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OFFICE SECURITY ADVISOR

PROGRESS REPORT ON
HIGH ALTITUDE PLASTIC BALLOONS
CONTRACT NONR-710 (01)
December 22, 1952 to December 3, 1953
VOLUME XII
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PROGRESS REPORT ON RESEARCH AND DEVELOPMENT IN THE FIELD OF HIGH ALTITUDE PLASTIC BALLOONS

CONDUCTED UNDER
CONTRACT NONR-710(01), NR 211 002
FOR PERIOD DECEMBER 22, 1952 to DECEMBER 3, 1953
WITH THE
OFFICE OF NAVAL RESEARCH

AND SPONSORED JOINTLY
BY THE ARMY, NAVY, AND AIR FORCE

PREPARED BY THE
DEPARTMENT OF PHYSICS
UNIVERSITY OF MINNESOTA
MINNEAPOLIS 14, MINNESOTA

PROGRESS REPORT ON CONTRACT 710(01)

From December 22, 1952, to December 3, 1953

VOLUME XII

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Section I

PROJECT SUMMARY AND PROGNOSIS

The principal work of the Project during the period covered by this report can be divided into several sections. The first section, balloon physics, concerns flight constants flights, step flights and temperature flights designed to study the balloon and the environment in which the balloon flies. The second general program might be called the cylinder balloon program, in which we have studied the properties of balloon without tapes. The third sub-divison would consist of the Mylar program which, although not divorced from the cylinder balloon program, is considered to be separate as it involves the development of a vehicle for high altitude work using the plastic, Mylar. These various programs will be discussed in order. Each of these categories is treated in very much greater detail in the report proper and the purpose of this summary is to indicate in a few words the significant contributions of the Project during this year.

The program of balloon physics began in the early period of this report and is a continuation of flight constants flights originally introduced on the Project to study the response of the balloon to a change in free lift or to a change in buoyancy. The general philosophy of these flights was that one should be able to sit on the ground and fly the balloon by remote control observing its response to dropping of ballast and to cutting of tow balloons attached to it. A number of these flights were made and several of these were quite successful. There were, however, several fundamental limitations to flights of this sort which finally led us to abandon the flight constants sort of flight and substitute in its place a much more desirable means of obtaining this information. The principal difficulty with the flight constants flights centered around the problem of radio controlling the balloon after learning by means of radio what the balloon was doing. In line-of-sight operations there is little trouble in hearing from the balloon and being able to transmit to it. A large number of secondary difficulties always develop when radio control is attempted during a balloon flight. In this case it was necessary to control the cutting of the tow balloon, the valve in the top of the balloon to valve gas, and various ballast dropping mechanisms. A sample of the kind of trouble which arises with radio control but which is not inherent in the radio itself was the failure in one flight of the valve to open in the top of the balloon because of the generation of noise by the valve motor which would block the radio receiver and cut off the command signal. The flight constants flights were plagued by a number of difficulties of this sort and the equipment was, in general, complicated enough so that, in spite of careful check-out before flight, frequently parts of the equipment would fail and decrease the usefulness of the flight. Before these flights were stopped, however, several flights were obtained in which the balloon was flown by radio control and some data on free lift and drag were obtained from these flights. This data is discussed in Volume IX, Section VI, of this report.

When it became evident that the flight constants flights were consuming more of the Project's efforts than their value justified, we set about thinking on the problem of how to obtain information on the velocity vs.

free lift as a function of altitude for a balloon by simpler means. We finally hit upon the method which we now call the step flight technique for studying balloon performance. This method from the very first was extremely successful and a good deal of the Project effort has been devoted to promoting this technique and to obtaining data by means of it. It is anticipated that this work will continue.

In brief, the principle of the step flight is to carry out mechanically what one would like to do to measure balloon performance. Namely, to go along with the balloon, hold it at rest at various points in the atmosphere, and then cause it to rise and descend at a fixed rate of rise at which time one would note the changes in force occurring with respect to the balloon at rest. Now it is quite simple to state the problem in this way, but it is somewhat more difficult to invent in practice a balloon system for doing it. The system which is used is to fly two balloons attached together by a steel cable. The top balloon, called a tow balloon, is a balloon whose properties are under test. The balloon to which this test cell is attached is a balloon which is always completely full and equipped with a duct, and a gondola which controls the gross weight of the system. This latter balloon is called the platform balloon. The flight of the platform balloon is controlled by changing the gross weight of the system by dropping ballast, and since it is always full and valving one can precisely determine the time-altitude characteristics of this platform balloon simply by determining the way in which the gross weight of the system is changed. As the platform balloon determines the time-altitude curve, the tension with which the tow balloon pulls on the platform is measured and telemetered from a system in the gondola attached to the platform balloon.

The general procedure in these flights was to inflate both balloons on the ground so that the system would level first at an altitude of 7 or 8,000 feet. The tension to the tow balloon would then be well determined at this altitude and it was from this altitude essentially that the flight began.

After a long enough time at this altitude for the tension to stabilize, ballast would be steadily dropped from the platform balloon so as to produce a rise rate of, say, 500 ft/min. As this rate was established the tension measured to the tow balloon would first drop rapidly by an amount equal to the aerodynamic drag on the tow balloon and then drop more slowly as the thermodynamic drag on the tow developed. It finally reached an equilibrium value which would be maintained as long as the system would continue to rise.

When the platform balloon's ballast stops dropping, the system comes to rest quite rapidly with the aerodynamic drag of the tow balloon disappearing first and finally the thermodynamic drag disappearing and being evidenced by warming of the gas in the tow balloon and increasing the tension measured between the two balloons. It can be seen that in addition to giving aerodynamic and thermodynamic drag this technique allows one to determine what the weigh-off of the balloon is at different places in the atmosphere compared with its ground value.

The very significant factor determined in connection with the weigh-off at different altitudes was that the balloon gains free lift as it rises, during the day, almost as much as the value of the sunset effect. That is, a balloon which is weighed off neutral on the ground will find itself with something like 7 or 8% free lift by the time it reaches the stratosphere. Much of this warming takes place as the balloon passes into the stratosphere itself and this accounts for the fact that balloons do not slow down at the tropopause as would be predicted by the fact that their thermodynamic drag should increase by nearly a factor of two, in accordance with the change in lapse rate of the ambient air. That the drag actually does increase was definitely and clearly demonstrated on these flights but the increase in drag was compensated for by the increase in free lift due to the warming with altitude.

The step flights have already shown that the aerodynamic drag, as we suspected, was an important factor only at low altitudes. At high altitudes, with large balloons, the controlling factor which determines the rate of rise is the heat transfer into the balloon, producing so-called thermodynamic drag. Results with step flights at night seem to show that the increase in free lift with altitude is not nearly so large as it is in the daytime and that the sunset effect should very definitely be a function of altitude. We felt that in the step flights for the first time we have been able to measure directly the behavior of a balloon at various altitudes at various rates of rise and have a scientific approach to the problem of describing the motion of a free balloon. The nomographs of thermodynamic and aerodynamic drag (Volume IX, Section VI) have been constructed on the basis of results from the step flights, but they should be accepted with some reservations until more step flights have been performed to determine whether the nomographs have to be altered for flights during the day as compared with flights at night, and so forth.

In addition to the step flight technique we have studied the balloon physics problem by measuring the temperatures of the balloon gas and the outside air during flights in which the balloon is purposely made to undergo motions in which the thermodynamic drag will change abruptly. These temperature flights have been very successful and the resultsof temperature measurements in general have been in agreement with results of the step flights.

The combination step flights and temperature measurements have been carried out together, the temperature of the gas in the tow balloon being telemetered to the platform which in turn relayed this information by telemetering to the ground station. Temperature measurement is complementary to the tension measurement. It shows, among other things, that large temperature gradients in the balloon do not exist.

The temperature measurements have shown that the gas in the balloon cools below the equilibrium value during ascent and warms above equilibrium value during descent as would be expected from our previous work. They show, furthermore, that the superheat of the balloon gas does not change at balloon sunset but that the balloon descends at the rate required in order to maintain this superheat approximately constant. When ballast is dropped and the balloon undergoes an adiabatic bounce, leveling off at night, the temperature changes abruptly as would be predicted from the previous studies, and levels off at the night time superheat which turns out to be approximately zero. In other words, the temperature measurements have indicated that a polyethylene balloon, at rest floating at night, has a gas temperature approximately equal to the temperature of the outside air and that this temperature is increased in the daytime by the superheat produced by the sunrise effect.

The sunrise, sunset effect has now been measured accurately by dropping precisely the required sunset ballast and allowing the balloon to level off below its full ceiling. During this process the temperature is measured so that the sunset effect is determined both in terms of the ballast required and in terms of the temperature change produced by day and night difference. It has also been measured in step flights both for sunrise and sunset by ballasting the platform balloon to keep it from descending at sunset and measuring the tension with which the tow balloon pulls on the platform throughout a 24-hour period. This flight was extremely interesting and showed that tension maintained essentially constant throughout the middle parts of the day and night with the sunrise effect coming in over a period of about two hours and with the sunset effect coming in over approximately the same length of time. Apparently about a third to a half of the solar effect is produced by the direct light of the sun on the polyethylene and the remainder is produced by scattered radiation from the ground and by infra-red.

One of the earliest results of the Balloon Project during its first year was the observation that a number of our balloon failures were caused by the presence of the tapes on the balloon. Very frequently we found in packing balloons that tapes had pulled loose from their original resting place and stuck in some other place, pulling a hole. The immediate solution to this problem was the use of double wall "cast iron" balloons which could have holes pulled in one layer of the polyethylene without destroying the gas tightness. We did not feel, however, that this was a satisfactory solution to the problem and believed that the presence of tapes in a balloon are definitely detrimental. They create the hazard of failure of the balloon by tapes sticking and, in addition, increase the sunset effect because of their blackness to solar radiation. We originally observed another detrimental effect of the tapes which is extremely serious at night. This effect is that at temperatures of -20 or -30° the tapes do not stick to the polyethylene and, if the balloon is subpressure, the outside air pressure will force the bottom portions of polyethylene off the tapes and destroy the balloon. The difficulty with the tapes is, in brief, that they are likely to stick where they are not supposed to if the tapes are warm, or if the plastic is cold they may not stick at all. It is very probable that the large mortality rate of balloons ascending at night is due to the fact that the material separates itself from the tapes. During the day, no doubt, the tapes are quite warm and therefore maintain their adhesiveness. In the hope of solving some of these problems we have attempted to use the so-called "cylinder" balloons.

The cylinder balloon is simply a tube of polyethylene designed so that it will always have enough circumferential dimension to eliminate circumferential stress, in whatever manner the balloon is used. The duct appendix introduced by the Balloon Project last year can be used to set the zero pressure level of the balloon to any height that is desired, thereby determining the ratio of balloon height to diameter. The tube of polyethylene is gathered at each end and the duct appendix is brought out from the top of this tube. It is relatively easy to show that, starting with a cylinder of material, the requirement is satisfied that the meridional tension is everywhere the same and the plastic is stressed equally in a meridional direction at all points. A cylinder type balloon can be made with straight heat seals and the ultimate load carrying capacity of such a balloon is very readily calculated, as pointed out in this report.

A number of flights of cylinder balloons have been made to determine the characteristics of their behavior and most of these cylinders were made of Mylar because it was desired at the same time to test the feasibility of constructing a Mylar balloon. The properties to be described here, however, refer to cylinder balloons in general and the Mylar program will be discussed separately. Although cylinder balloons have very obvious advantages for lifting large weights they have some disadvantages in flight performance which were discovered in studying the flight series starting with Flight 60.

The first cylinder balloons were of volumes approximately equal to the volume of a 20-foot diameter shaped balloon. When the first of these cylinders was flown, it was observed to reach ceiling, accelerating as it rose (a characteristic of free balloon flight), and upon reaching ceiling the balloon overshot, turned around and began descending again at a very appreciable rate. This behavior had not been anticipated and no provisions had been made for stopping it, so the balloon descended all the way to the ground. It was immediately evident, of course, that the reason for this particular behavior was that the slack volume present in a cylinder balloon allowed it to overshoot its full ceiling during the process of valving. In other words, the superpressure required for valving may cause the balloon to swell up to such an extent that it may temporarily rise to a ceiling above the ceiling at which it would be stable. In so doing, of course, it has overvalved and, unless the warming of the gas following the reaching of ceiling is adequate, the balloon can never be stable again. It is clear, however, that if the balloon reaches ceiling at a slow enough rate the warming of the gas will be adequate to cause it to reach stability. It is interesting to note that <u>all</u> balloons must overshoot their ceiling and the reason that they do not immediately descend afterwards is because of the fact that the thermodynamic drag has produced a cooling of the gas which acts rather like money in the bank in the sense that warming of this gas can pay for any small amount of overvalving which has occurred. The subsequent cylinder flights showed that this indeed was true, that at a particular rate of rise a cylinder balloon would reach ceiling and level off in a stable manner. For the ratio of balloon to duct diameter which we used it turned out that this rate of approach to ceiling was 400 ft/min and the fact was discovered by flying subsequent cylinder flights and equipping these with ballast drops which would be activated when the balloon initially overshot and descended, and would allow the balloon to approach ceiling successive times at slower and slower rates. A ballasted balloon system would operate quite well with a cylinder balloon but would have an initial expenditure of ballast while the overshooting of the cylinder was being compensated. Aside from this fact no bad behavior of the cylinder balloon was observed and the Mylar cylinders were indeed observed to fly quite well. One such cylinder which was launched from Minneapolis landed in Buffalo, New York.

We believe that we have demonstrated the fundamental properties of cylinder balloons and also that they may be of some principal importance in military applications because of their ease of construction, a long tube, and because of their large load-carrying properties and their probable reliability due to the fact that they do not have tapes to cause trouble in storage or in flight. The point should be made, however, that large cylinder balloons are somewhat difficult to launch by the University of Minnesota method and a number of attempts were made to fly a polyethylene cylinder without success. It should not be, however, a difficult problem to launch a cylinder balloon from a platform, and flights made by Howell in his Air Force work have shown that cylinder balloons could be readily launched from the Moby Dick covered wagon.

The Mylar program was partly wedded, as was noted before, to the problem of cylinder balloons and as such has been partially discussed. Because of the fact that Herb Shelly, Inc., of Farmington, Minnesota, had successfully sealed flat sheets of Mylar material together, we decided to work with them in producing experimental Mylar cylinders for balloon flights. Reports from General Mills, Inc., who had flown small samples of Mylar in regular flights, indicated that Mylar might not be desirable for balloon material since there were some deleterious effects observed in high altitude exposure. We felt it was important to see whether Mylar could be used and also to test a Mylar cylinder. Because of its high ratio of tensile strength to density, Mylar does make it possible to consider a superpressure balloon, and for this reason a program of leak testing of Mylar was originated with Karl Kammermeyer at the University of Iowa through subcontract with General Mills, Inc.

The kind of Mylar balloons flown was the type described in the cylinder program, slack Mylar cylinders, as well as "infinite superpressure" cylinders equipped with a bubbler can and designed to operate under a superpressure of approximately 4 mb. It has been found, in brief, that small Mylar cylinders behave well and seem to show no bad effects due to high altitude exposure over a period of at least 24 hours. It was also shown to be possible to superpressure these small Mylar cylinders by an amount sufficient to make them float stably like a cork for a period of several hours. The leakage problem has shown that Mylar itself is good enough so that with moderate care in handling one couldhope to approach diffusion leakage of the material which would be entirely adequate for stability during daytime flight. It is very possible, however, that if one were to superpressure the balloon enough to eliminate sunset effects, leakage would become so large that the ballast required to compensate for leakage would be as high as sunset effect. This, however, has not been determined and the superpressure program is proceeding. Another method of putting the cylinders together, in addition to the Herb Shelly heat seal, was introduced at the University. It consists of gluing the Mylar with a polymerizing glue. The glue seals have been shown to be very good at low temperatures and have also been found to be adequately leak free to make a good superpressure balloon. The low temperature properties of the Mylar, plus the fact that it has high strength, should make it an ideal balloon vehicle if it can be successfully sealed in production.

This report also contains a series of nomographs which allow the calculation of the "natural shape" balloon for any combination of load and material weight.

One flight was made to test the feasibility of retransmitting Loran signals for locating balloons, and this flight is described, together with an analysis of this problem.* The conclusion is that it is not reasonable to expect to be able to use Loran retransmission for other than line-of-sight rebroadcasting, unless the new low frequency Loran net is sometime set up. The limitation is simply imposed by power bandwidth criteria.

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* Flight 82; Volume X, Section II.

Meteorological Section

The meteorological work can be placed in two categories:

(1) Study of meteorological factors affecting balloon performance, and

(2) Survey of the information gathered on the upper level flow with a view toward predicting the course of the balloon.

The primary contributions under the first category are the studies of the infra red flux in the atmosphere and the computation of the infra red heating (or cooling) of the balloon fabric. At present this study seems to indicate that the change in infra red cooling on polyethylene fabric at 10,000 and 30,000 feet may be the equivalent of half the effect of solar radiation.

The work on wind measurements has consisted of determining the general seasonal flow patterns, at higher levels in the atmosphere, and a summary of the physical characteristics of the flow at the floating elevation of the balloon. The one important conclusion from available data is that the high stratosphere flow does not possess the large scale velocity fluctuations of the troposphere. It is unlikely therefore that forecasting will be improved by attempting to draw weather charts since the flow systems would be too small to enter upon a synoptic map. The best forecasting aid at high levels appears to be a constant altitude balloon trajectory of several hours duration which would be used unmodified to extrapolate subsequent trajectories.

Future Work

The infra red calculations are being continued, the present effort being directed toward determining the seasonal variation.

Work on the various scales of motion and the characteristics of the flow shown by the constant altitude balloon trajectories also continues. A number of high level trajectories made by the SKYHOOK project are now available with better control of time and camera operation. A number of lower level flights should also be available shortly from the University studies of the superpressure balloon.

The Project during the next period will pursue further many of the experiments discussed in the preceding pages. The step flight technique will be used very extensively and it is hoped to investigate the effect of various gases in the balloon other than helium. It will be recalled that an early result of the Project was the study of the effect of air contamination produced by sucking in through the bottom appendix in the balloon, and this effect can now be studied quantitatively by introducing a known amount of air into the balloon on the ground and causing it to go through a series of steps.

It will be necessary to investigate the warming of the balloon with altitude as a function of the time of year and to repeat the day and night flights and to study step flights at several different rates. The cylinder balloon program, or some modification of the cylinder balloon program which uses balloons partially shaped and partially cylindrical, will be carried on because of our firm conviction that in order to have a reliable military vehicle it is necessary to eliminate the tapes from the balloon. The Mylar program has been extremely encouraging and it now appears that DuPont will be producing Mylar in large quantities in the near future. Mylar balloons should allow superpressure flights which are at a very constant pressure altitude at least during a part of the day not affected by sunset. A Mylar cylinder will probably allow the lifting of very much larger loads than could have been conceived of with shaped polyethylene balloons. As an example of this we have in the Project lifted 600 lbs on six-pound Mylar balloons. In addition to these advantages, the Mylar balloon development may allow flight at very much higher altitude, and this will be attempted during the coming year because of our belief that investigations at new altitudes and new latitudes will bring out facts desperately needed by the military programs if they are to be pursued on a sound basis.

Section II

FLIGHT SUMMARIES

(Flights 56-100)

Flight 56

Flight 56 was a radio controlled flight constants flight launched from Pierre, South Dakota, 23 January 1953, at 1632 GMT. It consisted of a Winsen 73-foot double wall balloon and a General Mills tow balloon No. 372-C. The plan of the flight was to tow the large cell to an altitude of approximately 50,000 ft, cut the tow cell by radio, thereby observing a fast descent followed by a slower descent due to the thermodynamic warming of the gas. After the descent rate had been established, the plan was to drop ballast bags producing a ballast bounce, and after the new rate was established to drop a second ballast bag to drive the balloon to ceiling. After sunset had taken place it was planned to drop a third ballast bag to compensate for sunset. This was the most successful of all the radio controlled flight constants flights which were attempted and it gave some data concerning flight behavior. This data is analyzed in Volume IX, Section VI. The rough characteristics of the actual flight were as follows: The balloon ascended at the rate of approximately 800 ft/min to an altitude of 50,000 ft where the tow balloon was cut by radio. Following this cutting of the tow the initial descent was through approximately 4,700 ft during which time the balloon acquired through adiabatic compression its final equilibrium temperature. The balloon was allowed to descend until it reached an altitude of 35,000 ft, at which point the ballast bag was blown by radio and the balloon underwent adiabatic bounce, finally leveling off. Whether the balloon levels at this point or has a slow descent rate is not certain, since the next ballast bag was blown too soon, because of a misunderstanding of the rapidly read telemetered altitude, to allow the rate to be maintained long enough to be certain as to its magnitude. Following the second ballast drop the balloon bounced adiabatically again for 2800 feet and then acquired a rate of ascent of approximately 134 ft/min. This rate of ascent was slowly increasing and had acquired a value of approximately 190 ft/min when the balloon had reached 62,000 ft. At this point the telemetering which had previously been somewhat erratic failed completely and no further information on the balloon altitude was obtained. Shortly after it was certain that no more altitude data would be obtained, the radio release was activated and the balloon was successfully blown down and landed near Wacondia, South Dakota.

Conclusions

Flight 56 was a quite successful flight constants experiment in which the vertical motion of a balloon system was controlled from the ground by radio. Data on the rate vs. free lift of a balloon in the daytime were obtained from the flight and are analyzed and discussed in Volume IX, Section VI. Because of difficulty of deciding precisely what the balloon was doing in flight, one of the ballast bags was prematurely blown. If this had not happened more reliable data could have been obtained from the flight. This demonstrates one of the shortcomings of radio control, namely that it may be difficult to decide soon enough what the precise behavior of the balloon is and to act correctly in performing the radio control operations.

Flight 57

Flight 57 was launched at 1530 GMT, 25 January 1953, from the winter launching site at Pierre Municipal Airport. This flight was the first one in a series to measure with thermistors inside the balloon the spatial distribution of balloon gas temperatures. The balloon used was a double wall Winzen 73-foot cell exactly similar to those flown on many occasions on the Project. It is constructed with two layers of one-mil material and weighed 273 pounds packed by the Minnesota method. The thermistors were placed inside the balloon in droppers similar to the droppers used to lower the radio antenna from the gondola. The thermistor dropper was smaller in size and padded with foam rubber to protect the balloon from damage. They are designed to drop out the thermistor on the end of a roll of wire when the balloon has reached 10,000 feet or so in the air. The thermistor will then fall down against the fabric but eventually hang free as the balloon expands. The details and analysis of this temperature flight and others will be found in Volume IX, Section V, of this report. The flight and launching were quite successful. The balloon climbed with an initial rate of 809 ft/min, reached ceiling at 945 ft/min, and flew level from 1700 until 2040 GMT, when it began the usual pre-sunset descent. The timer blowdown actuated at 2220 and the load was released. It was recovered in excellent condition. It was noticed on this flight that the high altitude winds in the stratosphere were easterly which is quite the exception for this time of the year between the fall and spring equinoxes when the wind is generally westerly all the way up into the stratosphere.

The flight was recovered at Gann Valley, South Dakota. The gondola on this flight transmitted pressure in the usual way using the Olland Cycle.

The temperatures, however, included an infra-red detector, air temperature and balloon temperatures. These were recorded in a specially designed recording unit for this purpose. Recovery of the gondola was essential to get the temperature record back. In connection with the operation of the flight it should be noted that the temperature record shows that the thermistors were against the balloon fabric on the ascending portion and a sharp drop in temperature was observed when the thermistors cleared the fabric and hung free in the balloon.

Conclusions

The flight operation was completely successful and the recovery gave a suitable record of the thermistor values throughout the flight. Conclusions derived from the temperature data will be found in Section V, Volume IX, of this report.

Flight 58

Flight 58 was launched 27 January 1953 at 1645 GMT from the Pierre, South Dakota, Municipal Airport. The purpose of the flight was to measure flight constants rates of rise and descent with various lifts using the radio control for valving and ballast dropping. The technique included a tow balloon to provide enough lift to take the load to about 55,000 feet, at which time the tow would be cut by radio command and the rest of the assembly would then descend and would be ballasted into equilibrium, thereby giving the ballast equivalent of a certain rate downward. From then on the flight was to be controlled by ballasting and valving. The main balloon was a Winzen double wall 73-foot cell and the tow balloon was a General Mills, Inc. 30-foot balloon. The flight telemetered on

1746 K.C. and also on 6835 K.C. The command receiver operated on 3415 K.C. The ballast was in the form of increments and there was a ballast stepper which would cut in succession first the tow balloon, then 32 lbs, 30 lbs, 34 lbs, 26.5 lbs and 25 lbs. The flight was launched with scattered clouds and a 5-mile/hr northwest wind. It had an average rise rate of 720 ft/min up to the altitude at which the tow balloon burst, at which time radio control could not be completed to release the tow. The tow therefore burst but remained attached to the assembly and the whole flight came down again. Radio control was not established so ballast could not be dropped. The low altitude release actuated at about 1320 and the load came down on the parachute. The tow balloon burst at 100 mb, a little below the theoretical tow burst, and the assembly after rising at 720 ft/min dropped at around 800 ft/min to 105 mb, at which time the rate decreased to 320 ft/min and remained constant at this value until blowdown. This exhibits the usual adiabatic compression when descending and the accompanying slowing down of the balloon.

Conclusions

No flight constant data was obtained and again we have a failure of the radio command system despite careful preflight checkout. It is thought that the failure of the command system was due to the thermal delay relay which is inserted between the resonant relay and the instrument to be controlled and that this thermal delay relay could not heat up enough to close the contact.

Flight 59

Flight 59 was made 12 February 1953 and was launched at 2200 GMT. It was the first attempt with a Mylar balloon manufactured by Herb Shelly, Inc.

The balloon was a 1/4-mil cylinder with 45-foot gores designed with a maximum diameter of 25 ft. It was equipped with a duct which was cut 15 ft from the bottom. The balloon was fabricated into a cylinder using clamp rings at the top and bottom to connect to the duct and the harness respectively. The balloon alone weighed six pounds; with all the fixtures it weighed 29 pounds. The theoretical ceiling was 65,000 ft. The balloon was equipped with a light weight gondola and the air displaced was 79 lbs with a free lift of 13.9% of the air displaced. The balloon was weighed off in the hangar at Pierre Airport and was walked out into the open with a 13 mi/hr northwest wind and a ground temperature of 30°. The balloon took off into the air, but after rising a few hundred feet settled back to the ground on the Airport property and was destroyed by the wind.

It is not certain what was the cause of the failure. Either the balloon was weighed off heavy or it failed at takeoff due to the low shock resistance of Mylar heat seals.

