select*** to internal rate.

E. Increase the ***Intensity*** until the valve opens and a pressure rise is observed in the ***Main Chamber*** each time the valve fires. The valve should open at a setting between 10 and 25.

F. Vary the ***Internal Rate, Intensity*** and ***Duration*** while observing and recording the pressure at the ***Main Chamber Ion Gauge Tube*** and at the ***Turbomolecular Pump No. 1 Thermocouple Gauge Tube.*** Note that the ***Duration*** setting should always be greater than the ***Intensity*** setting to avoid overlapping the open and close cycles of the ***Pulsed Valve.***

G. Repeat step F above for several different settings of the backing pressure.

H. Repeat steps C through G for ***Pulsed Valve No. 2.***

VI. Pulsed Valve Post Alignment Tests

A. Temporal Profile

1. Turn on the ***Mass Spectrometer*** and let it warm up at least 1 hour.
2. Rotate the ***Rotary Platform*** to align the ***Mass Spectrometer*** axis with the ***Pulsed Valve No. 1*** axis.
3. Set the ***Mass Spectrometer*** to detect only mass 32.
4. Set ***Pulsed Valve No. 1*** to raise the pressure in the ***Main Chamber*** no higher than 10^{-7} torr and begin pulsing at 10 Hz.
5. Scan the ***Photon Counter Gate*** to measure the temporal profile of the oxygen pulse. Gate width should less than 10% of the pulse duration.
6. Vary the ***Intensity*** and ***Duration*** of ***Pulsed Valve No. 1*** and repeat the temporal profile measurements. Adjust the gate width as required.
7. Rotate the ***Rotary Platform*** to align the ***Mass Spectrometer*** axis with the ***Pulsed Valve No. 2*** axis.
8. Set the ***Mass Spectrometer*** to detect only mass 28.
9. Repeat steps 4 through 6 for ***Pulsed Valve No. 2*** and nitrogen gas.

B. Spatial Profile

1. Insure that ***Seal Plate No. 1 (F/N 16)*** is in place on the front of the ***Mass Spectrometer Mount (F/N 8).***
2. Turn on the ***Mass Spectrometer*** and let it warm up at least 1 hour.
3. Rotate the ***Rotary Platform*** to align the ***Mass Spectrometer*** axis with the ***Pulsed Valve No. 1*** axis.
4. Set the ***Mass Spectrometer*** to detect only mass 32.
5. Set the ***Pulsed Valve No. 1 Intensity*** and ***Duration*** to reasonable values as determined from previous measurements.
6. Set the ***Photon Counter Gate*** to sample a flat portion of the oxygen pulse.

7. Rotate the ***Rotary Platform*** at least 5° to one side of the molecular beam axis.
8. Scan the ***Rotary Platform*** across the molecular beam while recording one data point every 0.5°. Continue until reaching a plateau on the opposite side of the beam axis.
9. Scan the ***Rotary Platform*** back in the opposite direction recording data as above.
10. Average the results of steps 7 and 8 to construct a spatial profile of the molecular beam.
11. Repeat steps 7 through 9 several times to average the results.
12. Repeat steps 3 through 11 to measure the spatial profile of the ***Pulsed Valve No. 2*** nitrogen beam.

CROSS SECTION VACUUM CHAMBER

ALIGNMENT PROCEDURE

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I. Center of Rotation
  - A. Raise the *Top Flange* above the *Chamber Shell Assembly.*
  - B. Break the electrical connections between the *Mass Spectrometer* and the *Mass Spectrometer Feedthrough Flange.*
  - C. Set *Top Flange* on alignment table.
  - D. Remove *Mass Spectrometer* from *Mass Spectrometer Mount.*
  - E. Mount *Seal Plate No. 1* to the front of *Mass Spectrometer Mount.*
  - F. Mount *Plexiglass Alignment Plate* to the rear of *Mass Spectrometer Mount.*
  - G. Attach *Centering Pin Assembly* to *Mass Spectrometer Mount.*
  - H. Mount HeNe to lab jack which is positioned on floor.
  - I. Position HeNe beam so it passes along an axis through the front *Seal Plate No. 1* and through the rear *Plexiglass Alignment Plate.*
  - J. Extend *Centering Pin* and lock in place.
  - K. Adjust *Centering Pin Assembly* until *Centering Pin* intercepts the HeNe beam.
  - L. Slowly rotate *Mass Spectrometer Mount* until *Centering Pin* no longer intercepts the HeNe beam.
  - M. The direction of rotation of the *Centering Pin* will indicate its position relative to the center of rotation. Adjust the *Centering Pin Assembly* to place the *Centering Pin* closer to the center of rotation.
  - N. Repeat steps L and M until the *Centering Pin* always intercepts the HeNe beam. If this is not possible, the *Mass Spectrometer Mount* or the *Alignment Plates* have been machined incorrectly.
  - O. Lock translators on *Centering Pin Assembly* to prevent motion.
  - P. Verify that the *Centering Pin* is still marking the center of rotation (Steps L and M).

II. Beam Valve Housings
  - A. Leave *Centering Pin Assembly* and *Alignment Plates* in place. Starcell ion pump and other heavy hardware to be mounted on the *Top Flange* should be in place.
  - B. Replace *Top Flange* onto *Chamber Shell Assembly.* Bring remote cable for *Centering Pin* out through one of the side ports. Exercise care to prevent snagging the remote cable or disturbing the placement of the *Centering Pin Assembly* in any way.
  - C. Securely bolt *Top Flange* in place.
  - D. Remove *Beam Valves* from *Quick Disconnects.*
  - E. Retract *Centering Pin,* if not already retracted.
  - F. Mount *Vertical Mounting Brackets* to 10" and 13.25" flanges opposite *Beam Valves.* If necessary, use (old) copper gaskets to secure rotatable flanges.
  - G. Mount *Slotted Support* to each set of *Vertical Mounting Brackets* with *Mounting Blocks.* The lower and outside set of mounting holes are used on the 13.25" flange. The other set is used on the 10" flange.
  - H. Mount HeNe and steering mirrors to each *Laser Alignment Table.*
  - I. Attach *Laser Alignment Table* to each *Slotted Support.*

J. Start with the axis passing through the 10" flange. Position the HeNe beam and the *Mass Spectrometer Mount* so the HeNe beam passes down the axis of the *Mass Spectrometer Mount* as defined by the *Plexiglass Alignment Plate* and *Seal Plate No. 1.* Record angular position of the *Rotary Platform.*
K. Use *Adjusting Assemblies* to translate skimmer position to pass the HeNe beam through the skimmer.
L. Place graph paper over *Quick Disconnect* opening for use as a reticule.
M. Determine if HeNe is passing through the center of the *Quick Disconnect* opening. If the beam is correctly centered, skip to step O.
N. If necessary, shim *Pulsed Valve Cover (F/N 6,7)* to pass HeNe through *Skimmer* and through center of the *Quick Disconnect.* (These are not the circular shims provided for discrete linear translation of the *Beam Valve Housings.* Rather, they are either washers or pieces of shim stock placed between the *Upper Support Bracket (F/N 20)* and the *Pulsed Valve Covers (F/N 6,7)* and are intended to create discrete angular translations.)
O. Extend the *Centering Pin* to verify beam placement through center of rotation. Retract *Centering Pin.*
P. Verify orthoganality of the *Adjusting Assembly.*
Q. Rotate *Mass Spectrometer Mount* 90° to HeNe beam axis passing through the 13.25" flange.
R. Repeat steps J through P for this HeNe beam axis.
S. Place the *Mass Spectrometer Mount* at some arbitrary position that does block either of the HeNe beam axes. Turn on both HeNe's. Extend the *Centering Pin.* Verify both axes intersect at the center of rotation.
T. Note the angular separation between the two axes. They should be orthogonal.
U. Record position of *Threaded Rods* for horizontal and vertical motion on both *Adjusting Assemblies.*
V. Remove *Top Flange* and place on alignment table.
W. Replace *Top Flange* onto *Chamber Shell Assembly.* Bolt securely in place.
X. Place the *Mass Spectrometer Mount* at some arbitrary position that does block either of the HeNe beam axes. Turn on both HeNe's. Extend the *Centering Pin.* Verify both axes intersect at the center of rotation.
Y. Repeat steps V through X twice more (for a total of three times) to verify reproducibility.
Z. Repeat this verification at some future time.

III. Gas Beams

A. Remove *Top Flange* from the *Chamber Shell Assembly.*
B. Install *Mass Spectrometer* in the *Mass Spectrometer Mount.* Make electrical connections to the *Mass Spectrometer.* (See Assembly Procedures for details.)
C. Replace *Top Flange* on the *Chamber Shell Assembly* and bolt securely

in place.

D. Install both *Beam Valves.* (See Assembly Procedures for details.)

E. Evacuate *Cross Section Vacuum Chamber* following instructions in Vacuum System Operation document.

F. Turn on the *Mass Spectrometer* and allow it to warm up for at least one hour.

G. Position *Mass Spectrometer* on gas beam axis #1.

H. Set the *Mass Spectrometer* to detect only the gas species present in the *Beam Valve #1.*

I. Pulse *Beam Valve #1* at highest rate and intensity consistent with chamber pumping capacity.

J. Turn up the multiplier gain on the *Mass Spectrometer* to detect signal on mass spectrometer. Make adjustments to *Beam Valve #1* or *Mass Spectrometer* operating parameters as needed.

K. Once signal is detected, make transverse adjustments to *Beam Valve* position to maximize detected signal. (Large adjustments should not be necessary.) DO NOT make any adjustment that will change the orthogonality of the two beams.

L. Try moving the *Beam Valve* in the *Quick Disconnect* while monitoring the detected signal. If the signal is significantly affected, the *Beam Valve* will need to be secured.

M. Repeat steps F through L for the second beam.

N. Select typical operating parameters for the *Beam Valves.*

O. Perform temporal study of gas pulses using the *SRS Counter.* (See Initial Tests document for details.)

P. Adjust relative timing of the two *Beam Valves* and the *Counter* to insure temporal alignment.

Q. Rotate *Mass Spectrometer* away from the gas beams and look for a scattered signal to verify spatial and temporal alignment.

R. Vertically translate one of the *Beam Valves* with the *Adjusting Assembly* to verify proper overlap of the two gas beams.

IV. Standard DCS

Proper verification of alignment will be a reproduction of a previous thermal DCS.

V. CO_2 laser

A. Vent *Cross Section Vacuum Chamber* to atmosphere. (See Vacuum System Operation document.)

B. Install optical rails and focusing lens on O_2 *Beam Valve Housing.*

C. Mount steering optics on optical table.

D. Remove O_2 *Beam Valve* and *Gas Expansion Nozzle* from *Quick Disconnect.*

E. Install HeNe in CO_2 beam path for use as a beam trace, if desired.

F. Perform initial alignment of optics using HeNe beam.

G. Verify colinearity of HeNe beam and CO_2 laser beams.

H. Fire CO_2 laser at low power, using fax paper for detection. (CAUTION: The focused laser beam will be very dangerous. Take special care when working in tight quarters.) Avoid placement of particulates from the fax paper inside the *Chamber Shell Assembly*.

