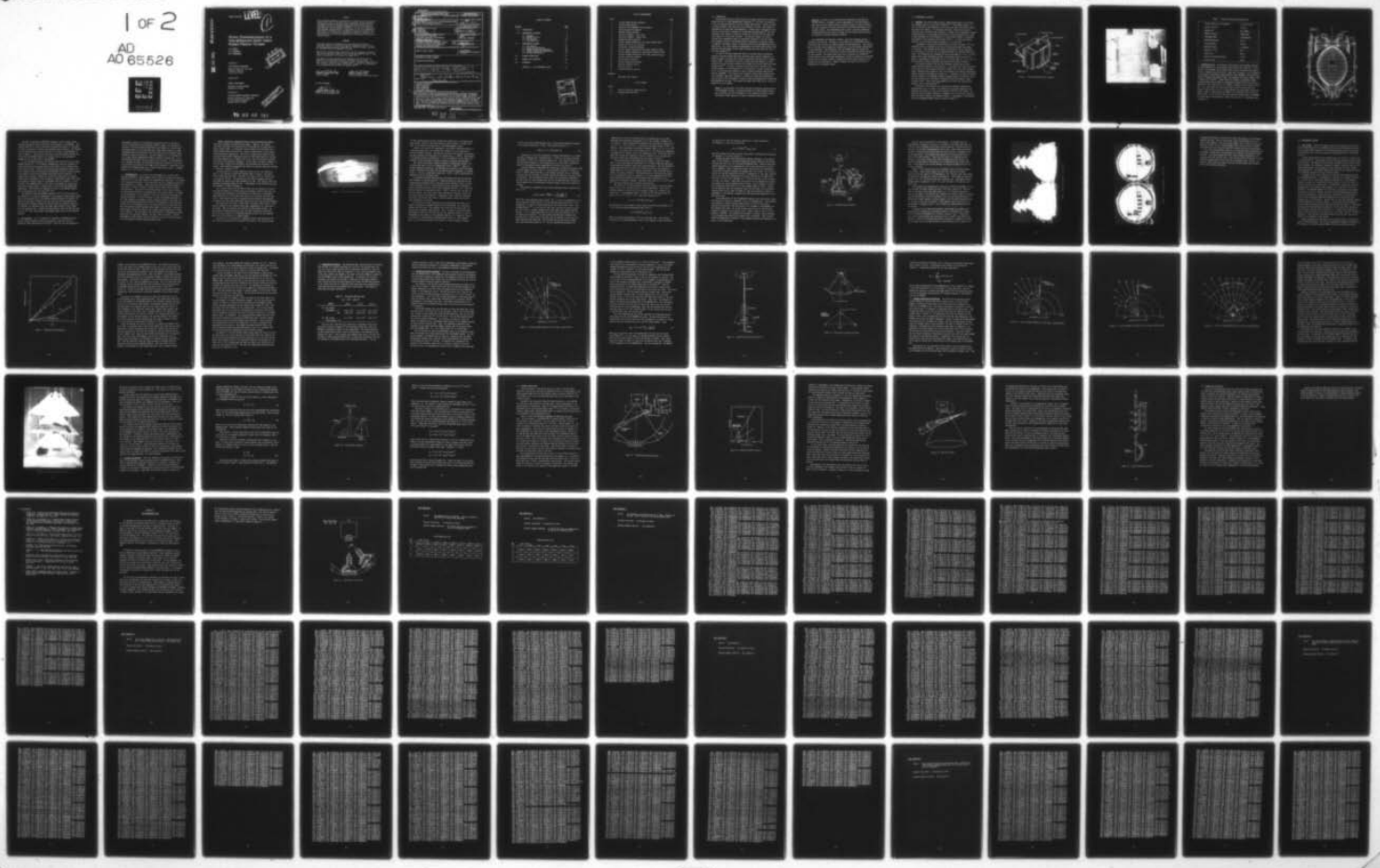
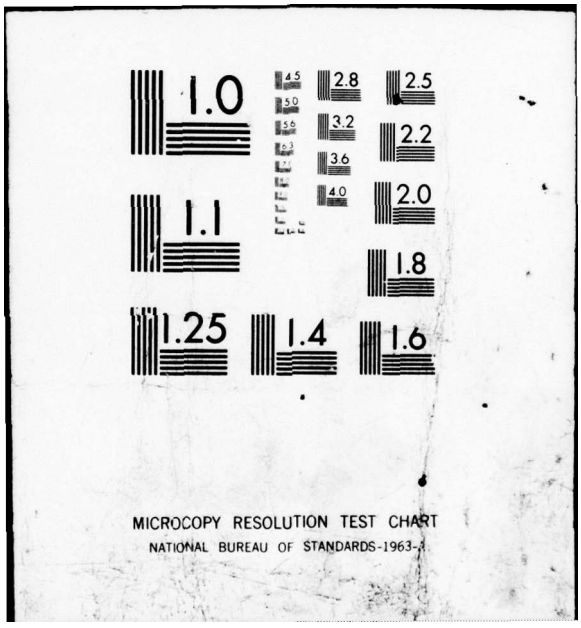
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LEVEL II

Plume Characterization of a One-Millipound Solid Teflon Pulsed Plasma Thruster

L.C. Pless
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Prepared by

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(JPL PUBLICATION 78-96)

October 1978

Phase I Final Report

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Prepared for:

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FOREWORD

This final report was prepared by the Jet Propulsion Laboratory, California Institute of Technology and was sponsored by the Air Force Rocket Propulsion Laboratory under MIPR No. F04611-77-X-0026, Job Order No. 305812QR through an agreement with NASA.

Work on this contract began in March 1977 and was completed in February 1978 and the pertinent studies of this period are reported herein. This report was submitted by the authors in August 1978.

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An evaluation was made of the pulsed plasma thruster plume-wall backscatter characteristics of the MOLSINK facility. On the thruster axis, the MOLSINK backscatter was found to be 1.23×10^{-2} $\mu g\text{-}cm^{-2}\text{-}pulse^{-1}$. This backscatter drops off to zero as the angle between the axis and wall location reaches 40°. This wall backscatter was found to be essentially symmetric about the plume axis. The total integrated backscatter from the MOLSINK wall is approximately equal to 5% of the total mass injected from the pulsed plasma thruster during the discharge pulse.

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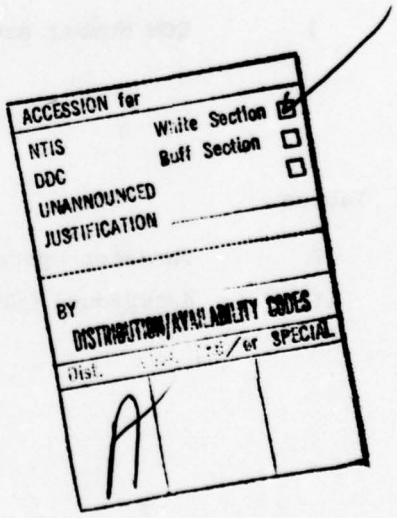
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1.0 INTRODUCTION

Pulsed plasma thrusters (PPT) using solid teflon propellant are inherently simple and have a flight-demonstrated reliability,[1] and thus, are expected to be of increasing interest for future flight applications. Earlier versions of these thrusters, with only tens of micropounds of thrust, were limited to drag make-up and east-west stationkeeping. A higher power, millipound thrust, version of this device, suitable for north-south stationkeeping,[2] has been developed, with roughly 20 times the propellant flow rate and 100 times the total impulse of the earlier versions. The exhaust plume of the smaller thruster has a negligible effect on spacecraft surfaces,[3] but the larger, more energetic plume of the scaled-up PPT is potentially of greater concern. In addition, the plume's effect on sensitive spacecraft instrumentation may be significant. For these reasons, investigations of the PPT plume structure and backflow characteristics of this larger thruster have been under way since it was first assembled.[4]

In order to directly assess the effect of the PPT plume on spacecraft surfaces, previous studies have been conducted using various diagnostics to directly measure the plume flux towards a spacecraft upstream of the thruster exhaust plane. Unfortunately, accurate results have been masked by a back-scattered flux of particles reflected and eroded from the test facility vacuum chamber walls.[4] In order to minimize this effect and to develop a more accurate measure of the plume-spacecraft interaction, a study is being carried out at the Jet Propulsion Laboratory using a special Molecular Sink Vacuum Facility (MOLSINK). This facility has a gaseous helium cooled anechoic-type liner (MOLTRAP) especially designed to minimize any plume-wall backscatter, thus providing a PPT environment in which accurate plume-spacecraft interaction measurements may be made. The current PPT plume study under way at JPL may be separated into two phases:

Phase I: An evaluation of the PPT plume-wall backscatter characteristics of the MOLSINK facility, a conceptual design for a PPT backflow measurement technique, and the development of a low temperature quartz crystal microbalance (QCM) design to be used in measuring this backflow.

Phase II: A study of the plume-spacecraft interaction utilizing the MOLSINK facility, including a direct measurement of the plume backflow mass flux into the thruster plane at various distances from the thruster axis and a measure of the PPT plume mass flux profile downstream of the thruster nozzle. This information will be used to develop preliminary scaling laws which will serve to define the net backflow mass flux onto an arbitrarily located spacecraft surface.

The experiments and analyses of Phase I have been completed and are detailed in this report. Included is a description of the MOLSINK facility as modified for use with the plasma thruster and QCM diagnostics. The development of the QCM circuit design and calibration at liquid nitrogen temperatures is also discussed. The backscatter from the MOLTRAP anechoic surface was measured in total and at two specific locations using QCM test arrays designed for this purpose. The results have been used to evaluate the backscatter characteristics of the PPT plume impacting on typical locations in the MOLSINK facility and to develop a method of measuring the PPT plume backflow in the presence of this backscatter. Phase II efforts are under way and will be documented in a subsequent report.

2.0 EXPERIMENTAL APPARATUS

2.1 THRUSTER The pulsed plasma thruster under investigation in this study was designed and built at Fairchild Republic[1,4] under AFRPL contract for use in north-south stationkeeping of satellites and other applications requiring large total impulse. The operating principle, identical to previous thrusters flown on several space missions, is based on the sublimation, partial depolymerization, and subsequent acceleration of teflon propellant by a high current discharge in close proximity to a solid teflon surface. A detailed description of this thruster can be found in Ref. 1. A brief description, pertinent to the thruster plume development, is included here.

A schematic of the pulsed plasma thruster is shown in Figure 1.[5] The discharge cavity is bounded on the top and bottom by parallel electrodes, 7.6 cm apart. The discharge cavity sides are bounded by teflon propellant fuel bars kept 0.76 cm apart by a retaining shoulder cut into the anode electrode. The propellant bar thickness set the cavity depth at 3.3 cm. The discharge cavity faces downstream through a rectangular nozzle (not shown in Figure 1) extending at a half-angle of 15° to a final size of $\sim$ 11.5 x 16.5 cm. Some pertinent thruster operating characteristics are shown in Table I.

The thruster assembly used for the described testing differs from a flight-qualified thruster in two respects: 1) the more costly helical coiled teflon fuel rods were replaced with short straight fuel rods, and 2) commercially available mylar capacitors were used instead of the special high-energy density capacitors developed for flight use. In addition, in order to relieve the heat loading on the MOLSINK cryogenic pumping system, the thruster pulse rate was dropped from 6 sec/pulse to between 20 and 40 sec/pulse, unless otherwise noted. These repetition changes do not effect the thruster discharge or plume characteristics.[4]

The thruster was enclosed in an electrically isolated aluminum box, approximately 0.4 m on a side. To prevent the oil-filled capacitors from freezing, the interior of this box was heated to 20-26°C at all times. To check for proper thruster operation, a Rogowski coil on one of the capacitor leads was used to monitor the thruster current. A photograph of the thruster with its rectangular Mykroy nozzle is shown in Figure 2.

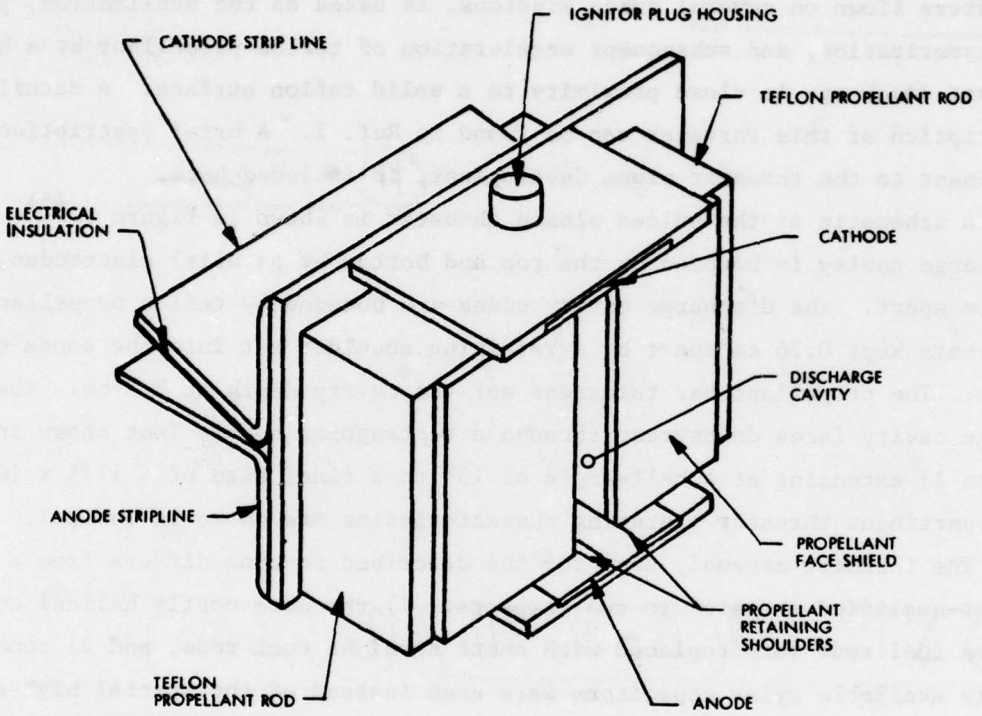


Figure 1. Pulsed Plasma Thruster Schematic

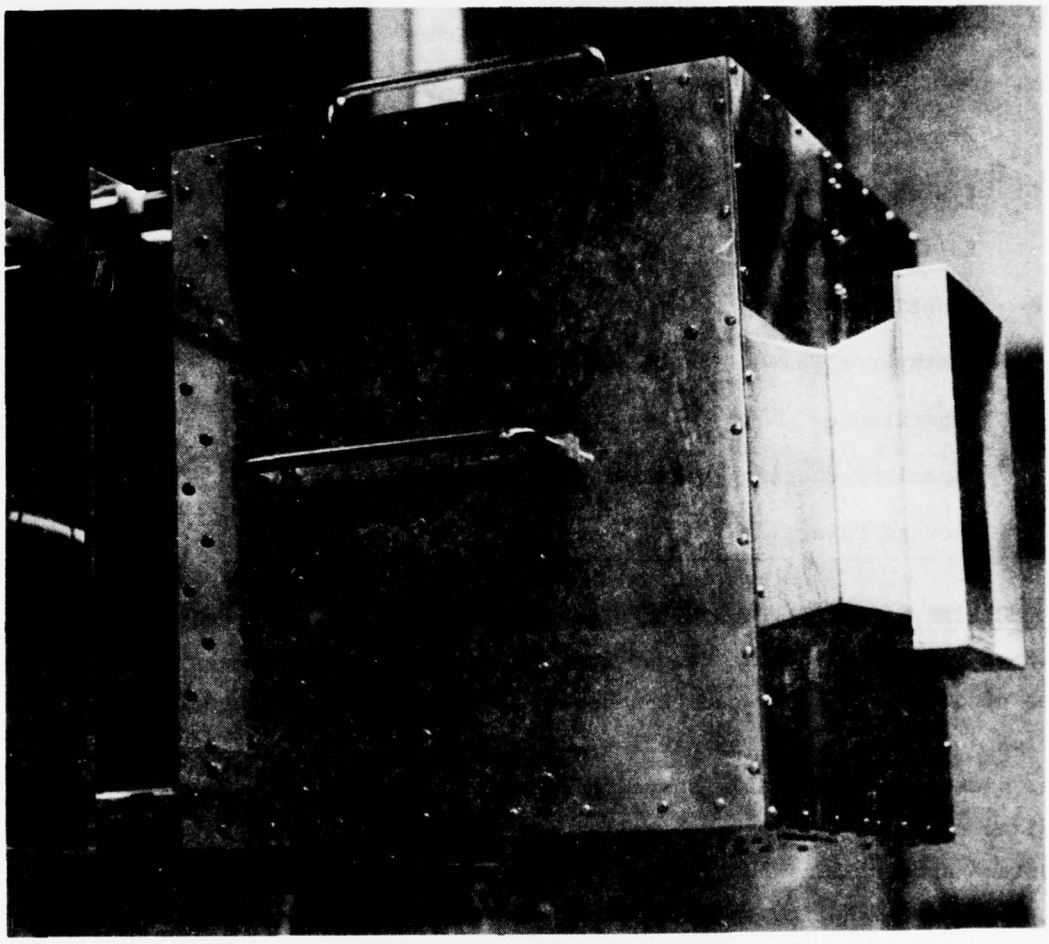


Figure 2. Pulsed Plasma Thruster

TABLE I. Thruster Operating Characteristics

Average Thrust (at 6 sec/pulse)	4.44 mN (1 mlb)
Specific Impulse	1750 sec
Impulse bit	26.5 mN-sec
Exhaust Velocity	17000 m/sec
Propellant Mass	1.56 mg/pulse
System Efficiency	26.1%
Pulse Duration	45 μsec
Repetition Rate	6 sec/pulse
Energy per Pulse	691 J
Capacitance	240 μf
Capacitor Charging Voltage	2.4 kV
Average Power	145 W

2.2 MOLSINK FACILITY The Molecular Sink Facility was designed to provide an ideal simulation of the vacuum and cold sink of outer space.[6] It consists of an ultra-high vacuum chamber with a liquid nitrogen cooled liner to provide a thermal isolation barrier. This liner encloses a 2.75 m (effective outer diameter) spherically shaped Molecular Trap (MOLTRAP), which has black anodized aluminum wedge-shaped walls, and resembles an anechoic chamber with a surface area of 186 m^2. These walls are cooled by a manifold of tubes carrying gaseous Helium (gHe) at a temperature between 10 and 15K and thus, represent a very large surface for cryogenic pumping of gases produced by the PPT. This large anechoic collecting surface is particularly useful for thruster plume studies, due to its high pumping rate and minimal backscatter. Figure 3 shows a cross-sectional schematic of the MOLSINK facility with the PPT in place. As can be seen, the actual enclosed volume within the MOLTRAP is shaped like an ellipsoid with a major axis of about 2.5 m and minor axis of about 2 m.

