T H E U N I V E R S I T Y O F M I C H I G A N

COLLEGE OF ENGINEERING
Department of Electrical Engineering
Space Physics Research Laboratory

Quarterly Status Report No. KQ-8
for the period
1 September through 30 November 1961

PRESSURE MEASUREMENTS BETWEEN EARTH AND MOON

Prepared on behalf of the project by

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ORA Project 03555

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INTRODUCTION

This is the eighth status report describing the research effort under contract NASw-133, and it covers the period September 1 through November 30, 1961. This contract provides for the testing and calibration of pressure measuring devices capable of indicating total pressures down to 10^{-12} mm Hg. At least one of these devices is to be used to measure the atmospheric pressure on the Moon.

RESEARCH EFFORT DURING THIS PERIOD

Recent research has been carried out with the main objective being the selection of a Redhead gauge and suitable electronics which can be used for the Surveyor lunar atmospheric pressure measurement experiment.

As was stated in our previous status report, the Geophysics Corporation of America (GCA) has been developing metal-ceramic Redhead gauges. A preliminary test of their model R-1 gauge was reported previously. During the period covered by this report we received a model R-3 gauge from GCA and have made preliminary tests comparing it to an NRC commerical Redhead gauge. These preliminary tests have yielded enough information to summarily decide to use this gauge in the Surveyor instrument package.

The R-3 GCA Redhead gauge we received for testing has remained vacuum tight after a half dozen or so bakeout cycles to 700° F. It is claimed by GCA that the gauge could be baked at least up to 450° C if required; however, we have operated the gauge in our laboratory down to pressures of 5×10^{-13} mm Hg, as indicated by an NRC commercial Redhead gauge, without

requiring higher bakeout temperatures than the 700° F previously mentioned. During our tests of the gauge the interelectrode resistance has remained greater than 10^{14} ohms.

The objective of the initial tests of the R-3 gauge was to get some idea of the operating characteristics of the gauge, such as sensitivity and starting characteristics, and also to see if the gauge operated at pressures below 10^{-10} mm Hg since it had never been tried before. It was found that the gauge did operate down to pressures of 5×10^{-13} mm Hg, or it should be stated as operating down to output currents of approximately 1×10^{-13} amp., since actual pressures are unknown until calibration. However, the output of the gauge was quite noisy and the gauge showed some instability in discharge as was indicated by an occasional shifting of sensitivity. The noise, and possibly the shifting of sensitivity, are felt to be due primarily to the unpolished condition of the electrodes of the gauge. It was felt that the relatively rough surfaces and sharp corners of the electrodes were causing sporadic field emission. Subsequent gauges are to have polished electrodes with the hope that this will decrease the noise and instability experienced with this gauge.

It was decided that the starting characteristics of the gauge may not be adequate for possible lunar pressures. Therefore, GCA is working on some artificial means of starting the gauge, which will be incorporated in subsequent gauges delivered to us for use in the Surveyor instrument package.

Since it had been decided to use the GCA Redhead gauge, assuming the troubles stated previously are rectified, the required electronics could now be chosen. The Jet Propulsion Laboratory (JPL) had done some work on the electronic components selection previous to the transfer of the responsibility of the

packaging of the experiment to the University of Michigan. One item of interest that they had obtained was a breadboard model of a high voltage power supply designed by the Matrix Company. This power supply was selected by GSFC and the University of Michigan to be used in the lunar experiment. The specifications of this power supply are included in Appendix A of this report.

An electrometer amplifier will be used to detect the output current of the Redhead gauge. This amplifier will be developed and fabricated by our laboratory. Preliminary specifications of this instrument are given in Appendix B.

A breakoff seal will be utilized to seal the gauge under vacuum after calibration. This seal will be removed by a pyrotechnic device after the package is on the Moon. GSFC has designed such a breakoff seal, and this, or something similar, will be used on the Surveyor package.

A complete outline of the Surveyor lunar atmosphere experiment is included in Appendix C. This outline gives the most recent thoughts on the experiment but may be altered as the spacecraft system dictates.

