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OFFICE SECURITY ADVISOR

PROGRESS REPORT ON
HIGH ALTITUDE PLASTIC BALLOONS
CONTRACT NONR-710 (01)
DECEMBER 13, 1951 to JUNE 15, 1952
VOLUME III
SECRET SECURITY INFORMATION

Copy No. 3 1

SECRET

PROGRESS REPORT ON
RESEARCH AND DEVELOPMENT
IN THE FIELD OF
HIGH ALTITUDE PLASTIC BALLOONS

CONDUCTED UNDER
CONTRACT NONR-710(01), NR 320 159
FOR PERIOD DECEMBER 13, 1951 to JUNE 15, 1952
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

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SECRET

PROGRESS REPORT ON CONTRACT #710(01)

From Initiation of Contract to June 15, 1952

VOLUME III

SECRET SECURITY INFORMATION

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SECRET

PROGRESS REPORT ON CONTRACT #710(01)

From Initiation of Contract to June 15, 1952

INTRODUCTION AND SUMMARY

Work on the subject contract was initiated on September 3, 1951, by a telegram to the University of Minnesota indicating that funds for this contract would be available. The contract listed four specific tasks on the contract:

1. Research and Development on the Balloon as a Vehicle.
2. Research and Development on Associated Instrumentation.
3. Research and Development of Countermeasures.
4. Research and Development in Specific Meteorology.

This progress report covers the work performed under the contract during the period in which the first twenty balloon flights were made. This period ends June 15, 1952. Work under the subject contract will be described briefly here under the headings corresponding to the tasks in the contract.

1. <u>Research and Development on the Balloon as a Vehicle.</u>

One of the first decisions which were made in connection with pursuing this work was that a more satisfactory launching method needed to be developed before rapid research on the behavior of the balloons could be carried out. In undertaking this development, our philosophy was the following: First, balloons should be launched in such a way that accurate weigh-off of the free lift could be carried out. In previous plastic balloon operations, the launching method adopted had committed the investigators to calculate the lift on the basis of pressure and volume of gas inserted in the balloon.

Since the free lift, which determines the rate of rise, is of the order of ten percent of the weight of displaced air, it is easy to see that a ten percent error in calculation of the gross lift could either double the free lift or reduce it to zero. Since it was believed desirable to know the free lift to ten percent, this would impose a requirement of knowledge of the gross lift to one percent —a value almost impossible to achieve without weighing off the balloon.

The second requirement which was set up for a launching system was that a launching should be possible in relatively high winds. This requirement almost automatically limits one to using the system in which the amount of exposed polyethylene is minimum. Several systems were tried in Flights #1, #2, #3, and #4. By Flight #5, the basic features of the present launching method were developed. This method is described in detail in the section of the report entitled Launching and Packing. Flight #6 was the first completely successful flight launched by this system. In Flight #7, several minor difficulties in the rigging of the balloon caused the launching to be unsuccessful, and, in turn, led to the improvement of a number of details in the system. Flights #8 through #20 were all launched successfully with this system without any regard to ground winds. Flight #9, for example, was launched in the open without the benefit of a wind screen, in an 18-knot wind. There was no evidence in any of these flights of damage to the balloon caused by the launching system. Because of the simplicity of the system, it has been possible to launch a full scale flight with only two men, and in principle, it could be carried out by one man alone. The balloon can be airborne within an hour after the time the equipment arrives at the launching site.

In connection with development of vehicles, we have investigated balloon shape. This work is included in the section entitled Balloon Shape, and, briefly, consists of the following calculations: Calculations have been made of the stresses in the present cone-on-sphere balloon and the volume defect produced in these balloons at various gross loads. Similar calculations have been carried out for a balloon consisting of a sine wave joining a sphere, to indicate that much more satisfactory stress distributions can be obtained than exist in the cone-on-sphere balloon. Finally, calculations have been made of the "natural" shape balloon, following the lead on this subject indicated by Professor Ralph Upson and the General Mills Aeronautical Laboratory. It was found possible to formulate this problem in such a way that it could be solved using the analogue computer at the University of Minnesota. The "natural" shape balloon is that balloon which has zero stress around a circumference. It is the shape that a flat sheet of polyethylene would take on if it were filled with water and picked up. The calculations included in this report are for the case in which the weight of the balloon fabric is small compared to the gross load. By mechanization of the problem with the computer, it is possible to solve for the shape under any circumstance of fabric weight, and such solutions will be included in later reports. Families of curves have been calculated for weightless natural shape balloons, with zero pressure at the bottom and with sub- and super-pressure at the bottom.

Another section of the report dealing with the research and development of vehicles is the section entitled Balloon Physics.

This section contains a mathematical study of the equation of motion of balloons; a series of simulated balloon flights made on the analogue computer, using as a basis of the calculation the results of the previously quoted study; and a series of nomographs. The nomographs have proved to be quite useful for rapidly determining the theoretical ceiling of balloons, the sunset time on the balloons, and certain thermodynamic features of balloon flight which are described in detail in the text. One feature of the University of Minnesota launching method is that an aluminum ring is present on the balloon which acts as an automatic appendix, sliding down as the balloon fills out, and keeping the balloon almost spherical above it, and straight below it. The mathematics associated with the behavior of this girdle are included in the Balloon Physics section.

2. Research and Development on Associated Instrumentation.

In order to successfully launch instrumentation to determine the behavior of the balloon in flight, it was felt to be desirable to consolidate this instrumentation in a unitized package. This package includes the packed parachute, pressure telemetering system and transmitter, command receiver, barograph and temperature recorder, and cameras which photograph the balloon and terrain below. The unitized gondola was introduced in Flight #4, and has been used ever since. Pressure telemetering is carried out on a low frequency, 1600 Kc. to 1800 Kc., and the sensing instrument is the bellows which makes contact with a modified Olland cycle. The absolute accuracy of this system is limited by the accuracy of calibration, and has been found to be good to within a millibar at high altitude. It is much more sensitive than this to relative changes in altitude, and readily shows a change of less that 200 feet out of 85,000 feet. Because of the low frequency transmitter and the consequent long antenna, it was necessary to devise instrumentation to release the antenna after the balloon was in the air. The reception and analysis of the balloon transmissions are carried out in a tracking center equipped with receiving and data-recording equipment. A camel-back semi trailer is being outfitted to act as a mobile tracking center. A DAQ direction finder system is used to obtain bearings on the balloon.