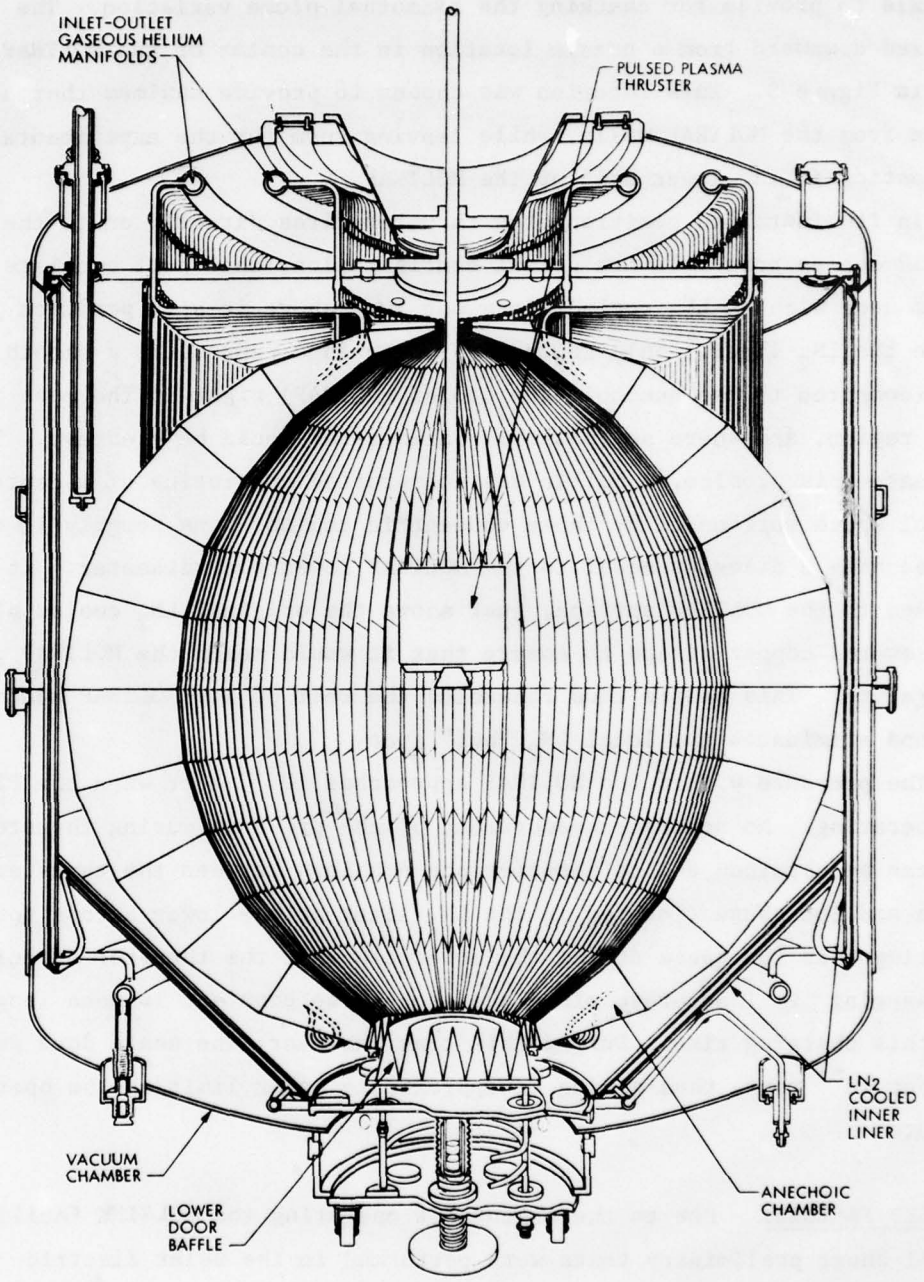


Figure 3. Molecular Sink (MOLSINK) Vacuum Chamber

The PPT is installed in MOLSINK by hanging it from a support shaft reaching through the upper access port and an opening in the MOLTRAP. This support shaft may be rotated externally allowing the thruster to turn about its axis to provide for checking the azimuthal plume variation. The thruster is fired downward from a nozzle location in the center of the MOLTRAP, as seen in Figure 3. This location was chosen to provide maximum thermal isolation from the MOLTRAP walls, while leaving room for the experimental diagnostics in the lower half of the MOLTRAP.

In its installed position, the thruster fires directly on to the lower MOLTRAP access port. In its normal configuration, this port consists of a vacuum door with an LN_2 cooled plate set just above it at a position just inside the LN_2 liner. This LN_2 cooled plate thus represents a smooth "hot" spot (compared to the anechoic gHe cooled MOLTRAP) right in the most intense plume region, and where any possible backscatter would be greatest. To eliminate this problem, a baffle was constructed consisting of a central conical spire surrounded by three concentric conical fins roughly 15 cm deep and reaching a diameter equal to the MOLTRAP lower port diameter. It was attached to the MOLTRAP surface, just above the original LN_2 cooled plate, with several copper straps to ensure that it would reach the MOLTRAP gHe temperature. This baffle thus resembles the rest of the MOLTRAP anechoic wall and eliminates the local LN_2 "hot" spot.

The pressure within the MOLTRAP approaches 10^{-12} torr when the PPT is not operating. No accurate measurement of the pressure during thruster operation can be obtained due to interference problems between the thruster discharge and ion gauge (located in the LN_2 liner at the lower access port). Operating this ion gauge during the off-cycle when the thruster capacitors are charging is inaccurate since the gauge time constant is much longer than this charging time. During this time, however, the scale does get down to about 10^{-9} torr, thus giving an approximate upper limit on the operating pressure.

2.3 SEP FACILITY Due to the expense of operating the MOLSINK facility, several short preliminary tests were performed in the Solar Electric Propulsion (SEP) high-vacuum test facility. This facility was designed for

performance testing of ion bombardment thrusters as part of the Solar Electric Propulsion System Technology (SEPST) program. The SEP facility consists of two interconnected high-vacuum test chambers, a console type monitoring station, low voltage and high voltage power supplies, an IDAC (integrated data acquisition and control) system and the necessary support systems to operate the facility. The main chamber is a 2.3 m diameter by 4.6 m long, partial hemispherical-ended, cylindrical vacuum tank. It is horizontally positioned for easy removal of the one end. All instrumentation, cabling, and power pass through bulkhead-type connectors to the test article which is attached to the chamber end by adapters. Evacuation is provided by oil diffusion pumps and a liquid-nitrogen-cooled liner. A chamber pressure of 1×10^{-6} torr is possible.

2.4 INSTRUMENTATION As a part of the development of a series of PPT diagnostic methods, a double Langmuir probe, similar to a model developed at Fairchild [4] for the same purpose, was designed and constructed. It consists of two tungsten electrodes, 1.0 cm long and 0.152 cm in diameter, parallel to each other and 0.5 cm apart. These electrodes were biased with respect to each other at various voltages to measure the PPT plume current-voltage characteristics. The shape of this characteristic can be used to estimate the plume plasma densities and temperatures at the probe location. Included in this design was a 1.9 cm diameter 6 turn coil electrode surrounding the sensing electrodes. This coil was used to clean the sensing electrodes of PPT plume deposits by setting up a glow discharge between it and these electrodes and bombarding them with electrons. The operation of this probe was checked out in a preliminary test in the SEP facility with a LES-9 type PPT. The time-resolved current wave shape was similar to that found at Fairchild under similar conditions, however, the average current magnitude was significantly smaller. This discrepancy can be attributed to differences in probe construction or operation, however, the exact cause is unknown. Further development of this Langmuir probe was postponed, until its use was required in the millipound PPT plume characterization study.

Doublet temperature compensated Quartz Crystal Microbalances (QCM's) were used to measure the mass from the plume. Briefly, two crystal controlled oscillators are formed with two electrodes on the same side of a natural quartz blank. An electronic circuit extracts the difference frequency between these two oscillators, which is proportional to the relative electrode mass and temperature. The use of a common quartz blank for both oscillators and careful temperature control of this blank keeps the relative electrode temperature at a minimal value, thus, only the relative electrode mass effects the difference frequency. In use, mass is allowed to deposit on one electrode, slowing its oscillation, and increasing the difference frequency. This frequency is measured and related to the mass deposition through a calibration constant.[7,8,9]

Because there was no known commercial source for the low temperature QCM's, it was decided to build the necessary QCM's in house. Two quartz crystal types have been used: one with a cut angle of 39° 49' and one with a cut angle of 40° 28'. The crystals all have 0.95 cm diameter platinum electrodes and operate at a basic frequency of 5 MHz. The crystal cover used provided an acceptance angle of 114°. A photograph of this QCM with the cover plate removed is shown in Figure 4.

Due to some concern that the QCM circuitry was too sensitive to survive the noisy environment of a teflon thruster discharge, several tests were run to determine the reliability of QCM operation in this type of environment. These tests were run in the SEP vacuum facility and utilized the LES-9 type of PPT. This thruster was used to generate typical thruster environmental conditions until the larger millipound thruster arrived from Fairchild-Republic.

The first unit built used a field effect transistor (FET) circuit. This QCM was installed on the thruster plume edge, approximately 0.5 meter from the nozzle. When the thruster was started, the QCM stopped working. An investigation revealed that one of the oscillator transistors had failed. The circuit was repaired, the shielding reworked and the test was repeated. Again, the circuit failed in a similar manner.

The next unit to be tried was a commercial hybrid oscillator-mixer circuit, which also failed when the thruster was started. The probable causes

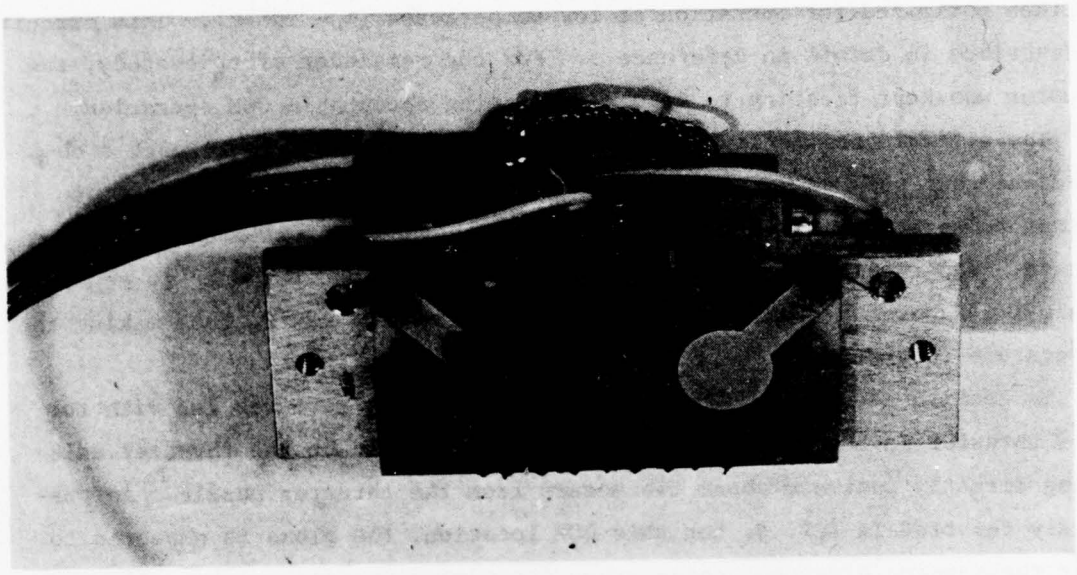


Figure 4. Quartz Crystal Microbalance

of these failures were traced to ground level shifts due to the high current pulse levels, pickup in the interconnecting coaxial leads, or induced voltages in the crystal electrodes due to the plasma magnetic field.

Finally, the circuit was redesigned to use bipolar transistors while, to eliminate ground shifts, the thruster was floated as in its operation at Fairchild Republic Company. The QCM was tested with the thruster successfully and then optimized for operation at low temperature ($\sim$ - 200°C). This circuit is described in detail in Reference 5. For the remainder of this study, the thruster was kept floating to insure continuing acceptable QCM operation.

The crystal oscillation frequency depends on temperature through a coefficient that goes to zero for temperatures round - 200°C.[7] Thus, for optimum temperature stability, the QCM should be operated at about this temperature. Experience has shown that the QCM oscillation frequency is constant within ± 1 Hz over a temperature range from - 220 to - 180°C, thus making the temperature control relatively easy.

To confirm acceptable QCM operation, one further test was run with the LES-9 thruster in the SEP facility. A QCM was mounted on the thruster axis facing directly upstream about two meters from the thruster nozzle. As previously reported in Ref. 4, for this QCM location, the plume is expected to erode the sensing electrode rather than depositing material on it. After the QCM had temperature stabilized at about - 180°C, a shutter over the QCM crystal was opened. The output signal then confirmed the expected erosion and verified the proper QCM operation. Immediately after a definite indication of erosion, the shutter was closed to prevent further erosion and a subsequent degradation of the QCM.

To relate the net mass deposition on the QCM sensing electrode to the change in difference frequency between the two electrodes, the calibration constant must be known. This constant can be derived from theoretical considerations or measured experimentally. Ref. 7 derives an equation between the deposition mass per unit area, ΔM, and the frequency change, Δf, that is independent of the density of the deposited material, $\Delta M = K\rho_g N\Delta f/F_c^2$ where K is a measure of the deposition uniformity and is equal to 1 for a smooth layer, ρ_g is the quartz density (2.65 g/cm^3), N is the frequency constant

of an AT cut crystal (1670 kHz mm) and F_c is the nominal operating frequency of the crystal oscillators (5 MHz). This equation reduces to:

$$\Delta M/\Delta f = 1.77 \times 10^{-8} \text{ g/cm}^2 \text{-Hz} \qquad (1)$$

Initially, to check this calibration constant experimentally, an attempt was made to deposit argon (freezing point = - 189°C) on the liquid nitrogen cooled QCM (∿ -200°C) at a controlled known rate. This attempt failed since the argon vapor pressure at this temperature is so large that a significant amount of the deposited mass revaporized and obscured the results.

A second attempt at experimentally calibrating the QCM was performed using a method similar to that of Ref. 8. This procedure consists of cooling the QCM to - 200°C, depositing water on the sensing electrode until a reasonable layer is built up, and then, in vacuum, heating the QCM until the water begins to evaporate. This evaporation rate is known via an analytical expression derived in Ref. 8, thus the mass loss rate off the QCM electrode is known and can be compared with the difference frequency change to give the calibration constant.

The analytical expression for the water evaporation rate, corrected from Ref. 8, is:

$$\ln \dot{\Delta M} = 30.888 - \frac{6091.4}{T} + \ln \left[\frac{1}{C} \sqrt{\frac{M}{2\pi RT}} \right] \qquad (2)$$

where $\dot{\Delta M}$ is the evaporation rate in g/cm^2 -sec, T is the ice temperature, M is the ice molecular weight (18 g), R is the universal gas constant (8.3 x 10^7 erg/gm-mole - K) and C is the Clausing factor for the QCM cover plate. This Clausing factor [10] is the ratio of water vapor escaping through and around the cover plate to vacuum, divided by the total vapor flux leaving the QCM surface. It is a complicated function of the cover plate geometry, and is not known very accurately. For this reason, the QCM being calibrated was equipped with a spring-loaded cover that could be removed, in situ, once the water deposition was completed. This insured that the effective Clausing factor was identically equal to 1.0. For the calibration procedure, the

temperature for the ice on the QCM crystal is assumed equal to the QCM mounting block temperature maintained at 153 ± 5K, through a feedback control system. Thus, the theoretical QCM mass flow rate given by equation (2) is $1.99 \pm 1.5 \times 10^{-9}$ g/cm^2 -sec. The measured frequency change is 102 ± 13 Hz/hour, so the experimental calibration constant ($\Delta M/\Delta f$) is $7.0 \pm 6.5 \times 10^{-8}$ g/cm^2 Hz. The large error bar is primarily due to the exponential dependence on temperature of equation (2) for the evaporation rate. This final value of $\Delta M/\Delta f$ does include the theoretical value of equation (1) in the error bar and thus provides some confirmation that this value is correct.

