THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
Department of Aeronautical and Astronautical Engineering
High Altitude Engineering Laboratory

Quarterly Progress Report

UPPER AIR RESEARCH AT HIGH LATITUDES

(Covering period from 1 April 1962 through
30 June 1962)

Submitted for the project by
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ORA Project 04926

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INFLATABLE SPHERES

The High Altitude Engineering Laboratory of the University under NASA headquarters Contract No. NASw-140, is engaged in the development of an inflatable sphere technique for obtaining air density at altitudes up to 100 kilometers. The goal is to make available a radar-tracked passive sphere system which can be carried aloft in many rockets as an adjunct to the main payload. To this end spheres of the ROBIN type with special ejectors were obtained and flown. A completely computerized data reduction method is nearing completion. The aerodynamics of the technique is the same as that of earlier versions of the sphere technique developed at Michigan. For a description of the development of the technique see the reports of the above contract.

The grenade payload on Nike-Cajun vehicles which have been used in the contract of this report (Goddard Space Flight Center NASr-54(02)) are ideal for carrying one of the inflatable spheres for test purposes. It has proved feasible to substitute a sphere for one of the twelve grenades on several flights thereby not only testing the sphere but also providing two atmospheric structure experiments in a single payload. Following is a description of the work with the spheres which were put in the grenade rockets.

A four foot diameter inflatable sphere with metallized surface, and a one meter diameter sphere with internal corner reflector (Robin) had been ejected from Nike-Cajun rockets 10.37 and 10.40, respectively, as previously reported. In the first case, the balloon was tracked by radar, but apparently did not inflate properly, as evidenced by the rate of descent, and by the characteristics of the radar AGC record. In the second case, the balloon was not acquired by radar, hence faulty inflation was suspected.

Accordingly, a series of inflation investigations was carried out during the current quarter. The suitability for this purpose of a four foot diameter environmental chamber at the Bendix Systems Division, Ann Arbor, Mich., was determined by a quick test on 12 April 1962. A corner reflector sphere which had been used during ejection tests at Ann Arbor in October 1961, and which had been in unconstrained storage since that time, was placed in the chamber and subjected to reduced pressure. The trapped air contained in the sphere was greater than normal, due to inward atmospheric diffusion, which could not have occurred to the same extent if the sphere had been packed between staves ready for firing in the "Dart" configuration. At a simulated altitude of 100,000 feet, the sphere appeared to be about 60% to 80% inflated from trapped air, and at 120,000 feet it was completely spherical in form. The maximum simulated altitude reached in this test was approximately 215,000 feet (0.1 mm Hg ambient pressure), and the inflation capsule failed to operate.

A four foot metallized sphere, packaged for firing, remained from the October 1961 firings, and it was decided to fire this sphere from a single mortar, closed with a styrofoam plug and asbestos coating to simulate an actual nose cone, and subsequently subject the sphere to reduced pressure in the environmental chamber. High speed motion pictures of the firing were planned to study the action of the staves and sphere during ejection. This sphere was packed with the so-called "four stave" configuration, in which a pair of very thin semi-cylindrical staves fit inside the outer structural staves to prevent the sphere from being pinched by the stiff outer staves.

The ejection test was carried out on 30 April 1962. The test setup is shown in figure 1. The test mortar, with the upper end cut on a slant and stuffed to simulate a nose cone mortar, is placed on a box, with a 300 frame per second Fastair camera below it, aimed upward. The panels on the pole beside the mortar are one foot wide and one foot apart, to indicate distance

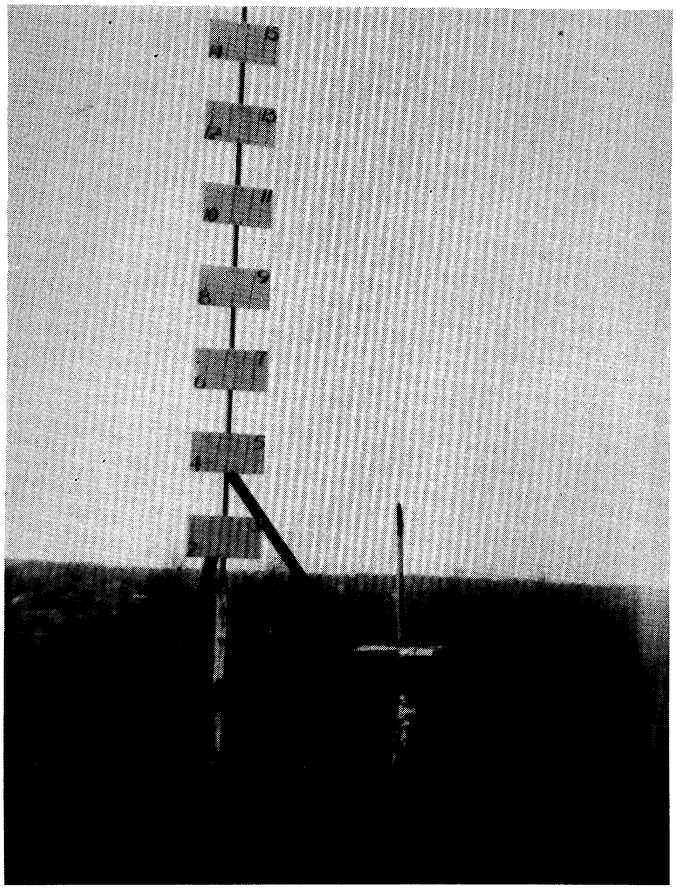

Figure 1. Balloon Ejection Test Setup Showing Fastair Camera at Base of Mortar.

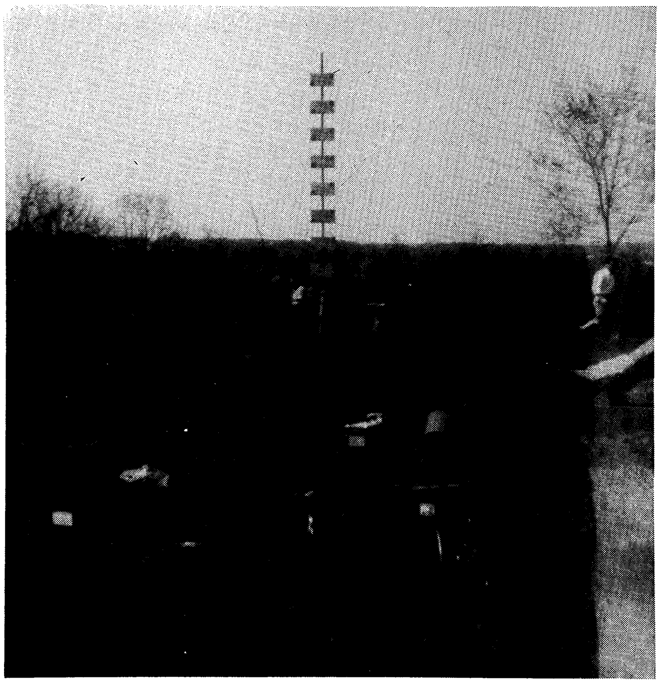

Figure 2. Overall View of Ejection Test Setup. Eastman High Speed Camera in Foreground.

above the mortar base. An overall view (figure 2) shows a Kodak High Speed camera in the foreground. This camera operated at 3000 frames per second.

