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UNIVERSITY OF MICHIGAN

ATMOSPHERIC PHENOMENA AT HIGH ALTITUDES

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Submitted for the project by:

L. M. Jones

UNIVERSITY OF MICHIGAN PROJECT PERSONNEL

Both Part Time and Full Time

Bartman, Fred L., M.S., (EE), Research Engineer
Bozeman, Herbert C., Laboratory Assistant
Chaney, Lucian W., B.S., Research Engineer
Grabowski, Walter, Laboratory Technician
Jones, Leslie M., B.S., Project Supervisor
King, Jay B., B.A., Research Assistant
Liu, Vi Cheng, PhD., (AE), Research Engineer
Loh, Leslie, M.S., Chemist
Munroe, Hugh F., Designer
Neill, Howard W., M.S., Research Engineer
Nichols, Myron., PhD., Consultant
Schaefer, Edward J., M.S., Research Engineer
Swets, Maxine, Secretary
Titus, Paul A., Research Technician
Wenk, Norman J., B.S., Research Associate
Wenzel, Elton A., Research Technician
Whittington, Robert C., Laboratory Assistant

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ATMOSPHERIC PHENOMENA AT HIGH ALTITUDES

Department of Aeronautical Engineering

1. INTRODUCTION

This is the first in a series of reports on Contract No. Da 36-039 sc-125 describing high altitude meteorological experiments being carried out by the University of Michigan for the Meteorological Branch of the Signal Corps. The program is a continuation of one that has been under way since July 1946 on Contract No. W-36-030 sc-32307. For background material the reader is referred to the Final Report on that contract.

2. SUMMARY

2.1 Sampling Aerobees SC-13 and SC-17

SC-13 was fired October 27. No samples were obtained. SC-17 was fired December 19. One or two samples are thought to have been obtained.

2.2 Jato Ejection of Nose Cone

The forward cones of Aerobees SC-13 and SC-17 were successfully ejected by Jato in flight. A test firing of the forward cone of the probe Aerobee was successfully carried out at WSPG.

2.3 Probe Aerobee SC-15

SC-15 was fired December 11. The rocket failed at take-off and no results were obtained.

2.4 Drag Measurements on Aerobee Models

Wind tunnel measurements of drag and stability were made on models of the normal, sampling and probe Aerobees.

2.5 Analysis of Upper Air Samples for the Isotope Ratio $N^{14}N^{14}/N^{14}N^{15}$

A Letter to the Editor of the Physical Review discussing diffusive separation up to 55 km in the light of mass spectrometric measurements of $N^{14}N^{14}/N^{14}N^{15}$ at the University of Virginia was written.

2.6 Analysis of Air Samples Enriched with Helium

Selective adsorption analyses of an air blend enriched with helium were run.

3. SAMPLING AEROBEES SC-13 AND SC-17

The openers, sealers and general configuration of the new-type sampling Aerobees SC-13 and SC-17 were described in the previous progress report (No. 19) on this program. The instrumentations were completed and shipped to White Sands for firings on October 26 and November 7, respectively.

SC-13 was scheduled for firing at 1730 on October 26th. Weather conditions were good and pre-flight preparations proceeded without difficulty. However, trouble was encountered with the cut-off system at X-1 minute. An examination of the receiver revealed that a clip connection to the B battery had become unfastened. It was impossible to ready the missile for firing that day before darkness, so the firing was scheduled for 0600 the following morning. The rocket was launched at 0620 with no difficulty. From Askania, burnout occurred at 43 seconds at a vertical velocity of 3320 feet per second. Peak altitude was calculated from these data as 254,000 feet (MSL). The predicted peak altitude was 330,000 feet. (See Section 6)

All rocket devices performed satisfactorily, radar beacon giving an exceptionally good record and indicating Jato ejection and bottle operation. The forward cone was ejected at 75.5 seconds and the parachute at 164.5 seconds. Parachute operation was satisfactory, lowering the instrumentation with little damage at a point 25.55 miles at azimuth 7°41'54" from the Navy launcher. The parachute was a reinforced eight foot diameter nylon ribbon type. The release mechanism was similar to those used on recent Signal Corps Aerobees. Although damage to the instrumentation was not severe it appeared to have hit with greater velocity than similar payloads dropped with a ten foot chute.

No air samples were obtained because of the failure of the bottle sealers to operate. The squib wires were burned but the black powder had failed to ignite. It is now realized that it is characteristic of black powder to fail to ignite at reduced pressure. One of the sealers was operated on the ground after recovery from the missile. Using the same squib (re-wired) and powder as in flight, the sealer operated satisfactorily and produced a good seal.

All of the knife openers were actuated, but one apparently stalled half-way through the cut. The reason for the failure is not known. The other two opened the tubes satisfactorily. The $C^{14}O_2$ contaminator pyrotechnic knife operated but did not rip a hole in the "roof-top" seal so that no gas was released.

Because of the failure to obtain samples on SC-13, the instrumentation for SC-17 was shipped to Ann Arbor for changes. The following changes were made:

1) The sealers were pressurized by applying vacuum grease to the cylinder wall and rubber bands and vacuum grease to the squib threads. The sealer was successfully fired at reduced pressure.

2) The parachute release mechanism was moved forward to the base of the cone carrying the sample bottles. Thus the beacon and cut-off receiver were not included in the parachute load which was thereby reduced to 81 pounds.

3) Removable skin sections were installed which permitted easy access to the instrumentation.

Upon completion of the changes the instrumentation was shipped to White Sands for firing on December 18th. The firing was scheduled for 1600 on the 18th but because of propagation difficulties at the cut-off system frequency the missile was postponed until the following day. The difficulty in receiving sufficient signal strength at the cut-off receiver in the missile with high power output from the transmitter was said by WSPG Technical Division personnel to be characteristic of desert ground level propagation conditions at sundown. The firing was accomplished at 1152 on December 19th. No pre-flight difficulties with the instrumentation or rocket equipment was encountered.

Rocket performance was essentially the same as SC-13, the peak altitude being 267,000 feet (MSL) based on Askania data at 45.5 seconds and a vacuum trajectory thereafter. Beacon radar tracked until 23.5 seconds and from 31.0 to 32.5 seconds after which there were no signals. Askania tracking ceased at 53 seconds. The last telescope observation of the missile was at 83 seconds although T-III observed the smoke puff of the nose cone ejection at 85.8 seconds. The timer setting for ejection was 86.5 seconds. No attitude data will be available at the times of nose cone ejection or bottle sampling.

Parachute ejection was not observed. However, the parachute operated satisfactorily lowering the bottles with very little damage at a point approximately 28 miles north, 6 miles east of the Navy tower.

Because of the low altitude performance of SC-13, the bottle timing sequence of SC-17 was delayed to increase the possibility of obtaining at least 70 km samples. The sampling altitudes, based on Askania observations and a vacuum trajectory, were as follows:

	Time (secs)	Feet (MSL)	Kilometers (MSL)
Open bottle B-6	92.5	212,000	64.6
Close B-6, Open B-8	97.5	222,000	67.7
Close B-8, Open B-9	102.5	230,000	70.1
Close bottle B-9	107.5	238,000	72.6

The lowest bottle (B-6) apparently operated satisfactorily. The rim of the intake tube was evenly encrusted with sand and peened over as if the end of the tube had been exposed at impact. Further, the Pirani gage was intact and indicated a pressure of 100 ± 30 μHg. The missile Mach number was 1.5 at this altitude. From Rayleigh's relation the ratio of pitot tube pressure to ambient is 3.4. Based on Grimminger's[1] ambient pressures the pitot tube pressure would be 462 μ Hg and on NRL[2] pressures 258 μ Hg. The corresponding ambient pressures are 136 μHg and 76 μHg.