While researching the QCM calibration procedure, a paper was found (Ref. 9) which describes the calibration of a virtually identical QCM using vacuum sputtered aluminum rather than evaporating water. The only difference in QCM construction was in the use of conductive epoxy at JPL instead of indium solder for the crystal mounting connections. This difference has no effect on the QCM calibration. The measured data in this paper were within 2% of the theoretical value of equation (1) and when combined with the previous calibration procedure provide satisfactory confirmation of the theoretical calibration constant. Therefore, this value of 1.77×10^{-8} g/cm^{-2} Hz^{-1} was used throughout the following investigations.

The ability of the QCM to measure small mass fluxes is directly proportional to the total operating time for a given measurement. The rate of frequency change is given by the net frequency change, Δf, divided by the total time, T. The measured flux, S, is equal to the QCM calibration constant, (1.77×10^{-8} g/cm^{-2} - Hz^{-1}) times this frequency rate:

$$S = 1.77 \times 10^{-8} \frac{\Delta f}{T} \text{ g/cm}^{-2}\text{-sec}^{-1} \qquad (3)$$

The resolution of the frequency counter limits the smallest measurable Δf to ± 1 Hz, thus the smallest measureable mass flux is:

$$S = \frac{1.77 \times 10^{-8}}{T} \text{ g/cm}^{-2}\text{-sec}^{-1} \qquad (4)$$

which is inversely proportional to the net operating time. The effective resolution of the QCM measurement is due to the frequency counter resolution

of equation (4), and the frequency changes due to random temperature fluctuations (± 1 Hz), and is given by:

$$\pm \Delta S = \frac{3.54 \times 10^{-8}}{T} \text{ g/cm}^{-2}\text{-sec}^{-1} \qquad (5)$$

The error induced from other sources, such as time or calibration inaccuracies, is negligible for normal values of T.

Having developed a QCM design which operates acceptably at low temperatures in the presence of the PPT discharge and having calibrated this design, 20 units were built for the following PPT-MOLSINK tests. These 20 units were tested individually at LN_2 temperatures, and 17 were selected for installation in MOLSINK. These 17 QCM's were found, when tested at LN_2 temperature, to have base difference frequencies ranging from ∿2 to 20 kHz. As a check to insure that the QCM calibration constant is independent of this base frequency and of the other small differences in the QCM construction, two QCM's were selected, one with a base frequency of 1.75 kHz and one with a base frequency of 19 kHz, and tested. These QCM's were placed as close together as possible and exposed to a vacuum evaporated water source. The two changes in difference frequencies were within 1 Hz of the average change of 106 Hz. Because the net deposited mass was essentially equal for both QCM's, the calibration constants must also be equal to within 1%, thus the calibration constant is independent of the QCM base frequency and other associated differences in the QCM construction.

Local measurements of the PPT-MOLSINK backscatter were made using several QCM's mounted in molecular "skimmers" tied to the MOLTRAP wall. These skimmers were designed to isolate (skim) a small portion of the PPT plume and to examine the backscatter from this portion as it impinges on the MOLTRAP wall. Two skimmers were used: one on the thruster axis and one at the PPT plume boundary 40 degrees off the thruster axis. Figure 5 shows a view of the two skimmers in MOLSINK. The skimmers were designed to provide a well-collimated 2.54 cm diameter beam which would interact with the MOLTRAP. QCM's mounted inside the hemispherical portions of the skimmers measured the backscatter as a result of this interaction.

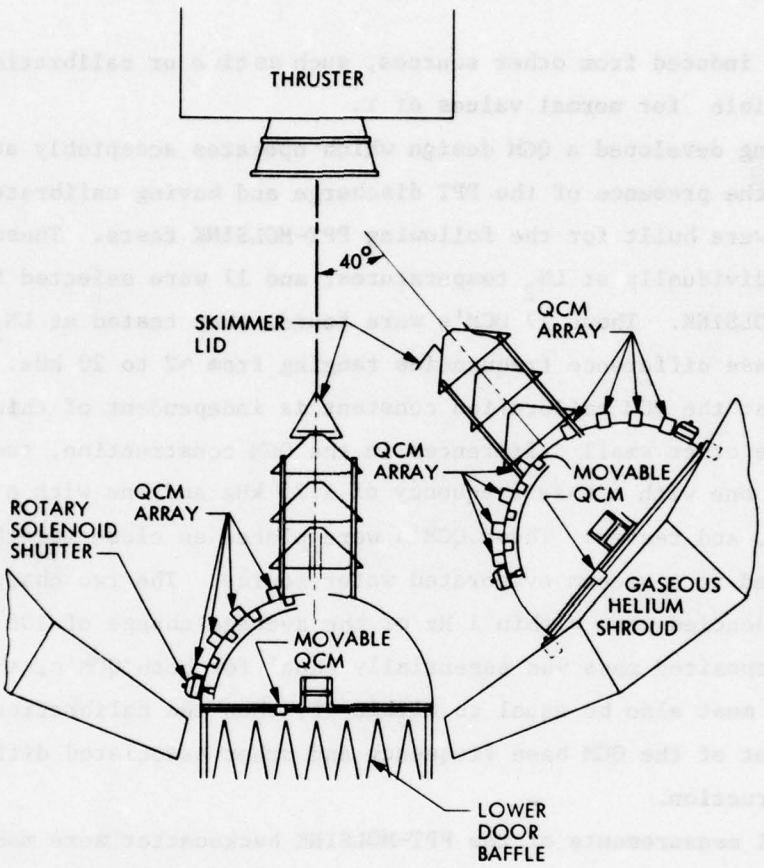


Figure 5. MOLSINK Skimmer Assembly

Figure 6 shows a photograph of the skimmers. The skimmer with the perpendicular collimator is for use in the center of the beam, while the one with the tilted collimator is for the off-axis position. Various electronics boxes for the internal instrumentation can be seen. These boxes are mounted on teflon thermal isolators and heated with strip heaters to acceptable operating temperatures. The skimmers were equipped with spring-loaded lids to control the plume entrance. These lids were opened by supplying an overcurrent to fuse wires holding them closed, causing the wires to melt, and allowing springs (made of molybdenum for low temperature use) to pull them open. The spring for the on-axis skimmer can be seen in Figure 6 at the top of the collimator.

Figure 7 is an internal view of the skimmers, with the on-axis skimmer on the right. This on-axis skimmer has only four QCMs since any mass reflected from the center of the axisymmetric door reflector that this skimmer is mounted on is expected to also be axisymmetric. These QCMs are mounted at angles of 8^{o}, 23^{o}, 38^{o} and 53^{o} from the collimator axis. The eight off-axis skimmer QCMs are mounted at $\pm 6^{o}$, $\pm 22^{o}$, and $\pm 36^{o}$ and $\pm 51^{o}$ from the collimator axis.

Both skimmers were equipped with rotating plate shutters designed to control the QCM view angle between the usual 114^{o} down to about 42^{o}. This was done by rotating a plate with small holes in it to a position directly in front of the QCM's. The shutters were installed to provide a means of decreasing the QCM deposition rate if necessary, since once the deposition mass on a QCM sensing crystal reaches a critical amount, the difference frequency drops to zero and no data can be obtained. These shutters can be seen in each of the skimmers in Figures 5 and 7. As it turned out, these QCM shutters were not needed.

In addition to the previous equipment, each skimmer was supplied with a movable QCM and stepper motor mechanism mounted on a parallel rail arrangement just above the MOLTRAP wall, as seen in Figures 5 and 7. These QCM's were used to sweep through the collimator beam to provide a flat reflecting surface to verify that the beam was getting through the collimator by increasing the mass flux to the QCM's mounted on the hemisphere, and to monitor the

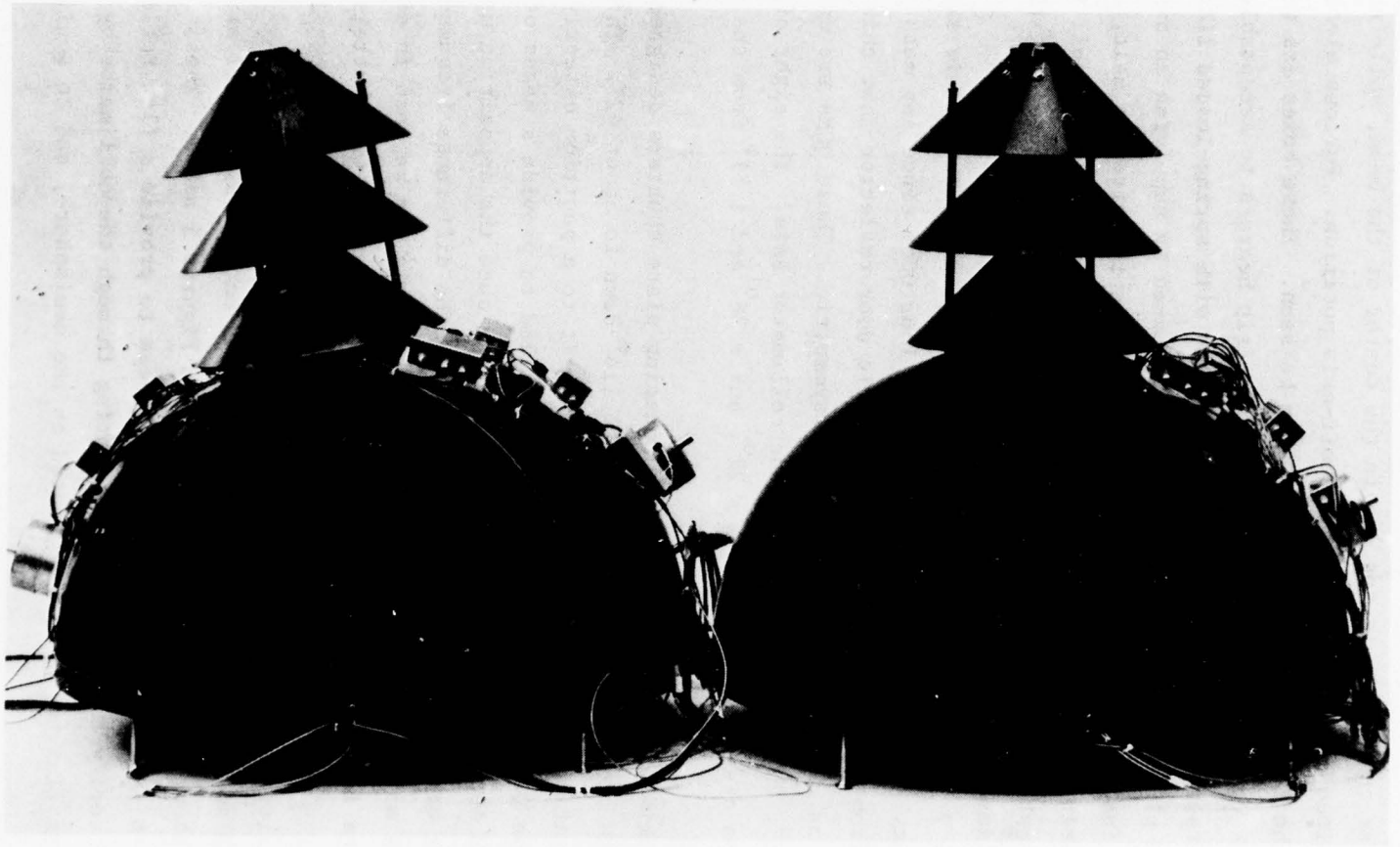


Figure 6. Molecular Skimmers - Outer View

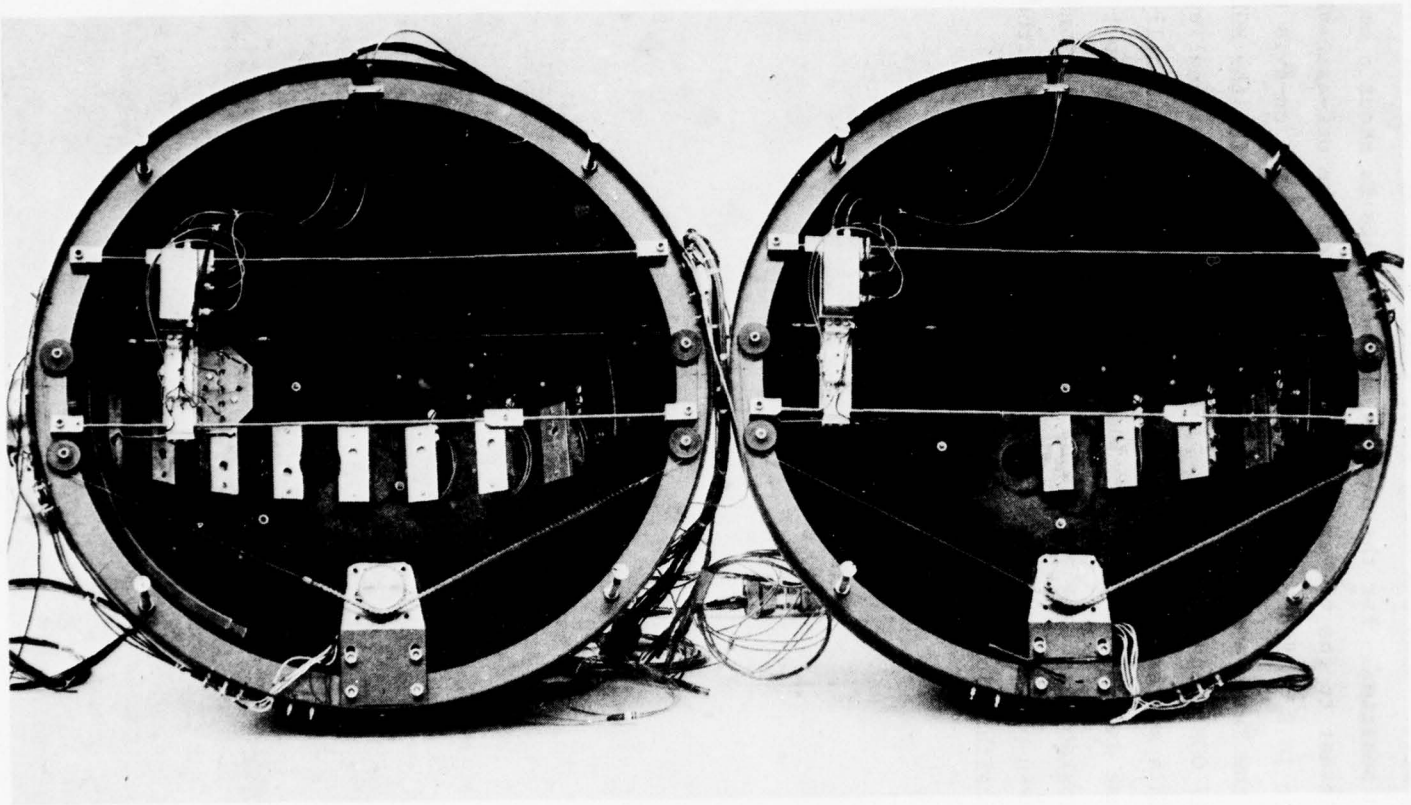


Figure 7. Molecular Skimmers - Inside View

collimated beam shape by observing the movable QCM signal as the QCM sweeps through this beam. When not being used, these scanning QCMs were set in their parked position. For the on-axis skimmer, this is about 8 cm from the side-wall closest to the off-axis skimmer, while for the off-axis skimmer this position is 8 cm from the side-wall furthest from the on-axis skimmer.

Due to the large amounts of data to be collected during the MOLSINK test (including 17 QCM's and 21 thermocouples) an automatic data handling system was used. This system sampled the data output channels periodically and recorded these data on paper tape. This tape was used as the input of a data reduction program which plotted the data in graphical form. The best fit slopes of these plots were used to find the net mass fluxes into the QCM's via the QCM calibration constant.

3.0 EXPERIMENTAL PROGRAM

3.1 TEST HISTORY Before the primary testing to determine the actual back-scatter characteristics of the MOLTRAP walls, several preliminary tests were run to insure proper operation of the millipound thruster after its arrival from Fairchild, and to check the thruster and QCM operations in the MOLSINK facility.

To check the operation of the thruster after its arrival, a test was run in the SEP facility. The thruster was installed and operated per instructions from Fairchild. The thermal control system, consisting of the resistor heated metal container, the thermistor temperature feedback controller, and the associated thermocouples, was checked for proper operation at liquid nitrogen (LN_2) temperatures. No unusual behavior was found and the thruster operation was considered acceptable for the following studies.