The sphere had been packed with the inflation capsule at the center and a one gram ejection charge was used. The high speed motion pictures of the firing showed that the four staves separated cleanly from the sphere and there was no apparent interference. The sphere remained folded and fell to the ground with no damage (figure 3). The inertia force of the capsule during ejection caused compression wrinkles for about an inch of the length of the folded sphere material, as shown to left of center in figure 3, but apparently caused no damage. The sphere is shown in figure 4, together with the four staves, the teflon wrapping which contains the folded sphere inside the staves, the styrofoam plug, and the top bulkhead (with o-ring), none of which suffered any damage other than the normal compression of the lower end of the styrofoam plug.

The sphere was placed in the Bendix environmental chamber on 1 May 1962. The sphere is shown at the start of the tes, at atmospheric pressure, in figure 5. The balloon began to unfold at once due to trapped air, but did not expand as rapidly as the Robin which had been tested previously, due to the smaller volume of trapped air. The appearance of the partially inflated sphere at 0. 34 mm ambient pressure (approximately 180, 000 ft simulated altitude) is shown in figure 6. The balloon was apparently completely spherical at about 200, 000 feet simulated altitude and there was little change in appearance the rest of the way down to the lowest pressure reached (5.5×10^{-5} mm; approximately 350, 000 ft.). The appearance of the surface of the sphere at this altitude is shown in figure 7. The compression wrinkles which appeared below the capsule after ejection came out well. The sphere completely filled the diameter of the cylindrical chamber, and the field of view of the camera was insufficient to show the entire sphere. The pumping time required for the chamber to reach the peak altitude was 65 minutes, and the balloon remained for approximately 20 minutes above 250, 000 ft. There was no evidence of activation of the inflation capsule. As the pressure was increased, the first sign of collapse of the balloon appeared at about 200, 000 ft., the same point at which it became spherical during inflation. The total time above this altitude was 72 min. It was therefore concluded that there was no leakage. The environmental chamber and the deflated balloon at the end of the test are shown in figure 8.

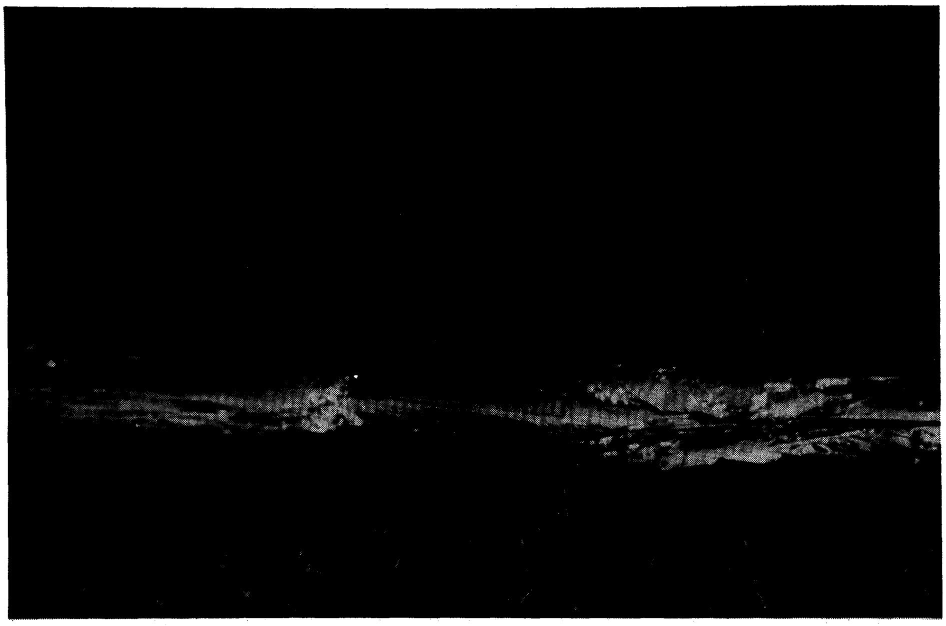

Figure 3. Folded Sphere After Ejection Test.

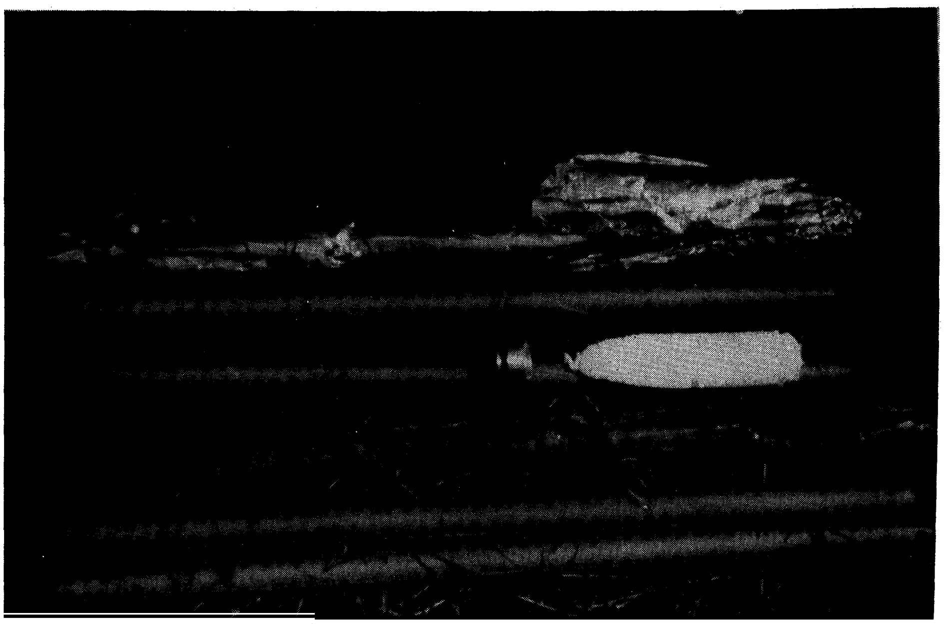

Figure 4. Folded Sphere and Other Encapsulation Parts After Ejection Test.