It is unlikely that useful samples were captured in the middle and highest bottles. An imprint of the top portion of the tube was made on the top of the opener knife in the case of the middle bottle (B-8). Also the tube rim was not peened over and not caked with sand. These facts indicate that the top portion of the tube was in place at impact although it was not found. The top portion of the tube of the highest bottle (B-9) was found in position at impact. The Pirani gages for both of these bottles were open so that pressures cannot be measured until the bottles are opened. As in SC-13, the contaminator knife was actuated but failed to rip a hole in the "roof-top" seal.

Fig. 1 shows the forward end of SC-13 prior to firing. The knives are in position to cut the thin steel portions of the intake tubes. The small cold weld seals made in the laboratory after bottle evacuation can be seen at the top of each intake tube. Fig. 2 shows the Jato ejected cone of SC-13 mounted in place. The cone separates at the joint seen about 6" below the bottom of the flame ports. Fig. 3 shows the bottle section and parachute of SC-17. The lower left hand tube seen in Fig. 4 is on bottle B-6 in which a sample is thought to have been obtained. The imprint of the top of the tube of bottle B-8 can be seen on the lower right hand knife. Fig. 5 illustrates the sealers in closed position after recovery and Fig. 6 shows the three cold weld seals made by the sealers which have been removed.

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1 Griminger, G., Project Rand Report R105, Nov. 1948.

2 Havens, R., Koll, R., LaGow, H., Naval Research Laboratory Report "Pressures and Temperatures in the Earth's Upper Atmosphere," March 1950.