Flight 60

Flight 60 was launched 15 February 1953 at 1937 GMT. It was the second attempt with a 1/4-mil Mylar cylinder balloon made by Herb Shelly, Inc. It was an exact duplicate of Flight 59 and the flight duration was set for 20 hours for the purpose of measuring the sunset effect and the flight characteristics of the Mylar cylinder balloon. It was equipped with telemetering beacon, low altitude release, but no ballast drop. On this flight the seals were individually hand checked throughout and the entire balloon was checked for holes and all scratches observed were taped over. The balloon alone weighed 6.83 lbs and was made with 25 gores and 25 seals. The duct was also made of Mylar and was made of one flat sheet rolled into a tube and connected on seal#25 externally. This flight was launched with 73.5 lbs of air displaced and a free lift of 10.9% of air displaced. The time-altitude curve shows the rate of rise from 1000 to 400 mb was 700 ft/min, an increasing rate of rise with increasing altitude. The rate was 750 ft/min from 400 to 150 mb, and from 150 mb to the highest altitude reached of 77 mb the rate was 1100 ft/min. The balloon reached 77 mb, which was a little higher in pressure than the theoretical ceiling of 73 mb applicable to a balloon of 8900 cubic feet. The balloon immediately started down again at 320 ft/min. It increased its rate at the tropopause (100 mb) to 450 ft/min and reached the low altitude blowdown of 430 mb when the parachute released. Calculations showed that the duct was cut quite high and that the balloon actually exceeded the theoretical ceiling for the duct as actually flown. The time-altitude curve shows that the balloon spent approximately ten minutes above the valving altitude because of its cylindrical shape and the possibility of increasing its volume. This possibility of overshooting its ceiling is characteristic of the cylinder balloon and not of the Mylar balloon. In this case, the balloon descended from 77 mb to 88 mb and then leveled for a short time, about two minutes, and then started on down again. It is assumed that the 88 mb level is the point where the balloon stopped valving and at this point the warming on descent took over and kept the balloon stable for awhile until a new equilibrium rate of 320 ft/min was established.

The conclusions from this flight are concerned inherently with the behavior of the cylinder balloons. In this case we have a subpressure cylinder with a rather high rise rate. The characteristic of such a balloon determined from this flight is that it will overshoot its theoretical ceiling and overvalve and immediately descend again. The reason for this is that the volume of a cylinder balloon may be greatly increased with a very small superpressure produced by valving.

Flight 61

Flight 61 was similar to Flights 59 and 60 and was launched 17 February 1953 at 1951 GMT from the University of Minnesota Airport at Minneapolis. We used a Mylar 1/4-mil cylinder balloon 45 ft long and 25 ft in diameter with the bottom of the appendix 15 ft above the balloon bottom (balloon M-3). This flight, however, carried two ballast drops to send the balloon back to ceiling if it should descend initially as Flight 60 did. The ballast was set to drop four lbs at 44,800 ft and two lbs at 33,500 ft. The gondola was one of the small light weight variety that had been developed specially for this flight. The gross load was 57 lbs. The balloon was given a free lift of 6.6% of the displaced air. The balloon alone weighed 6 lbs but with the fittings the packed weight was 11 lbs, 6 ounces. The initial rate of rise to 450 mb was 467 ft/min. Between 400 and 200 it was 650 ft/min, and between 200 and ceiling altitude it was 864 ft/min. The balloon exceeded the predicted theoretical ceiling for the duct cut one-third of the way up the balloon, which was 83 mb, and reached a top altitude of 76 mb. It turned around immediately and began to descend at 199 ft/min. At 100 mb it speeded up to 303 ft/min and reached the ballast level at 150 mb where four pounds of ballast were dropped. This gave the balloon an upward velocity of 220 ft/min and it went back up to the new theoretical ceiling for the decreased load which was 77 mb. It rounded off at 77 mb for about twenty minutes and then began to descend again. The last descent is produced by sunset. The descent rate was 260 ft/min down to 200 mb, where the balloon slowed down and had a speed of 143 ft/min when it reached the second ballast level where two pounds of ballast were dropped. This sent the balloon back up again with a variable speed and the balloon eventually reached 195 mb but then settled somewhat and floated off at an altitude between 200 and 250 mb, when the signal was lost. The flight pattern exhibits the same type of instability as observed on Flight 60. Namely, that the balloon overshoots its theoretical ceiling, overvalves and becomes heavy in descent. This behavior seems to be characteristic of subpressure cylinder balloons when the rise rate is too high. After the first ballast drop the rise rate was 220 ft/min and in this case the balloon apparently did not overshoot its theoretical ceiling very much, but the exact situation here is confused by the onset of sunset, which at any rate would cause the balloon to drop. One can estimate that the sunset effect on this balloon is equivalent to between one and two pounds of ballast, which would make the percentage between two and four percent of the air displaced. There is also a suggestion that the balloon was leaky due to the fact that it rose with a rather positive rate of 150 ft/min and then began to descend again, but this behavior is not certainly attributable to leakage, as balloons in neutral equilibrium below the ceiling are often observed to rise and fall during flight probably because of changes in the balloon temperature from radiation or air temperature variations. Another uncertain factor in determining the sunset rate is that the pre-sunset effect was acting on the balloon before it reached ceiling the second time, which means that it valved in accordance with a lower superheat which would decrease the apparent sunset effect. The flight released by low altitude release after approximately 16 hours 10 minutes of flight. The load landed four miles north of Ithaca, New York.

Conclusions

The main conclusion from this flight is again about the instability of cylinder balloons with high rise rates. Their volume can increase above the theoretical ceiling determined by the duct and they can overvalve. One would conclude from this flight that a rate of 250 ft/min rise rate is safe, and a rate of 864 ft/min is too high for this particular subpressure cylinder balloon and this size of duct. The second conclusion is that the sunset effect is somewhat uncertain but it lies between two and four percent.

Flight 62

Flight 62 was launched 23 February 1953 at 1822 GMT from the Pierre, South Dakota, airport. It was another Mylar balloon identical with Flights 59, 60 and 61. It was a 1/4-mil Mylar #M4, 45-foot long cylinder balloon, 25-foot diameter, manufactured by Herb Shelly, Inc. However, in this case the appendix was cut 10 feet along the gore up from the bottom of the balloon. The flight was equipped with the small gondola with two ballast drops, the first four pounds and the second two pounds, set at 45,000 and 34,000 feet respectively. The purpose was to test the flight characteristics of the Mylar subpressure balloon, particularly the stability at ceiling. The gross load was 55 pounds and 9.1% of the displaced air was set in free lift. The balloon took off with an initial rate of 560 ft/min, speeded up uniformly and reached 820 ft/min as it approached ceiling. The balloon reached maximum altitude and within two minutes started down again with a rate of 160 ft/min initially, slowing to 70 ft/min after passing the 100 mb region. At 130 mb it began to speed up again, reaching 220 ft/min, and at 155 mb the first ballast was released - four pounds of steel shot. Following this the balloon rose through a noticeable bounce and acquired an upward rate of 380 ft/min, which slowed to 290 ft/min at 100 mb, and the balloon reached the new theoretical ceiling and leveled for 30 minutes. The balloon then began a pre-sunset descent and after another 30 minutes speeded up to 130 ft/min. It continued to speed up, reached 180 ft/min, and at 130 mb which is apparently the tropopause for the day it increased to 260 ft/min. It slowed a little bit to 208 ft/min and dropped two pounds of ballast at 250 mb. It then bounced about 10 mb and went perfectly level until the signal was lost at about 2300 GMT. From the level portion following the second ascent one can compute what the original theoretical ceiling should have been, and this comes out to be 70.5 mb. Therefore it is readily seen that the balloon overshot its ceiling by 4 mb, at which time it overvalved and became heavy and descended. This behavior is characteristic of all of the cylinder flights where the ascent rate is too high. However, after dropping the second ballast the ascent rate was 290 ft/min, which permitted the balloon to level without overshooting, or at least the warming during level flight was sufficient to compensate the overvalving so that the balloon became stable. This flight gives a very good value for the sunset effect on the Mylar balloon and the two pounds of ballast dropped was exactly correct to compensate sunset. This gives a sunset effect of 3.3% of the displaced air. It is interesting that the small bounce following the drop of ballast at sunset, which is about 780 feet in height, corresponds to a temperature change from adiabatic expansion between .75% and 1.8%. This does not seem to be in close agreement with the percent ballast drop in this particular case.

Conclusions

The conclusions, again concerning the stability of the cylinder balloon or the subpressure cylinder balloon, are that 820 ft/min is too high a rate of rise to bring the balloon to equilibrium at ceiling with a balloon-to-duct diameter ratio of 50. However, 290 feet per minute is not too high, and the balloon will be expected to level. The sunset effect is 3.3% of the displaced air on the Mylar balloon at 250 mb. The sunset effect value of 3.3% is substantially lower than that for a polyethylene balloon, which is 5% for the one-mil single taped variety. The sunset effect on the Mylar balloon was measured at 250 mb.

Flight 63.

Flight 63 was launched 23 February 1953 at 2043 GMT from the Pierre, South Dakota, Municipal Airport. The flight was made for the purpose of measuring balloon gas temperatures, with five thermistors distributed inside the balloon to get balloon temperatures through sunset and through the bounce produced by ballast drop. The balloon was a Winzen double wall #73-2X100V-256 polyethylene. The temperature information was recorded in the gondola. The thermistors were arranged as follows: one was in the center of the spherical portion; one on a level with the center on each side, about ten feet in from the edge; one thermistor was held in the center of the lower portion of the balloon by a tie rope, so that prior to launching it would be held in the center of the inflated portion and would measure the balloon gas temperature on the ground. The flight was launched in calm wind conditions, 35-40°F, with clear skies. This flight was equipped with a ballast drop to operate at 75 to 150 mb and sequenced to drop 25 lbs of steel shot at each of these two pressures. It contained the usual up and down cameras, low altitude blowdown and pressure telemetering on 1746 K.C.

The time-altitude chart shows that the balloon had an ascent rate of 598 ft/min to 250 mb, then went at 700 ft/min to 90 mb. The rate decreased a little bit to 548 ft/min to ceiling where the balloon floated at 28.5 mb for 70 minutes. Pre-sunset rate was 160 ft/min, and it established 530 ft/min after sunset on the balloon and speeded up to 610 ft/min by the time the balloon reached the ballast drop at 77 mb. Immediately after dropping the ballast the balloon bounced upward 1410 ft and then established a downward drift of 40 ft/min. The adiabatic temperature decrease on the bounce was 6.8°, or $\frac{\Delta T}{T}$ is 3.2%. $\frac{\Delta W}{W}$ for the ballast drop is 4.8%. It seems that as usual the change in temperature divided by the temperature is a little lower than the fractional ballast drop. The balloon continued to descend at a gradually increasing rate and by 0529 GMT was moving at 200 ft/min at the 200 mb level. It decreased to 60 ft/min following this, but at 0745 GMT it hit the low altitude release and the load was put on the parachute. The signal was obtained all the way to the ground, making the time-altitude record complete. Unfortunately, the flight at the time of this summary had not been recovered so none of the temperature data is available. The flight will be an excellent one for the purpose if the equipment is found.(*)

Conclusions

The conclusions are that this was a typical example of the type of flight which has been flown by this Project to study vertical flight motion, the effect of dropping ballast, adiabatic changes in temperature, sunset

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(*) At the time of proofing this section, the flight has been recovered and the data completely analyzed. It is included with other temperature data in Section V, Volume IX, of this report.

rates, etc, inasmuch as this information is available from the time-altitude chart. Temperature information, if available when the gondola is recovered, will be presented in another section of this report.

Flight 64

Flight 64 was launched the 24th of February 1953 for the purpose of measuring flight constants by radio controlled ballast drop and radio controlled valving. The method was to raise a 73-ft balloon and gondola by means of a tow balloon which would be cut loose by radio release and the main balloon would then be heavy and would descend. Ballast would then be dropped to level it, so that the ballast drop corresponding to a given descent rate would be determined. The main balloon was a Winzen double walled 73-ft #255 which weighed 271 lbs. The theoretical ceiling was 85,000 ft. The telemetering transmitter operated on 6835 K.C., the command receiver operated on 6420 K.C., and there was a sequence command ballast dropper which would drop a series of increments. The ballast drops were 33, 31, 30, 33 and 26 lbs respectively. The balloons were inflated in a low overcast, 28°F, at the Pierre, South Dakota Municipal Airport on the southeast side of the hangar. The tow balloon displaced 82.3 lbs of air and the main balloon 664 lbs. The assembly was launched without any difficulty but as the top of the main balloon inflated it was observed that the assembly was coming back to the ground again. At this time the tow balloon was cut loose by command and the main balloon settled to the ground just off the southeast end of the airstrip on the side of a hill and the gas rapidly left the balloon. The balloon was recovered in perfect condition so that one was able to determine the cause of the failure. It was that the packing slit in the top of the balloon had not been sealed and the gas escaped through it. It was an opening about 12-14 inches in length.

Conclusions

There were no conclusions relative to the main purpose of the flight.

Flight 65

Flight 65 was launched 26 February 1953 at 1440 GMT. It was a duplicate of Flight 64 and the purpose was to measure flight constants with tow balloon and radio controlled ballast drops. The planned duration was set for 24 hours. The balloon was #253 double walled and weighed 272 lbs. The details of the gondola and ballast drops are just like Flight 64. The tow balloon was inflated to 105 lbs displaced air, and the main balloon to 646 lbs. In this case, due to the fact that the helium trailer at Pierre had become mired, the balloon assembly was launched next to the helium tank car on the track at the Pierre, South Dakota, stockyard siding. A detailed check-out was made over the command circuit from the airport down to the stockyard, and all the apparatus was working perfectly by command control. The launching took place with some turbulent wind but the launching went very well. After the balloon was in the air it was found that command could not be established so the assembly rose until the tow balloon burst. The entire assembly then returned to the ground. The low altitude release separated the gondola from the balloon and also dumped the ballast packages, and the balloon came down on parachute and was recovered near Gann Valley, South Dakota. The cause of the failure could not be ascertained on the recovery of the gondola.

Conclusions

There are no conclusions connected with the main purpose of the flight. The repeated failure of this type of operation makes it begin to appear an impractical way to obtain the desired data.

Flight 66

Flight 66 was launched 12 March 1953 at 1858 GMT. The purpose of this flight was to measure the effect of ammonia on flight characteristics in the winter, and the inflation was made with pure ammonia. The balloon was a General Mills, Inc. 116-ft diameter #22-1161-A made of Visking one-mil material and with the duct added by the University and constructed of 5-ft diameter material. The flight was set up for 36 hours with pressure-operated ballast drop to drop 92 lbs at 60,800 ft and 100 lbs at 26,600 ft. The 1161 balloon is designed from the natural shape theory with zero fabric weight. It contains 42 gores, 84 load tapes and has a volume of 711,000 cubic feet. With ammonia inflation this should mean a theoretical ceiling of 86,000 feet. The ammonia was boiled into the balloon using the heat exchanger reported earlier and the steam jenny, and the inflation proceeded without difficulty. The balloon weight was 312 lbs, and the launching took place on an overcast day in a temperature of 38°F with a 12-15 mile per hour south wind. The launching was from the windscreen at the old University of Minnesota airport. The time-altitude curve shows that there was an initial acceleration up to 500 mb but that the rate was then constant, very close to 1000 ft/min, all the way to 44 mb, at which point the balloon failed and the load returned to the ground. The load was released by the low altitude release mechanism. The parachute opened satisfactorily, but the remains of the balloon came down with it. The balloon tapes landed in a tree separate from the gondola, apparently intact, but with very little material remaining on. The package was returned in good condition.

Conclusions

The conclusions are that, like other 1161 one-mil balloons, a failure was encountered during ascent. This seems to be characteristic of this type of balloon and differs in this respect from 73-ft balloons of various types which have been flown under this Project. It is not certain whether this apparent weakness in the 1161 balloon is due to the one-mil material or to some defect in the construction which weakens the balloon near the top.

Flight 67

Flight 67 was launched 4 April 1953 at 1955 GMT. It was for the purpose of measuring balloon gas temperatures, air temperatures, and the earth infrared temperatures through sunset. The flight was set up almost exactly the same as Flight 63, which is described in the summary for that flight. Five thermistors were placed in the balloon and a thermistor was placed in the lower part of the balloon so that it would be in the center of the inflated portion on the ground. The other thermistors were distributed throughout the fully inflated balloon at ceiling. The flight schedule was set up to have the balloon level at ceiling well before sunset, have the balloon descend at sunset until it encountered a ballast drop which would compensate out the sunset and keep the balloon level until it was cut down by a timer just before midnight. The balloon used was a double-wall Winzen 73-ft cell #255, weighing

$275\frac{1}{2}$ lbs. The theoretical ceiling was 83,000 ft and the balloon reached 80,500 ft. The flight was completely successful and the data which was recorded in the gondola was recovered in good condition. The balloon rose at approximately 700 ft/min. The temperature data has been analysed in detail and is reported in another section of this report, but in summary it was found that the balloon gas was approximately 10° cooler than the air in the troposphere. As the balloon rose through the stratosphere this negative superheat decreased and reached zero at 70,000 ft. The superheat was approximately zero degrees when the balloon reached ceiling. It superheated by 16° with a time constant of ten minutes following arrival at ceiling. This superheat was maintained through sunset and during the post sunset descent, until ballast was dropped, at which time the superheat dropped to approximately zero degrees. The gondola was recovered $4\frac{1}{2}$ miles northeast of St. Charles, South Dakota. The flight stayed in the vicinity of Pierre during the day, which showed that the winds had definitely shifted following the spring equinox to easterlies at high altitudes.

Conclusions

This was a successful operation. The principal conclusions regarding balloon temperatures and behavior following ballast drops will be summarized in another section of this report.

Flight 68

Flight 68 was the first flight in a program to measure the constants in the equation of motion of balloons using a new approach. Previously the attempt was made to measure flight constants by means of a command radio control system with which the balloon would be made to valve gas and drop ballast so that the free lift involved at various rates of rise and descent could be measured. Experience with approximately twenty flights in the radio control program has convinced us that such a program should be discontinued because of the large number of failures in the flights and because of the meager amount of information obtained. Many of the failures were due to difficulties in the radio control system itself. Other failures were due to the balloon or other instrumentation critically involved in the flight, so that all told the probability of a successful flight was very low. The new approach to the problem consisted of providing a lead balloon or platform to which to anchor the vehicle to be tested. The platform would be sent through a prescribed time-altitude program and the free lift of the test balloon measured by a tensiometer telemetered back to the receiving point. The time-altitude program selected for the initial experiment was a series of steps combining a constant rate of rise and a level portion,followed by another constant rate of rise and a level portion, etc.

Flight 68 was a checkout of the platform itself. The program was to level the flight successively at 20, 30, 40 and 50 thousand feet and to connect these level portions by constant rise rates of 500 ft/min. This was to be done by means of a controlled ballast drop which would vary the ceiling altitude of the balloon in a prescribed way. The initial step upwards would be made with the balloon nearly full. It would valve and level at the first step. This would be determined by the volume of the balloon and the total quantity of ballast carried. In this case, the load was 700 lbs with a 30-ft diameter balloon, and the first step occurred at 10,000 ft. By means of a timer, ballast would be released from the first set of ballast tanks in such a way that the ceiling altitude of the balloon would increase at a rate of 500 ft/min. This required that the ballast be dropped exponentially but this was approximated by means of the proper height of the container and orifice size. The complete details of the step flights will be found in Section VI, Volume IX, of this report. The first flight in this program, #68, was launched 11 April 1953 at 1538 GMT. The balloon was a General Mills, Inc. #52 30-ft diameter, equipped with rayon filament tapes, a special clamp ring in the bottom to carry the load, and a duct appendix aluminum clamp ring in the top. This balloon had a 90° total cone angle, and the duct was terminated at the bottom of the balloon. The ballast containers were housed in a frame which also carried the instrumentation gondola.

On this flight, altitude and air temperature only were telemetered. The time-altitude curve shows that the platform did in fact behave exactly as expected. The initial rise rate was 780 ft/min to the first step, where the balloon oscillated a little bit and then floated level. It then rose, after approximately one hour, at a rate of 520 ft/min at 20,000 ft. After the second hour it rose at 510 ft/min to 30,000 ft. After the third hour it rose at 510 ft/min to an altitude a little less than 40,000 ft. After the fourth hour it rose to about 44,000 ft and floated level for about an hour and then began to descend a little bit until the release time, which was at 2200 GMT. The ballast drops were accomplished by releasing the end of the hose which was held up above the liquid level. The hose contained an orifice of the proper size to give the desired flow. This flight marked the first use of the temperature transmitter which telemetered the thermistor resistance by a series of pulses coming at a rate determined by the resistance. The pulse generator was calibrated with standard resistors described in detail in this report. This temperature generator was designed with the ultimate idea of transmitting air temperatures on all of the flights made on the Project. The flight was launched on an overcast day from the University of Minnesota airport. The air temperature was 33°F and the wind was calm. The flight performed just as expected. An interesting feature of the flight was that the balloon could be used as an absolute gas thermometer. That is, one could use the volume and air pressure to calculate the air temperature. The temperature so calculated agreed with the thermistors to within a degree. The gondola was eventually recovered at Mensie, Ontario, Canada and both the cans and the instrumentation gondola were returned in good condition.

Conclusions

The success of this first flight in the new series was immediate and gave promise of success when the tow balloon could be connected. The simple timer device to drop the hoses and the method of producing rates of rise by ballast drop were proved to be sound in principle. The thermistor transmitter gave temperatures in very good agreement with those calculated using the balloon as a gas thermometer. It was concluded also that, by the changes in tension observed between the test cell and platform while the platform was floating level and while the platform was started and stopped, one could independently evaluate the increase in free lift due to altitude alone, the aerodynamic drag force, and the thermodynamic drag force at various altitudes and for various rates of rise. With this as a thesis, the instrumentation was gotten under way for carrying the test balloon and measuring its lift while the platform followed the time-altitude program of Flight 68.

Flight 69

Flight 69 was launched 20 April 1953 at 1618 GMT. It was a flight test of a zero pressure Mylar cylinder #M7A constructed by Herb Shelly, Inc. The cylinder was 25 feet long and the circumference was 98 ft. The balloon and clamp ring fitting were used to gather the cylinder and install a duct at the top. The duct was run all the way to the base of the balloon, producing the zero pressure condition there. The bottom was clamped with a small tire and orlon girdle. A Mylar diaphragm across the tire sealed off the balloon. The gondola was set for 24 hours and a water tank heat ballast was added. Ballast drops were provided with three pounds at 150 mb and three pounds at 250 mb. Besides pressure, the air temperature and the temperature inside the gondola were telemetered. This flight was considered necessary to further investigate the flight characteristics of the cylinder balloons, as the flights with subpressure cylinders showed that instability could be produced at ceiling by too high a rise rate, at least with this size of balloon. The theoretical ceiling was 58,000 ft and the flight was launched in a 10-12 mile/hour wind from the University of Minnesota airport with scattered cirrus clouds. It accelerated somewhat and achieved a rate of 560 ft/min, after a noticeable bendover at the tropopause, and reached precisely its theoretical ceiling of 80 mb where it floated level for just one hour. It then began to descend slowly and reached 187 ft/min at the 200 mb level. The ballast drop of three pounds at 245 mb sent the balloon up at 80 ft/min, but due to sunset the balloon rounded off, floated level for about 30 minutes, and then descended with increasing rate until the signal was lost at about 0400 GMT on 21 April. The signal was received, however, by a portable recorder in the tracking plane which maintained contact until the end of the flight. The load was recovered at the US Army Proving Ground at Madison, Indiana.

The air temperature values, when compared with the St. Cloud sounding for the day, lie somewhat below in the troposphere, show a tropopause not quite as cold, and agree quite well in the stratosphere. The first ballast drop failed to operate at 150 mb, and the second one alone was not enough to compensate for sunset plus the descent rate established before sunset. There was evidence on this flight that this was a leaky balloon, although there was a level portion upon reaching ceiling. The balloon showed stability upon reaching ceiling with a square corner. Some trouble was experienced with the launching due to the winds and the bubble behind the wind screen. Some fancy track work was necessary to get the gondola in the air and the antenna was knocked out of the dropper and unwound across the ground. This did not, however, apparently damage the antenna.

Conclusions

The zero pressure cylinder showed stability upon reaching altitude with reasonable rates of rise to a much greater extent than a sub-pressure cylinder balloon. There is evidence of leakage of helium in this flight. The exact sunset effect was not obtained due to the failure of the first ballast drop and the descent of the balloon prior to sunset.

Flight 70

Flight 70 was launched 27 April 1953 at 1828 GMT. It was a test of a superpressure ¼-mil Mylar balloon, cylinder type, 117 feet in circumference, Herb Shelley #M9. It weighed 15.5 lbs completely fitted for flight. This balloon carried a special very light-weight gondola with a 10.260 megacycle transmitter with the timer set for 11.5 hours. The gross load was 21 lbs. The theoretical ceiling for the superpressure balloon, for which exact gore length was 43 ft, 8½ inches, was 87,500 ft with 21 lbs gross load. The flight was launched with the free lift added and the balloon tied off. This balloon had been tested at a superpressure of 1 mb by inflation with air in the arena. The free lift then could be 1 mb at 19.7 mb, or 5% of the air displaced, which was 26 lbs. This limited the free lift to 1.3 lbs. The actual free lift was 22.5 ounces which was 5.4% of the air displaced. This free lift was not that initially inserted into the balloon for the following reason: the balloon was inflated with a free lift of about one pound and tied off and launched. It took off, drifted across the old University Airport, and began to descend again. The balloon was caught and brought back to the windscreen and additional free lift was put in. This time the balloon took off and went up to an elevation of about 1,000 ft where it remained level and then started to descend when the sun was obscured by a cloud. It was observed to drop to within a few hundred feet of the ground, hovering over a farm to the SE of the airport. The sun appeared again and the balloon rose--this time leveling at about 4,000 ft. It was observed from the airport that the sun was again obscured by a cloud and the balloon again started down. The launching crew took off after it and arrived at a field near the Twin Cities Arsenal with the balloon descending directly down toward the ground. The balloon antenna dangled within two or three feet of the ground. The balloon then took off again and went up to 7,000 ft where it leveled for a time and then started up again and shortly afterwards failed and the load came down on the parachute and was recovered on the east shore of Turtle Lake. It was suspected that the balloon was damaged by military aircraft which were flying around in the clouds in that vicinity and probably the prop wash from one of these planes tore the balloon.

Conclusions

The conclusions are that in this particular case the balloon was very sensitive to radiation effects which may be connected with its Mylar construction and which were definitely associated with cloudiness. The balloon rose and descended as the sun appeared and disappeared. The failure of the balloon was probably due to the prop wash from military planes which made repeated passes at it.

Flight 71

Flight 71 was launched 4 May 1953 at 1237 GMT. The purpose was to measure the flight characteristic of the zero pressure balloon, which in this case again was a Mylar ¼-mil Herb Shelly #M8. It was a 45-ft cylinder with the duct cut at the bottom of the balloon. Theoretical ceiling was 60,000 ft and the flight time was set for 24 hours. The ballast was one 3-lb package which was fired at 150 mb with the backup at 250 mb. The blowdown was set for 355 mb. The balloon was inflated and launched without undue difficulty and had an initial rate somewhat less than 500 ft/min, but at 800 mb speeded up to 660 ft/min and went up to ceiling from 400 mb at 684 ft/min. It leveled off at 59,300 ft very close to theoretical ceiling and remained level for about 50 minutes after which it began a slow descent. There was a very sharp increase in rate at 100 mb which, according to the temperature soundings obtained on the flight and also the weather bureau, coincided with a break in the temperature sounding. The balloon increased its downward speed at this point from 96 ft/min to 300 ft/min and came all the way to the ground with a final speed of 556 ft/min. The load and balloon were recovered in good condition and were taken back for inspection. The balloon was carefully gone over and no obvious holes were found, although some tears were found that occurred on impact. The seals were taken back to Herb Shelly, Inc., and ten of the test tubes which on this flight were provided on each gore for pressure test prior to flight were then tested. Aside from seal 7-8 which burst at 20 millimeters the others were all equal to or greater than the minimum specification of 50 millimeters set up for the manufacture of the balloon. Apparently this flight did not cause the material to deteriorate noticeably, at least as revealed in this burst test of the seals. The ballast dropping mechanism did not work, nor did the low altitude blowdown, and it was found on recovery that this was caused by a burned out lead wire which connects the movable pen arm of the blowdown bellows with the squib circuit. Somehow this arm became grounded and the wire was burned off.