FUTURE WORK

Future work under this contract will consist of coordinating the efforts of the suppliers of the components required for the lunar atmosphere experiment package. Upon receipt of the electronic components and the Redhead gauge, complete laboratory tests will be initiated, with the eventual packaging and calibration of the Redhead gauge for delivery to JPL for incorporation in the Surveyor spacecraft.

MONTHLY COST BREAKDOWN

Month	Wages		Overhead	Expendable Materials	Equip-ment	Travel
	Student	Professional				
Sept.	$ 467	$ 516	$ 491	$ 763	$41	$787
Oct.	437	437	431	1659	0	181
Nov.	681	1987	1334	444	7	0
Totals	$1585	$2940	$2256	$2866	$48	$968

GRAND TOTAL $10,663

Approximately 4% of the total allotted funds remains as of November 30, 1961.

APPENDIX A

Matrix 4KV Power Supply Specifications

1.	Input voltage	:	29 volts ±2%
2.	Mid-value output voltage	:	within range of 4000 volts
3.	Regulation	:	±2% (all causes
4.	Number of outputs	:	one
5.	Load current	:	0 to 10 μa
6.	Temperature	:	-50° C to +125° C
7.	Input current	:	less than 25 m.a. @ full load
8.	Ripple	:	less than 2.5 volts peak to peak
9.	Oscillator starting	:	reliable starting for fast and slow line voltage buildup
10.	Short circuit reliability	:	short circuiting output shall not damage any component
11.	Weight	:	12 oz. approximately
12.	Size	:	approximately 4" x 2" x 2"
13.	Vibration	:	mariner A specifications
14.	Non-operative at launch		
15.	Discharge time constant	:	3 hours minimum
16.	Sterilization	:	125° C 24 hours
17.	Short soak	:	-50° C and +125° C

APPENDIX B

University of Michigan Electrometer Amplifier Specifications

1.	Input voltage	:	29 volts $\pm$1%
2.	Input current	:	approximately 40 ma
3.	Current range	:	approximately 10^{-6} amps to 10^{-14} amps
4.	Ranges	:	7
5.	Range selection	:	automatic with manual override
6.	Size	:	approximately 4" x 3" x 2 3/4"
7.	Weight	:	approximately 2 lbs.
8.	Operating temperature	:	-50° C to +125° C
9.	Sterilization	:	125° C 24 hours

APPENDIX C

Lunar Atmosphere Experiment

A. Description and Principle of Operation

The single purpose for this experiment is to measure the total atmospheric pressure on the Moon's surface. This measurement will be made by using a metal-ceramic Redhead gauge with suitable electronics. The experiment package contains a sensor gauge with magnet, pressure seal with break-off device, an electrometer amplifier and a high voltage power supply.

The Redhead gauge is an ionization gauge device which employs a crossed electric and megnetic field to (1) increase the effective path length of the ionizing electrons, and (2) decrease the x-ray effect which limits the low current level of most ionization gauges. The gauge has been used in the laboratory to measure pressures in the high 10^{-13} mm Hg range. It is felt that the gauge will be capable of measuring pressures below this when lower pressures can be produced in the laboratory. The sensitivity of the gauge is about 5 amp/mm Hg for nitrogen.

The ion current is monitored by the electrometer amplifier which produces an output compatible with the spacecraft telemetry requirements. The high voltage power supply produces 4000 volts dc for the anode of the gauge. The gauge with electrometer and power supply will be calibrated in the laboratory against known standards, then evacuated to as low a pressure as possible and sealed off to prevent contamination. A break-off device will open the seal after the experiment is on the Moon.

The package for the first Surveyor flight will be capable of detecting Redhead gauge output currents from 10^{-14} amp to 10^{-6} amp.

B. Physical Interface

1. Weight

A.	Sensor	0.6 lbs.
B.	Magnet	2.0 lbs.
C.	Pressure seal and break-off device	.5 lbs.
D.	Electrometer amplifier	2.0 lbs
E.	High voltage power supply	.8 lbs.
F.	Package, wiring, plugs, etc. (approx.)	2.0 lbs.
	TOTAL	7.9 lbs.