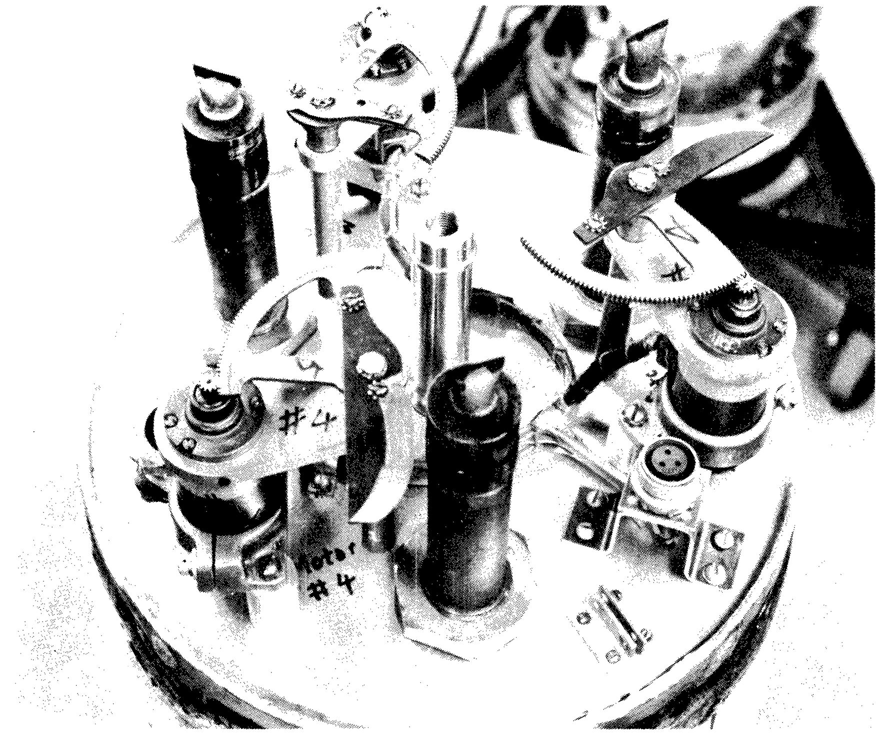


Fig. 1. Bottle Openers Prior to Flight, SC-13

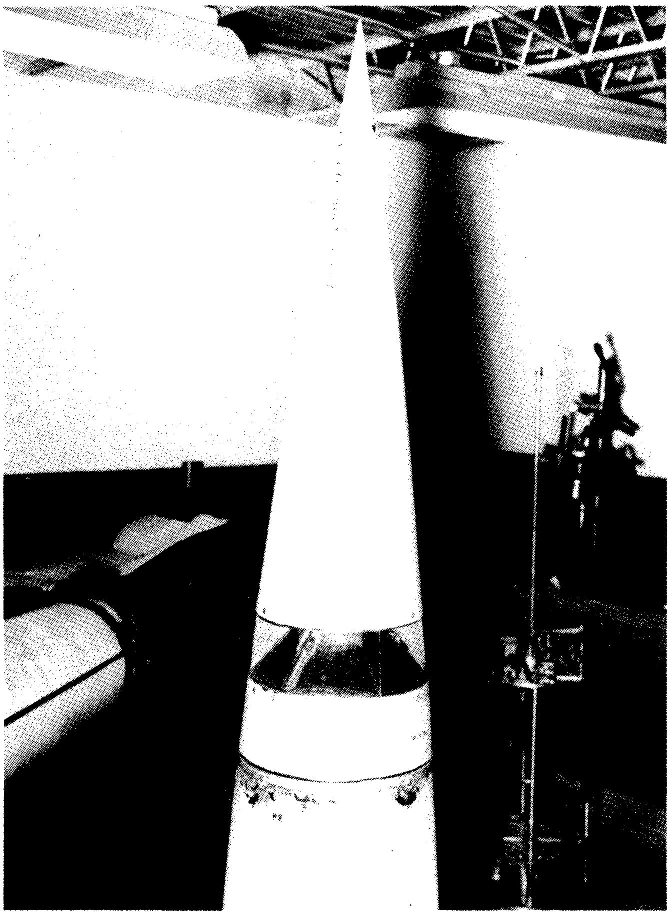


Fig. 2. Ejectable Nose Cone Showing Flame Ports, SC-13

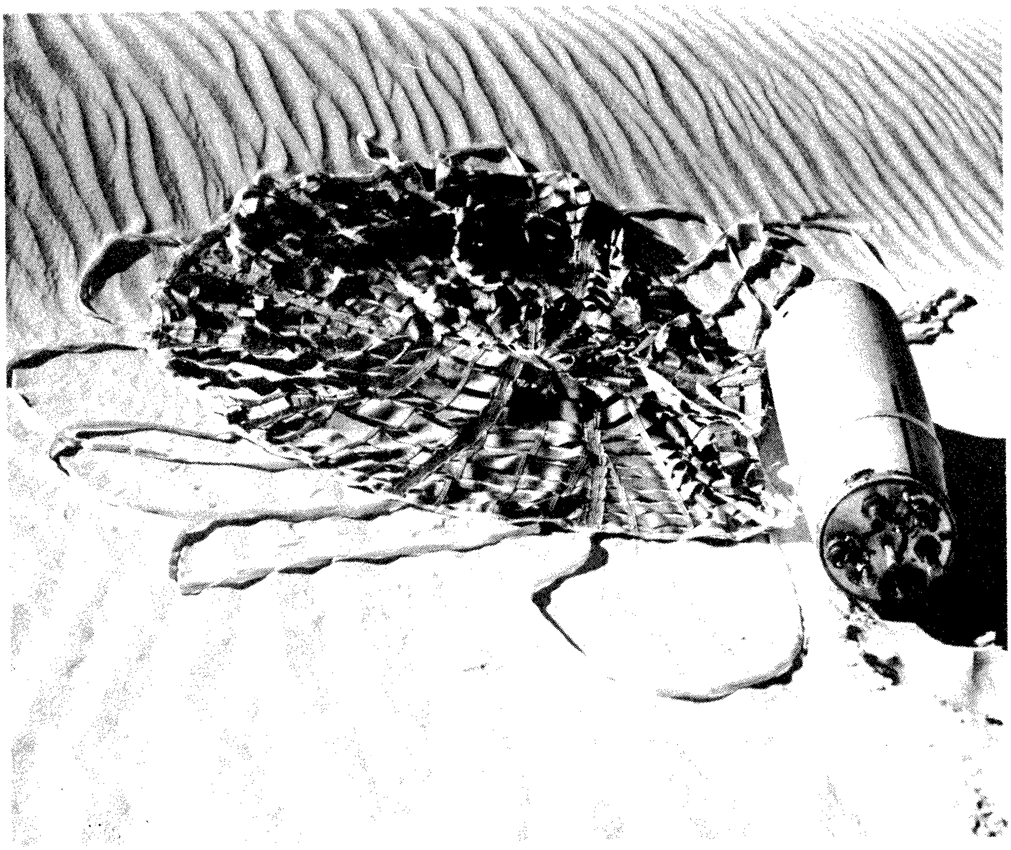


Fig. 3. Instrumentation Recovery, SC-17

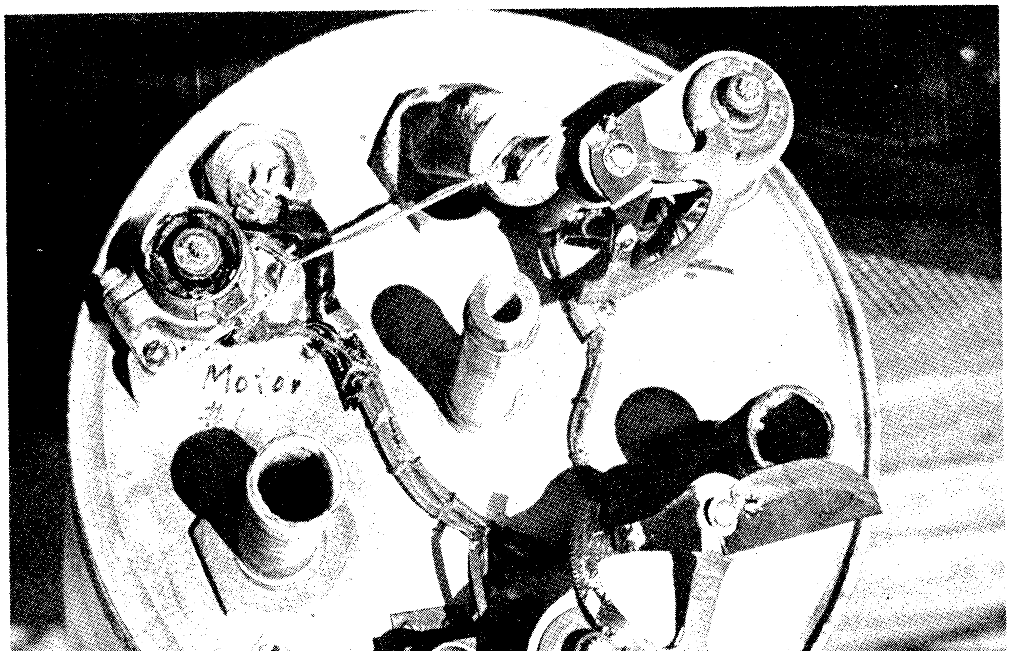


Fig. 4. Intake Tubes and Openers, SC-17

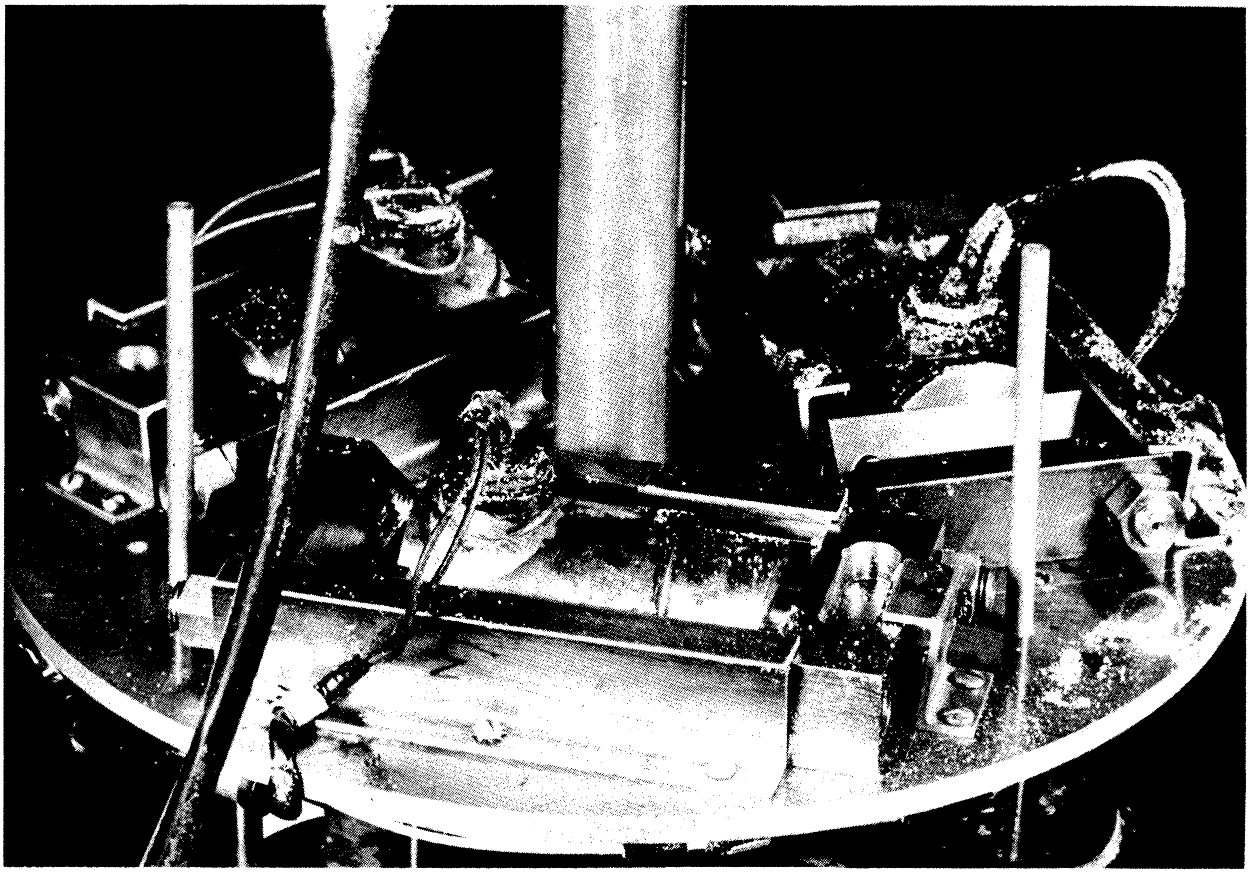


Fig. 5. Bottle Sealers After Operation, SC-17

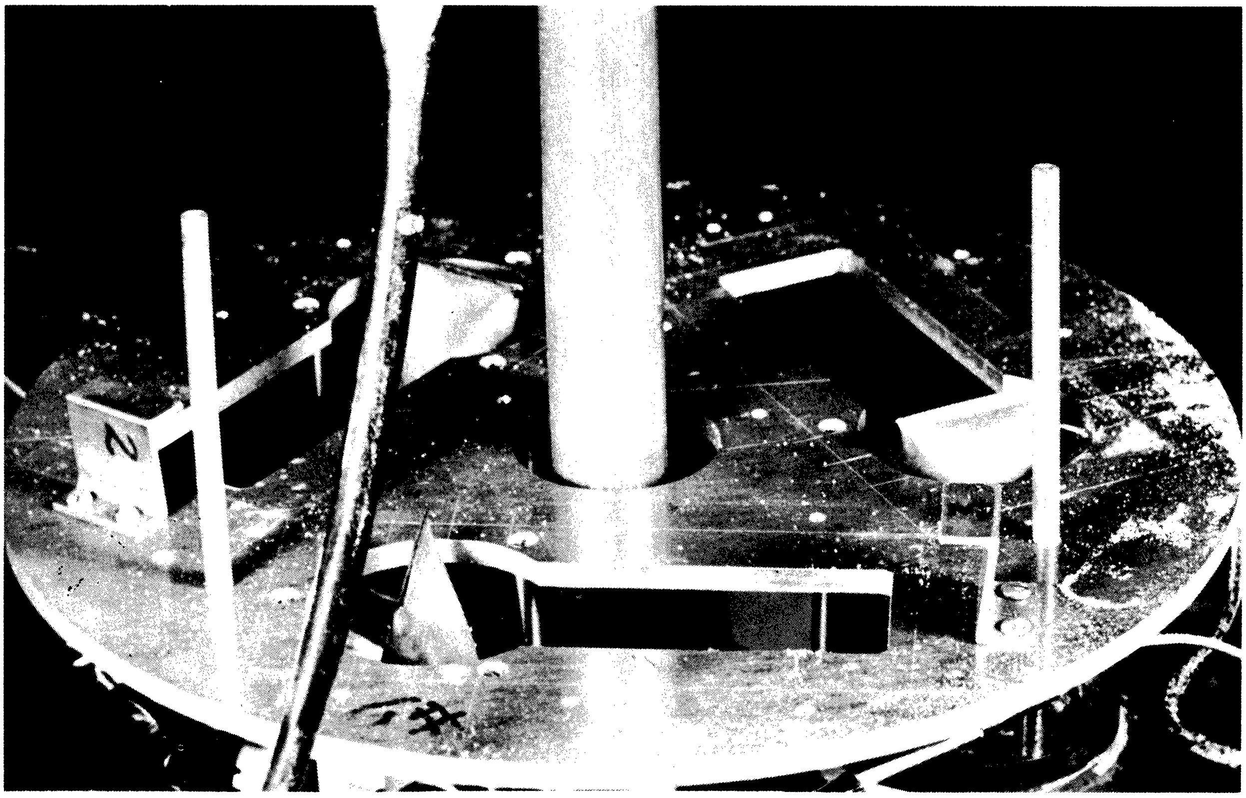


Fig. 6. Cold Weld Seals Made in Flight, SC-17

4. JATO EJECTION OF NOSE CONE

The ejection of the forward cone of SC-13 by Jato was observed with considerable interest because it was planned to use this method of exposing instrumentation on probe as well as sampling Aerobees. Nose cone ejection was indicated at the correct time by widening of the beacon pulse. Ejection was also observed by telescope as was the angle of attack of the missile. Fig. 7 is taken from advance elevation and azimuth information from telescopes III and IV supplied by WSPG Annex, BRL. Nose cone ejection took place at 75.5 seconds and it can be seen that no radical change in the angle of attack of the missile took place in the following 15 seconds. Unfortunately, no angle of attack information is available during the bottle sampling intervals of either SC-13 or SC-17 or during nose-cone ejection of SC-17.