Conclusions

The conclusions from this flight are that again the zero pressure cylinder was shown to be stable on reaching ceiling in the sense that it did not overshoot, overvalve and descend as did the subpressure cylinders. The rate of rise in this case was nearly 700 ft/min. However, a loss of lift was incurred after approximately 30 minutes, which caused the descent and eventual landing of the balloon. The Mylar did not deteriorate during this exposure at high altitudes for approximately four hours. The balloon may have been leaky in the porous sense but there were no obvious holes or imperfections visable before flight or afterwards.

Flight 72

Flight 72 was launched 6 May 1953 at 1511 GMT. The purpose of this flight was to repeat Flights 69 and 71 with the Mylar ¼-mil cylinder balloon to check the behavior of those flights in which they went to ceiling and remained there a short time and then descended. The theoretical ceiling of this flight was 59,000 feet. The balloon was # M8A made by Herb Shelly, Inc. It was the same one flown on Flight 71 with four panels replaced. The zero pressure level was at the base of the balloon. The flight time was set for 12 hours and the gondola carried a 1638 KC transmitter, up and down cameras, and one 3-lb ballast package. The gross load was 88 lbs with 5 lbs of free lift, which was 4.7% of the displaced air. The gondola, like that flown on Flights 70 and 71, contained a water heat ballast tank. The flight was launched from the University Airport, clear weather with no wind, temperature 59°. On this flight the antenna was unrolled on the ground prior to launching so that a complete flight record would be obtained. The balloon had a rise rate of 530 ft/min which was more or less constant up to 400 mb where the balloon apparently opened a hole. It reversed and started down and the low altitude release cut the package from the balloon at 500 mb. The balloon and load were recovered at Waconia, Minnesota.

Conclusions

Conclusions from this flight are that the balloon, which had been repaired from the previous flight, was defective, causing a premature failure.

Flight 73

Flight 73 was launched 13 May 1953 at 1847 GMT. The purpose of the flight was to measure balloon temperatures with thermistors at seven positions inside the balloon, to make air temperature and earth infrared measurements during sunset and during the thermodynamic bounce following release of ballast. The balloon was a Winzen # 73-2X100V-257, 72.8 ft in diameter. It was a double wall, one-mil cell with a duct appendix with wires and thermistors installed at packing time. The balloon was packed 31 December 1952 by Hanson, Smith, Huch and others. The gondola contained a 4-watt transmitter on 1638 KC, antenna dropper, Olland Cycle, usual CAA safety devices, timers set for 10 hours,up and down cameras, and a thermistor and infrared recording outfit for cycling amongst the various thermistors in the balloon. It also contained a blinker beacon to meet CAA requirements.

The theoretical ceiling was 82,600 ft. The balloon was launched from the University of Minnesota airport at Minneapolis. The temperature was 45°F, about .5 cirrus overcast, and a NW wind of 5-10 miles per hour. The flight displaced 595 lbs of air and the free lift was 40 lbs or 6.7% of the displaced air, the inflation medium being helium. The flight had an upward velocity which did not change much. It started out at 822 ft/min, dropped to 741 above the tropopause, and reached 850 again which it maintained until it reached its ceiling of 81,400 ft very close to the theoretical ceiling. The theoretical ceiling was reached at 2020 GMT and the balloon then floated level for two hours, after which it began a slow descent which showed a tendency to increase, and at 2430 GMT it reached 76 ft/min. At balloon sunset it accelerated to 276 ft/min and reached the ballast-dropping altitude of 72 mb at 0152 GMT May 14. There was evidence of a ballast drop, as the balloon bounced upward, but it then continued on down at 168 ft/min, which is difficult to understand if the full 35-lb bag had been expended at that time. The balloon continued down, and accelerated to 180 ft/min when it hit the backup ballast level of 165 mb at 0244 GMT, at which time there was very definite indication that more ballast was released. The balloon bounced again and slowed down to 62 ft/min. Inasmuch as the two ballasting altitudes were wired to separate squibs into the same 35-lb ballast bag, it was evident that the first squib at the high altitude point had not dropped all of the ballast and at the firing of the second one had dropped an additional quantity. One might assume that the total amount was dropped by the second ballast drop, which did not quite compensate the sunset effect as the balloon had a residual downward velocity. One might also assume that the whole 35 lbs was not dropped even at the second level and that the balloon therefore continued to descend at a much lower rate.

The flight terminated by timer release at 0413 GMT. The signal was heard all the way to the ground but the velocity seemed much too high for descent on the chute. It was assumed that the load broke off the parachute and dropped free to the ground. At the time of writing this report the load has not been recovered and the data contained in the thermistor recorder is at present lost. On this flight a series of exposures were made through the ten-inch astronomical telescope on top of the Physics Building, as the balloon was nearby over the Twin Cities.

Conclusions

No scientific data was obtained due to the fact that the gondola was not recovered. The failure of the ballast drop to dump the ballast properly means that one has to be meticulous about the way the squib is placed in the bottom of the ballast bag so that a large hole is positively opened at the moment of explosion.

Flight 74

Flight 74 was set up for the purpose of testing a Mylar cylinder balloon under superpressure conditions in flight. The balloon was completed on the 18th of May 1953, and was equipped with rings and seals on the end, as described in this report (See Section III, Volume IX) by Herb Sheily, Inc., under the direction of William Huch of this project. The balloon was No. M-10, Mylar A, ¼-mil thickness, 45' gore length cylinder with 103' 10" circumference and 85' appendix measured from the top of the balloon. The flight was set up for a duration of 24 hours and contained a 1638 KC transmitter. The gondola contained the usual flight and safety equipment and a ballast dropper which would drop three pounds at 150 mb and another three pounds at 250 mb. The gondola contained a water tank heat ballast and the launching was to be from the University of Minnesota airport. The gross load of this flight was 72 lbs and the inflation was made through the duct into the top of the balloon. The inflation proceeded without difficulty but when the balloon was erected it began to blow about in the wind and due to several delays this continued for about one-half hour. During a gust the balloon ruptured along a seal and dumped on the ground. The flight was then cancelled and the balloon was taken back for an analysis of the torn seam. The test tubes which were still in the balloon were used to pressure test the seals and it was found that only one of the gores was below 50 mm, namely #25, which burst at 10 mm of superpressure. The balloon was then repaired on Shelly's table to use over again on the next flight. The conclusion from this flight, which was corroborated by flights reported later, was that the shock resistance of the Mylar heat seal is very low although the pressure test is in a satisfactory range. There were no conclusions regarding the behavior of the balloon at superpressure because of the cancellation of the flight.

Flight 75

Flight 75 was launched 22 May 1953 at 1147 GMT. It was an exact repeat of Flight 74, in fact the same balloon was used which had been returned to Shelly and repaired for this flight. It was repaired on May 21 for the flight on the 22nd. The balloon was inflated through the duct without incident and the trailing end of the duct, which was one balloon height longer than the balloon to provide the superpressure, was laid out on the ground prior to release. This balloon was launched by the Huch technique, that is, a loop was formed into the cylinder balloon a little below the bubble by means of some plastic and it was anchored through this loop through the torque wrench. The remainder of the balloon material was tied up onto the loop so that a weigh-off could be obtained. The weigh-off was obtained with the gondola hanging from the loop so that the complete load was airborne and a very good value of 5 lbs free lift was obtained. The air displaced was 97.5 lbs, the gross load being 79 lbs, 2 oz. The launching was carried out by walking the balloon up, using several loops of plastic, until the load had been picked up and the assembly was released without delay. Unfortunately, the long appendix which hung down below the balloon and which was weighted a little bit with about a 5 or 6 oz weight, swung around when the balloon became airborne, then wrapped around the gondola preventing the antenna ball from dropping so that no radio signal was obtained and, of course, the fouling of the appendix would cause the balloon to burst at altitude.

The load was not recovered so no records at all were obtained of the flight performance of this experiment.

Flight 76

Flight 76 was also a repeat of Flight 74, using a Herb Shelly Mylar balloon # M-12, ½-mil Mylar A, 45 ft gore length with the one superpressure height duct appendix. The balloon was 117 ft in circumference and weighed 14 3/4 lbs and was completed 25 May 1953 by Herb Shelly, Inc., with supervision by Huch on the end assemblies. The gondola was exactly the same as that flown on Flight 74, contained control instrumentation for CAA, up and down cameras, two 3-lb ballast drops at 150 and 250 mb respectively, and was set up for 24 hours. The gross load on this flight was 81 lbs, with 94 lbs of displaced air, and the balloon was launched by the same technique carried out on Flight 75 but with a rather high wind of 25 to 30 miles per hour from the northwest. Ground temperature was 58° with clear skies and the launching was at the University of Minnesota airport behind the windscreen. On this flight the duct again twisted around the gondola, as it did on Flight 75, but this time the radio signal was received and a time-altitude curve for the balloon was obtained up to ceiling. The balloon burst upon reaching ceiling, the load free fell and no signal was obtained after this. The time-altitude curve shows an acceleration, the initial rate being 420 ft/min. It increased to 675 in the stratosphere and finally reached 700 just before reaching ceiling. The load was recovered late in 1953 by a hunter at Black

River Falls, Wisconsin. It had been considerably damaged by animals but the indications were that the parachute had not opened, which is characteristic of some of the flights in which a balloon failure is encountered above the low altitude safety release altitude. A small fragment of the balloon was found with the load but not sufficient to pull out the chute when it was severed from the load at 30,000 ft altitude.

Conclusions

No conclusions can be made about the superpressure performance of this balloon although the launching was all right. The main conclusion is that there is a fundamental difficulty with the long appendix trailing behind the balloon. It is probably not a good operational idea and even on experimental basis seems to be difficult to get off the ground successfully.

Flight 77

Flight 77 was launched 4 June 1953 in another attempt to fly a superpressure Mylar cylinder, and it was set up exactly like Flight 74. Mylar M-13 balloon constructed by Herb Shelly, Inc., on June 3 weighing 16 lbs, 10 oz, was used. It was a 45-ft gore length cylinder, 105 ft in circumference, made of Mylar A with the duct appendix extending 25 ft below the balloon base. The instrumentation was just like that used for Flight 74 and included transmitter on 1635 KC, antenna dropper, up and down cameras, safety controls and two 3-lb ballast drops to operate at 147 mb and 252 mb. It also contained the water ballast and air temperature pulse generator to transmit thermistor readings in the air near the gondola. The inflation medium was helium.

This flight was launched by the Huch technique similar to the other Mylar cylinder balloons, and got into the air allright with a 15 mile/hour southerly wind and overcast cloud conditions. The appendix did foul on the gondola but it is not certain whether it was sufficiently badly fouled to cause the balloon to burst. The balloon apparently rose for awhile and then stopped under the overcast at approximately 10,000 ft. It was sighted by the Civil Defense network floating over western Wisconsin but was found 3½ months after the time of launching in the woods, five miles south of Clam Falls, Wisconsin.

The down camera was obscured by the tangled duct but the up camera took pictures throughout the flight. It also showed a record of the Olland Cycle which allowed construction of a time-altitude curve. The balloon rose at 240 ft/min for about six minutes and leveled off at 3200 ft. It then floated between 3200 and 4100 ft for an hour and a half, after which it descended at about 200 ft/min almost to the ground, rose again at about 200 ft/min to 3200 ft, descended again, rose and finally descended to the ground after a total flight time of two and one-half hours.

Conclusions

Either up and down drafts or radiation was responsible for this unusual behavior. The balloon rose and descended several times before finally catching in the trees. This is the second case of this behavior with a Mylar cylinder balloon.

Flight 78

Flight 78 was launched 9 June 1953 at 1045 GMT. This flight was the first attempt with the complete step flight arrangement of two balloons, following the successful flight of the platform part of this technique flown on Flight 68. The purpose of the flight was to measure the altitude warming at equilibrium at various altitudes up to 54,000 ft and to measure the thermodynamic and aerodynamic drag on the tow balloon at a number of different altitudes. The technique consists of setting up a platform as carried out in Flight 68, using a 30-ft balloon with the altitude regulated by the gross load of the system. This is made large enough to change the full volume ceiling of this 30-ft balloon from 10,000 ft to 54,000 ft. A tensiometer measured the force on the tow balloon, when it was floating level, when it was moving, and when it was accelerating. The tow balloon was No. 73-2X100V-303 Winzen double wall, 72.8 ft in diameter, with a straight appendix on the bottom and no duct. The straight appendix was tied off as the balloon never reached its full ceiling on this flight. It was packed by Hanson, Smith and Hoberg April 29 and weighed 259 lbs. The platform balloon was a 30-ft diameter General Mills, Inc. cell constructed of 2-mil polyethylene numbered 301-C equipped with a duct appendix made of the large size red inflation tubing. It was equipped with a top grommet and a bottom harness also equipped with a grommet so that the load cable to the captive balloon could be fed down through the platform balloon. The bottom harness was an aluminum clamp arrangement described in detail in the instrumentation section of this report and sufficiently strong to hold the heavy load of 800 lbs. This balloon weighed 63 lbs net. The final ceiling with all ballast expended was 54,000 ft. The flight was set up for 8 hours. The gondola, which was carried by the captive balloon but was located down below the platform, contained a 3415 KC transmitter and a newly developed pulse multiplexed telemetering system. The ballast consisted of 484 lbs of Skelly "S" fluid which was released by dropping hoses to give the required time-altitude curve. This instrumentation is described in detail in the instrumentation section of this report. (Volume X, Section I.)

The tow balloon was packed by the Minnesota method and inflated to a gross lift of 383 lbs, allowing 33 lbs of free lift which would therefore be the initial tension reading, or approximately the tension reading on the level section at 10,000 ft. The 30-ft balloon was inflated to 650 lbs, then transferred to the load and weighed off carefully to a free lift of 20 lbs. The technique of inflating and handling these balloons is described in detail in the section on step flight techniques (Volume IX, Section VI-A). The total air displaced by the entire system was 1225 lbs and total free lift was 53 lbs, giving 4.3% as the percent free lift. Besides the gondola, which was carried by the captive balloon, ballast tank #11, hose dropper #12, tensiometer #11 and infrared bridge #12 were carried on the platform balloon.

The flight was made on a very calm clear morning because of the anticipated difficulties in launching the tandem balloon arrangement. In this case the launching was carried out by removing the corset from the captive balloon, pulling the diaphragm ripcord and then letting the captive balloon about 100 ft up in the air on a control line. In order to prevent the balloon from twisting around the mooring cable to the platform, a rudder was used with a second control line. With the captive balloon held up in the air over the platform, both balloons would then be released. The procedure was followed as well as possible, but it was not practical to control the balloon this way due to lack of coordination between the various people holding lines. However, the balloons were released without accident except that when the ballast tanks were sent into the air the squibs fired and the entire instrumentation was cut loose from the balloons and fell about 6 or 8 feet to the ground. It was ascertained that the low altitude release had been cocked probably by jarring in the truck on the way out and had not been inspected just prior to launch. Due to some slight decreases in pressure, this device fired the squibs and cut the load loose. The ballast cans were damaged somewhat but the other instrumentation was in good condition. The balloons were recovered at Colfax, Wisconsin.

In setting up this operation the entire process of checking out the gear, filling the cans with ballast, taking the apparatus out to the airport, etc., was rehearsed the day before the flight to establish the necessary time schedule to make certain that there would be no hitch in the launching because of the need for a very low wind which required that the launching be made promptly at sunrise. A number of serious difficulties were found and eliminated by this rehearsal.

Conclusions

The thinking about launching changed somewhat after this attempt, and it was decided next time to release both balloons from the ground together and put a shock cord on the cable between them to absorb the shock when the captive balloon was constrained by the platform. The complications of handling the captive balloon from the ground with long ropes were too great to be practical.

Flight 79

Flight 79 was launched 17 June 1953 at 1103 GMT. It was an exact repeat of Flight 78 and used the step flight techniques to measure altitude warming, aerodynamic and thermodynamic drag on a 73-ft double wall 1-mil polyethylene balloon in the daytime. Experiences with launching Flight 78 had shown that launching to be unsatisfactory, and in Flight 79 the two balloons were released simultaneously from the ground, the tow balloon being the packed 73-ft which was launched exactly as usual with the Minnesota method, the other one being the almost fully inflated 30-ft carrying the heavy weight ballast tanks. The tow balloon was weighed off with sand and walked out from the windscreen. The corset was then removed on the ground and the balloon cut loose from the sandbags simultaneously with the release of the platform balloon. The launching was very smooth, both balloons rose at approximately the same rate at first. The tow balloon then got ahead of the platform, inflated its top, and extended itself very nicely and the flight was airborne. The tow balloon was number 73-2X100V-306 with standard appendix on the bottom which was tied off. The tow balloon weighed 257 lbs. The platform balloon was a General Mills,Inc. type 301-C, 30 ft in diameter, made of 2-mil polyethylene and weighed 68 lbs. The instrumentation was precisely the same as flight 78 except that a down camera was added to the tow balloon to photograph the platform balloon in flight so that if the two balloons were not in a vertical line corrections in tension could be made for the angle of the cable connecting the tow to the platform. It was actually found that this correction was very small after the initial stages of the ascent. The total air displaced by the system was 1073 lbs, the free lift was 112 lbs, or 8.15%. The programming of the ballast drop was such as to bring the balloon level at 10,000 to 12,000 feet, at 22, 33, 44 and 55 thousand feet, approximately. This calculation was made neglecting changes in the tension of the tow balloon, which in actual practice cause small deviations from this program. The program is the same as that carried out in the first flight, in which just the platform balloon was flown without the tow balloon at all. The time-altitude curve for Flight 79 shows the initial rise and leveling at 670 mb or 11,000 ft. The balloon remained level for 32 minutes and then began to climb at a rate of 340 ft/min to the next level step. The ballast flow stopped at 455 mb on this step. The balloon continued to rise due to warming of the tow to 445 mb or 20,540 ft. Actually this step was not quite level but showed a continually upward trend of 50 ft/min and the second hose began to flow at 1238. The rate on this step was only 200 ft/min and accordingly the balloon did not reach the next step before the third hose began to flow at 0732. The rate was then 540 ft/min which is close to the desired rate of 500 ft/min and the third hose stopped its flow at 0752. The balloon continued to warm slowly, climbing and reaching an altitude of 145 mb or 45,500 ft. The load was released by timers at 1518 on schedule. The time-altitude curve is not that desired except for part of the first and second step. The rate was supposed to have been 500 ft/min between each level portion, the level portion extending for 30 minutes. Apparently the flow through the hose was low between the first and second steps and also between the second and third steps, and the fourth hose did not drop at all, or did not release ballast. It was thought that this anomolous behavior was caused by air which became trapped in the hoses and caused the fluid to fill the hose below the orifice, thereby changing the characteristics of flow and decreasing it. The down camera pictures showed just when the hoses dropped and on the third drop the camera window became noticeably fogged, presumably by some of the "Skelly" fluid which had gotten on the window when the third hose came down. It was plain that the fourth hose never did release and it was presumed that the plastic material froze and was so stiff that it remained curved up even when the release tab fell out of the hose dropper. The time-altitude curve was telemetered and also recorded in one of the down cameras, and the two are in rather good agreement. Inspection of the tension-time curve shows that although there are some correlations with the time-altitude curve there seemed to be some kind of difficulty, for example, sticking or jamming of the tensiometer mechanism or cable. One can see the initial increase in tension as the balloon reached its first step and then went on to about 67 lbs maximum. Then there was a rather small decrease when the balloon began to move up from the first to the second step and again an increase when the balloon leveled on the second step. From then on the tension is approximately constant despite the fact that the balloon was moving upwards at 500 ft/min at one point. It was obviously necessary to repeat this flight and no analysis of the tension data could really be made with any guarantee of reliability. The record was also obtained by the Green Bay, Wisconsin, station in the Balloon Project trailor and this record was essentially the same as that obtained at the University Airport in the Twin Cities. The infrared detector also gave data on this flight but the data so far has not been correlated and exhibited some rather eccentric behavior which leads one to mistrust it. The balloons were recovered at Hillboro, Wisconsin, and the gondola at Chilton, Wisconsin.

Conclusions

Flight 79 showed that a real step forward had been made in the launching procedure and that the launching was very simple when both balloons were launched simultaneously. The failure of the hose droppers was accounted for by the fact that the hoses were too small below the orifice and that air could be evacuated so that liquid filled the whole tube and this was corrected in later flights. The reason for the failure of the tensiometer was not known on this flight.

Flight 80

Flight 80 was launched July 3, 1953 at 1106 GMT, and was the first step flight to give good data on the drags and warming effects as a function of altitude. The flight was set up just like Flight 78 with the time-altitude curve programmed by the platform balloon with steps at 11, 22, 33, 44 and 55,000 ft. The balloons used were a Winzen double-wall No. 73-100V-304 with a duct appendix, bottom skirt tied off, and duct full length of the balloon. The duct is not needed for the step flights but this balloon was available and therefore was used. The platform balloon was a GMI type 301E, 30' diameter No. 44 equipped with duct appendix and the regular harness for step flights. It was made of 2-mil polyethylene. The theoretical ceiling was 54,000 ft, maximum altitude reached was 50,600 ft. The duration planned was five hours and the flight lasted for five hours. The instrumentation was just like Flight 78 except a down camera was included on the tow balloon like Flight 79. A cosmic ray counting telescope was included on this flight to replace sand that had been used as a counter balance. One change was made in this flight over 79, namely that instead of hanging 100 lbs of sand on the tow balloon the tow balloon was given 160 lbs of free lift so that when it picked up the gondola and the lower assembly the net tension would read 60 lbs. In Flight 79 the instrumentation gondola was carried by the tow balloon and the lead balloon was ballasted with 100 lbs of sand, and a free lift of 60 lbs was added. The idea in Flight 80 was that the tension in the cable would now be 160 to 200 lbs including the warming and this would make the tow balloon more stable and keep it in position better over the platform. As a result of this very large free lift, when the tow balloon was cut loose from its mooring at the launching time along with the release of the lead balloon it got into the air rapidly, spilled off its canopy and went up sidewise with the canopy and the tow cable holding the two ends of the inflated lower bubble. However, by the time it reached the 10,000 ft level the gas began to transfer to the top and finally the balloon erected in the proper manner above the platform. Apparently no gas had been lost as the tension reading was the proper value to agree with the ground weigh-off. The total displaced air on the flight was 1451 lbs, the total free lift 213 lbs or 14.7%. The increase in free lift, of course,is because the platform balloon originally has to pick up the instrumentation gondola at take-off. This gondola is supported by the tow balloon flight. About 100 lbs more free lift is needed to lift this instrumentation gondola on the lead balloon. The details of the time-altitude time-tension curve, tensions, etc. are discussed in other sections of this report. However, the time-altitude curve followed very closely the planned behavior, leveling off on the first step at 14,000 ft, at the second step at 25,000 ft, on the third step at 37,000 ft and (these values include the increase in altitude due to warming of the tow balloon) on the fourth step the balloon warmed a great deal and reached an altitude of 50,500 ft. The fourth hose did not drop and so there were only four level steps on this flight instead of the anticipated five. However, the apparatus worked very well and the time-altitude and time-tension curves correlate in a very interesting manner. The tension is observed to drop sharply as the balloon begins to ascend, then it decreases more slowly, and finally reaches an equilibrium value prior to the end of the step. At the end of the step when ballast stops flowing the tension begins to increase as the tow balloon warms and it increases above the value on the previous level step, showing the effect of altitude warming. As one ascends into the stratosphere the effects get much larger, the aerodynamic part of the drag decreases but the thermodynamic increases, and for this reason the warming becomes larger. The final value of the tension, which on the first step reached a value of 80 lbs, was 116 lbs or a gain of 36 lbs due to warming with altitude in the radiation field to which the balloon is exposed. Thus for the first time on this flight an effect which had been predicted a long time before was verified experimentally, that the balloon, at least under the conditions of radiation to which this flight was exposed, gained superheat with altitude and this superheat would then contribute to the upward velocity of the balloon if it were a free vehicle. The increase in velocity during ascent that is often observed is thus accounted for. In fact, if the balloon were weighed off neutral on the ground there could be enough free lift gained to take it all the way to ceiling because of this effect. The gondola was recovered 60 miles south of Green Bay, two miles west of Spool Hills, Wisconsin.

Conclusions

The important conclusions from this flight are summarized in the section dealing with step flight analysis, namely Section VI, Volume IX. It was demonstrated that there is a large altitude warming effect which adds to the free lift of a balloon under the conditions of radiation to which this flight was exposed, that the drag is largely thermodynamic as was expected, and that the aerodynamic part gets smaller as the atmosphere becomes more rarified. It was demonstrated that the step flight technique is admirably suited to obtaining the various kinds of drags and measuring the factors influencing a balloon in flight in a manner which is impossible by other methods. The step flight method measures the forces acting on a balloon while it is moored and while it is moving up or down. It also demonstrated that the launching could be accomplished without undue difficulty although on this flight the fact that the canopy slid off indicated that probably the top should be allowed to inflate on the ground most of the way before release; in fact this was carried out on most of the subsequent flights. The results of this step flight were so encouraging that it was decided to devote a large amount of the effort of the project to such flights.

Flight 81

Flight 81 was a temperature flight designed to measure temperatures of the balloon gas, outside air, infrared from the ground, and gondola interior temperatures. It was launched on the 7th of July, 1953, at 1910 GMT. The balloon was a Winzen 73' double wall equipped with a duct appendix and with the thermistor dropper installed inside the gondola. It was launched in the standard University of Minnesota fashion. In order to observe the temperature change in the gas during an adiabatic bounce, the gondola was equipped with ballast drops which would occur when the balloon had descended to 76 mb and to 151 mb. At the upper ballasting altitude 35 pounds of ballast would be dropped. At the lower ballasting altitude 10 lbs could be dropped. This was the first flight equipped with complete telemetering for temperature measurements. It was extremely fortunate that the temperatures were telemetered in this flight, since the load has never been recovered. In addition to telemetering the temperatures they were also recorded on a multichannel temperature recorder. The launching took place at the University of Minnesota airport in 30 mile/hour wind. The balloon was held down at both ends and behaved quite stably although the wind was so high that the grass was blowing down flat. The wind was so high that when the balloon was released it rose perhaps half the height of the windscreen and took off horizontally across the field. The rate of rise was so low compared to the horizontal velocity that it is likely that the balloon would have struck a tree or other object had there been such obstruction in the way. However, it flew off across the part of the field where the grade was favorable and the launching was successful. The initial rate of rise was approximately 500 ft/min, which increased to approximately 700 ft/min before the balloon reached ceiling with a square corner. It appears that the balloon reached a ceiling almost 4000 ft below theoretical ceiling in this flight. It seems impossible that this large an error could be due to error in the telemetered altitude. Unfortunately, the gondola has never been recovered to allow determination of the altitude from the down pictures. It is most likely that an error in the weight of the gondola occurred in this flight, which accounts for the marginal weigh-off of the balloon almost leading to disaster with a very low initial rate of rise. The balloon began descending at ground sunset at 70 ft/min and accelerated to 300 ft/min at balloon sunset. It reached the upper ballast altitude at 0247, at which point it dropped 35 lbs of ballast and rose rapidly after dropping this ballast, finally establishing after the bounce an equilibrium rate of 139 ft/min. The rate slowed down somewhat at a pressure altitude of 45 mb and by the time of blowdown at 0514 the balloon had not reached its theoretical ceiling again although it was still climbing. The 35 lbs of ballast represented 7.1% of the air displaced by the flight and therefore should have been more than adequate to compensate for the sunset effect expected to be approximately 6%. That it was indeed adequate is evidenced by the fact that the balloon continued to rise after the ballast had been dropped. The temperature measurements on this flight were quite successful and were described in Section V, Volume IX of this report. The balloon was recovered at Newport, Minnesota, but the load has never been recovered.