3. Research and Development of Countermeasures.

Only preliminary thinking has been carried out in connection with countermeasures, and nothing is included in this first report on the subject.

4. Research and Development in Specific Meteorology.

The trajectories of the balloon flights are being analyzed to provide information on the flow in the upper air. The system of camera tracking has been checked by theodolite and has proved quite successful in providing accurate balloon positioning. The accurate and frequent positioning has already revealed some significant details on the fine structure of the wind at high elevations. The detailed trajectories at constant altitude during the spring period of light winds show rapid changes of wind speed and direction. In these cases the large-scale flow, as would be depicted on the weather map, is obscured by the small scale fluctuations (fluctuations with periods of a half hour or less). This phenomenon has, so far, only been observed in the stratosphere.

The photographs have also provided an independent measure of altitude and, therefore, a means of computing atmospheric temperatures. There are, however, limitations in the accuracy of this method for the computation of temperatures and better methods of direct measurement may be devised.

Although this report does not include detailed interpretation of the flights, the principal results obtained from this series of flights fall in these categories:

1. Flight characteristics of balloons with and without appendicies.
2. The affect of air intake on balloon behavior.
3. The rate of descent produced by sunset on balloons which can take in air during descent, and the behavior of these balloons when ballasted by command operation.
4. Preliminary indications of the behavior of ammonia-filled balloons were obtained in Flights #11, #15, and #17. These indications are that because of the infra-red absorption properties of ammonia, it promises to be an important stabilizing factor in balloon flights.

This series of flights indicates that research should be continued on the following problems:

1. Appendix Design. The design of an appendix which excludes air during balloon descent but allows the balloon to valve freely upon reaching ceiling must be carried out. Without such an appendix, it is not possible to reproduce flight conditions, or to make a balloon rise to its original ceiling once it has descended.
2. Flight Constants. In order to interpret rate of rise and descent data, controlled flights must be made in which ballasting and valving are carried by command on a balloon which does not take in air during its motion.

3. Mixtures of Inflating Gases. Further experiments will be carried out using ammonia and helium-ammonia mixtures to exploit this interesting technique.

SUMMARY OF OPERATIONAL RESULTS ON THE BALLOON PROJECT

1. Introduction

To date a total of 20 launching attempts have been made on this program for the general purpose of developing the launching technique, testing instrumentation, and wherever possible, measuring the balloon performance as carefully as possible to better understand the factors governing the vertical and horizontal flight of plastic balloons. While adhering to the basic objectives of studying balloon performance, each flight was instrumented for a specific purpose which often depended on the results obtained on a previous flight. This provided a maximum speed in perfecting techniques. The general philosophy was to provide each flight with instruments which would give as much information as possible about the behavior of the particular balloon used, so that one would not have to depend on statistics to correct various difficulties which developed in the program.

Along with the development of packing, launching, instrumentation, and flight measurements, the operational side has been developed to provide good tracking and recovery of equipment, which not only saves effort in reproducing the instruments but also gives very valuable information where a malfunction is encountered.

This report will give a summary of various features of this series of flights. At present the experiments are not complete enough to warrant a detailed report which would present at the same time reliable data on the constants which go into the equations of motion, effect of superheat, earth radiation, etc.

It is also the general philosophy of the project to develop a flight which can be entirely controlled from the ground so that the response of the balloon to changes in the amount of lifting gas and ballast can be studied.

It is felt that in the long run this information is necessary to design a suitable automatic device which will control the balloon in a specific way during the flight.

Besides developing a new method of launching, experiments have been begun using ammonia for inflation in place of helium for various reasons which will be outlined below.

Due to the summer meteorological situation in Minnesota, the balloon flights are kept in an area where radio contact, recovery, and tracking can be carried out easily. This facilitates the basic experimental work. For the long range objectives of the program, however, in which very long duration flights will be conducted, instrumentation is in an advanced stage of development, and it is expected that this phase of the program will be under way during the fall and winter, when balloon flights will not be confined to the Twin Cities area.

2. Flights Using Helium Inflation

Of the 20 flights or attempted flights, all but three used helium as the lifting gas. The first three flights were essentially launching experiments and carried a preliminary type of radio telemetering gear. Beginning with Flight No. 4 a more or less standardized type of gondola was used which contained all the instrumentation in one package. A discussion of the basic gondola which is currently in use is contained in another section of this report. Complete data including time-altitude curves for all flights are included.

Usually several simultaneous experiments were carried out on each flight, for example, testing of command receivers, measurement of sunset effect on balloons of various thicknesses, photographing the balloon in flight to aid in locating stresses in the plastic and to observe the operation of the appendix valves, obtaining photographic trajectories and time-altitude curves, etc.

In the course of these flights data has been obtained on the following subjects:

a. Effect of sunset on balloons of 1, 1.5 and 2-mil thickness.

b. The rate of rise as a function of gross load and free lift.

c. The behavior of the launching technique under various weather conditions.

d. The operation of command devices installed in the balloon.

e. The precise behavior of balloons with and without appendices and the effect of appendices.

f. The appearance of the balloon as viewed from the gondola throughout the entire flight.

g. Trajectories measured by the balloon down camera, theodolite, and airplane tracking.

h. The development and testing of timers, blow-down devices, flash lamps, etc., as required by CAA regulations.

i. The perfection of a telemetering link suitable for the spring and summer operations for relaying pressure, temperature, ballast information, and serving as an indicator for the command operations.

j. The appearance of the balloon as seen from a camera in its crown.