A second test was then carried out to check the PPT and QCM operations in the MOLSINK facility. The thruster was installed as described in section 2.2 of this report, while three QCMs were installed on a radial support bracket in a plane 51 cm behind the thruster nozzle, 38 cm, 51 cm and 64 cm from the thruster axis, respectively. The QCM radial bracket was initially perpendicular to the longer nozzle dimension i.e., parallel to the teflon feed bars. The MOLSINK chamber was cooled with LN_2 only while the thruster was fired once every 36 seconds. Both the PPT and the QCM operations were found to be acceptable. During this test, the thruster was rotated 90^o so that the three background QCMs were perpendicular to the shorter nozzle dimension and to the feed bars. This was done to check the azimuthal symmetry of the background flow from the thruster. The QCM difference frequencies plotted versus operating time for this test are shown in Figure 8. The slopes of these curves are directly proportional to the net mass flux, through the QCM calibration constant found in Section 2.4. Rather than continuing to present these rough data in the main part of this report, they are recorded in Appendix A. Only the mass flux values deduced from these data will be presented in the remainder of this report.

Having completed the preliminary testing satisfactorily, the main back-scatter testing was begun. The complete experimental assembly, including the PPT thruster, the three background QCMs and the two previously described

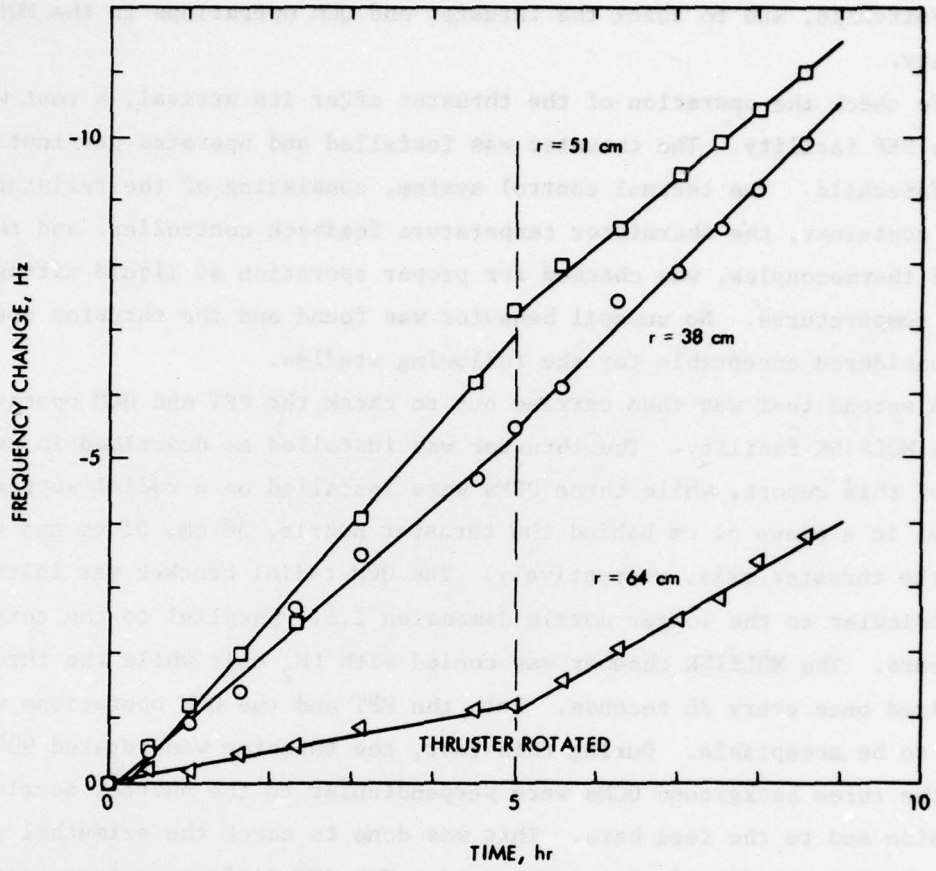


Figure 8. Background QCM Frequencies

skimmers, was installed in the MOLSINK facility. The skimmers were mounted on the inner edges of the MOLTRAP anechoic fins, one on the thruster axis and one 40^{o} away from this axis. Initially, the areas between the fins were left uncovered, allowing plume particles to enter the skimmers from around and underneath the hemispherical shields. Thus, the QCM's in the skimmers measure the wall backscatter from the 2.5 cm diameter skimmer collimator and from this edge leakage. Installation and checkout of the complete system was completed on October 21, 1977, when the pumpdown was started. Due to an initially large outgassing rate and various problems with the gaseous helium cooling system, the MOLTRAP temperature did not reach operating levels ($\sim$ 14K) until October 28. Several of the QCMs failed when the tank reached gaseous Helium temperatures, but heating their electronics assemblies started them working again.

During the first segment of this test, data were taken only from the on-axis skimmer and the three background QCMs. The scanning QCM, mounted in the on-axis skimmer at the MOLTRAP surface, was intended to measure the input profile of the collimator beam, however, the moveable platform used to hold this QCM moved on its support tracks in very abrupt jumps which lead to a rapid breakdown of the relatively fragile QCM. Despite this problem, some scanning QCM data were taken, until a clamping diode on the stepper motor shorted and burned out the control circuitry. The scanning QCM position was then unknown, so the test was stopped. The tank was warmed up and vented, the circuit repaired, several thermocouples were added to monitor critical areas, and the test was restarted on November 16, 1977.

After the thruster was started, and prior to opening the skimmer collimator lids, a continuity test on the on-axis skimmer fuse link was done which indicated an infinite resistance and an open lid. Rather than venting the tank and starting over, the test was continued in the hope that the on-axis lid was, indeed, open. Data were taken from both skimmers and the background QCMs. For part of this test segment, the PPT pulse repetition rate was changed from 36 sec/pulse to 23 sec/pulse to increase the data accumulation rate. The net deposition rates per time increased accordingly while the deposition rates per pulse remained constant. Data were taken from the skimmer's scanning QCMs in their parked positions, and no scanner movement

was attempted. This test segment was stopped on November 20, 1977. When the tank was opened, the on-axis skimmer lid was found to be closed, thus the previous data are due to the plume backscatter under the skimmer edge. The skimmer test circuit was found to have a break in an internal tank lead wire.

A skirt was added to the base of the on-axis skimmer to prevent backscatter under the skimmer edge and the test was restarted on November 28, 1977. Again, data were taken from the parked scanning QCMs as well as from the skimmer QCMs. When sufficient data of this type had been taken, the on-axis scanning QCM was moved into the collimator beam, however, before any data were available the thruster was found to be off. An investigation revealed the problem was inside the tank, so this test segment was terminated on December 2, 1977. When the thruster was removed, a coaxial adapter in the thruster charging line was found to be blown apart. The problem was repaired and the wiring system for the thruster was inspected.

For the final test segment, a skirt was added to the lower edge of the off-axis skimmer, to prevent backscatter leakage. The test was continued on January 19, 1978, but because of minor problems with the MOLTRAP cooling system, operating temperature was not reached until January 30, 1978. Data were taken from both skimmers and the scanning QCMs. The off-axis skimmer QCM signals were still outside the instrumentation resolution after several days of operations indicating that either the plume backscatter or the plume density itself is negligible. The scanning QCM was stepped into the collimator beam to measure the incoming collimated beam and to provide a smooth reflecting surface which should enhance any backscatter. Once in position the scanning QCM was found to be inoperable so no direct collimated beam measurements were possible. The skimmer QCM signals remained small, even with the smooth scanning QCM reflecting surface, thus it is concluded that the PPT plume density is negligible at this off-axis location.

On February 5, 1978 the thruster high voltage supply was found to be off. The overcurrent trip circuit had shut off the supply after its regulator had failed and may have charged the thruster capacitors to 4 kV for about 30 sec. Rather than stopping the test, the charging voltage was set manually at 2 kV (down from 2.4 kV), assuming that the mass per pulse can be scaled with the square of the voltage ratio.[11] The test was stopped when sufficient data were taken on February 6, 1978.

3.2 BACKGROUND QCM RESULTS The background QCM's mounted behind the thruster (See Section 3.1) provide information on the sum of the upstream mass flux from the thruster plume backflow and the plume-wall backscatter. Data were taken with these QCM's under two conditions: first, with the MOLTRAP cooled by LN_2 only, without the skimmers, and second, with the skimmers in place and with the MOLTRAP cooled to gHe temperatures. In addition, for the first condition, the thruster was rotated to check the net QCM signal symmetry. This rotation was from the usual position (0°) where the QCMs were parallel to the teflon feed bars to a position (90°) where they were perpendicular to these feed bars and on the cathode side of the thruster. The results of these tests are shown in Table II.

TABLE II. Background QCM Flux Data

($\mu g \cdot cm^{-2} \cdot pulse^{-1}$)

RADIUS	38 cm	51 cm	64 cm
#1) LN_2 cooled no skimmers - 0°	0.98×10^{-4}	1.27×10^{-4}	0.21×10^{-4}
- 90°	1.09×10^{-4}	0.92×10^{-4}	0.65×10^{-4}
#2) gHe cooled with skimmers - 0°	4.2×10^{-4}	3.15×10^{-4}	2.62×10^{-4}

The first test, with only LN_2 cooled walls, represents a worst case backscatter situation compared to the second gHe cooled test, since the MOLTRAP cryopumping is minimal at LN_2 temperatures. The large increase in the QCM fluxes between tests 1 and 2 is attributed to the presence of the skimmers for test 2. This increase thus suggests that most of the mass flux arriving at these background QCMs is due to plume-wall backscatter, as will be confirmed by the skimmer data in the following discussion. The two

thruster positions of test 1 show little differences in QCM signals indicating that the plume-wall backscatter is relatively independent of the thruster azimuthal position and, thus, is approximately azimuthally symmetric.

3.3 SKIMMER BACKSCATTER MAGNITUDE In order to estimate the net backscatter from the MOLTRAP walls, this backscatter was measured locally by the skimmers. The particular information required for this estimate is given by the results of the skirted skimmer tests, where only the backscatter from the two 2.54 cm diameter skimmer collimator beams was measured.

The results of the skirted on-axis skimmer measurement are shown as the solid line in Figure 9, where the net mass flux into the QCMs mounted on the skimmer hemisphere is plotted versus the angular location of the QCM with respect to the hemisphere center. The QCM data points at 23° and 53° are within the effective QCM resolution calculated to be 10^{-5} μg cm^{-2} $pulse^{-1}$ for this measurement. These data show a strong dependence on scattering angle as would be expected from a narrow beam reflecting off the concentric baffle arrangement on the MOLTRAP lower door. This baffle (See Section 2.2) is symmetric about the collimator-thruster axis, thus the data is also expected to be symmetric.

The off-axis skimmer data with the skirt in place was taken over a five day period with a PPT pulse rate of 36 sec/pulse. None of the off-axis QCMs ever reached a signal within the effective QCM resolution, thus the net backscatter flux is less than 10^{-6} μg cm^{-2} $pulse^{-1}$ for any QCM location within the off-axis skimmer hemisphere. As discussed in Section 3.1 this low signal is primarily due to a negligible plume density at the skimmer location 40° away from the thruster axis. Thus, the plume-wall backscatter must originate in the region where the highest density part of the plume intersects the MOLTRAP wall, i.e., in a region within 40° of the PPT axis.

From the results of these skirted skimmer tests, it is possible to estimate the net mass flux being backscattered off the MOLTRAP surface. For the on-axis skimmer, the measured flux of Figure 9, integrated over the inner hemispherical skimmer area, gives the total backscattered flux produced by the incoming collimated 2.5 cm beam. To simplify this integration and because of the relatively large error in the data of Figure 9, the flux distribution over the hemispherical surface will be assumed uniform and equal

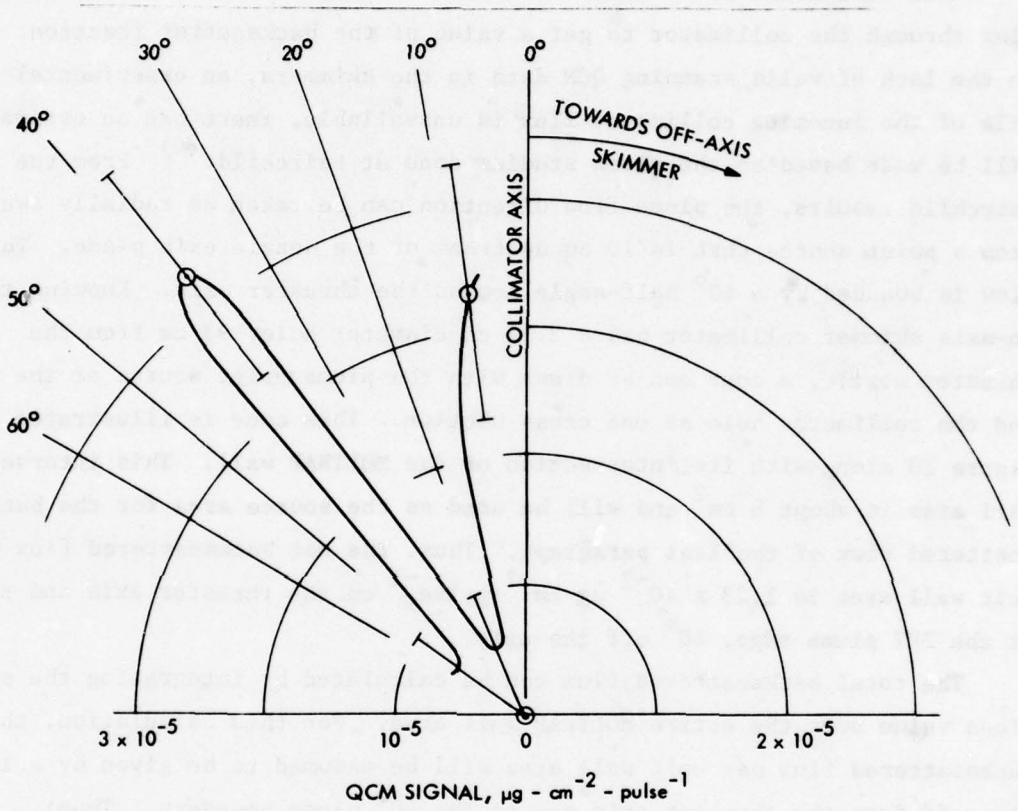


Figure 9. On-Axis Skimmer Backscatter (Lid Open, Skirted Base)

to the estimated average value of 2.5×10^{-5} μg cm^{-2}-$pulse^{-1}$. This assumption will result in an over-estimate of the net backscatter. For a 25 cm radius skimmer hemisphere the area is 3926 cm^2 and the total backscattered flux becomes 9.8×10^{-2} μg-$pulse^{-1}$ for the on-axis skimmer. For the off-axis skimmer the backscattered flux is essentially zero.

This calculated backscatter flux must be compared to the incoming plume flux through the collimator to get a value of the backscatter fraction. Due to the lack of valid scanning QCM data in the skimmers, an experimental profile of the incoming collimated flux is unavailable, therefore an estimate will be made based on the plume studies done at Fairchild.[4] From the Fairchild results, the plume flow direction can be taken as radially away from a point source that is 10 cm upstream of the nozzle exit plane. This radial flow is bounded by a 40° half-angle around the thruster axis. Knowing the on-axis skimmer collimator has a 2.54 cm diameter hole, 93 cm from the thruster nozzle, a cone can be drawn with the plume point source at the apex and the collimator hole as one cross section. This cone is illustrated in Figure 10 along with its intersection of the MOLTRAP wall. This intersected wall area is about 8 cm^2 and will be used as the source area for the backscattered flux of the last paragraph. Thus, the net backscattered flux per unit wall area is 1.23×10^{-2} μg-cm^{-2}-$pulse^{-1}$ on the thruster axis and zero at the PPT plume edge, 40° off the axis.