Conclusions

The principal scientific conclusions reached from this flight based on the temperature measurements are described in Section V, Volume IX. The temperature measurements on this flight showed conclusively that the superheat of gas in the balloon does not change at sunset but does change abruptly when ballast is dropped and the balloon rises, allowing the gas to cool adiabatically during the process. This flight also demonstrated that the University of Minnesota launching method allows launching in relatively high winds, in a gusty situation. The wind during this flight was approximately 30 mi/hr. This flight demonstrated the desirability of telemetering information on flights wherever possible. The seven balloon temperatures which were measured on this flight were telemetered on the multichannel telemetering system and the data would not have been obtained had it not been telemetered since the gondola was never recovered.

Flight 82

Flight 82 was a flight designed to test a Loran navigational system receiver which retransmits Loran information to the ground for decoding. It was flown 10 July 1953 on a General Mills, Inc. 301-C 90° cone-on-sphere balloon equipped with a duct appendix. The planned duration of the flight was 11½ hours, the actual duration was four hours because of a very leaky balloon. The fact that the balloon was leaky was suspected before takeoff.

After inflation the balloon lost about four lbs of free lift in 15 minutes. The balloon leveled below theoretical ceiling and then descended to ballast level, dropped ballast, rose to ceiling and descended until the blowdown warning came on indicating that the flight was blown down because of reaching the blowdown altitude. Very little telemetered altitude data is available since the altitude telemetering was multiplexed with the Loran signal, with the Loran signal being transmitted most of the time. The time-altitude curve was obtained from the Olland Cycle record on the camera. The Loran transmitter was a 100W transmitter, although it is not certain how much power was actually radiated from the antenna. The write-up of the Loran test will be found in Volume X, Section II, of this report. The recovery of the gondola was at Stanwood, Iowa. The recovery crew reported that because of the large amount of power generated by the transmitter when they opened the gondola, it was like reaching into an oven. Apparently the heat generated from the high powered transmitter may be adequate to keep the gondola warm at night.

Conclusions

This flight represented a successful Loran test. However, the balloon was quite leaky and did not stay in the air long enough to give as long a test as was desired. The results of the Loran test are described in Volume X, Section II.

Flight 83

Flight 83 had as its purpose to test the performance of a large polyethylene cylinder balloon. A launching attempt was made on 16 July 1953 with a General Mills cylinder made of 1-mil polyethylene and equipped with end rings to make the end fittings. These rings were made out of 3/8" aluminum tubing 27 inches inside diameter. It was equipped with a 54" flat width duct from the top of the balloon all the way to the base. The cylinder did not have tapes. The purpose of the flight was to test the stability performance of a large polyethylene cylinder, since we had previously found that small cylinders overshot their ceilings and required ballast to drive them back up to ceiling at a slow rate. The gondola was therefore equipped with 72 mb and 154 mb ballast drops, which were 15 lbs and 25 lbs of steel shot. The balloon was packed on the standard University of Minnesota packing method, which was, however, somewhat difficult to apply because of all the excess material present in the cylinder balloon. The balloon never got off the ground. The initial phases of the inflation proceeded all right, but after the bubble was partially filled, the large amount of excess material present in the cylinder fell down on one side making a very cumbersome and unwieldy bubble. Apparently when the material fell over to the side the diaphragm rip cord became entangled with the large mass of material in the cylinder which was all present at one side of the bubble. The corset was removed satisfactorily but when the time came to pull the diaphragm it appeared to be impossible to rip the diaphragm because of the way the diaphragm ripcord was entangled in the extra material. It is possible that if one took pains to keep the diaphragm ripcord free of the material cylinder balloons could be launched by this method.

Conclusions

A cylinder balloon is more difficult to launch by the University of Minnesota launching method than is a shaped balloon, but it is likely that this launching method could be used for large cylinders.

Flight 84

Flight 84 was another attempt to launch a cylinder balloon. The balloon used on this flight, which was attempted on 23 July 1953, was the same balloon used on Flight 83. It had been repacked and repaired after the attempt on Flight 83, in which the balloon was ripped along one gore. In this attempt, instead of planning to pull the diaphragm ripcord, as was done on Flight 83, it was planned to allow the tube deflator to deflate the inner tube in flight and thereby cause the gas transfer. The initial stages of inflation went as on Flight 83, with the extra material in the cylinder balloon again falling over to the side. When the corset was removed, this extra material hung down like a pony tail and the balloon took off all right with the extra material hanging over the side. The tube deflator operated in flight, but when the inner tube fell out the girdle slid up the balloon and caught the rings at the top which secured the duct thereby tearing off the duct and deflating the balloon at an altitude of approximately 10,000 ft. The length and duration of the flight was approximately 30 minutes and the balloon came down near St. Paul, Minnesota,complete with all of the gear.

Conclusions

It is impossible to allow the gas transfer to take place suddenly in the air by removing the tire, because the bubble of gas will push the girdle upwards toward the top of the balloon, thereby destroying it. This is somewhat similar to an experience encountered in one of our early launching attempts in which the girdle slipped off the top after the tire became loosened from the girdle due to faulty tire deflator. This was another unsuccessful attempt to launch a large cylinder balloon, this time unsuccessful not because of the excess fabric but because of the decision to attempt to try to let the top of the balloon erect after suddenly releasing the pressure from the tire inside the girdle.

Flight 85

Flight 85 was a test of a superpressure Mylar cylinder made by Herb Shelly. The cylinder was 32 ft long by 14 ft in diameter, weighing 1 lb 15 oz. It was equipped with a 10.262 megacycle transmitter and Olland Cycle and time blowdown set for five hours. The air displaced by the flight was 10.6 lbs, and it was launched with 9.4% free lift. The launching was on 24 July 1953. Because it was desired to obtain the behavior of this balloon for five hours in rather high winds,it was decided to launch it west of the Twin Cities and launching took place west of Murdock, Minnesota. The launching weather was unfavorable but the launch was attempted nevertheless, and because of rather high winds at launching some fluid was tipped from the valve and the antenna was snapped off. The balloon took off all right aside from this, but no telemetering signal was received and the equipment was not recovered. Since this flight did not carry a down camera, even recovery would not allow us to determine its behavior.

Conclusions

A small superpressure cylinder was launched but because of rough launching conditions the antenna was torn off and no data about balloon behavior was obtained.

Flight 86

Flight 86 had as its purpose a night time step flight to determine the drags and warming with altitude at night. It was launched on 30 July 1953 at 0302Z. The platform balloon in this case was a General Mills 301E 2-mil polyethylene filament tape balloon. It was equipped with a 27-inch flat width duct appendix to the base of the balloon, had aluminum bottom fittings and grommets at the top and bottom for the cable to pass through this balloon. The tow balloon was a double wall Winzen 73-ft with no duct appendix tied off at the bottom. Since this balloon is always held at a level below its full ceiling, it is not necessary for it to have the ability to valve. In addition to the standard complement of cameras this flight carried a camera hanging on the tow balloon which was to photograph the position of the platform balloon below it. The ballast instrumentation consisted of the tanks which carried 484 lbs of Skelly S and which were caused to ballast by the dropping of hoses at predetermined times during the flight. The flight was to have four steps each consisting of a 500 ft/min ascent followed by a 40-minute level section. The level altitudes were to be separated by approximately 10,000 ft. The air displaced by the tow balloon was 486 lbs, that by the lead balloon at takeoff, 914 lbs. The inflation and launching of the two balloons proceeded quite smoothly. The tow balloon was not allowed to inflate its top on the ground and apparently very early the tow balloon was damaged and leaked very badly. The scheduled duration of the flight was 15 hours, the actual duration was 35 minutes. The assemblage landed at Turtle Lake but was spotted, although it was night time, by the Beechcraft plane which very readily saw the flashing beacon. This flight had been equipped with a beacon flasher which consisted of four automobile headlights blinking about once every two seconds. The recovery crew drove along the road and spotted the blinker beacon off the highway. The platform balloon was hanging up in the air moored by the completely deflated tow balloon. The recovery crew drove into the spot where the balloons were down and pulled down the platform balloon, tying the steel cable to the bumper of a car. The tow balloon was driven out from the rather inaccessible place where it happened to come down and the stake truck brought to that position. It was possible to pull down the tow balloon and transfer the ballast tanks to the hydraulic hoist without any damage. When it was attempted to deflate the platform balloon it became evident that this balloon had been damaged by the steel cable which pulled down across its top during the process of snaking this balloon out of the woods. The tow balloon tore open and fell to the ground. The equipment was in good shape and was flown on Flight 87. It appears to be possible to launch the step flight successfully although in this case the tow balloon somehow or other was damaged. No data was obtained on this flight since the leaky tow balloon caused the assembly to come down in a very short time. Subsequent examination of the tow balloon in Williams Arena revealed a hole about 10 ft from the top of the balloon which was probably responsible for the failure. It is possible that this hole was produced when the knot was pulled securing the top of the balloon to the ground.

Flight 87

Flight 87 was another attempt to obtain a step flight at night. It was launched on 4 August 1953 at 0310Z and utilized a Winzen double wall 73 ft as the tow balloon and a General Mills 301E 90° cone-on-sphere as the platform balloon. The equipment that was flown on Flight 87 was the same gear that flew on Flight 86 with essentially no change. The tow balloon displaced 488 lbs of air and the platform balloon 914 lbs at takeoff. The scheduled duration of flight was 15 hours, the actual duration was 12 hours 16 minutes. Good data were obtained both by the Minneapolis station through telemetering and the Green Bay station through telemetering. The tensiometer and Olland Cycle were recorded on the cameras in flight which were recovered. The flight came down at Stetson, Maine, and Mantis, who was at Woods Hole, Massachusetts, went up to Bangor, Maine, to look at the equipment and to send back the instrumentation cameras. It appears on this flight that the flight was not terminated by timers or by low altitude blowdown. It was reported by the finder that when he saw the assemblage first it consisted of two balloons. He was frightened by these balloons and went back into the house, brought out his wife and returned to notify the military policy. Between the time he first saw them and the time he returned with his wife, the top balloon had disappeared. The balloon which was present with its equipment was the platform balloon and it had dragged the equipment across a field. The balloon was finally damaged so that it deflated. The most likely explanation for the observation was that the whole assembly came down together and that after striking the ground the tow balloon tore loose and ascended again to ceiling. There were reports later in this day that the balloon was seen at high altitude at Ellsworth, Maine, approximately 25 miles southeast of the Bangor, Maine, impact point.

The launching of Flight 87 proceeded quite smoothly and was carried out in almost exactly the same way as Flight 86. The only modification in the launching technique was that the tow balloon was allowed to almost completely inflate its top on the ground. The analysis of the data from this flight is discussed in Section VI-A of Volume IX. In this flight only three of the four hoses dropped. The fourth hose froze up and did not dump its ballast. The data, however, showed drags and warming with altitude at night as well as a complete curve of tension change throughout sunrise.

Conclusions

Scientific conclusions on this flight will be summarized in Volume IX, Section VI-A. The principal operational conclusions were that the launching proceeded smoothly. The equipment worked well with the exception of the fact that one hose did not drop. The gear was recovered after 12 hours of flight, in Maine.

Flight 88

Flight 88 was a superpressure test of a polyethylene cylinder balloon 14 ft long and 32 ft in circumference, made of 1-mil material. It was launched on 6 August 1953; the theoretical ceiling was 30,000 ft. The scheduled duration was five hours and it was to be operated at approximately 2 mb superpressure. It was equipped with a bubbler at the bottom which would produce and hold the superpressure on valving, and it was given 1 lb free lift at launch. This represents 7.7% of the air displaced. Unfortunately, no data are available on this flight since the 10 megacycle transmitter which was tuned to the antenna on the ground and which was transmitting on the ground became de-tuned after takeoff and no telemetering signal was received.

Conclusions

No data were obtained on this superpressure flight due to the fact that the 10 mgc transmitter became de-tuned after takeoff and transmitted no signals during the flight.

Flight 89

Flight 89 had as its purpose to test a Mylar superpressure balloon. The balloon used was No. M-18 manufactured by Herb Shelly, Inc., of ½-mil Mylar and weighed 3 lbs 9½ oz and had been leak-tested and patched. It was flown on 12 August 1953 with the takeoff at 1957Z. The scheduled duration of the flight was six hours. The actual duration was approximately four hours. The telemetering took place again on a frequency of 10.7 megacycles with the transmitter having been reworked to get away from the detuning trouble which occurred on Flight 88. The flight was equipped with a superpressure bubbler valve with the superpressure set at 2 mb. In order to launch the balloon it was inflated behind the windscreen with both ends of the balloon held down to make it occupy as small a space as possible. Inflation and layout proceeded smoothly in spite of a brisk wind which forced the balloon to take off nearly horizontally. The transmitter worked properly on this flight. The balloon rose at a rather low rate of rise, approximately 400 ft/min, reached ceiling, never leveled and began descending at approximately 200 ft/min. The rate of descent increased somewhat as the balloon reached lower altitudes and the equipment was recovered with the balloon attached at Cateract, Wisconsin. In spite of the fact that the balloon must have had some leakage in order to produce this time-altitude curve, it was not extremely leaky, since the farmer observed that at 9:15 the following morning the balloon was still in the air, moored to the ground by the antenna wire. There was erratic telemetering at times on this flight, presumably caused by the Olland Cycle rotor.

Conclusions

Data were obtained on a flight with a Mylar balloon designed to be superpressured. Apparently when the balloon reached ceiling the superpressure produced a leak and the balloon descended quite rapidly. This flight also had an aluminum Olland Cycle rotor which misbehaved from time to time and was responsible for the fact that a complete time-altitude curve was not obtained.

Flight 90

Flight 90 was a single step flight designed to measure at a constant altitude the changes in tension suffered by a moored balloon. The tow balloon was a double wall Winzen 73 ft, the platform balloon was a General Mills 301F. The scheduled duration of the flight was 20 hours, the actual duration was 14 hours 23 minutes. Blowdown took place by means of the low altitude release. This flight was equipped with the standard multi-channel telemetering gear now used on step flights. It did not carry the aluminum cans with Skelly S since it was designed to go up and level at one altitude and stay at or above this altitude. In order to make up the weight on the platform balloon, dead weights were hung on the arm which would normally carry the ballast cans. The launching proceeded smoothly. It was witnessed by a number of the Moby Dick Air Force people brought out to the flight by Major Vaughn. In the course of the launching the tow balloon was again allowed to inflate its top on the ground and apparently because the diaphragm was not completely ripped out this process took longer than usual but did not cause any undue amount of trouble, and both of them took off. The flight was designed to measure the change in tension throughout the day. Unfortunately, just before the balloon reached ceiling the tensiometer froze up and did not give any indications after the balloon reached ceiling. Some information about the magnitude of the sunrise effect can be obtained by the change in altitude produced at sunrise. This data is in agreement with more precisely determined sunrise effects obtained with single step flights subsequent to Flight 90. Because, however, of the failure of the tensiometer due to freeze-up, the basic purpose of this flight was not accomplished. The equipment was recovered at Whitehall, Michigan, after it had floated in Lake Michigan for approximately a day.

Conclusions

This flight was designed to measure the change in tension of a balloon floating at level altitude throughout the day. Because of the fact that the tensiometer froze up just as the assembly reached ceiling this result was not accomplished. Some data on the change in tension during the part of the day in which warming takes place were obtained from this flight by noting the change in altitude of the assembly. This data will be discussed in the Section on step flights.

<u>Flight 91</u>

Flight 91 was a daytime step flight launched on 5 September 1953 at 1217 GMT. Tow balloon was a Winzen 73-ft double-wall, packed in the standard University of Minnesota manner with thermistor droppers installed. The platform balloon was a General Mills Type 301F with the usual platform balloon fittings. The purpose of the flight was to measure aerodynamic and thermodynamic drags at a higher rate, namely 750 ft/min, on a step flight which had two full steps after the first weigh-out step at 10,000 ft. The multi-channel telemetering was used as usual in the step flight, and the change in altitude was produced by dropping ballast with the hose dropper arrangement and the aluminum cans filled with Skelly S. The duration planned was 16 hours, actual duration was unknown, since the telemetering signal was lost after 8 hours 15 minutes. In addition to the telemetered tensiometer and Olland Cycle data, a thermistor pulse generator and a low-powered transmitter hung from the tow balloon and transmitted to the platform balloon the measured temperatures in the tow. These temperatures were then relayed to the ground station by putting them on one channel of the multi-channel telemetering system. The tow balloon displaced 649 lbs of air, the platform 1058 lbs of air, at takeoff. A number of pictures of Flight 91 (the launching) are included in the section on analysis of step flights. (Section VI, Volume IX) The launching proceeded very smoothly. The technique used on Flight 91 has now become standard technique on step flights. Both balloons are given some free lift before takeoff and are released simultaneously. When in the air the tow balloon, which has been given more free lift than the platform balloon, climbs above the platform and inflates its top on the first level step at 10,000 ft if not before. In Flight 91 the tow balloon was not allowed to inflate its top on the ground but did this in the air. Because of the tension in the line leading to the platform balloon, as soon as the top began to inflate the material tipped over and hung down like a pony tail. Both balloons ascended to the first level step with the top balloon not erect. However, as soon as the balloon leveled on the first step the tow balloon assumed this upper position and properly inflated its top. The remainder of the flight proceeded normally.

There were two level steps as planned. After the first weigh-off step at 660 mb, the balloon rose at 700 ft/min and leveled at 300 mb for a period of approximately an hour. It then began rising again according to the schedule at slightly less than 700 ft/min and finally leveled off at an altitude of approximately 120 mb. The telemetered temperatures were relayed through the telemetering channel on the platform balloon during the first level section at 660 mb and during the ascent between 660 and 300 mb. Tensiometer data were obtained throughout the flight up to the time at which the balloon leveled at its last step at 1645Z. The magnitude of the total drag is readily obtained on the first step. On the second step because of the large amount of thermodynamic drag the time which the balloon spent climbing at 700 ft/min was not adequate to develop the equilibrium of drag. After reaching the top level step the tensiometer stopped giving signals, presumably because of the freeze-up. It should be pointed out that in the early design of step flights, such as Flight 91, the tensiometer was exposed to the environment and could get quite cold.

Conclusions

Flight 91 was a successful two-step step flight, giving drag data at the rate of approximately 700 ft/min. The flight behaved properly and gave data for the majority of the required time. Several factors became evident because of the telemetering in this flight. One was that the telemetering of tensions and pressures should be on a multiple basis to avoid failures of the kind that occurred late in this flight when the tensiometer failed to give data. The other factor which became apparent was that one should take pains to select a frequency for individual flights which will guarantee that data is receivable at one or both of the telemetering stations throughout the total length of flight. This can be done, and in order to be consistent with receiving the information it is necessary that one fly step flights only on those days when the radio propagation is favorable and when the ionosphere is giving good reflections. This can be determined in advance by utilizing the Bureau of Standards prediction charts and by getting the current situation on WWV transmissions.

Flight 92

Flight 92 was a single-step flight launched 16 September 1953 at 0931 GMT. It was to be a single-step 24-hour step flight to investigate the changes in tension in a moored balloon throughout the 24 hours. The Winzen balloon was a double wall 73-ft, and the platform balloon was a General Mills type 301E. The scheduled duration of this flight was 24 hours. The actual duration was at least 21 hours and 35 minutes, the time of radio contact. Flight 92 was the first flight in which we applied the philosophy of double telemetering all important pieces of information. It proved to be a good move. Both Oll and Cycle records came through well, but one tensiometer failed early in the flight. The other tensiometer, however, telemetered for the entire time. The extra care taken in connection with radio propagation was also worthwhile in this flight, as we maintained radio contact for almost the entire 24 hours. Since this was a single-step flight it did not require any hose drops and in order to be sure that the platform balloon stayed full througnout the flight the instrumentation contained a follow-up ballast control of the type used by Howell on Moby Dick. This follow-up ballast control could drop steel shot at any time the level of the system dropped. The air displaced by the tow balloon was 634 lbs, by the platform, 514 lbs. The analysis of the data from this flight is contained in Volume IX, Section II-A.

Conclusions

The principle of double telemetering all important information on step flights paid off in Flight 92 and will be followed generally in the future. Flight 92 is a successful single-step flight in which essentially all of the pertinent data throughout the flight were received by one or the other telemetering stations on one or more telemetering channels. This flight allows one to determine the way in which the sunrise and sunset effects come in during flight and gives values for the rate of change of tension with respect to time.

Flight 93

Flight 93 was a superpressure Mylar balloon test. It was launched on 24 September 1953 at 1754 GMT. It was a University of Minnesota glue seal ½-mil Mylar cylinder balloon with a gore length of 13 ft and a circumference of 34.2 ft. The intended duration of this flight was approximately four hours. The actual duration was 4 3/4 hours. The air displaced by this flight was 12.4 lbs and it carried a free lift of one lb. It was equipped with a superpressure bubbler which was set at four mb. Radio contact was maintained with it on 10.71 megacycles for three hours 43 minutes. The flight landed five miles west of Wassau, Wisconsin, and both the balloon and gondola were recovered.

The flight rose at a rather slow rate of rise, 440 ft/min, and leveled at ceiling at 1853 GMT. It showed the characteristics that one would predict for a superpressure balloon, namely actual stability around the floating level. The balloon rose at 1900 GMT approximately 5 mb above the initial floating level of 400 mb. At 1920 it descended about 7 mb below this level, rising back to it again at 1930 and slowly climbing 5 mb between 1930 and 2025. At 2035 apparently the balloon lost its superpressure and no longer showed its stable behavior, giving a descent at a rate of about 200 ft/min, which apparently was maintained all the way to the ground. We believe that it is extremely significant that a balloon floating in the troposphere below 30,000 ft demonstrated this extremely stable behavior during the time in which it maintained superpressure. Leakage tests made on this balloon in the laboratory prior to flight had shown us that it would be able to hold superpressure for approximately two hours, which was exactly what was observed during flight. This was the first glue seal balloon made at the University and we therefore took pains to study the condition of the balloon after it was returned. All nine of the gores were examined and after being flown, packed in a box, and returned, we were able to find only two tears in the entire balloon. All nine of the glue seals were still intact and all seemed to show good strength characteristics. The center section of this balloon was cut out and 23 samples were taken to test for leakage. Since it was known that the balloon had some leakage before flight, and it showed it during flight, we were concerned in determining whether this leakage occurred in the seals or the material. Of the 23 samples, 13 were samples which contained seals and 10 were samples of the material with no seal. Of these 23, 20 samples showed only diffusion leakage, three showed leakage in excess of diffusion. Two of these were in the material and one was in a piece of the material with a seal. Since even those samples with seals on them contained mostly material in terms of area, it seems likely that the glue seals were tight and that all the leakage observed here was due to material leakage.

Conclusions

Flight 93 demonstrated that superpressure balloons can be made to perform stably even in an unstable atmosphere below the tropopause, ascending above and descending below but always returning to equilibrium altitude. This balloon for Flight 93 was a glue seal experimental balloon made at the University, and after recovery of the balloon the seals were all intact and testing for leakage determined that the glue seals were very tight but that the material of the balloon, which was Mylar almost two years old, showed appreciable leakage which accounted for the loss of superpressure after a period of two hours.

<u>Flight 94</u>

Flight 94 was designed to be a four-step night flight. We had observed in night Flight 87, which was a four-step night flight, that the drags were appreciably less, at the same rate, than they were in the daytime, and the purpose of Flight 94 was to check this data. Although it was designed to be a four-step flight, the balloon actually went only three steps after the initial leveling off at 700 mb. In addition to the fact that only three of the four hoses dropped, one of the hoses that did drop must have been partially clogged with frozen material because the rate of rise on the step between 470 and 310 mb was appreciably less than the calculated value for this ballast drop. The highest altitude reached by this flight was 180 mb, and after floating at 180 mb for approximately one hour the balloon began descending as if both the tow balloon and lead balloon had some leakage. A tension record was obtained throughout the flight, as well as a time-altitude curve, and temperatures were telemetered from the tow balloon to the lead balloon and thence to the ground station. This flight is discussed in some detail in the analyses of the temperature flights, Volume IX, Section V. It is also considered in Volume IX, Section VI. Because of the freeze-up of one of the hoses on this flight, we decided that it was imperative that step flights be discontinued until a ballast system had been designed utilizing steel shot, thereby eliminating the possibility of frozen ballast.

Conclusions

This flight gave three steps at approximately the design rate. Two of the steps were at the proper rate, one step was at a rather slow rate. It gave data on warming with altitude at night as well as drags of the balloon at night. It gave temperatures measured at several places in the top balloon as it went through the steps. Both the tow balloon and the platform balloon seemed to show some leakage, but in spite of this it can be considered as a successful multi-step night step flight.

Flight 95

Flight 95 was a launching attempt carried out on 2 October 1953 with a large polyethylene cylinder balloon. The balloon was a General Mills tapeless cylinder 120-ft gore length balloon with approximately the same volume as a ¼-million cu ft 733. The launching method that was tried was to attach the girdle approximately 1/3 of the way down from the top of the balloon and tie to the girdle a rope which could be passed through a ground pulley and to a vehicle, thereby allowing the balloon to be let out on this rope into the air. The inflation took place through a hose inserted in the balloon just above the girdle and the weigh-off could be carried out in the tie line that went up to the girdle. The balloon inflation was carried to completion with weigh-offs being made on the tie-down between the girdle and the tie-down stakes. After the balloon had been erect for a short period of time it was noticed that the bubble was becoming smaller and the weigh-off showed a decreasing tension. Consequently, the launching was cancelled and the balloon was brought back to Williams Arena for examination and repair. It was found that while being whipped about in the wind during the launching attempt on Flight 95 a hole had developed where the duct attached to the cylinder. This hole was repaired and the same balloon was used on Flight 96.

Conclusions

Because of the large amount of material in a cylinder balloon, the launching method which was attempted on Flight 95 caused the balloon to be subjected to somewhat more damage than would have been experienced by a shaped balloon. This wind damage caused a failure in the balloon which made it necessary to cancel the launching and take the balloon back for repair. This flight, like other attempts to launch <u>large</u> polyethylene cylinders, has pointed up the difficulty of launching large cylinder balloons because of the very great amount of extra material in them.