3. Flights Using Ammonia Inflation

Three such flights have been made, the first of which used a mixture of helium and ammonia. It was considered worthwhile to investigate ammonia as a lifting gas because the diffusion leakage is 2.9 times less than helium, because it can easily be stored in liquid form both for the initial inflation of the balloon and in the gondola itself for replenishing the gas in the balloon, and because its infrared absorption is large while that of helium is negligible. Ammonia carried as liquid ballast can be evaporated into the balloon with an advantage of 1.7 times in weight over dropping liquid ballast to maintain altitude. If ammonia is dissociated by ultra violet, an additional amount of lift is gained because more molecules are formed at the same pressure.

The ammonia flights did not differ in the general instrumentation from the helium flights. The behavior of balloons inflated with ammonia, however, is quite different, and the results are believed to be very significant. In the case of ammonia, the lifting gas constitutes a large part of the gross load. Due to the greater density, about a 15,000 foot lower ceiling altitude is obtained for the same payload and balloon volume than with helium.

In the ammonia flights, strong earth radiation effects were observed; for example, a flight which had been level during the day began to descend at sunset, but abruptly leveled off during the night and began a slight climb again at approximately 40,000 feet. A flight launched with a low free lift and an initial rise rate of 400 feet/ minute accelerated during the ascent to 1,060 feet/minute. These facts, plus other observational data obtained on the ammonia flights, are being fitted into a consistent picture of the flight performance of ammonia balloons, but at this time the general statment can be made that ammonia inflation appears to have many advantages over helium for long-duration flights.

As stated above, there is a loss in altitude suffered with ammonia which can be regained by the use of a larger size balloon. It would also be desirable to use a larger balloon, as the 73-foot size with the new packing technique does not provide sufficient inflation volume in the bottom 1/3 of the balloon if ammonia is used to carry the desired payload. Since the ammonia gas valves only about 1/6 as fast as helium, some re-design of the balloon appendix opening is also necessary. It is expected that all the necessary modifications can be included in the new balloon shape under development (the zero circumferential stress type balloon).

FLIGHT NO. 1

This flight was launched December 8, 1951, at 0900. The balloon was a General Mills 2 mil thick 851. The material was Visking DE-2400. The purpose of the flight was to test the launching method. In line with the objectives of our project, to develop a launching method allowing weigh- ff and utilizing a minimum size bubble, we investigated on this flight the following method: The parachute, which would act as a load-carrying parachute at the termination of flight, was picked up and attached to a large ring (used only during this operation) so that the upper part of the parachute acted as a bag. Small metal rings were spliced into the shroud lines where they joined the cloth on each shroud line. The balloon was accordian-pleated, starting from the bottom, into this bag with enough of the balloon left out to produce the bubble. At a position at the bottom of the bubble, rings were attached by tape to each gore of the balloon on the load tapes. A rope was passed through the rings on the balloon and the rings on the parachute lines. There were two or three balloon rings between each parachute ring. The line was in turn passed through a squib cannon operated by a clock timer. The squib cannon was protected by glass wool and a metal can to eliminate injury to the balloon. The assembly was hung by the parachute rings in a large ring stand about 7 ft. high x 6 ft. in diameter. The complete assembly resembled an ice cream cone with the parachute shroud lines and the folded cloth acting as a conical bag hanging from the stand. The bubble of the balloon would carry the bag when inflated. The timers for load release were packaged at the crown of the parachute so that they actually were situated at the bottom of the bag. Before attempting this rather drastic launching method, experiments had been performed with 20' balloons attached to long lines so they could be pulled back to the ground. These preliminary experiments indicated that a parachute packaged in this way would open in a distance of about 50' to 75'. It was hoped that with this packaging method the parachute would act to help slow the fall of the balloon tail after its release in the air. In order to give the parachute time to open and break the fall of the load, a 100' piece of 100-lb. test line was attached between the balloon load ring and the parachute. In addition to this, 20 feet of double half-inch shock cord was inserted in series with this line. The ring stand was set up at the launching site, and the ice cream cone suspended from it with the uninflated bubble laid out to the side. Helium was blown in through a side incision until inflation was complete, at which time the plastic inflation tube was removed and the slit patched with tape. The assembly was weighed off with a spring balance and disengaged from the ring stand, which could be separated into two halves to facilitate removal from the balloon.

This flight carried a radio beacon 1746 kc, a dropping reel designed to unwind the antenna as the balloon went into the air, and a package of nuclear emulsions encased in a lead block to increase the load weight and give cosmic-ray data. The balloon tail was set to release one minute after launching. The balloon was set free when the squib cannon fired, the ice cream cone package fell away from the balloon and unfolded the tail of the balloon as the load dropped away. However, the parachute failed to open by the time the 100' line was fully extended and this line snapped, allowing the load to fall to the ground on the parachute. The balloon was not recovered. Subsequent calculations showed that about 500 feet of line would have been required to open the parachute and decelerate the load properly.

Conclusions

Methods of packaging the balloon which allow it to unroll itself in the air involve rather large accelerations and are probably to be avoided as a part of any launching scheme, unless elaborate precautions are taken to reduce these accelerations.

FLIGHT NO. 2

This flight was launched on January 18, 1952, at 0900. It was a General Mills 73' (733) 1 1/2 mil thick balloon. The balloon was packed in the sub-basement of the Physics Building using the corridor and the elevator shaft for hanging and draping the fabric. This flight, like No. 1, was a launching test. It was felt that the method of No. 1 had undesirable features, and a new method of folding the balloon was tried. Except for minor details, the launching method used in Flight No. 2 is the method used at present and was adopted in the complete series of flights from No. 2 to No. 20. This method is described in some detail in Section No. 2 entitled "Packing and Launching." At the time of Flight No. 2, no corset or inflation plug was used. The canopy hung freely from the inflated bubble, and helium was blown in through the open appendix by a plastic tube. The lower edge of the canopy was equipped with hold tapes attached to the balloon load tapes. These were to enable the launching crew to control the bubble in a wind. Figures 1 and 2 in Appendix 1 show various aspects of the inflation which was carried out in practically zero wind. The balloon carried a load consisting of parachute, timer release, and ballast. After weighing off, the diaphragm ripcord was pulled. When it was ascertained that gas was transferring into the canopy, the balloon was released. The gas transferred completely in about two minutes and at this time the balloon levelled off. It was apparent that helium had been trapped under the canopy and contributed to the free lift. This helium escaped when the balloon unfolded. The balloon then drifted away, descending very slowly, and was recovered about 30 miles away from the launching site. The section of the balloon clamped between the girdle and the tire was brought back to the laboratory and unfolded. There was no damage observable that could be attributed to packing or launching.