I. Mount detecting surface (glass, graphite-coated metal, etc.) to end of *Beam Valve*.
J. Insert *Beam Valve*, with detecting surface, into the *Quick Disconnect*.
K. Fire the CO_2 laser (low power) enough pulses to mark the detecting surface. (The number of required pulsed is to be determined beforehand.)
L. Remove the detecting surface and inspect to determine placement of focused CO_2 laser beam.
M. Adjust the CO_2 optics to bring the focused beam position to the desired position.
N. Repeat steps I through M until CO_2 laser is properly aligned. Use this time to note the sensitivity of the focused position to the placement of the steering optics. Also note the range of allowed motion of the optics to prevent missing the *Gold-coated Mirror (F/N 81)*.
O. Install O_2 *Beam Valve* and *Gas Expansion Nozzle* in *Quick Disconnect*. Pump down *Cross Section Vacuum Chamber* following instructions in <u>Vacuum System Operation</u> document.
P. Turn on the *Mass Spectrometer* and allow to warm up at least 1 hour.
Q. Set temporal alignment of O_2 pulses and photon counter gate.
R. Set *Mass Spectrometer* to detect only mass 32.
S. Verify normal system operation.
T. Set the *Mass Spectrometer* to detect only mass 16.
U. Characterize background signal from O_2.
V. Begin pulsing CO_2 laser.
W. Look for signal due to atomic oxygen. Once signal is detected, slowly translate CO_2 laser beam to maximize signal.

ORGANIZATION:

CHART NO.:

