ENGINEERING RESEARCH INSTITUTE
UNIVERSITY OF MICHIGAN

ATMOSPHERIC PHENOMENA AT HIGH ALTITUDES

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Submitted for the project by:

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ATMOSPHERIC PHENOMENA AT HIGH ALTITUDES

Department of Aeronautical Engineering

1. INTRODUCTION

This is the eighth in a series of quarterly reports on Contract No. DA-36-039 SC-15443 describing high-altitude meteorological experiments being carried out by the University of Michigan for the Meteorological Branch of the Signal Corps. This program is a continuation of one which was carried out between July 1946 and August 1950 on Contract No. W-36-039 sc-32307 and from August 1950 to December 1951 on Contract No. DA-36-039 sc-125. For background material the reader is referred to the final reports on these contracts and the previous ones of this series.

2. SUMMARY

The work during the quarter was devoted to the investigation of adsorption in sampling bottles, the development of a new bottle-preparation technique, and the preparation of sampling Aerobee SC-34.

3. SAMPLING EXPERIMENT

3.1 Sample Analysis

The results of bottle C-7-B flown on V-2 59 on 20 May 1952 were received from Professor Paneth. This bottle was originally thought to be worthless as the upper half of the seal leaked when tested at Michigan. It appears now that the bottle is good, as an amount of gas consistent with others on the same rocket was obtained and a leak check performed at Durham was negative. The results are as follows:

Sample Bottle	Rocket Number	Date of Sampling	Peak Altitude km MSL	Open km	Close km	Mean km	km Open
C-7-B	V-2 59	5-20-52	124	79.9 (66.1)	85.9	82.9 (76.0)	6.0 (19.9)

Close Ambient Pressure mm Hg	Close Pitot Pressure mm Hg	Bottle Pressure mm Hg	Amt. of Sample cc NTP	Analysis[a] (Durham) He	Ne	A	O_2
0.0036	0.044	0.0033	.032	1.396	1.020	0.93	0.26

(a) $\frac{\text{Vol. ratio to } N_2 \text{ in sample}}{\text{Vol. ratio to } N_2 \text{ in ground air}}$.

Mean deviations based on a few runs usually less than ± 0.005.

There are a few items of interest to be noted in comparing this bottle with previous ones.* The bottle pressure is about equal to ambient pressure for the closing altitude. The same is true for the other bottles of this rocket. In general, it is expected that the bottle pressure will be about equal to the pitot pressure for the closing altitude; but on this rocket there is evidence that the nose cone was in place during sampling so that approximately ambient pressure would be obtained. The amounts of separation in a bottle are, in general, expected to be characteristic of the opening altitude. In eight other bottles from three rockets the amount of separation increases more or less smoothly with increasing opening altitude. The separation in C-7-B, however, is characteristic of an altitude lower than its planned opening altitude. Several explanations for this have been considered, and the most probable appears to be as follows: An examination of the circuit diagram shows that a last-minute modification made in the circuit at WSPG could have been made in such a way as to cause C-7-B to open at 66.1 km instead of 79.9 km. This value is given in parentheses in the above table so that the separation can be compared with that of other bottles near the same altitude. It cannot now be proven, however, that C-7-B opened at the lower altitude.

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*For a tabulation see The Measurement of Diffusive Separation in the Upper Atmosphere, Oxford Conference on Upper Atmospheric Rocket Exploration, August 1953.

3.2 Control Experiments

Several control experiments designed to determine the cause of separation in control bottles were described in the previous report. Progress in these experiments during the quarter was as follows:

3.21 Recheck of B-18-P and B-20-P. The vials containing ground air were ruptured in the bottles and the pressure monitored. The correct predicted pressures were obtained. In B-18-P this pressure (approximately 20 μ Hg) remained constant for more than a month, and the bottle was shipped to Durham. In B-20-P the pressure rose above 200 μ Hg in 24 hours, indicating a leak which may have occurred when the glass vial was rupture. This bottle (which, together with B-21-P, showed separation in the initial control experiment) will be prepared again for a second control analysis.

3.22 Examination of vials similar to those used in B-20-P and B-21-P. The contents of these vials have not yet been analyzed but are next on the Durham schedule following bottle C-7-B.

3.23 New vials. The preparation of vials of Durham air to be placed in new control bottles was completed. The vials were recently received at Michigan.

