ENGINEERING RESEARCH INSTITUTE
UNIVERSITY OF MICHIGAN

ATMOSPHERIC PHENOMENA AT HIGH ALTITUDES

Department of the Army
Contract No. DA-36-039 SC-15443
(Meteorological Branch, Signal Corps)

<u>Progress Report No. 1</u>   <u>Quarterly Report</u>

for the period

January 1, 1952, to March 31, 1952

Department of the Army Project No. 3-99-07-22
Signal Corps Project No. 172B

Submitted for the project by:

M. H. Nichols

UNIVERSITY OF MICHIGAN PROJECT PERSONNEL

Both Part Time and Full Time

Bartman, Fred L., M.S., Research Engineer
Becker, Frederick H., Research Technician
Beckett, Bob L., Laboratory Assistant
Carothers, R. Dale, Research Technician
Chaney, Lucian W., B.S., Research Engineer
Colliau, Frank D., Machinist
Cousland, Charles P., Laboratory Assistant
Filsinger, Edward A., Machinist
Gleason, Kermit L., Machinist
Hansen, William H., B.S., Research Associate
Harrison, Lillian M., Secretary
Jones, Leslie M., B.S., Project Supervisor
King, Jay B., B.A., Research Associate
Liu, Vi Cheng, Ph.D., Research Engineer
Loh, Leslie T., M.S., Chemist
Neill, Howard W., M.S., Research Engineer
Nichols, Myron H., Ph.D., Prof. of Aero. Eng.
Samborski, Cassimere, Machinist
Schaefer, Edward J., M.S., Research Engineer
Titus, Paul A., Research Technician
Wenk, Norman J., B.S., Research Engineer
Wenzel, Elton A., Research Associate

TABLE OF CONTENTS

ILLUSTRATIONS

ATMOSPHERIC PHENOMENA AT HIGH ALTITUDES

Department of Aeronautical Engineering

1. INTRODUCTION

This is the first 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.

2. SUMMARY

The work during the first quarter of 1952 was mostly devoted to the preparation and testing of equipment for two rocket flights in May.

2.1 Sampling

Seven sample bottles in three separate assemblies are being prepared for firing in V-2 59 scheduled for 6 May. Further work and investigation toward improving the reliability of cold welding was carried out.

2.2 Sphere Experiment

Tests of the ejection of the sphere apparatus described in the previous report have been carried out at the high altitude chamber of the Aero Medical Laboratory at Wright-Patterson Air Force Base. Results of the tests required some modification of the apparatus. An Aerobee sphere installation is being prepared for flight in May. More data on drag coefficient of spheres have been received from the Aero Ballistic Research Department of the U. S. Naval Ordnance Laboratory at White Oak, Maryland.

3. ATMOSPHERIC SAMPLING

The principal change in the sampling technique developed during the last quarter is in the cold-welding process. Previously, the inside of the copper intake tube was cleaned by a chromic acid solution and rinsed with distilled water prior to evacuation. Sowter[1] recommends cleaning by buffing with a wire brush driven at high peripheral speed rather than by chemical cleaning inasmuch as the latter leaves a film on the metal. Consequently, a number of tests were made, and the results of the two cleaning processes were compared.

Two types of tests were made. One consisted of putting a pair of sealing jaws in a strength-of-materials tester and cold welding 1/4-inch wide strips of copper cut from the Revere type L copper tubing, which is used for the intake tube on the sample bottles. The total force on the jaws could be measured during the welding process. It was found that the buffing produced stronger welds than did the chemical cleaning. The copper appeared to flow together at lower pressures if cleaned by buffing. Indications are that the buffing results in a lower pressure required for welding than does the chemical cleaning. This is substantiated by the fact that the welds are wider in the case of buffing as indicated schematically in Fig. 1. The other type of test was made with the black-powder sealer and the Revere type L tubing used for the intake tubes on the sample bottles. As before buffing was compared with chemical cleaning. Here again a stronger and wider weld was obtained with the buffing. Therefore, it was decided to incorporate the buffing technique into the preparation of the sample bottles.

As explained in the previous report, the Philips gage is soldered onto the end of the intake tube and is broken off and ejected by the pyrotechnique opener. In the process of assembling the sample bottle, the copper intake tube is hard soldered to the bottle and the Philips gage is then hard soldered to the intake end of the copper tube. Then the cap of the Philips gage is soft soldered in place (It is necessary to soft solder the cap on because of the glass-insulated lead to one of the electrodes of the gage).