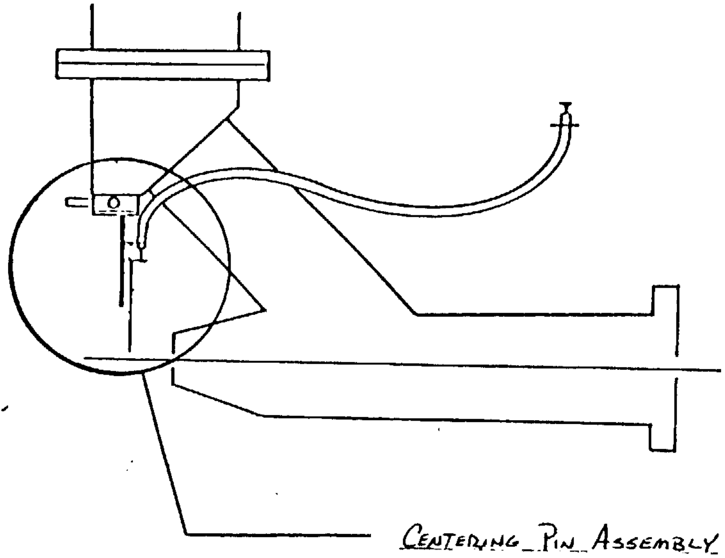
MARSHALL SPACE FLIGHT CENTER

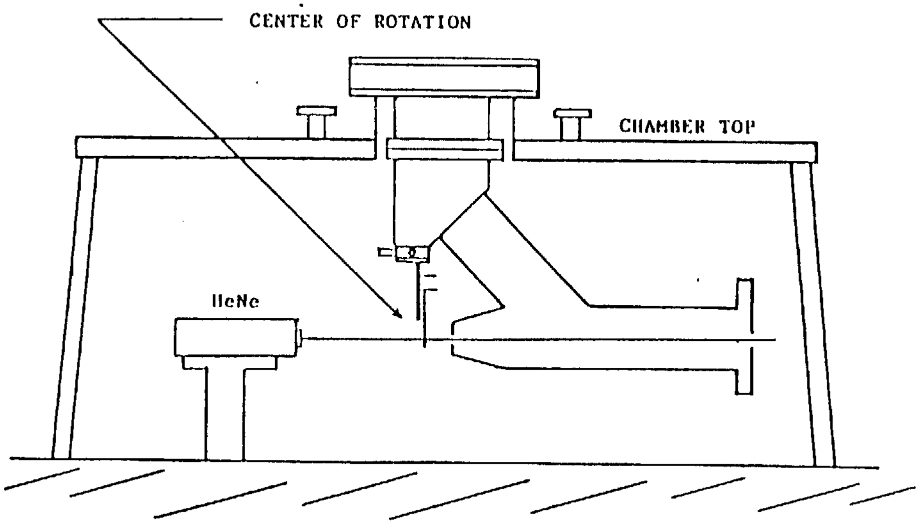
CROSS SECTION PROGRAM REVIEW

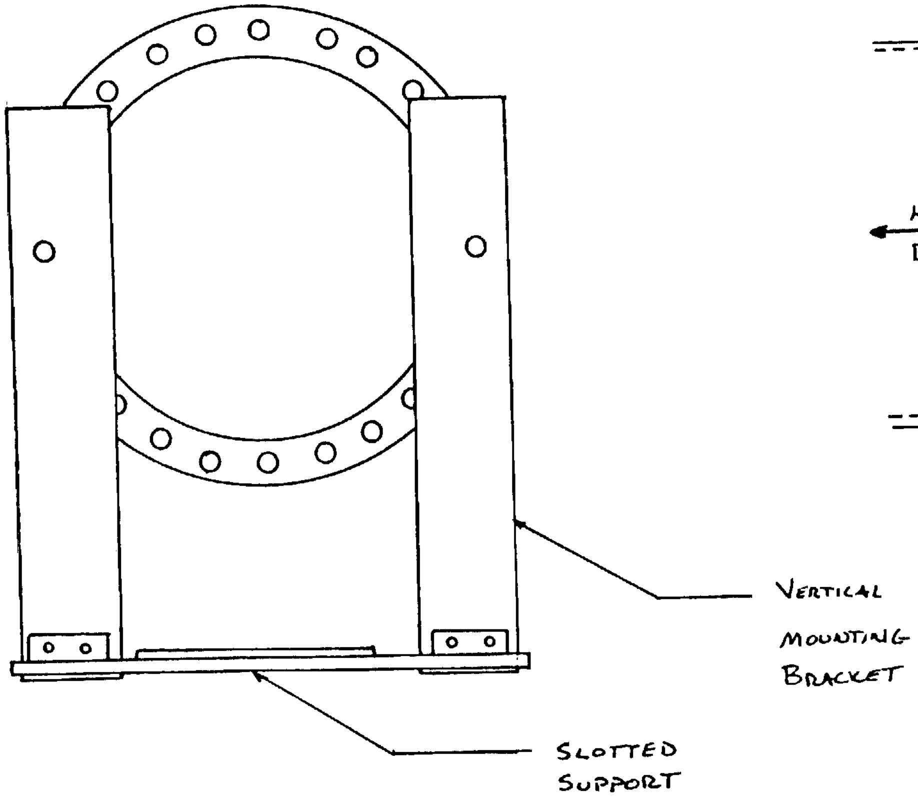
NAME: G. GERMANY

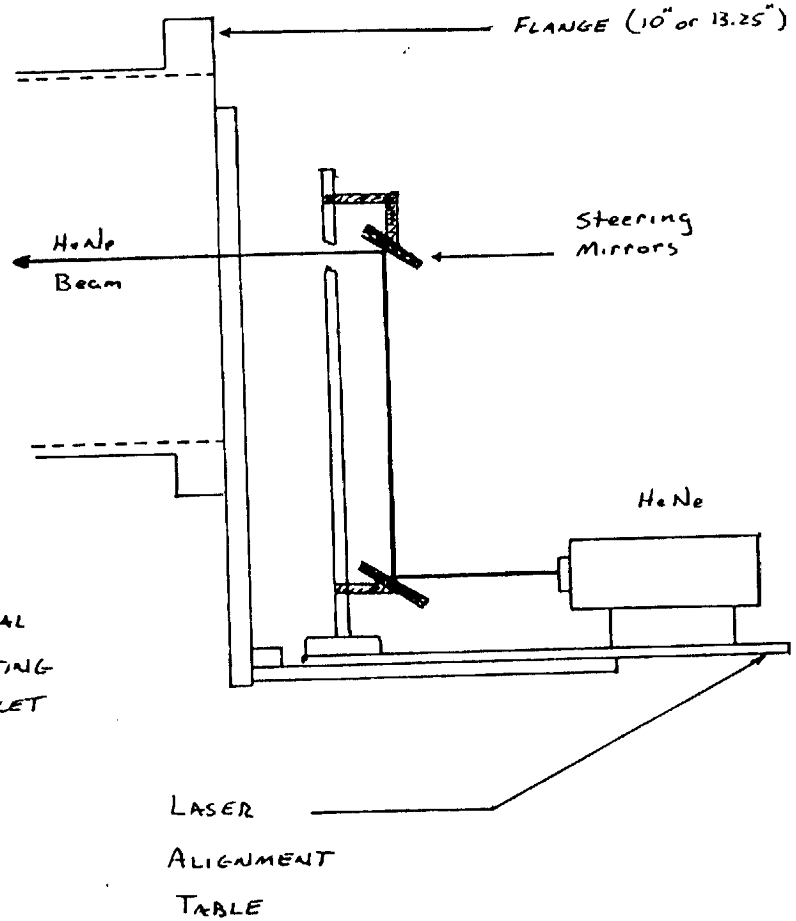
DATE: 14 JULY 1988

CENTER OF ROTATION



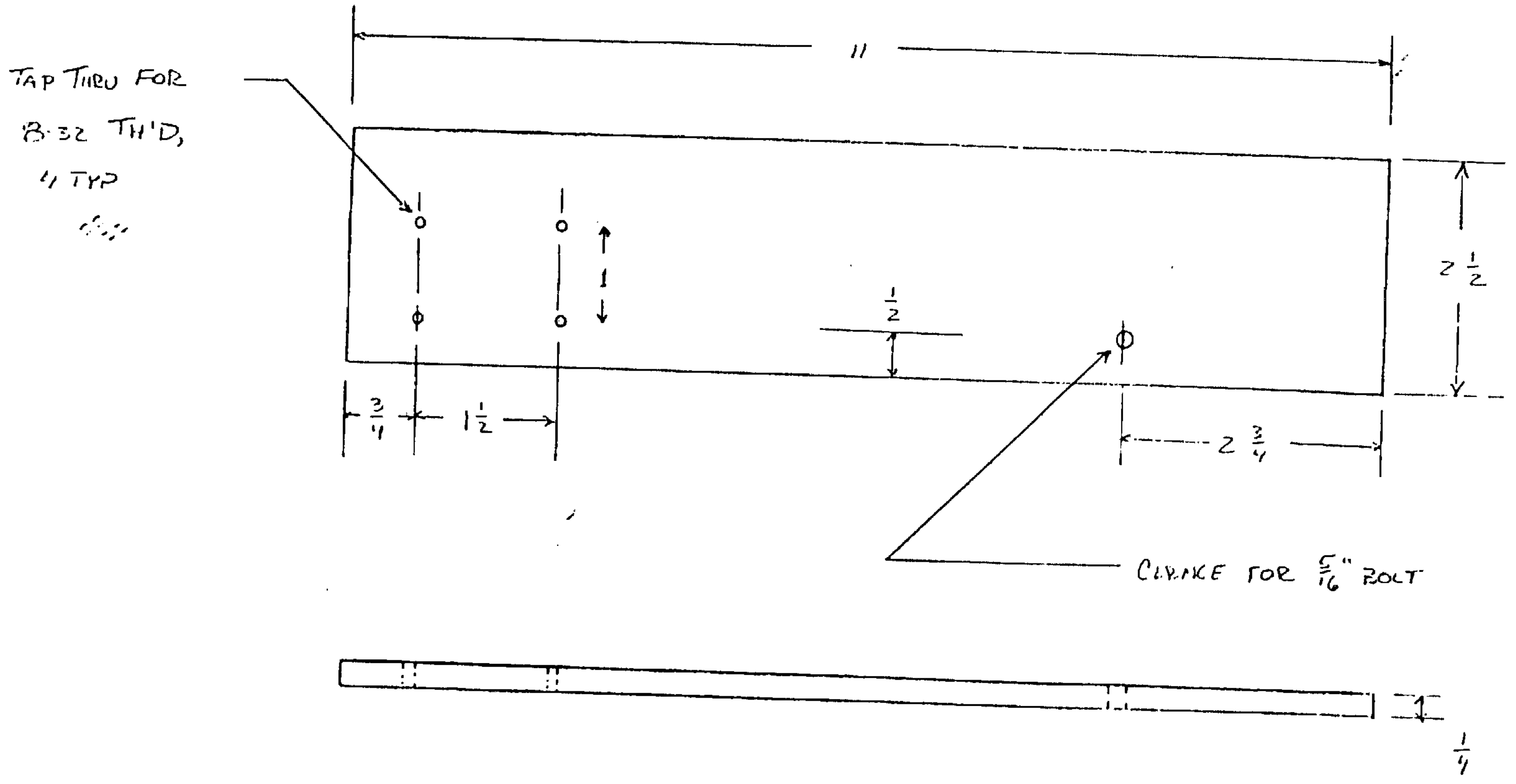


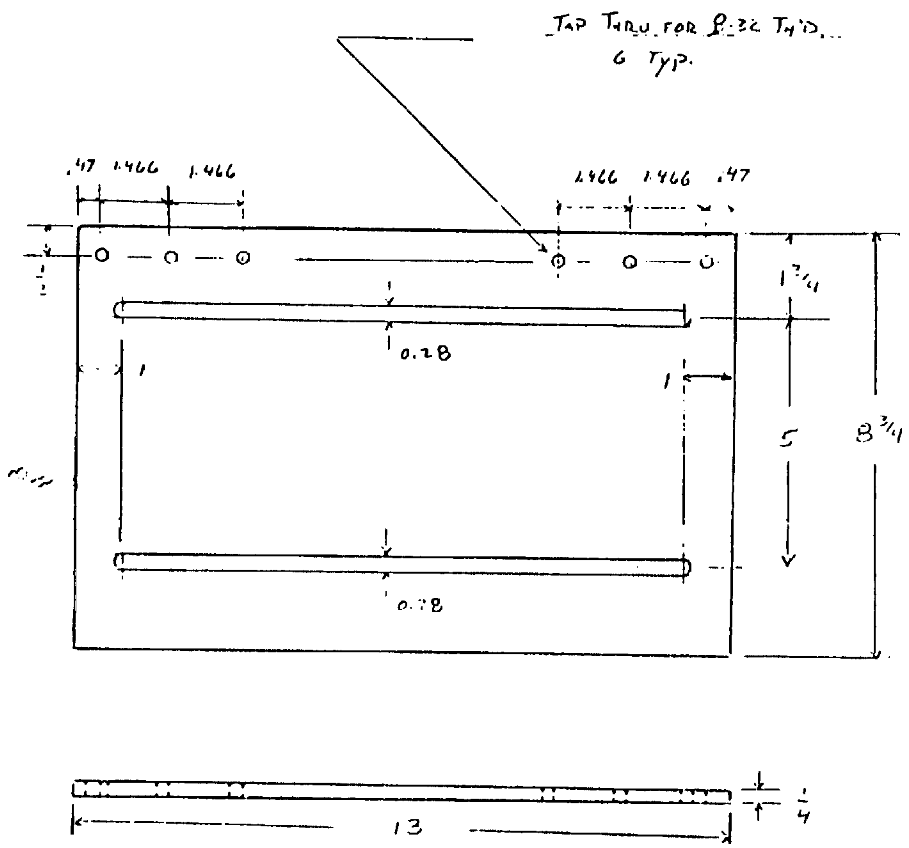

VERTICAL
MOUNTING
BRACKET
SLOTTED
SUPPORT


FLANGE (10" or 13.25")
Steering
Mirrors
HeNe
Beam
HeNe
LASER
ALIGNMENT
TABLE

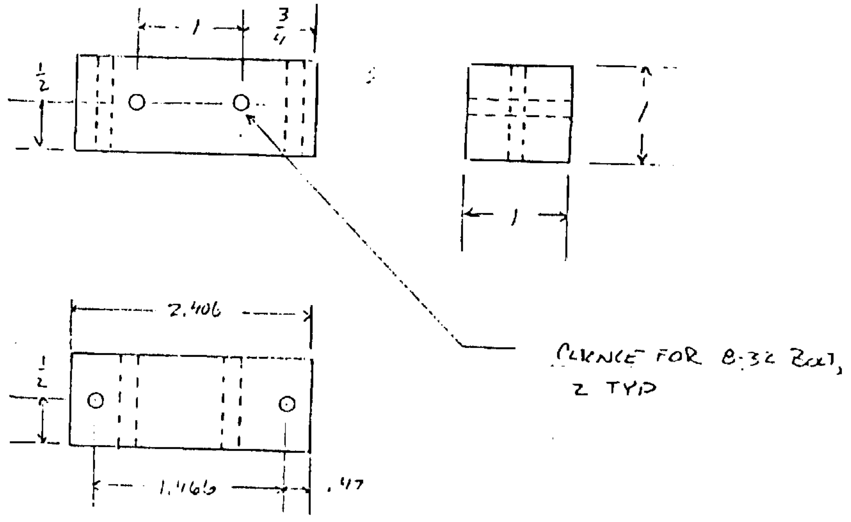
VERTICAL MOUNTING BRACKET QTY: 4 MATERIAL: Al

GLYNN GERMANY E555 4-8343





SLOTTED SUPPORT QTY: 2 MATERIAL: Al
GLYNN GERMANY E555 4-8343



MOUNTING BLOCKS QTY: 4
MATERIAL: Al

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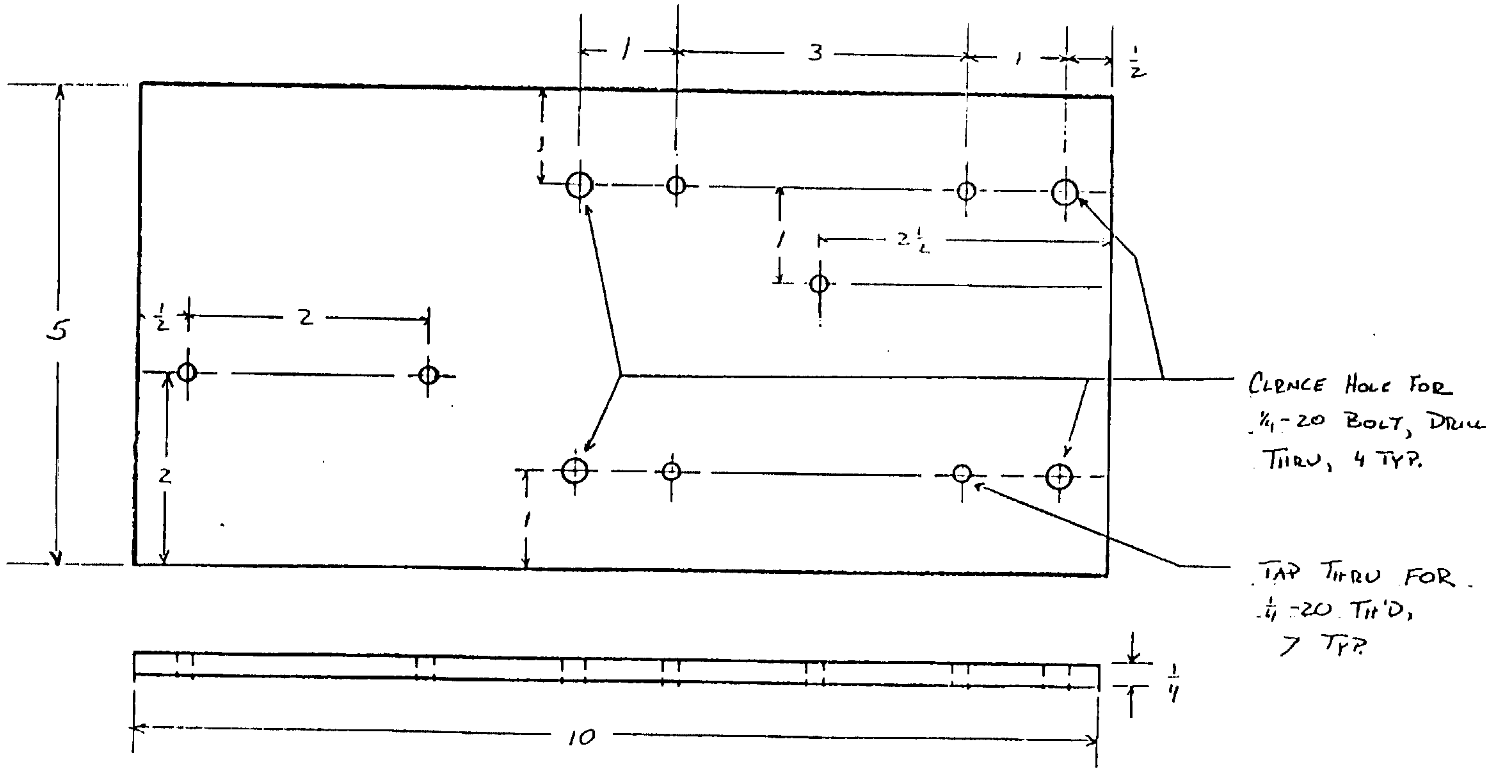
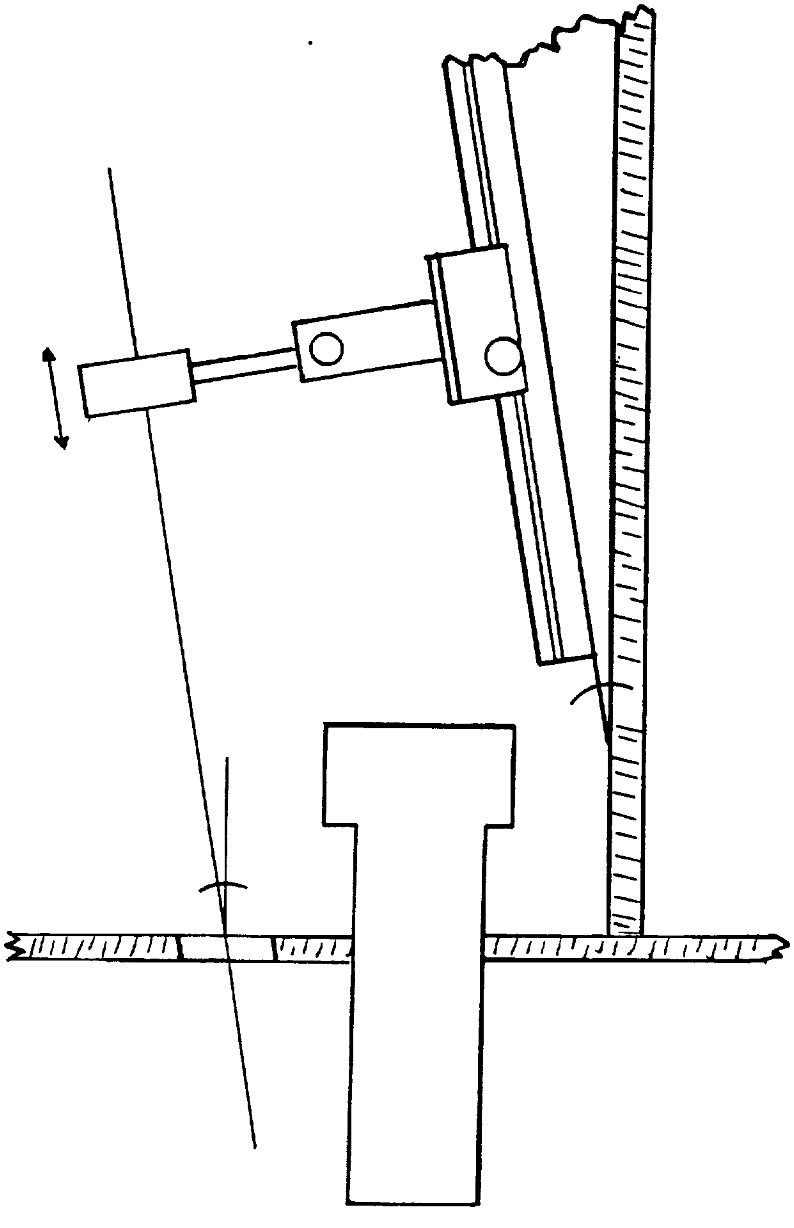
LASER ALIGNMENT TABLE ____ QTY: 2 ___ MATERIAL: AL