Prior to the firing of SC-15 (probe Aerobee), an ejectable cone similar to the one used in flight was fired from a mock-up of the probe cone. The firing took place on Tuesday, December5, from the ship's deck in the Navy blockhouse area. Three of the mock-up probe rods were fitted with Pirani gages. The gages were in operation. Two motion picture cameras at 90° to each other were aimed at the apparatus. Two Bowen-Knapp camera stations were also operated. The firing was accomplished without difficulty. The cone ascended smoothly and remained aerodynamically stable throughout the flight. It weather cocked and landed point first a few hundred feet west of the blockhouse. The Pirani gages and mock-up cone on the deck were completely undamaged, although the cone was tipped over.

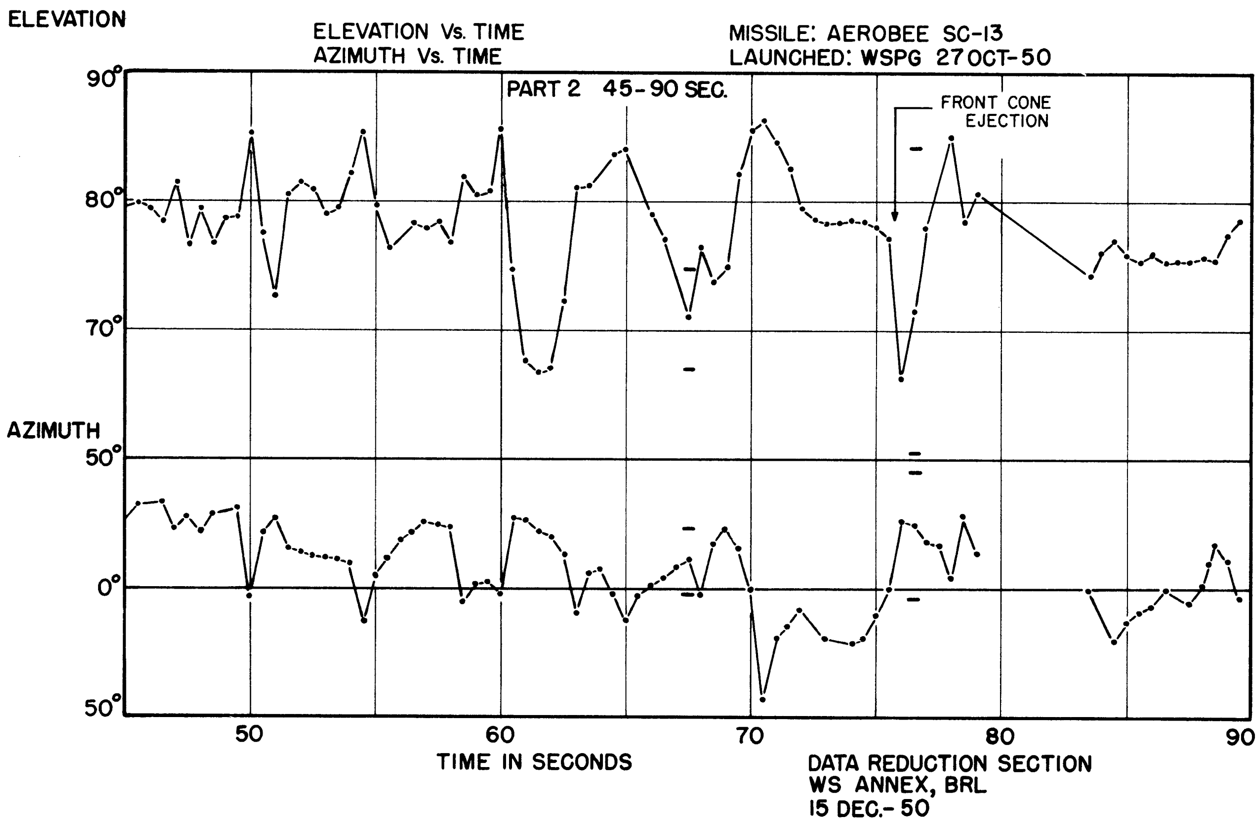


Fig. 7. Azimuth and Elevation, SC-13

Examination of the films showed that the cone took off vertically. The underneath cone was raised by suction about 12 inches off the deck. It rotated in mid-air and fell on its side when it hit. The "skirts" of the ejectable tip flared outward for an instant and were then sucked in to the limit of their travel. Since the cone rotated through about 45° as it fell, some unbalance force must have been applied to it. However, it is impossible to ascertain from the test what the nature and magnitude of the force was and, more particularly, what it would be in flight. In flight, for instance, it is unlikely that any "suction" force would exist because of the low ambient pressure. Angle of attack data from tracking are the final criteria of the effect of Jato ejection on missile stability and more such data will be sought. As a result of this test and the successful ejections of the cones of SC-13 and SC-17 it appears that the technique is practical. Fig. 8 shows the cone just after take-off.