3.3 Total Adsorption

The investigation of total adsorption in sample bottles was continued. A second bottle was placed on the original system in preparation for another adsorption test. In this test spectroscopically pure N_2 was introduced in increments of about 1 μ Hg. In the first run a discrepancy of about 8 per cent was noted between the amount of gas admitted and the amount finally measured in the bottle. The difficulty was traced to the non-uniform cross-section of the capillary tube of the McLeod gage used to measure the final bottle pressure. A calibration of the scale was made and the readings of the N_2 run corrected. The experimental error in pressure is estimated now as less than ± 2 per cent. Two further runs on this bottle were made using N_2. The results are as follows:

Run No.	N_2 Admitted Pressure μ Hg	N_2 Measured in Bottle Pressure μ Hg
1	25.35	25.3
	35.21	35.0
2	12.68	12.4
	25.27	24.7
	37.77	37.3
3	20.69	20.3

These data show that there is no immediate loss of N_2 within the experimental error. The final pressures in the bottle were also monitored for several days after the last increment had been admitted with the following result:

Run	Initial Pressure		Final Pressure		Days Elapsed
	Date	Pressure μ Hg	Date	Pressure μ Hg	
1	Oct. 16	17.1	Nov. 9	17.2	24
2	Nov. 9	26.7	Nov. 19	26.5	10
3	Dec. 18	21.6	Dec. 30	21.8	12

These data show that within experimental error there is no change of N_2 in periods of one to three weeks.

A new system built for adsorption measurements was described previously. The final stopcock ahead of the bottle is critical in this work because it must not leak even small amounts of gas over a period of weeks. A valve, seen in Fig. 1, which operates positively by closing of the inlet tube with a rising column of vacuum pump oil, was constructed and placed in series with the stopcock. The valve developed a leak in the sylphon bellows and was removed for repair. In the meantime a bottle was placed on the system (using the original stopcock) and pumping begun. It appears that the system has been outgassed successfully and is reasonably leak tight. An adsorption run will be made shortly on the bottle.

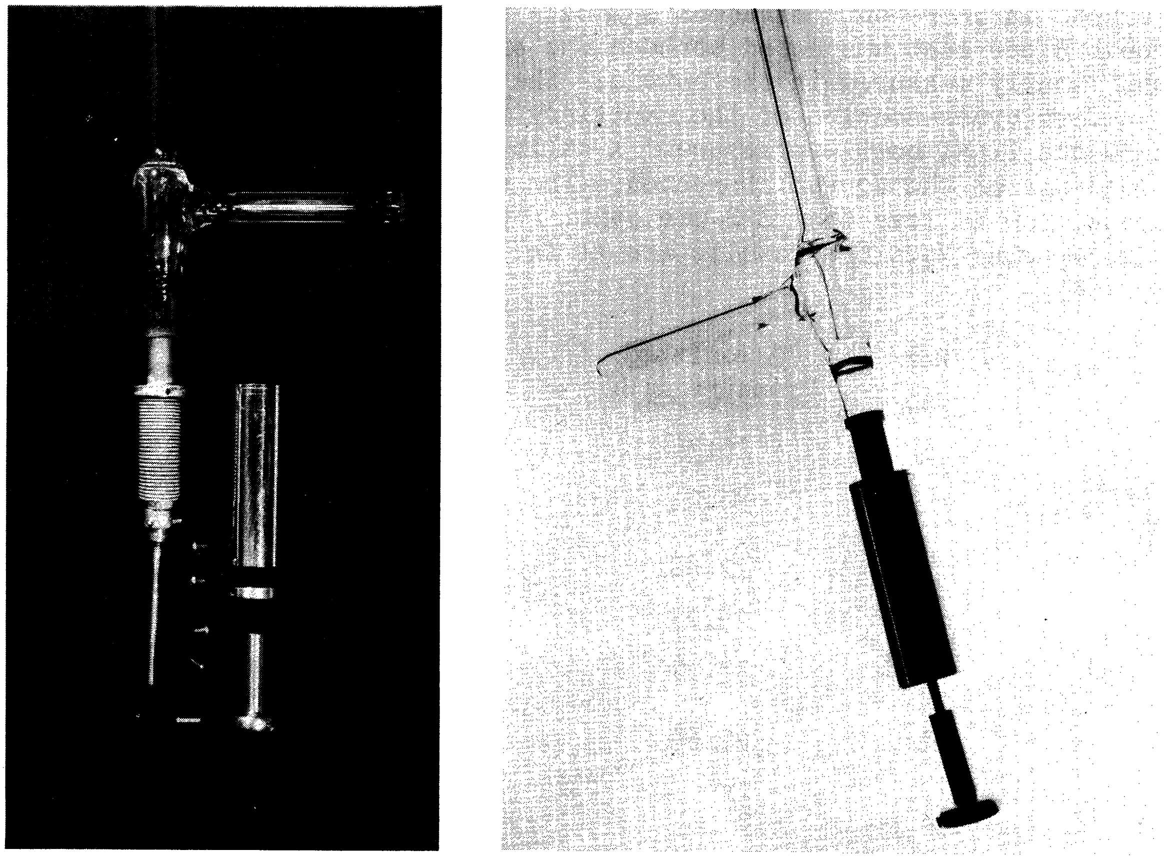

Fig. 1. Oil Valve.