GLYNN GERMANY E555 4-8343





CROSS SECTION VACUUM CHAMBER

VACUUM SYSTEM OPERATION

I. Cryopump Start Up
- A. Insure that the ***Sorption Pumps*** have been recently baked.
- B. Check that the ***Cryopump Compressor*** has a minimum of 240 psig helium. If not, refer to the ***Cryopump Operator's Manual*** for instructions on adding helium gas.
- C. Close the ***Gate Valve.***
- D. Fill ***Sorption Pump Dewars*** with liquid nitrogen and let them cool down while proceeding with ***Venturi Pump*** roughing.
- E. Turn on compressed air at > 60 psig to ***Venturi Pump*** and open the ***Venturi Pump Valve*** and the ***Cryopump Roughing Valve.***
- F. Continue roughing with the ***Venturi Pump*** down to 150-170 torr.
- G. Close the ***Venturi Pump Valve*** and shut off the compressed air.
- H. Rough the ***Cryopump*** to about 1 torr using ***Sorption Pump No. 1*** and then valve it off.
- I. Rough the ***Cryopump*** to less than 25 millitorr with ***Sorption Pump No. 2.*** Continue roughing until the outgassing rate is low enough to hold the pressure below 50 millitorr for 1 minute.
- J. Turn on the ***Cryopump*** cooling water.
- K. Close the ***Cryopump Roughing Valve*** and close ***Sorption Pump No. 2.***
- L. Turn on the ***Cryopump*** by switching on the main power switch/circuit breaker on the ***Cryopump Compressor.***
- M. Periodically check the pressure in the ***Cryopump*** for the next 20 minutes to insure that the pressure stays below 50 millitorr. If the pressure rises above this point, reopen ***Sorption Pump No. 2*** to bring the pressure back below 25 millitorr.
- N. After approximately 20 minutes, the ***Cryopump*** should begin cooling down and the pressure should drop below 1 millitorr.
- O. The ***Cryopump*** should be cooled down to 20 K in approximately 2 hours. Refer to the ***Cryopump Operator's Manual*** troubleshooting section if the pump does not cool down within this time.

II. Vacuum Chamber Roughing
- A. Insure that the ***Sorption Pumps*** have been recently baked.
- B. Connect the ***Roughing Manifold Flexible Hose*** to the ***All Metal Valve*** on the ***Mass Spectrometer Roughing Port Adapter.***
- C. Fill ***Sorption Pump Dewars*** with liquid nitrogen and let them cool down while proceeding with ***Venturi Pump*** roughing.
- D. Turn on compressed air at > 60 psig to ***Venturi Pump*** and open the ***Venturi Pump Valve,*** the ***Main Chamber Roughing Valve*** and the ***All Metal Valve*** on the ***Mass Spectrometer Roughing Port Adapter.***
- E. Continue roughing with the ***Venturi Pump*** down to 150-170 torr. This should take approximately 30 minutes.
- F. Close the ***Venturi Pump Valve*** and shut off the compressed air.
- G. Begin roughing with ***Sorption Pump No. 1.***
- H. Turn on the cooling water to the ***Turbomolecular Pumps.***
- I. Turn on both ***SD-450 Mechanical Pumps*** and start both ***Turbomolecular Pumps*** after the ***Main Chamber*** has reached a pressure of 50 torr. The ***Turbomolecular Pumps*** must achieve a pressure of < 0.75 torr in 5 minutes. If not, further roughing is required prior to turning on the ***Turbomolecular Pumps.***
- J. Valve off ***Sorption Pump No. 1*** at a pressure of about 1 torr. Begin

immediately to regenerate ***Sorption Pump No. 1.***

K. Open the valve on ***Sorption Pump No. 2*** and continue roughing down to below 50 millitorr. This is well below the ***Cryopump*** crossover pressure of 400 millitorr.

L. Close the ***Main Chamber Roughing Valve*** but leave the ***All Metal Valve*** on the ***Mass Spectrometer Roughing Port Adapter*** open.

III. High Vacuum Pumping

A. Open the ***Cryopump Gate Valve.***

B. Continue roughing the ***Mass Spectrometer Chamber*** until the pressure is below 10^{-4} torr. Use the freshly regenerated ***Sorption Pump No. 1,*** if necessary, to achieve this pressure.

C. Close the ***All Metal Valve*** on the ***Mass Spectrometer Roughing Port Adapter*** and the valve on ***Sorption Pump No. 1.***

D. Switch on the ***StarCell Ion Pump Power Unit*** and the high voltage on the ***StarLink Control Unit*** when the pressure in the ***Mass Spectrometer Chamber*** drops below 10^{-4} torr. If the ***StarCell Ion Pump*** will not start, wait until the pressure drops below 10^{-5} torr and try again.

E. Move the ***Roughing Manifold Flexible Hose*** to the ***VacIon Pump Roughing Valve.***

F. Begin differential pumping of the ***Rotary Platform*** with the ***SD-90 Mechanical Pump*** and with the ***VacIon Pump*** when the ***Main Chamber*** pressure drops below 10^{-6} torr. The ***VacIon Pump*** will probably have to be roughed out to about 10^{-3} torr.

IV. Bake-out Procedure

A. Wrap ***Heating Tape*** around the ***Mass Spectrometer Roughing Port Adapter.***

B. Wait until the pressure in the ***Main Chamber*** is less than 10^{-6} torr.

C. Turn on the ***Bake-out Lamps.*** Adjust the ***Variacs*** to meet the temperature criteria given below.

D. Turn on the ***Heating Tape.*** Adjust the ***Variacs*** to meet the temperature criteria given below.

E. Turn on the ***StarCell Ion Pump Bake-out Heaters.***

1. The ***StarCell Ion Pump Bake-out Heaters*** will provide a bake-out temperature of ≈120°C at the pump element and ≈200°C at the getter. This temperature is insufficient for initial activation or for regeneration of the getter.

2. Wrap 3 layers of aluminum foil around the ***StarCell Ion Pump*** if full bake-out/regeneration is required. This should provide a temperature of ≈250°C at the pump element and ≈350°C at the getter. Note: Do not do an initial activation of the getter until the pressure in the ***Mass Spectrometer Chamber*** has reached 10^{-8} torr.

F. Monitor the temperature of the ***Rotary Platform*** to insure that it does not exceed 150°C.

G. Monitor the temperature of the ***Torr Seal Epoxy*** holding the ***Laser Window*** to insure that it does not exceed 150°C.

H. Monitor the temperature of the ***Pulsed Valves*** to insure that they do not exceed 150°C.

I. Monitor the temperature of the ***Turbomolecular Pump No. 1 and No. 2*** conflat flanges to insure that they do not exceed 120°C.
J. Continue bake-out for 24 hours.
K. Turn off ***Bake-out Lamps, Heating Tape*** and ***Ion Pump Bake-out Heater.***

V. Regeneration Procedures
A. Cryopump
1. Regeneration of the ***Cryopump*** is required when the activated charcoal within the pump reaches its capacity for cryosorption. This is usually indicated by a rise in base pressure in the vacuum chamber and/or a rise in the partial pressure of hydrogen in the vacuum chamber. See the ***Cryopump Operator's Manual*** for an estimate of the operation time between regenerations.
2. If hazardous gases have been pumped since the last regeneration, the ***Pressure Relief Valve*** must be vented to the outside.
3. Close the ***Gate Valve.***
4. Turn off the ***Cryopump Compressor.***
5. Turn off the ***Cryopump*** cooling water.
6. Connect the ***Cryopump Purge Valve*** to a cylinder of dry nitrogen or argon.
7. Open the ***Cryopump Purge Valve.***
8. Purge dry nitrogen or argon at 15 psig into the ***Cryopump*** for 90 minutes using ambient temperature gas or 70 minutes using heated gas (gas temperature: 100°C maximum). Check the ***Remote Temperature Monitor*** to insure that the ***Cryopump*** has reached room temperature.
9. Close the ***Cryopump Purge Valve.***
10. Alternatively, steps 5 through 8 can be skipped and the pump allowed to warm up on its own. This will require a longer warm up time. Check the ***Remote Temperature Monitor*** to insure that the ***Cryopump*** has reached room temperature.
11. Complete the Cryopump Start Up procedure outlined above to restart the ***Cryopump.***

B. StarCell Ion Pump Getter Module
1. The need for regeneration is indicated by a decrease in the pumping speed for getterable gases other than hydrogen.
2. To ensure meaningful lifetime (greater than 500 hours between regeneration cycles) and optimum pumping performance the ***Getter Module*** should not be exposed to pressures greater than 2×10^{-8} torr.
3. A ***Getter Module*** that has been exposed to atmospheric pressure is saturated and will require regeneration.
4. Wrap 3 layers of aluminum foil around the ***StarCell Ion Pump.***
5. Turn on the ***StarCell Ion Pump Heaters.***
6. Monitor the temperature of the ***StarCell Ion Pump*** until it levels off at a maximum value.
7. Continue heating the ***StarCell Ion Pump*** for a minimum of 5 hours. The temperature should be ≈250°C at the pumping

elements and ≈350°C at the ***Getter Module*** during the regeneration. The pressure must be below 10^{-4} torr during regeneration.