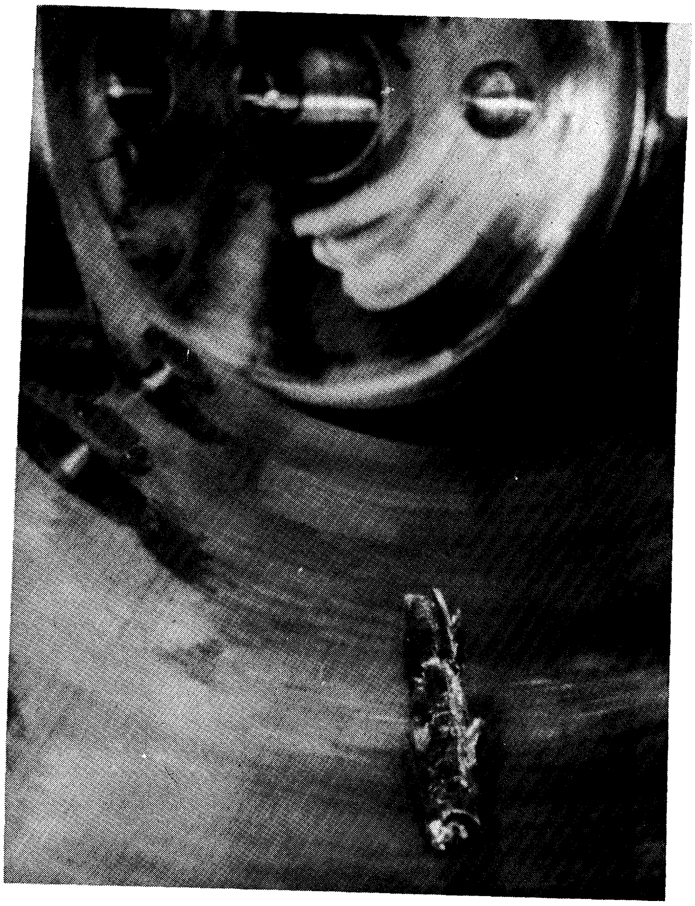

Figure 5. Folded Sphere in Altitude Chamber at Atmospheric Pressure.

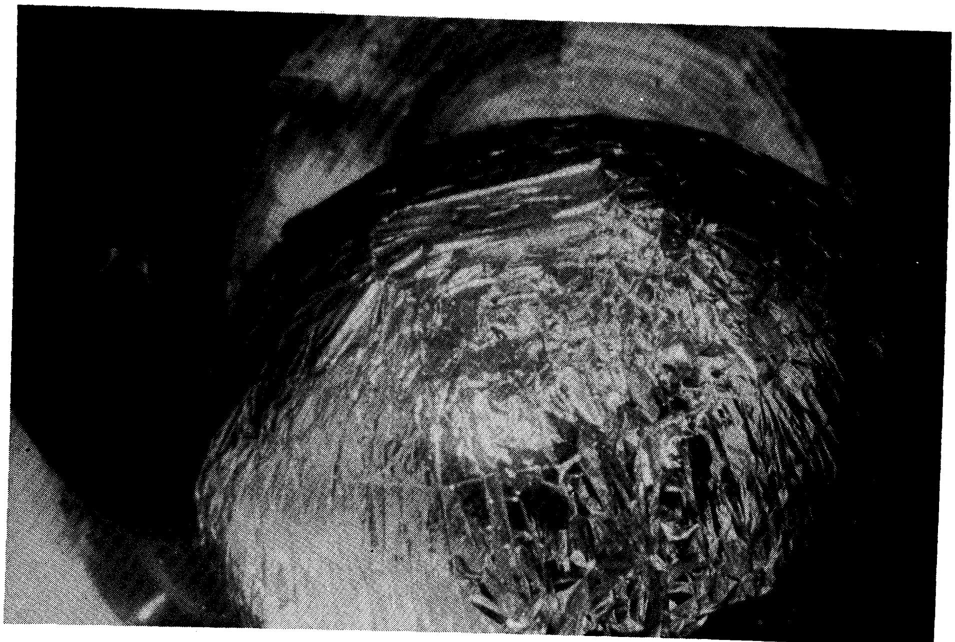

Figure 6. Partially Inflated Sphere at 180, 000 Feet, Simulated Altitude.

Figure 7. Appearance of Sphere at 350, 000 Feet, Simulated Altitude.

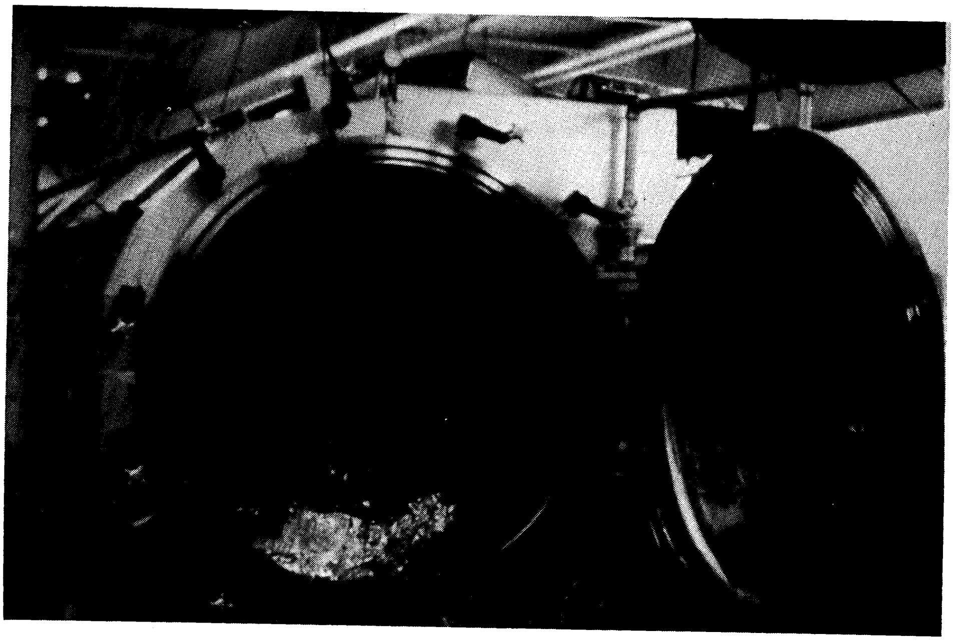

Figure 8. Deflated Balloon and Altitude Chamber at End of Test.