3.4 Analysis Facilities

Some changes in the facilities for analyzing samples are impending. The major part of this work for the past seven years has been performed at the University of Durham by Professor Paneth and his co-workers. Professor Paneth, now at the Max Planck Institute, Mainz, has started the construction of a new and improved analyzer there. The work at Durham is now scheduled to terminate in about three months although there is some expectation of continuing for a few months more. Construction of an analyzer will also be undertaken at Michigan. It will be designed to measure the amounts of N_2, O_2, He, Ne, and A in amounts of air of the order of 0.03 cc NTP with a precision such that the ratios of the latter four gases to N_2 may be known to about ± 0.5 per cent.

3.5 SC-34 and Sample Bottles

Several design changes for peak sampling Aerobee SC-34 were completed. Provision was made for installing a DOVAP unit for accurately determining the peak altitude. The beacon location was changed for ease of servicing and to permit the beacon to operate all the way down to aid in finding the bottles quickly. The timer was redesigned to provide a control pulse in the middle of the Jato thrust interval to accomplish the double separation (bottles and nose cone from rocket, bottles from nose cone) operation. The new timer, seen in Fig. 2, was built and tested. The rocket circuit diagram was completed. The design of SC-34 is now essentially complete. Further

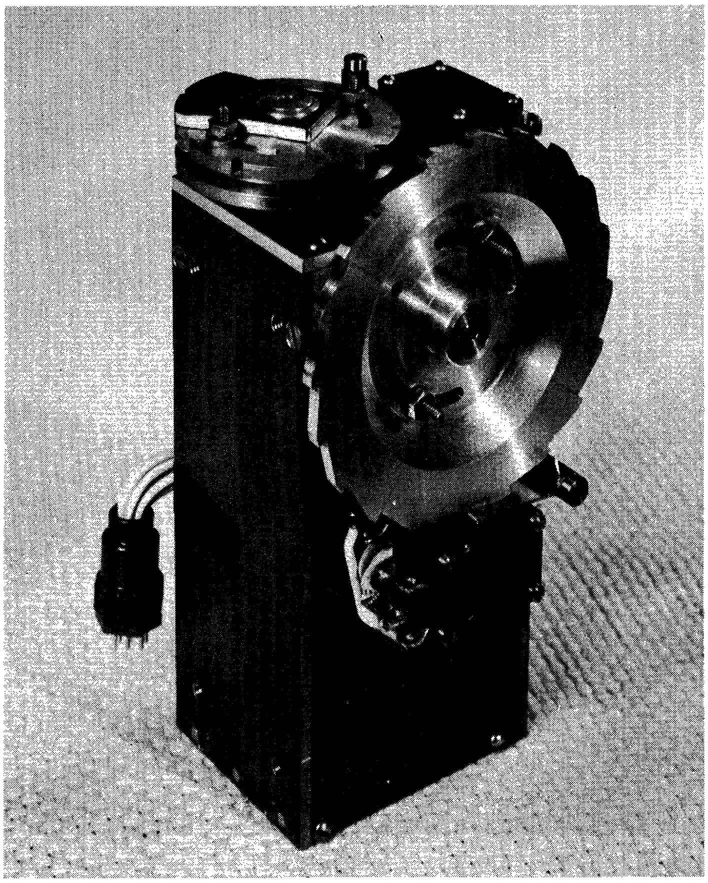

Fig. 2. Timer, SC-34.

construction will be held until the need for the samples is indicated by the results of current control experiments. The development of a new method of sealing the bottles prior to evacuation will, however, be continued.

The objective of the new technique is to eliminate all soldering operations after the cleaning operations and to permit brushing and visual inspection of the bottle surface just before evacuation. Four types of 2-inch diameter seals were tried as follows:

a) Straight press fit, steel to steel. In this seal the steel surfaces scored, and the seal was not successful.

b) Straight press fit with copper plating on the plug. This seal was successful.

c) Tapered press fit, steel to steel with ground and lapped surfaces. This seal was successful.

d) Tapered press fit, plug copper-plated. This seal was not successful, but it is thought that the failure was due to the machining of the hole and that a good seal is possible.