Conclusions

This launching was encouraging, as it demonstrated that the gas transferred properly and gave no apparent damage to the balloon. We believed at this time that with further developments the Minnesota launching method would be satisfactory for our purposes.

FLIGHT NO. 3

This flight was launched February 8, 1952, at 1630. The balloon was a General Mills 851 1-mil thick balloon. The ground wind was 20 knots. The launching took place behind the windscreen, and the weather map showed a definite jet stream at 30,000 ft. As in Flight No. 2, this balloon was packed under adverse conditions in the Physics Building sub-basement. In spite of the fact that we had not gotten a balloon to altitude by this time, we optimistically scheduled Flight No. 3 for 24 hours, and incorporated in this flight a ballast control mechanism. The flight, however, should be realistically considered as a second test on the new launching method. Several changes were made in the launching method. Instead of allowing the canopy to hang down, it was secured to the bottom of the balloon by a tire and girdle arrangement similar to the one which acts as a gas valve during the flight. The corset at the bottom was a counterpart of the canvas girdle used at the top except that it was equipped with canvas straps which could be used for holding the balloon down. At take-off time, this lower girdle is removed by releasing the air in the inner tire and pulling this tire out through the ropes. The girdle is then allowed to go with the flight. This girdle also served to make a gas-tight clamp for the inflation tube, which in Flight No. 3 consisted of the standard red polyethylene tubing heat-sealed to a flared-out section that clamps under the girdle. Flight No. 3 was also the first flight which we equipped with a low altitude release (nicknamed "Buddy's ball"). The details of this device are described in Section No. 5 entitled "Instrumentation." In addition to 10 gallons of kerosene for ballast, timers, and a ballast control mechanism, the flight carried a cosmic-ray telescope and 9 1/2 lbs. of photographic plates. To satisfy the CAA requirement, a blinking light was also flown. This was the first flight in which a standard packed cargo chute was used. This method has been utilized on all of our subsequent flights. The packed chute is opened at the instant of release by having its ripcord attached to the balloon. It is a great aid in keeping the balloon load compact and will not give trouble in case of balloon failure, provided a low altitude release is present on the flight which guarantees that the load is separated from the balloon at some time during the flight. A photograph of the load is shown in Appendix 2. As in Flight No. 2, the launching method worked very satisfactorily with one shortcoming. The corset at the bottom of the balloon, which had been equipped with canvas handles, was used to hold the balloon after gas had been put in. There was enough gross lift in this flight so that the corset slipped off prematurely allowing the canopy to free itself and drape down. In spite of the 20 knot wind and the fact that the canopy was free for some 10-15 minutes during launching, no trouble was encountered because of this. After the balloon was launched, it disappeared into an overcast and no data was obtained by the telemetering link. The reason for this was that on this flight we had flown a first model antenna dropper. This consisted of a reel which allowed the antenna to unwind after the balloon was in the air. During launching a helium bottle was dropped on the reel and damaged it to the extent that only about half of the antenna came down. The load from this flight was recovered two months later on April 7, at Reed City, Michigan. It is very probable that the balloon was damaged in the jet stream and carried at this altitude for an appreciable distance. The load recovered was in rather poor condition, and it was not possible to determine whether or not the ballast system had operated. At the time of this flight we began to be concerned about the effect of the jet stream on balloons. Homer Mantis made an analysis of approximately 12 of our previous Skyhook flights and discovered very high correlation between balloons which broke at 30,000 feet and the presence of the jet stream.

Conclusions

The flight gave a second successful demonstration of the launching method, and gave indications that the jet stream may be a potential hazard to balloons.

FLIGHT NO. 4

This flight was launched March 1, 1952, at 0922, and used a General Mills 73' 2-mil thick balloon equipped with a standard appendix. This balloon was packaged in the Physics Building sub-basement. During the draping in the elevator shaft, the balloon dropped when a line snapped but was repaired and, except for some twisting and unevenness in the distribution of the fabric, was unaffected. Like Flight No. 3, the canopy was clamped at the bottom with a tire and girdle arrangement and handling loops on the canvas girdle. It was intended in this flight to test the balloon performance and launching method. The flight was purposely made short (3 1/2 hours) to assist in recovering the gondola. For the first time a unitized gondola had been prepared, prototypes of which were used for the remaining flights of this series. This gondola is described in Section No. 5 on "Instrumentation," and a photograph of it is shown in Appendix 2. The gondola included a 1746 kc beacon, a 220 mc beacon, timers, and Buddy's ball. On this flight the transmitting antenna was carried out by a meteorological balloon, because of the apparent impracticability of the unwinding reel used on Flights 2 and 3. Considerable difficulty, however, was encountered in using this balloon due to high static voltages on the antenna and the difficulty of handling the balloon in the wind. The load included nuclear emulsions and a single counter cosmic-ray sonde hung from the outside of the balloon. The sonde transmitted pressure and cosmic-ray data over a high frequency channel. The balloon was weighed off with a spring balance and launched without difficulty. The 1746 kc beacon gave no data, probably because of an improper frequency setting prior to launching. Pressure-time data was obtained, however, from the cosmic-ray sonde from which it was evident that the balloon rose slowly to 28,000 ft. and then began to descend. Shortly after this the cosmic-ray sonde signal was lost as the balloon moved rapidly away in the high velocity wind region. The gondola was recovered shortly after impact, about 1700, in eastern Michigan. The launching was facilitated by tie-down rings which were secured by stakes in the ground. This balloon was evidently weighed off incorrectly as shown by its low rise rate (see Operation Chart for Flight No. 4).