8. Turn off the ***StarCell Ion Pump Heaters.***
9. The maximum number of regeneration cycles of a ***Getter Module*** is 30. Therefore, do not activate the getter unless it is required!

C. Sorption Pumps
   1. Remove the ***Styrofoam*** LN_2 ***Dewar***, if it is present.
   2. Plug the ***Bake-out Heater Jacket*** into a 110V AC outlet.
   3. Continue heating the ***Sorption Pump*** until it reaches approximately 250°C. If the ***Sorption Pump*** is not needed immediately, it can be baked-out overnight.
   4. Rough out the ***Sorption Pump*** with the ***Venturi Pump.***
   5. Unplug the ***Bake-out Heater Jacket.***

VI. Shut Down Procedure
   A. Turn off the ***Mass Spectrometer.***
   B. Turn off the ***StarCell Ion Pump.***
   C. Turn off the ***VacIon Pump*** and the ***SD-90 Mechanical Pump*** to discontinue differential pumping of the ***Rotary Platform.***
   D. Close the ***Gate Valve.***
   E. Turn off the ***Turbomolecular Pumps*** and the ***SD-450 Mechanical Pumps.***
   F. Turn off the cooling water to the ***Turbomolecular Pumps.***
   G. The vacuum chamber will be partially vented by the ***Turbomolecular Pump Vent Valves.***
   H. The vacuum chamber can be vented to atmosphere through the ***Venturi Pump Valve.***

Appendix B

Summary

Cross section results obtained are summarized in the two attached figures. Figure 1 shows the cross section obtained over the center of mass angular range 0° to 30°. Figure 2 shows the detailed behavior for angles less that 10°.

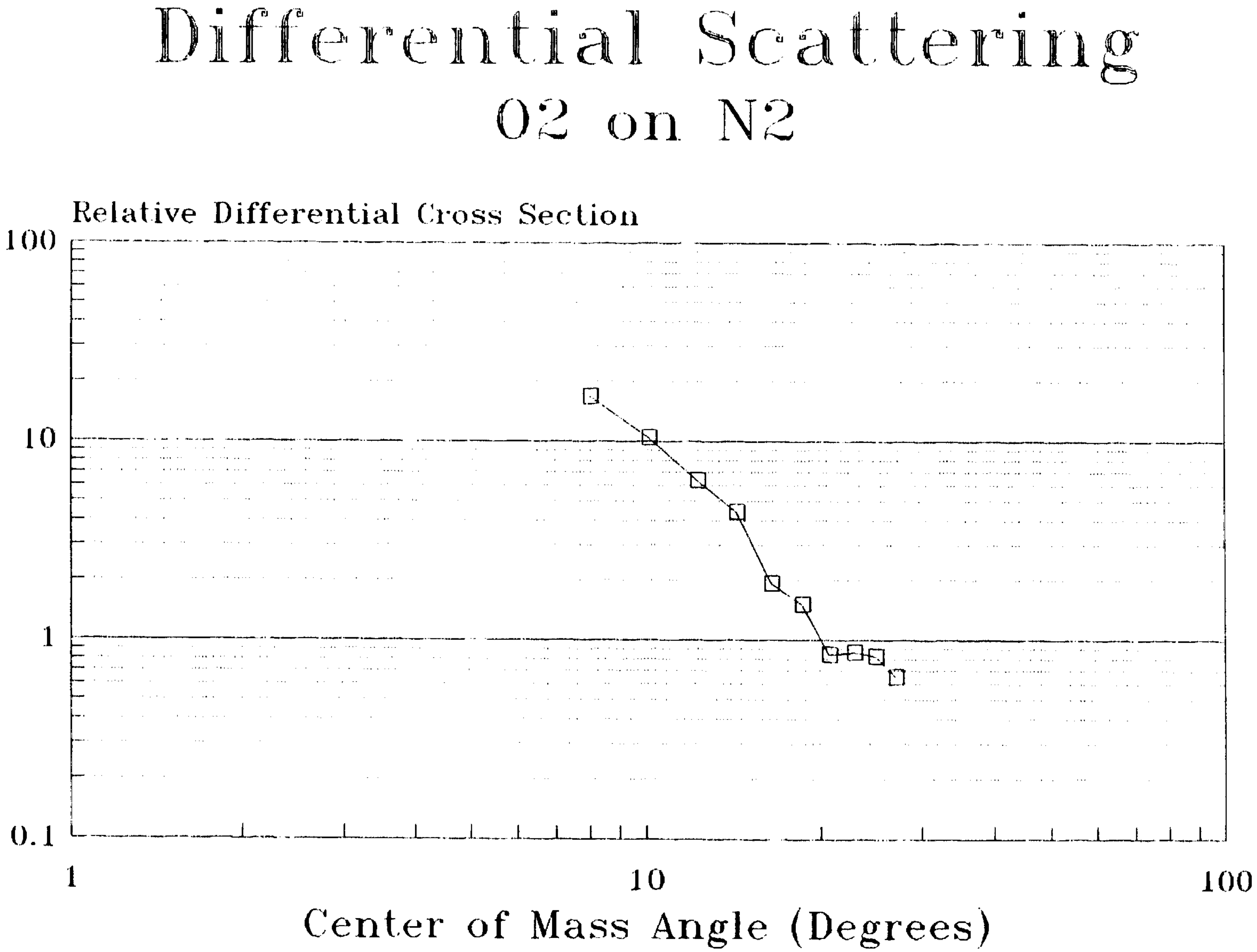

Differential Scattering
O2 on N2
Relative Differential Cross Section
100
10
1
0.1
1
10
100
Center of Mass Angle (Degrees)

Figure 1

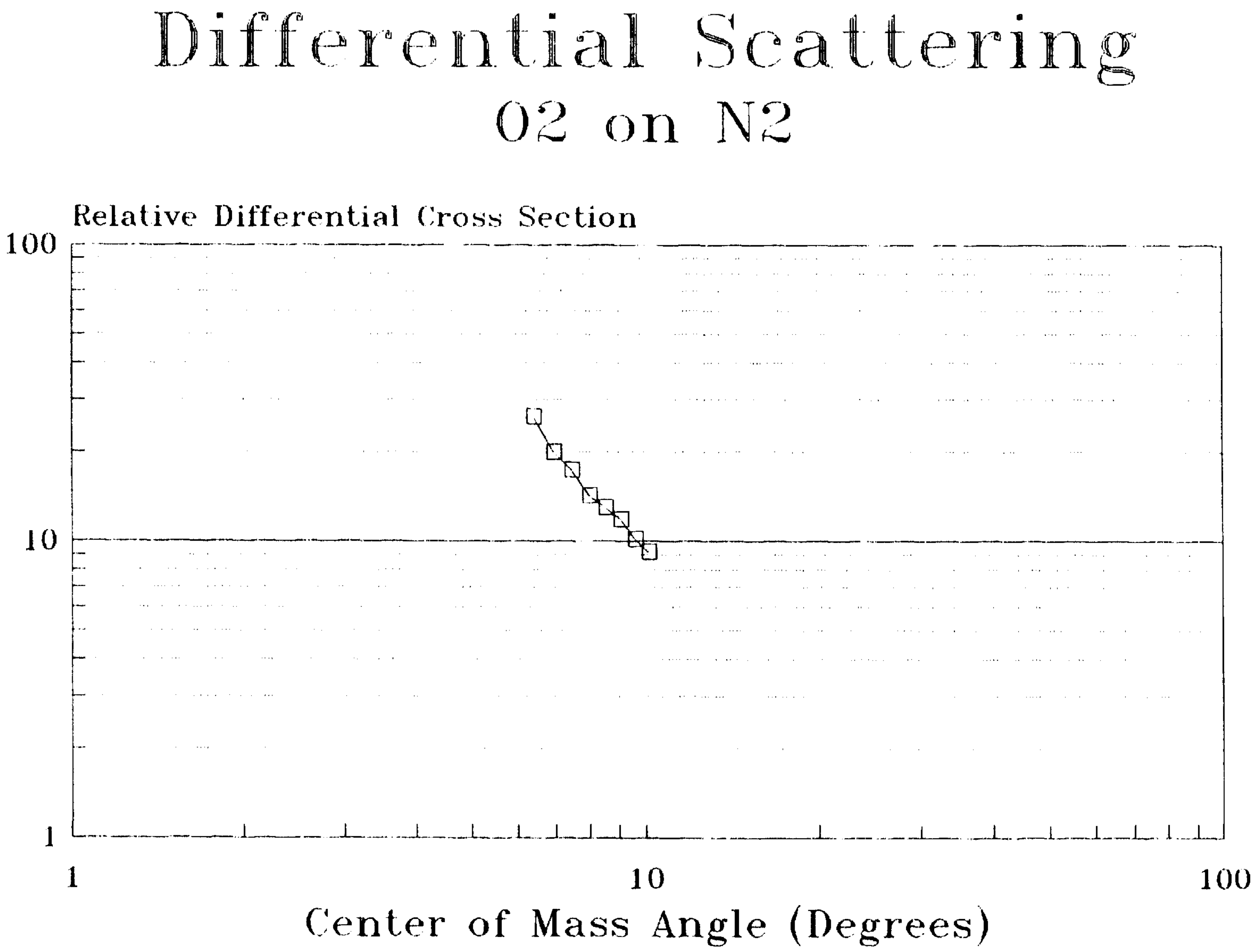
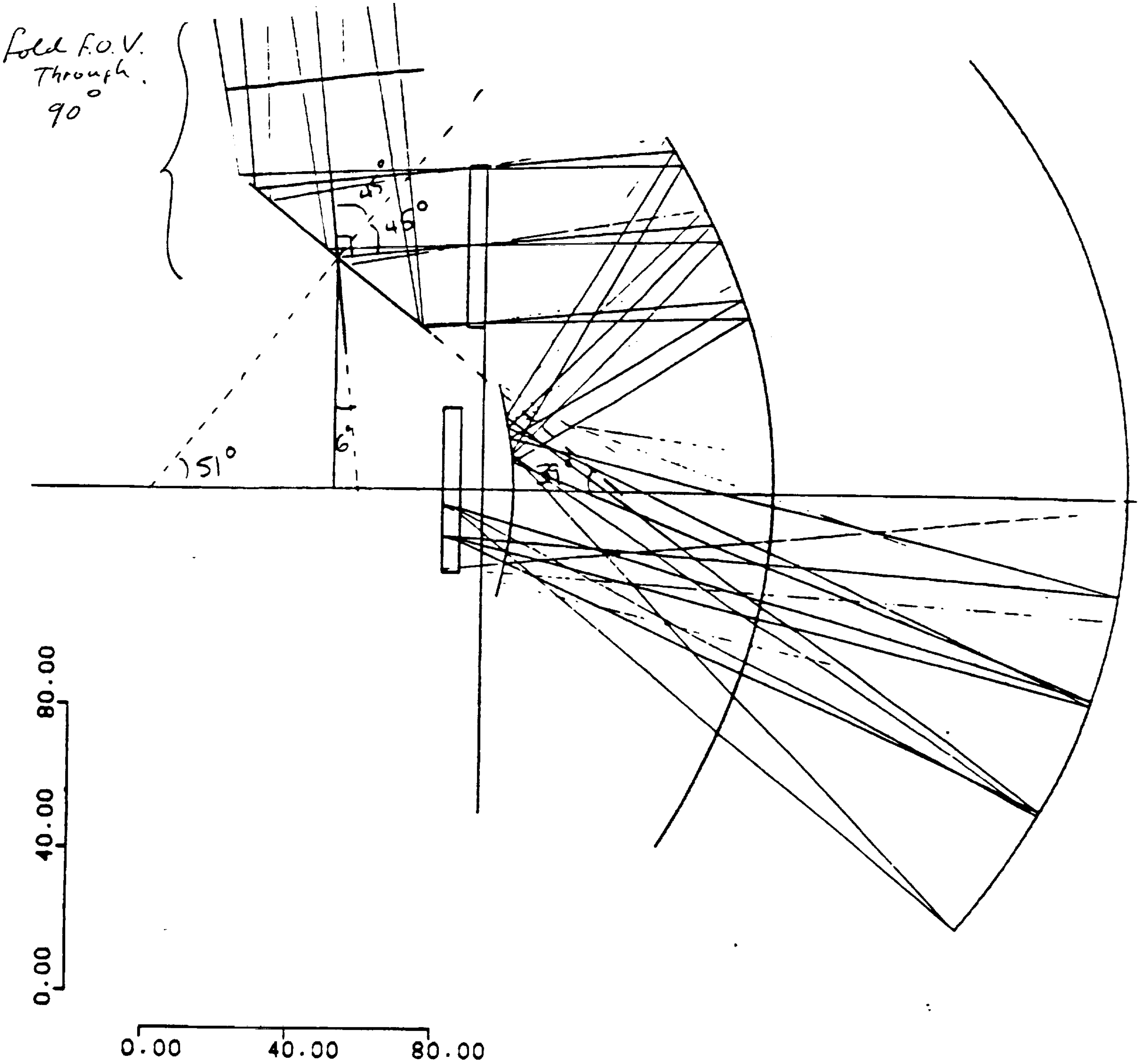