Flight 96

Flight 96 was another attempt to launch the 125-ft polyethylene cylinder balloon which was damaged in Flight 95. The flight was equipped with a pressure-controlled ballast drop consisting of 21 lbs, 20 lbs, and 19 lbs, which could be dropped when the balloon reached altitudes corresponding to 65, 102, and 140 mb. The idea of this was to determine whether the large cylinder balloons are as unstable as the smaller cylinders have appeared to be. The launching attempt was carried out on 8 October 1953 and was accomplished in the same way that Flight 95 was attempted. The girdle was attached to the balloon one-third of the way down from the top and tied down by a long rope to the carryall which was able to control the position of the bubble. The inflation proceeded smoothly; the carryall could let the rope out until the entire balloon was in the air lifting the load. There was a moderate wind of perhaps 10 knots, and we experimented for about 10 minutes, letting the balloon up and pulling it back down again, to show that it was possible to handle the balloon in this manner. The balloon was launched at 1752 GMT and began ascending at a rather high rate. The average rate of rise between the ground and 30,000 ft was 1,000 ft/min. Between 30,000 ft and 52,000 ft the rate of rise was 1200 ft/min, and the rate of rise was approximately 1500 ft/min between 100 and 60 mb. When the balloon reached 54 mb it burst and the load broke loose, free falling into the St. Croix river. The cameras were recovered and examination of the up camera pictures showed that in the several minutes preceeding balloon burst the diameter of the bubble had increased very rapidly and the girdle apparently was not slipping down. It is quite possible that the girdle became fouled in the large amount of material in the cylinder and could not slip off. The high rate of rise may have made it impossible for the balloon to valve. It is undoubtedly true that the high rate of rise aggravated the situation and caused the balloon failure.

Conclusions

The large polyethylene cylinder balloon was successfully launched by the method of holding it with the girdle and controlling it with a rope attached to a truck passed through a tie-down pulley. However, on reaching an altitude of 59,000 ft the balloon burst, and this burst appears to have been caused by the girdle not properly moving over the large amount of material in the cylinder balloon. It was certainly aggravated by the exceedingly high rate of rise, in the vicinity of 1500 ft/min at this altitude.

Flight 97

Flight 97 was an attempt to launch a large ¼-mil heat seal Mylar cylinder No. M-19 manufactured by Herb Shelly, Inc. The launching was carried out on 19 October 1953. Although this balloon has the same volume as a ¼-million cu ft shaped balloon, its weight, complete with fittings, was only 93 lbs. In order to insure the best possible chance of success with this heat seal balloon, the balloon was manufactured with test tubes on each seal, that is each of the heat seals had been statically tested to a tensile strength corresponding to one lb/inch. The balloon was packed in Williams Arena by the standard technique and no difficulties were encountered. The initial stage of inflation proceeded smoothly and both ends of the balloon were held down in the conventional University of Minnesota manner until approximately one-half of the gross lift had been accomplished.

The top was then allowed to erect, which it did, apparently without too much shock. However, the shock was sufficient to cause failure of one of the heat seals, and the inner bubble was seen to be collapsing. Because it was obvious that once the corset was pulled the gas would simply escape from under the canopy, it was decided to attempt to salvage the balloon by holding the balloon on the ground. When this was done the part of the balloon previously secured by the corset rose very rapidly in the air and tumbled back down again with many broken heat seals. We examined the heat seals very carefully for shock strength and found that all of these seals were very much inferior to the material. Only a slight shock was required in order to cause any heat seal in the balloon to fail. It was apparent in this test that the shock resistance of these heat seals is so poor that it is virtually impossible to imagine a $\frac{1}{4}$-mil large volume heat sealed cylinder made of Mylar with the present seal.

Conclusions

This test showed that the shock resistance of the Mylar seals is not adequate to sustain even very moderate launching shocks. We feel that this demonstrated that a large volume $\frac{1}{4}$-mil cylindrical Mylar cylinder is at the present moment not feasible if constructed with heat seals even of the best present available quality.

Flight 98.

Flight 98 took place 29 October 1953 at 1729 GMT. This flight was another attempt to launch a polyethylene cylinder 125 ft long and 1-mil thick, manufactured by General Mills. The balloon was equipped with a duct appendix fastened at the top by a clamp ring 30 in in diameter. The balloon was set up to be a zero pressure natural shape with the duct extending all the way to the bottom. The bottom fitting was double ring type with a polyethylene tie-off. The bubble was secured by clamping the tire and girdle into the balloon. The balloon as ordered from the manufacturer was laid across the girdle placed with its plane in a horizontal position. The tire was then pushed down from the top and inflated into the girdle so that the balloon pressed into the girdle, across the tire, and out again. The tire and girdle were connected by 100-lb nylon string to a small parachute. During launching, tie-down was effected by putting a rope of 3,000-lb nylon around the girdle which rode in a vertical plane as the bubble erected. The gas was fed in through a vacuum cleaner hose clamped to the duct just above the girdle attachment point. The vacuum cleaner hose was secured to the girdle to prevent tearing the duct. The duct was not fastened to the balloon above the girdle. It was attempted to launch this balloon in the same manner as Flight 96, in which a 500-ft length of 3,000-lb nylon was fastened to the girdle, fed through a pulley to the carryall. The balloon could be let up slowly into the wind until the load had cleared the ground. The line would then be cut and the balloon would be far enough from the ground so that the load would not touch. The inflation and weigh-off were accomplished without any difficulty. The balloon was let up a way into the wind to see if the prescribed method could be followed. It was noted that the wind was so strong that the balloon whipped about severely and it was necessary to pull it back to the ground. Shortly thereafter, the balloon began to lose lift and finally was collapsed onto the ground cloth. A large tear was found in the top directly attritutable to the high local stresses in one part of the cylinder about eight inches from the clamp ring. The pleats in the duct at the top had been pulled out and several small holes had been made by the tapes. The main hole was one foot square. All the holes were repaired and the balloon was reinflated. This time it was not let up in the air but was launched by cutting the tie rope so that it took to the air much like a conventional platform launching. The crew of about five people held the gondola and fed it into the air as the balloon passed over at fairly high speed. The balloon had a very low rise rate of approximately 20 ft/min, and leveled at about 10,000 ft for approximately 30 minutes, after which it began descending. The load was released by the low altitude safety device and came down by parachute.

Conclusions

Again the vulnerability of the cylinder balloon to wind was demonstrated in this launching, where the extra material in the cylinder caused it to whip around to the extent it was damaged and had to be deflated, repaired, and reinflated. Apparently this repair at the launching site was not adequate because the balloon showed some leakage, staying in the air only 2½ hours. A contributing factor to the fact that the balloon did not reach ceiling was the rather marginal free lift, which caused the initial rise rate of this balloon to be less than 50 ft/min. This weigh-off error was probably caused by the Bernoulli force produced by the wind coming over the windscreen.

Flight 99

Flight 99 was launched November 13, 1953 from the new University Airport. It was the first test cell made by Herb Shelly, Inc., on his contract to produce low leakage balloons. It had been tested in the laboratory and was found to have a leakage close to diffusion leakage. The launching took place on a rather gusty day and in the first attempt to launch the balloon kerosene from the bubbler can was spilled and the balloon had to be brought back to the hangar. The bubbler can was filled and the launching took place, although the balloon got quite a beating in the wind before it got off. The calculated superpressure volume of this balloon was 270 cubic feet. Its theoretical ceiling, with the gross load of 9.8 lbs, should have been 28,500 ft. The purpose of the flight was to check the stability of a Mylar superpressure balloon, and the superpressure was set for 4 mb. The balloon ascended with a constant rate of rise of 400 ft/min to an altitude of 540 mb, at which point it began descending at 1000 ft/min. This was well below its superpressure ceiling of 495 mb.

The conclusion which must be drawn is that the balloon ruptured due to damage produced by the rough launching. The balloon and gondola were recovered five miles south of Lindstrom, Minnesota.

Conclusions

No conclusions of superpressure stability were obtained in this flight due to the fact that the balloon burst before reaching ceiling.

Flight 100

Flight 100 was another superpressure test of the Mylar test cell. The balloon was a ½-mil Mylar test cell made by Herb Shelly. The balloon weighed two pounds 10 ounces. The total load weight was five pounds 2 ounces, and the free lift was one pound. Telemetering took place on 10 mgc. The superpressure bubbler was set at 4 mb. The launching took place from the new University Airport with the balloon being inflated inside the hangar. Although the free lift was 10% of the air displaced on this flight, the rate of rise from the ground to 30,000 ft was 390 ft/min. The balloon took superpressure well and leveled off at 1920 GMT. It floated absolutely level within an mb or two, at least until 2020 when the telemetering signal was lost. This balloon had been previously tested for leakage in the laboratory and was found to have a leakage corresponding to diffusion leakage. It should therefore be very tight at the low temperature at ceiling. It was indeed quite free of leaks, since the load was recovered in the vicinity of St. Louis, Missouri. This is the down point predicted from the high altitude winds for this day, assuming that the balloon stayed at superpressure ceiling until brought down by sunset. The 4 millibar value of the superpressure set on this flight is not adequate to superpressure out sunset effects, but is only adequate to take care of minor fluctuations in lift which occur throughout the day.

Conclusions

This is another successful example of a Mylar superpressure cylinder which shows high stability. The balloon apparently floated very near the stable superpressure ceiling from the launching time of 1750 GMT until sunset brought it down in the vicinity of St. Louis. It is believed that the ½-mil Mylar cylinders can be made good enough to provide a very level superpressure vehicle for use at least for periods as long as 8 hours where sunset need not be superpressured out.

FLIGHT NUMBERS	56	57	58	59	60	61	62	63	64
FLIGHT DATA									
Date Flown	23 January 1953	25 January 1953	[illegible]	[illegible] February 1953	[illegible] February 1953	17 February 1953	[illegible] February 1953	[illegible] February 1953	26 February 1953
Time	1630 GMT	1527:30 GMT	1645 GMT	—	1937 GMT	1951 GMT	1810 GMT	[illegible] GMT	Balloon failure at launch
Balloon Type	[illegible]	Balloon No. [illegible] Wt. [illegible] Unit [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Reilly [illegible] Mylar [illegible] [illegible] diameter [illegible]	[illegible]	Winzen [illegible] [illegible] [illegible] Polyethylene
Date Packed and Persons	[illegible] Manson, Smith, Edwards, [illegible] Valve installed at Pierre, South Dakota by Smith, [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] February 1953 [illegible]	[illegible]	Edwards, [illegible], Moberg, [illegible] 1/21/53 Manson, Smith 2/15/53
Balloon Weight	[illegible]	[illegible]	[illegible]	[illegible] (Balloon only [illegible])	[illegible]	[illegible]	[illegible]	[illegible]	17.0
Altitude Theoretical Maximum	[illegible]	[illegible]	[illegible]	[illegible]	58,000	[illegible]	[illegible]	[illegible]	[illegible]
Purpose	Flight Constants Thermograph [illegible] Sudden lift changes	Temperature measurement [illegible]	Flight Constants [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] through sunset	Flight constants by radio distribution ballast
Duration Planned	21 Hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24 Hours
Actual Duration	[illegible]	[illegible]	2 Hours 51 Minutes	[illegible]	[illegible]	[illegible] 9 [illegible] 39 [illegible]	11 Hours 10 Minutes	[illegible]	10 minutes
How Released	Command [illegible]	Timer	[illegible]	—	[illegible]	[illegible]	Low Altitude Release	[illegible] Release	Balloon failure
GONDOLA DATA									
Gondola No.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Radio Gear	Xmtr [illegible] B.C. Xmtr [illegible] 6635 B.C. Antenna Drpr [illegible] Receiver [illegible]	Xmtr [illegible] Antenna Drpr [illegible]	[illegible]	Xmtr [illegible] 1610 B.C. [illegible]	[illegible] Olland Cycle #41	[illegible]	Xmtr [illegible] Antenna Dropper [illegible] Olland Cycle [illegible]	[illegible]	Xmtr [illegible] B.C. Antenna Dropper [illegible] Olland Cycle [illegible] 2 R.P.M. Receiver [illegible] Xmtr [illegible] 1766 B.C. Antenna Dropper #39 [illegible]
Plum Down	Plumdown #52 Camera [illegible] Plumdown face	Plumdown [illegible] Camera [illegible]	Plumdown [illegible] Camera [illegible]	[illegible]	[illegible] Camera #33 Plumdown face	Plumdown [illegible] [illegible] Camera #32	Plumdown [illegible] [illegible] Camera #13	[illegible] Holds [illegible] Fires 5.0V Camera [illegible]	Plumdown [illegible] Cocks [illegible] Holds [illegible] Fires 20,200 Fire [illegible] Camera #39
Cameras	Up [illegible] 1 R.P.M. Down [illegible] 1.5 R.P.M.	[illegible] [redacted]	[illegible]	[illegible]	[illegible] 1 R.P.M. [illegible]	[illegible]	[illegible]	[illegible] - bimodown face [illegible]	Up [illegible] 50 Hours Down [illegible] 24 Hours-bimodown face
Ballast	Sequence Ballast Drpr [illegible] 1. Two Balloon 4. [illegible] 2. [illegible] 5. [illegible] 3. 320 6. [illegible]	[redacted] —	[illegible]	—	—	[illegible]	Ballast Dropper [illegible] [illegible] [illegible] -40 shot [illegible] -20 shot	Ballast Dropper #64 [illegible] Operated [illegible] at	Ballast Dropper #37P Sequence; command operated 1. Two 4. 320 2. 260 5. 340 3. 290 6. 440
Flight Control	None	[redacted] —	—	—	—	—	None	None	None
Light	Palmer Beacon [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] #43	Palmer Beacon #43
Cosmic Ray	None	—	—	[illegible]	—	—	None		
Temperature Recording / Miscellaneous	Balloon valve #23 Batteries no. 51, T-33 Olland Cycle [illegible] 2 R.P.M. Distribution Box [illegible] Signal Coder [illegible] Control Box [illegible]	Battery #52 [illegible]	[illegible]	[illegible]	Batteries T-46, T-45 750 maximum load - miniature parachute	[illegible]	Batteries [illegible]	[illegible] [illegible] Recorder [illegible] [illegible] Battery [illegible] [illegible] [illegible] Air Thermistors	Batteries #53, T-40 Distribution Box #54
LAUNCHING									
Inflation Medium	Helium	Helium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Helium
Displaced Air	Main [illegible] Tow [illegible] Total [illegible]	[illegible]	Main [illegible] Tow [illegible] Total [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Main 664 Tow 82.3 Total
Gross Lift	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	572 101
Gross Load	[illegible] 71 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	572 71
Free Lift	[illegible] 135 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 30
Percentage Free Lift of Gross Load / Lift / Air Displaced	[illegible] (165) [illegible] 10.[illegible] (65) [illegible] -9.45 (55.5) [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].25 [illegible] [illegible].5	45 — —
Rate of Rise 1000 to 500 mb / 500 to 100 mb / 100 mb to ceiling	1600 to 500 [illegible] Ft/min [illegible] 779 Ft/min	[illegible]	[illegible]	—	[illegible]	[illegible]	After all ballast drops [illegible] [illegible]	1000 - 500 mb 589 ft/min 500 - 100 mb 700 ft/min 100 - ceiling 548 ft/min	None
Weather Clouds / Ground Wind / Other	Overcast Rest [illegible] Temperature [illegible]	[illegible] Cover Calm [illegible]	[illegible]	[illegible]	Some Cirrus [illegible]	[illegible]	High thin haze [illegible]	[illegible] haze (cleared later) [illegible]	Low overcast 8 Mh 280°
Launching Site	Pierre, South Dakota	Pierre, South Dakota	[illegible]	[illegible]	[illegible]	University of Minnesota Airport	Pierre, South Dakota	Pierre, South Dakota	Pierre, South Dakota

FLIGHT NUMBER	62	63	64	65	66	67	68	69	70
FLIGHT DATA									
Date Flown	21 February 1953	23 February 1953	26 February 1953	25 February 1953	12 March 1953	6 April 1953	11 April 1953	20 April 1953	27 April 1953
Time	1040 CST	0841 CST	Balloon failure at launch	1442 CST	1054 CST	1555 CST	1538 CST	1048 CST	[illegible]
Balloon Type	[illegible] & Mylar [illegible] of [illegible] 10' above balloon bottom	Simson 073-2 & 100-9-254 73' Cone-on-sphere Polyethylene	Simson 073-2 & 100-9-255 73' Cone-on-sphere Polyethylene	Simson 073-2 & 100-9-253 1-mil Two GMI 1010 077 Cone-on-sphere Polyethylene	GMI 077-1161-4 Nylon reinforcing at top of duct. Winzing 1-mil Duct added 1/28/53 15' dia. duct to bottom Spun Girdle-14 PSI [illegible] Pressure, 7 wires under girdle 11 & 8 Antenna	Simson 073-2 & 100-9-255 73' Cone-on-sphere Duct cut at girdle	GMI #52 Rayon Filament Tape 30' Duct 55' Duct appendix Aluminum Ring in Top Aluminum Thimble in Bottom	Mylar B-Ti .00035" 45' x 90' Circumference Cylinder 20#. Pressure at Base (See Misc. below) Water Tank Heater	Mylar - Mark Shelly B-9 45' Cylinder 117' circumference Natural shape super-pressure cylinder
Date Passed and Passers	21 February 1953 Nash, Shelly	Smith, Lehti, Neberg, Johnson 1/21/53 Hanson, Smith, Gergen, Edwards 2/21/53	Edwards, Johnson, Neberg, Lehti 1/21/53 Hanson, Smith 2/15/53	12/26/52 Hanson, Edwards, Smith, Gohman	3/3/53 Nash, Hanson, Edwards, Lehti, Neberg	Gohman, Neberg, Lehti, 1/21/53 Hanson, Edwards, Smith 3/27/53 (Repassed after flight [illegible])	4/10/53	4/13/53 Nash, Shelly	4/23/53 Nash, Shelly
Balloon Weight	130	2590	2710	2720	3120	2750	[illegible]	[illegible]	140(15.50 fitting [illegible])
Altitude Theoretical Maximum	42,000 40,100 (overshot)	85,000 80,2[illegible]	85,000	78,000 58,000	86,000 74,5[illegible]	83,000 81,500	65,500 64,800	58,000 57,0[illegible]	27,800 7,[illegible]
Purpose	[illegible]ing stability of Mylar [illegible]pressure balloon	Balloon temperatures through sunset and ballast drops	Flight constants by radio controlled ballast	Flight constants with two balloon drops and radio controlled ballast bounces	Effect of NH_3 on flight characteristics in winter	Balloon temperatures, air temperature and earth infra-red through sunset.	"Lead balloon" [illegible] Vehicle control data	Altitude stability of Mylar cylinder balloon with pressure level at base.	Stability of super-press cylinder balloon
Duration Planned	24 Hours	10 Hours	24 Hours	24 Hours	30 Hours	9 Hours	8 Hours	24 Hours	11 Hours 30 Minutes
Actual Duration	11 Hours 30 Minutes	11 Hours 10 Minutes	10 Minutes	1 Hour 40 Minutes	1 Hour 15 Minutes	~8 [illegible]	~7 Hours	10 Hours	1 Hour 21 Minutes
How Released	Low Altitude Release	Low Altitude Release	Balloon Failure	Low Altitude Release	Balloon burst Low Altitude Release	Low Altitude Re[illegible]		Timer	Balloon Tore
GONDOLA DATA									
Gondola No.	180	6	5	15	2	13	170	19C	00
Radio Gear	[illegible] #0097 1638 k.c. [illegible] Dropper #45 [illegible] Cycle #41	Rcvr #0091 1746 k.c. Antenna Dropper #4[illegible] Oliens Cycle #81	Rcvr #0139 1635 k.c. Antenna Dropper #43 Oliens Cycle #44 2 R.P.M. Receiver #0121 6420 Rcvr #0097 1746 k.c. Antenna Drop #39 [illegible]	Rcvr #2093 1746 k.c. #0132 [illegible] Antenna Drop #39, #40 Oliens Cycle #44 Receiver #01[illegible] 6420 k.c.	Rcvr #2133 6690 10 W Rcvr #0096 1638 k.c. Antenna Drop #37 Oliens Cycle #44	Rcvr #0140-7 1638 k.c. Antenna Drop #52 Oliens Cycle #40	Rcvr #0164 1634 k.c. 40 Antenna Dropper #54 Drops at 1310 Oliens Cycle #45 2 R.P.M.	Rcvr #0169 1638 k.c. 4 Watts Antenna Dropper #44 Drops at 400 Oliens Cycle #44 2 R.P.M.	Rcvr #0081 10,260 k.c. Oliens Cycle #88 "special"
Blow Down	[illegible]own #[illegible] Cones 39,000 Fires 27,000 [illegible] #03	Blowdown #61 Cones 45,000 Holds 4.[illegible] Fires 31,000 Fires 5.0[illegible] Camera #45	Blowdown #55 Cones 29,000 Holds 4.[illegible] Fires 20,000 Fire 5.0[illegible] Camera #39	Blowdown #55 Camera #39	Altitude #61 Cones 29,500 Fires 20,500 Camera #40	Altitude & Timer #5 Cones 46,000 Fires 30,000 Camera #51	Altitude Plowdown #4 Cones 45,000 Fires 38,000	"Function Plus single unit for blowdown. Ballast release blinker and [illegible] Camera #40	Timer set for 11.5 Hours
Cameras	#88 10 Hours #31 24 Hours Blowdown back	Up #35 10 Hours Down #45 18 Hours - blowdown back Balloon camera #1[illegible] Camera Mount #3	Up #44 50 Hours Down #39 24 Hours-blowdown back	Up #44 Down #39 Blowdown back	Up #47 10 Hours Down #46 30 Hours Blowdown Tube	Up #47 1 RPM 16 Hours Down #51 1/5 RPM 10 Hours Plowdown back	Up #50 "[illegible]" Filter 50 Ft. Plus-X 1 R.P.M. 10 Hours Down #48 "A" Filter 60 Ft. Plus-X 1/5 R.P.M. 60 Hours	Up #51 1 RPM 10 Hours Down #49 1/5 RPM 84 Hours Blowdown tube	None
Ballast	[illegible]st Dropper #40 [illegible]quence Pressure Operated [illegible] 14,000 [illegible]gh altitude blow 16,000-40 [illegible] [illegible] altitude blow 31,000-80 [illegible]	Ballast Dropper #44 Sequence Pressure Operated 750 [illegible] 25 # steel shot	Ballast Dropper #329 Sequence; pressure operated 1. Two 4. 340 2. 340 5. 340 3. 290 6. 440	Ballast Dropper #373 Sequence [illegible] Operated 1. Two 4. 340 2. 287 5. 340 3. 990 6. 440	Ballast Dropper #65 Sequence Pressure Operated 90# High drop 60,000 100# Low drop 26,600	Ballast Dropper #66 Sequence Pressure Operated Cache 64,000 (High drop 41,800 30# (Low drop 44,000	Liquid Ballast Drop #1 "Shelly" oil Ballast drop timer and Blowdown #11	Steel Shot #1 - 3.0# Drops at 150 mb #2 - 3.0# Drops at 250 mb • Sequence Control Programmer	None
Flight Control	None	None	None	None	None	None	—	—	Drop
Light	[illegible]er Beacon #45	Blinker Beacon #43	Blinker Beacon #43	Blinker Beacon #43	Blinker Beacon #48	Blinker Beacon #49	—	Blinker (Sequence control programmer)	—
Cosmic Ray	None					Cosmic Ray Plates 20 pounds (for NRC of Canada)	—	—	—
Temperature Recording Miscellaneous	[illegible]ries #7-31	Batteries - #7-57 Vacuum Tube voltmeter #VO-1 Thermistor Photo Recorder #VO-11 Special 30V Battery # 840 Special Battery case [illegible] Air Thermistors	Batteries #53, T-40 Distribution Box #54	Balloon valve #21 Signal Coder #20 Receiver Control Box #0040 [illegible] Batteries #53, T-40 Distribution Box #54	Batteries T-40, T-80 & 95 Thermostat and heating lamp for battery box	Special battery pack #0-11 Infra-red Bridge #1 Batteries #57 Thermistor Photo Recorder #12 Voltmeter #11	Temperature Pulse Generator #8201 Thermistor for outside temperature measurement Battery T-50 Dry cells - 90V & 270V	Batteries [illegible] Temperature Pulse Generator #8202 One thermistor inside gondola One thermistor outside gondola One calibration resistor (Balloon data continued) Aluminum clamp ring fitting at top. Duct app. to base. Small tire and orlon girdle at base. [illegible]	—
LAUNCHING									
Inflation Medium	Helium	Helium	Helium	Helium	NH_3	Helium	Helium	Helium	Helium
Displaced Air	71.3	586	Main [illegible] Two 87.1 Total	Main [illegible] Two 105 Total 751	1710	616	919	101.2	25.9
Gross Lift	61.50	505#	579 101	572 99 671	700#	531#	79[illegible]#	87.5#	22# 6.5 ounces
Gross Load	55#	445#	572 71	573 49 622	652#	471#	713#	82.5#	21#
Free Lift	6.5#	60#	[illegible] 30	-1 50 49	56 #	60#	80#	5#	22.5#
Percentage Free Lift of Gross Load / Lift / Air Displaced	9.1 10.6 11.8	10.25 11.9 13.5	45 — —	[illegible]	3.3 8.0 8.6	9.75 11.3 12.75	8.7 10.1 11.2	4.95 5.7 6.06	5.4 6.3 6.7
Rate of Rise 1000 to 300mb 300 to 100mb 100mb to ceiling	[illegible] ballast drop: 152-66.5mb 290 Ft/min [illegible]mb 580 Ft/min [illegible]	1000 - 500 mb 589 ft/min 500 - 100 mb 700 ft/min 100 - ceiling 568 ft/min	None	[illegible]	985 Ft/min 1012 Ft/min 1016 Ft/min	700 ft/min 650 ft/min 750 ft/min	680-460mb 500 Ft/min 460-300mb 445 Ft/min 305-206mb 540 Ft/min 203-152mb 480 Ft/min	980-500mb 550 Ft/min 500-300mb 654 Ft/min [illegible]	348 Ft/min (second ascent)
Weather Clouds Ground Wind Other	High thin haze 3 MPH 35° - 40°F	Light haze (cleared later) Calm 35° - 40°F	Low overcast 8 MPH 28°F	[illegible]	Overcast 12-15 MPH switching to NW 38°F	Clear to Scattered 8 M.P.H. north 47°F	Overcast 0 33°F	Scattered Cirrus 10-12 M.P.H. 43° F	Scattered cumulus-broken thin cirro-stratus Calm 50°F
Launching Site	[illegible], South Dakota	Pierre, South Dakota	Pierre, South Dakota	[illegible]	University of Minnesota Airport	Pierre, South Dakota Airport	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport
TRACKING									

[illegible] Frequency	1760 k.c. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1766 k.c.
Time in Contact Miscellaneous		[illegible]	2 Hours 39 Minutes	—	3 Hours	~16 Hours 10 Minutes	[illegible] Hours [illegible] Minutes	11 Hours 16 Minutes
Airplane Type Hours in Contact	—	Beechcraft [illegible] until release	Beechcraft [illegible] until release	—	—	—	Beechcraft 5732 B Berger, Magnus About [illegible] Minutes	Beechcraft 5732 B Berger, Magnus 1 Hour
Truck When dispatched	—	2030 Continuous until release	—	—	—	—	None	None
Theodolite Stations in Hours in Contact	—	Pierre Municipal Airport 1940 to 2225	—	—	—	[illegible] University Airport 2000 - 2105 [illegible]	None	None
RECOVERY IMPACT								
Estimate Before Flight	—	—	—	—	[illegible]	[illegible]	Eastern US	[illegible] of Minneapolis
Actual Impact Balloon	Lawton, Iowa	[illegible]	[illegible]	[illegible]	Unrecovered	—	Unknown	[illegible], Rt. 61 [illegible]
Load	1 Mile North of [illegible], South Dakota	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10 mi South of [illegible], Michigan	14 mi SW Rhinelander, Wisconsin
Dates and Time Balloon	2330 - 21 January 1953	2230 - [illegible] January 1953	2000 - [illegible] January 1953	[illegible]			—	—
Load	2330 - 21 January 1953	2230 - [illegible] January 1953	2000 - [illegible] January 1953	[illegible]	2100, 2230 [illegible] February 1953	1610 - [illegible] February 1953	—	—
Notified of Position How When	Telephone 0830 - 24 January 1953	Telephone 2050 - [illegible] January 1953	Tracking plane [illegible] 2100 - [illegible] January 1953	—	Telephone 1330 - [illegible] February 1953	Telephone 1730 - [illegible] February 1953	Telephone 2 October 1953	Balloon - Telephone Gondola - Telephone Camera - Telephone Camera - [illegible] 1953 Balloon - 25 February 1953 - 0610 Gondola - 2 November 1953
Recovered by Balloon Load	Edwards, Anderson Edwards, Anderson	[illegible], Berger	[illegible], Anderson	—	[illegible]	[illegible]	Sent express by state police	Berger, Edwards Fromm - Smith
Gear Recovered	Complete Assemblage* *Damaged by fall	Gondola - [illegible] Balloon Hardware	Gondola [illegible] Balloon and balloon hardware	—	Complete assemblage except balloon	Gondola Parachute	Gondola	Balloon & hardware, balloon crown, camera thermistors (one thermistor missing) Gondola camera Gondola - very badly damaged by animals and vandals
Miscellaneous	Good weigh-off and launching. Olland Cycle Reference [illegible] [illegible] contact and erratic [illegible] finally failed completely. Good radio contact.	[illegible]	[illegible]	—	This was the first [illegible]		Gondola damaged by animals	
CAA CONTACTS								
Preflight	1530 - [illegible]	1600 - [illegible]	1650 - [illegible]	2000 - [illegible]	1935 - [illegible]	[illegible]	1730 - [illegible]	1900 - [illegible]
Takeoff	1609 - Thompson to [illegible]	1530 - [illegible]	165[illegible] - Berger to [illegible]	[illegible]	1940 - [illegible]	1954 - [illegible]	None recorded	Pierre CAA makes own observations
In Flight	Not Recorded	Base from tracking [illegible]	Base from tracking [illegible]		815 - [illegible]	—	*	
Termination	Not [illegible]	2240 - Rush to Anderson Out of air 2300 vicinity of Gann Valley, South Dakota	[illegible] from tracking [illegible] Pierre [illegible]	CAA at [illegible]	2043 - [illegible]	—	*	
GONDOLA RECORDS								
Up Camera	Film run of flight until impact	[illegible]	[illegible]	—	[illegible]	[illegible]		
Down Camera	Film run of flight until release	[illegible]	[illegible]	—	[illegible]			Film destroyed
Other	—	—	[illegible]	—	[illegible]	[illegible]		Film destroyed
[illegible] NOTIFICATIONS								crown - 220 exposures
Launch	—	—	—					
Inflight	—	—	—		—	2140 - 17 Feb - Howard	2040 - 23 February 1953 - Chase	0200 - 24 February 1953 - Chase
Termination	—	—	—			0745 - 18 Feb - Chase 1430 - 18 Feb - Chase 2213 - 18 Feb - Chase	1420 - 24 February 1953 - Chase	1420 - 24 February 1953 - Chase
PHOTOGRAPHIC COVERAGE OF LAUNCH, ETC.								
16 mm Motion Picture	—	—	—		—	200 ft launching preps. and launch		
Rolliflex	—	—	—		—	18 frames	11 rolliflex shots	
Other	—	—	—		—	(Astro)4 frames		[illegible] rolliflex shots - prelaunch and launch
PRINCIPAL CHARACTERISTICS OF FLIGHT	Two release and first [illegible] [illegible] by radio [illegible] thermodynamic [illegible].	Easterly [illegible] altitude. [illegible]	The balloon remained [illegible] balloon after [illegible] weight [illegible] altitude, terminating flight.	[illegible]	[illegible] by a [illegible] This might [illegible]	Balloon [illegible] valved [illegible]	Balloon [illegible]	[illegible] level at ceiling for [illegible] developed a sunset rate [illegible] 25# of ballast [illegible] produced a bounce [illegible] a descent at 40 ft/min. [illegible] were not obtained because of non-recovery of gear.