Conclusions

Success was again achieved with the launching technique, but means for improving the weigh-off and of controlling the long 1746 KC antenna were obviously necessary. The unitized gondola greatly facilitated the operation. This flight possible indicated the effect of the jet stream on the balloon, but there is some uncertainty because of the excessive handling during packaging.

FLIGHT NO. 5

This flight was launched March 15, 1952, at 0916. It was a Winzen 73' 1-mil thick balloon. This was the first balloon to be packed in Williams Arena, and was equipped with a plate on the top which allowed the balloon to be pulled up by winches. The plate is described in Section No. 2 on "Packing and Launching." The purpose of the flight was to check balloon performance and the launching method. The intended duration of the flight was 3 1/2 hours, and it was released by timers. It was the first flight which was equipped with a camera to photograph the balloon during flight (Appendix 3). For details, see Section No. 5 on "Instrumentation." The camera was equipped with a Bolsey lens, aperture f8, 1/100th of a second exposure time, "G" filter, and Plus X film. The pictures were overexposed, but it waspossible to make good prints from them and the exposure was reduced on subsequent flights. It was also the first occasion on which we used torque wrenches for weighing off the balloon. For details, see Appendix No. 4 on "Launching and Packing Equipment" and Section 2 on "Launching and Packing." This was the first flight to be equipped with a rolled antenna ball which was dropped by means of a pneumatic delay switch. The flight also carried the first barograph and 60 lbs. of lead-enclosed photographic plates. The girdle on the balloon was a polyethylene-wrapped canvas girdle. The fitting at the bottom of the balloon consisted of a straight tubular plug and a 6' long aluminum pipe fastened to the standard rubber inflation hose. The canopy was secured by a canvas girdle used in Flight No. 5 for the first time. This plug was installed and the girdle wrapped around the balloon on the launching line before inflation. The launching went very well, and the flight continued to rise until it was terminated by the timers. It had not reached ceiling altitude by this time. It was discovered from examination of the up-pictures that the tire had fallen out at the proper altitude, approximately 15,000 ft., but that the polyethylene-wrapped canvas girdle did not slip down. Laboratory experiments and calculations on the mechanics of the girdle problem demonstrated that with a polyethylene-wrapped canvas girdle one would not expect the girdle to slip until the enclosed angle of the balloon above it approached 180°. The coefficient of friction of polyethylene on polyethylene turns out to be between one and two. For the solution of the girdle problem, see Section No. 4 on "Miscellaneous Calculations." At the time during the flight when the upper two-thirds of the balloon became completely full and when the girdle was called upon to slip initially, gas apparently was valved, decreasing the rate of rise. After the initial slipping, the pictures show that the girdle works its way down the tail of the balloon as the gas expands above it, maintaining a spherical balloon with a straight tail below it. By release time the girdle had slipped approximately half of the way down the balloon tail, and at the release was approximately 20' above the load. The telemetering contact with the balloon was good throughout the flight. The barograph gave a good flight record, and agreement between the barograph and telemetered altitudes was satisfactory. The load from this flight was recovered two miles north and two miles east of St. Charles, Minnesota, on March 15. It was followed to the ground by the Beachcraft airplane.

Conclusions

The method of clamping the canopy with the corset was quite satisfactory. The antenna dropper which unrolls the ball seems to be a satisactory way to solve the antenna problem. Very satisfactory photographs of the balloon in flight can be obtained with a relatively simple camera. The barograph design was believed to be adequate. The use of the torque wrenches to weigh off the balloon worked out very well, and they were adopted at this stage for all subsequent flights. The accuracy of the telemetered pressure data which utilized the standard baroswitch modulator was not adequate for our purpose. The analysis of the girdle problem lead to the idea of using the girdle as an automatic appendix ring and also lead to a series of design changes on the girdle.

FLIGHT NO. 6

This flight was launched March 29, 1952, at 0858. It was a Winzen 73' 1-mil thick balloon. The ground wind at launching was 12-18 knots. The purpose of this flight was to study balloon performance. This balloon and all subsequent balloons through Flight No. 20 were packed in Williams Arena. The expected duration was 5 hours; the actual duration was 5 hours, and the load was released by timers. The radio instrumentation was identical to Flight No. 5, and the flight carried both an up camera and a camera which photographed the ground. The up camera was equipped with a Bolsey lens, aperture f-11, 1/100 of a second exposure, G filter, and Plus X film. The down camera also had a Bolsey lens, operated at f-8, 1/100 of a second, and it was equipped with a G filter. The barograph on this flight had an added disc which gave a temperature record in the gondola and which will be referred to as a thermograph. The girdle on this flight was a large cloth girdle rigged with squibs and a pressure-firing mechanism so that at approximately 10,000 feet the girdle was completely removed. This assembly is shown in Appendix 4. To try to discover any shortcomings of the launching method, this flight was launched by only two men. It was launched behind the wind screen in a 15-knot wind, and no real troubles were encountered. It was not necessary to call for any additional help, and Winckler and Ney carried through the entire launching procedure including unloading the balloon, checking out the gondola, etc. The time required from the arrival of the truck to launching was 39 minutes. The flight was recovered 4 miles west of Chippewa Falls, Wisconsin, and was found on the day of the flight. The theoretical ceiling on the flight was 95,000 feet. The balloon climbed to this altitude within the accuracy of the baroswitch modulator and floated level until released by the timers. The canvas girdle was blown off properly at 8,500 feet and free-fell to the ground.

Conclusions

The fact that the balloon floated level at ceiling gave us confidence that the launching method was not damaging the balloons. It was clear on this flight that two men could easily launch 73' balloons by this method, although some additional instrumentation was indicated. The future flights utilized block and tackle for easy handling of the balloon.