Differential Scattering
02 on N2
Relative Differential Cross Section
100
10
1
1
10
100
Center of Mass Angle (Degrees)

Figure 2

Appendix C

TORR'S TELESCOPE

09:38:40-------- 1/ 5/90



UVI Straylight Analysis

Objective:

To maintain the straylight level of the system at least 1 order of magnitude lower than the naturally occurring day/night glow in the scene being imaged.

Key contributors:

Direct and diffuse light from the sun and earth limb reflected thru the system

Design variables:

Baffle geometry and surface finish

Optical bench internal surface finishes

Mirror smoothness

Design Considerations

- Baffle
  - Envelope constraints and number of internal vanes
  - Manufacturability of baffle subassembly
  - Baffle surface finish

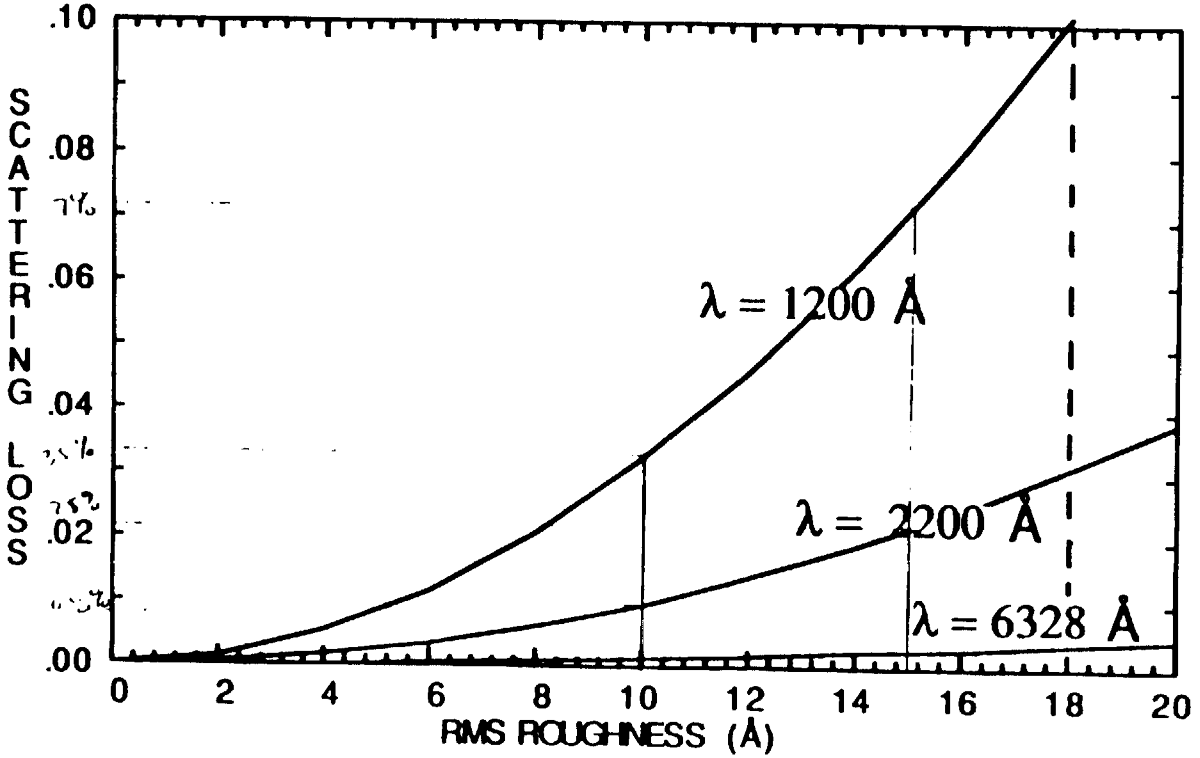
- Optics
  - How much energy is scattered out of the image as a function of μ-roughness?
  - How smooth can one polish electroless-nickel plated, diamond turned optics?

- Internal surfaces
  - Are internal vanes required?
  - What surface finishes provide adequate absorption and are compatible with the manufacturing process?

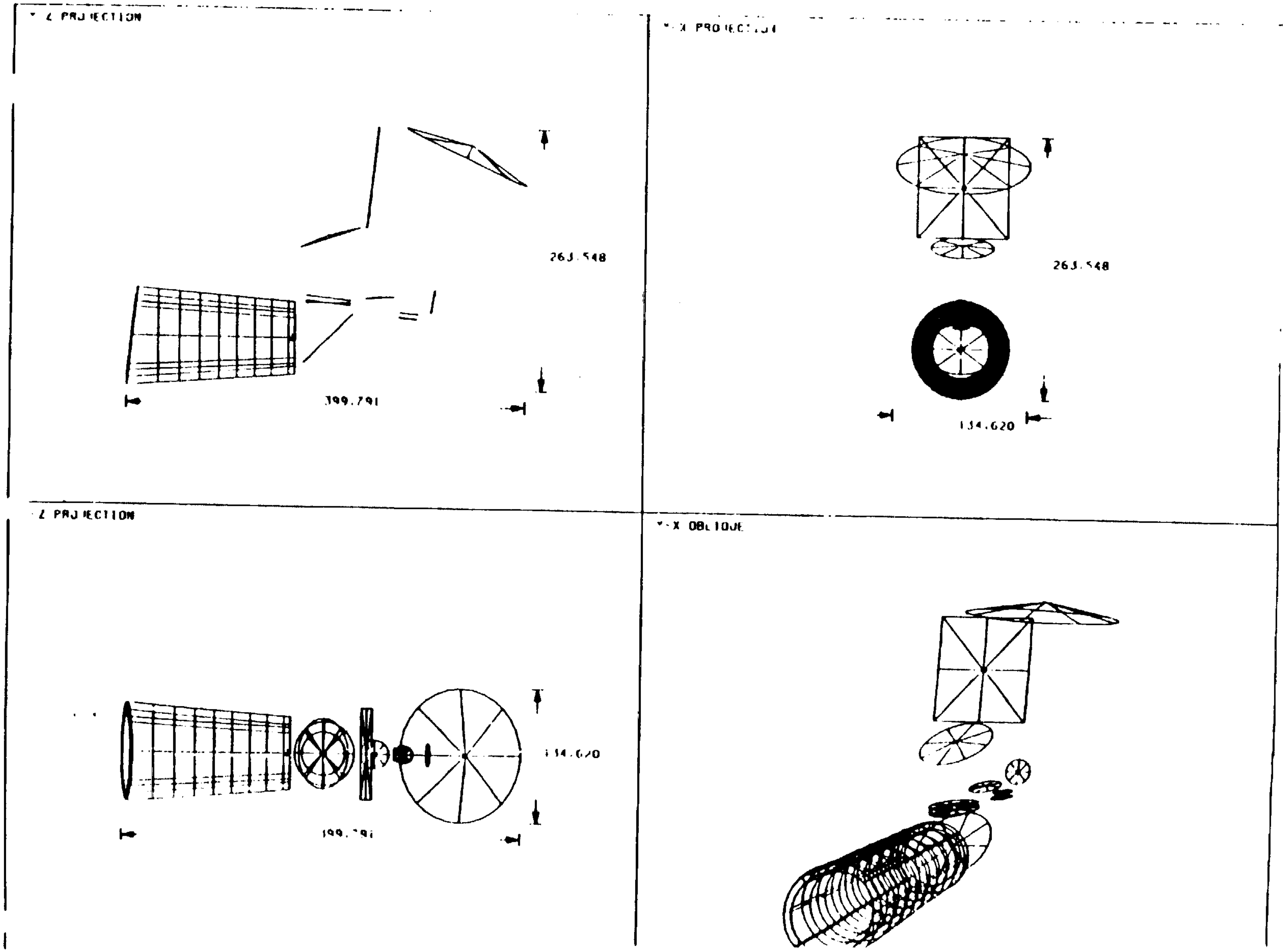
Straylight Analysis

- Performed Total Integrated Scatter (TIS) analysis to determine required mirror μ-roughness specification
- Detailed APART model of UVI was developed and baffle design and internal configuration were optimized
- APART model run using Chemglaze (Z306) and ITTRI MH21-IC paints for baffle coating and Chemglaze for internal surfaces and 15Å rms μ-roughness for each mirror