It has been intended to use the high speed motion pictures taken during the ejection test on 30 April to determine the ejection velocity, but the timing marks did not appear on the film. However, a study of the films indicated little or no likelihood that the balloon could be damaged during ejection. The compression wrinkles which appeared below the capsule after ejection apparently were not significant, but it was felt that it might be desirable to reduce their intensity by reducing the ejection charge, if possible. Accordingly, on 8 May 1962, three dummy balloons were fired through mortar tubes stuffed with styrofoam and covered with asbestos to simulate a nose cone. The ejection charges were single capsules, with a squib on each end, filled with $\frac{1}{4}$ gram of black powder. The usual ejection charge for balloons was a single capsule with one gram of black powder and two squibs. All three ejections were satisfactory and it was therefore decided to reduce the ejection charge to $\frac{1}{2}$ gram for future firings.

The ejection tests and environmental chamber tests indicated a strong possibility that difficulties encountered with the flight spheres are traceable to inflation capsule failure rather than balloon damage. A series of tests was planned to investigate the capsule activation. These tests included laboratory tests of capsules at Ann Arbor, and ejection tests of complete spheres in the altitude chamber at Wright-Patterson Air Force Base. The latter tests were arranged by the Schjeldahl Co., Northfield, Minn., from whom the capsules and spheres had been procured.

The inflation capsule is a thin walled aluminum cylinder made up of two cylindrical impact extrusions, each of which is open at one end, joined to form a closed cylinder. Two diametrically opposite holes are drilled, with a #60 drill, in the lateral surface about 1/8 inch from one end, over which a cap fits loosely. The cylinder is filled with the inflation medium (isopentane) through these holes, by means of a hypodermic syringe. A strip of rubber about $\frac{1}{4}$ inch wide and 1/32 inch thick is wrapped over the end of the cylinder, covering the holes, and is held in place by the cap. This seals the openings and prevents escape of the isopentane. The cap is retained in place by friction between it and the rubber gasket, and between the rubber and the cylindrical capsule. Before the cap is installed, a plastic lozenge, or "pillow", is placed underneath it. This "pillow" contains a small amount of air and is gas-tight. When the ambient pressure surrounding the completed capsule is reduced, the air in the "pillow" expands, forcing the cap off and releasing

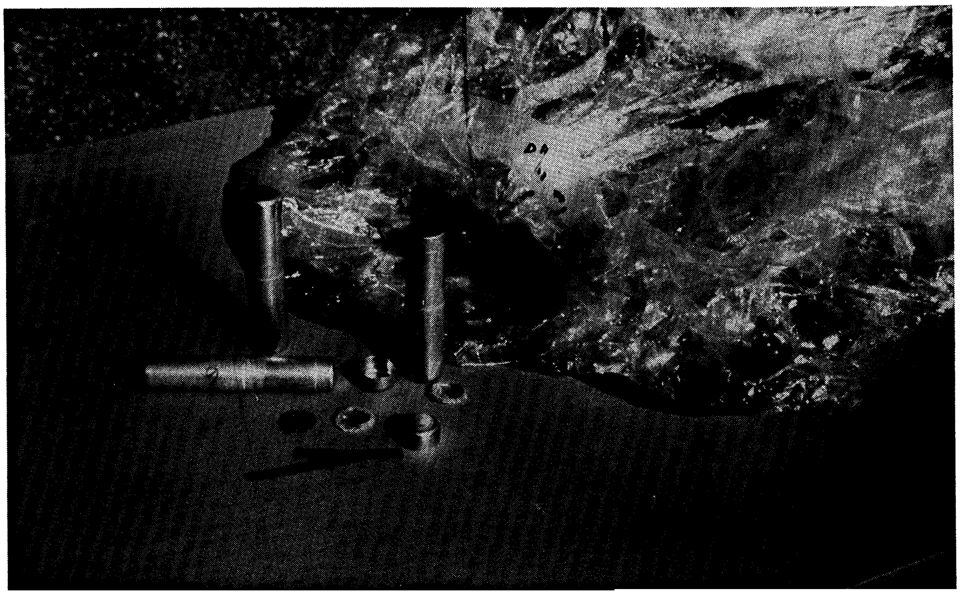

Figure 9. Corner Reflector Sphere (Robin) and Inflation Capsules.

Figure 10. Sphere, Staves, Inflation Capsule, Sealing Tape, and Low Heat Electric Iron.

the isopentane in the capsule. As this is released through two diametrically opposite holes, the reaction forces on the capsule are substantially counterbalanced. Three capsules are shown in figure 9. One of these has the cap installed with the rubber gasket in place. The other two have the caps removed and caps, gaskets, and "pillows" are beside the capsules. Also shown is a 1/16 inch thick rubber disc about the same diameter as the "pillows". The purpose of this disc will be described in connection with later tests.

By 12 May 1962, the Schjeldahl Co. had completed and filled 12 inflation capsules. Six of these (the odd numbered ones) were shipped to Ann Arbor for laboratory tests, and the remaining six were taken to Wright Field for the Altitude chamber tests. These were standard capsules, except that the holes were drilled with a #72 instead of a #60 drill.

The capsules received at Ann Arbor were not completely filled, as indicated by splashing when shaken, but it was assumed that the correct amount of isopentane had been included. Weights were tabulated on arrival. Numbers 1, 5, and 11 were subjected to vacuum conditions under a bell jar on 15 May 1962. The remaining three capsules were stored until 22 May and tested at that time, but without modification, so the results of all tests are tabulated here. The caps and rubber sealing strips were replaced after testing on some of the capsules, and these were retested.

Results of Capsule Tests

	Ambient Pressure	
Capsule No.	First Motion of Cap	Release of Gas
1	6.0 in.Hg.	1.5 in.Hg.
1 - 1st repeat	4.0	1.5
1 - 2nd repeat	8.0	1.5
11 (inverted)	2.5	0.5
5	5.0	0.5 (after several minutes)
3 (inverted)	10.0	6.5
7 (inverted)	19.0	10.0
9 (inverted)	10.0	0.5
3 (upright)	13.0	3.0
7 (upright)	19.0	3.0
9 (upright)	6.0	1.0

The tests indicated considerable non-uniformity of release characteristics. The altitude corresponding to the pressures at which gas was released ranged from 27, 000 ft. to 90, 000 ft. This is well below the altitude at which the balloons are ejected from the rocket, but in some cases the remaining pressure difference was small, and the performance of these capsules was considered marginal.