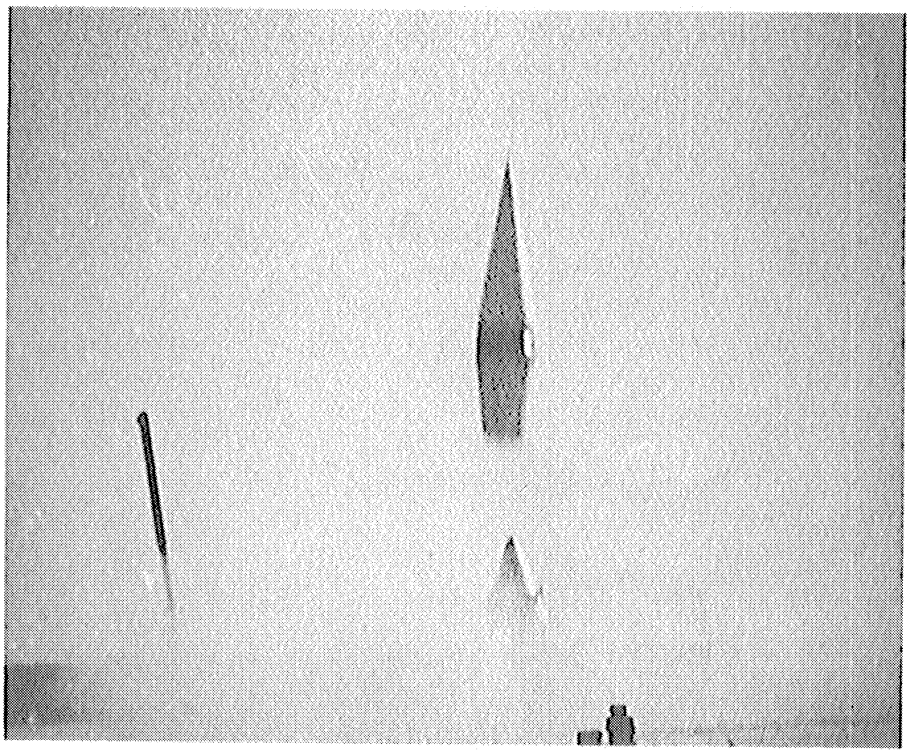


Fig. 8. Jato Ejected Nose Cone Test

5. PROBE AEROBEE SC-15

Various components of the probe Aerobee design were described in Progress Report No. 19. Fig. 9 is a schematic of the instrumentation assembly and Figs. 10 are photographs of the SC-15 assembly. The apparatus was shipped to White Sands for firing in conjunction with the "T-Day" program for coordinated ambient temperature measurements.

SC-15 was fired at 1004 on Monday, December 11. The firing was scheduled for 0900 of the same day but was delayed because of various difficulties. The only trouble encountered with the instrumentation was the inability of the Yardney Al-HR-1 "Silver Cells" to supply starting current to the probe motor. These had been substituted at a late date for Willard NT-6 lead-acid cells to reduce payload weight. The Yardney cells supplied their rated current, but no tests had been made of their ability to supply the motor starting current. The Silver Cells were replaced with NT-6's after which no further difficulties were encountered.

Observers reported that missile operation was abnormal almost from the instant of take-off. The smoke which normally envelopes the tower seemed to contain either bright yellow smoke or flame. The missile pitched and yawed immediately after leaving the tower and soon fell off the booster in a southeast direction. The booster passed the missile and continued upward. At about the same time the ejectable cone fell off the instrumentation cone. The missile impact occurred about seven hundred yards east of the launcher and was accompanied by a large explosion.

Examination of the tracking films by BRL generally confirmed the visual observations:

Explosion on east side of missile (about 30" from bottom of tail and 50' up the tower)	0.36 second (B-K)
Booster burnout	2.55 seconds (B-K)
Nose tip off; missile leans east; missile flame out	2.7 seconds (B-K)
Booster passes missile	4.0 seconds (T-III)

Booster operation appears to have been normal at least for 1.2 seconds as the velocity up to this time compared favorably with previous successful missiles.

The cause of failure has not been definitely established. The fact that Doppler signals were received until 1.5 seconds indicates that premature tail blow-off did not occur as this would probably sever the antenna coaxial cable. Premature fuel line detonation did not occur as the severance fitting was recovered intact. The S.E. tail cone access port cover was recovered. Subsequent chemical analysis revealed that the deposit which coated the inside of the cover consisted of both acid and aniline and/or their combustion products.