The total backscattered flux can be calculated by integrating the previous value over the entire MOLTRAP wall area. For this calculation, the backscattered flux per unit wall area will be assumed to be given by a linear drop-off from the thruster axis out to the 40° plume boundary. Thus:

$$\dot{m}_{SA} = 1.23 \times 10^{-2} \left[1 - \frac{\Theta}{0.628}\right] \qquad (6)$$

where $\dot{m}_{SA}$ is the local value of the backscatter flux per unit wall area (μg-cm^{-2}-$pulse^{-1}$), Θ is the angle (in radians) measured from the thruster axis and the constant number, 0.628 is 40 degrees in radians. This linear function is shown in Figure 11 along with the measured data and a schematic of the integration over the MOLTRAP wall. For this integration, the MOLTRAP

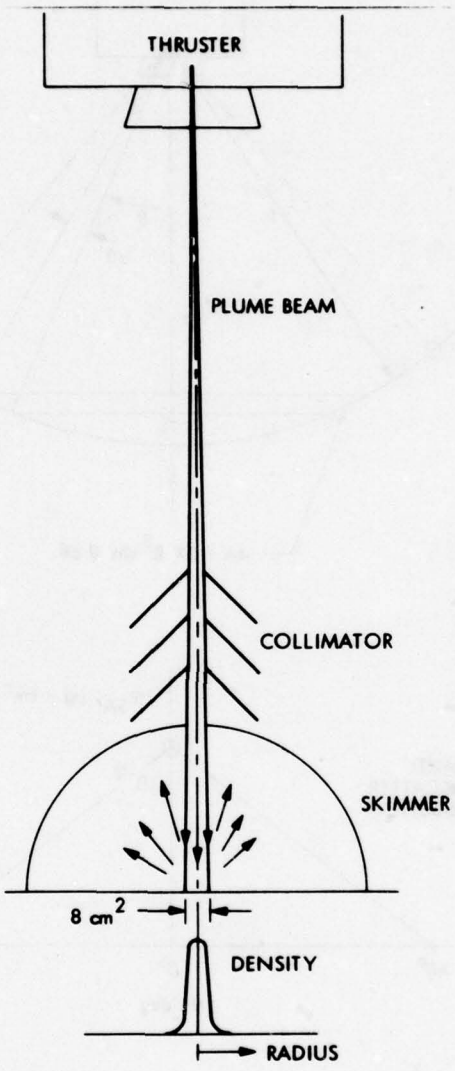


Figure 10. Backscatter Source Distribution

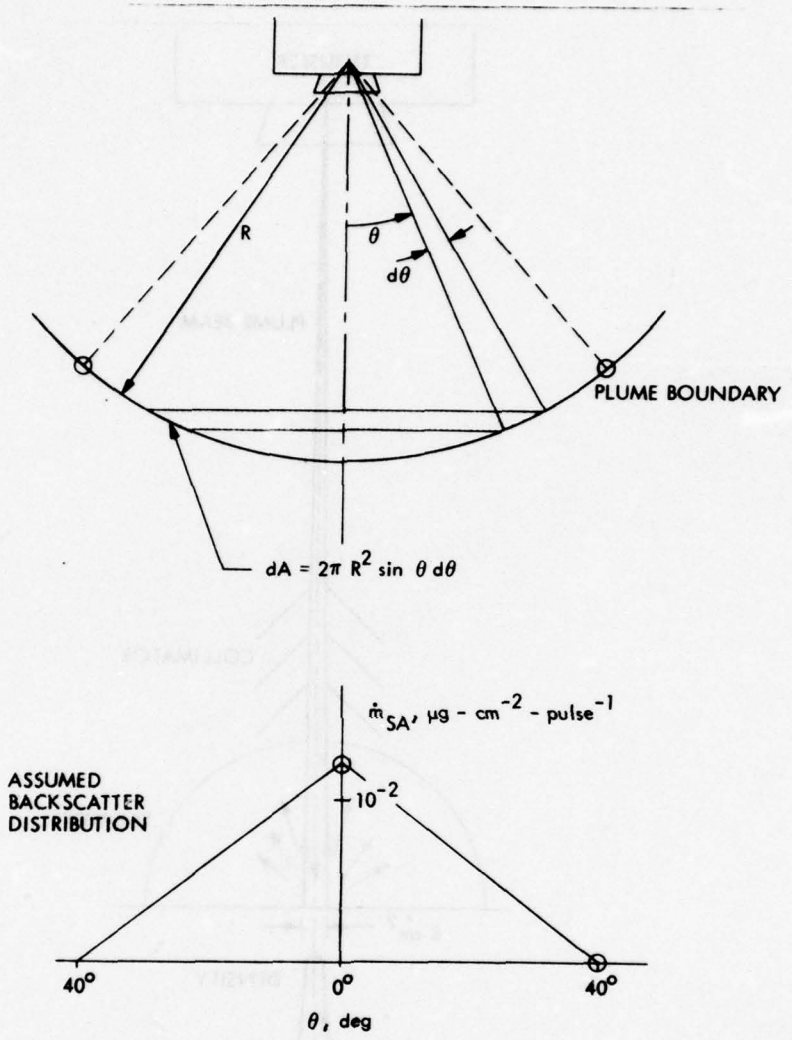


Figure 11. Backscatter Integration Method

surface can be taken as spherical, with a center at the thruster plume origin and a radius of 120 cm. A differential area element is also shown in Figure 11. Integrating Equation (6) over this area gives:

$$\hat{M}_S = \int_{0°}^{40°} \dot{m}_{SA}\, 2\pi R^2 \sin\theta\, d\theta$$

$$= 88.4 \quad \mu g\text{-pulse}^{-1} \qquad (7)$$

The net mass backscattered from the MOLTRAP wall is 88.5 $\mu g\text{-pulse}^{-1}$ or roughly 5.9% of the total mass (1.5×10^3 $\mu g\text{-pulse}^{-1}$) in the PPT plume. This net backscatter fraction is roughly five times smaller than the backscatter measured in the Fairchild vacuum facility,[4] primarily because of the anechoic baffling in MOLSINK.

3.4 SKIMMER BACKSCATTER DISTRIBUTION The data from the skirted on-axis skimmer (Figure 9) indicate that the backscatter from a localized plume segment is relatively non-uniform, due to the strong local changes in the slopes of the MOLTRAP walls. The overall backscatter is expected to be much more uniform since it represents an integrated value of the entire wall. This integrating effect can be seen in the data taken with the unskirted on-axis skimmer shown in Figure 12. The backscatter flux into the skimmer for this Figure is due to the collimated beam and also from the plume impinging on the MOLTRAP area around the skimmer hemisphere. Figure 13 shows the on-axis skimmer data taken with the collimator lid closed, thus only the backscatter flowing around the skimmer edge is being collected. The data of Figures 12 and 13 are comparable, confirming that the collimated beam signal is negligible. The magnitude of the edge leakage flux is much larger than that of the collimator flux because the effective source area is much greater. These data suggest that the overall backscatter distribution from the entire 40° half angle MOLTRAP wall region is approximately uniform. Furthermore, this implies that for distances well away from the wall-backscatter region, the backscattered flux can be taken as coming from a point source on the thruster axis at the MOLTRAP wall.

Some support for this conclusion can be found in the data obtained from the unskirted off-axis skimmer. This information is shown in Figure 14 where the QCM signals are plotted versus angle from the skimmer collimator axis. This

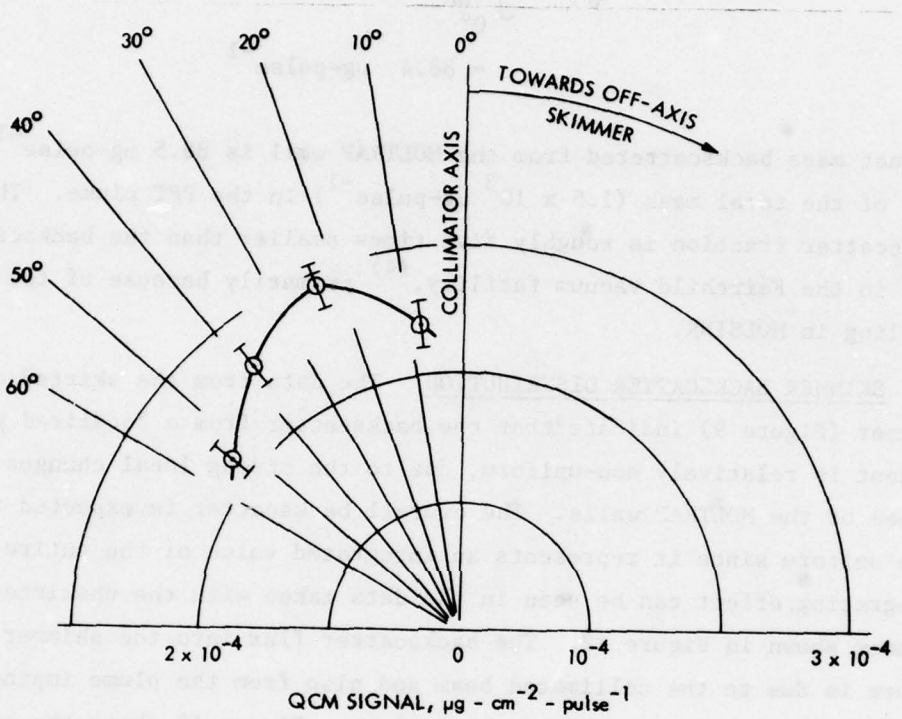


Figure 12. On-Axis Skimmer Backscatter (Lid Open, Unskirted Base)

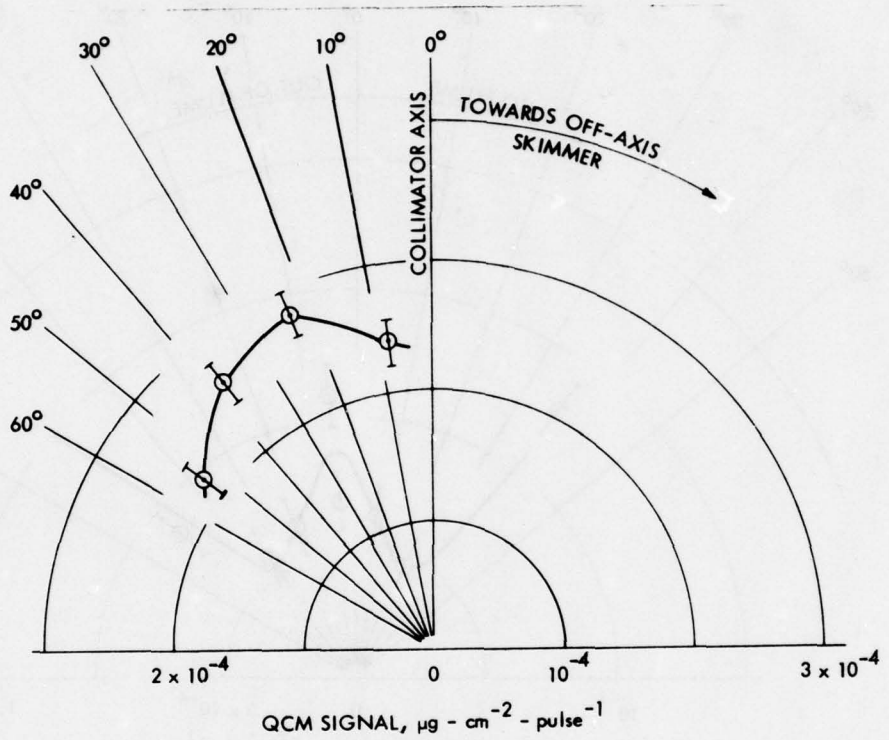


Figure 13. On-Axis Skimmer Backscatter (Lid Closed, Unskirted Base)

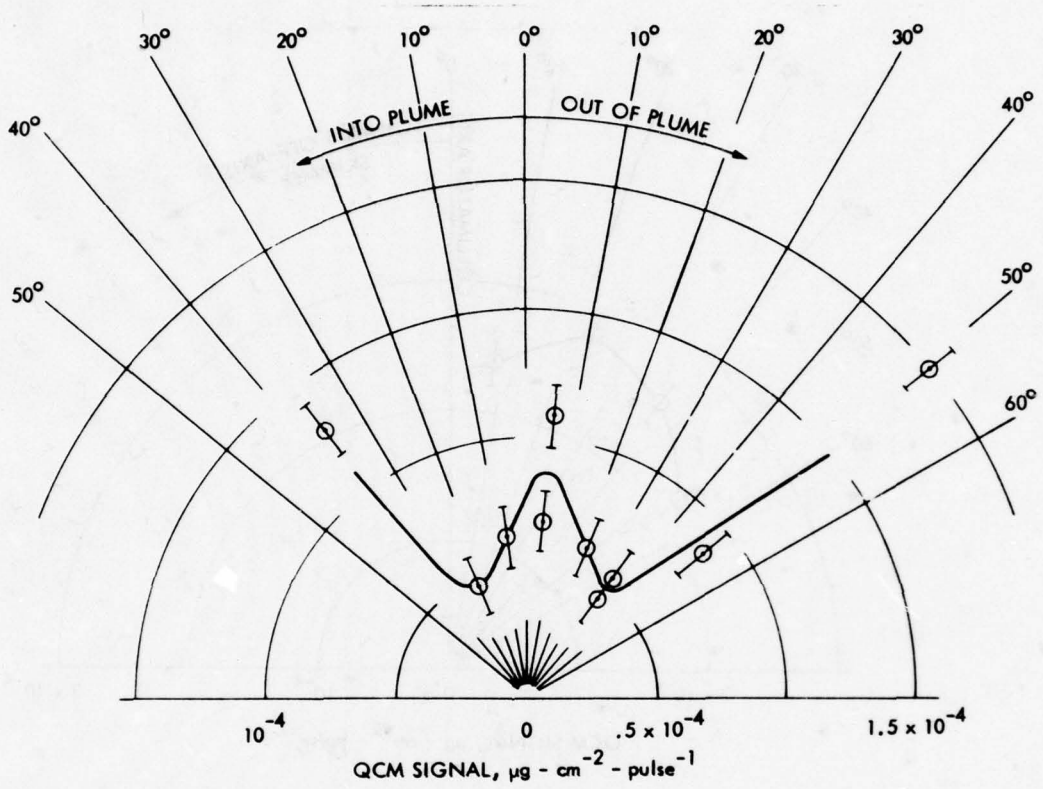


Figure 14. Off-Axis Skimmer Backscatter (Lid Open, Unskirted Base)

axis is directed along a 40^{o} line from the PPT nozzle and is such that clockwise angles in this figure indicate directions out of the plume, while counterclockwise angles indicate directions toward the plume center. These data show a mass flux distribution symmetric about a 5^{o} angle out of the plume. The net signal represents contributions primarily from backscatter flowing underneath the skimmer hemisphere edge, since the skirted, off-axis skimmer measurements are negligible. The backscatter flow into the off-axis skimmer is strongest on the lower side closest to the plume axis as evidenced by the 5^{o} offset in the flux data. Even with this non-uniform incoming flux, the measured distribution of Figure 14 is much more uniform than that of Figure 9 indicating that the backscatter does indeed reach a reasonably uniform angular distribution about the plume axis.

Additional evidence on the wall-backscatter flow distribution can be found by examining the erosion-deposition patterns on the skimmer collimators after their removal from the test environment. Figure 15 shows a photograph of the on-axis skimmer collimator after the MOLSINK test. At the start of this test the collimator cones had a black anodized finish. As seen in Figure 15, the upper cone has remained clean while the lower two cones have multicolored patterns over their upper surfaces out from about 1 cm from the collimator hole. The colored patterns are attributed to thin, variable depth deposits of plume material. The clean regions around the edges of the cone collimator holes and over the entire top cone are due to the "scrubbing" action of the high energy plume as it strikes these surfaces and is collimated by them. The deposits must be due to material scattered from the MOLSINK walls or other surfaces and not from material coming directly from the plume. Thus, the multicolored patterns give a qualitative measure of the wall-backscatter distribution.

The patterns on the on-axis skimmer collimator seen in Figure 15 are concentric about the plume axis, indicating that the backscatter is symmetric about this axis. The patterns on the off-axis skimmer were observed only on the side closest to the plume axis, indicating that, as expected, the wall backscatter comes from within the 40^{o} half-angle plume. In addition, some deposits were seen on the off-axis collimator top cone, indicating that the

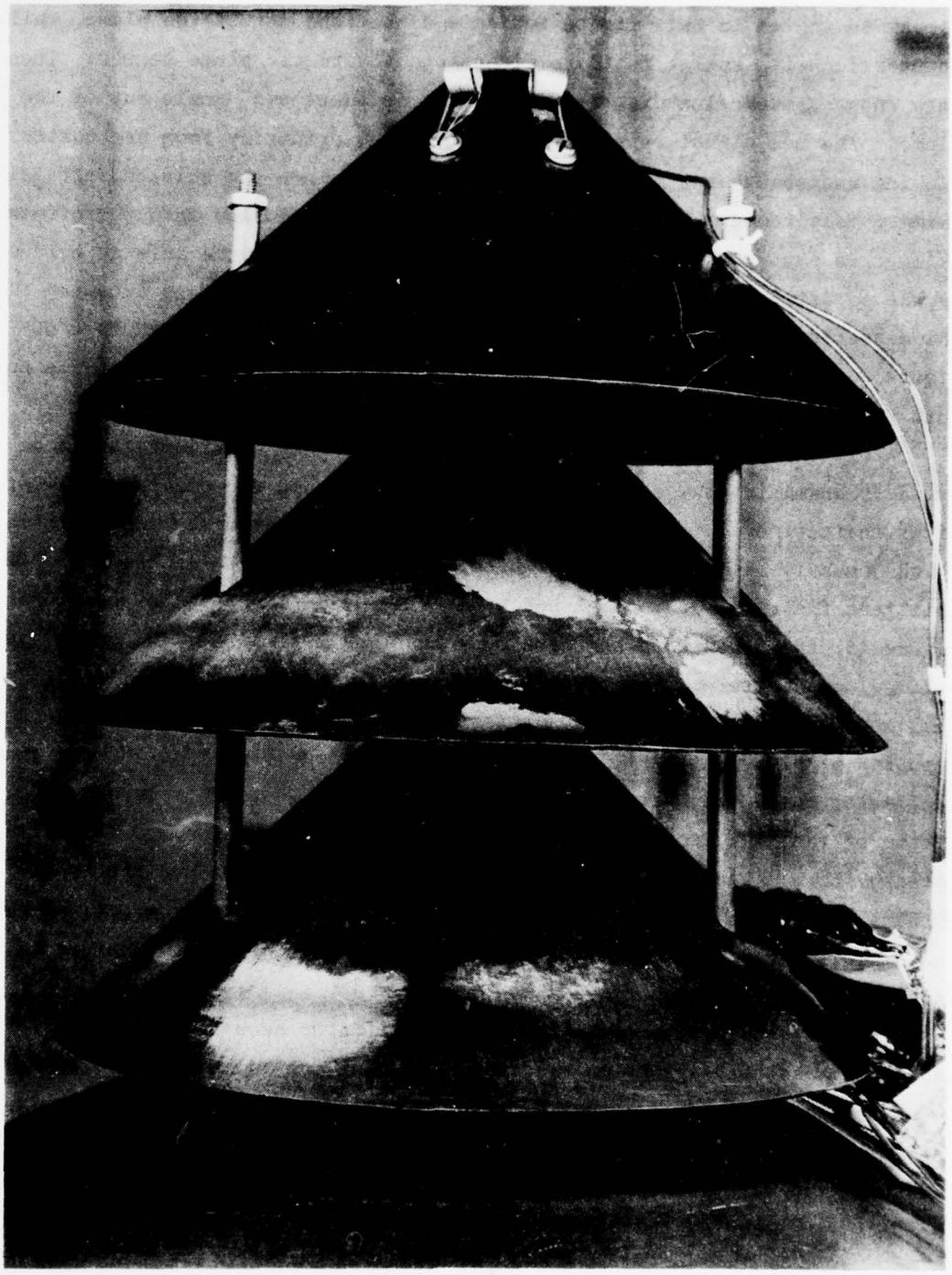


Figure 15. On-Axis Collimator Deposits

PPT plume "scrubbing" action is minimal and implying that the plume density is very low beyond 40° from the plume axis. This, again, is consistent with earlier conclusions.