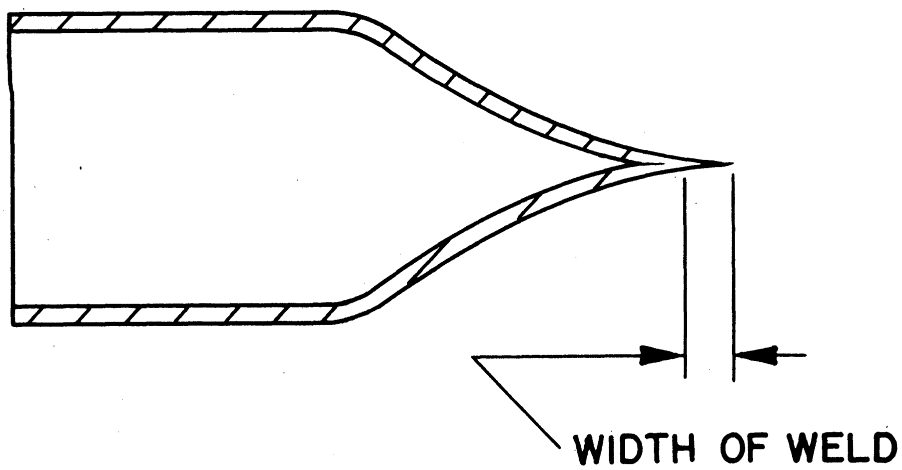

Fig. 1. Schematic Cross Section of Cold Weld.

In order to permit buffing the intake tube at the place where the cold weld is made after all soldering, etc., has been completed (It is desirable to perform the buffing after all soldering is complete in order to avoid contamination by vapors from the soldering flux, etc.) a steel-wire brush is dropped into the tube and held in place with a small magnet just prior to soldering the Philips gage cap in place.* The procedure is indicated schematically in Fig. 2. Fig. 3 is a photograph of this brush. Since it is dropped into the sample bottle after the buffing is complete, two flat springs are welded in place as shown in Fig. 3 to keep the brush from re-entering the intake tube and possibly getting in the way of the sealer. After all soldering is complete the tube is then buffed by mounting the sample bottle on a lathe and holding the buffing brush, which is now inside the copper intake tube, with a magnetron magnet. This is illustrated by the photograph of Fig. 4. When the bottle is rotated in the lathe, the brush being held by the magnet, a satisfactory buffing job can be accomplished. It is planned to buff the inside of the tube after the sample bottle is evacuated in order to obtain a very clean surface.

It should be mentioned that the effect of gold-plating the copper on cold-welding was investigated. A layer of gold about 0.002 inch thick was laid down by electroplating from a solution of potassium gold cyanide. No difference in behavior, as compared to copper, was obtained. As in copper, cleaning by buffing gave a stronger and wider weld. Since there appears to be no advantage gained by gold-plating, it will not be adopted at this time.

