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Final Report

on

Contract NAS8-26715

A STUDY AND ANALYSIS OF THE MSFC LUNAR ROVING VEHICLE DUST PROFILE TEST PROGRAM

by

C. Howell Mullis
Principal Investigator

November, 1971

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INTRODUCTION AND BACKGROUND

Rather early in the Lunar Rover Vehicle (LRV) design and test program, it was recognized that dust could create problems and produce unacceptable hazards for the astronauts engaged in LRV missions. Some of the problems and hazards identified were:

a) dust could settle on the face plates of the astronauts helmets; because they wear such cumbersome gloves, it would be impossible to clean dusty face plates;

b) dust clouds could be thrown ahead of the vehicle obscuring obstacles ahead;

c) dust could settle on instrument panels obscuring dials, or even harm the instruments themselves;

d) rocks and pebbles could be picked up by the wheels and hurled with enough force to injure the astronauts or damage equipment.

These problems were identified independently both at NASA headquarters and at Marshall Space Flight Center. Once the questions were raised, answers were sought.

It was found that almost no information was available on the behavior of dust in a vacuum environment, and no studies had been made of the behavior of dust under reduced gravity. J. D. Halajian at Grumman Aircraft had conducted a study to try to explain the behavior of dust as a cohesive soil on the moon when it should have behaved as a cohesionless soil since no moisture is present on the moon's surface. It is well known that moisture is required on earth for fine-grained soil to exhibit the very complex physicochemical soil mechanics phenomenon known as cohesion. Since apparent cohesion was detected during Surveyor missions and confirmed during Apollo missions, there was obviously another explanation. J. D. Halajian hypothesized that under reduced pressure and high heat, the surface of the individual dust particles would be "boiled clean" of impurities and, thus, exhibit the so-called "clean body" effect. He was able to verify this hypothesis experimentally in the laboratory.

There was another problem identified early in the design of the LRV. This was the problem of weight. When the question of dust was raised, the weight watchers challenged the importance of dust when fenders were proposed as the solution to dust. This impasse was finally broken by management decision, and thin, ligat-weight fiber glass fenders were ordered designed for the LRV. Still, there was no way of knowing whether any design was effective unless it could be tested under lunar conditions.

In the spring of 1970 a modest, trial test program was authorized to study the dust problem and fender design. An ambient test fixture was designed to test the performance of a full-sized wheel under one-sixth gravity (1/6 g.) test conditions. The reduced gravity was to be obtained by flying the test fixture in an Air Force C-135A aircraft.

The test fixture was constructed at Marshall Space Flight Center, Alabama. The soil used was a Lunar Soil Simulant (LSS) manufactured at the U.S. Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Early in the Apollo program a team of soils engineers and geologists had been appointed to evaluate lunar soil data and develop criteria which would allow the manufacture of lunar soil simulants on earth using terrestial materials which would most closely duplicate lunar soils. They established five such lunar soil simulants. The LSS which most closely duplicated expected soil conditions at the Apollo 15 site was LSS-4. In Table 1 of this report will be found the characteristics of LSS-4.

TABLE 1

SOIL MECHANICS CHARACTERISTICS OF LUNAR SOIL SIMULANT (LSS) 4

Official Name: Lunar Soil Simulant 4

Parent Rock Source: Basalt Rock Company, Napa, California

Specific Gravity of Solids: 2.85

Dry Density: 1.5 g/cc

Secant Friction Angle: 38.5°

Cohesion: Trench, 0.11 psi; Bevameter, 0.12 psi

Grain Size Distribution: D60 = 0.19 mm
D10 = 0.0065
Cu = 29.3

Distribution Classification: Well-Graded

Color: Cement Gray

Manufacturer and Test Laboratory: U.S. Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi

The test fixture was ground tested at Marshall Space Flight Center and found to perform in a satisfactory manner. It was then disassembled and shipped to Dayton, Ohio where it was flight tested in July of 1970. Much was learned in these tests, both as to the behavior of dust under reduced gravity and to methods of obtaining better results.

It was found that the dust problem was as critical as the most pessimistic had predicted and forced opponents of fenders to concede that they were required. As a result of these tests, it was decided to conduct a test program to study the influence of vacuum on the behavior of dust as well as that of gravity.

A second generation test fixture was designed. A detailed description of this device is contained in the next section of this report.

DESCRIPTION OF THE TEST EQUIPMENT

The test fixture consists of a circular bed eight feet in diameter. On the bed is a soil trough 22 3/4 inches wide with a track diameter of five feet, two inches. Located at the center of the bed is a vertical shaft which supports a horizontal arm with the LRV wheel, suspension system, and drive motor at its outer end.

At the top of the vertical shaft is mounted a 24 position slip ring. The purpose of the slip ring is to accommodate the test instrumentation, lighting, and cameras. Diametrically opposite the wheel is another horizontal arm with a soil tiller at the end. The soil tiller is used to return the lunar soil simulant to the proper density after each test run. The two horizontal arms are so attached that when one is lowered, the other may be raised; i.e., when the wheel is in operation, the tiller is raised out of the soil and, conversely, when the tiller is being used to prepare the soil,the wheel is raised.

Fitting over the entire test bed and vertical shaft is a hemispherical vacuum chamber. The chamber is eight feet in diameter and four feet high. It is made of one-quarter inch carbon steel plate with a three-eights inch skirt welded to the bottom of the chamber. The purpose of the skirt is to allow the chamber to be bolted to the test bed.

The chamber contains an access door which is secured by ten dogs. The access door has a three foot vertical clearance and a one foot, eight inch horizontal clearance.

Three camera and viewing ports are provided in the shell of the vacuum chamber and one port in the access door. Camera brackets are provided at two of the shell viewing ports and in the door port. The other shell port is blanked off at present and was not used during this test program.

There are camera brackets attached to the horizontal wheel arm. These brackets are so oriented that one camera tracks the front of the wheel, and the other tracks the rear of the wheel.

There are two internal lighting systems within the chamber. One is a conventional lighting system, and the other is used for photography.

Two vacuum pumps are provided in the system. Normally only one pump at a time is used to evacuate the chamber. The other pump is held on stand-by as a backup. Each pump has a capacity of 30 standard cubic feet of air per minute.

Finally, the entire assembly is mounted on a structural frame. The purpose of the frame is to provide sufficient bolt holes to allow the assembly to be secured to the aircraft in such a manner that the assembly will withstand an aircraft deceleration of 16 g's.

The entire assembly weighs 9600 pounds when filled with 10 1/2 inches of lunar soil simulant. Air bearings are provided so that the assembly can be moved without damage to structure or assembly.

The wheel is provided with a spring assembly which allows a normal force to be applied to the wheel that is independent of gravity. All internal operations, such as running or lifting the wheel, tilling soil, etc., are remote controlled from the outside.

In Figure 1 of this report is shown a view of the test fixture mounted in the C-135A aircraft. In the foreground are the vacuum pumps and some of the instrumentation.