FLIGHT NO. 7

This flight was launched April 7, 1952. It was a Winzen 73' 1-mil thick balloon with DE-2500 plastic. The balloon was packaged in Williams Arena by a 3-man packing crew. It was rigged with an over-sized canvas-covered tire and valve assembly, and the large size outer canvas jacket and blow-off like that described for Flight No. 6. In addition, the canopy was clamped at the bottom by a nylon-wrapped 600x 16 tire and canvas girdle of the type used in Flights 3 and 4. The purpose of the flight was to study balloon performance, and a unitized gondola the same as that used in Flight No. 6 was prepared. In this operation the launching was attempted in a 21-knot wind in the shelter of the wind screen. The launching equipment now included a block and tackle, and pulleys and tie-down points at each end of the balloon. The tie-downs consisted of 3-foot metal stakes welded to a ring assembly. On this flight the balloon was equipped with a tire and girdle at the bottom to hold the corset and inflation tubing in the manner used on Flights 3 and 4. When the balloon was partially inflated and still in the horizontal position, the bottom tire slipped from the girdle and released the canopy. Control was then lost of the bubble. The balloon extended itself and was torn on the wind screen supports. The reason for the failure was a feature of the packaging which had not been obvious before this test, namely, that the top end of the balloon was anchored by a line connecting to the top ring. When the balloon achieved some lift, there was a tendency for the top line to pull the top of the balloon out and strip the canopy from the lower section. The tire and girdle at the bottom were not sufficiently tight to prevent this.

Conclusions

The technique of holding down both ends of the balloon is greatly to be desired, but this cannot be done by pulling on the ring attached to the balloon crown. A modification of the rigging was made on subsequent flights so that the top tie-down rope passed through a hole in the top plate and was secured to the suspension ring on the tire-valve assembly. The tension developed in the bubble due to the inflation was then supported by the lower 1/3 of the balloon, and there was no tendency to pull the canopy off this section. It was decided to cut this top rope off before launching and to let the loose end pull through the top plate as the balloon extended itself in the air. A rubber close-off valve was built into the bottom of the hole through the top plate, which made the balloon gas tight when the upper line passed completely through.

FLIGHT NO. 8

This flight was launched April 10, 1952, at 0926. It was a Winzen 73' 1 1/2 mil thick balloon. The appendix hole on the balloon was 48" in diameter, and the appendix was removed by us. The balloon was launched behind the wind screen at the University of Minnesota Airport in a 14-knot N-NW wind. The purpose of the flight was to study balloon performance without an appendix through the daylight hours. The expected duration was 6 hours; the actual duration was 6 hours. The release was by the timers. In accordance with the experience from Flight No. 7, this balloon was arranged with a rope going through the loading plate on top and secured to the inner tube inside by nylon straps. During the inflation this allows one to hold the gas bubble by its two ends and not strip the canopy off. In Flight No. 8 we returned to a corset to secure the canopy by the inflation tube attached to a turned plywood plug, to which was fastened a length of vacuum cleaner hose equipped with a swivel. This, in turn, attached to the standard rubber inflation hose. In addition to this, the canvas girdle was replaced by an aluminum girdle wrapped with nylon tape and cornstarched when inserted into the balloon. (See photographs in Packing and Launching section.) We had verified by experiment that such a girdle, once the inner tire was released, would slip down the balloon at a cone angle for the balloon of 60° The instrumentation on this flight was the same as Flight No. 6 except that the baroswitch modulator had been replaced by a double-helix Olland cycle designed to give maximum accuracy in pressure measurements. The aluminum girdle previously mentioned was allowed to drop during flight onto the gondola. This flight carried cosmic ray gear, and the final position of the girdle was on the boom, which is evident from the photograph in Appendix 2. The exposure on the cameras had been changed, and the up camera carried an Ilex lens, aperture f-11, shutter speed 1/150 of a second, and Plus X film. The use of the Ilex lens was to improve the angle of view of the balloon. The camera was tilted so as to show the balloon with a small ring of sky showing even when the balloon was fully inflated. The down camera carried a Bolsey lens, aperture f-11, 1/300 of a second, and Plus X film. Both cameras had G filters. The additional gear carried on this flight consisted of a Geiger counter telescope and an assembly consisting of 4 single Geiger counters. The balloon was launched easily behind the wind screen in a 14-knot wind. It climbed to an altitude of 10,000 feet below its theoretical ceiling, and floated level until release after 3 hours of level flight. The flight took place on a very clear day, and the plane was following the balloon at the time of release. At the instant of release, however, the plane made a sharp turn, and both observers in the aircraft lost the balloon. The parachute was never sighted, and the load could not be seen on the ground. Because we knew the area so well, we conducted two air searches over approximately 10 x 10 square miles and did not find the load. On April 23, thirteen days after the flight, the balloon was found at Medford, Wisconsin, in the northeast corner of the area which we had unsuccessfully searched. Since the balloon had been equipped with a ripcord, we reasoned that the load should be nearby and conducted a third air search in the vicinity of the recovered balloon. The load was found during this air search after approximately two hours of flight.

Conclusions

The fact that the balloon leveled off at an altitude below its theoretical ceiling is attributable to the fact that the balloon could air in during its ascent. That it did take in air appears to be evident from the time-altitude curve which showed that the rate of rise steadily decreased as the balloon reached higher and higher altitudes. An extremely accurate trajectory was obtained by Mantis' group from the down pictures taken during the flight. The trajectory is included in this report. The up pictures clearly demonstrate the intake of air in the balloon at intermediate altitudes and the circumferential stress lines in the region of the balloon below the equator.