It was learned, after arrival at Wright-Patterson Air Force Base, that the capsules had not been filled correctly, so the capsules to be used in the altitude chamber tests were completely filled by means of a hypodermic syringe. Four ejection tests were planned. Three spheres were packed the night of 17 May 1962 at the motel and the fourth was packed at the base during the tests on 18 May. Packing procedure for the two-stave configuration was as follows:

1. A slit about 3 in. long was made in the sphere, the inflation capsule was placed inside, the slit was closed with plastic tape, and sealed with heat from an electric iron designed for this purpose (figure 10).

2. A vacuum pump was connected to a $\frac{1}{4}$ inch diameter hole in the sphere, and most of the trapped air was removed. The vacuum connection was then removed and a patch was quickly placed over the hole and sealed by means of the hot iron. A very small amount of air entered the balloon during this process.

3. The balloon was folded into a cylindrical shape about 18 inches long and one inch in diameter with the capsule near one end.

4. The folded balloon was wrapped in teflon sheet 5 mils in thickness and placed between the staves, with the capsule at the forward end. The excess teflon was then trimmed off and the protruding ends were pushed back between the staves with a thin piece of plastic. The staves were held together with tape until placed in the aluminum grenade tube.

5. The staves and enclosed balloon were inserted axially into the grenade tube, the top bulkhead was riveted in place with two shear rivets (after vacuum grease had been applied to the rubber o-ring) and a $\frac{1}{4}$ gram ejection charge was inserted in the ejection chamber.

The four-stave configuration was difficult to pack because of the fragility of the inner staves which are 1/32 inch thick. The procedure used involved loading the sphere into two staves leaving the teflon covering about three feet long on one end. The excess teflon wrapping was then used to pull the sphere assembly axially from the two staves into a four-stave assembly which had been previously taped together. The one meter diameter metallized sphere was much easier to manipulate than the corner reflector sphere, as much less material was involved.

For the tests in the altitude chamber, the aluminum grenade tube containing the sphere was placed on a steel shelf about four feet above the floor, and held in place with shot bags. This setup is shown in figure 11. The apparatus below the shelf is concerned with Arcas Robin tests which were conducted at the same time. At the opposite side of the chamber a net was suspended nearly vertically, rubberized hair packing material was placed on the net for shock absorbing, and covered with polyethylene sheet to prevent abrasion of the sphere by the packing material.

The tests were photographed by three high-speed cameras. One placed at the rear of the test mortar operated at 400 frames per second, and two side cameras operated at 1000-1500 frames per second. Prints of the films of these tests were requested at the time of the tests but had not been received as of the end of this reporting period.

Four tests were planned comprising two one meter diameter metallized spheres and two one meter corner reflector spheres. One of each type was packed in 2 staves, and one of each in four staves. The results of the tests are as follows:

Test No. 1.--Metallized sphere, two staves. Ejection satisfactory at chamber altitude 140,000 ft. The staves struck the backstop about 10 feet apart. Initial inflation was partial, probably due to trapped air. After four minutes the capsule suddenly released and the balloon inflated fully. After ten minutes at altitude, the chamber was returned to ground level. The balloon remained fully inflated down to 112,000 ft.

Test No. 2.--Corner reflector sphere, four staves. Ejection was satisfactory at chamber altitude 154,000 ft. The staves separated well and struck the backstop 6-8 ft apart. One of the inner staves was broken at one end, apparently by bouncing against the roof of the chamber. Initial inflation was partial with capsule release and complete inflation taking place several seconds later. This time was variously estimated as 5 to 15 seconds. After ten minutes at altitude the chamber was returned to ground level. The balloon remained fully inflated down to 99, 000 ft. This balloon was inspected at Northfield, Minn. on 24 May and a small pinhole was found in one gore after a pressure test had indicated the presence of a small leak. The hole was patched and the balloon satisfactorily passed a leak test.

Test No. 3. --Metallized sphere, four staves. The ejection was apparently satisfactory but the initial inflation appeared to be only partial. Figure 12 shows the balloon striking the backstop. The exposure was only 1/25 second so all moving objects are blurred, but three of the four staves are visible, well clear of the balloon. The fourth stave missed the backstop and struck the wall well to the left fracturing the end of the stave. The balloon never inflated fully (figure 13) and, after the test, inspection showed a slit about 6-7 inches long at a joint between two gores. The slit is perfectly straight, and involves only the material of the tape used to join the gores and does not appear to be a tear. The capsule cap was still on the capsule but was tilted and the capsule was empty. Balloon, capsule, and staves are shown in figure 14.

Test No. 4. --Corner reflector, two staves. This balloon was packed at the chamber after the preceding tests and for this test two of the plastic "pillows" were placed under the capsule cap instead of one. Ejection was satisfactory at 150, 000 ft, and inflation took place immediately. After ten minutes at altitude, the chamber was returned to ground level. The balloon began to deflate at 132, 000 ft. Inspection at Northfield on 24 May showed a triangular tear nearly $\frac{1}{4}$ inch on a side immediately adjacent to the vacuum connection. The Schjeldahl representative stated that the most likely explanation was a small wrinkle under the patch which was placed over the vacuum connection hole before packing the balloon for the test. This wrinkle could induce a stress concentration which might cause a tear to develop during inflation.

Inasmuch as the maximum altitude attained in these tests was 154, 000 ft, there was some feeling that the inflation capsules which functioned in a questionable manner during these tests might have performed satisfactorily if the balloons had been ejected at higher altitudes. However, the difference in pressure between 150, 000 ft and 300, 000 ft is small, and could contribute little to the force necessary to remove the cap. It was therefore considered that the tests clearly indicated that the performance of the standard capsule.