In figure 2 is seen the wheel assembly, fender and suspension system as seen through the access door. The wheel has been raised and the LSS has been tilled.

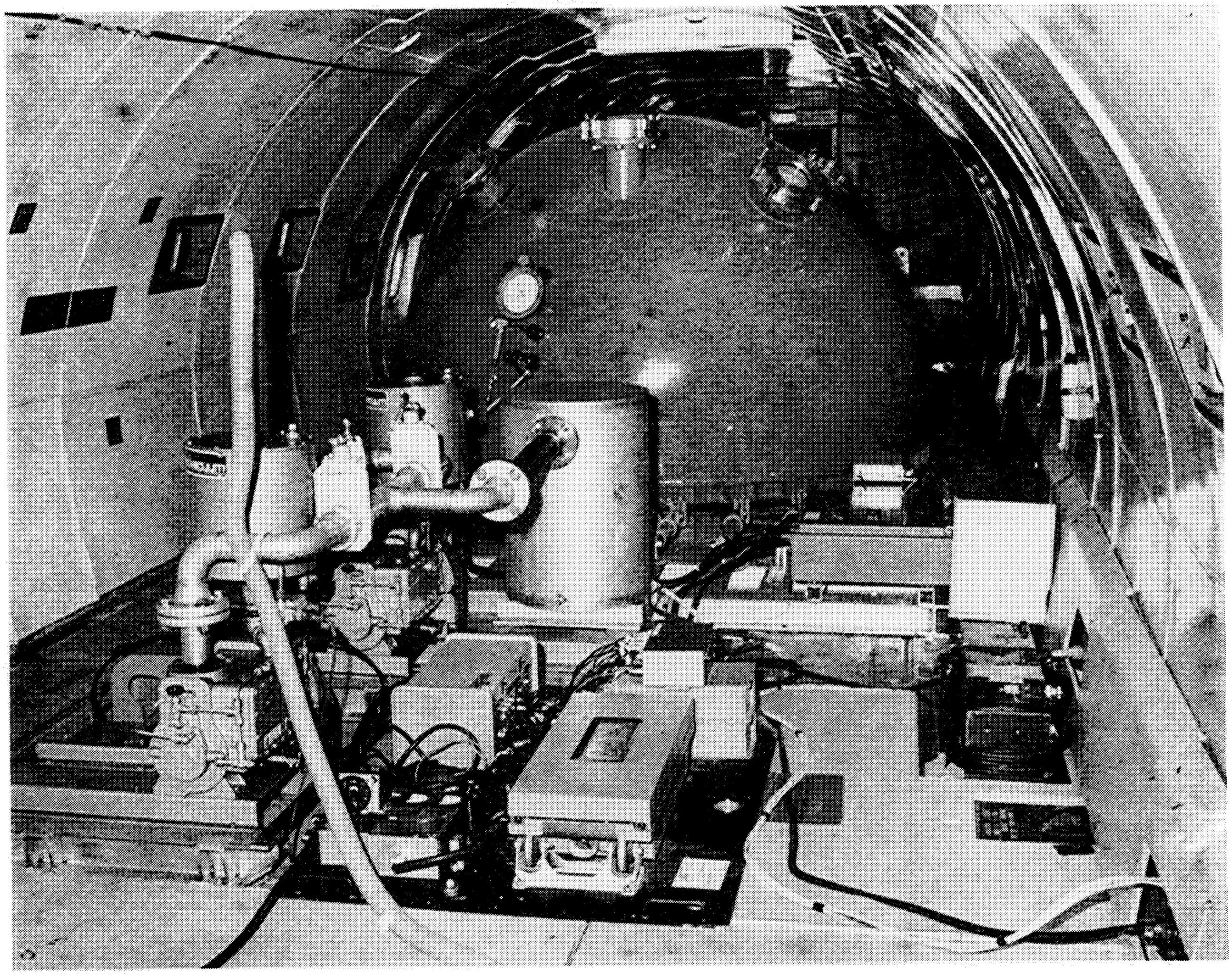

Figure 1--Text Fixture and Instrumentation in C-135A aircraft.

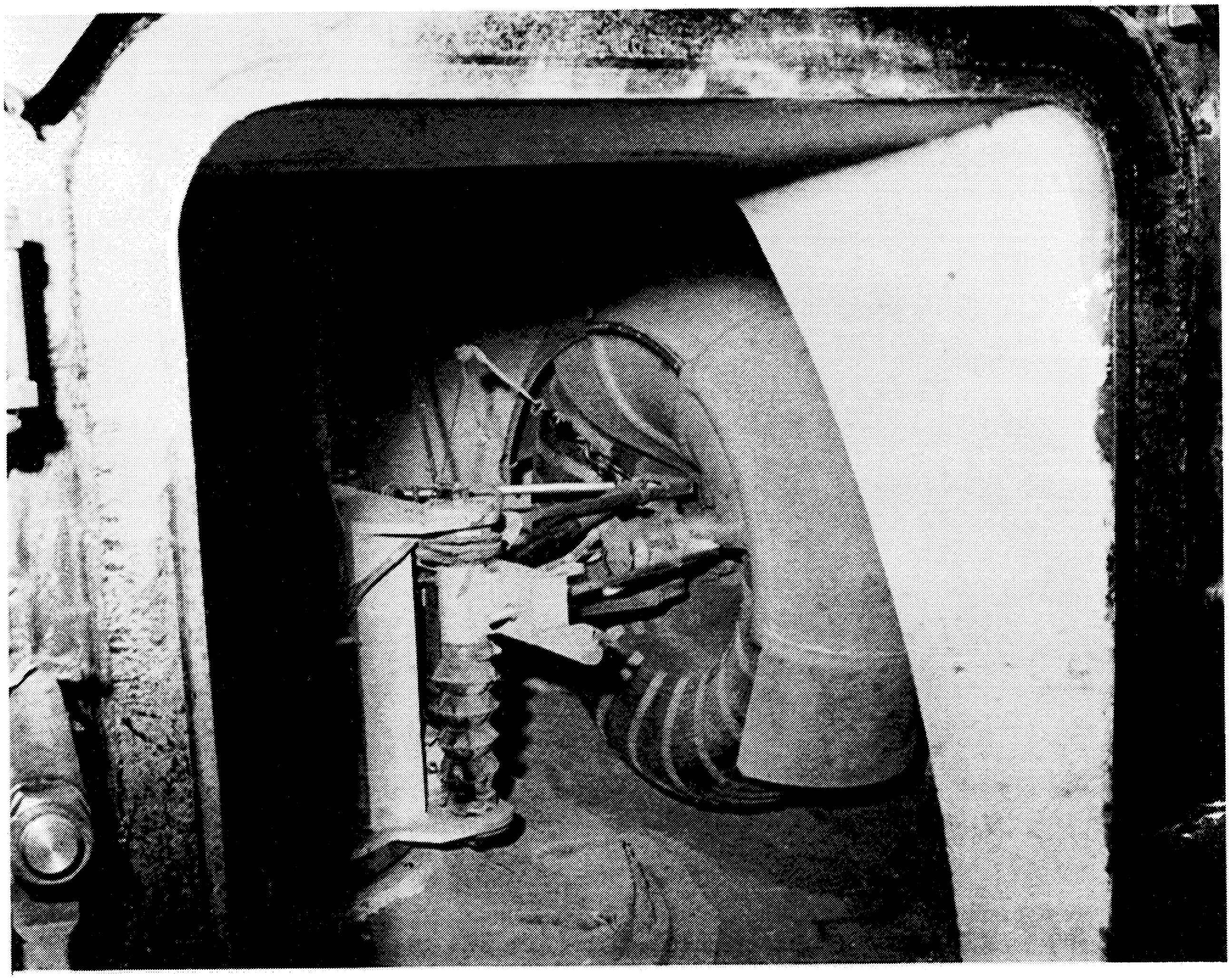

Figure 2--Close up of Wheel and Fender.