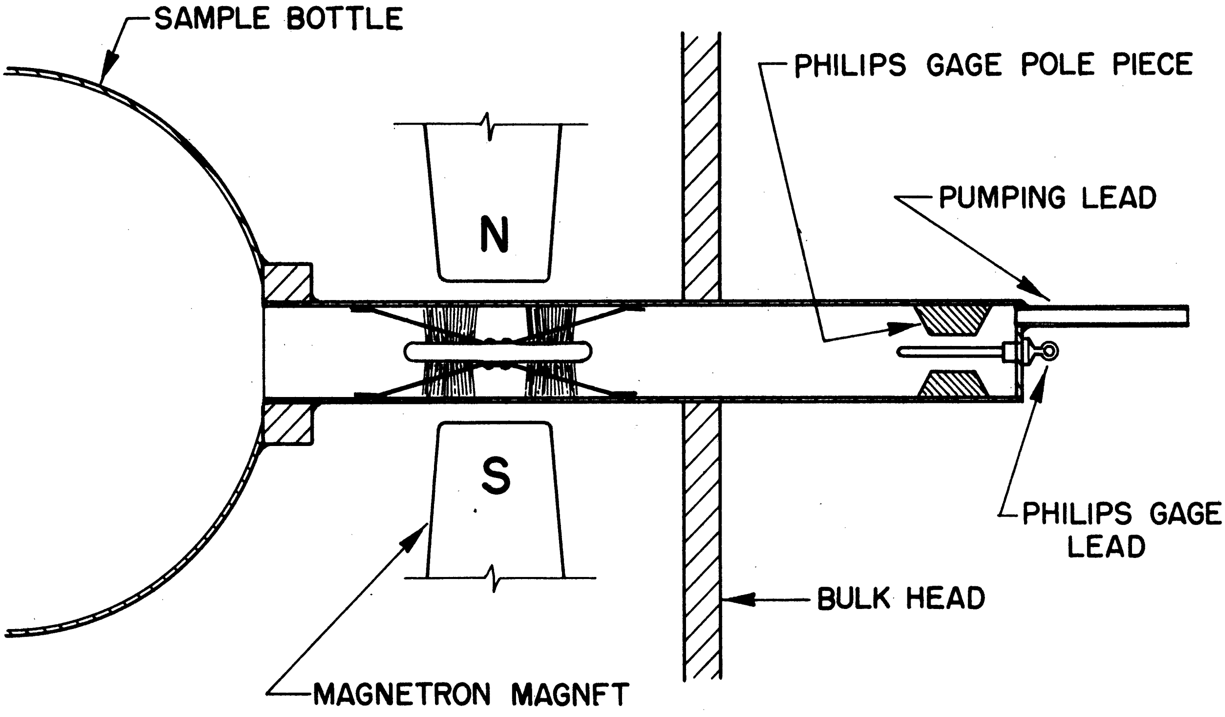

Fig. 2. Schematic of Buffing Process.

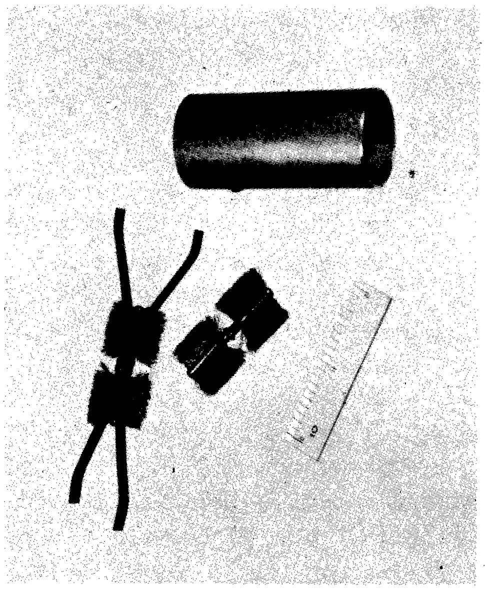

Fig. 3. Photograph of Steel Brush Used for Buffing. A section of intake tubing is shown as well as a brush without the flat springs attached.

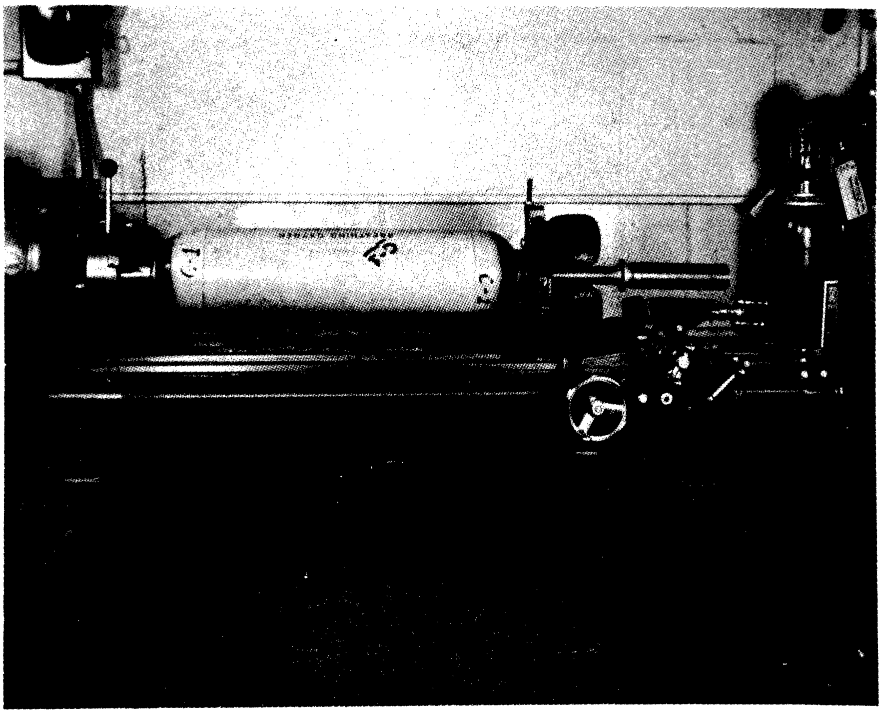

Fig. 4. Photograph of Setup for Buffing the Inside of the Intake Tube. The sample bottle is rotated by the lathe; and the magnetron magnet, just to the right of the steady rest, holds the buffing brush stationary inside the intake tube.

Several weeks time during the quarter was spent on the complete over-hauling of the helium leak detector. The oil diffusion pump was taken apart and cleaned. A broken tube socket in the ion collector was replaced and a new 10^{11}-ohm input resistor installed.