The data taken with the unskirted on- and off-axis skimmers must be strongly affected by the presence of the skimmers themselves (see Table II), thus any conclusions about the behavior of the backscatter in MOLSINK in its usual configuration (without the skimmers) must be approximate. These data indicate general trends, at best, and must be taken in that light.

The picture that emerges from all the previous discussion is that the backscattered material from the plume-tank wall interaction originates in a region on the MOLTRAP wall bounded by the 40° half angle plume. The PPT plume is almost totally absorbed, with only 5.9% of the flux becoming backscatter. This backscatter flows upstream away from the wall in an approximately uniform distribution about the plume axis, and must eventually collide with the thruster and the upper MOLTRAP walls.

As a further check on this expected backscatter behavior, the net backscatter flux into the background QCM's behind the thruster (see Section 3.1) can be calculated and compared to the measured values. The backscatter flux at the MOLTRAP wall has been found to be 5.9% of the total plume mass or 88.4 $\mu g\text{-pulse}^{-1}$. Assuming a uniform distribution about a hemispherical surface centered on the plume axis-tank wall intersection with a radius equal to the distance to the background QCM's ($\sim$ 180 cm) gives an area of: $2\pi R^2 = 2.03 \times 10^5\ cm^2$. This becomes a flux per unit area of: $88.4/2.03 \times 10^5 = 4.34 \times 10^{-4}\ \mu g\text{-cm}^{-2}\text{-pulse}^{-1}$. This calculated backscatter flux should be compared to the first case in Table II where the backscatter at LN_2 temperatures without the skimmers was measured. This comparison indicates the calculated value is roughly four times as large as the measured value, which in the light of the assumptions made is a good agreement.

3.5 SECONDARY BACKSCATTER Once the backscatter flux reaches the upper wall area, it will undergo a second interaction with the MOLTRAP surface. Some will be absorbed while some may be reflected to continue to increase the general flux levels in MOLSINK. A measure of the 2nd bounce backscatter fraction can be found by considering the available data from the scanning QCM's mounted in the skimmers. These QCM's were mounted facing up towards the

skimmer hemispherical domes, such that, when in a position outside of the collimated beams, the net signal from them is due to backscattered material from the MOLTRAP wall that has either arrived directly or bounced once from the inner hemisphere wall.

Referring to Figure 16, the net output signal, S_1, from a QCM mounted on the skimmer surface is given by:

$$S_1 = \dot{m}_1 - \dot{m}_2 \tag{8}$$

where $\dot{m}_1$ is the backscatter from the first PPT plume-MOLTRAP wall interaction and $\dot{m}_2$ is the second bounce backscatter off the QCM surface. The net output signal, S_2, from the scanning QCM is given by:

$$S_2 = k\dot{m}_1 + \dot{m}_2 \tag{9}$$

where k is the fraction of backscatter reaching this QCM compared to the hemisphere QCM. These equations assume no third bounce flux comes off the scanning QCM.

The fraction k must be less than one since the scanning QCM is well off to the side of the original backscatter source, while the hemisphere QCM is in a much better location.

Equations (5) and (6) represent a system with three unknowns, $\dot{m}_1$, $\dot{m}_2$, and k. To solve this system one of these unknowns must be specified a priori. Because k is bounded from zero to one, it will be assumed equal to zero for a worst case analysis. Thus:

$$\begin{aligned} S_2 &= \dot{m}_2 \\ S_1 &= \dot{m}_1 - \dot{m}_2 \end{aligned} \tag{10}$$

The results from Figure 9 indicate the average hemisphere QCM signal is 2.5×10^{-5} $\mu g\text{-}cm^{-2}\text{-}pulse^{-1}$. This value will be taken as S_1. The measured

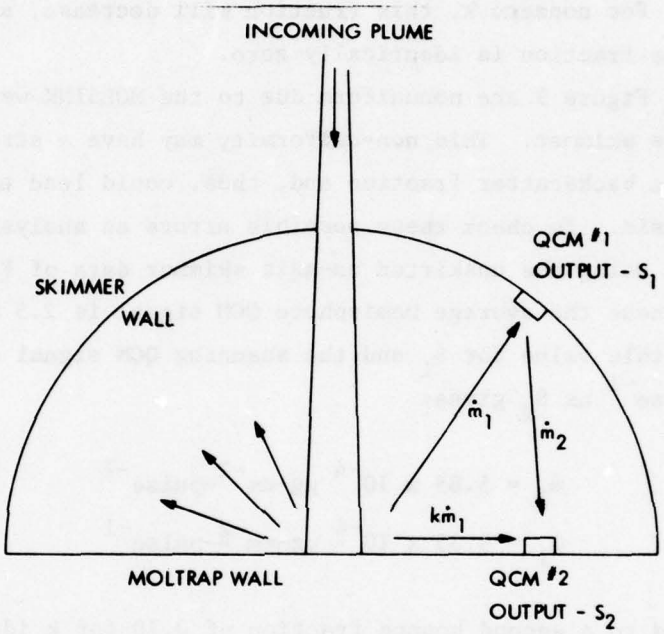


Figure 16. Second Bounce Schematic

value of S_2 for the same experimental parameters is 1.91×10^{-5} $\mu g\text{-}cm^{-2}\text{-}pulse^{-1}$. Solving the previous system gives:

$$\dot{m}_2 = 1.91 \times 10^{-5} \ \mu g\text{-}cm^{-2}\text{-}pulse^{-1}$$
$$\dot{m}_1 = 4.41 \times 10^{-5} \ \mu g\text{-}cm^{-2}\text{-}pulse^{-1} \qquad (11)$$

Thus the second bounce backscatter fraction defined is $\dot{m}_2/\dot{m}_1$ equals 0.43, assuming $k = 0$. For nonzero k, this fraction will decrease, and for $k = 0.76$ the second bounce fraction is identically zero.

The data of Figure 9 are nonuniform due to the MOLSINK wall construction under the on-axis skimmer. This non-uniformity may have a strong effect on the second bounce backscatter fraction and, thus, could lead to errors in the proceeding analysis. To check these possible errors an analysis identical to the previous one using the unskirted on-axis skimmer data of Figure 12 may be used. For this case the average hemisphere QCM signal is 2.5×10^{-4} $\mu g\text{-}cm^{-2}\text{-}pulse^{-1}$. Using this value for S_1 and the scanning QCM signal equal to 5.8×10^{-4} $\mu g\text{-}cm^{-2}\text{-}pulse^{-1}$ as S_2 gives:

$$\dot{m}_2 = 5.85 \times 10^{-4} \ \mu g\text{-}cm^{-2}\text{-}pulse^{-1}$$
$$\dot{m}_1 = 8.35 \times 10^{-4} \ \mu g\text{-}cm^{-2}\text{-}pulse^{-1} \qquad (12)$$

These values lead to a second bounce fraction of 0.70 for k identically zero; however, for this experimental situation k must be greater than zero, since the scanning QCM is in a good position to get input flux directly from the backscatter around the skimmer lower edge. Assuming $k = 1$ gives:

$$\dot{m}_2 = 1.67 \times 10^{-4} \ \mu g\text{-}cm^{2}\text{-}pulse^{-1}$$
$$\dot{m}_1 = 4.17 \times 10^{-4} \ \mu g\text{-}cm^{-2}\text{-}pulse^{-1}$$

and the second bounce fraction becomes 0.40. These two values of the second bounce fraction (0.40 and 0.70) include the value of 0.43 found from the data of Figure 9 and indicate that in general the second bounce backscatter fraction is around 0.40.

4.0 PLANNED FUTURE WORK

The second phase of this effort will be a study of the PPT plume-spacecraft interaction utilizing the MOLSINK facility for measurements of the plume backflow mass flux into the thruster plane at various distances from the thruster axis, and of the PPT plume mass flux profile downstream of the thruster nozzle.

Because of the relatively large PPT plume backscatter in the MOLSINK over the wall areas directly in the PPT beam, a direct measurement of the plume backflow is impossible. Based on the understanding developed in this discussion and on the Fairchild plume study,[4] it is possible to develop an indirect method using collimated QCM's which can measure the backflow without being effected by the backscattered flux.

Figure 17 shows the proposed technique for measuring the backflow. In this design, a collimated QCM is rotated around a fixed point at the entrance of the collimator. The view angle of this QCM is finite, therefore the contributing volume is a cone with a volume element, dV. The insert in Figure 17 indicates the kind of data that should be derived from such a measurement. Note that the greatest backflow would be expected at 90^{o}--decreasing to a lower value in the downstream direction. However, it is expected that the backscatter from the walls will predominate when the view of the QCM includes areas on the wall where the most energetic exhaust particles collide. When the distance from the exhaust plane to focal point of the QCM array (distance x in Figure 17) is increased it would be expected that the backflow measured would decrease because the density (or collision probability) is decreasing in the plume. This idea is shown in Figure 18. Note that the backscatter from the walls would be expected to increase because the QCM's are positioned closer to the wall.

The interpretation of these data in terms of total backflow depends on some understanding of the mass distribution in the plume, i.e., the relationship between the mass flux and the angle from the thruster axis. The collimated QCM views a volume of approximately conical shape. Each volume element within this cone has a density and angular orientation to the primary beam unique to its position and a specific solid angle with respect to the QCM;

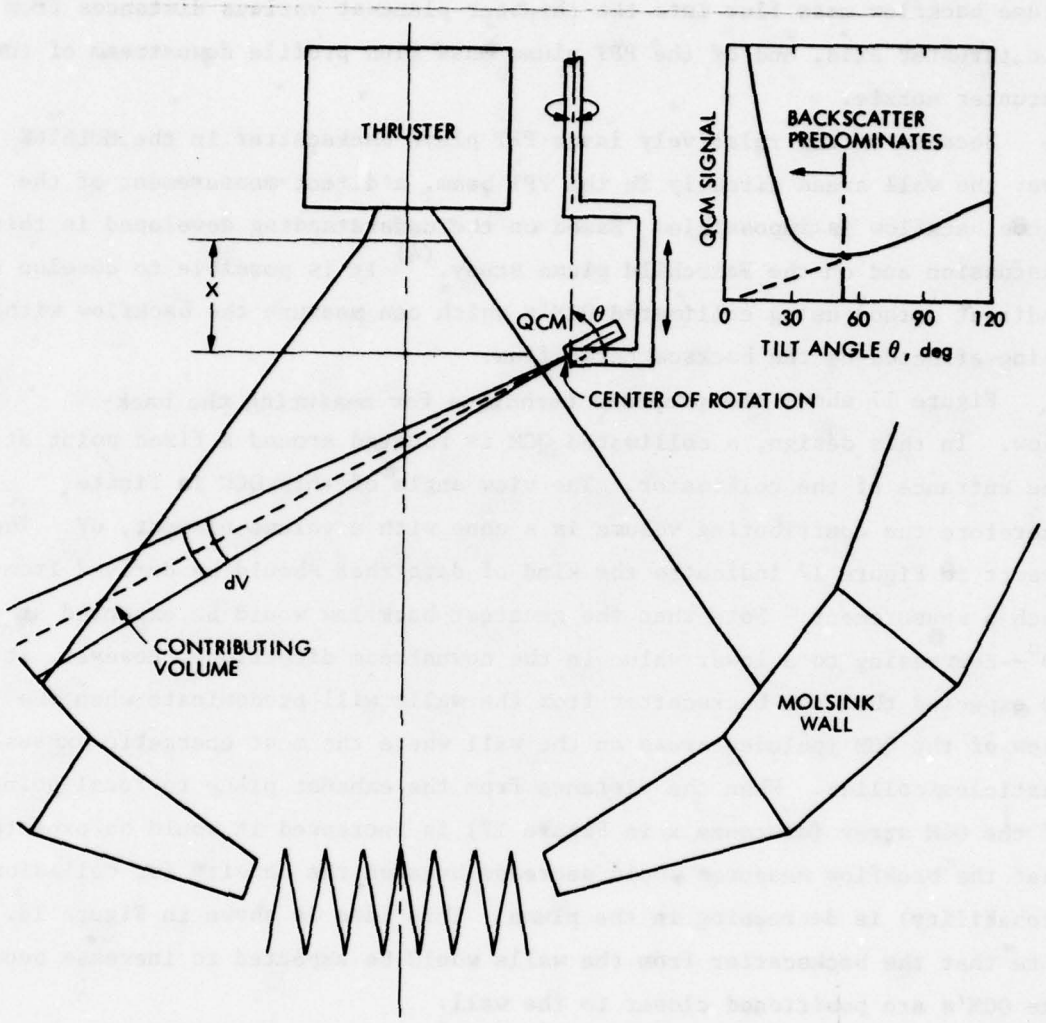


Figure 17. Backflow Measuring Technique

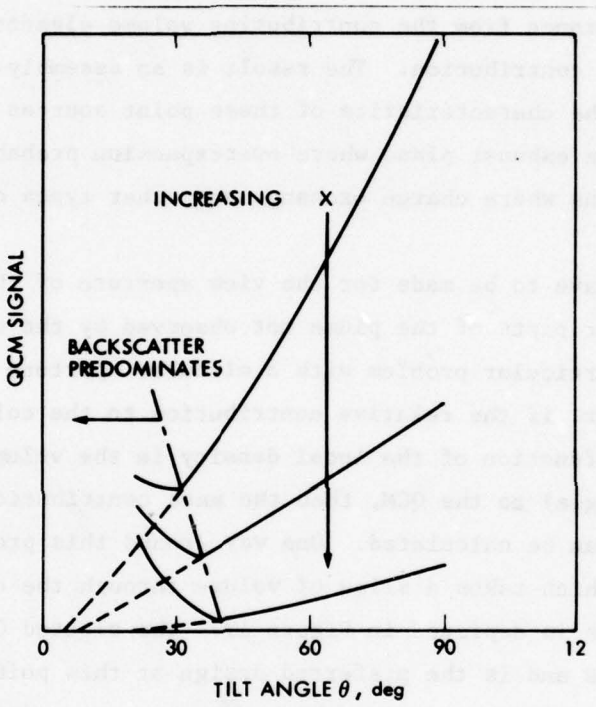


Figure 18. Expected Backflow Results

therefore, a knowledge of the primary mass distribution is needed to properly weigh the contributions from each volume element. A more detailed understanding would require the density distributions as a function of time during the firing process; however, this is beyond the scope of this effort.

The simplest approach of analysis is to use the lumped source technique which is a method of normalizing the flux measured at various angles to account for the different view volumes. Subsequently, the source is lumped at the focal point along the axis. A refinement of this would be to take account of the distance from the contributing volume element and the QCM to weigh the relative contribution. The result is an assembly of point sources along the axis. The characteristics of these point sources would vary from the region near the exhaust plane where overexpansion probably occurs to the downstream positions where charge exchange and other types of collisions would predominate.

Corrections have to be made for the view aperture of the collimated QCM to take account for parts of the plume not observed by the collimated probe. This would be a particular problem with a circular aperture as shown in Figure 19. However, if the relative contribution to the collimated QCM can be evaluated as a function of the local density in the volume element and the distance (solid angle) to the QCM, then the mass contribution coming from the remaining volume can be calculated. One way around this problem is to use a slotted view QCM which takes a slice of volume through the entire active plume region. This is depicted in Figure 19. The slotted QCM has many attractive features and is the preferred design at this point.