TEST OBJECTIVES AND PROCEDURES

Four test objectives were identified for this test program. These are as follows:

1. to evaluate the performance of the LRV fender designs and configurations;
2. to develop an understanding of the suspended solids behavior of lunar soil with respect to astronaut-vehicle performance and efficiency;
3. to identify and evaluate the problems generated by wheel-fender interactions; and
4. to develop a fuller understanding of lunar soil mechanics.

Tests were conducted as a two phase testing program. Phase I was a set of ground tests in which instrumentation and equipment was de-bugged and personnel became familiar with the equipment. During this phase, test procedures and parameters were developed for incorporation into Phase II. During Phase I, tests were conducted both under ambient and under vacuum conditions.

Early in Phase I, it was decided to conduct qualitative tests to see just what role fenders did play in solving the dust problem. Accordingly, a fender was fabricated of heavy lucite. It was so constructed that almost the whole wheel (top, both sides, front and rear) was enclosed.

Tests were conducted under ambient conditions and it was demonstrated to the satisfaction of all concerned that the more fender cover provided, the less suspended dust was generated. The wheel was observed to pick up as much dust as usual, but the fender trapped the dust and directed it downward in such a fashion that even though the wheel was always travelling in a dust puddle, the dust stayed close to the bottom of the test fixture and caused little trouble.

Partially as a result of these tests and partially as a result of theoretical calculations made by Boeing engineers, flaps were added to the prototype fender. It was felt that this addition would provide sufficient coverage to the wheel to reduce the dust level to acceptable limits. The soundness of this decision was demonstrated through additional testing.

Some people were concerned that because the LRV wheels are woven wire mesh, the meshes might possibly trap rocks or pebbles in the meshes and later hurl these pebbles in such a fashion that the astronauts and/or equipment could possibly be damaged. Therefore, it was decided to prepare a special soil bed of one inch to pea gravel sized crushed basalt and see if this did, indeed, happen. It was found that this phenomenon did not occur at speeds that were within the range of LRV capabilities. These tests were so conclusive that no further tests using this special material were conducted.

Test parameters for Phase I were established as follows:

1. wheel RPM;
2. wheel normal force; and
3. degree of vacuum.

A series of runs were made increasing wheel RPM with each run. The normal force was kept constant. Then the normal force was increased an increment and another series of runs made at different RPM's. The entire procedure was conducted both under ambient pressure and at varying degrees of vacuum.

Since this test program did not lend itself well to conventional soil mechanics laboratory testing procedures, it was planned to utilize photography and photoelectric cells in a quantitative as well as qualitative manner. It was assumed, from the start, that this would be a trial-and-error type procedure in an attempt to find a combination that would yield the most meaningful results.

It was further decided that the acceptance criteria would be on a "best-effort" basis.

While conducting the Phase I tests, it was found that numerous technical difficulties were encountered with the photoelectric cells. Due to the press for time in getting ready for the Phase II program, photoelectric cells were reluctently dropped from the program.

The Phase II program was a duplication of the Phase I tests except they were conducted aboard an Air Force C-135A aircraft which flew parabolas that produced 1/6 g. conditions. The Phase II tests were conducted by Marshall Space Flight Center and contractor support personnel during the periods May 5 and 7 and May 10-12, 1971. A total of 65 tests were conducted and significant data are presented as Appendix A to this report.

In Figure 3 is seen the very close fit of the assembled vacuum chamber in the C-135A The vacuum pumps and some of the instrumentation is shown in Figure 4. The wheel, fender, fender flap, suspension system, and tilled soil are seen in Figure 5. The camera is looking through the opened access hatch. The white stripes on the wheel are to aid in determining wheel position and RPM's during these tests; they are not on flight wheels.

These flight tests were typical of many tests that are conducted using newly designed equipment and sophisticated instrumentation in that a series of annoying malfunctions occurred and had to be corrected. For example, on May 5 the voltage measurement cable was damaged during the tests. As a result, most of the voltage data were lost and no power calculations could be made. The May 5 tests were repeated on May 10 and a good set of data was obtained.

A portion of the film coverage for the tests of May 6 and 7 were damaged. These tests were repeated on May 12 in two additional flights.

Throughout the tests, an annoying, interesting and still unexplained thing happened. During flight tests, observers heard a penetrating metallic noise interpreted to be bearing friction noise. This noise was also recorded on the voice channel of the instrumentation tape and could possibly suggest higher power requirements for wheel operation in this series of tests. This