The pyrotechnic opener described in the previous reports has been modified to incorporate two O-ring seals to give a better seal against gases from the combustion of the powder escaping into the region ahead of the front bulkhead. In this design care was given to reducing fabrication costs. Fig. 5 is a schematic of the new type of opener. Tests on the leakage from this opener were made by sealing it into a vessel, consisting of a section of iron pipe, attached to a vacuum system and McLeod gage as shown in Fig. 6. The volume of the system is 2.7 liters. Some trouble was experienced at first with the seal at the end of the pipe (right end in the Figure). After this was repaired the following data were taken on two different openers of the type shown in Fig. 5.

"Outgassing" of Opener

No. of Run	Date	Background Leakage		"Leakage" in Front of Bulkhead* Time	Pressure
1	4/15-17/52	0.8	in 20 min.	0 sec.	0.1
				5 sec.	0.2
				1 min.	3
				2 min.	8
				3 min.	10
				4 min.	11.5
				6 min.	14
2	4/25/52	0.9	in 6 min.	0 sec.	0.15
				15 sec.	0.7
				60 sec.	3
				120 sec.	6.5

* Data given in μ of pressure measured with a McLeod gage in a total volume of 2690 ml.

Since the amount of gas which leaked past the O-ring seals is infinitesimal compared with the flux of air past the intake tubes, it is considered that the O-ring seals are satisfactory.

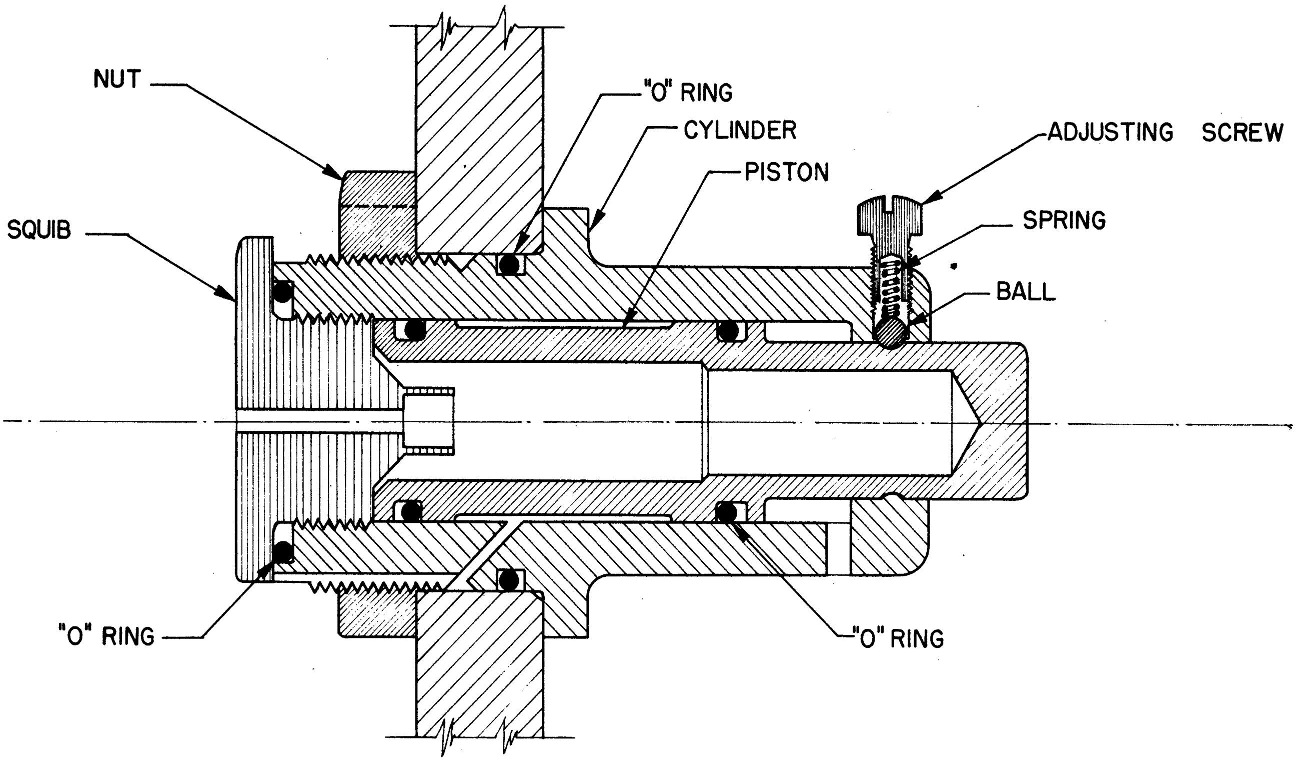

Fig. 5. Cross Section of New Type Pyrotechnic Opener.