CONFIDENTIAL INFORMATION

Page

Time in Contact Miscellaneous	1630 P.C. 9 Hours 4 Minutes	1746 P.C. 11 Hours [illegible] Minutes	[illegible]	[illegible] 4 Hours 28 Minutes	[illegible] 56 Minutes	[illegible] 4 Hours 18 Minutes	1639 [illegible] 8 Hours 12 Minutes	[illegible]	[illegible] 1 Hour 11 Minutes
Airplane Type Hours in Contact	Beechcraft 5702 B Gorgon, Magnus About 55 Minutes	Beechcraft [illegible] Gorgon, Magnus 1 Hour	—	None	None	Beechcraft [illegible] 1 Hours 5 Minutes Magnus	Cessna - Harris [illegible] 8 Hours 11 Minutes	Beechcraft - 18 - [illegible] 9 Hours Magnus - Moss	U.S. Army AF jets, Cessna 170
Truck When Dispatched	None	None	—	None	None				
Theodolite Stations on Hours in Contact	None	None		None	None	Pierre, South Dakota 2000 - 0135 - 5 April 1 Hours 35 Minutes			Aurora Airport - 1830 1 Hour 10 Minutes
RECOVERY IMPACT									
Estimate Before Flight	Eastern US	100 Miles East of Minneapolis	None	None		100 Miles E of Minneapolis	Iron River, Michigan	Eastern U.S.A.	
Actual Impact Balloon	Unknown	Carsons Resort, Rt. 8, Marshan, Wisconsin (Camera) Tomahawk, Wisconsin	Pierre Airport	[illegible] Valley, South Dakota	Hillsdale, Wisconsin	North of Herrick, South Dakota			East Shore of Turtle Lake, [illegible] Minnesota
Load	10 mi South of Shingleton, Michigan	14 mi SW Rhinelander, Wisconsin		[illegible] Valley, South Dakota	Hillsdale, Wisconsin	43 Miles NW of [illegible], South Dakota	Massey, Ontario	U.S. Army Proving Ground, Madison, Indiana	Same
Dates and Time Balloon	—	—		1642 - 12 March 1953	2030 - 12 March 1953	2300 - [illegible] April 1953			1830 - 27 April 1953
Load	—	—		1646 - 12 March 1953	2013 - 12 March 1953	2300 - [illegible] April 1953		0007 - 21 April 1953	1830 - 27 April 1953
Notified of Position How When	Telephone 2 October 1953	Balloon - Telephone; Gondola - Telegraph; Camera - Telephone; Camera - 15 April 1953; Balloon - 25 February 1953 - 0610; Gondola - 2 November 1953		Telephone 11 March 1953 - 0030	Telephone from Sheriff's Office at Merrill, Wisconsin 0110 - 13 March 1953	Telephone from Father [illegible] of Herrick 1545 - April [illegible]	Telephone 27 April 1953	Contact maintained by tracking plane Entire flight	Telephone 2000 - 27 April 1953
Recovered by Balloon Load	Sent express by state police	Gorgon, Edwards; Pranse - Smith		Shipped via Railway Express	[illegible]	Smith, Pranse	Shipped via mail express	Magnus-Moss Gondola was picked up and brought back on return from tracking	Hoy, Ruch, Thorness, Winckler; Hoy, Ruch, Thorness, Winckler
Gear Recovered	Gondola	Balloon & hardware, [illegible] camera thermistor [illegible] dropper missing, Gondola camera		Load and Parachute	Load and Parachute; Balloon left in trees	Gondola and Infra-red detector (No balloon hardware returned)	Gondola, Ballast Can, Assembly	Gondola, Parachute	Complete Assemblage
Miscellaneous	Gondola damaged by animals	Gondola - very badly damaged by animals and vandals							
CAA CONTACTS									
Preflight	1730 - Stewart to	1800 - Ruch to	1800 - [illegible] to Pierre CAA	1345 - Stewart to Pierre CAA	1700 - Stewart to Pease	1915 - Hoy to Pierre CAA	1409 - Howard to Pease	1550 - Stoddart to Blake	No data
Takeoff	None recorded	Pierre CAA makes own observations	Pierre CAA made own observations regarding launch time	1445 - Stewart to	1855 - Howard to Pease	1955 - Magnus to [illegible]	153[illegible] - Howard to Pease	1618 - Stoddart to Blake	—
In Flight	*			None		Direct Reports to Pierre CAA			—
Termination	*		2100 - [illegible] to Pierre CAA	None	2140 Stewart to [illegible]	Direct Reports to Pierre CAA	0130 - Stewart to 12 April —	(21 April) [illegible] - Magnus to Indianapolis, Indiana CAA	—
GONDOLA RECORDS									
Up Camera		Film destroyed		120 Exposures	Camera failed before take-off	Film run of entire flight including exposures after impact - 775 exposures	No data	~350 Frames exposed	—
Down Camera		Film destroyed		25 Exposures		29 exposures	—	70 exposures	—
Other		crown - 220 exposures		None		None	—	—	—
WEATHER CENTRAL NOTIFICATIONS									
Launch	2040 - 23 February 1953 - Chase	0800 - 24 February 1953 - Chase		None		None	No data	1639 - Ruch	—
In Flight									—
Termination	1420 - 24 February 1953 - Chase	1420 - 24 February 1953 - Chase						0302 - Ruch	—
PHOTOGRAPHIC COVERAGE OF LAUNCH, ETC.									
16 mm Motion Picture				None	400 feet black and white	Bell & Howell [illegible] ( ) of props for launch and launch	[illegible] Auto Load 200 ft of launching preparations and launch	B&H Auto Load-[illegible], Hours of gear, inflation, prelaunch and launch	B&H [illegible] - 150 ft - preflight and inflation
Rolliflex	11 rolliflex shots	8 rolliflex shots - prelaunch and launch			21 exposures	37 exposures of launching technique and gear	13 Shots of gear and launching preparations	4 rolls (18 exp) of pre-flight and launch sequence	1 roll shot (36 exps) during layout, inflation and launch
Other									—
PRINCIPAL CHARACTERISTICS OF FLIGHT	Balloon overshot ceiling presumably because of high rate of rise and natural [illegible] of cylinder - Began descending at [illegible] ft min. [illegible] of ballast were dropped at [illegible] - Balloon changed rate from [illegible] ft min down to [illegible] ft min [illegible] - Balloon floated level at ceiling for [illegible] min - Began descending at sunset at rate of [illegible] ft min - 20 of ballast dropped at 2340 [illegible] produced bounce and leveled the flight.	Balloon floated level at ceiling for 75 minutes - developed a sunset rate of 400 ft/minute. [illegible] of ballast dropped at [illegible] produced a bounce followed by a descent at [illegible] ft min. Temperature data were not obtained because of non-recovery of gear.	Control was established [illegible] due to a rigging hole left in the top of the balloon flight [illegible] and descended near the Pierre Airport. Balloon was recovered and used over on flight.	Command was not established [illegible] the burst and the entire assembly came down. The ballast bags were [illegible] by the [illegible] device.	In spite of rather low free lift balloon acquired a rate of rise of [illegible] ft min - the balloon failed on ascent - this is the second time a [illegible] lift has failed for no apparent reason.	Successful temperature and infra-red flight - the balloon gas was approx. 10°C cooler than the air in the troposphere - as the balloon rose through the [illegible] the negative superheat [illegible] and reached zero at 70,000 ft (750 f/m rise rate) the superheat was [illegible]°C when the balloon reached ceiling-it superheated [illegible] with a time constant of [illegible] minutes at ceiling-this superheat was maintained thru sunset and during descent until ballast was dropped at which time the superheat dropped to [illegible].	Successful step flight with "Lead Balloon". The time altitude curve was determined by the rate of dropping ballast and the flight performed just as expected - the balloon was used as an [illegible] gas thermometer and the temperatures obtained agreed with thermistor measured temperatures to within a degree.	Test of zero pressure Mylar balloon floated level for one hour - [illegible] slow descent-ballast was dropped [illegible] at 245 mt and the balloon began ascending at [illegible] ft/min- at the time that the sun faded on the ground the ascent stopped-5 minutes later at the time of balloon sunset it began a slow descent and increased its rate at the tropopause.	This flight was launched twice - the first time it rose about [illegible] feet and settled back. The second time it rose to [illegible] feet and came back down to [illegible] ft - it rose again at [illegible] ft min to [illegible] feet - leveled for [illegible] minutes then descended at 320 ft/min for approx. 5 feet-rose again at 350 f/m to [illegible] ft. leveled for [illegible] minutes-floated to [illegible] feet, then descended.

4

FLIGHT NUMBER	71	72	73	74	75	76	77	78	[illegible]
FLIGHT DATA									
Date	4 May 1953	[illegible] May 1953	13 May 1953	15 May 1953	16 May 1953	[illegible] May 1953	[illegible] June 1953	[illegible] 1953	[illegible]
Time	1237 GMT	1511 GMT	1617 GMT	Balloon burst at ground	1517 GMT	1223 GMT	1556 GMT	1445 GMT	
Balloon Type	Mylar-4 [illegible]; .002" thick [illegible]; [illegible] ft. cylinder [illegible]; [illegible] ft. circumference [illegible]; [illegible] balloon length	Mylar-4 [illegible]; Same as for flight #71. [illegible] Bar pressure level of [illegible] of balloon	Mylar [illegible]; [illegible] diameter [illegible]; [illegible] antenna [illegible]; [illegible]; [illegible] and thermistors installed	Mylar "A" [illegible]; .002"; [illegible] long cylinder; [illegible] circumference; [illegible] ft antenna taped to tag	Mylar "A" [illegible]; Same as flight #[illegible] - balloon repaired and reused	Mylar "A" [illegible]; .002" [illegible]; 55' cylinder 75' below bottom; [illegible] ft circumference of balloon	Mylar "A" [illegible]; 45' Cylinder 105' circumference; [illegible] appendix 75' below balloon [illegible]	[illegible] 2-mil; [illegible] diameter; General Mills, Inc.; [illegible]	Ringen #7 [illegible]; Standard [illegible]; Valve [illegible]; Heat sealed [illegible]; [illegible]; No [illegible]; antenna
Date Formed and Packers	[illegible] April 1953; [illegible]	[illegible] May 1953; (Balloon [illegible])	First passed - [illegible] December 1952; Thermistors installed [illegible] May [illegible]; Hanson, [illegible]	13 May 1953; [illegible]	[illegible]	25 May 1953; [illegible]	2 June 1953; [illegible], Inc.	[illegible]; Top grommet bottom harness cable installed by Hanson and Pearson	[illegible]/53; Hanson, [illegible]
Balloon Weight	[illegible] pounds	14.075 pounds	[illegible] pounds		[illegible]	[illegible]	[illegible] lbs [illegible]	[illegible] 63 lbs (net)	257 lbs
Altitude Theoretical Max. Reached	[illegible] feet; [illegible] feet	[illegible] feet; [illegible] feet	[illegible] feet; [illegible] feet	Balloon [illegible] after [illegible] inflation	[illegible] feet; Unknown	[illegible] feet; [illegible] feet	[illegible]; 8,500	[illegible]	
Purpose	To obtain [illegible] of [illegible] balloon [illegible]	To repeat and verify performance of [illegible] balloon [illegible] after [illegible] flight as observed in flights [illegible] and #71.	Balloon [illegible], air temperature and earth infra-red measurements during sunset and [illegible]	To test Mylar cylinder [illegible]	Same as flight #[illegible]	Same as flight #[illegible]	Same as flight #74	[illegible] thermodynamic [illegible] drag on 79' balloon [illegible] technique during day.	Same as [illegible]
Duration Planned	[illegible] hours	[illegible] hours	[illegible] hours	24 hours	[illegible] hours	[illegible] hours	[illegible] hours	5 hours	
Actual Duration	[illegible] hours [illegible] minutes	[illegible] hour [illegible] minutes	[illegible] hours [illegible] minutes	---	Unknown	1 Hour 53 Minutes	1 [illegible] 10 Minutes	Not airborne	[illegible]
How Released	Descent on balloon	Low altitude descent	Timer	----	Unknown	Balloon burst	Balloon burst	Premature [illegible] firing	
GONDOLA DATA									
Gondola Number	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	55	
Radio Gear	Xmtr #[illegible] - [illegible] [illegible] Batts; Antenna Dropper #[illegible] - drops at [illegible]; Olland Cycle #[illegible] - [illegible] RPM	Xmtr #[illegible] - [illegible] Batts; Antenna Dropper #[illegible] - Drops at [illegible]; Olland Cycle #[illegible] - [illegible] RPM	Xmtr #[illegible] [illegible] Batts; Antenna Dropper #[illegible] - drops at [illegible]; Olland Cycle #[illegible] - [illegible] RPM	Xmtr [illegible] Batts; Antenna Dropper #[illegible] - drops at [illegible]; Olland Cycle [illegible]	Same as flight #[illegible]	Xmtr #[illegible] [illegible] Batts; Antenna Dropper #[illegible] - drops at [illegible]; Olland Cycle #[illegible] [illegible] RPM	Xmtr #[illegible] [illegible]; Antenna Dropper #[illegible] drops at [illegible]; Olland Cycle #[illegible] [illegible] RPM	Xmtr #[illegible] [illegible] K.C.; Antenna Drop #[illegible]; [illegible]; Commutator and Pulse Network #[illegible]	Xmtr #224 [illegible]; Olland Cy[illegible]; Antenna [illegible]; Note 45° [illegible]; Commutator [illegible]
Pipe Down	Contained in Sequence Control Programmer #[illegible]; Pipe Down at [illegible] - [illegible] feet	Contained in Sequence Control Programmer #[illegible]; Pipe Down at [illegible] - [illegible] feet	[illegible]	Contained in Sequence Control Programmer #11; Pipedown at 355 mb-26,100 ft	Same as flight #[illegible]	Contained in Sequence Control Programmer #[illegible]; Pipedown at [illegible] mb, [illegible] feet	Sequence Control Programmer #[illegible]; Pipedown at [illegible] mb, [illegible]	[illegible]; [illegible] #13; Hose dropper timer #12	Sequence [illegible]; Pipedown [illegible]
Cameras	Up #[illegible] - [illegible] RPM - Background [illegible] film [illegible]; Down #[illegible] - [illegible] RPM-Background [illegible] film [illegible] feet	Up #[illegible] - [illegible] RPM-Background [illegible] film [illegible]; Down #[illegible] - [illegible] RPM - [illegible] film [illegible] feet	Up #[illegible] [illegible] RPM-Background [illegible] film [illegible] feet; Down #[illegible] [illegible] RPM-Background [illegible] film [illegible]	Up (#53) 1 RPM - Background I 10 Hour run; Down (#51) 1/5 RPM - Background I 84 feet - blowdown [illegible]	Same as flight #74	Up #[illegible] 1 RPM [illegible] feet of film; Down #[illegible] 1/5 RPM [illegible] feet of film	Up #[illegible] 1 RPM; Down #[illegible] [illegible] RPM, [illegible], [illegible] film	Up #[illegible]; Down #[illegible] [illegible] (Type [illegible] RPM)	Up #42 [illegible]; Down #6. [illegible]; Crown Ca[illegible]
Ballast	[illegible] pound package shot - 150 mb; 3 pound package shot - 250 mb	[illegible] - [illegible] pound packages at 150 mb at 250 mb	[illegible] pound packages at 72 mb at 150 mb	2 - [illegible] packages; 1st drop - [illegible]; 2nd drop - [illegible]	Same as flight #[illegible]	[illegible] - [illegible] packages; 1st drop - [illegible] mb; 2nd drop - [illegible] mb	2 - [illegible] packages; 1st drop - [illegible] mb; 2nd drop - [illegible] mb	[illegible] fluid, [illegible] load [illegible] of altitude	Same as f[illegible]
Flight Control	None	None	None	None			None	None	
Light	Controlled by Seq. Control Program.	Sequence Control Programmer	[illegible] #[illegible]	Controlled by Sequence Control Program.	Same as flight 74	Same as flight 74	Sequence Control Programmer	None	
Cosmic Ray	None		None	----		None	None	None	
Miscellaneous	Water Tank #[illegible]; Batteries T-[illegible], [illegible]; Thermistor Pulse Generator #[illegible] M[illegible]	Water Tank #[illegible]; Batteries T-[illegible], T-[illegible]; Thermistor Pulse Generator #[illegible] M[illegible]	Thermistor Photo Recorder #12; Batteries (53); Battery Pack #1312; Voltmeter #11; Infra red Bridge #1	----; Batteries 57, 58; Water tank #[illegible]; Temperature Pulse generator #[illegible] M-2	Same as flight #[illegible]	Batteries T-57, T-58; Water tank #[illegible]; Temperature Pulse generator #[illegible] M-2	Water tank #[illegible]; Temperature Pulse Generator #[illegible]; Batteries T-61, 66	Special [illegible] flight instrumentation; Tank [illegible] #[illegible]; Hose Dropper #[illegible]; Termometer #[illegible]; [illegible] Bridge #[illegible] (Infra red bridge) and Air Thermistor Generator #2201	Special [illegible]; Hose Drop[illegible]; Tank [illegible]; T[illegible]; Infra-red [illegible]; and Air T[illegible]
LAUNCHING									
Inflation Medium	Helium	Helium	Helium	Helium	Helium	Helium	Helium	Helium	
Displaced Air	[illegible]	[illegible]	595	Balloon burst	[illegible]	[illegible]	[illegible] lbs	Tow [illegible] / Platform 732	Tow 471
Gross Lift	[illegible] pounds	[illegible] pounds	[illegible] pounds	before any	[illegible]	[illegible]	[illegible] lbs	[illegible] / 674	423
Gross Load	[illegible] pounds	[illegible] pounds	[illegible] pounds	79 lbs 2 oz lift measurements	[illegible]	[illegible] lbs	[illegible] lbs [illegible]	[illegible] / 654	361
Free Lift	[illegible] pounds	[illegible] pounds	40	were made	[illegible]	[illegible] lbs	[illegible] lbs	11 / 2[illegible]	[illegible]
Percentage Free Lift of Gross Load / Lift / Air Displaced	[illegible]%; [illegible]%; [illegible]%	[illegible]%; [illegible]%; [illegible]%	6.72%; 7.0%; 6.7%		[illegible]%; [illegible]%; [illegible]%	[illegible]%; [illegible]%; [illegible]%	[illegible]%; [illegible]%; [illegible]%	Tot. Air Disp. = 1225; Tot. Free Lift = 53; % = 4.3	Tot. Air [illegible]; Tot. Free [illegible]; %
Rate of Rise [illegible]-[illegible] / [illegible] - [illegible] / Ceiling	[illegible] [illegible] ft/min; [illegible] [illegible] ft/min	[illegible]	822 ft/min; 741 ft/min; 854 ft/min			[illegible] - 100mb 675 [illegible]; 100- 65mb 700 feet/minute		No launch	
Weather Clouds / Ground Wind / Other	Clear; None; Temp. [illegible]	None; None; Temp. [illegible]	[illegible]; [illegible]; Temp. [illegible]	Clear; 15 MPH; Not recorded	Overcast; [illegible]; [illegible] 45°F	[illegible]	Overcast; [illegible] mph; Temperature [illegible]	Clear; Very low wind; [illegible] not recorded	[illegible]
Launching Site	University Airport, Minneapolis, Minn	University Airport, Minneapolis	University of Minnesota Airport	University Airport, Minneapolis	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	University [illegible]