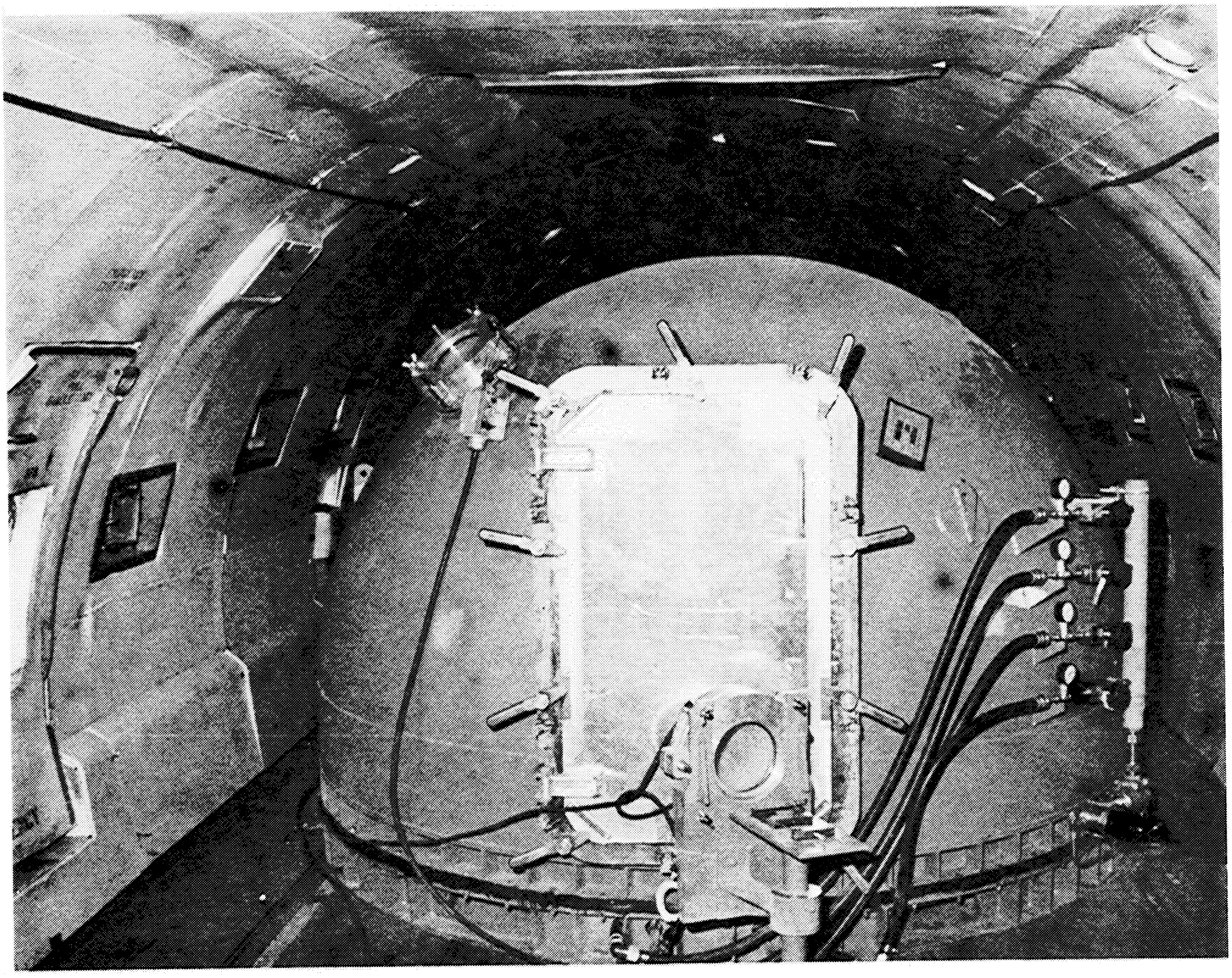

Figure 3--Showing Close Fit of Test Fixture in C-135A Aircraft.

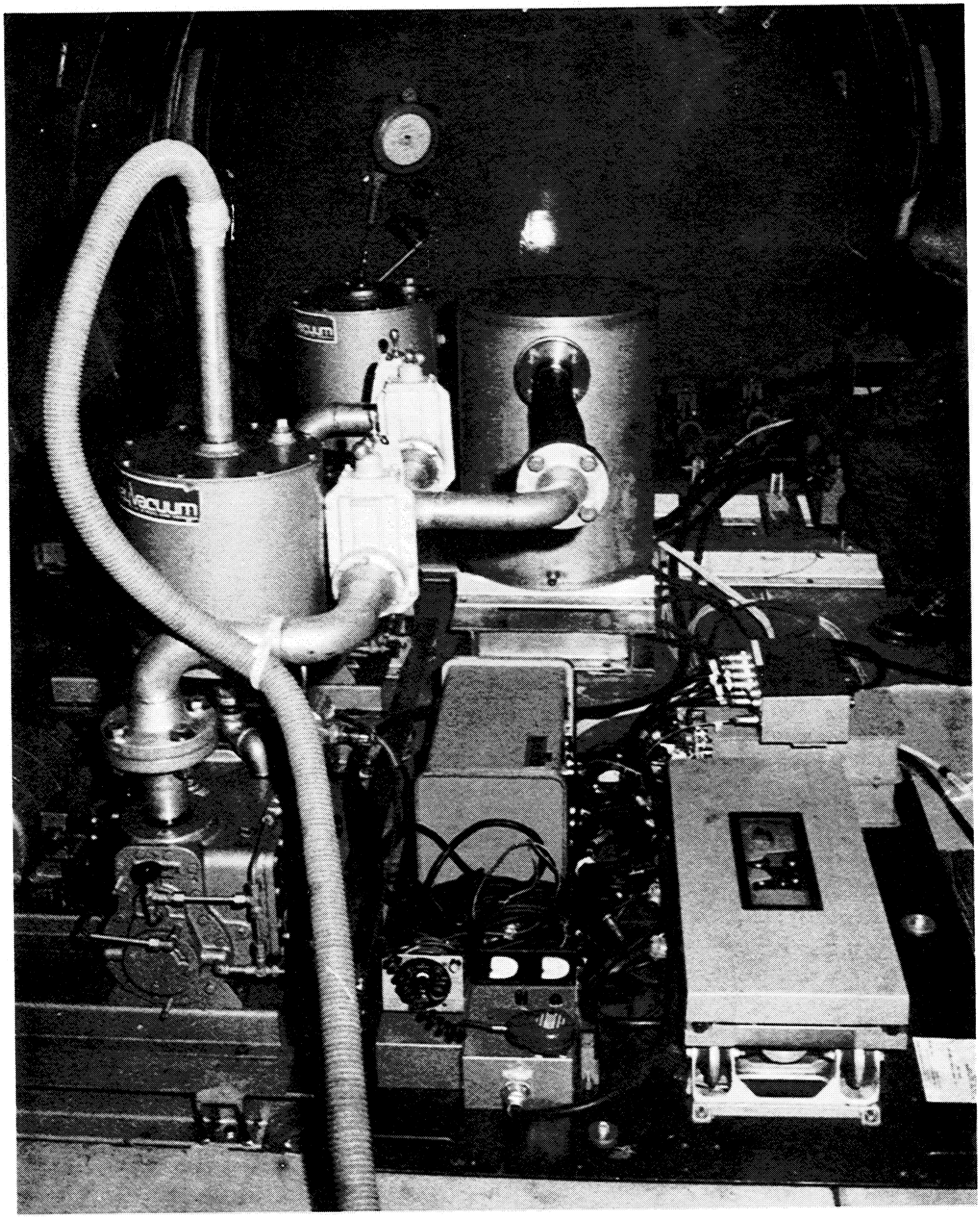

Figure 4--Vacuum pumps and Instrumentation.