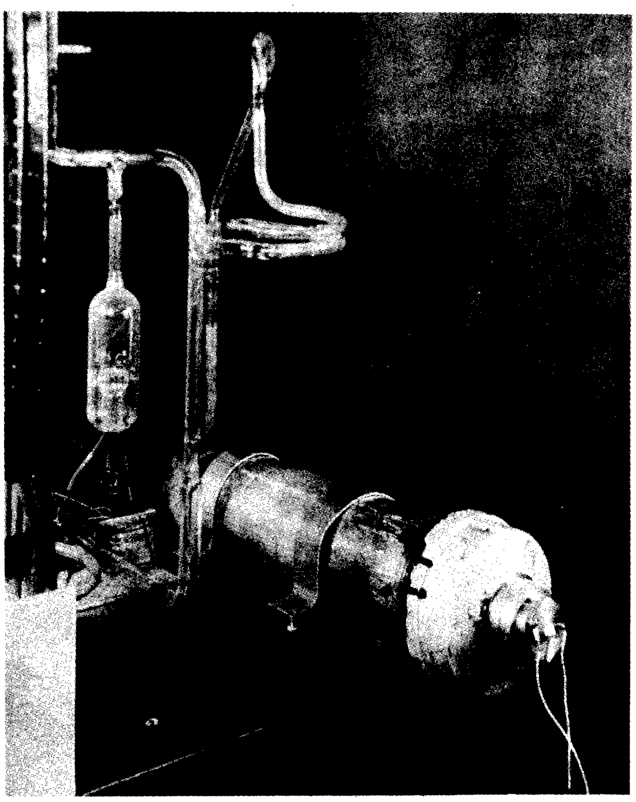

Fig. 6. Photograph of Apparatus Used to Measure Leakage of Pyrotechnic Opener. The chamber is made of steel pipe and the opener can be seen at the end toward the reader.

4. INSTRUMENTATION FOR V-2 NO. 59

As pointed out in the previous report, it is planned to use three sample assemblies which are essentially the same as those used with the Aerobee. The arrangement was shown schematically in Fig. 8 of the previous report. Various components of the system have been completed. Fig. 7 is a photograph of the ejectable nose cone. Three separate timers have been constructed: one for each Aerobee-type installation. These are shown in Fig. 8. Fig. 9 shows a test setup which includes three timers, blockhouse control console, and the three parachute assemblies which contain the blast ring and piston assemblies for disconnecting the sample assembly from the rocket.

It is planned to open the bottles one each at the following altitudes: 50, 60, 70, 75, 80, 90, and 100 km. Two of the three units each contain three sample bottles of 500 cubic inches volume, and the third unit designed for the 100-km opening contains one bottle of 2000 cubic inches volume.

Three silicon-rubber-coated Fiberglas parachutes will be used, one for each unit. In two of the parachutes the ribbon is 1750-pound test and in the third 1100-pound test. The weight of the heavier parachute is 31 pounds and the lighter 18 pounds. The volume is 1700 cubic inches for the heavy parachutes and 1100 cubic inches for the light parachute. There have been no test flights of these parachutes. They have been forwarded to Alamagordo for aircraft drop test and hanging.

The Jato-ejected nose cone weighs 175 pounds, including the Jato. The nominal thrust of the Jato is 800 pounds, but this will be reduced to about 500 pounds by the deflection cone.

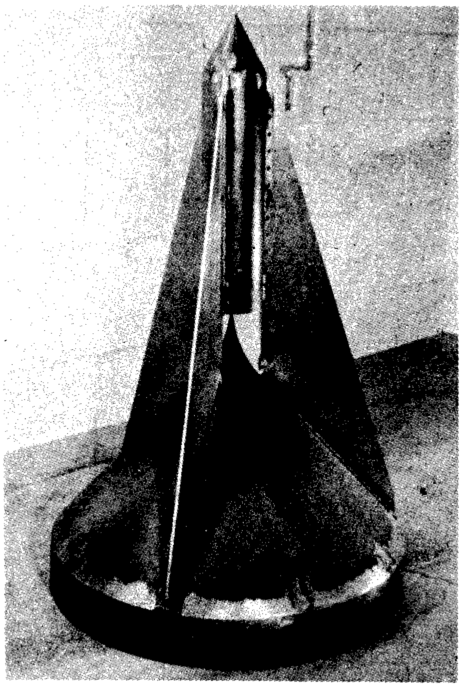

Fig. 7. Photograph of Ejectable Nose Cone for V-2 No. 59 Sampling Installation.