The jig for holding the parts while the fit is made in a Tinius-Olsen testing machine is seen in Fig. 3. A cut-apart press-fit plug is shown mounted on an assembly fixture in Fig. 4.

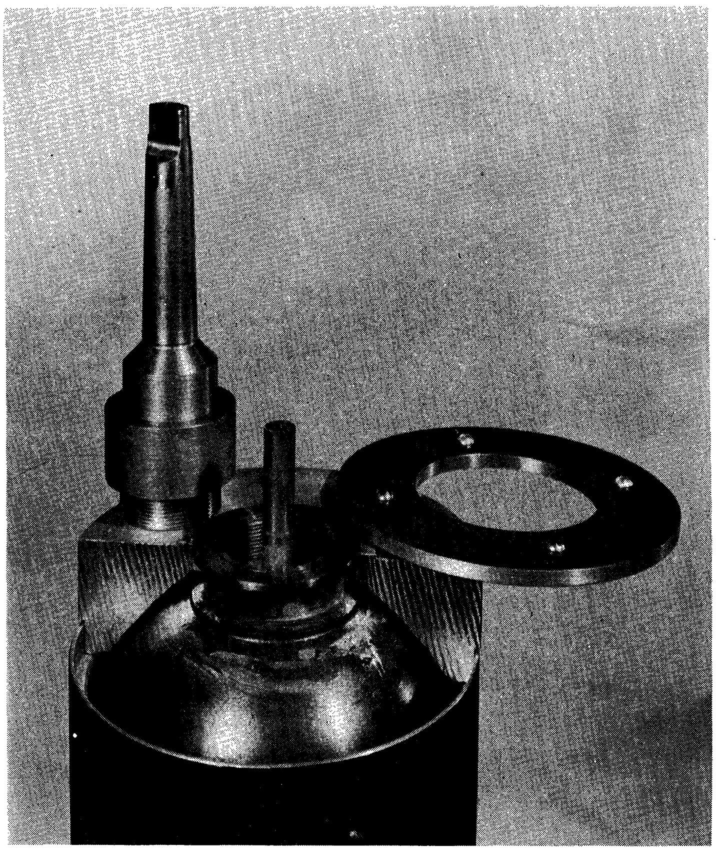

Fig. 3. Jig for Making Press-Fit Seals.

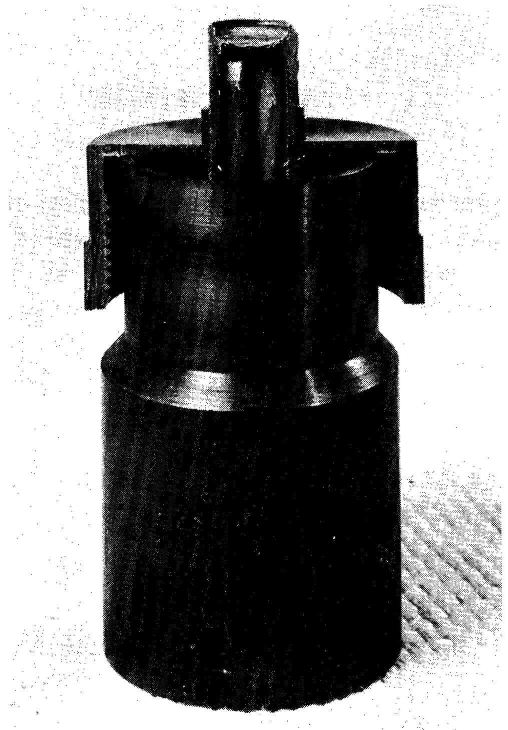

Fig. 4. Cut-Apart Plug and Assembly Fixture.

Although it appears that vacuum-tight seals can be made by some process similar to one of the above, there are two additional features which an ideal seal might have: It is desirable to eliminate the necessity for extremely precise machining. It is also highly desirable to be able to assemble and disassemble the seal. The latter would be particularly useful in bottles used for control experiments in adsorption. Since vacuum-tight joints can be made in copper tubing with small-size flare fittings, it was thought that a 2-inch diameter flare fitting might be successful. The design of an experimental flare fitting is shown in Fig. 5.