Total Integrated Scatter Curve



APART Model Diagrams



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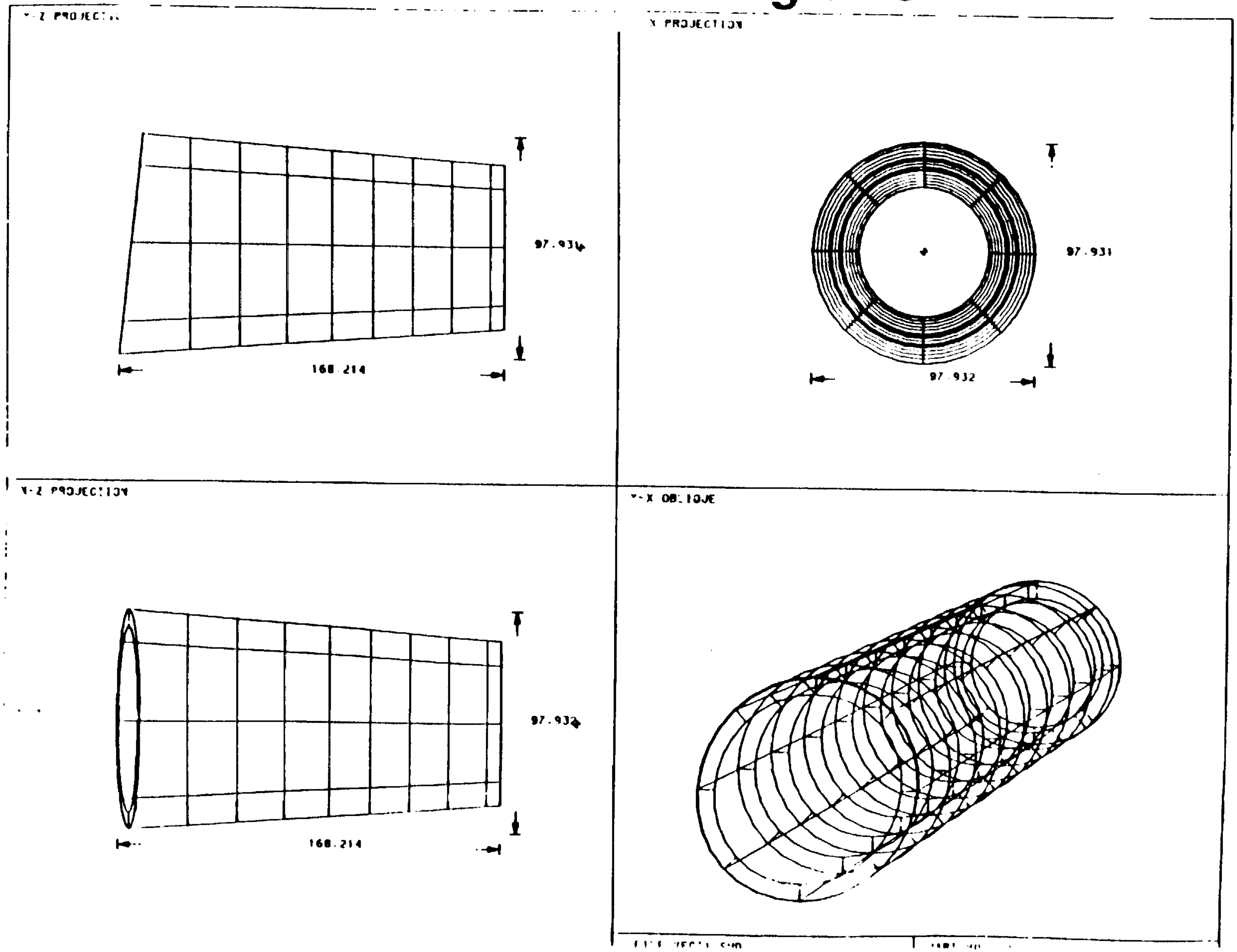
OF POOR QUALITY

APART Model Diagrams



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Straylight Analysis Results

Wavelengths Å	Mean Background (W/cm2)	Straylight Throughput - In-Band Altitude = 2 Earth Radii (W/cm2)			Straylight Throughput - In-Band Altitude = 9 Earth Radii (W/cm2)		
		0 deg.	90 deg.	135 deg.	0 deg.	90 degrees	135 degrees
1191 - 1241	7.351E-08	0E+00	0E+00	2.79E-14	0E+00	0E+00	2.79E-14
1279 - 1304	4.570E-08	0E+00	0E+00	7.59E-14	0E+00	0E+00	7.59E-14
1331 - 1381	4.395E-09	0E+00	0E+00	1.28E-13	0 E+00	0E+00	1.28E-13
1400 - 1700	1.127E-09	0E+00	0E+00	4.21E-12	0E+00	0E+00	4.21E-12
1468 - 1518	1.331E-10	0E+00	0E+00	4.10E-13	0E+00	0E+00	4 .10E-13
1700 - 2000	9.465E-10	7.67E-14	3.59E-15	2.06E-11	5.04E-14	1.00E-14	2.06E-11
2125 - 2175	7.392E-09	3.88E-14	1.82E-15	9.69E-12	2.54E-14	5.08E-15	9.69E-12

UVI Straylight Summary

- E-Model baffle is presently coated with Chemglaze.
- Current baffle configuration and surface finish selection meet straylight requirements with margin.

Appendix D1

DR. D.G. TORR

Error Analysis

AL4

Aluminium that we can deposit

```
Material with Code_Number  1 Deposition Error =     0.0%

Material with Code_Number  2 Deposition Error =     0.0%
```

```
              Transmittance Average
30.000-
      I
      I
      I
      I                     ****
22.500-                 ****    **
      I                *          *
      I               *            **
      I              *               **
      I            **                  **
15.000-           *                      ***  *
      I          *                          **
      I
      I        **
      I      **
 7.500-     *
      I  *  *
      ** **
      I
      I
 0.000ooooooooooooooooooooooooooooooooooooooooo
    120.0     132.5     145.0     157.5     170.0

              oooo  Target Function           **** Calculated Function
```

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	5.0383
122.50	0.0000	5.2545
125.00	0.0000	5.1208
127.50	0.0000	7.1354
130.00	0.0000	9.7090
132.50	0.0000	10.9046
135.00	0.0000	14.6368
137.50	0.0000	16.8879
140.00	0.0000	19.0211
142.50	0.0000	22.0205
145.00	0.0000	22.9793
147.50	0.0000	23.3842
150.00	0.0000	23.7365
152.50	0.0000	22.9371
155.00	0.0000	20.9018
157.50	0.0000	19.4782
160.00	0.0000	17.9484
162.50	0.0000	15.9820
165.00	0.0000	14.3897
167.50	0.0000	14.1559
170.00	0.0000	14.2743

#

Film No (Inc/M)	Thick. [nm] No Error	Thick. [nm] With Error	Cod No	Material
1	21.00	21.00	1	MGF2S-1
2	25.00	25.00	2	A49
3	21.00	21.00	1	MGF2S-1
4	25.00	25.00	2	A49

```
#

                    E r r o r   A n a l y s i s

                                  AL4


      Material with Code_Number  1 Deposition Error =    0.0%

      Material with Code_Number  2 Deposition Error =   10.0%


              Transmittance Average
20.000-
      I
      I                     *****
      I                   **     *
      I                  *        **
15.000-                 *           *
      I                *             **
      I               *                *
      I              *                  *
      I             *                    *
10.000-            *                      *****
      I           *
      I          *
      I        **
      I       *
 5.000-     **
      **** *
      I   *
      I
      I
 0.000ooooooooooooooooooooooooooooooooooooooooo
    120.0     132.5     145.0     157.5     170.0

              oooo  Target Function           **** Calculated Function
```

#

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	3.8742
122.50	0.0000	3.6747
125.00	0.0000	3.4286
127.50	0.0000	4.6587
130.00	0.0000	6.2715
132.50	0.0000	6.9568
135.00	0.0000	9.4369
137.50	0.0000	11.0442
140.00	0.0000	12.7640
142.50	0.0000	15.4652
145.00	0.0000	16.9137
147.50	0.0000	17.7130
150.00	0.0000	18.4359
152.50	0.0000	17.9358
155.00	0.0000	16.2290
157.50	0.0000	14.9417
160.00	0.0000	13.5339
162.50	0.0000	11.7911
165.00	0.0000	10.4141
167.50	0.0000	10.1391
170.00	0.0000	10.1192

Film No (Inc/M)	Thick. [nm] No Error	Thick. [nm] With Error	Cod No	Material
1	21.00	21.00	1	MGF2S-1
2	25.00	27.50	2	A49
3	21.00	21.00	1	MGF2S-1
4	25.00	27.50	2	A49

```
#

                    Error Analysis

                         AL4


Material with Code_Number  1 Deposition Error =    0.0%

Material with Code_Number  2 Deposition Error =  -10.0%


            Transmittance Average
   30.000-                 *******
         I                *       **
         I               *          **
         I             **             **
         I            *                 **
   22.500-           *                    *
         I                                 **
         I          *                        *****
         I
         I        **
   15.000-       *
         I      *
         I
         I     *
         I    *
    7.500-****
         *
         I
         I
         I
    0.000ooooooooooooooooooooooooooooooooooooooooo
       120.0     132.5     145.0     157.5     170.0

        oooo  Target Function          **** Calculated Function
```

#

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	6.7001
122.50	0.0000	7.6746
125.00	0.0000	7.7918
127.50	0.0000	11.0660
130.00	0.0000	15.0913
132.50	0.0000	17.0108
135.00	0.0000	22.2367
137.50	0.0000	25.0082
140.00	0.0000	27.1788
142.50	0.0000	29.8694
145.00	0.0000	29.8447
147.50	0.0000	29.6764
150.00	0.0000	29.5916
152.50	0.0000	28.5387
155.00	0.0000	26.2871
157.50	0.0000	24.8165
160.00	0.0000	23.2619
162.50	0.0000	21.1715
165.00	0.0000	19.4337
167.50	0.0000	19.3080
170.00	0.0000	19.6521

#

```
Film No    Thick. [nm]    Thick. [nm]
(Inc/M)     No Error      With Error   Cod No   Material
------------------------------------------------------------------------
   1           21.00          21.00      1      MGF2S-1
   2           25.00          22.50      2      A49
   3           21.00          21.00      1      MGF2S-1
   4           25.00          22.50      2      A49
```

```
#


                       Error Analysis

                            AL4



       Material with Code_Number  1 Deposition Error =  -10.0%

       Material with Code_Number  2 Deposition Error =    0.0%



                 Transmittance Average
30.000-
      I
      I
      I
      I             *****
22.500-           **     *
      I                   **
      I          *          ***
      I         *              **
      I        *                 **
15.000-       *                    **
      I      *                       ***
      I                                 **
      I     *                             *****
      I    *
 7.500- ***
      **
      I
      I
      I
 0.000ooooooooooooooooooooooooooooooooooooooooo
     120.0     132.5     145.0     157.5     170.0

             oooo   Target Function            **** Calculated Function
```