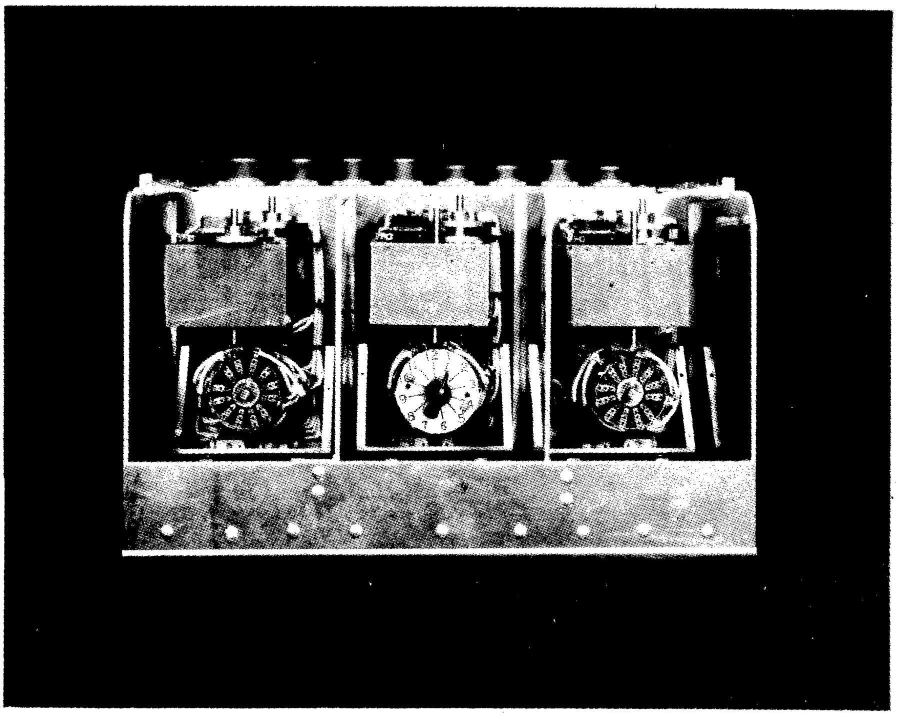

Fig. 8. Photograph of the Three Timers for the V-2 No. 59 Sampling Installation.

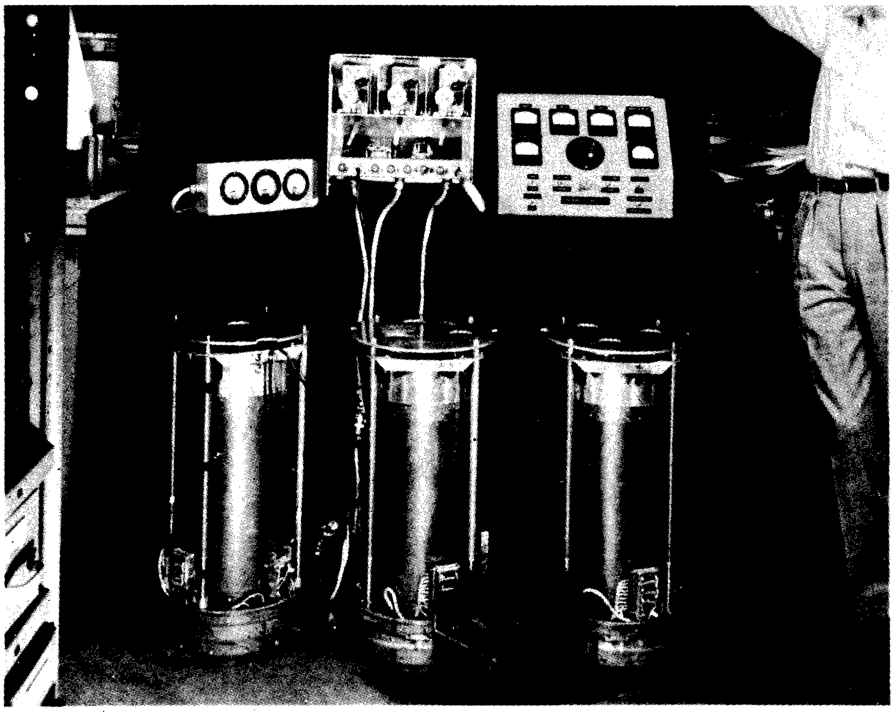

Fig. 9. Photograph of the Test Setup for the V-2 No. 59 Sampling Installation. This shows the three timers, blockhouse control, and monitor on the bench and the three parachute containers on the floor.

5. SPHERE EXPERIMENT

The equipment described in the previous report was tested in the high-altitude chamber at the Aero Medical Laboratory at Wright-Patterson Aif Force Base on February 4th and 5th, 1952. The objective was to eject the sphere under conditions simulating as closely as possible those expected in an actual rocket flight. In addition to using the actual sphere apparatus including Dovap, the two most important conditions simulated were those of low pressure and rocket inertia. The pressure condition was obtained in the high-altitude chamber, and the inertia condition was simulated by mounting the apparatus on a heavy, low-friction, wheeled dolly. Vibration and acceleration conditions were not simulated, but some of the components had been previously shake-table tested in the laboratory.