FLIGHT NO. 9

This flight was launched April 23, 1952, at 0934. It was a Winzen 73' 1-mil thick balloon. This was one of the balloons which we found to have sticky tapes. It was sent back to Winzen to be cornstarched, and it was equipped with an antenna for 6 mc, a destruction tape, and a tape harness. The appendix was removed. It was rigged in Williams Arena with a nylon-wrapped girdle and an aluminum inflation plug with the attached vacuum cleaner hose to replace the wooden inflation plug used in Flight No. 8. The launching took place at the New Brighton Arms Plant in the absence of any windbreak, and was carried out in an 18-knot wind. The purpose of the flight was to check the sunset effect and the effect of ballast dropped at night, as well as to test a communication link carried out by way of the balloon. This will be described below. The timers were set for 27 hours. The actual duration of the flight was 16 1/2 hours, and the termination was by Buddy's ball. The instrumentation utilized the Olland cycle for pressure measuring, and the low-frequency beacon was a 5-watt beacon, as opposed to the 1-watt beacons previously flown. The flight also carried a 6420 receiver (a modified Sentinal receiver). There was a cycling device which alternately connected the input of the beacon to the Olland cycle and to the output of the receiver. This allowed us to transmit to the balloon on 6420 KC and listen to the retransmitted signal on 1724 KC. This flight had two Buddy's balls, one for low altitude release and the other designed to drop ballast if the balloon descended below 50,000 feet. The gondola was constructed with a 3/8" steel pipe looped above it to deflect the falling girdle away from the up camera. The up camera had a Bolsey lens, aperture f-9, exposure time 1/50 of a second, and was loaded with Kodachrome film. The down camera had a Bolsey lens, aperture f-11, exposure time 1/200 of a second, with a G filter and Plus X film. Ballast to be dropped by the ballast blow-off consisted of 30 pounds of steel blasting shot. The antenna dropper on this flight was a pressure operated device (see Appendix 3). The flight also carried the lead block containing cosmic-ray plates weighing 60 pounds. There was a cornstarch bomb attached to be triggered by the low-altitude release. The launching went very well, in spite of the absence of the wind screen and the presence of the 18-knot wind. During the day of April 23, we established intermittent contact from the radio shack by way of 6420 KC to the balloon, and thence by way of 1724 KC to the aircraft. We were able to communicate by means of the balloon link when direct 6420 KC communication was impossible. The balloon climbed to an altitude 2,000 feet below the theoretical ceiling, floated level for three hours, began descending before sunset, and developed a rate of 60' per minute by sunset. At sunset this rate increased to 120' per minute, which was maintained until the balloon reached approximately 50,000 feet, at which time the descent became more rapid. It reached the altitude at which the low-altitude release took effect during the night, and contact was lost. The ballast drop was subsequently found to have failed, due to a shorted battery in the ballast blow-down. The gondola was recovered 15 days later after floating in Lake Michigan during this time. The film in both cameras was all right in spite of the 15-day submersion. The recovery point was 25 miles from Sturgeon Bay between Chamberlain Island and Strawberry Island.

Conclusions

The characteristic slowing down of the balloon at high altitudes indicates that it took in air because of the absence of the appendix, but the fact that it reached a ceiling which was almost its theoretical ceiling indicates that little helium was lost, and the valving was mostly air. The reason for the loss of lift after three hours of level flight is not clear, but it is possibly related to the loss of lift observed by Howell's group in Moby Dick flights. Since the rate established was constant, it appears to be a loss of a fixed amount of lift rather than a leak. The increase in the rate of descent at sunset is caused by the loss of a fixed amount of lift at this time. The decrease in the rate of descent in the vicinity of 40,000 feet may be due to the warming of the balloon as it gets closer to the earth because of the infra-red absorption of the polyethylene. It appears to be possible to transmit the radio signals through the balloon and thereby utilize its extended line-of-sight range. This test also helped us to find troubles in the radio receiver equipment used on the flight. It is one step in the development of a satisfactory command system.

FLIGHT NO. 10

This flight was launched April 29, 1952, at 1506. It was a Winzen 73' 1-mil thick balloon of DE-2500 plastic. The balloon was rigged in Williams Arena with a nylon-wrapped girdle and an aluminum inflation plug as used in Flight No. 9. During rigging the tire burst as a result of defective nylon tape wrapping. This released the balloon from the suspension, and it settled to the floor. An 18" diameter hole was blown in the balloon crown by the exploding tire, but it was patched with polyethylene tape. This balloon was re-rigged without difficulty. It was equipped with a ripcord but had no appendix. The purpose of the flight was to study the sunset effect on a 1-mil helium-inflated balloon. Accordingly, it was launched in the afternoon so that a few hours of level flight would be achieved before the sun set on the balloon, to reveal the presence of leaks or other sources of loss of lift. A standard gondola containing a 1-watt beacon on 1638 KC with Olland cycle pressure modulator, duplex timers, Buddy's ball, up and down cameras, photographic plates, and a motor-cycled blinker unit for night operation was prepared. The gondola was equipped with a girdle catcher like that used on Flight No. 9. No ballast was used. Launching was accomplished from the wind screen at the University Airport without difficulty in a 10-knot breeze. The balloon exhibited the characteristic decrease of rise rate as it approached the theoretical ceiling usually seen on balloons not equipped with appendices. Furthermore, the balloon leveled about 3,000 feet below the theoretical ceiling, which is almost certainly an indication of air intake and, in this case, excess valving of helium. The balloon floated level until sunset, at which time it descended at a rate of 120 feet per minute to an altitude of 88,000 feet, where it remained level for one hour until the load release point at 2140.

For the first time a signal was received while the load was descending. This behavior was achieved evidently by the effect of a 1-pound lead weight which had been fastened to the bottom of the antenna and which constituted the core of the antenna ball when wound up in the dropper. The down camera on previous flights clearly revealed that the 400-foot antenna hanging below the gondola tangled around the gondola and parachute, and cut off the beacon signal at the release time when not equipped with this weight. The balloon and load were recovered in nearby locations at Rock Falls, Wisconsin (near Eau Claire), the day following the launching.

Conclusions

This flight exhibited all the characteristics of a balloon not equipped with an appendix, which as discussed in Flight No. 8, results in an intake of air at a point about 2/3 of the way to ceiling. Evidently in this case the air mixed somewhat with the helium so that the balloon valved out part of its helium with the air and leveled at an altitude determined by the relative proportions of air and helium remaining inside the cell. It is notable that the descent resulting from the loss of super-heat at sunset ceased at 88,000 feet, and that the balloon leveled at this altitude. The barograph trace was in essential agreement with the telemetering record in this respect. This is the only flight of the series which exhibited this type of behavior after sunset with helium.