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	5.4811
122.50	0.0000	6.7583
125.00	0.0000	7.2357
127.50	0.0000	10.9585
130.00	0.0000	15.5247
132.50	0.0000	17.4241
135.00	0.0000	22.2128
137.50	0.0000	23.7059
140.00	0.0000	23.7500
142.50	0.0000	23.7061
145.00	0.0000	21.4050
147.50	0.0000	20.0739
150.00	0.0000	19.0251
152.50	0.0000	17.7155
155.00	0.0000	15.8185
157.50	0.0000	14.6093
160.00	0.0000	13.4484
162.50	0.0000	12.1421
165.00	0.0000	11.0877
167.50	0.0000	10.9877
170.00	0.0000	11.1422

Film No (Inc/M)	Thick. [nm] No Error	Thick. [nm] With Error	Cod No	Material
1	21.00	18.90	1	MGF2S-1
2	25.00	25.00	2	A49
3	21.00	18.90	1	MGF2S-1
4	25.00	25.00	2	A49

Appendix D2

Error Analysis

AL4

Improved Al quality

```
Material with Code_Number  1 Deposition Error =     0.0%

Material with Code_Number  2 Deposition Error =     0.0%



              Transmittance Average
30.000-
      I                 *
      I               **
      I
      I              *   *
22.500-
      I             *     *
      I
      I            *       *
      I           *         *
15.000-                      *
      I          *            **
      I                         **
      I         *                 *
      I        *                   **
 7.500-       *                      **
      I      *                         ****
      I    **                              ****
      I ***
      **
 0.000ooooooooooooooooooooooooooooooooooooooooo
    120.0     132.5     145.0     157.5     170.0

             oooo  Target Function            **** Calculated Function
```

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	1.3381
122.50	0.0000	2.6573
125.00	0.0000	3.0568
127.50	0.0000	5.0645
130.00	0.0000	8.0271
132.50	0.0000	10.8290
135.00	0.0000	16.2635
137.50	0.0000	21.0045
140.00	0.0000	27.2726
142.50	0.0000	28.0888
145.00	0.0000	20.4468
147.50	0.0000	16.6352
150.00	0.0000	13.8623
152.50	0.0000	12.2536
155.00	0.0000	10.4514
157.50	0.0000	8.6700
160.00	0.0000	7.2393
162.50	0.0000	6.1205
165.00	0.0000	5.3024
167.50	0.0000	4.6410
170.00	0.0000	4.0508

#

```
Film No   Thick. [nm]    Thick. [nm]
(Inc/M)    No Error      With Error  Cod No  Material
--------------------------------------------------------------------------------
   1            21.00          21.00    1    MGF2S-1
   2            25.00          25.00    2    AL1
   3            21.00          21.00    1    MGF2S-1
   4            25.00          25.00    2    AL1
```

Error Analysis

AL4

```
Material with Code_Number  1 Deposition Error =    0.0%

Material with Code_Number  2 Deposition Error =   10.0%
```

```
               Transmittance Average
30.000-
      I
      I
      I
      I
22.500-
      I                 *
      I               **
      I                  *
      I              *
15.000-                   *
      I             *      *
      I            *        *
      I           *          *
      I                       ***
 7.500-          *               **
      I        **                  **
      I      **                      ***
      I    **                           *******
      *****
 0.000ooooooooooooooooooooooooooooooooooooooooo
    120.0     132.5     145.0     157.5     170.0

           oooo  Target Function          **** Calculated Function
```

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	0.8078
122.50	0.0000	1.5728
125.00	0.0000	1.7933
127.50	0.0000	2.9519
130.00	0.0000	4.6920
132.50	0.0000	6.3837
135.00	0.0000	10.0013
137.50	0.0000	13.5254
140.00	0.0000	18.9402
142.50	0.0000	21.0685
145.00	0.0000	15.0880
147.50	0.0000	11.9475
150.00	0.0000	9.6493
152.50	0.0000	8.3385
155.00	0.0000	6.9173
157.50	0.0000	5.5362
160.00	0.0000	4.4688
162.50	0.0000	3.6941
165.00	0.0000	3.1473
167.50	0.0000	2.7183
170.00	0.0000	2.3454

```
Film No   Thick. [nm]   Thick. [nm]
(Inc/M)    No Error     With Error  Cod No  Material
------------------------------------------------------------------------------
   1           21.00          21.00    1    MGF2S-1
   2           25.00          27.50    2    AL1
   3           21.00          21.00    1    MGF2S-1
   4           25.00          27.50    2    AL1
```

Appendix D3

Error Analysis

AL4

The best Al quality

```
Material with Code_Number  1 Deposition Error =    0.0%

Material with Code_Number  2 Deposition Error =    0.0%
```

```
            Transmittance Average
50.000-
      I
      I
      I           ***
      I
37.500-
      I              *
      I          *
      I
      I               *
25.000-
      I
      I         *      *
      I
      I        *        *
12.500-
      I       *          *
      I      *            **
      I     *               ***
      I*****                   ***********
 0.000*ooooooooooooooooooooooooooooooooooo*****
    120.0     132.5     145.0     157.5     170.0

           oooo  Target Function          **** Calculated Function
```

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	0.8360
122.50	0.0000	2.0478
125.00	0.0000	2.4125
127.50	0.0000	5.0081
130.00	0.0000	10.8704
132.50	0.0000	19.2750
135.00	0.0000	43.4132
137.50	0.0000	43.5124
140.00	0.0000	27.1262
142.50	0.0000	13.8311
145.00	0.0000	7.6158
147.50	0.0000	5.4196
150.00	0.0000	4.0140
152.50	0.0000	3.1759
155.00	0.0000	2.4399
157.50	0.0000	2.0137
160.00	0.0000	1.6764
162.50	0.0000	1.4122
165.00	0.0000	1.2352
167.50	0.0000	1.0707
170.00	0.0000	0.9300

```
Film No   Thick. [nm]   Thick. [nm]
(Inc/M)    No Error     With Error  Cod No  Material
------------------------------------------------------------------------------------
   1           21.00         21.00     1    MGF2S-1
   2           25.00         25.00     2    AL
   3           21.00         21.00     1    MGF2S-1
   4           25.00         25.00     2    AL
```

Error Analysis

AL4

Material with Code_Number 1 Deposition Error =   0.0%

Material with Code_Number 2 Deposition Error = -10.0%

```
              Transmittance Average
60.000-
      I           *
      I            *
      I             *
      I
45.000-          *   *
      I
      I
      I               *
      I         *
30.000-                *
      I        *
      I
      I       *         *
      I                  *
15.000-      *
      I                   **
      I     *               **
      I   **                  *****
      ****                         ************
 0.000ooooooooooooooooooooooooooooooooooooooooo
     120.0     132.5     145.0     157.5     170.0

              oooo  Target Function           **** Calculated Function
```

Transmittance - average   Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	1.5604
122.50	0.0000	3.8764
125.00	0.0000	4.6031
127.50	0.0000	9.5195
130.00	0.0000	19.8416
132.50	0.0000	32.4807
135.00	0.0000	55.8174
137.50	0.0000	52.1141
140.00	0.0000	36.2268
142.50	0.0000	21.2486
145.00	0.0000	12.8020
147.50	0.0000	9.4722
150.00	0.0000	7.2172
152.50	0.0000	5.8253
155.00	0.0000	4.5649
157.50	0.0000	3.8211
160.00	0.0000	3.2214
162.50	0.0000	2.7390
165.00	0.0000	2.4125
167.50	0.0000	2.1088
170.00	0.0000	1.8465

```
Film No    Thick. [nm]    Thick. [nm]
(Inc/M)     No Error      With Error   Cod No   Material
--------------------------------------------------------------------------------------------------
   1           21.00          21.00       1     MGF2S-1
   2           25.00          22.50       2     AL
   3           21.00          21.00       1     MGF2S-1
   4           25.00          22.50       2     AL
```

Error Analysis

AL4

```
Material with Code_Number  1 Deposition Error =    0.0%

Material with Code_Number  2 Deposition Error =   10.0%
```

```
            Transmittance Average
40.000-
      I
      I
      I             *
      I            *
30.000-           *
      I
      I              *
      I
      I
20.000-          *    *
      I
      I
      I                *
      I
10.000-         *
      I        *        *
      I       *          *
      I      *            ***
      I *****                ********
 0.000**ooooooooooooooooooooooooooooo**********
     120.0     132.5     145.0     157.5     170.0

          oooo  Target Function          **** Calculated Function
```

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	0.4520
122.50	0.0000	1.0902
125.00	0.0000	1.2726
127.50	0.0000	2.6269
130.00	0.0000	5.7845
132.50	0.0000	10.7190
135.00	0.0000	30.7823
137.50	0.0000	34.7045
140.00	0.0000	19.2048
142.50	0.0000	8.5359
145.00	0.0000	4.3561
147.50	0.0000	3.0058
150.00	0.0000	2.1785
152.50	0.0000	1.6971
155.00	0.0000	1.2840
157.50	0.0000	1.0477
160.00	0.0000	0.8633
162.50	0.0000	0.7221
165.00	0.0000	0.6283
167.50	0.0000	0.5408
170.00	0.0000	0.4665

```
Film No    Thick. [nm]    Thick. [nm]
(Inc/M)     No Error      With Error   Cod No   Material
-------------------------------------------------------------------------------------------------
   1          21.00          21.00        1      MGF2S-1
   2          25.00          27.50        2      AL
   3          21.00          21.00        1      MGF2S-1
   4          25.00          27.50        2      AL
```

```
                Error Analysis

                     AL4



   Material with Code_Number  1 Deposition Error =   10.0%

   Material with Code_Number  2 Deposition Error =    0.0%



            Transmittance Average
50.000-
      I
      I
      I
      I                 *
37.500-                *
      I               *
      I
      I                  *
      I              *
25.000-
      I
      I             *     *
      I
      I            *       *
12.500-           *         *
      I                      *
      I          *            **
      I        **               ***
      I   *****                    ***********
 0.000****oooooooooooooooooooooooooooooooooooo*
     120.0     132.5     145.0     157.5     170.0

          oooo  Target Function          **** Calculated Function
```

Transmittance - average Incident angle = 0.00

Wavelength [nm]	Spectral F.-Target [%]	Spectral F.-Calculated [%]
120.00	0.0000	0.5959
122.50	0.0000	1.1535
125.00	0.0000	1.2738
127.50	0.0000	2.1579
130.00	0.0000	3.6884
132.50	0.0000	5.4298
135.00	0.0000	11.5122
137.50	0.0000	20.0968
140.00	0.0000	35.7216
142.50	0.0000	40.0382
145.00	0.0000	20.1873
147.50	0.0000	12.1295
150.00	0.0000	7.6971
152.50	0.0000	5.5125
155.00	0.0000	3.8311
157.50	0.0000	2.9894
160.00	0.0000	2.3727
162.50	0.0000	1.9074
165.00	0.0000	1.6164
167.50	0.0000	1.3662
170.00	0.0000	1.1612

Film No (Inc/M)	Thick. [nm] No Error	Thick. [nm] With Error	Cod No	Material
1	21.00	23.10	1	MGF2S-1
2	25.00	25.00	2	AL
3	21.00	23.10	1	MGF2S-1
4	25.00	25.00	2	AL

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