2. Volume

A.	Sensor 3" x 2½" x 1¼" - 1 cu. in. for feed thru s	10.4 cu. in.
B.	Magnet with supports 3½" x 3½" x 2½" (sensor fits into a portion of this volume)	30.6 cu. in.
C.	Pressure seal (external to package)	4.0 cu. in.
D.	Electrometer 3" x 4" x 2 3/4"	33.0 cu. in
E.	High voltage power supply 2" x 2" x 4"	16.0 cu. in.
	APPROX. TOTAL	94.0 cu. in
F.	Overall internal package dimensions 4" x 5" x 5 3/4"	115.0 cu. in

3. Orientation

The gauge has a view angle of approximately one hemisphere. The orientation of the instrument package must be such that the influx of contaminating gases through the view angle must not contribute a partial pressure greater than 10^{-14} mm Hg. Contaminating gases are defined here as those gases caused by outgassing of the experiments carried by the spacecraft, the spacecraft itself and possibly the disturbed lunar surface. The initial gas evolved from the

retro-rocket is expected to produce a local pressure much higher than 10^{-14} mm Hg, possibly for some days after landing, but the pressure will probably decrease to a tolerable level within a few days so that the Moon's atmospheric pressure will be measured if continuous contaminating gases are not present.

The orientation of the centerline of the view angle with respect to the Sun or some other reference system must be known.

The orientation requirements do not have to be met during transit.

4. Manipulation

No manipulation, other than boom extension, will be required.

C. Electrical Interface

1. Power requirements (supplied by spacecraft)

A. High voltage power supply +29.0 Vdc ±1%, 0.5 watts

B. Electrometer amplifier +29.0 Vdc ±1%, 1.0 watts

C. Break-off device +22 Vdc unregulated, 3 watt seconds (pyrotechnic)

D. Power required for temperature control - unknown at present.

2. Commands

A. Apply 22 Vdc to break-off pyrotechnics (occurs only once)

B. Apply 29 Vdc to high voltage power supply

C. Apply 29 Vdc to electrometer amplifier

D. Remove 29 Vdc from high voltage power supply

E. Remove 29 Vdc from electrometer

F. Automatic range selection

G. Manual range selection

H. Range step and calibration.

3. Output Signals from Experiment to Telemeter System

A. Temperature sensing - the temperature of the sensor must be known within 5° C. It is assumed that the spacecraft system will provide the temperature sensing device. Sample once or twice during sampling period (5 minutes).

B. Electrometer output - 0 to 5 Vdc. Sampled a minimum of 5 times per minute during normal 5 minute data sequence. The data must be sampled 10 times per second during break-off sequence.

C. Range indication 0 to 5 Vdc. Sampled 2 per minute.

4. Received Data Requirements

A. Temperature - accurate to within 5° C

B. Electrometer amplifier output - absolute voltage level within 2%

C. Range indication - absolute voltage level within 5%

D. Sensor orientation as outlined in B-3 above

5. Spacecraft Cabling Requirement

Cabling mentioned does not include that required for thermal control.

Cabling required will include that which is necessary to apply commands as described in C-2 above, and also must include:

One (1) power ground

One (1) telemetry ground

Two (2) thermocouple pair

One (1) electrometer amplifier output (0-5 Vcd)

One (1) range indication output (0-5 Vdc).

D. Operation and Sampling Sequence

The desired operating and sampling sequence is divided into three parts. A sampling sequence will preceed break-off, both before and after boom extension. The sampling sequence will require about 5 minutes and will be initiated approximately once every hour. During the break-off operation, sampling should take place from a few minutes before break-off to about 5 minutes after break-off. After the break-off has been accomplished, a sampling sequence of 5 minutes duration initiated approximately once every hour for the lifetime of the spacecraft is expected.

E. Switching Sequence

Commands F, G and H are requested for manual range switching as a back-up for the automatic range switching which will be incorporated in the electrometer amplifier. If the automatic range selector malfunctions or unforseen problems arise requiring the use of the manual range switching commands, a command sequence, determined by the data received at the time of the malfunction, will be initiated.

F. Environmental Requirements

1. Temperature

   A. The operating temperature range of the complete experiment package is -50° C to $+125^{\circ}$ C.

   B. The non-operating temperature range of the package is -150° C to $+125^{\circ}$ C.

2. Pressure

   The influx of contamination gases through the sensor view angle should be limited as described under orientation.

3. Sterilization

   Experiment package must be sterilized using a heat-soak process.