The items to be observed in the test were:

1. To see if the sphere itself could survive the forces of inflation and ejection.

2. To see if the Dovap unit would continue to operate during and after the sphere ejection.

3. To determine the timesof decompression of the inner cylinder and the inflation of the sphere. If these times could be obtained, a reasonable estimate of the forces acting on the sphere during ejection could be made.

4. To see if the plywood half cylinders holding the sphere would be damaged during the ejection in such a manner as to hinder or damage the sphere during the ejection.

In preparation of the test model some trouble with leaks in the sphere access doors was experienced. However, it was possible to reduce the effects sufficiently for the test by determining the leak rate and the time required to reduce the altitude-chamber pressure to suitable pressure level and pressurizing the sphere to a higher pressure than normal to compensate for the leaks. Ropes, mats, and sandbags were used to protect the altitude chamber from the effect of the primacord blast and the ejection of the sphere.

The following results were obtained: (1) The principle of ejection appears to be satisfactory, but the expansion of the sphere after ejection appears to be too violent as evidenced by damage to the sphere in the neighborhood of the sphere access doors, destruction of the inner plywood cylinder holding the Dovap unit and damage to the wooden half cylinder in which the equipment is held prior to ejection (See Fig. 34 of the previous report). (2) The Dovap unit appeared to operate satisfactorily throughout the test.

On the basis of these tests it was decided to use an airtight inner cylinder in which sufficient air is stored to inflate the sphere when it is ejected. Fig. 10 is a schematic of the proposed arrangement. The sphere is packed in the nose section of the rocket so that the valve at the top of Fig. 10 is in the closed position as shown. When the sphere is ejected, the