FLIGHT NUMBER	77	78	79	80	81	82	83	84	85
FLIGHT DATA									
Date	4 June 1953	9 June	11 June 1953	[illegible] July 1953	7 July 1953	11 July 1953	16 July 1953	23 July 1953	24 July 1953
Time	1954 GMT	1045 GMT	1103 GMT	1108	1910 GMT	0042 GMT	Cancelled - after balloon burst	1649 GMT	1601 GMT
Balloon Type	[illegible] (M-1) [illegible]ylinder 135' circumfer[illegible] [illegible] 95' to balloon base	[illegible]-Balloon [illegible] Winzen double-[illegible] 72.0', 1-mil [illegible] Straight [illegible]	[illegible]	Winzen 71-100P-304 Poly. Duct app 2ft at top of bal. grommet ring, duct full length of bal. inflation disc on bottom and rigging cable 5 swivel; GMT [illegible] 2018 Duct 4 Rubbers for step flight 2-mil	Winzen 71-211GBP-252 Polyethylene Duct app 40ft from girdle 11 x 8 mt. straight app on bottom 4 wires on girdle P. Pusher 1½ turn with gage 3 wires for valve 1 tote load under girdle corset and girdle [illegible] tapes	GMI 101-C Polyethylene 90° cone-on-sphere Filament taped Duct app down to base of balloon App on bottom tied off 7 Rubbers under corset	GMI cylinder 8' 1-mil polyethylene End rings - 2 oz 1/8 alum tubing Duct 52° flat width 27° 1 1/2 to base of balloon	Same as flight 83	Herb Sholly cylinder H-20 14 ft X 32 ft Mylar Super pressure
Date Packed and Packers	3 June 1953 Herb-Sholly, Inc.	2? April, Hanson, Smith, Moberg; [illegible]	[illegible] Hanson, Smith, [illegible]	[illegible] Hanson, Smith, Moberg	12/29/52 - Hanson, Smith, Edwards, Moberg 6/1/53 - Hanson, Edwards, Smith, Moberg	7/8/53 Hanson, Edwards	Hanson, Edwards, Smith, Hurt 7/15/53	7/15/53 - Hanson, Edwards, Smith, Hurt 7/21/53 - " (Repaired and repacked) 7/22/53 - " (Repacked)	not packed
Balloon Weight	16 lbs 11 oz	252 lbs (packed) [illegible]	257 lbs [illegible]	[illegible]	249 lbs	69 lbs	216½ lbs	216½ lbs	1 lb 15 ounces
Altitude Theoretical Maximum	94,000 8,400	[illegible] 0	[illegible]	[illegible]	85,000 80,000	65,000 (before ballast drop) 63,650 68,500 (after ballast drop)	91,000 ------	91,000 13,000	30,000 No data
Purpose	[illegible] flight #76	Measure altitude [illegible] and aerodynamic [illegible] by step flight [illegible]	Same as flight #78	Same as flight #79	Temperature Flight	Test Loran navigational system	Test GMI Polyethylene Cylinder balloon	Same as flight 83	To test Mylar super pressure behavior
Duration Planned	24 Hours	5 Hours	5 Hours	[illegible] Hours	10 Hours	11½ Hours	24 Hours	24 Hours	5 Hours
Actual Duration	1 Hours 18 Minutes	Not airborne	[illegible] Hours 16 Minutes	[illegible]	10 Hours 1 Minute	4 Hours	--------	25 Minutes	No data
How Released	Balloon burst	Premature equi[illegible]	Timer	Timer	Timer Blowdown	(Leaky Balloon)	--------	Defective inner tube release valve	No data
GONDOLA DATA									
Gondola Number	17?	[illegible]	[illegible]	[illegible]	19	I-56	14	14	21
Radio Gear	[illegible] 1618 K.C. [illegible] Dropper #50-grams at [illegible] [illegible] Cycle #02 [illegible] RPM	Xmtr #2261 [illegible] K.C. Antenna Drop #83 Olland Cycle #[illegible] Commutator and Pulse Network #2291	Xmtr #[illegible] K.C. Pulse [illegible] Olland Cycle #[illegible] 2 RPM Antenna Dropper #[illegible] [illegible] Commutator and Pulse Network #2291	Xmtr #[illegible] K.C. Antenna Dropper #[illegible] Olland Cycle [illegible] Commutator and Pulse forming network [illegible]	Xmtr #2244-48 1415 K.C. Ant Dropper #46 Olland Cycle #95 Commutator & pulse forming network 2417-81	Xmtr #2242 1415 K.C. Antenna Dropper #42 Olland Cycle #87 Commutator & Pulse Forming network 2411 Loran Rcvr. 2171 K.C. 1950	Xmtr #2166 1638 K.C. Antenna Drop #39 Olland Cycle #9?	Xmtr #2166 1638 K.C. Same as flight 83	Xmtr #2222 10260 K.C. Olland Cycle #99 Antenna rolled out at launch
Plow Down	[illegible]ce Control Programmer #[illegible] [illegible] at 348 mb, 24,750'	Camera time-over Low altitude blowdown [illegible] Nose dropper timer #12	Sequence Control Programmer #[illegible] Blowdown - [illegible] mb = [illegible]	Blowdown - [illegible] mb = [illegible] feet Sequence Control Programmer	Sequence Control Programmer #23 High drop - 76 mb Low drop - 151 mb Blowdown - 300 mb	Sequence Control Programmer #21 Drops ballast 297 mb Blowdown 168 mb Misc. Honeywell Timer #6	Sequence Control Programmer #21 High Drop 72 mb Low Drop 154 mb Blowdown 145 mb	Same	Timer #21
Cameras	[illegible] 1 RPM [illegible] 1/5 RPM, [illegible] 35' film	Up #[illegible] Down #41 [illegible] (Tot? 1 RPM)	Up #[illegible] 1 RPM [illegible] film telemeter [illegible] Down #[illegible] Crown Camera Mount #[illegible] camera #16	Up #42 - [illegible] filter, [illegible] Down #[illegible] [illegible] filter [illegible] Crown camera mount #1 (camera #[illegible])	Up #45 10 Hours 1 RPM Down #41 24 Hours 1/5 RPM	No up camera Down #48 30 ft (30 hours) 1/5 RPM	Up #?? 40' 5 Hours 1 RPM Down #? 24' 21 Hours 1/5 RPM	Same	None
Ballast	[illegible] lb [illegible] 1st drop - 107 mb 2nd drop - 152 mb	185 lbs [illegible] control of altitude	Same as flight #[illegible]	[illegible] 484 lbs [illegible]	35 lbs steel shot	40 lbs steel shot	15, 25 lbs steel shot	15 lb and 25 lb steel shot	[illegible]ne
Flight Control	None	None	None	None	None	None			
Light	[illegible]nce Control Programmer	None	None	None	Sequence Control Programmer	Sequence Control Programmer	Sequence Control Programmer	Same	None
Cosmic Ray	None	None	None	Vertical telescope [illegible]	Single Counter	None	Single C.R. counter C.R. emulsion pack	None	None
Miscellaneous	[illegible] tank #[illegible] [illegible]ature Pulse Generator #[illegible] [illegible]ries T-61, 66	Special step flight instrumentation Tank assembly #1[illegible] Nose Dropper #12 Tensiometer #11 I R Bridge #12 (Infra red bridge) and Air Thermistor Generator #2281	Special step flight instrumentation Nose Dropper and Timer #12 Tank assembly #11 Tensiometer #11 Infra-red Bridge #12 and Air Thermistor Generator #2281	Special step flight instrumentation Thermistor Pulse Generator #[illegible] Infra-red Bridge #[illegible] Tensiometer #[illegible] Nose Dropper and Timer #[illegible] Tank Assembly #17	Thermistor Pulse Generator #2282 Infra Red Detector #21 Balloon Thermistor Pulse #2171 Water Tank #15 Batteries 6V #48	Batteries 6V T-52, T-70, #47 Water tank #16 (Special battery - 2V-18 amp hrs.)	Temperature Pulse Generator #2201 Batteries 211 amp. hr. cells Water tank #14	Same	Batteries 2 V #20
LAUNCHING									
Inflation Medium	Helium	Helium	Helium	Helium	Helium	Helium	Helium	Helium	Helium
Displaced Air	[illegible] lbs	Tow [illegible] / Platform [illegible]	Tow [illegible] / Platform [illegible]	Tow [illegible] / Platform [illegible]	550	270	417	415	10.6
Gross Lift	[illegible] lbs	[illegible] / [illegible]	[illegible] / [illegible]	[illegible] / [illegible]	474	250	355	357½	9.125
Gross Load	[illegible] lb [illegible] oz	[illegible] / [illegible]	[illegible] / [illegible]	[illegible] / [illegible]	424	220	325	327½	8.125
Free Lift	[illegible] lbs	32 / [illegible]	42 / 51	[illegible]	50	30	30	30	1
Percentage Free Lift of Gross Load / Lift / Air Displaced	5.?% [illegible] [illegible]	Tot. Air Disp = [illegible] Tot. Free Lift = [illegible] % = [illegible]	Tot. Air Disp = 1311 Tot. Free Lift = [illegible] % = [illegible]	Tot. Air Disp = [illegible] Tot. Free Lift = [illegible] % = [illegible]	9.1% 10.5% 11.8%	10.?% 12.0% 13.?%	7.3% 8.5% 9.?%	7.2% 8.4% 9.2%	9.4% 11.0% 12.?%
Rate of Rise 1000 - 300 mb / 300 - 100 mb / 100 mb - ceiling		No launch		[illegible]	500mb - 140mb 684 ft/min 140mb - 33mb 478 ft/min		----	---	No data
Weather Clouds / Ground Wind / Other	Overcast [illegible] 15 mph Temperature 73°F	Clear [illegible]	Clear [illegible]	Clear [illegible] knots [illegible] °F	Partly cloudy 30 MPH Wind 80 - 85°F	Clear 4 Knots ? 20.5°C		Scattered light cumulus NW 10 - 12 knots 80° F	Wind and rain Overcast SE - 15 70°F
Launching Site	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport		University of Minnesota Airport	West of Murdock, Minnesota
TRACKING									

Radio Frequency	1638 K.C. 4 Watts	1638 K.C. 4 Watts	1638 K.C. 4 Watts	1638 K.C. 4 Watts	1638 K.C. 4 Watts
Time in Contact Miscellaneous	Entire flight	Entire flight	Entire flight after antenna drop 9 hours 19.5 minutes		
Airplane Type Hours in Contact	University Beechcraft 5 hours 3 minutes	Not recorded	Not recorded	Not recorded	Not recorded
Truck When Dispatched Hours in Contact	Not recorded	Not recorded	Not recorded	Not recorded	Not recorded
Theodolite Stations On Hours in Contact	University of Minnesota Airport [illegible] to 1700	University of Minnesota Airport [illegible] to [illegible]	University of Minnesota Airport 18[illegible] to 2015	—	
RECOVERY IMPACT					
Estimate Before Flight	Vicinity of Omaha, Nebraska	None	Buffalo, Minnesota		Buffalo, New York
Actual Impact Balloon	On land adjacent to Huffard Farm, Roberts, Wisconsin	Vincent Goetz, Waconia, Minnesota (about 1 mile out)	Westboro, Wisconsin	NOT LAUNCHED	NOT RECOVERED
Load	Huffard Farm, Roberts, Wisconsin	Sarah Peterson, Waconia, Minnesota (About half way between Victoria and Waconia)	Not recovered		
Dates and Time Balloon	1810 CST-4 May 1953	Not recorded	1 June 1953	Unknown	Unknown
Load	Same	1619 - 6 May 1953		Unknown	Unknown
Notified of Position Balloon Load	Telephone 1830 - 4 May 1953	Telephone 1700 - 6 May 1953	Air Defense Command 3 June 1953		
Recovered by Balloon Load	Haas, Hanson Haas, Hanson	Hanson, Horger Hanson, Horger	Unrecorded		
Gear Recovered	Complete Assemblage	Complete Assemblage	Balloon and thermistor droppers		
Miscellaneous		Balloon was rebuilt after flight #71 The antenna was unrolled purposely on the ground to get a complete flight record.			
CAA CONTACTS					
Preflight	None	1[illegible]3 - Howard to Blake	1945 - Howard to Hanna	1314 - Stoddart to Dripps	1100 Howard to Brown
Takeoff	1313 - Howard to Brill	1718 - Stoddart to Lerner	1914 - Stoddart to Dripps	None	1140 Stoddart to Vesplant
Inflight	Reported by tracking plane	None	0845 - Stoddart to Brill	None	None
Termination	1815 - NCA-22 (Magnus)	1622 - Stoddart to Lerner	14[illegible]-Stoddart to Buss	Flight cancelled	1430 (23 May) Welinski to Buss
GONDOLA RECORDS					
Up Camera	Exposures of entire flight	Exposures of entire flight	NOT RECOVERED	Not launched	Not recovered
Down Camera	Exposures of entire flight	Exposures of entire flight		—	—
Other	None	None		—	—
[illegible] WEATHER CENTRAL NOTIFICATIONS					
Launch	041342 Howard	None	130015 Chase	—	221320 Stoddart
Inflight	None	—		—	22[illegible] Welinski
Termination	via mail 042300 Stoddart	—	By mail Welinski	—	By mail Welinski
PHOTOGRAPHIC COVERAGE OF LAUNCH, ETC.					
16mm Motion Picture	Lg. Bell&Howell -175 feet Sm. Bell&Howell -200feet	Sm.Bell&Howell - 4 rolls 200 ft	Bell&Howell - 400 feet, Supreme X of pre-launch and launch	75' Pre launch	Bell & Howell "[illegible]" 300 feet of film exposed - covers pre-launch and launch
Rolliflex	28 frames - Balloon inflation and erection	29 frames - Balloon inflation and erection	3 Rolls, Plus-X, Preflight of balloon and gear - launch	24 exposures including inflation, wind whipping balloon, shots of rip in heat seal.	8 Exposures covering pre-launch prep and launch
Other	None	Astro - 12 frames - Balloon in air	Astro #1-Sequence on balloon inflation, erection of top and launch, ~20 exposures, #2 Series of exposures of balloon floating at alt. thru 10" [illegible]		Astro, 10 frames of balloon after launch.
PRINCIPAL CHARACTERISTICS OF FLIGHT	After valving and floating level at ceiling for about an hour the balloon started to descend. It accelerated very slowly to a descent rate of 556 ft/min.	Balloon apparently opened a hole at 27,000' floated level a few minutes then descended to the low altitude release level.	The pre-sunset effect starting at about 1600 caused the balloon to descend to 37 mb at sunset. The 35 lb ballast, which dropped in two sections, resulted in an almost level flight.	Balloon ruptured prior to launch due to snap in turbulence over wind screen	Appendix fouled and believe prevented antenna from dropping.

CONFIDENTIAL INFORMATION

	1638 K.C. 4 Watts	1638 K.C. 4 Watts	1638 K.C. 4 Watts	1638 K.C. 4 Watts	[illegible]
[illegible] drop [illegible]			Entire flight		
	Not recorded	Not recorded	Cotama, Stoddart-Stoddart Name	Not recorded	None
	Not recorded	Not recorded	Not recorded	—	—
[illegible] Airport	—		Navy B/N Airport 1240 to 1310	—	—
		Buffalo, New York	Eastern U.S.	Eastern U.S.	Eastern [illegible]
[illegible]	NOT LAUNCHED	NOT RECOVERED	Black River Falls, Wisconsin	5 mi South of Glen Falls, Wisconsin	Colfax, [illegible] Union, [illegible]
			Same	Same	Load not airborne
	Unknown	Unknown	Unknown	Unknown	1300 - 9 June 1953
	Unknown	Unknown	Unknown	—	Not airborne
			Telephone 28 November 1953	Telephone 19 September 1953	Telephone 1610- 9 June 1953
			Ronald Hanson	Charles E. France Charles E. France	Burton [illegible]
[illegible] droppers			All recovered [illegible] top of balloon	Complete assemblage excepting some harness and balloon (badly shredded)	Balloon and Rudder ring Launch by letting [illegible] up on blocks, then releasing cornet [illegible] 100 feet off the ground
	1314 - Stoddart to Dripps	1100 Howard to Brown	1055 Stoddart to Brown	1600 - Howard to Hanson	1010 - Howard to [illegible]
	None	1110 Stoddart to Vesplant	1200 Stoddart to Brown	1600 - Stoddart to Hanson	1100 - Howard to [illegible]
	None	None	None	None	None
	Flight cancelled	1430 (23 May) Welinski to Buss	1430 Howard to Dripps	Unknown	Unknown
	Not launched	Not recovered	Entire flight	Entire flight	NOT AIRBORNE
	—	—	Entire flight	Entire flight	
	—	—			
	—	281330 Stoddart	None	None sent	Not Airborne
	—	27[illegible] Welinski	—		
	—	By mail Welinski	—		
[illegible] I	75' Pre launch	Bell & Howell "[illegible]" 300 feet of film exposed - covers pre-launch and launch	Bell & Howell "[illegible]"-150 feet of preps for launch, camera not working properly	Bell&Howell "[illegible]"-6 rolls, layout, inflation, weigh-off, launch	45 ft
[illegible] of balloon	24 exposures including inflation, wind whipping balloon, shots of rip in heat seal.	5 Exposures covering pre-launch preps and launch	3 rolls (36 exposures), covering balloon layout, pre-inflation, gear weigh-off, launch, preparations	2½ rolls, same as above	60 frames
[illegible] inflat. [illegible] launch. - 20 exposures of [illegible] 127 mm		Astro, 10 frames of balloon after launch.	Astro, 10 exposures of balloon in flight after launching.	Astro - 15 frames of balloon in flight	Astro - 7 Frames - balloon [illegible] Automatic - 88 frames, inflation, [illegible]
[illegible]rting at [illegible] balloon to [illegible]t. The [illegible]pped in [illegible] an	Balloon ruptured prior to launch due to snap in turbulence over wind screen	Appendix fouled and believe prevented antenna from dropping.	Appendix fouled. Balloon burst at ceiling. Appendix twisted around gondola at launch.	Appendix wound around gondola subsequent to launching so that no radio signal received.	Low altitude release [illegible] at launching moment [illegible] gondola 10 feet to ground.

[illegible] K.C. & [illegible]	3415 K.C.	3415 K.C.	3415 K.C.	3415 K.C.	3425 K.C.	
			4 Hours 46 Minutes	Entire flight	Entire flight	NOT LAU[illegible]
Not recorded	None	Mass, Minster Entire flight	Oceana - Minster, Mass Entire flight	Not recorded	Not recorded	
—	—	—	None	None	None	
[illegible]	—	—	None	None	None	
[illegible] U.S.	Western Wisconsin	Lake Michigan	Green Bay, Wisconsin	Hudson, Wisconsin	Greenville, South Carolina	
[illegible] of [illegible] Falls, Wisconsin	Colfax, Wisconsin Union, Wisconsin	Cornfield -Hilbert, Wisconsin	Kiel, Wisconsin	Newport, Minnesota	Unrecovered	
None	Load not airborne	Chilton, Wisconsin	60 mi south of Green Bay, 2 mi west of School Hill, Wisconsin	Unrecovered	Stanwood, Iowa (½ way between Stanwood and Clarence)	
Unknown	1300 - 9 June 1953	1600 - 17 June 1953	Unknown	Unknown	———	
—	Not airborne	1600 - 17 June 1953	~1700 - 3 July 1953	———	~1730 - 11 July 1953	
Telephone 19 September 1953	Telephone 1610 - 9 June 1953	Telephone 1605 - 17 June 1953	Telephone 1710 - 3 July 1953	Telephone 13 October 1953	Telephone 11 July 1953	
Charles E. France Charles E. France	Morton Atkinson	Edwards, France Edwards, France	Empress Stewart, Hansen	Hansen	France, Edwards	
[illegible] assemblage [illegible] [illegible] balloon (badly shredded)	Balloon and Rudder ring	Complete Assemblage	Complete Assemblage	Balloon hardware, thermistor droppers and single counter	Gondola, Parachute & parachute box	
	Launch by letting tow up on lines, then releasing corset and diaphragm 100 feet off the ground	Both balloons released simultaneously from ground. Tow had 100 lbs sand and 60 lbs free lift.	Simultaneous release, tow had no sand but 160 lbs free lift on launch			
[illegible] - [illegible] to [illegible]	[illegible] - Howard to Blake	1925 - Chase to Brown	0947 - Chase to Erlewein	1845 - Chase to Hanna	0004 - Chase to Lenner	1611 - Chase to [illegible]
[illegible] - [illegible] to [illegible]	1300 - Howard to Blake	1304 - Chase to Brown	1106 - Chase to Erlewein	1913 - Chase to Beech	0043 - Chase to Beasley	Compelling notice 1659 - Chase to [illegible]
None	None	None	None	0312 - Chase to Lenner 0420 - Chase to Lenner	None	
Unknown	Unknown	1630 - Chase to Buss	1609 - Chase to Brown	0510 - Chase to Lenner	0455 - Chase to Beasley	
Entire flight	NOT AIRBORNE	Entire flight	None	Unrecovered	None	Not [illegible]
Entire flight		Entire flight	Entire flight (none from tow)	———	17 Frames	
		265 from tow balloon		———	None	
None sent	Not Airborne	171113 Chase	031125 Chase	071425 Chase	110115 Chase	None
			None	None	None	———
		By mail Chase	031726 Chase	110115 Chase	110508 Chase	———
[illegible], inflation, [illegible], launch	45 ft	200 feet-prelaunch & launch	225 feet	225 Feet - Bell & Howell	100 Feet - Bell & Howell	50' super XX, 15[illegible] 100'
[illegible], same as above	60 frames	54 frames	102 frames at launch	32 Frames of launch	7 Frames at launch	50 Frames at la[illegible]
[illegible] - 15 frames of balloon in [illegible]	Astro - 7 Frames - balloon inflation Automatic - 54 frames, inflation, launch [illegible]	Astro - 36 frames - balloon in air Automatic - 108 frames inflation & launch	Astro - 38 frames, balloon in air	Astro - 8 frames in air Telescope - 26 frames at ceiling		Astro - 3 frame[illegible]
[illegible] gondola [illegible] to launching so that no radio [illegible] received.	Low altitude release blew squibs at launching moment dropping gondola 20 feet to ground.	Good launch. Steps not correct due to faulty release of ballast by hoses, tensiometer sticky -- gave poor record.	Large free lift of tow (160 lbs) caused it to upset during launch. Top finally inflated near 10,000 feet. Good flight. Last hose did not release ballast.	Good take off in high wind. Telemetered temperatures received throughout flight.	After inflation balloon lost approx. 4 lbs free lift/15' for a period of time before launch. Possibly had a stuck tape on duct. Leveled below theoretical ceiling, then descended till blowdown warning came on and flight evidently came down on chute.	Balloon inflate[illegible] off and diaphrag[illegible] burst in high w[illegible] Second attempt [illegible] because of high [illegible]

CONFID[illegible]

1625 K.C.		1638 K.C.	10.260 M.C.	Radio Frequency
Entire flight	NOT LAUNCHED	Entire flight	No signal received	Time in Contact Miscellaneous
Not recorded		Not recorded	None	Airplane Type Hours in Contact
None		None	None	Truck When Dispatched Hours in Contact
None		University of Minnesota Airport 20 Minutes	None	Theodolite Stations on Hours in Contact
				RECOVERY IMPACT
Greenville, South Carolina	None	None	Eastern Wisconsin	Estimate Before Flight
Unrecovered		St. Paul, Minnesota	Unrecovered	Actual Impact Balloon
Stanwood, Iowa (½ way between Stanwood and Clarence)		St. Paul, Minnesota	Unrecovered	Load
-----		1715 - 23 July 1953		Dates and Time Balloon
~1730 - 11 July 1953		1715 - 23 July 1953		Load
Telephone 11 July 1953		Telephone 1730 - 23 July 1953 1724 - 23 July 1953	[redacted]	Notified of Position Balloon Load
Franse, Edwards		Franse, Smith, Malinski - Corryall Same		Recovered by Balloon Load
Gondola, Parachute & parachute box		Complete Assemblage		Gear Recovered
				Miscellaneous
				CAA CONTACTS
0004 - Chase to Lanner	1611 - Chase to Kruke	1551 - Chase to Beasley	None	Preflight
0043 - Chase to Beasley	Cancelling notice 1659 - Chase to Base	1703 - Chase to Base	None	Takeoff
None		None	None	Inflight
0455 - Chase to Beasley		1717 - Chase to Base	None	Termination
				GONDOLA RECORDS
None	Not launched	26 Frames, duration of flight		Up Camera
17 Frames		5 Frames, duration of flight		Down Camera
None		None		Other
				WEATHER CENTRAL NOTIFICATIONS
110115 Chase	None sent	None sent	None	Launch
None	----	----		Inflight
110506 Chase	----	----		Termination
				PHOTOGRAPHIC COVERAGE OF LAUNCH, ETC.
100 Feet - Bell & Howell	50' super XX, 150' background 100'	100' Balloon horizontal. 100' of balloon in air(diaphragm release and erect) 200' erecting balloon on ground-launch		16mm Motion Picture
7 Frames at launch	50 Frames at launch	42 Frames at launch	8 Frames at launch	Rolliflex
	Astro - 3 frames at launch	Astro ~30 frames		Other
After inflation balloon lost approx. 4 lbs free lift/15' for a period of time before launch. Possibly had a stack tape on duct. Leveled below theoretical ceiling, then descended till blowdown warning came on and flight evidently came down on chute.	Balloon inflated, erected, weighed off and diaphragm ripped when it burst in high wind. Second attempt 22 July cancelled because of high winds.	Evidently when the special tube deflation valve released the tube, the girdle slid toward the undeflated top of the balloon because of the gas behind it and because the top of the balloon hung down. When it came to the top of the balloon it ripped the duct clamp rings off and the balloon deflated.	Rough launching. Tipped some fluid from valve and snapped the antenna. No signal received. Launching crew-Maas, Mantis and Rush. Good weigh-Off.	PRINCIPAL CHARACTERISTICS OF FLIGHT

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FLIGHT NUMBER	86	87	88	89	90
FLIGHT DATA					
Date Flown	31 July 1953	5 August 1953	6 August 1953	12 August 1953	13 August 1953
Time	0302 GMT	0310 GMT	Not recorded	1957 GMT	0557 GMT
Balloon Type	Winzen 73-100V-306 GMI 301E, 2-mil 2x1-mil Poly, 90° poly. Filament tapes cone-on-sphere, No [illegible] flat width duct duct, skirt ap. 11 ap to base of bal. x 8 antenna, corset alum. bottom fitting and thimble, 7 wires Grommets at top under aluminum girdle. Cable thru balloon	Same as flight 86	GMI Vikking Cylinder 14 ft long 32 ft circumference one-mil	Shelly ½-mil Mylar M-18	GMI 301F Vikking - Hot jet sealed Winzen 73-2X100V-3[illegible] Polyethylene No duct, straight rigging, straight appendix on bottom
Date Packed and Packers	4/21/52 Hanson, Smith Hoberg 7/27/53 Hanson, Edwards	8/3/53 Hanson, Smith Edwards	Not packed	Not packed Leak tested and patched	8/10/53 Hanson, Edwards, Smith
Balloon Weight	253 lbs 55 lbs	274½ lbs	3 5/8 lbs	3 lbs 9½ ozs	230 lbs
Altitude Theoretical Maximum	---- 1000 ft	---- 48,700	30,000 No data	---- 36,000	---- 58,000
Purpose	Night time step flight	Night time step flight	To test polyethylene super-pressure balloon behavior	To test Mylar super pressure balloon behavior	Single Step step flight
Duration Planned	15 Hours	15 Hours	5 Hours	6 Hours	20 Hours
Actual Duration	35 Minutes	17 Hours 16 Minutes	No Data	1 Hours	11 Hours 23 Minutes
How Released	Leaky Tow Balloon	Timer	No Data	Leaky Balloon	Low Altitude Release
GONDOLA DATA					
Gondola No.	55	55	213	214	6[illegible]
Radio Gear	Xmtr #2243 3415 K.C. Antenna Dropper #23 Drops 300 ft Olland Cycle #96 Commutator & Pulse Forming Network #2411MP	Same as flight 86	Xmtr #2221 10.710 MC Olland Cycle #88 (Special)	Xmtr #2451 10.71 MC Olland Cycle #101	Xmtr #2243 3415 K.C. Antenna Dropper #121 drops 2000 ft Olland Cycle #95 Commutator & Pulse Forming Network #2411
Blow Down	Sequence Control Programmer #22 Blowdown 350 mb	Same as flight 86	None	None	Sequence Control Programmer #22 Blowdown 350 mb
Cameras	Up Camera #62 50 ft 10 hrs 1 RPM Down Camera #61 15 ft 15 hrs 1/5 RPM Balloon Camera #16 50 ft, 10 hrs 1RPM	Up #62 10 Hours 1 RPM Down #61 15 Hours 1/5 RPM	None	None	Up #71 (special) 4 RPM 20 Hours Down #46 (special) 2 pictures 24 ft 24 hours - background 3
Ballast	484 lbs Skelly "G"	Same as flight 86	None	None	None
Flight Control	None	None	None	None	None
Light	Blinker Beacon #51	Same as flight 86	None	None	Blinker Beacon #52 Super Flasher #1
Cosmic Ray	Cerenkov Counter		None	None	None
Temperature Recording Miscellaneous	Batteries T-73, T-74, T-75 Thermistor Pulse Generator #2283 Infra Red Detector #22 Special Step Flight Instrumentation Ballast Tank Assembly #11 Tensiometer #11	Same as flight 86	Super Pressure valve Special Battery 2V 32, 11	Super Pressure valve Special battery 2V 44, 54	Battery #51 Thermistor Pulse Generator #2283 Infra-red Detector #23 Special Step Flight Instrumentation Tensiometer #12 Hose Dropper & Timer #14 Platform Arm #1
LAUNCHING					
Inflation Medium	Helium	Helium	Helium	Helium	Helium
	Tow / Lead	Tow / Lead			Tow / Lead
Displaced Air	486 / 914	488 / 914	13.05	10.3	477 / 914
Gross Lift	419½ / 787	420½ / 787	11.25	8.9	402 / 305
Gross Load	354½ / 674	355½ / 674	10.25	7.9	347½ / 194
Free Lift	65 / 113	65 / 113	1	1	54½ / 111
Percentage Free Lift of Gross Load / Lift / Air Displaced	Total Displaced Air 12.7% Total Gross Lift 14.8% Total Gross Load 17.3%	Total Displaced Air 12.7% Total Gross Lift 14.7% Total Gross Load 17.3%	7.7% 8.8% 9.6%	9.6% 11.2% 12.7%	Total displaced air 20.2% Total Gross Lift 23.4% Total Gross Load [illegible]%
Rate of Rise 1000-300mb / 300-100mb / 100-ceiling	No data	No data	No Data	600 - 375mb 375 ft/min	600 - 250 mb [illegible] ft/min 250 - 150 mb [illegible] ft/min
Weather Clouds / Ground Wind / Other	Clear 5 15 knots 66°F	Clear 5 knots 66°F	Broken clouds 5 to 10 knots 66°F	Scattered W 15 to 20 knots 75°F	Scattered 5 to 10 knots 64°F
Launching Site	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	Wold-Chamberlain [illegible] Airport	University of Minnesota Airport

