Final Report
Task Order H-30186D to BOA NAS8-97092

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1. DOCUMENTS

Included in Appendix I to this report is a complete set of design and assembly schematics for the high vacuum inner trap assembly, cryostat interfaces and electronic components for the MSFC HiPAT. Certain components were acquired from external vendors; otherwise, all fabrication and assembly of the assembly was done in the Department of Physics Machine and Electronics Shops. Testing of the assembly was carried out by Senior Scientist Raymond A. Lewis, NASA GSRP graduate student Kirby Meyer, and Engineer John Passaneau. Results of those tests are described in the next sections.

2. SUMMARY OF TESTS DONE UPON COMPLETION OF ASSEMBLY

(a) Vacuum Tests

(a.1) Vacuum chamber construction

Figure 1 shows the structure of the vacuum assembly, which encloses the HiPAT trap electrodes. The central vacuum pipe is connected by bellows to custom conflat flanges, which are sealed with annealed copper gaskets. The bellows are required to reduce heat flow from the room temperature outside to the 4.5 K region surrounding the central pipe.

The conflat flanges on the bellows mate with hybrid 8 inch flanges, which connect to nipples for external electrical and vacuum connections. The eight inch flanges will eventually be bolted to the HiPAT cryostat, with rubber O-ring vacuum seals. For tests of the inner vacuum, the cryostat was replaced by a set of six 1/4-20 threaded rods for mechanical rigidity.

(a.2) Vacuum assembly test results

The vacuum system was assembled, and transported to SpectruMedix Corp. of State College, PA for testing. The tests were carried out with the help of Mr. Bob Burfield, using a Veeco helium leak detector.

Initially, the vacuum was not good enough to make credible measurements. At the advice of Mr. Burfield, the flanges were disassembled in the field, and the 10-32 bolts in the hydrid flanges were shortened by 0.25 inches. Upon reassembly, it was found that the bellows which mate with the hybrid 8 inch flanges were vacuum-tight (at a rate <1.E-8 atm-cc/sec leak rate).

However, the 2.75 and 5.4 inch hydrid gaskets still leaked at a rate of 1.E-7 atm-cc/sec, even after their bolts had been shortened. The system was transported back to Penn State University for further investigations.
Before disassembling, the assembly was arranged with its axis vertical, and filled with Alconox and warm water overnight. Further cleaning, advised by Mr. Burfield, included a second fill of Alconox and warm water, followed by clear water and distilled water rinses. The vacuum system was turned horizontally, and cleaned with ethanol. A residue of iron filings was found when the flanges were unbolted.

The source of the leaking hybrid flanges was traced to an error in placement of knife edges. According to Mr. R. McKuhn of Lesker's, the knife edge should be near the inside edge of the copper gasket, for a seal with bolts inside the gasket. The knife edges on both the 2.75 and 4.5 inch parts of the hybrid flanges were found to be placed near the outside edge of the copper gaskets.

The knife edges on the hybrid flanges were machined off, and replaced with knife edges of the proper diameters. The vacuum system was reassembled, and returned to SpectruMedix Corp. for testing. The 4.5 inch hybrid seal was found to be leak-tight, at a rate < 1.E-9 atm-cc/sec. A piece of masking tape inadvertently left on the 2.75 inch hybrid seal explained a leak rate of 1.E-7 atm-cc/sec leak. The downstream part of the vacuum system was disassembled in the field, and the tape was removed. After reassembly, the leak rate in the 2.75 inch hybrid seal was reduced to 3.E-8 atm-cc/sec.

(a.3) Summary of vacuum tests

The sealing of the vacuum system is sufficient for its intended use in HiPAT, where it is enclosed by the cryostat outer vacuum system. The vacuum will permit use of the UHV portion of the system stand-alone. This permits more flexibility in baking, which is easier to perform before inserting the trap into the cryostat.

(b) Electronics Tests

(b.1) Arrangement for high voltage tests

The macor rings, 0-8 threaded rods, and the six cylindrical electrodes were cleaned and assembled. A piece of 30 gauge enamel-coated copper wire was affixed to one of the electrodes with a 0-80 gauge bolt. The wire was threaded through holes in the macor rings. The two 8 inch flanges on the ends of the HiPAT vacuum pipe were removed, and the electrode assembly inserted.

One of the 2.75 inch conflat flanges was used to mount a 40 KV high voltage feedthrough. The 30 gauge wire was attached to the feedthrough. Continuity was checked using an ohmmeter, with a probe to reach the electrodes inside the vacuum pipe.
(b.2) High voltage test results

The first tests were performed in air, with the 8 inch flanges removed to allow for visual observations. The Power Designs power supply was connected to an ammeter and a high voltage 1 Mohm current-limiting resistor. Except for the final connection to the 1/4-20 bolt on the 40 KV feedthrough, SHV connections were used throughout. No corona discharge was observed, and no current (<0.01 mA) was observed when the supply was raised to 2 KV.

Tests at higher voltage were made, using nitrogen gas to allow for higher breakdown conditions. The 8 inch flanges were replaced (using the old gaskets), and another 2.75 inch flange was connected to a nitrogen feed tube. Nitrogen was flowed through the system from the downstream end, keeping the upstream 8 inch flange loose enough to allow the nitrogen to flow. The system was tested as described above, running the supply to its limit of 3 KV. No leakage current (<0.01 mA) was observed.