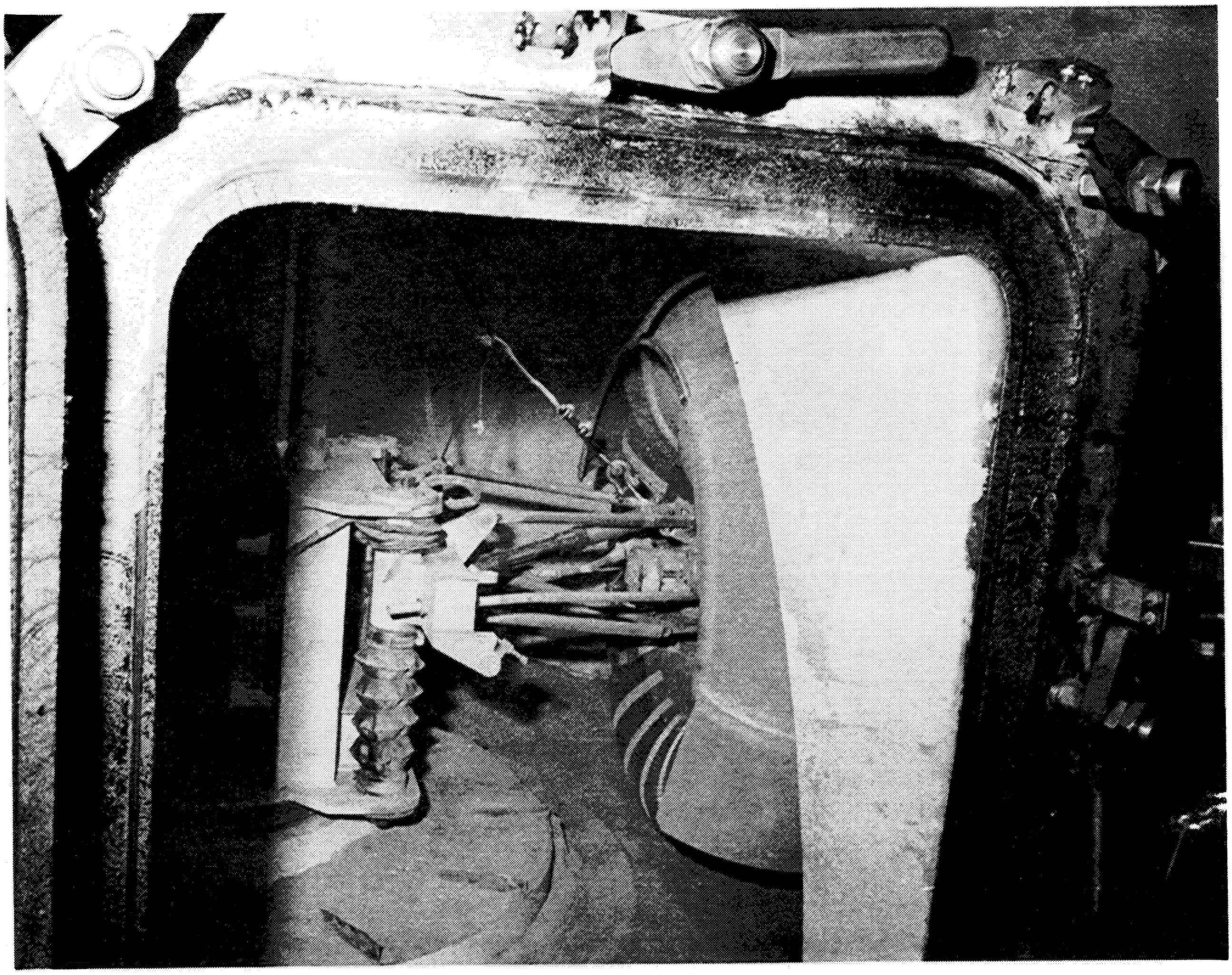

Figure 5--Wheel, fender, suspension system and tilled soil.

noise was apparently present in all the tests, but was especially noticeable during soil tilling operations.

This noise was not detected during Phase I tests nor was it detected when, subsequent to the above described tests, the LRV test fixture was utilized to conduct a series of tests requested by MSC, Houston. These tests did not utilize the wheel drive mechanism. Only the tiller and grader portions of the carriage were operated.

At the last minute it was decided to add one more test to the program. An iron bar was installed in the soil bed to simulate an obstacle. Tests were conducted to observe the behavior of wheel, fender, flap and suspension system when an obstacle was encountered under test conditions. Following this, a hole was dug near the bar to present another obstacle. The only test procedure variation was that no tilling was possible during this series of tests. Post flight analysis of test films revealed that the system worked beautifully while overcoming obstacles. When the flap struck the bar it deflected enough to clear the bar and then returned to its original shape. In Figure 6 may be seen the flap brushing the bar.

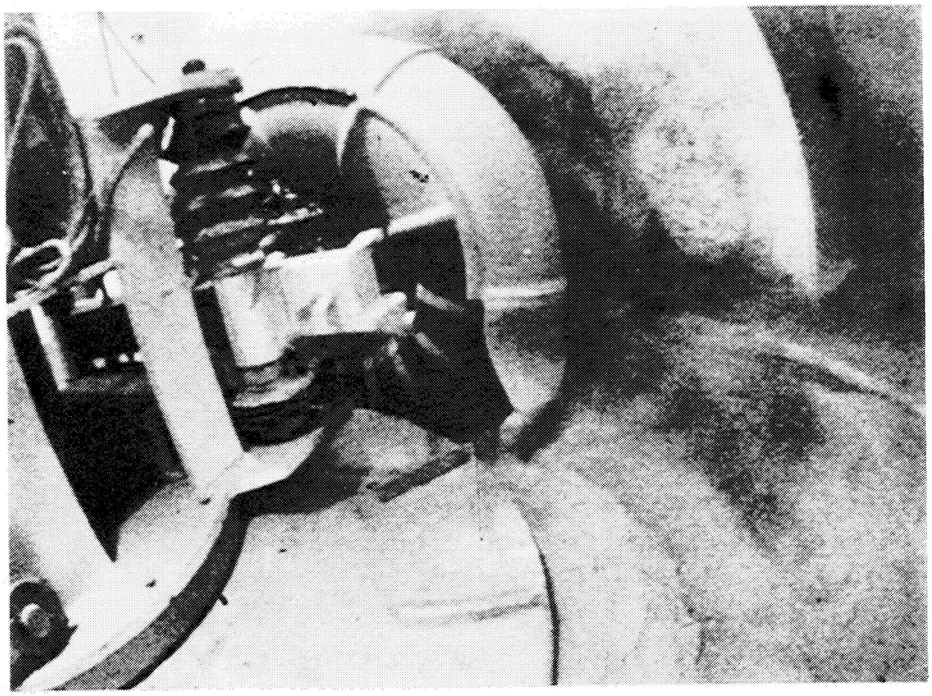

Figure 6--Fender Flap striking obstacle.

TEST RESULTS

The results of the test program can be evaluated from many perspectives depending on the interests and requirements of any particular analyzer. For the purposes of this report, the test results will be evaluated with respect to how well the test objectives of this particular contract were met and satisfied.

Raw data, test films and processed data from many Marshall sources were utilized in this study. The most valuable source was the many reels of color film taken during the test program. These films are stored in the archives of S&E-ASTN-SMS, and are available for review upon request.

Many internal Marshall reports were reviewed. It was felt that the most pertinent reports were S&E-ASTN-T1(71-82) of May 26, 1971; S&E-ASTN-T1(71-101) of June 23, 1971; and S&E-ASTN-SMS(71-25) of July 6, 1971.