In the actual plume, particles which may be scattered in the direction of the QCM may be scattered away depending on the distance from the QCM and the local density. However, in terms of backflow--the only important particles are those which actually leave the active plume region and strike the QCM. Beyond that point the particles can be assumed to be in molecular flow with a mean free path of tens of meters; therefore, the lumped point sources can be projected back into regions where the spacecraft surfaces might be present.

Approximately five measurements along the thruster axis, say at 10 cm intervals beginning at the exhaust plane, should be able to quantify the major source of backflow. As shown in Figure 18, it may be possible to make

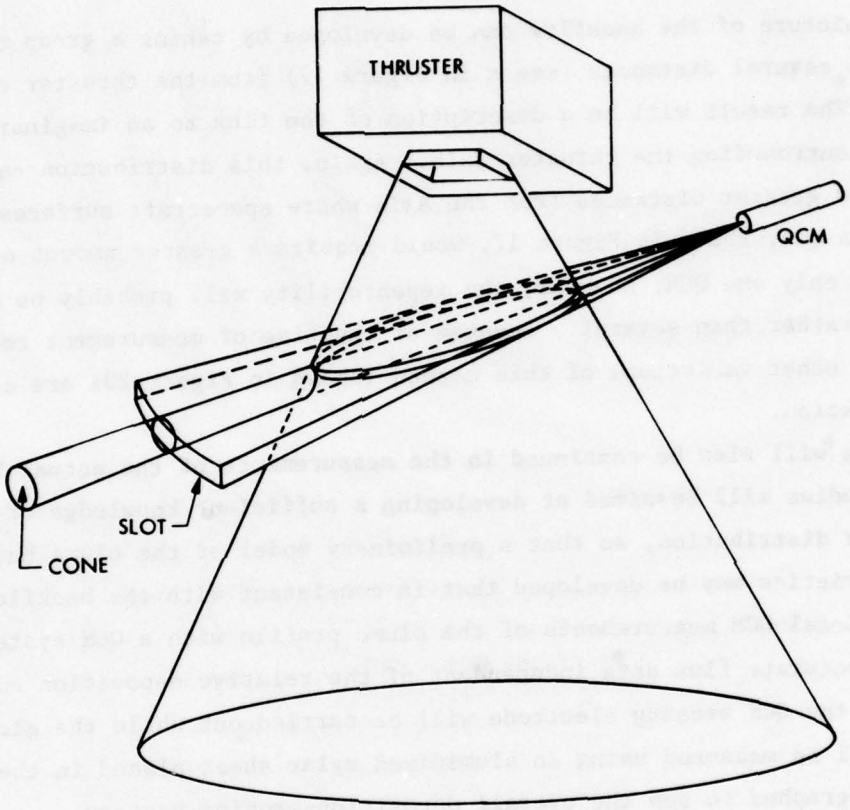


Figure 19. QCM View Volumes

a reasonable extrapolation of the data to account for the measurements when the backscatter from the wall predominates. Corrections have to be made to account for the change in projected area with the cosine of the angle with respect to the surface normal vector. Evaluation should be reasonably simple with this technique because the contribution from each solid angle with respect to the area element can be directly measured or extrapolated between measurements.

A picture of the backflow can be developed by taking a group of measurements at several distances (see x in Figure 17) from the thruster exhaust plane. The result will be a description of the flux to an imaginary cylindrical surface surrounding the thruster axis. Again, this distribution can be projected to greater distances from the axis where spacecraft surfaces may reside. The technique, shown in Figure 17, would require a greater amount of time because there is only one QCM; however, the repeatability will probably be better with one QCM rather than several. Because of the time of measurement required with one QCM, other variations of this method (shown in Figure 20) are also under consideration.

Work will also be continued in the measurements of the actual PPT plume. These studies will be aimed at developing a sufficient knowledge of the plume mass flux distribution, so that a preliminary model of the plume backflow characteristics may be developed that is consistent with the backflow measurements. Local QCM measurements of the plume profile with a QCM system designed to give accurate flux data independent of the relative deposition and erosion rates of the QCM sensing electrode will be carried out while the global plume shape will be measured using an aluminized mylar sheet placed in the PPT plume and photographed to see the overall deposition-erosion pattern.

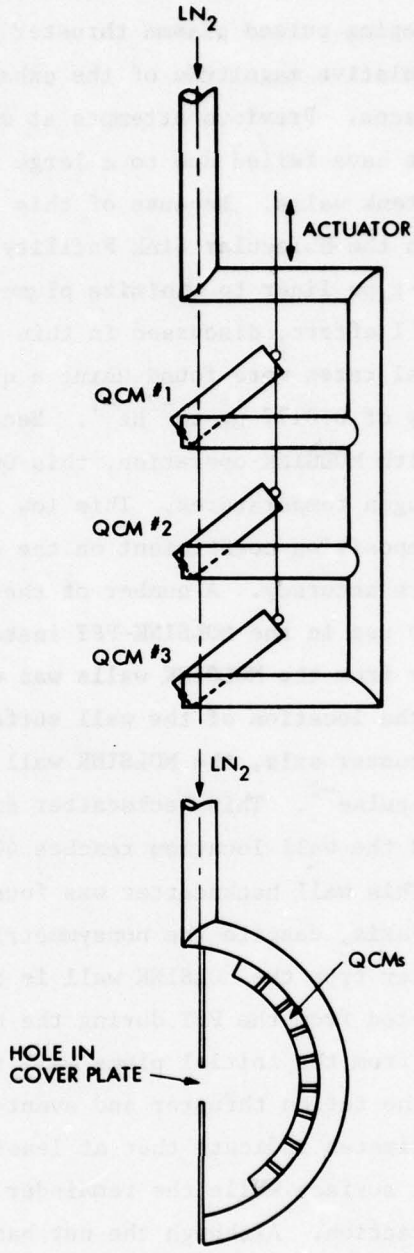


Figure 20. Backflow Measuring Options

5.0 SUMMARY AND CONCLUSION

Due to the high propellant flow rate and total impulse associated with the north-south stationkeeping pulsed plasma thruster system, questions have arisen concerning the cumulative magnitude of the exhaust plume backflow effect on spacecraft surfaces. Previous attempts at measuring this effect in ordinary vacuum facilities have failed due to a large backscatter of plume material from the vacuum tank walls. Because of this problem, studies have been initiated at JPL with the Molecular Sink Facility which uses a cryogenically cooled anechoic-type liner to minimize plume-wall backscatter. These studies include the Phase I effort, discussed in this report.

Local material arrival rates were found using a quartz crystal microbalance with a sensitivity of 0.0177 $\mu g\text{-}cm^{-2}Hz^{-1}$. Because of the cryogenic temperatures associated with MOLSINK operation, this QCM assembly was developed to operate at liquid nitrogen temperatures. This low temperature operation ensures a high material deposition coefficient on the quartz crystal sensing surface, thus improving its accuracy. A number of these QCM's were constructed and tested for use in the MOLSINK-PPT installation.

The total backscatter from the MOLSINK walls was measured and found to be strongly dependent on the location of the wall surface with respect to the thruster axis. On the thruster axis, the MOLSINK wall backscatter was found to be 1.23×10^{-2} $\mu g\text{-}cm^{-2}\text{-}pulse^{-1}$. This backscatter drops off to zero as the angle between the axis and the wall location reaches 40°, corresponding to the PPT plume boundary. This wall backscatter was found to be essentially symmetric about the plume axis, despite the nonsymmetric PPT nozzle. The total integrated backscatter from the MOLSINK wall is approximated equal to 5% of the total mass injected from the PPT during the discharge pulse.

The backscatter flux from the initial plume wall intersection flows directly back up towards the teflon thruster and eventually hits the upper MOLSINK wall surface. Estimates indicate that at least 50% of this flux is absorbed by the upper wall surface while the remainder continues to flow towards a third wall interaction. Although the net backscatter is less than one fifth of the backscatter found in an ordinary vacuum facility, it is still too large to allow a simple direct measurement of the PPT plume backflow.

Based on the measured plume-wall backscatter characteristics, an indirect method of measuring the net PPT plume backflow has been developed. This method is based on the use of collimated QCM's to observe selected regions of the PPT plume out of sight of the backscatter and will be used in the future Phase II of this study to evaluate the total plume backflow.

6.0 REFERENCES

1. Rosen, S.G., "Colloid and Pulsed Plasma Thrusters for Spacecraft Propulsion", AIAA/SAE Paper No. 73-1254, AIAA/SAE 9th Propulsion Conference, Las Vegas, Nev., Nov. 1973.

2. Guman, W.J., and Palumbo, D.J., "Pulsed Plasma Propulsion System for North-South Stationkeeping", AIAA Paper No. 76-999, AIAA International Electric Propulsion Conference, Key Biscayne, Fla., Nov. 1976.

3. Guman, W.J., and Begun, M., "Exhaust Plume Studies of a Pulsed Plasma Thruster", AIAA/DGLR Paper No. 78-704, AIAA/DGLR 13th International Electric Propulsion Conference, San Diego, Calif., Apr. 1978.

4. Guman, W.J., and Begun, M., "Pulsed Plasma Plume Studies", Air Force Rocket Propulsion Laboratory, Final Report, AFRPL-TR-77-2, Mar. 1977.

5. Palumbo, D.J., Begun, M. and Guman, W.J., "Pulsed Plasma Propulsion Technology - Interim Report for Period 10 May 1973 - 10 July 1974", AFRPL-TR-74-50, Fairchild Industries, Farmingdale, N.Y.

6. Stephens, J.B., "Space Molecular Sink Facility", 2nd Aerospace Mechanisms Symposium, May 1967.

7. Holland, L., ed., Thin Film Microelectronics, John Wiley & Sons, Inc., 1965.

8. Glassford, A.P.M., "An Analysis of the Accuracy of a Commercial Quartz Crystal Microbalance", AIAA Paper No. 76-438, July 1976.

9. Philips, R.W., et al., "Spacecraft Contamination Under Simulated Orbital Environment", J. Spacecraft, Vol. 14, No. 8, p.501, Aug. 1977.

10. Clausing, P., "The Flow of Highly Rarefied Gases Through Tubes of Arbitrary Length", J. Vac. Sci. Tech., Vol. 8, No. 5, pp. 636-646.

11. Vondra, Robert, Thomassen, Keith, and Solbes, Albert, "Analysis of Solid Teflon Pulsed Plasma Thruster", AIAA Paper No. 70-179, January 1970.

APPENDIX A

PPT EXPERIMENTAL DATA

To determine the value of the mass flux to a given QCM, the frequency of this QCM must be monitored versus time for a sufficient period to allow an accurate determination of the rate of frequency shift. This rate is equal to the slope of the QCM frequency versus time curve (for example, see Figure 8, page 22) and is found by a linear regression analysis. It is then multiplied by the QCM calibration constant (1.77×10^{-8} g-cm^{-2}-Hz^{-1}) to give the QCM mass flux. For each mass flux quoted in the main body of this report (see Figures 8, 9, 12, 13, 14, and 16), there exists a series of QCM frequency measurements over time used to calculate this value. This appendix contains, for reference, a tabulation of these raw QCM frequency data.

To develop an accurate picture of the MOLSINK-PPT backscatter, tests were run under several experimental conditions. These conditions included changes in thruster position and pulse rate as well as changes in skimmer operation (skirted or unskirted, open or closed lids, etc.). They are discussed in detail in the main body of this report. In this appendix, the QCM data are separated into seven major conditions, with each condition described prior to each data table. These tables contain only those data actually used to calculate the QCM fluxes discussed in the main report. The remainder of the data are judged to be invalid due to various problems with the test operation.

For the first two experimental conditions, the QCM data were taken by hand, while, for the remainder, the data were automatically recorded on paper tape and printed out with a teletype-printer. This automatic recording system not only monitored the time and QCM frequencies but also monitored the outputs of 27 type T thermocouples located throughout the MOLSINK environment, including the QCM's themselves. The thermocouple data were recorded on output channels 1 through 27 while channels 0, 49, and 50 were used as calibration test outputs.

The following data tables include printouts of this thermocouple data, although only the time and QCM frequencies are relevant here. The time was measured with a 24 hour clock in hours, minutes and seconds and is printed out on channel 22 with a prefix T. The QCM frequencies, in hertz, are recorded on data channels 51 through 67 and have an F prefix. The particular channel number corresponding to a given QCM is shown in Figure A-1.

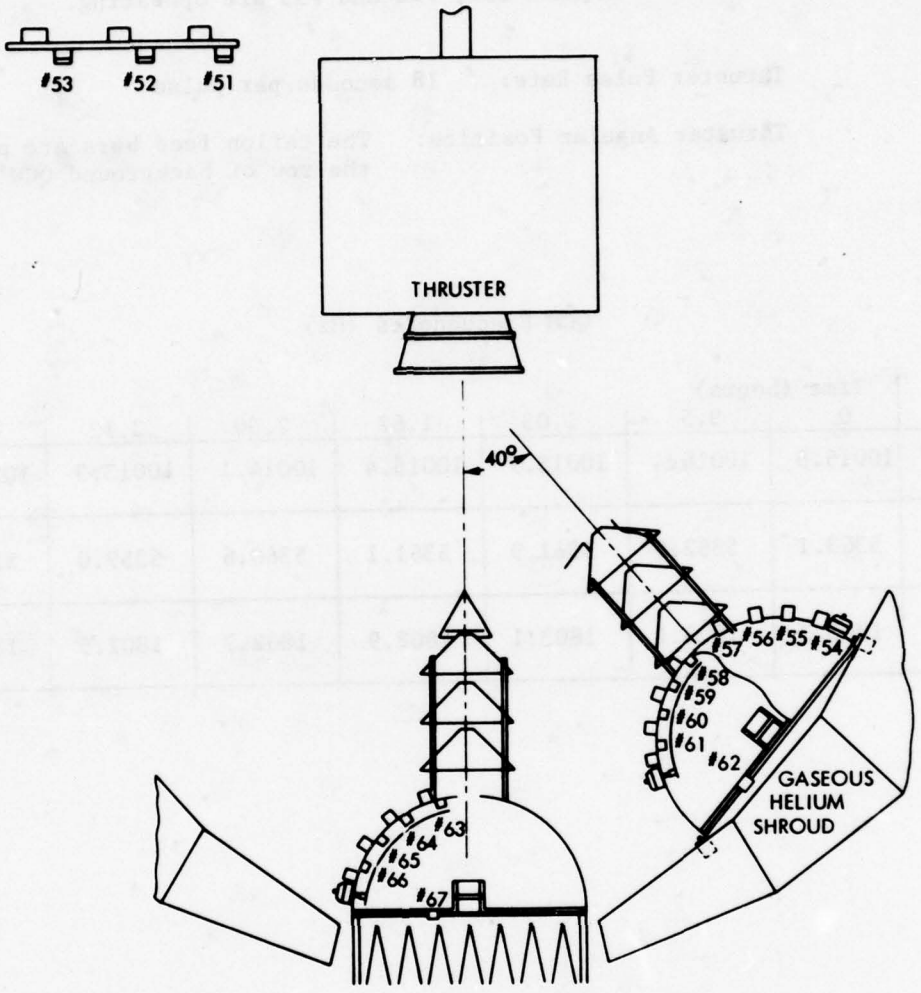


Figure A-1. QCM Number and Location

TEST CONDITION 1

Set-Up: The skimmers are not installed. Only the background QCM's #51, #52 and #53 are operating.

Thruster Pulse Rate: 18 seconds per pulse

Thruster Angular Position: The teflon feed bars are parallel to the row of background QCM's.

QCM Frequencies (Hz)

QCM #	Time (hours) 0	0.5	1.03	1.62	2.30	3.12	4.53	5.0
51	10016.8	10016.4	10015.9	10015.4	10014.1	10013.3	10012.1	10011.3
52	5363.1	5362.6	5361.9	5361.1	5360.6	5359.0	5356.9	5355.8
53	1803.3	1803.1	1803.1	1802.9	1802.7	1802.5	1802.2	1802.1

TEST CONDITION 2

Set-Up: See Condition 1.

Thruster Pulse Rate: 18 seconds per pulse.

Thruster Angular Position: To teflon feed bars are perpendicular to the row of background QCM's.

QCM Frequencies (Hz)

QCM #	Time (hours) 0	0.58	1.23	1.98	2.48	2.98	3.48
51	10010.6	10010.0	10008.7	10008.2	10007.5	10006.9	10006.2
52	5355.0	5354.3	5353.7	5302.9	5352.4	5351.9	5351.3
53	1801.8	1801.4	1800.9	1800.5	1800.2	1799.6	1799.2

TEST CONDITION 3

Set-Up: The skimmers are installed with all 17 QCMs. They are not skirted. QCM's #62 and #67 are giving spurious data.

Thruster Pulse Rate: 36 seconds per pulse.