To test the system at higher voltage, a Heathkit power supply was used. The power supply was connected directly to the HV feedthrough, as the meter isolation and SHV cables are limited to 3 KV. No evidence of arcing was detected when the power supply was turned up to 5 KV. No physical evidence for arcing was noted when the electrodes were dismounted after the tests.

(b.3) Results of tests with preamp connected to the electrodes

Two of the electrodes inside the vacuum tube were connected to a new GaAs preamp. The preamp was mounted in the downstream section of the vacuum tube, and connected to the outside through a 10 pin, 2 KV high voltage feedthrough. The 40KV feedthrough was disconnected during the preamp tests.

Figure 2 shows a trace of the frequency spectrum obtained when the preamp was turned on. The Johnson noise peak appears at 38 MHz (upper trace), implying that the inter-electrode capacitance is about 10 pf. To verify the authenticity of the Johnson noise peak, the preamp was operated outside the vacuum tube, allowing a brass rod to be inserted into the nominal 4 microhenry inductance coil. The middle trace shows that the Johnson noise peak shifts upward significantly in frequency, as expected for a diamagnetic brass rod. The lower trace shows that no significant structure appears at 38 MHz with the preamp turned off.

(b.4) Summary of high voltage and preamp tests

Application of up to 5 KV on the electrodes indicated no evidence of discharge or current leakage. Preamp response to Johnson noise signals is large and responsive to circuit changes as expected. All systems appear to be operating as designed.
HiPAT Vacuum System

Figure 1
Figure 2

Amplitude, dBm

-90

-100

-110

-120

-130

28M 32M 36M 40M 44M 48M

Frequency

open coil

brass rod

preamp off
304 s.s. pipe, 3.5" OD
0.120" thickness
1 REQUIRED
MAT. COPPER
8 REQUIRED

(3) DRILL & TAP 6-32 THRU.

PHYSICS ELECTRONICS SHOP
COPPER RING

001-02

SHEET 1 OF 1
1 REQUIRED

- (8) \( \phi 0.116'' \) THRU ALL
- (8) \( \phi 4.25'' \pm 0.0015'' \)
- \( \phi 3.75'' \pm 0.0015'' \)
- \( \phi 5.125'' \pm 0.0015'' \)
- \( \phi 4.75'' \pm 0.0015'' \)
- \( 22.5'' \)
- \( 45'' \)

- (2) TAP 6-32 THRU ALL

- \( \phi 3.53'' - 0.002'' \)
LEGEND OF PARTS (QUANTITY)

1. MDC 8" O.D. Nonrotatable Bored Flanges (2) One w/ 8" Conflat Knife Edge & One w/out (Please see attached print for flange details)

2. 6" O.D. Stainless Steel Tubing (1)

MAT'L: STAINLESS STEEL #304

OVC REAR SPOOL

BRIAN SARSFIELD

DATE: 3/3/99

QUANTITY: 1

UNITS: INCHES
PRINT SHOWS FLANGE & REAR ROT. BLANK ASSEM. SEE REAR MOD. ROT. BLANK PRINT FOR DETAILS. FLANGE ONLY HAS MODIFIED BORE. (SEE NOTE)

FLANGE IS TO BE CUSTOMIZED WITH BORE Ø6.0, FOR ABILITY TO RECEIVE HALF NIPPLE TUBE O.D.

SECTION A-A

6.0000 +0.0015

6.0000 -0.0015
FLANGES HAVE 20 HOLES EACH.

FRONT AND REAR FLANGES TO BE WELDED TO TUBING ALL AROUND FOR SEAL.

CLEAN SHIELDING OFF BEAD.

DETAIL
Scale 1.000

SECTION A-A

A

180°

90°

60°

2.7300

7.1280

6.1250

87.50

See Detail B

DATE:
3/3/99

UNIT:
INCHES

MATERIAL:
STAINLESS STEEL

#304

REAR FEEDTHROUGH SPOOL

BRIAN SARGISFIELD

QUANTITY:
1

m I _ I m I _
1 REQUIRED

PHYSICS ELECTRONIC SHOP
THIRD AFT MACOR RING

MACOR ROD 3/00

2.36±0.003"

ø2.36±0.003"

ø1.6250"

ø1.8650"

(3) 0.0625" THRU ALL

(9) 0.125" THRU ALL

30°

15°

ø2.1225"
MATERIAL
COPPER, TYPE 101

<table>
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<th>PART NO.</th>
<th>A</th>
<th>QUANTITY</th>
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<tr>
<td>05-009</td>
<td>3.116&quot;</td>
<td>2</td>
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<tr>
<td>05-010</td>
<td>2.683&quot;</td>
<td>2</td>
</tr>
<tr>
<td>05-011</td>
<td>1.933&quot;</td>
<td>2</td>
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*NOTE: DO NOT DECREASE I.D.*

PHYSICS ELECTRONICS SHOP

ELECTRODES

DRAWN KIRBY MEYER 5/20/99
CHECKED
MFG.
ENG.

CONTRACT NO.

APPROVALS

DATE

SIZE CODE IDENT NO. DRAWING NO. REV.

A 05-009

SCALE NONE PENN STATE UNIVERSITY SHEET OF
8 PIECES REQUIRED

CLEAN I.D.

R.I. 2.45 +0.003

R.I. 184.4

.0625"
Work has been completed on the design and fabrication of the high vacuum trap assembly. After vacuum tests and electronics tests the trap was shipped to Marshall Space Flight Center.