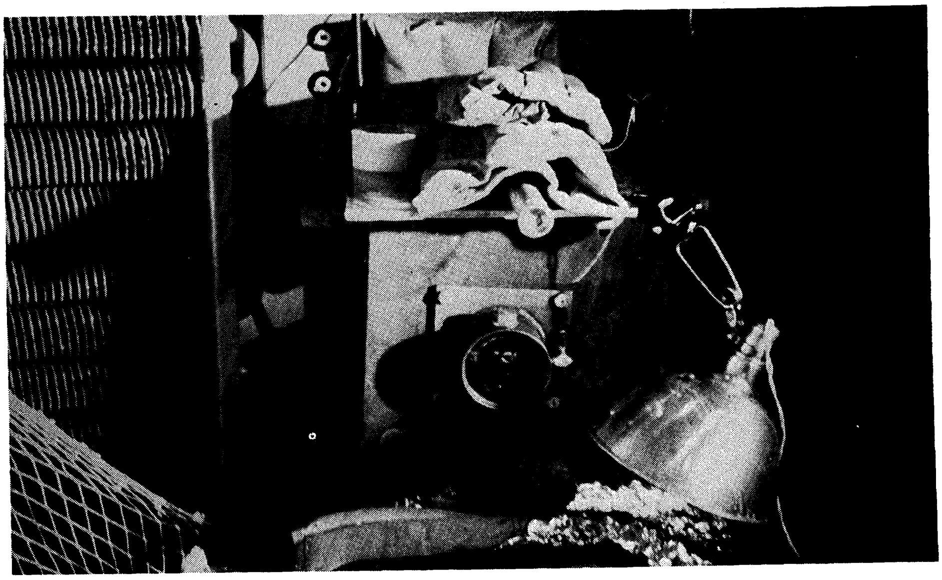

Figure 11. Arrangement for Inflatable Sphere Tests in Altitude Chamber.

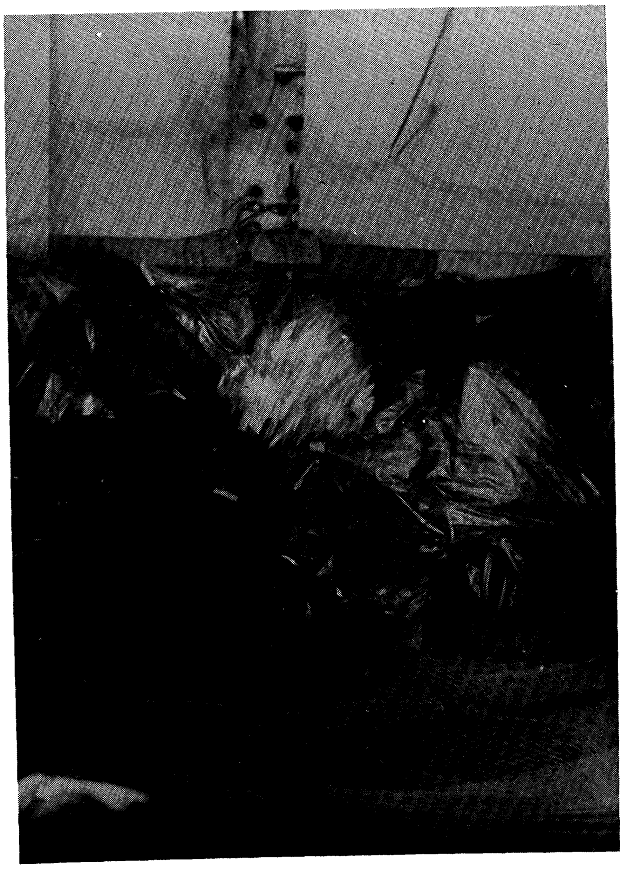

Figure 12. Metallized Sphere Striking Backstop.

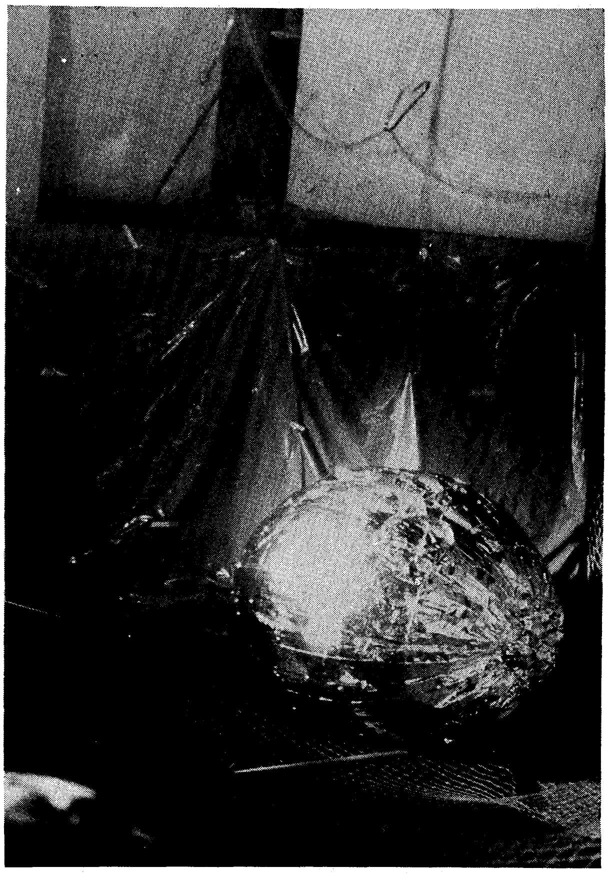

Figure 13. Partially Inflated Sphere in Altitude Chamber.

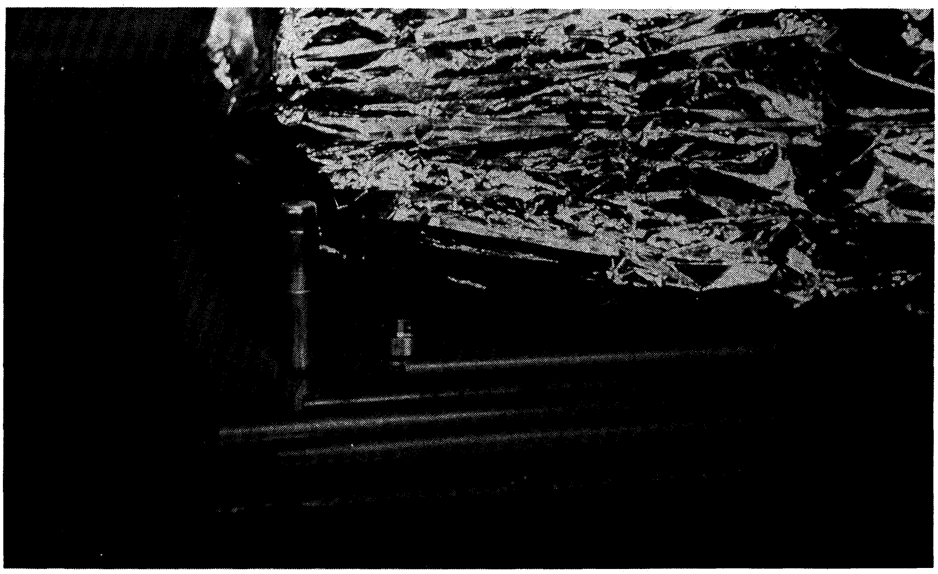

Figure 14. Metallized Sphere After Altitude Chamber Test.

is marginal at best. It was considered that balloon damage was not due to the ejection procedure and could be minimized by much more stringent inspection of balloons. The four-stave configuration appears to offer no advantages over the two-stave configuration.