Thruster Angular Position: See Condition 2.

```
222  T120000  000 0+0000095 001 0-0054406 002 0-0050996 003 0-0052396
004 0-0039006 007 0-0044126 008 0-0043716 011 0-0045056 013 0-0043446
 014 0-0043436 015 0-0043456 016 0-0042796 017 0-0042126 018 0+0005576
 020 0-0045236 021 0-0053146 022 0-0024956 023 0-0047586 024 0-0037616
 025 0-0049096 026 0-0031286 027 0-0057616 049 0+1000058 050 0-0999958
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 066 0F0020143 067 0F0000003
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 020 0-0045546 021 0-0053606 022 0-0024726 023 0-0047866 024 0-0036596
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 066 0F0019913 067 0F0000003
```

TEST CONDITION 4

Set-Up: The on-axis skimmer has a closed lid. QCM's #62 and #67 are in their parked positions next to the skimmer walls.

Thruster Pulse Rate: 36 seconds per pulse.

Thruster Angular Position: See Condition 2.

```
  222  T154529  000 0+0000076 001 0-0056026 002 0-0054476 003 0-0052726
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015 0-0047946 016 0-0047246 017 0-0041446 018 0+0005946 019 0-0025336
020 0-0052026 021 0-0058816 023 0-0053416 024 0-0032866 025 0-0053416
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031 0-0047986 032 0-0046216 033 0-0054096 034 0-0058796 035 0-0061336
049 0+1000078 050 0-1000018 051 0F0097983 052 0F0050863 053 0F0019233
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020 0-0052126 021 0-0058786 023 0-0053396 024 0-0028746 025 0-0053326
026 0-0043946 027 0-0042536 028 0-0043076 029 0-0046886 030 0-0048286
031 0-0044146 032 0-0045836 033 0-0054116 034 0-0058916 035 0-0061376
049 0+1000078 050 0-1000038 051 0F0097803 052 0F0050693 053 0F0019113
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064 0F0048753 065 0F0030263 066 0F0017943 067 0F0000003
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010 0-0043876 011 0-0040746 012 0-0039656 013 0-0047826 014 0-0047946
015 0-0047866 016 0-0047156 017 0-0041396 018 0+0005526 019 0-0023496
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064 0F0048753 065 0F0030253 066 0F0017933 067 0F0000003
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026 0-0043926 027 0-0042256 028 0-0042866 029 0-0046716 030 0-0048276
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222  T040001  000 0+0000066 001 0-0055926 002 0-0054396 003 0-0052706
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049 0+1000078 050 0-1000038 051 0F0097743 052 0F0050643 053 0F0019073
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026 0-0044016 027 0-0042056 028 0-0042586 029 0-0046506 030 0-0048226
031 0-0043616 032 0-0045826 033 0-0053986 034 0-0059536 035 0-0061356
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026 0-0044036 027 0-0042036 028 0-0042586 029 0-0046436 030 0-0048226
031 0-0043496 032 0-0045816 033 0-0054026 034 0-0058446 035 0-0061346
049 0+1000068 050 0-1000028 051 0F0097713 052 0F0050603 053 0F0019043
054 0F0082953 055 0F0016333 056 0F0000003 057 0F0044943 058 0F0048703
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064 0F0048683 065 0F0030213 066 0F0017853 067 0F0000003
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 026 0-0044026 027 0-0041936 028 0-0042496 029 0-0046356 030 0-0048196
 031 0-0043426 032 0-0045806 033 0-0054776 034 0-0059406 035 0-0061396
 049 0+1000078 050 0-1000038 051 0F0097693 052 0F0050583 053 0F0019033
 054 0F0082943 055 0F0016323 056 0F0000003 057 0F0044933 058 0F0048713
 059 0F0188903 060 0F0000003 061 0F0103643 062 0F0055193 063 0F0037393
 064 0F0048673 065 0F0030203 066 0F0017843 067 0F0000003
222  T080001  000 0+0000056 001 0-0055916 002 0-0054376 003 0-0052696
 004 0-0041216 005 0-0039916 007 0-0043286 008 0-0043056 009 0-0043806
 010 0-0043506 011 0-0040316 012 0-0039486 013 0-0047806 014 0-0047936
 015 0-0047846 016 0-0047146 017 0-0041386 018 0+0005606 019 0-0023236
 020 0-0052236 021 0-0058796 023 0-0053416 024 0-0028536 025 0-0053296
 026 0-0044006 027 0-0041846 028 0-0042426 029 0-0046356 030 0-0048256
 031 0-0043366 032 0-0045786 033 0-0054716 034 0-0059386 035 0-0061356
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054 0F0082933 055 0F0016333 056 0F0000003 057 0F0044933 058 0F0048703
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064 0F0048663 065 0F0030203 066 0F0017833 067 0F0000003
222  T090001  000 0+0000046 001 0-0055936 002 0-0054406 003 0-0052726
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010 0-0043496 011 0-0040306 012 0-0039456 013 0-0047836 014 0-0047956
015 0-0047856 016 0-0047156 017 0-0041396 018 0+0005096 019 0-0023946
020 0-0052556 021 0-0058816 023 0-0053446 024 0-0028706 025 0-0053316
026 0-0044056 027 0-0041816 028 0-0042396 029 0-0046316 030 0-0048246
031 0-0043316 032 0-0045806 033 0-0054546 034 0-0058886 035 0-0061386
049 0+1000078 050 0-1000028 051 0F0097653 052 0F0050543 053 0F0019013
054 0F0082933 055 0F0016323 056 0F0000003 057 0F0044933 058 0F0048713
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064 0F0048653 065 0F0030183 066 0F0017823 067 0F0000003
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TEST CONDITION 5

Set-Up: See Condition 4.

Thruster Pulse Rate: 23 seconds per pulse.

Thruster Angular Position: See Condition 2.

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222  T120001  000 0+0000046 001 0-0055946 002 0-0054426 003 0-0052736
004 0-0041186 005 0-0039896 007 0-0043316 008 0-0043046 009 0-0043806
 010 0-0043476 011 0-0040286 012 0-0039386 013 0-0047846 014 0-0047976
 015 0-0047876 016 0-0047166 017 0-0041416 018 0+0005986 019 0-0025036
 020 0-0052066 021 0-0058796 023 0-0053436 024 0-0029046 025 0-0053316
 026 0-0044066 027 0-0041666 028 0-0042246 029 0-0046196 030 0-0048196
 031 0-0043206 032 0-0045846 033 0-0055196 034 0-0060416 035 0-0061346
 049 0+1000088 050 0-1000018 051 0F0097603 052 0F0050493 053 0F0018983
 054 0F0082913 055 0F0016303 056 0F0000003 057 0F0044923 058 0F0048703
 059 0F0188883 060 0F0000003 061 0F0103643 062 0F0055193 063 0F0037333
064 0F0048623 065 0F0030153 066 0F0017783 067 0F0000003
222  T12100i  000 0+0000046 001 0-0055926 002 0-0054406 003 0-0052726
 004 0-0041186 005 0-0039896 007 0-0043306 008 0-0043066 009 0-0043826
 010 0-0043506 011 0-0040336 012 0-0039416 013 0-0047876 014 0-0047976
 015 0-0047886 016 0-0047176 017 0-0041426 018 0+0005816 019 0-0026296
 020 0-0052226 021 0-0058816 023 0-0053446 024 0-0029076 025 0-0053306
 026 0-0044086 027 0-0041696 028 0-0042226 029 0-0046196 030 0-0048246
031 0-0043236 032 0-0045896 033 0-0054956 034 0-0059836 035 0-0061356
 049 0+1000088 050 0-1000008 051 0F0097593 052 0F0050493 053 0F0018973
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222  T122001  000 0+0000026 001 0-0055956 002 0-0054426 003 0-0052736
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 015 0-0047866 016 0-0047156 017 0-0041426 018 0+0005956 019 0-0027516
 020 0-0052146 021 0-0058786 023 0-0053426 024 0-0029106 025 0-0053306
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054 0F0082903 055 0F0016303 056 0F0000003 057 0F0044923 058 0F0048703
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064 0F0048613 065 0F0030153 066 0F0017783 067 0F0000003
222  T123001  000 0+0000026 001 0-0055936 002 0-0054426 003 0-0052736
004 0-0041196 005 0-0039896 007 0-0043306 008 0-0043066 009 0-0043826
010 0-0043506 011 0-0040336 012 0-0039416 013 0-0047856 014 0-0047976
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 031 0-0043316 032 0-0045926 033 0-0055096 034 0-0060126 035 0-0061376
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054 0F0082913 055 0F0016293 056 0F0000003 057 0F0044923 058 0F0048703
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222  T124001  000 0+0000036 001 0-0055956 002 0-0054426 003 0-0052746
004 0-0041196 005 0-0039906 007 0-0043316 008 0-0043066 009 0-0043806
010 0-0043496 011 0-0040326 012 0-0039396 013 0-0047816 014 0-0047906
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020 0-0052126 021 0-0058806 023 0-0053446 024 0-0029176 025 0-0053316
026 0-0044096 027 0-0041786 028 0-0042326 029 0-0046216 030 0-0048256
031 0-0043316 032 0-0045936 033 0-0054876 034 0-0059506 035 0-0061386
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010 0-0043506 011 0-0040326 012 0-0039406 013 0-0047806 014 0-0047936
015 0-0047836 016 0-0047126 017 0-0041426 018 0+0006086 019 0-0025136
020 0-0052126 021 0-0058796 023 0-0053416 024 0-0029196 025 0-0053316
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222  T160001  000 0+0000116 001 0-0055906 002 0-0054396 003 0,0052646
004 0-0041126 005 0-0039816 007 0-0043256 008 0-0043006 009 0-0043776
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015 0-0047646 016 0-0046936 017 0-0041366 018 0+0006256 019 0-0027096
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026 0-0043856 027 0-0041606 028 0-0042196 029 0-0046086 030 0-0048076
 031 0-0043216 032 0-0045756 033 0-0054136 034 0-0059416 035 0-0061346
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222  T170001  000 0+0000126 001 0-0055926 002 0-0054406 033 0-0052656
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 026 0-0043846 027 0-0041666 028 0-0042206 029 0-0046086 030 0-0048016
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059 0F0188853 060 0F0000003 061 0F0103633 062 0F0055173 063 0F0037253
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222  T030001  000 0+0000196 001 0-0055936 002 0-0054396 003 0-0052666
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010 0-0043186 011 0-0040056 012 0-00391P6 013 0-0047406 014 0-0047516
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031 0-0043176 032 0-0045426 033 0-0053146 034 0-0057696 035 0-0061396
049 0+1000058 050 0-1000068 051 0F0097173 052 0F0050073 053 0F0018703
054 0F0082783 055 0F0016193 056 0F0000003 057 0F0044853 058 0F0048663
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064 0F0048373 065 0F0029943 066 0F0017593 067 0F0000003
```

TEST CONDITION 6

Set-Up: The on-axis skimmer is skirted around its base. QCM's #62 and #67 are in their parked positions next to the skimmer walls.

Thruster Pulse Rate: 36 seconds per pulse.

Thruster Angular Position: See Condition 2.

```
222  T150000  000 0-0000096 001 0-0056376 002 0-0054766 003 0-0053106
004 0-0051156 005 0-0053346 006 0-0000476 007 0-0053026 008 0-0052996
009 0-0053356 010 0-0053326 011 0-0053086 012 0-0052786 013 0-0049996
014 0-0050596 015 0-0050506 016 0-0049706 017 0-0050586 018 0+0007916
019 0-0015956 020 0-0053676 021 0-0056846 023 0-0055156 024 0-0049026
025 0-0053066 026 0-0045656 027 0-0053016 028 0-0053356 029 0-0054066
030 0-0051116 031 0-0053426 032 0-0050556 033 0-0056836 035 0-0061586
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059 0F0190163 060 0F0031743 061 0F0102783 062 0F0023673 063 0F0039463
064 0F0050513 065 0F0030813 066 0F0019403 067 0F0000003
222  T150200  000 0-0000136 001 0-0056186 002 0-0054566 003 0-0052886
004 0-0050976 005 0-0053156 006 0-0000286 007 0-0052856 008 0-0052836
009 0-0053446 010 0-0053166 011 0-0052926 012 0-0052626 013 0-0049846
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014 0-0050676 015 0-0050606 016 0-0049866 017 0-0050756 018 0+0008136
019 0-0014366 020 0-0053626 021 0-0056736 023 0-0055196 024 0-0049356
025 0-0053136 026 0-0045776 027 0-0053256 028 0-0053606 029 0-0054266
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049 0+1000098 050 0-1000028 051 0F0096803 052 0F0049513 053 0F0018673
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059 0F0190103 060 0F0031693 061 0F0102683 062 0F0020543 063 0F0039433
064 0F0050513 065 0F0030783 066 0F0019413 067 0F0000003
```

TEST CONDITION 7

Set-Up: Both skimmers are skirted around their bases. QCM #62 was moved from its parked position into the collimator beam at 12:17 on February 4.

Thruster Pulse Rate: 23 seconds per pulse

Thruster Angular Position: See Condition 2.

```
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004 0-0046556 005 0-0042746 006 0+0001736 007 0-0045146 008 0-0043556
009 0-0042796 010 0-0047426 011 0-0043556 012 0-0050136 013 0-0051356
014 0-0052236 015 0-0052086 016 0-0051406 017 0-0050816 018 0+0005876
019 0-0026826 020 0-0054006 021 0-0058386 023 0-0055626 024 0+0010306
025 0-0047346 026 0-0047296 027 0-0044886 028 0-0050026 029 0-0051536
030 0-0053106 031 0-0050036 032 0-0052346 033 0-0052366 035 0-0064796
049 0+0999978 050 0-1000058 051 0F0092103 052 0F0045523 053 0F0016043
054 0F0000003 055 0F0015793 056 0F0000003 057 0F0000003 058 0F0000003
059 0F0188723 060 0F0000003 061 0F0103383 062 0F0000003 063 0F0033503
064 0F0050190193 065 0F0030683 066 0F0019493 067 0F0030373
222  T105940  000 0+0000026 001 0-0056306 002 0-0054186 003 0-0053606
004 0-0048496 005 0-0042766 006 0+0001676 007 0-0045176 008 0-0043606
009 0-0042826 010 0-0047496 011 0-0043606 012 0-0050196 013 0-0051426
014 0-0052286 015 0-0052156 016 0-0051476 017 0-0050886 018 0+0005776
019 0-0027216 020 0-0054026 021 0-0058406 023 0-0055666 024 0+0010206
025 0-0045846 026 0-0047256 027 0-0044876 028 0-0050026 029 0-0051526
030 0-0053126 031 0-0050056 032 0-0052376 033 0-0052396 035 0-0065076
049 0+0999988 050 0-1000048 051 0F0092053 052 0F0045493 053 0F0016013
054 0F0082733 055 0F0015793 056 0F0000003 057 0F0000003 058 0F0000003
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064 0F0050193 065 0F0030693 066 0F0019503 067 0F0030373
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014 0-0052296 015 0-0052156 016 0-0051466 017 0-0050906 018 0+0005666
019 0-0028146 020 0-0054016 021 0-0058426 023 0-0055676 024 0+0010126
025 0-0045846 026 0-0047356 027 0-0044926 028 0-0050066 029 0-0051566
030 0-0053136 031 0-0050036 032 0-0052356 033 0-0052396 035 0-0064946
049 0+1000008 050 0-1000028 051 0F0092003 052 0F0045443 053 0F0015983
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049 0+0999998 050 0-1000028 051 0F0091953 052 0F0045403 053 0F0015963
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014 0-0052316 015 0-0052166 016 0-0051476 017 0-0050926 018 0+0006496
019 0-0027456 020 0-0054026 021 0-0058426 023 0-0055716 024 0+0009916
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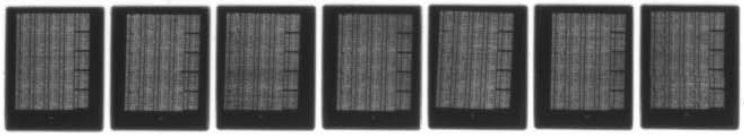
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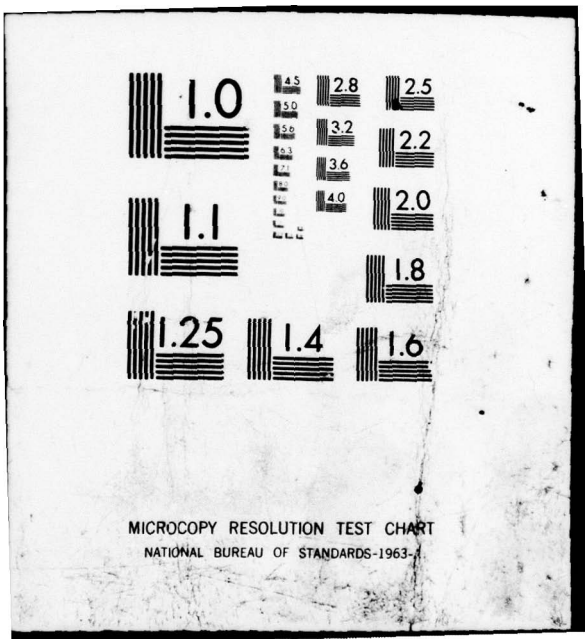
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UNCLASSIFIED JPL-PUB-78-96 AFRPL-TR-78-63 NL

2 OF 2
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