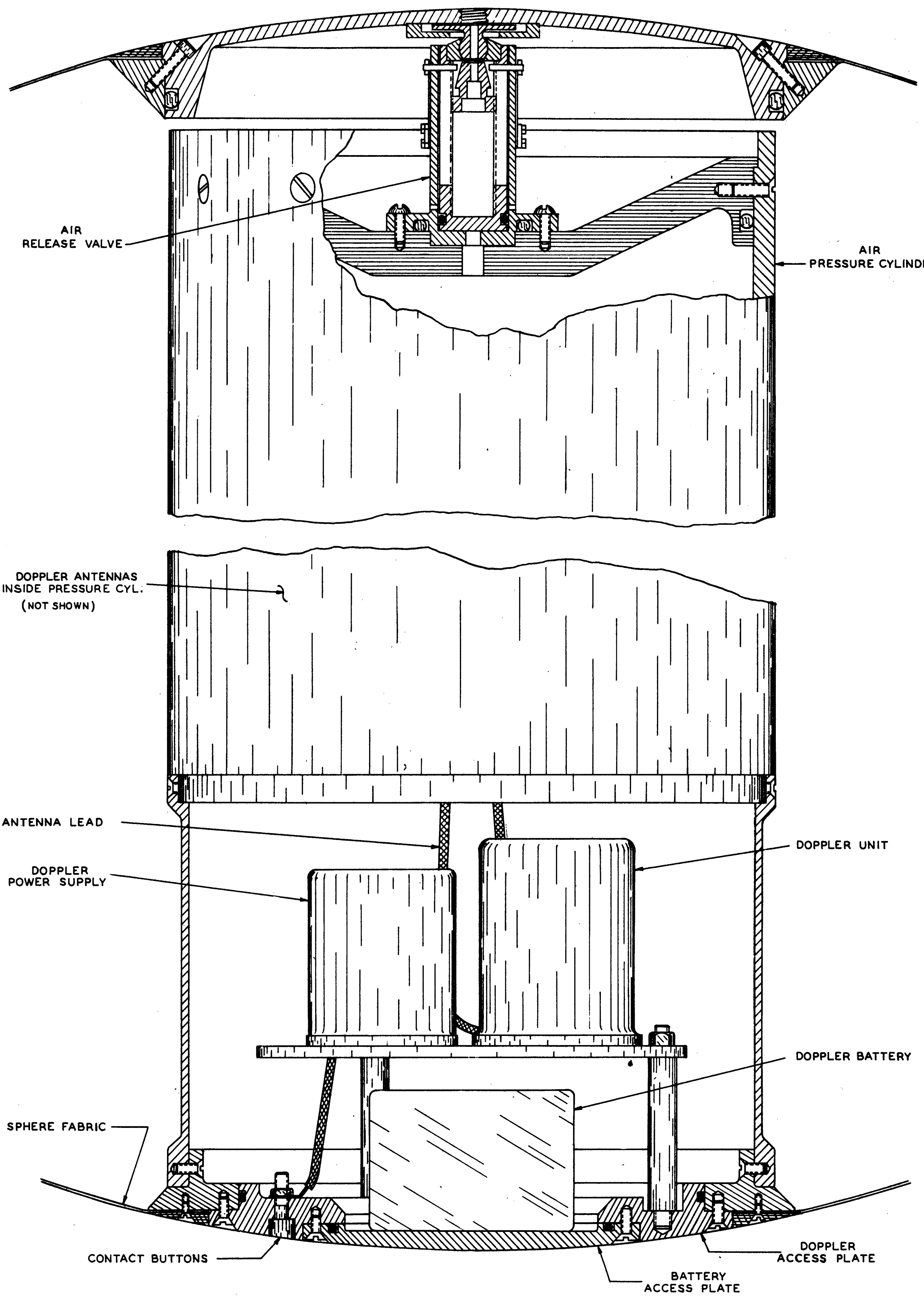

Fig. 10. Schematic of Pressure Cylinder, Valve, and Doppler in the Redesigned Sphere Apparatus.

separation between the access doors increases, thereby valving the air from the pressure cylinder. The air escape holes are small enough to permit only a gradual inflation of the sphere. There will be about .5 psia in the sphere and 50 psia in the cylinder prior to ejection. A Textolite cylinder wrapped with Fiberglas cord will be used. The end plates will be of Micarta fastened in with screws. The doppler antenna will be inside of the cylinder as sketched in Fig. 9. This will require redesign of the doppler antenna and packaging. A cross-loops system similar to the bumper installation will be considered. The auxillary circuits will be the same as those described in the last report.

The Naval Ordnance Laboratory has obtained data on C_D of spheres in addition to those reported in the previous report. These are given in the table below.

Sphere Drag Coefficients

Shot	C_D	M	Re x 10^{-4}	Shot	C_D	M	Re x 10^{-4}
358 C	0.9419	2.15	8.397	432	0.9796	1.72	0.262
358 D	0.9468	2.77	27.006	433 B	0.8995	2.86	0.435
360 A	0.9415	1.66	4.669	434 C	1.0224	1.80	0.266
360 C	0.9370	2.62	7.454	435	0.9343	3.01	6.883
360 D	0.9469	2.62	18.607	436 A	0.9383	3.01	1.518
361 B	0.9158	1.46	3.200	437 A	0.9235	2.57	3.313
361 C	1.0117	1.44	9.962	437 B	0.9552	2.71	1.514
361 D	0.9725	2.62	39.969	437 D	0.9228	1.52	4.320
362 A	0.9384	2.83	2.150	438 B	0.8843	1.46	1.155
362 C	1.0000	1.94	31.584	438 C	0.9324	2.85	9.791
362 D	0.9986	1.90	47.096	438 D	0.9546	2.96	11.280
363 C	1.0191	1.60	11.108	439 A	0.9396	2.71	9.228
363 D	1.0120	1.78	18.322	439 B	0.9552	1.25	5.798
364 C	0.9408	2.71	16.533	440 A	1.0914	2.15	50.454
364 D	0.9504	2.66	27.471	440 C	0.9338	4.20	48.940
365 A	0.8952	2.53	0.926	440 D	0.9624	3.13	73.539
366 A	0.9509	2.80	1.333	441 A	0.9055	4.69	20.982
366 B	0.9397	2.67	1.942	441 B	0.9639	3.48	84.457
367 A	0.9433	1.79	3.890	442 A	0.9864	1.66	0.449
367 B	0.9476	1.66	5.036	442 B	0.8504	1.28	1.161
				443 A	0.9560	1.17	0.166
				443 C	0.9058	4.58	9.384
				444 A	0.7890	1.07	0.142
				444 B	0.6316	0.82	0.114

6. REPORTS WRITTEN AND LABORATORIES VISITED

No reports were issued during the quarter. The following laboratories were visited during the course of the work:

Aero Ballistic Research Laboratory, NOL
Aero Medical Laboratory, WPAFB
Ballistic Research Laboratory, APG
Goodyear Tire and Rubber Company
Naval Research Laboratory

7. FUTURE PROGRAM

One V-2 rocket including seven sample bottles and one Aerobee rocket including a sphere experiment will be fired in May.

8. ACKNOWLEDGMENT

Thanks are due the Meteorological Branch of the Signal Corps for cooperation and support, to the Ballistic Research Laboratories of the Aberdeen Proving Ground for assistance in development of the doppler radar for the sphere experiment, to the Aero Medical Laboratory of Wright-Patterson Air Force Base for the use of the high-altitude chamber, and to the Aero Ballistic Research Laboratory at White Oak for additional drag data on spheres.

References:

(1) A. B. Sowter, Welding Journal, 28, 149, (1949).