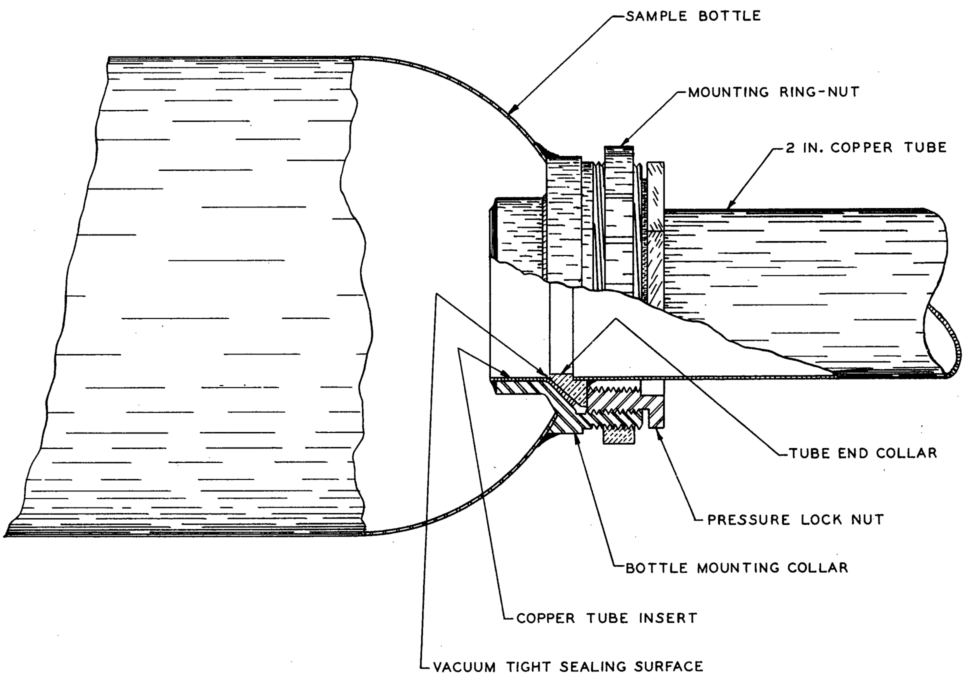

Fig. 5. Flare-Fitting Vacuum Joint.

4. SPHERE EXPERIMENT

Neither the sphere nor the tail cone from sphere Aerobee SC-31, fired on 29 September, have been recovered. It was thought that some evidence as to the cause of the large pitch and yaw of this rocket might be obtained from an examination of the tail cone. A close inspection of the T-V telescope film of this rocket revealed that the nose cone did not come off until at least two full excursions of the yaw motion, which began at burnout, had occurred.

No results were calculated from Aerobees SC-30 and SC-31 as the trajectories have not been received from BRL.

5. LECTURES, PAPERS, AND REPORTS

Professor Sydney Chapman of Oxford University was in residence at the University of Michigan during the quarter as Visiting Professor of Solar and Terrestrial Physics in the Department of Astronomy. It was the pleasure of the Upper Atmosphere Project to sponsor Professor Chapman's visit.

While here he gave a series of weekly lectures on the earth's atmosphere titled as follows: The Lunar Tide in the Earth's Atmosphere; The Solar Tide in the Earth's Atmosphere; The Earth's Magnetic Field and its Secular Variation; Theories of the Geomagnetic Field and its Changes; The Solar and Lunar Daily Changes of the Geomagnetic Field; The Dynamo Theory of the Daily Geomagnetic Changes; Geomagnetic Disturbance: Its Morphology; Geomagnetic Disturbance: It Time Relationships; The Aurora Polaris: Its Morphology; The Aurora Polaris: Its Time Relationships and Spectrum; Theories of the Aurora and Geomagnetic Disturbance; The Advance of a Neutral Ionized Solar Stream into the Geomagnetic Field.

In addition to the above lectures, Professor Chapman gave two colloquia, one at the Observatory on the subject of Photochemistry of Oxygen and Nitrogen in the Earth's Atmosphere, the other at the Physics Department on Meteors in the Upper Atmosphere. At a meeting of Sigma Xi he lectured on The Aurora.

The following papers prepared by Professor Chapman during his stay will be published: "Atmospheric Tides" for Scientific American, an account of next year's total eclipse and the aurora borealis for Sky and Telescope, a paper on the brightness of the sky during a total solar eclipse, and one on the ionization of the D-layer during sudden ionospheric disturbances.

No reports were issued during the quarter. A conference on project work was held at Evans Signal Laboratory.

6. FUTURE PROGRAM

The investigation of causes of separation in upper-air samples other than by upper-air phenomena will continue. Construction of a new analyzer will begin.

7. ACKNOWLEDGMENT

Thanks are due the Meteorological Branch of the Signal Corps for continued cooperation and support.