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88	89	90	91	92	93	
6 August 1953	12 August 1953	13 August 1953	5 September 1953	16 September 1953	21 September 1953	
Not recorded	1957 GMT --	0557 GMT	1217 GMT	0931 GMT	1754 GMT	
...ing Cylinder 14 ft long ...ircumference	Shelly ½-mil Mylar M-18	GMI 301F Viking - Hot jet sealed Winzen 73-2X100V-311 Polyethylene No duct, straight rigging, straight appendix on bottom	Winzen 73-2X100V-308 Poly 72.8' dia Standard Packing Duct to girdle Thermistors installed GMI 301F #47 30' dia. 2½-mil Bottom plate installed. 24" flat width duct 96' cable	Winzen 2X100V-307 Polyethylene, 73' dia. Straight rigging, duct to girdle GMI 301E, #49 30' dia, 2½-mil Bottom plate installed, 24" flat width duct 96' cable	U/M - 1 Mfg. 18 August-28 August. ½-mil Mylar Eff. gore length 33 ft. Circumference 34.2 ft.	Winzen - double ... 72.8 ft mistors No duct Straight
Not packed	Not packed Leak tested and patched	8/10/53 Hanson, Edwards, Smith	8/25/53 Hanson, Edwards Smith	9/3/53 Hanson, Smith Lahti 9/2/53 Hanson, Smith	8/28/53	9/21... Hanson, Smi...
3 5/8 lbs	3 lbs 9½ ozs	230 lbs	283½ lbs 66½ lbs	276 lbs 61½ lbs	4 lbs 1 oz	261...
30,000 No data	---- 36,000	---- 58,000	54,000 50,000	---- 67,000	22,000 23,500	
... polyethylene super- ...e balloon behavior	To test Mylar super pressure balloon behavior	Single Step step [illegible]	Two step day step flight	Single step 24 Hour step flight	Super pressure mylar glue seal cylinder	St...
5 Hours	6 Hours	20 Hours	16 Hours	24 Hours	4 Hours	
No Data	4 Hours	14 Hours 23 Minutes	Unknown	Unknown	3 3/4 Hours	
No Data	Leaky Balloon	Low Altitude Release	Unknown	Unknown		
213	214	61	X-58	61	215	
...21 10.710 MC ...cle #88 (Special)	Xmtr #2451 10.71 MC Olland Cycle #101	Xmtr #2243 10.15 M.C. Antenna Dropper #121 drops 2000 ft Olland Cycle #96 Commutator & Pulse Forming Network #2411	Xmtr #2245M2 Olland Cycle #122 Antenna Dropper #122, drops 900mb Commutator & Pulse Network #2551 Balloon pulse Xmtr #2471 10.71 MC Balloon pulse Rcvr #2541 10.71 MC	Xmtr #2243 Olland Cycle #121, 123 Antenna Dropper #121, drops at 900mb Commutator & Pulse Forming Network #2492	Xmtr #2457 Olland Cycle #102	Xmtr #2... Antenna Olland Rcvr # Commuta... Balloon
None	None	Sequence Control Programmer #22 Blowdown 354 mb	Sequence Control Programmer #26 Blowdown 390 mb Timer #51	Sequence Control Programmer #25 Blowdown at 310mb	None	Sequenc... B... Down ca... Timer #
None	None	Up #71 (special) ½ RPM 20 Hours Down #46 (special) 2 pippers 24 ft 24 hours - background 3	Up #71 ½RPM 20 hrs Down #46 1/5 RPM 30 hrs 2 pippers Multi-channel pulse recorder #2	Up Camera #50 ½RPM 20 Hrs film Down Camera #61 1/5RPM 30 Hrs film	None	Up #67 1/1... Down #7... 1/2...
None [1]	None	None	Sequence Control Programmer drops 20 lb steel shot at 250 mb 60 lb steel shot at 322 mb 484 lbs Skelly "B"	Pressure follow-up servo #1 150 lbs magnetic steel shot	None	Hose dr... Tensio... Ballast
None	None	None	None	None	None	
None	None	Blinker Beacon #52 Super Flasher #1	Sequence Control Programmer Flasher #52	Sequence Control Programmer Super flasher #2	None	Flasher
None	None	None	None	None	None	
...r Pressure valve ...cial Battery 2V 32, 33	Super Pressure valve Special battery 2V 44, 55	Battery #51 Thermistor Pulse Generator #2283 Infra-red Detector #13 Special Step Flight Instrumentation Tensiometer #12 Hose Dropper & Timer #14 Platform Arm #1	Batteries # 57, T-76 Thermistor Pulse Generator #2285 Infra-Red Detector #25 Balloon Thermistor Pulse Generator #2461 Tensiometer #21 Hose Dropper #15 Platform Arm #2	Batteries #55, T-79 Tensiometers #22,23 Thermistor Pulse Generator #2284 Infra Red Detector #23 Yoke, Arm assembly Magnetic Ballast tanks #3 & 4 Magnetic Ballast Valves #11 & 12	Batteries 41 and 59	Thermi... Balloon Batter...
Helium	Helium	Helium	Helium	Helium	Helium	
		Tow / Lead	Tow / Lead	Tow / Lead		
		477 / 354	817 / 1058	651 / 514		
13.05	10.3	402 / 305	559 3/4 / 911½	546 / 442 3/4	16.54	
11.25	8.9	247½ / 194	391 3/4 / 802½	379½ / 317½	12.537	
10.25	7.9	54½ / 111	168 / 109	167½ / 125½	11.537	
1	1				1	
7.7% 8.9% 9.6%	9.4% 11.2% 12.7%	Total displaced air 20.2% Total Gross Lift 23.4% Total Gross Load 30.6%	Total displaced air 16.2% Total Gross Lift 13.7% Total Gross Load 23.2%	Total displaced air 25.5% Total gross lift 29.6% Total gross load 12.0%	6.87% 7.98% 8.68%	
No Data	850 - 375mb 375 ft/min	600 - 250 mb 335 ft/min 250 - 150 mb 1122 ft/min		None	None	
Broken clouds 5 to 10 knots 65°F	Scattered W 15 to 20 knots 70°F	Scattered 5 to 10 knots 60°F	Cloudless Not recorded 59°F	Clear 8 MPH Southwesterly 48.2°F	Clear - None [illegible]°F	
...ity of Minnesota Airport	[illegible] Airport	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	University of Minnesota Airport	

FLIGHT NUMBER	92	93	94	95	96	97	98	99	100
FLIGHT DATA									
Date Flown	16 September 1953	24 September 1953	29 September 1953	2 October 1953	8 October 1953	19 October 1953 No launch - balloon burst on ground	29 October 1953	13 November 1953	30 November 1953
Time	0931 GMT	1754 GMT	0132 GMT	Not airborne	1753 GMT		1729 GMT	1731 GMT	1750 GMT
Balloon Type	...100V-307 GMT 301R ... ft dia. ...-mil ...ght rig- Bottom plate in- ...to girdle stalled, 24" fla width duct 96' cable	U/M - 1 Mfg. 18 August-28 August. 1-mil Mylar Eff. gore length 13 ft. Circumference 36.7 ft.	Winzen - 21100W-342 double walled poly 72.8 ft dia. 3 thermistors installed. No duct Straight rigging; GMI type 301-P #42 30 ft dia 1.5 mil. duct to bottom. Inflation hose connection at bottom	GMI 72.8 ft diameter polyethylene 125 ft long cylinder girdle 24.7 ft from balloon top One thermistor suspended from duct ring	GMI 72.5 ft diameter polyethylene 125 ft long cylinder Girdle 1/3 way down balloon from top One thermistor suspended from duct ring.	Herb Shelly M-14 172 ft x 253 ft Mylar cylinder Duct flat width 4 ft 7 in duct to bottom of balloon, polished aluminum girdle, polished thistle and clamp ring	GMI cylinder #9 85 Gore length Polyethylene Duct to bottom of balloon Girdle clamped to balloon sideways Inflation fitting into duct above girdle	U/M test cell #1 Herb Shelly #4 ½-mil Mylar Cal. Sup. Pressure 270 cu ft; 14 x 32 ft dia. cylinder 11 ft 10 in effective gore length.	U/M test cell #2 Herb Shelly #3 ½-mil Mylar Bubbler set at 4 mb
Date packed and Packers	...Smith; 9/2/53 Hanson, Smith	8/28/53	9/21/53 Hanson, Edwards, Smith; 9/9/53 Edwards, Smith Hanson	Smith, Hanson, Edwards	Smith, Hanson, Edwards	7/9/53 Huch, Hanson, Smith, Edwards	10/28/53 Huch, Hanson, Smith, Edwards	11/4/53 Huch, Shelly	Huch, Shelly
Balloon weight	...te 61½ lbs	1 lbs ...	267 lbs; 49¾ lbs	238 lbs	238 lbs	93 lbs	218 lbs	3 lbs 14 oz (includes batt. can & fit)	2 lb 10 oz
Altitude Theoretical Maximum	---- 67,000	22,000 23,800	54,000 49,600	90,000 Not airborne	80,000 66,100	105,000 ----	68,500 10,000	19,000 16,400	30,000 30,500
Purpose	... 24 Hour stop flight	Super pressure mylar glue seal cylinder	Stop flight	Test stability of cylinder balloons	Repeat of flight 95	Test stability of cylinder balloon	Altitude stability, sunset effect	Super pressure mylar stability	Super pressure Mylar stability
Duration Planned	24 Hours	4 Hours	17.5 Hours	24 Hours	20 Hours	24 Hours	24 Hours	7 Hours	7 Hours
Actual Duration	Unknown	3 3/4 hours	5 Hours 35 Minutes	-	1 Hour 15 Minutes	--	1 Hour 55 Minutes	46 Minutes	Unknown after 2 hrs 25 minutes
How Released	Unknown				Balloon burst		Low altitude blowdown	Balloon failures	Not known
GONDOLA DATA									
Gondola No.	61	215	X-55	194	194	195	195	216	217
Radio Gear	...3 ...le #121, 123 ...opper #121, drops at 900mb ...& Pulse Forming Network #2492	Xmtr #2452 Olland Cycle #102	Xmtr #2551 1638 K.C. Antenna Dropper #49 drops at 300 Olland Cycle #124 2 RPM channel 2 #125 2 RPM Channel 4 Rcvr #75478-1 10.710 MC Commutator and Pulse Network #2491 Balloon transmitter #2472	Xmtr #2166 Olland Cycle #126 Antenna Dropper #39 drops at 900 mb	Xmtr #2166 1730 K.C. Antenna Dropper #39 drops at 900mb Olland Cycle #126 25PM 45° rotor	Xmtr #2161 1638 K.C. Antenna Dropper #57 Drops 900 mb Olland Cycle #129 2RPM 45° Rotor	Xmtr #2161 1638 K.C. Antenna Dropper #57 drops at 900mb Olland Cycle #129 45° rotor	Xmtr #2452 10.710 M.C. Olland Cycle #102 Antenna unwound at launch	Xmtr #2453 10.710 MC Olland Cycle #103 1 RPM 45° rotor Antenna unwound at launch
Blow Down	...Control Programmer #25 ...blowdown at 310mb	None	Sequence Control Programmer #27ML Blowdown 351 MB Down camera blowdown Timer #53 (set for 1800 GMT)	Sequence Control Programmer #21 blowdown at 130 mb Camera blowdown	Sequence Control Programmer #21 Blowdown 335 mb Down Camera blowdown	Sequence Control Programmer #30 fires 771 mb Down Camera Blowdown	Sequence Control Programmer #30 20 lb steel shot at 54 mb 19 lb steel shot at 170mb blowdown 295 mb	None	None
Cameras	#50 ½RPM 20 Hrs film ...ra #61 1/5RPM 30 Hrs film	None	Up #67 - 0 filter ½ RPM Ilex lens 1/150 f16 double pic 20 hr Down #70 A filter 1/5 RPM Bolsey lens 1/25 f 5.6 blowdown records	Up camera #66 1 RPM 10 Hrs Down camera #51 1/5 RPM 24 Hrs blowdown	Up #66 1 RPM 10 Hours Down #51 1/5 RPM 20 Hours blowdown	Up #63 1 RPM full load Down #48 1/5 RPM 24 Hrs - blowdown	Up #63 1 RPM Full load Down #48 1/5 RPM 24 Hours blowdown	None	None
Ballast	...Follow-up servo #1 ...magnetic steel shot	None	Hose dropper and timer #16 Tensiometers #31 & 32 45° shellac rotors Ballast tanks #13	Sequence Control Programmer 31 lbs steel shot at 66mb 20 lbs steel shot at 102mb 19 lbs steel shot at 160 mb	Sequence Control Programmer 21 lbs steel shot at 66 mb 20 lbs steel shot at 102mb 19 lbs steel shot at 160 mb	Sequence Control Programmer High drop 30 mb 6 lbs Low drop 13 mb 6 lbs Hi bomb 23 mb	Sequence Control Programmer	None	None
Flight Control	None	None	None	None	None	None	None	None	None
Light	...Control Programmer ...sher #2	None	Flasher #53 6V batteries T-85, T-86	Sequence Control Programmer	Sequence Control Programmer	Sequence Control Programmer	Sequence Control Programmer	None	None
Cosmic Ray	None	None	None	Cosmic Ray single counter	Cosmic Ray single counter sonde	Cosmic Ray single counter Cosmic Ray emulsion plates	4 x 4 pack emulsion plates Single counter sonde	None	None
Temperature Recording	...#55, T-79 ...ers #22,23 ...r Pulse Generator #2784 ... Detector #23 ...assembly ...Ballast tanks #3 & 4 ...Ballast Valves #11 & 12	Batteries 40 and 51	Thermistor Pulse Generator #2462M1 Balloon thermistor Pulse Generator #2462M1 Batteries #58, T-71	Thermistor Pulse Generator #2701 Water Tank #14 Batteries # T-63, T-66	Thermistor pulse generator #2701 Thermistors inside and outside gondola Water tank #14 Batteries # T-63, T-66	Batteries T-84 Water tank #15	Water tank #15 Batteries T-84	Battery	Batteries 64 & 70
Miscellaneous									
LAUNCHING									
Inflation Medium	Helium	Helium	Helium	Helium	Helium	Helium	Helium	Helium	Helium
Displaced Air	Lead 334 442 3/4	14.54	557 #; Lead 904 #	NOT AIRBORNE	520	NOT AIRBORNE	404	12.26	10.95
Gross Lift	[illegible]	12.57	481; 814½		448.5		348	10.56	9.43
Gross Load	317½	11.57	392; 709		368.5	176.5	326	9.56	8.43
Free Lift	125½	1	89; 105½		80.0		22	1.0	1
Percentage Free Lift of Gross Load, Lift, Air Displaced	...placed air 25.5% ...ss lift 29.6% ...ss load 42.0%	6.87% 7.95% 8.64%	Total Displaced Air 17.9 % Total Gross Lift 15.0 % Total Gross Load 17.6 %		15.40% 17.85% 21.70%		5.45% 6.32% 6.75%	8.15% 9.46% 10.47%	9.12% 10.60% 11.86%
Rate of Rise 1000 - 300mb, 300 - 100mb, 100 - ceiling	None	None	None		1000 - 400mb 970 ft/min; 400 - 110mb 1140 ft/min; 110 - 55 mb 1360 ft/min		No record during ascent	1000 to 540 mb 400 ft/min	1000 - 530 mb 390 ft/min; 530 - 315 mb 325 ft/min
Weather Clouds, Ground Wind, Other	Clear 8 MPH Southwesterly 48.2°F	Clear None 65°F	None	... 25 mph gusty	High cirrus Light from SSW 60°F	Clear light from SSE 65°F	Clear 20W - gusty 69°F	Scattered Cirrus SSE - Gusty	Clear NW 2 MPH 25°F
Launching Site	...y of Minnesota Airport	University of Minnesota Airport	None	University of Minnesota Airport	Old University of Minnesota Airport	Old University of Minnesota Airport	Old University of Minnesota Airport	New University of Minnesota Airport	University of Minnesota Airport

Radio Frequency	3415 K.C.	3415 K.C.	10.260 MC	10.170 MC	3415 K.C.	3415 K.C.	3415 K.C.	10.710 M.C.
Time in Contact Miscellaneous	Entire Flight		No Signal received	1 Hour	Entire Flight	3 Hours 15 Minutes	21 Hours 51 Minutes	3 Hours 13 Minutes
Airplane Type Hours in Contact	Twin engine Beech 15 Minutes	None	None	None		None	None	None
Truck When Dispatched	None	None	None	None		None	None	None
Theodolite Stations on Hours in contact	None	None	None	None		None	None	None
RECOVERY IMPACT								
Estimate Before Flight	Green Bay, Wisconsin	Green Bay, Wisconsin	None	None	Green Bay, Wisconsin	None	Northeastern, U.S.	None
Actual Impact Balloon	Turtle Lake, Minnesota	Stetson, Maine	Unrecovered	Between Sparta and Black River	Whitehall, Michigan	Unrecovered	5 miles West Coshocton, Ohio	5 miles west of Wausau, Wisconsin
Load	Turtle Lake, Minnesota	Stetson, Maine	Unrecovered	Between Sparta and Black River	Lake Michigan - outside Pentwater on the Michigan coast	Unrecovered	5 miles West Coshocton, Ohio	Same
Dates and Time Balloon	2158 - 30 July 1953	1430 - 6 August 1953		1745 - 12 August 1953	Unknown		Found 1400 - 17 September 1953	2240 - 24 September 1953
Load	2158 - 30 July 1953	1430 - 6 August 1953		1745 - 12 August 1953	2010 - 13 August 1953		Unknown	2240 - 24 September 1953
Notified of Position How When	Tracking Plane 2158 - 30 July 1953	Capt. Crean, A.F.B., Bangor, Maine Telephone		Telephone 0810 - 13 August 1954	Telephone 1035 - 16 August 1953		Telephone 9 November 1953	Telephone 0045 - 25 September 1953
Recovered by Balloon Load	Ney, Winckler, Howell, Atkinson, Bot Anderson, Smith	Mantis picked it up and shipped it to U/M by express		Smith - carryall Smith - carryall	Finder shipped via RR express Smith		Railway express Railroad Express	Hanson - carryall Hanson - carryall
Gear Recovered	Complete assembly including both balloons	Complete assemblage except the tow balloon fittings		Complete Assemblage	Gondola and Balloon Hardware		Balloon Hardware, platform arc, chute, rigging, gondola, and ballast servo.	Complete assemblage
Miscellaneous			Tmtr, Antenna matching was adjusted prior to launch with antenna parallel to the ground. After launch Tmtr became detuned due to change in antenna position. No signal received.			Tensiometer record stopped after 4 Hours 25 Minutes just as balloon reached 3rd step. Indications are that the motor froze at the higher altitude.		
CAA CONTACTS								
Preflight	0220 - Champlin to Brown	0215 - Champlin to Kriewein 5 August	None filed	None filed	0410 - Champlin to Brill	1115 - Howard to Brown	0905 - Howard to Brill	1735 - Howard to Sena
Take off	0315 - Champlin to Brill	0312 - Champlin to Kriewein 5 Aug	None	----	0600 - Champlin to Brown	1245 - Howard to Brown	0944 - Howard to Brill	1755 - Champlin to Mud
In Flight	None	None	None	----	----	None	None	None
Termination	0415 - Champlin to Brill	None	None	——	----	None	None	None
GONDOLA RECORDS								
Up Camera	Duration of Flight	248 frames, duration of flight	None	None	263 Frames, Duration of flight	Unrecovered	NOT	None
Down Camera	Duration of Flight	80 Frames, duration of flight	None	None	704 Frames, Duration of flight	——	RETURNED	None
Other			None	None	None	——	TO DATE	None
FWT WEATHER CENTRAL NOTIFICATIONS								
Launch	310335 Champlin	050430 Champlin	None filed	None	130650 Champlin	None	161326 Howard	None
In Flight	None	None	None	None	None	----	None	None
Termination	Mail Belinski	None	None	None	None	----	None	None
PHOTOGRAPHIC COVERAGE OF LAUNCH, ETC.								
16 mm motion picture	200 ft - lead balloon layout, inflation prelaunch	None	None	None	None	None	None	None
Rolliflex	63 Frames at launch	53 Frames at launch 5 Frames returned tanks	12 Frames at launch	25 Frames at launch	53 Frames at launch	77 Frames at launch	54 frames at launch	None
Other	None	None	None	None	None	None	None	Icoflex - 34 frames at launch
PRINCIPAL CHARACTERISTICS OF FLIGHT	Because of leaky tow balloon this flight was only in the air a short time. It landed at Turtle Lake with the lead balloon moored to the collapsed tow balloon. The lead balloon was easily sighted because it was about 75 feet up in the air.	Good data obtained on drags and altitude warming on this night step flight.	No data	Super pressure was not maintained. This balloon leaked and descended after reaching ceiling.	System floated OK but tensiometer failed early in the flight. The tensiometer data is primary data on step flights.	Data obtained for most of the time in this two step step flight.	Good 24 hour single step flight. Tension throughout flight as well as two channels of pressure data were received. Ballast follow up apparently worked satisfactorily.	1st first glued Mylar balloon successfully held super pressure at altitude. Stability at altitude was maintained for one hour and 30 minutes. During this time the super pressured balloon apparently rode through vertical motions of the air weathering them like a floating cork.

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Radio Frequency	1615 K.C.	10.710 M.C.	1638 K.C.	1638 K.C.	1637 K.C.	1638 K.C.	1638 K.C.	10.715 M.C.	10.710
Time in Contact Miscellaneous	21 Hours 51 Minutes	3 Hours 43 Minutes	5 Hours 35 Minutes	NOT AIRBORNE	51 Minutes		1 Hour 52 Minutes Antenna dropped 13 minutes after launch	Entire flight 16 Minutes	2 Hours 25 Minutes Signal disappeared at 2015 GMT
Airplane Type Hours in Contact	None	None	None		—				
Truck When dispatched	None	None	None		—		at launch - 1733 GMT - entire flt.		
Theodolite Stations on Hours in contact	None	None	None		—				
RECOVERY IMPACT									
Estimate Before Flight	...eastern, U.S.	None	Buffalo, New York		Flint, Michigan		None	None	None
Actual Impact Balloon	West Coshocton, Ohio	5 Miles east of Wausau, Wisconsin	Cary Lake, Michigan		4 Miles West of River Falls, Wisc.		5 Miles Southwest of Menomonie, Wisconsin	7 Miles S Lindstrom, Minnesota	4 Miles SE Collinsville, Ill
Load	West Coshocton, Ohio	Same	Unrecovered		4 Miles South of Hudson, Wisc. in St. Croix River		2½ miles NE of Baldwin, Wisc.	7 Miles S Lindstrom, Minnesota	4 Miles SE Collinsville, Ill.
Dates and Time Balloon	...00 - 17 September 1953	2310 - 26 September 1953	1630 - 22 October 1953		1905 - 8 October 1953		2015 - 29 October 1953	16 November 1953	Found: 6 December 1953
Load	Unknown	2210 - 25 September 1953	None		1905 - 8 October 1953		1933 - 29 October 1953	16 November 1953	6 December 1953
Notified of Position How When	Telephone 9 November 1953	Telephone 0065 - 25 September 1953	Telephone 22 October 1953		Telephone 0120 - 8 October 1953		Visual track to impact by project personnel	Telephone 16 November 1953	Telephone 0100 - 7 December 1953
Recovered by Balloon Load	Railway express Railroad Express	Hanson - carryall Hanson - carryall	Railway express		Edwards, France Edwards, France		Hanson, Edwards Serley	Edwards Edwards	Returned by Railway Express Returned by Railway Express
Gear Recovered Miscellaneous	...oon Hardware, platform arm, rigging, gondola, and ...	Complete assemblage	Cable, girdle, ring, balloon fabric thermistor pulse generator		Complete balloon, gondola and single counter		Complete assemblage After balloon was initially inflated it began to lose its lift and finally collapsed. A large tear was found in the top. Also several pleats had pulled loose at the top and a number of small holes made by the tapes. The main hole was about 1 ft sq. All the holes were repaired and the balloon was reinflated. The balloon was launched in a similar manner of platform launch.	Complete assemblage	...mplete assemblage
CAA CONTACTS									
Preflight	Howard to Brill	1735 - Howard to Wade	0025 - Chase to Brill 29 Sept.	1717 - Howard to Greenbush	1710 - Howard to Buss		1520 - Stoddart to Buss	None	...650 - Howard to ---
Takeoff	Howard to Brill	1755 - Champlin to Bud	0135 - Chase to Brill	1343 (cancelled)	1806 - Howard to Buss		1730 - Stoddart to Buss		
In Flight	None	None	1522 - Chase to Garby 1732 - Chase to Buss		1851 - Howard to Buss		1847 - Howard to Buss 1908 - Stoddart to Buss		
Termination	None	None	1753 - Atkinson to Garby		1902 - Howard to Buss		1938 - Howard to Buss		
GONDOLA RECORDS									
Up Camera	NOT	None	UNRECOVERED		None		3.2 frames	None	
Down Camera	RETURNED	None			None		None		
Other	TO DATE	None			None		None		
EMT WEATHER CENTRAL NOTIFICATIONS									
Launch	161326 Howard	None	290145 Chase		081752 Gergen		None	None	
In Flight	None	None	None		None		None		
Termination	None	None	291800 —		081920 Welinski		None		
PHOTOGRAPHIC COVERAGE OF LAUNCH, ETC.									
16mm motion picture	None	None	None		200 ft 16 mm 29 exposures - balloon in flight	250 ft 16mm	500 ft, 16mm	None	16mm 60 ft
Rolliflex	...mes at launch	None	None				None		
Other	None	Inoflex - 34 frames at launch	None				Astro - 12 frames balloon in flight		
PRINCIPAL CHARACTERISTICS OF FLIGHT	...24 hour single step flight. ...on throughout flight as well ...o channels of pressure data received. Ballast follow up ...ently worked satisfactorily.	1. First glued Mylar balloon successfully held super pressure at altitude. Stability at altitude was maintained for one hour and 50 minutes. During this time the super pressured balloon apparently rode through vertical motions of the air weathering them like a floating cork	Balloon system stopped and leveled three steps successfully and provided good tension and temperature data of tow balloon at night. Frozen ballast was believed cause of fourth step failure. Top altitude reached was 180 mb.	The attempted launching of a fully extended large cylinder balloon with a girdle below the bubble was cancelled after it was buffeted in the wind and began to lose gas. The tapes on the duct at the top ring stuck to other balloon fabric and pulled holes in the balloon during the buffeting.	The balloon in flight 95 was repaired and launched successfully by the same method. The rate of rise was high - 1000 fpm to 30,000 fpm and up to 1500 fpm to 59,000 ft at which altitude the balloon failed. Pictures showed the girdle was not slipping down the balloon properly, possibly because of the larger amount of fabric.	When balloon was erected there was a mild shock as the bubble reached the vertical position. One of the heat seals on the lower third of the balloon parted with a perceptable "pop" and the gas transferred out of the bubble into the canopy. When the corset was released, the canopy flew into the air and dumped the Helium causing several more seams to split. Following this a number of seals were checked and in most cases the seals could easily be broken by simply mildly snapping them. In some places the seals were much stronger and couldn't be split.	Balloon had low rate of rise - 20 ft/min. Leveled at 10,000 ft and began descending. [illegible] was released by low altitude safety device and came down on parachute.	The balloon was launched on a windy day. In the first attempt kerosene was spilled and the balloon had to be dragged upwind into the hangar to be refilled. The balloon failed as it approached ceiling probably the result of wind damage during launch.	Balloon had fairly constant rate of ascent to 30,000 ft. Where it leveled 1 Hour 20 Minutes after launch. It remained flating level until 2015 when the signal was lost.

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