There were four contract test specifications to be satisfied:

1. To evaluate the performance of the LRV fender designs and configurations.

A plexiglass fender was fabricated that almost completely enclosed the wheel. Ambient tests at 1 g. were conducted and it was quickly demonstrated that the more the wheel was covered, the less dust would go into suspension. Photographic studies revealed that the woven wire wheels generated as much dust as ever, but that the fender confined this dust and directed it downward where it remained.

An extension flap was added to the prototype fender. The length of this flap was determined by analytical calculations of Boeing engineers and was accepted by Marshall as the minimum desired fender addition. The flap was effective in reducing suspended dust in the plane of the wheel travel but did not aid in dust reduction emitted to the side. It was never clear whether the dust thrown to the side was the result of improper fender coverage, or because the wheel was moving in a circular path and the side dust was the result of centrifugal forces. No detailed study was made of this phenomenon because, by being thrown to the side, the dust was no longer a problem to astronaut or vehicle. In Figure 7 may be seen the dust thrown to the side as the wheel is turning toward the viewer. It can be seen that this dust presents no problem.

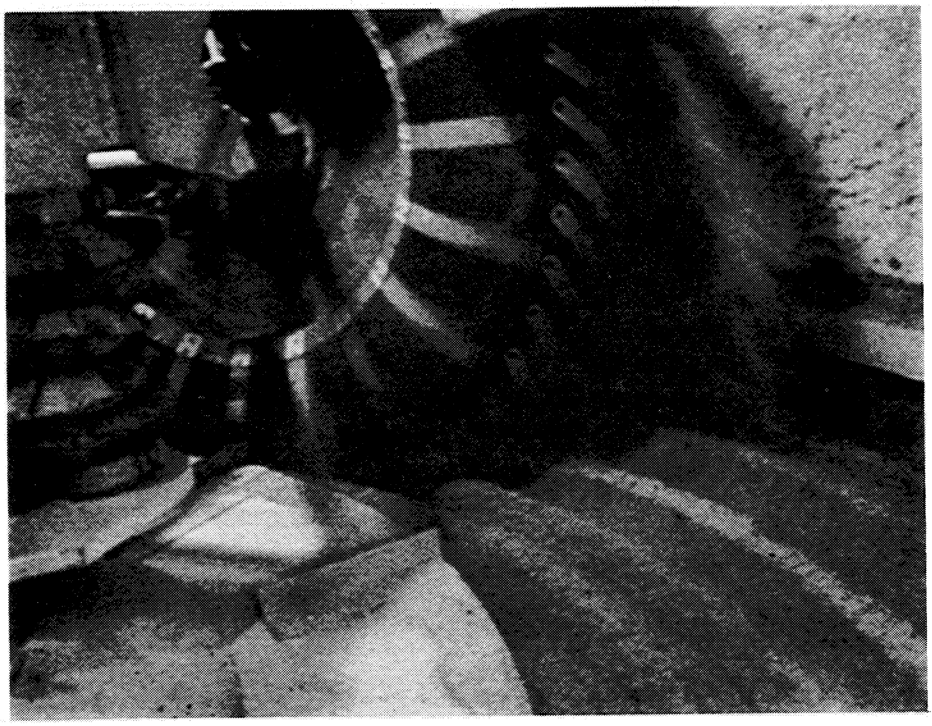

Figure 7--Showing Centrifugal Dust Trajectories.

It is felt that the test program demonstrated that the basic fender design was inadequate in performance. In the test program, it was further demonstrated that the more wheel coverage provided, the more one could control the inevitable dust produced by the woven wire wheels.

Finally, it was demonstrated that the flap addition to the prototype fender provided minimum acceptable dust control. It also demonstrated that the flap was flexible and tough enough to withstand blows from obstacles the wheel encountered (see Figure 6).

2. To develop an understanding of the suspended solids behavior of lunar soil with respect to astronaut-vehicle performance and efficiency.

In order to satisfy test objective 2, several different problems had to be studied.

a) How was the generated dust diffused?

b) Which diffusion paths were sources of potential trouble and which could be ignored?

c) What parameters seemed to play the biggest roles in "a" and "b" above?

Let the reader imagine that he is looking at an unfendered wheel travelling from his right to his left, and also travelling in a circular path around the reader. At any point in time imagine that the point of contact of wheel and soil is zero degrees on a compass rose. Then the top of the wheel would be 180° and the right quadrant would be 270°. The reader would see five distinct dust phenomena occurring simultaneously. A "rooster tail" of dust would be thrown out from the lower right quadrant. This is due primarily to shear failure in the soil as the wheel moves past. The dust from the front wheels would pose serious problems to the astronauts. The dust from the rear wheel "rooster tails" would be left behind as the vehicle moved forward and pose no problem. When the vehicle was going in reverse, the opposite would be true.

The second phenomenon the viewer would see would be dust moving around internally within the hollow wheel. This dust is not really a problem, although a mass transfer of dust is occurring continually.

The third phenomenon is a plume of dust being thrown off forward along the arc 120°-060°. This plume is potentially the most serious dust problem to astronaut and vehicle.

The fourth phenomenon is a dust "bow wave" moving forward with the wheel. This is a shear failure phenomenon. The wheel is always imbedded in the soil (rutting) and as the wheel moves forward, it presses against the soil slope and causes the soil to fail and move forward also. Thus, to move forward, the wheel must always try to climb the soil slope and, at the same time, push the failed soil ahead of it. This phenomenon causes no astronaut problem, but it does affect vehicle performance by requiring more power be used.

The fifth phenomenon observed is a lateral cloud of dust. This cloud is produced by centrifugal forces generated as the wheel travels in a circular path around the observer. This cloud is the vector sum of the first three phenomena. Since this cloud is moving normal to the path of travel, it does not pose a problem to astronaut or vehicle.

The parameters which most affected the dust generated were wheel normal force and wheel speed. The heavier the wheel load, the more "bite" the wheel got of the soil. This resulted in greater dust generation and a bigger "bow wave." The faster the wheel rotated, the bigger the "rooster tail" and the bigger the forward plume.

It is felt that test objective 2 was thoroughly studied and well understood.

3. To identify and evaluate the problem generated by wheel-fender interactions.

The most readily apparent problem associated with wheel-fender interactions was that of potential damage to the wheels and/or fenders if the wheels picked up, or threw, rock sized particles. A separate set of tests was conducted using crushed basalt ranging from one inch size down to pea gravel as the test material. During these tests a close watch was maintained for any sign of the wheel picking up rocks and none was observed. Therefore, it could be concluded that the probability of this potential danger occurring was very small and could be ignored.

It was speculated prior to the tests that the situation could exist that the wheel could represent a pump impeller and that the fender could represent a pump casing. In this event, the dust would represent the fluid. Since it takes power for a pump to operate, this power consumption would represent an unplanned drain on the already underpowered battery of the LRV. An attempt to study this power problem was incorporated into the test program. Pertinent data from these tests may be found in Appendix A to this report. A confused picture developed. Instead of the wheel-fender system requiring more power to "pump" dust around the system, it was found from data review that less power was required with fenders than without. It was also found that the greater the normal force on the wheel the less the power requirement. There is no logical explanation for these apparent anomalies to reason. Therefore, it is concluded that the power data itself is suspect.