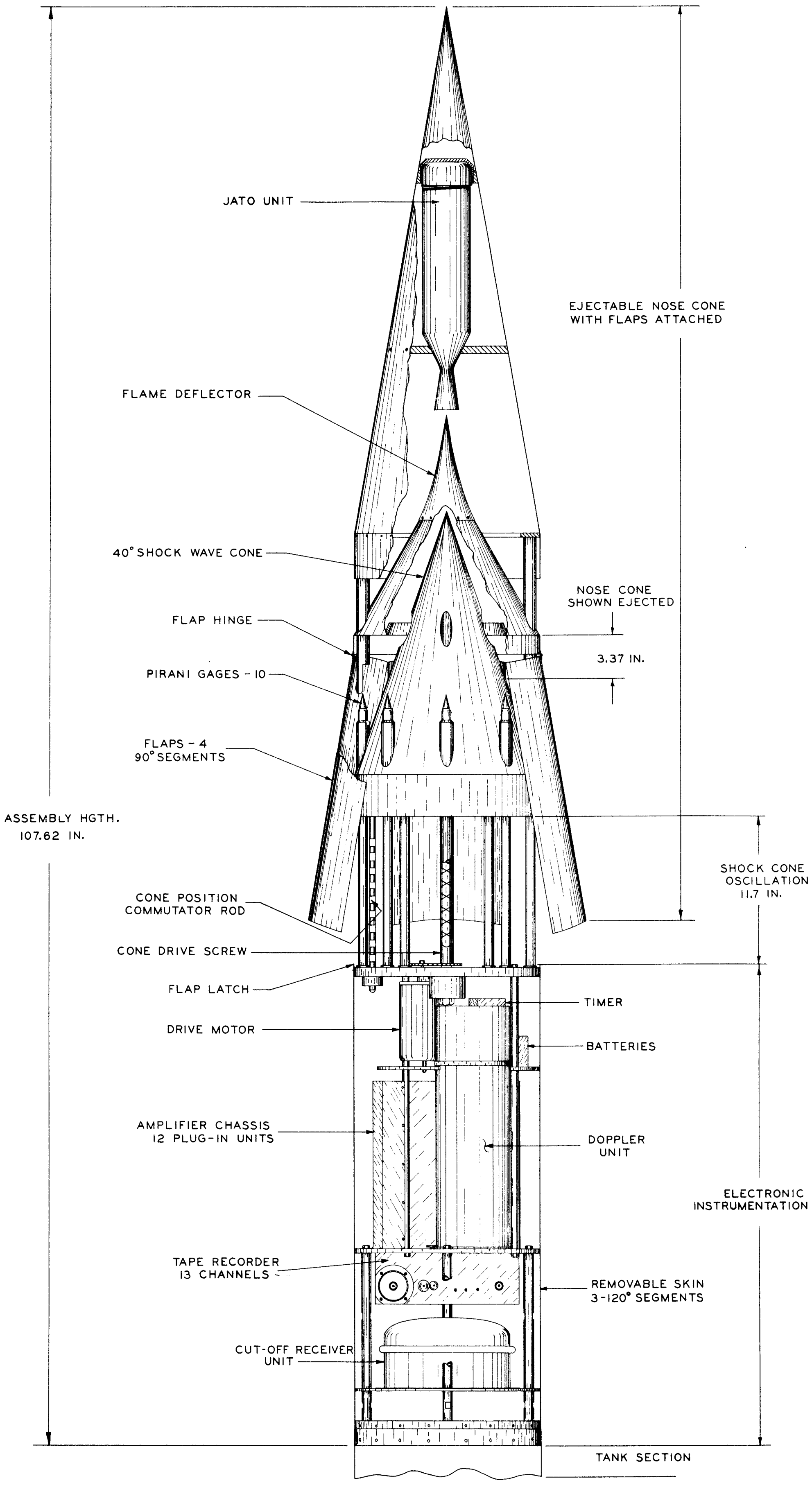
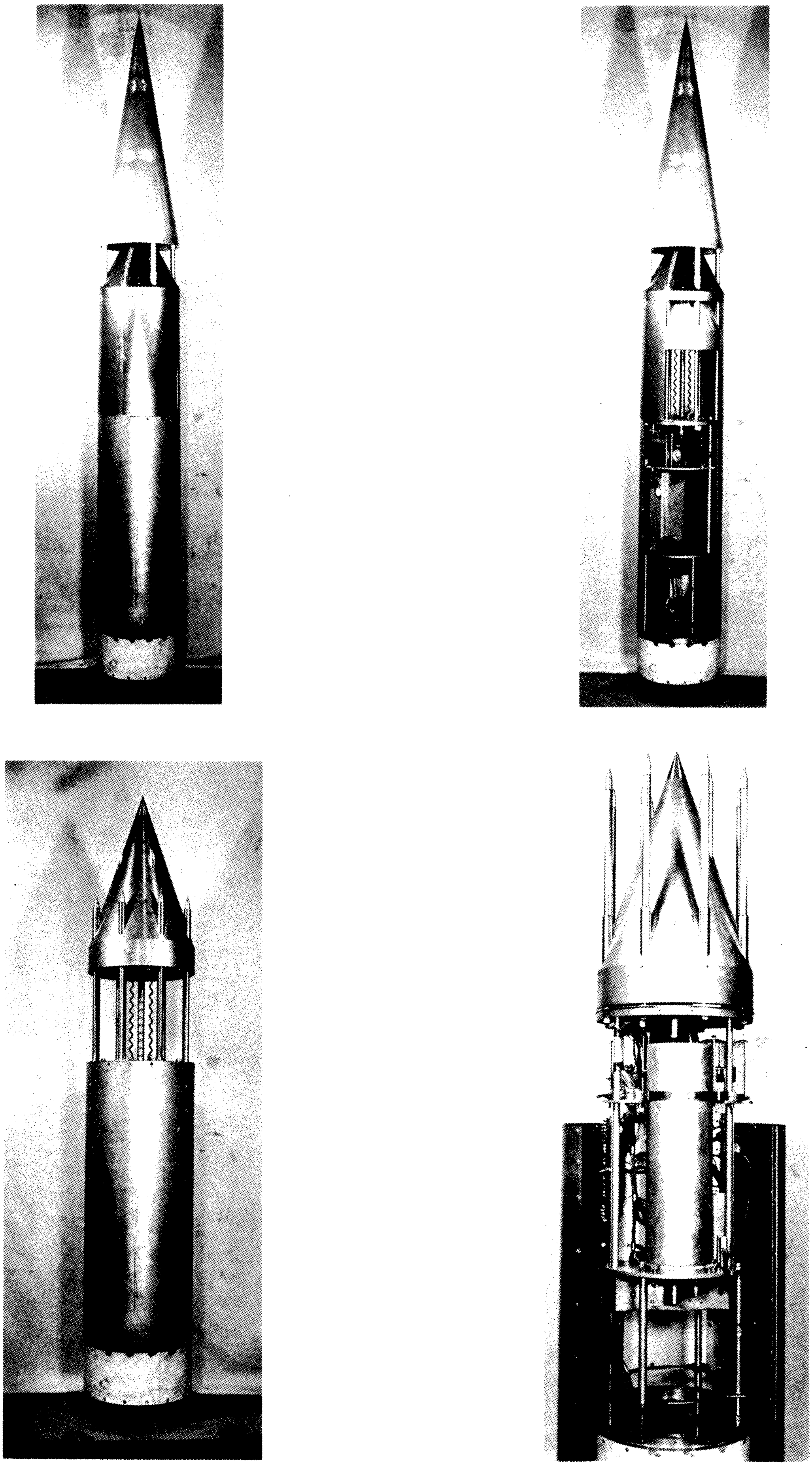


Fig. 9. Probe Aerobee Schematic



Figs. 10. Probe Aerobee Assembly

6. DRAG MEASUREMENTS ON AEROBEE MODELS

A summary* of the performance of Aerobees fired at White Sands from October 1947 to October 1950 indicates a downward trend in performance (as measured in terms of burnout velocity) vs. date of firing. This trend applies both to missiles which had no significant changes in the normal ogival nose cone shape as well as those which did. Inasmuch as the configurations of sampling Aerobees SC-13 and SC-17 and probe Aerobee SC-15 differed from the "standard" it was decided to make wind tunnel measurements of the drag and stability of these designs. This would make possible more accurate predictions of the performance of these rockets and also permit addition of their performance data (after corrections for drag) to the summary of Aerobee performance.

In the case of SC-13 and SC-17 the departure from "standard" was an annular flame port opening in the skin. The opening was 3 inches high, 36 inches back from the tip in the ogive. SC-15 was 8 inches longer than a normal Aerobee with extension. Its forward cone was very nearly right circular, 41 inches high, extending back to a cylindrical section the same diameter as the missile. The flame port on SC-15 was an annular opening 4 inches high, 44 inches back from the tip in the cylindrical section. See Figs. 2 and 10.

During the course of the design of these instrumentations it was estimated that the configurations would have little increased drag and negligible effect on performance. This was borne out to some extent by SC-11 which had a skin opening and right circular forward cone and which reached a peak altitude within about 20,000 feet of that predicted for a standard Aerobee of the same payload.

A model was constructed which could be fitted with nose cone copies of the standard, sampling and probe Aerobees. Three-component force measurements were made at Mach 1.94 and Mach 2.83 and yaw angle between 0° and 10°.

Preliminary calculations of the position of the center of pressure showed that there is no significant difference between the sampling and probe Aerobees and a normal Aerobee for yaw angles up to the maximum used in the tests (10°). Hence it seems unlikely that the aerodynamic stability of the missile would be affected.

Similarly it was found that the increase in drag coefficient for either the sampling or probe Aerobees is less than 10 percent greater than for a standard Aerobee at corresponding angles of yaw.

A preliminary estimate of the loss in peak altitude due to increased drag for SC-13 and SC-17 is less than 20,000 feet. This is based

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* Summary of Aerobee Performance, E. D. Zambelli, Technical Services Branch, White Sands Proving Ground, Las Cruces, New Mexico.