With two pillows under the cap, the capsule operated satisfactorily in test No. 4 so additional capsule tests were carried out at Ann Arbor on 22 and 23 May. The capsules were completely filled with isopentane for each test. In the first series of tests, two plastic "pillows" were placed under each cap and the capsules released at ambient pressures between 21 in.and 24 in. of Hg. The volume of two "pillows" was so great that there was some doubt that the capsules could be handled without causing leakage, and also the pressure at activation was not far below atmospheric (corresponding altitudes between 6000 and 9500 feet) so this arrangement was not considered satisfactory.

In a second series of tests one pillow and a rubber disc 1/16" thick were used. Each capsule was filled, sealed,and weighed. All were held for ten minutes at a pressure of 24 in. Hg. (6000 feet pressure altitude), returned to atmospheric pressure, and reweighed. None showed any loss of weight, so it was assumed that there was no leakage. Results of the release tests are indicated below. Each capsule was refilled (except for #11) and the test was repeated.

	Release Pressure	
Capsule No.	First Test	Second Test
1	7.0 in. Hg.	11.0 in. Hg.
2	13.0	11.0
5	7.0	16.5
7	14.0	12.5
9	9.0	11.0
11	1.0	--

There was some individual variation but,with the exception of capsule #11, release pressures fell in the range from approximately $\frac{1}{4}$ to $\frac{1}{2}$ of atmospheric. It was concluded that capsules 1, 3, 7, and 9 would probably be satisfactory for a rocket-borne balloon using one pillow and one rubber disc.

All capsules were refilled, capped, and weighed on 23 May. They were then taken to the Schjeldahl plant at Northfield, Minn. in the baggage compartment of a commercial airliner. They were reweighed on 24 May and none showed any loss of weight. Capsule #3 was selected for the next flight. A one-meter corner reflector sphere which had not been previously used in chamber tests was selected for the flight balloon. This successfully passed the standard leak test which consists of inflating the balloon to 10 millibars (4.0 in. H_2O) over pressure and holding for 30 minutes. The pressure drop in this interval must be less than 0.5 mb. At the same time, one of the corner reflector spheres used in the Wright Field altitude chamber tests was given an over pressure test to 12.5 in. H_2O. At this pressure, the dimensions were recorded as follows:

diameter at poles	1,009 mm
90° lateral diameter	1,007 mm
45° lateral diameter	1,011 mm

The flight balloon was packed in two staves and transported to Wallops Island in the passenger cabin of a commercial airliner (cabin altitude 2500 ft). At Wallops Island, the balloon was placed in the aluminum tube and the top bulkhead and ejection charge installed. The weight of the assembly, as installed in the nose cone, was 574.8 grams. This sphere was successfully ejected from Cajun rocket #10.43 on 6 June, 110 seconds after launch, at an altitude of approximately 64 statute miles. The balloon was tracked by radar down to 100,000 ft and preliminary reports indicate that inflation was probably satisfactory.

NIKE-CAJUN ROCKET FIRINGS

At the conclusion of firings conducted in March 1962, timer #22 was left at Wallops Island as a spare. This timer had been through environmental tests and was also used in horizontal and vertical tests on Cajun #10.41 and 10.42 during the period when blockhouse-to-launcher cable trouble resulted in repeated tests using different timers. During the summer of 1961 a grenade section bulkhead had been modified so that the photocells were mounted in the bulkhead and the amplifier board was to be eliminated. An 18 pin connector was to be used to connect the bulkhead and timer, and a transistor amplifier was to be mounted in the timer. This work was delayed by higher priority work, such as grenade vibration tests. During the previous quarter a miniaturized plug-in amplifier had been completed and three amplifiers of this design were built. Timer #20 was modified by providing a mounting on the timer base for this amplifier and an 18 pin connector for the grenade section bulkhead plug. This timer and the grenade section bulkhead were taken to GSFC on 1 April 1962 and subjected to environmental tests at the same time as the Superior Engineering Co. timer and amplifier which were to be used in the next firing. Environmental tests were satisfactory except that the delayed short reset screw was damaged, as in the case of another timer during the January tests, by vibration testing after the timer had been operated long enough to remove the short. The damaged screw was replaced at Wallops Island.

On Saturday, 14 April, horizontal tests were carried out on the spare timer #22 and a standard vacuum tube amplifier in Cajun #10.42. A horizontal test was carried out on the modified timer with a plug-in amplifier, but power was supplied externally, as the only internal batter available for horizontal tests at the time had a 90 wet B battery for vacuum tube amplifiers, whereas the transistor amplifiers were all wired for $22\frac{1}{2}$ volts. The two transistor amplifiers which had been flown earlier in the program were supplied with voltage dividers so they could be used with the standard 90 v. batteries. The telemetry record of this horizontal test was rather noisy, and in addition there were some peculiar dips in the record, about 10 microseconds in length, at the timer steps. This is about the length of time that the timer micro-switch remains closed, so it was reasoned that induction in the leads to the station B battery might be responsible. The test battery pack was rewired to give $22\frac{1}{2}$ volts and the test was repeated using internal power. The record was then normal, though somewhat noisy. Horizontal tests were carried out for all three plug-in amplifiers, and all were considered satisfactory.

It had been planned to use the first Superior Engineering Co. timer and amplifier for the next firing but trouble developed which had not been cleared up by Sunday night, so on Monday, 16 April, vertical tests were carried out on timer #22, using a SE Co. transistor amplifier, and on timer #20, with plug-in amplifier #3. Both tests were satisfactory and the decision was made to fly the #20 timer and plug-in amplifier. An instrument check, prior to loading grenades, was carried out at 0230 on Tuesday, 17 April, using a box of lights with three photo cells inside the box. This arrangement lends itself readily to instrument checks on the timer with plug-in amplifier, although the box is also wired so that a standard amplifier can be used. Each simulated grenade ejection is monitored and recorded at the telemeter trailer and in the blockhouse and, at the same time, the lights are visible both from the ramp and the blockhouse. The instrument check was satisfactory, so grenades were loaded, and the rocket was fired at 0428. All 12 grenades were observed visually and on the telemeter record and sound returns were received from all grenade explosions.