One of the most pertinent evaluations of wheel performance is slip, which is defined as the ratio of the difference between theoretical and actual distance travelled to the theoretical distance travelled. From an analysis of the data it was detected that at low speeds the affect of wheel normal force was minimal; i.e., the slip was about the same. However, at higher rates of speed, the wheel with the larger normal force had less slip and was therefore more efficient. This confirmed what had previously been expected.

It was feared that the paper thin fiberglass fender could not withstand the sand blast effect of the LSS over long periods of time. After each test run the fender was carefully examined for wear. During the entire testing period there was no evidence of wear anywhere on the fender; therefore, it was concluded that "sand blasting" is not of concern.

It is felt that test objective 3 was properly investigated.

Test objective 4 was to develop a fuller understanding of lunar soil mechanics.

There is virtually nothing in the literature concerning the behavior of soil in a reduced pressure environment. There was much speculation as to the most probable cause of the apparent cohesion of lunar soil, as reported by the astronauts. On earth, clay does not exhibit cohesion unless it has moisture present. In the reduced pressure of the moon, there was no possibility of there being any moisture, yet the soil exhibited apparent cohesion. Why? Vacuum conditions on the moon seem to cause all surface impurities on the individual soil grains to "boil off" leaving a "clean body." This clean body effect is what seems to cause the apparent cohesion. At the start of this test program a vacuum of several tors had been planned. Due to flight limitations this had to be abandoned and a pressure of 2-5 mm of mercury was the best that could be hoped for. This does not nearly approach hard vacuum conditions even though over 99 per cent of the air is evacuated. It was found that during the test program, whenever the pressure was less than 5 mm Hg, the LSS started to exhibit apparent cohesion. "Clumps" of LSS would be thrown up by the wheel and remain as a coherent mass until it struck some solid object, such as the chamber wall. It would then splatter upon impact. A lot of these clumps would stick to the sides of the chamber.

Due to the short time and limited budget availalbe for these tests, no remote controlled soil mechanics testing equipment was developed. The LSS was air dried before testing and the moisture content determined by standard techniques. The soil was retested for moisture content after being exposed to the reduced pressure of the test apparatus. Table 2 of this report is a summary of these moisture contents.

TABLE 2

MOISTURE CONTENT OF LUNAR SOIL SIMULENT

Test Condition	Air Dried, %	Vacuum, %
Ground Test	0.89	0.71
Ground Test	0.93	0.62
Flight Test		0.65
Ave	0.91	0.66

Per cent Change $\frac{0.91 - 0.66}{0.91} \times 100\% = 27.4\%$

Although the magnitudes of these moisture contents are small (a typical clay moisture content would be about 20 per cent), the per cent change is quite impressive. This indicates that at only 5 mm Hg pressure a great deal of surface "boiling" is taking place. Hence, the apparent cohesion detected during tests is most probably due to this clean body effect.

An attempt was made to exercise quality control of the LSS during tests by tilling the soil after each test until the same density was obtained. Penetrometer measurements were made to check tilling results. During the test program it was noted that penetrometer readings during flight tests were larger than those taken during ground tests. The significance of this would be that the soil was stronger during flights. There are two probable explanations for this. One is that the soil was compacted by g. forces; that is, for every 1/6 g. obtained, there is a corresponding two g. force. This two g. force could have compacted the soil. The other explanation is that air craft vibration compacted the soil. The author is inclined to choose the latter explanation.

When fine-grained soil is hurled into the atmosphere, it is diffused by air resistance. The grains are so small that they tend to float in the air.

Gravity forces tend to cause the grains to settle down and buoyant forces tend to cause them to remain in suspension. Settling time is a function of the well known Stokes law--the dust always ultimately settles.

At the start of this test program it was not known how changes in these body forces, gravity, air density, and buoyancy, would influence the generated dust. Reduced gravity should tend to cause a longer settling time, and hence, dust clouds should linger longer. Reduced air density should result in changed dust cloud patterns. Reduced buoyancy should cause the dust to settle faster. It was quickly demonstrated that changes in air density and buoyancy overcame changes in gravity and the dust problem was not nearly as serious under test conditions as it was under ambient conditions. Serendipity triumphs!

The dust continued to act as a fluid, but little or no dispersion occurred. The dust streamed out from the wheel as a jet and followed a natural trajectory back to the surface. This phenomenon is dramatically illustrated in Figure 8. Note the dust streams remaining discrete. Also note the clarity of the chamber. Under ambient test conditions, the chamber would be full of dust.

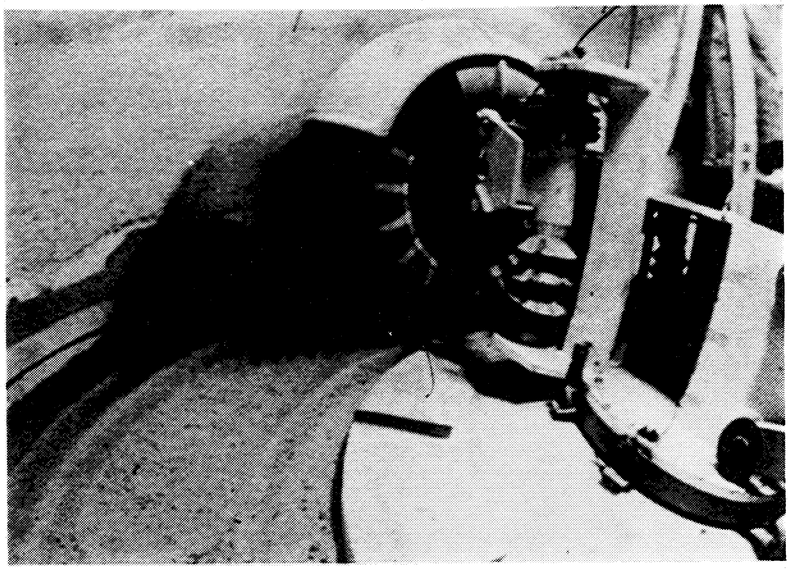

Figure 8--Jet-like Dust Trajectories in Vacuum Environment.

Figure 9 is a close-up of this same phenomenon as seen through the lower viewing port.