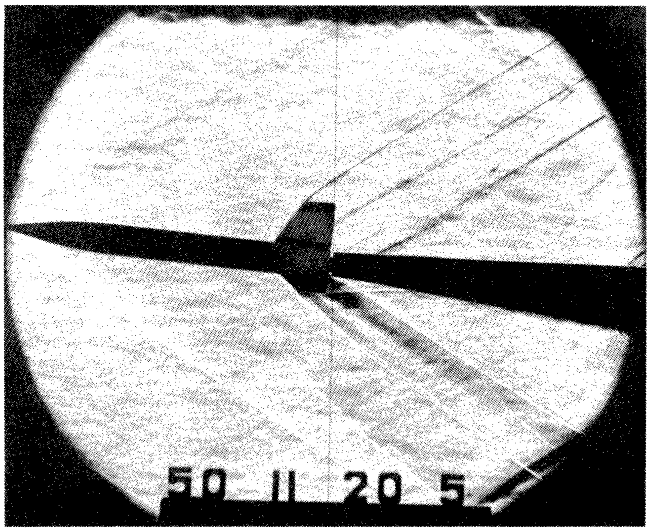

Fig. 11. Schlieren Photograph, Normal Aerobee Model, Mach 1.94

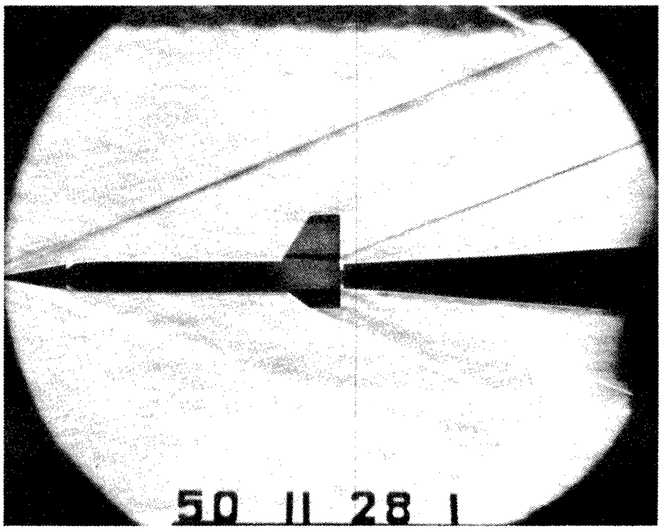

Fig. 12. Schlieren Photograph, Bottle Aerobee Model, Mach 2.83

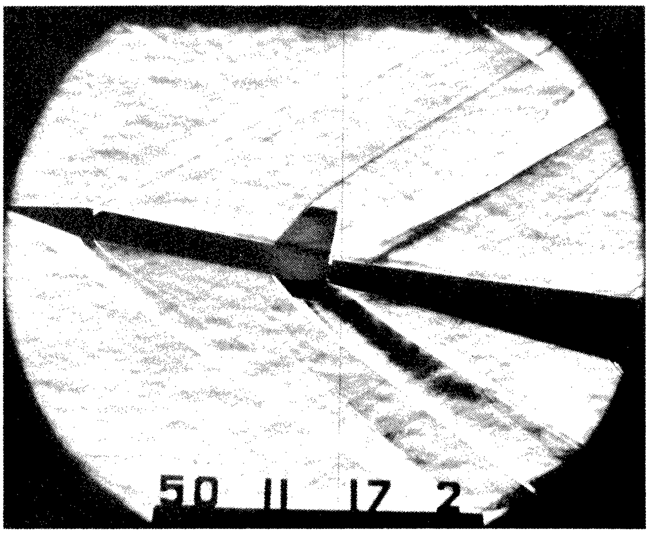

Fig. 13. Schlieren Photograph, Probe Aerobee Model, Mach 1.94

on the assumption that there would be no significant increase in drag after burnout; for instance, during or after nose cone ejection. That the assumption was correct is indicated by the fact that the calculated peak altitude of SC-13 (254,000 feet) based on Askania data at burnout and an assumed vacuum trajectory agrees fairly well with the actual peak altitude measured by radar (260,000 feet). The calculated peak altitude of SC-17 based on Askania data at burnout is 267,000 feet. Radar did not track to peak on SC-17. The losses in peak altitudes were 70,000 and 63,000 feet respectively, compared with the 330,000 foot peak altitude predicted. Thus the increased drag due to the altered configuration is not the cause of the major part of the loss in peak altitude.

The wind tunnel data reductions will be completed and used to calculate theoretical trajectories for SC-13, SC-17 and a normal Aerobee for comparison with actual trajectories. A technical memorandum describing the wind tunnel tests and results will be issued. Figs. 11, 12, and 13 are schlieren photographs of the models taken during the tests. The runs were made in the University of Michigan supersonic tunnel at Willow Run.

7. ANALYSIS OF UPPER AIR SAMPLES FOR THE ISOTOPE RATIO $N^{14}N^{14}/N^{14}N^{15}$

In October 1949 and May 1950 several upper air samples were forwarded to Dr. J. W. Beams at the University of Virginia for mass spectrometric analysis of the ratio $N^{14}N^{14}/N^{14}N^{15}$. The analyses were subsequently carried out by Dr. J. H. McQueen and the results published in the Physical Review. McQueen's conclusions about diffusive separation based on his results are at variance with the conclusions reached on the basis of He/N_2+A and Ne/A ratio measurements by the charcoal adsorption method. As yet the two results have not been reconciled. The situation is summarized in the following Letter to the Editor of the Physical Review which will appear in the near future.

"Does Diffusive Separation Exist

in the Atmosphere Below 55 Kilometers?

In a recent letter(1), J. H. McQueen infers that above 40 km diffusive separation increases the proportion of $N^{14}N^{14}$ molecules as compared to the $N^{14}N^{15}$ molecules. This inference rests on mass spectrographic analyses of six air samples obtained by rockets under an U. S. Army Signal Corps contract with the University of Michigan. For purposes of discussion (and also inasmuch as there are errors in the dates and altitudes of several of the samples), McQueen's table of results is reproduced here with the correct dates and with certain results obtained at the University of Durham and at the University of Michigan which will be discussed in a later paragraph.

Suppose that in a particular layer of the atmosphere there is no mixing at all. Then, for any constituent of molecular weight M, the height distribution in terms of the number of molecules, n, per unit volume is given by

$$n = n_o \, e^{-h/H} \tag{1}$$

where n_o = number of molecules per unit volume at the base of the layer, h = height above the base of the layer and, if it is assumed that the temperature T is essentially constant throughout the layer, H = RT/Mg where R is the molar gas constant. Now consider the relative concentration, $\rho = n'/n$, of two gases of molecular weights M and M'. From (1)

$$\rho = \rho_o e^{-(h/H' - h/H)} = \rho_o e^{-h/H_1} \tag{2}$$

where $H_1 = RT/(M'-M)g$ and ρ_o is the ratio at the base of the layer. The percent change, P, in ρ relative to ρ_o is from (2)

$$P = -100 \, (1 - e^{-h/H_1}) \tag{3}$$

McQueen's results imply that there is no diffusive separation up to about 47 km but that there is about a 3% separation at about 55 km, implying a cessation or reduction of mixing over the 8.4 km between mean levels of the two groups of samples. (The time interval between the two groups is only a few months, and in this region diffusion is too slow for any appreciable change in P between the two levels to occur during this interval). If it is assumed that no mixing occurs over the 8.4 km range and if T is taken as 280°K(3,4) then for the $N^{14}N^{14}/N^{14}N^{15}$ ratio, for which M' - M = -1, equation (3) gives P = 3.5% so that McQueen's results are not inconsistent in this respect. On the other hand, for the He/(N_2 + A) ratio (M' = 4, M = 28), equation (3) gives P = 134% under the same conditions; and for Ne/A, P = 107%.

Other portions of the samples analyzed by McQueen have also been analyzed by the charcoal absorption method at the University of Durham by Professor F. A. Paneth and co-workers(2) for He, Ne, A, and N_2 and by the writers for He, Ne and (N_2 + A). In these samples and in six others, the relative concentrations of the gases did not vary more than several percent from the corresponding values at the surface of the earth. At this time, analyses by the charcoal method have been made for only three of the six samples reported by McQueen (results on the three other samples will be reported later); results from these three samples are given in Table I in terms of percentage deviation of the relative helium (to nitrogen plus argon) concentration in the sample from the corresponding concentration at the surface of the earth, and in terms of the percentage deviation of the neon to argon ratio from the corresponding surface value.