Nike-Cajun rockets 10.43 and 10.44 were scheduled for 28 and 29 May, using SE Co. timers and amplifiers. A one-meter diameter corner reflector sphere replaced the 12th grenade in Cajun #10.43 and the timer was wired to eject this at the 109th step. Horizontal tests were carried out on 25 May and vertical tests on 28 May. The tests were considered satisfactory although some trouble was encountered with the Dovap transponder. The firings were cancelled on account of weather. On 30 May and again on 2 June weather appeared satisfactory and grenades were loaded. However, in each case, it was necessary to cancel on account of increasing cloudiness. Weather continued marginal until 6 June and University of Michigan personnel shuttled back and forth between Ann Arbor and Wallops Island during the interval. Cajun 10.43 was finally fired on the evening of 6 June. There was complete Dovap failure at 30 seconds so there was no telemeter record. However, all 11 grenades were ejected, and 11 sound returns were received. The 11th grenade was ejected at approximately 96 seconds at an altitude of 93 kilometers. It is assumed that the times of grenade explosions can be determined with sufficient accuracy from the radar AGC record, although at this time it is not known for certain if this is the case. The balloon was ejected at approximately 110 seconds. It was immediately acquired by radar and tracked for 20 minutes down to an altitude of about 100, 000 feet.

Nike-Cajun #10. 44 was scheduled for the morning of 7 June but was postponed after the associated sodium rocket failed. The rocket was finally fired on the evening of 7 June. All 12 grenades were ejected and detonated and all 12 sound returns were received.

PROJECT FIREFLY PARTICIPATION

During the Nike-Cajun rocket firings at Wallops Island about 1 June 1962, it was learned that the Air Force is planning a series of rocket firings at Eglin Field, Florida in which high explosive changes ranging from 8 to 40 lb in weight are to be detonated at altitudes between 95 and 250 kilometers. This series called "Project Firefly" is for the purpose of studying the "glow effect" sometimes observed during high altitude explosions. A total of eleven rockets will carry explosive charges. These will be 8 or 9 lb charges carried on Nike-Cajun rockets at altitudes between 90 and 120 kilometers, and 30 to 40 lb charges carried on Honest John-Nike-Nike rockets at altitudes up to 250 km. Some of the charges will be straight composition B explosive, while others will contain aluminum and/or other ionizing materials. Each rocket will carry four charges, which will be ejected simultaneaously, dispersed radially, and detonated by timers at intervals of several seconds.

It was felt that some of these explosions will occur at altitudes which will be of interest to the grenade program. This was discussed with personnel of GSFC and Schellenger Research Laboratory, Texas Western College, who concurred. Further discussions were held with Dr. Howard Edwards of Georgia Institute of Technology and Dr. Norman Rosenberg of Air Force Cambridge Lab. who extended us an invitation to participate at our own expense. At that time, the first firings were scheduled shortly after 1 August 1962 and the pre-briefing was scheduled for 23 July at Eglin Field. Our planning during the remainder of the current quarter was predicted on meeting these dates.

The primary purpose of our measurements will be to determine whether sounds from explosions of such magnitudes and altitudes can be picked up at the surface, and to determine the frequency spectrum of the received sound. Three types of transducers will be used; a hot-wire ballistic microphone such as is used in the sound ranging array at Wallops Island, which has a peak response at 4 cycles per second, a capacitance microphone with flat response down to 2 cycles/sec, and a microbarograph, with sensitivity in the range below one cycle/sec. Schellenger Research Lab. is able to furnish the equipment, and personnel to assemble and check out the system initially. The U. of M. will furnish personnel to assist in assembly and checkout, to operate the system at Eglin Field, and to assist in reduction of data, as required.

The U. of M. project director visited Schellenger Research Laboratory at El Paso, Texas on 15 June 1962. Detailed planning discussions were held with E. Alan Dean, Lee Chapin, and Paul Harris of Schellenger Lab. It was decided that the following equipment will be used, most which is available at Schellenger Lab.

2 Capacitance microphones and spare elements

2 Hot-wire microphones and spare elements

1 Microbarograph

2 Microphone terminator panels for hot-wire microphones

2 Precision Instrument magnetic tape recorders and power amplifiers

1 Sanborn Recorder

Test Equipment - 310 oscilloscope
Vacuum Tube Voltmeter
Triplett or Simpson Test Writer
Set of tools

WWV and short wave radio receiver

12 volt automobile batteries

We will require a site free of background noise and ideally this should be about a mile from the shoreline where the launchers are located. This will eliminate surf noise, but will keep the microphones as nearly as possible below the explosions. Power requirements will be 100 volts, 60 N, approx. 15 amp. If central station power cannot be supplied at the site, a generator will be required in which case it will be necessary to locate the microphones at considerable distances from the recorders, and there will be a requirement for several thousand feet of two and four conductor cable. A countdown phone is desirable but not necessary as the countdowns are broadcast. A small building at the site would be helpful but, if not available, a small rental van would serve the purpose. The largest piece of apparatus which might be used is a six-channel Sanborn recorder, which is 64 inches high. This is too high for a station wagon or panel truck but small vans are available from rental agencies. U. of M. personnel will install the microphones and construct the windscreens. The site should be selected and the microphone installation should be well underway before the pre-briefing, especially if remotely located microphones are necessary.

Near the end of the current quarter it was learned that the Project Firefly firings had been postponed to October. This removed the urgency from the preparations but U. of M. operating personnel will visit Schellenger Lab during July for further discussions of sound recording equipment and techniques.

MISCELLANEOUS NOTES

During the current quarter, contract NASr-54(02) was finally placed in effect. Account number 04926 had been extended through 31 May in advance of execution of a written agreement. Contract NASw-115 had expired, but the amount of the overrun cannot be determined until the Superior Engineering subcontract has been finally closed out.

Development of the mechanical timer and the transistor timer are continuing. A control box for the mechanical timer has been wired up, but certain safety aspects of the recycling operation remain questionable, and work on these is being carried out. The transistor timer circuit has been operated at elevated temperatures, with various components of the timer in or out of the oven. From this, it appeared that most of the temperature-time effect was due to the potentiometers. New potentiometers will be tried in an attempt to reduce the dependence of time on temperature.

The sound study is progressing slowly. There is considerable information available on the effect of charge shape and orientation on the intensity of the resultant blast pressure waves, but the relation of this to the production of low frequency sound, and the effect of burning rate are not known. It is probable that this will have to be determined experimentally.

Practically all project personnel have had no vacation for two years due to continued urgency of the program. Consequently, vacation schedules will result in considerably reduced project effort during the succeeding quarter.