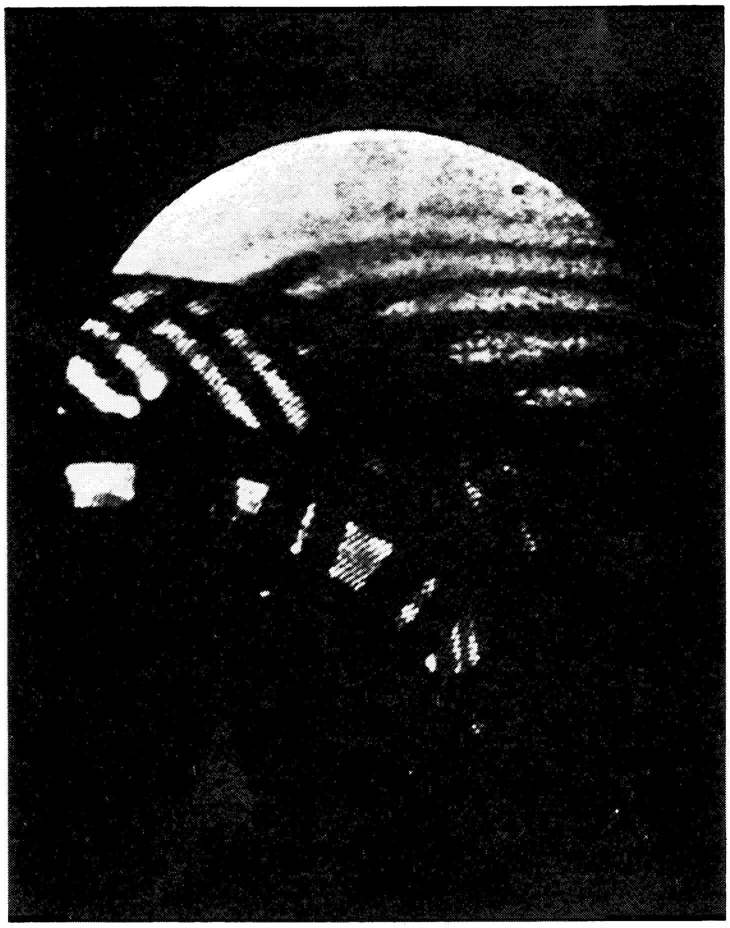

Figure 9--Close up of jet-like Trajectories.

It is felt that test objective 4 was satisfied since a great deal was learned about the behavior of soils under reduced pressure and gravity.

Thus, it has been shown that all four test objectives were satisfied during the test program.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be offered from the results of the test program:

a) The fender plus flap design is adequate for mission speeds.

b) Vacuum conditions tend to eliminate or reduce the problem of suspended dust clouds.

c) Reduced gravity conditions tend to increase the dust problem.

d) Vacuum conditions play a bigger role in the dust problem than gravity conditions do. The result is a reduced dust problem.

e) Normal forces on the wheel are more important with respect to slip than with respect to dust.

f) Slow starting speeds are necessary to minimize slip and reduce initial dust generation.

In addition to the above conclusions, the following recommendations are presented for consideration:

1. The vacuum chamber and test carousel are very versitile test devices. They were used by MSC, Houston for some tests of theirs that were not related to the dust profile tests at all. It is felt that other test uses could be made of this equipment. It is, therefore, recommended that the equipment be maintained in good condition and should be made available to others for their test requirements.

2. Since some of the data obtained during the test program was highly suspect, it is recommended that now that time is available the instrumentation people refine their equipment and "de-bug" suspect instrumentation.

APPENDIX

TABLE 3

REVISION 1, JUNE 21, 1971

SUMMARY OF LRV DUST PROFILE TEST DATA AT 1/6G, 6 MAY-12 MAY, 1971

Test Number	Motor Power Watts	Wheel RPM	% Slip	Chamber Pressure mm Hg
1/6g-Fender Installed-Soil Graded & Tilled-30 lb. Spring				
May 6				
1	296.0	46.5	26.1	3.50
2	63.0	23.3	12.8	3.75
3	63.0	26.0	12.8	4.00
4	293.0	46.5	27.3	4.00
5	268.0	45.7	20.7	4.25
6	53.0	26.0	19.3	4.50
7	53.0	26.8	12.8	NONE
8	288.0	46.5	36.8	NONE
1/6g-Fender Installed-Soil Graded & Tilled-60 lb. Spring				
May 7				
0				3.50
1	56.3	26.0	12.8	3.50
2*	56.3	26.0	12.8	3.75
3	279.0	465.	24.8	3.75
4	59.0	26.8	12.8	4.00
5*	63.0	26.0	12.8	4.00
6	267.0	48.5	20.7	4.25
7*	63.0	26.8	12.8	4.25
8	264.0	48.5	20.7	4.50
9	56.7	27.3	12.8	4.75
*Wheel in Reverse				
1/6g-Fender Not Installed-Soil Graded & Tiller-60 lb. Spring				
May 10				
1	288.0	46.7	19.3	3.50
2	57.7	24.0	12.8	3.75
3	58.0	25.3	12.8	4.00
4	277.0	50.0	22.2	4.00
5	270.0	46.7	20.7	4.00
6	55.3	26.0	12.8	4.50
7	285.0	46.0	20.7	4.50
8	48.0	24.0	19.3	4.50
9	48.0	26.8	20.7	NONE
10	248.0	50.0	32.9	NONE

TABLE 3 (con'd.)

REVISION 1, JUNE 21, 1971

SUMMARY OF LRV DUST PROFILE TEST DATA AT 1/6G, 6 MAY-12 MAY, 1971

Test Number	Motor Power Watts	Wheel RPM	% Slip	Chamber Pressure mm Hg
1/6g-Soil not Graded & Tilled-Fender Installed-Obstacles-Soil Not Graded & Tilled-60 lb. Spring				
May 11				
1*	58.3	20.0	12.8	3.75
2	52.2	26.0	12.8	4.00
3	55.1	20.5	12.8	4.00
4	50.4	28.7	14.5	4.00
5	262.0	48.7	19.3	4.25
6	266.0	48.7	20.7	4.25
7†	288.0	48.7	20.7	4.50
8	288.0	46.8	19.3	4.50
9†	288.0	50.0	20.7	4.50
10	262.0	48.7	20.7	4.50
*Soil Graded & Tilled		†Wheel in Reverse		
1/6g-Fender Installed-Soil Graded & Tilled-60 lb. Spring				
May 12 (1)				
1	53.0	26.0	12.8	3.75
2	53.0	28.7	12.8	4.00
3*	56.7	27.8	14.5	4.50
4	55.4	27.8	14.5	4.50
5*	56.7	27.8	12.8	4.75
6	284.0	47.7	14.5	4.75
7	257.0	48.5	26.1	4.75
8	260.0	47.7	20.7	5.00
*Wheel in Reverse				
1/6g-Fender Installed-Soil Graded & Tilled-30 lb. Spring				
May 12 (2)				
1	288.0	48.0	26.1	3.5
2	55.4	30.0	12.8	4.5
3	61.7	27.5	12.8	4.5
4	285.0	46.5	20.7	4.5
5	60.8	30.8	12.8	4.5
6	275.0	46.5	24.8	4.6
7	63.0	26.8	12.8	4.75
8	277.0	46.5	24.8	4.8
9*	47.0	26.0	12.8	4.9
10	278.0	46.5	24.8	4.9
*Wheel in Reverse				