The small concentration of helium in the earth's atmosphere implies escape of helium from upper atmospheric levels. This effect would increase the concentration gradient of helium over that computed on the basis of equation (1)(5). However, the neon to argon ratio is not subject to this effect since it is believed that these gases do not escape from the atmosphere.

Hence it seems that mixing must prevail at least up to about 60 km and that McQueen's results must be interpreted in some other way than by diffusive separation in the atmosphere.

Details of the sampling procedure, etc., used by the writers will be published elsewhere. We are indebted to Professor Sydney Chapman for discussions in connection with our results. The work at the University of Michigan is sponsored by a contract with the Meteorological Branch of the U. S. Army Signal Corps.

D. W. Hagelbarger
Leslie T. Loh
H. W. Neill
M. H. Nichols
E. A. Wenzel

Department of Aeronautical Engineering
University of Michigan
Ann Arbor, Michigan

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(1) J. H. McQueen, Phys. Rev. 80, 100, (1950).
(2) K. A. Chackett, F. A. Paneth, and E. J. Wilson, Jour. Atmospheric and Terrestrial Physics, 1, 49, (1950).
(3) R. Havens, R. Koll, and H. Lagow, "Pressures and Temperatures in the Earth's Upper Atmosphere", Naval Research Laboratory Report, March 1950.
(4) F. L. Bartman, V. C. Liu, E. J. Schaefer, "An Aerodynamic Method of Measuring Ambient Temperature of Air at High Altitudes", Engineering Research Institute University of Michigan Report (U.S. Army Signal Corps Contract) July 1950.

(5) S. K. Mitra, "The Upper Atmosphere", (Royal Asiatic Society of Bengal, Calcutta, 1947) page 21.

TABLE I*

Comparison of McQueen's results[1] with those of Paneth and co-workers[2] and those obtained at the University of Michigan. The percent deviation is from the corresponding ratios at the earth's surface - i.e. the quantity P in equation (3). The mean deviations are given.

	Height	Date	Separation (%) $N^{14}N^{14}/N^{14}N^{15}$ McQueen[1]	Separation (%) Paneth and Co-workers[2] He/(N_2+A)	Ne/A	Separation (%) He/(N_2 + A) (Univ. of Mich.
(19B)	54.7-58.3	7-21-49	3.9 ± 0.4			
(15C)	53.6-57.7	6-2-49	2.7 ± 0.2	0.3 ± 0.3	-1.3 ± 0.8	-3†
(5B)	49.0-59.8	7-26-48	2.7 ± 0.5			0‡
(25B)	50.4-53.3	12-6-49	0.4 ± 0.3			
(20B)	45.0-47.8	9-20-49	0.8 ± 0.3			
(28B)	41.4-44.9	12-6-49	less than 0.3			-0.3 ± 0.3#

* The samples are labelled by a number and a letter. The number refers to the original sample and the letter to the subdivision. The particular letters given in this table refer to the subdivisions sent to McQueen.

† Only one valid run was made on this subdivision of sample 15 so that a mean deviation cannot be deduced. This run was made early in the analysis program and it is estimated that the mean deviation is not greater than 3%.

‡ This is the average of two runs which were made early in the analysis program. It is estimated that the mean deviation is not greater than 3%.

This is the average of four runs." (End of quote)

8. ANALYSIS OF AIR SAMPLES ENRICHED WITH HELIUM

A further attempt to analyze for helium a blend of air which had been enriched with helium was made. Fig. 14 shows the blending apparatus.

Tube A is connected to a vacuum pump. Stopcock D is turned so that E and G are evacuated, F being open. D is turned so that H is evacuated, K being open and J lowered so that the mercury is just above K. Tube A is connected to a source of helium and stopcocks B and D turned to admit helium into C and H at atmospheric pressure. D is turned to cut-off E, G, and H. C is then repumped to a vacuum. B is then closed, A opened to roof air and B re-opened. D is turned to permit mixing of helium and air. Bulb J is raised and lowered several times to aid in mixing, K being open. D is again turned to shut off E, G, and H; and C is repumped and air again admitted and mixed. This process is done three times. Before admitting and mixing the last air D is turned so that E and G may be evacuted to remove any pure helium or "2nd" mixture which may have leaked past through D. D is then turned to admit the final mixture to E and G which are then removed for analysis.

The volumes of C and H are accurately known. C is 520.7 cc. between B and D. H is 9.46 cc. between the same point on D from which C was measured and K. The dilution ratio is 1.785×10^{-2}.

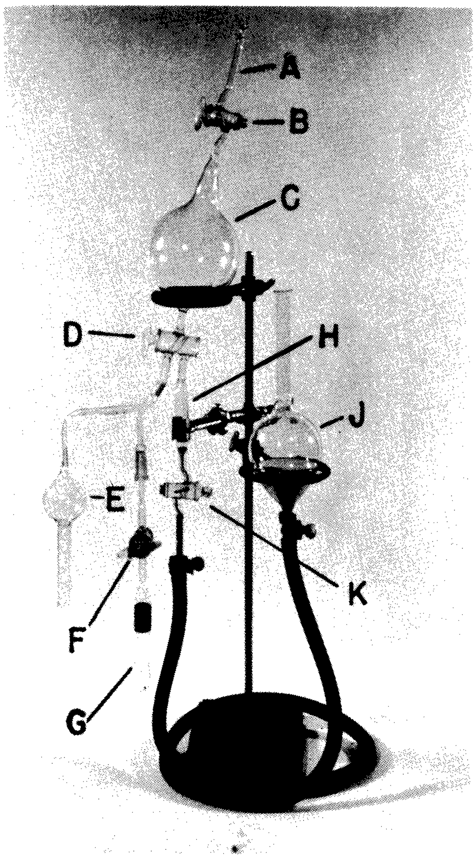

Fig. 14. Apparatus for Enriching Air with Helium

A blend was prepared which was calculated to contain 10.9 ppm helium and three analyses were run:

	O_2(%)	He(ppm)	Ne(ppm)
Blend	20.9	10.9	18.2
Run 1	20.4	13.7	
Run 2	20.55	13.9	19.3
Run 3	20.25	14.0	

These results are much improved over those of the first attempt reported in Progress Report No. 19. They establish that the analyzer is sensitive to increased helium. Inasmuch as the probable error of recent analyses of ground air for helium has been considerably less than the error in the enriched helium results, it is felt that the error in the latter may be in blending rather than analysis. A further attempt will be made to refine the blending technique for improved accuracy.

9. REPORTS ISSUED AND LABORATORIES VISITED

No reports were issued during the period. The following places were visited during the course of the work:

Ballistics Research Laboratory
Evans Signal Laboratory
General Electric Company
Henry Wild Company
White Sands Proving Ground

10. FUTURE PROGRAM

An investigation of the possibility of collecting air samples at 100 km or higher will be made. Probe Aerobee SC-19 will be completed and fired. The investigation of Aerobee drag will be completed. Further measurements of the ratio $N^{14}N^{14}/N^{14}N^{15}$ will be made. More blends of air enriched with He will be prepared and analyzed.

11. ACKNOWLEDGMENT

Thanks are due the White Sands Proving Ground and the Meteorological Branch of the Signal Corps for their cooperation and support. We are indebted to the Ballistic Research Laboratory for their cooperation in supplying Doppler for SC-15. The cooperation of the University of Michigan wind tunnel group in measuring Aerobee drag is acknowledged. Figures 1 to 6 and 8 are Signal Corps photographs.