FLIGHT NO. 11

This flight was launched May 8, 1952, at 1510. It was a 73' 1-mil Winzen balloon with cellulose acetate tapes. The balloon was equipped with an antenna during manufacture and a destruction tape. It did not have an appendix. The ground wind during launching was 5 miles an hour and gusty. The sky was overcast. The launching took place at the University Airport behind the wind screen. The expected duration of the flight was 6 1/2 hours; the actual duration was 4 1/2 hours. Release took place by means of Buddy's ball. The purpose of the flight was to make a sunset experiment with a balloon containing ammonia. Because calculations showed that the volume of our appendix bubblw was just barely adequate to allow a pure ammonia inflation, we decided to make a flight in which half of the lift was contributed by helium and the other half by ammonia. The theoretical altitude calculated for the mixture was 73,500 feet with the gross load at 262 pounds. The flight was equipped with standard instrumentation, and had, in addition, a rate-of-rise indicator and a strobelight flasher. The up camera had an Ilex lens, G filter, aperture f-13, photographed at 1/150 of a second. The down camera had a Bolsey lens, G filter, aperture f-16, photographed at 1/200 of a second. Both cameras used Plus X film. This flight also had the second model of girdle catcher, which consisted of a ring suspended above the gondola by rope so that when the girdle descends, it is not allowed to rest on the gondola. The inflation and launching of the balloon went smoothly. We did discover something that we could have anticipated, namely, that the bubble, when inflated with a denser gas, becomes very unstable and blows about, even in a mild ground wind, much more than a corresponding helium bubble. In this case, 633 pounds of air were displaced with a gross lift of 326 pounds, so essentially half of the mass of the entire assembly was concentrated in the balloon. This added mass gives the bubble inertia which is not present with helium. The balloon took off with a rate of rise of about 600 feet/minute, and in spite of the fact that it had no appendix, increased this rate of rise to something like 900 feet/minute before reaching altitude. This characteristic increasing rate of rise was later found to be always present in ammonia flights and will be explained in connection with Flight No. 17, where the effect is much more pronounced. Before reaching theoretical ceiling, the balloon decreased its rate of rise due to intake of air, but it reached an altitude of 80,900 feet, over 7,000 feet above theoretical altitude for the mixture. Since this difference is far beyond the error in pressure measurement, and since the balloon almost certainly took in some air, it seems to be evident that during valving, almost pure ammonia was valved with the helium layered on top of it. Subsequent experience has lead us to the belief that helium and either air or ammonia do not readily mix, and in balloon flights will form layers inside the balloon. The only mixing that had been attempted on this flight was to insert the ammonia first and then to blow the helium into the balloon below the ammonia. Almost immediately after reaching altitude, the balloon began descending at a constant rate of 280 feet/minute. It maintained this rate for two hours and released its load at sunset, having reached the altitude at which the low-altitude release operates. The load was recovered at Jim Falls, Wisconsin, the morning of May 9, the day following the flight. The first model of the Bohl rate-of-rise indicator gave a satisfactory record during the flight. The device is similar to the rate-of-rise indicator used in aircraft, consisting of a bellows connected to a reference volume which is allowed to communicate to the atmosphere through a capillary. The theory of the rate-of-rise indicator and a description of it will be included in Section No. 5 on "Instrumentation." The rate-of-rise indicator showed 10-20% changes in velocity which are probably due to variations in the atmosphere. The record obtained is included with the flight data. An interesting feature of the valving is evident from the rate-of-rise indicator. Aside from small fluctuations, the velocity during valving decreases linearly with time, at least in this case where first air and then ammonia must have been valved.

Conclusions

It is possible with the launching system to successfully fly balloons with ammonia. There is strong evidence in this flight that gases not actually mixed on a very microscopic scale will stratify and form layers in a balloon. This is a very important feature of balloon flight, since it means that a balloon that takes air through its appendix may very well valve most of the air back out again. The fact that the balloon descended after reaching ceiling was interpreted at the time of the flight to be due to over-valving as the balloon reached altitude. The experience in Flight No. 15, however, indicates that this interpretation is not correct. It is much more probable that the two layers of gas change the pressure distribution in the balloon, and the resulting shape factor and valving of gas may produce a loss in lift.

FLIGHT NO. 12

This flight was launched May 12, 1952, at 0929. It was a Winzen 72.8' 1.5-mil thick polyethylene (150-V-110) balloon equipped with a destruction tape, glass filament tapes, antenna, but no appendix. The balloon was packed in Williams Arena by the regular procedure. The purpose of the flight was to test the command radio link from the flight center to the balloon and back again, or from the aircraft through the balloon to the flight center, using the 6 mc command receiver and the 1724 KC 1-watt beacon. The theoretical ceiling was 93,000 feet, and the balloon attained an altitude of 90,000 feet. The planned duration was six hours, but the balloon was in the air 60-72 hours under circumstances described below. The gondola carried the usual instrumentation including up and down cameras, Olland cycle, beacon, low-altitude blow-off, and timer releases. In addition, an automatic camera was hung from the ring and plate assembly in the top of the balloon. This camera was one of the standard type but was mounted in a small hemisphere and padded with sponge rubber to prevent damage to the balloon during launching. It was equipped with an Ilex lens, 1/150 of a second at f-11, G filter. The 1-watt beacon was cycled in 2-minute intervals between the receiver output and the Olland cycle, but this cycling action was cut in shortly after the balloon reached altitude by a special timer. The balloon was also fitted out with a microphone in the throat of the balloon which was cycled into the beacon in place of the receiver output during the rising portion of the flight. The cycling took place every two minutes by an automatic timer. The microphone was supposed to pick up valving noise or flutter, etc., in the high velocity wind regions. The microphone was checked out at take-off, but no audible signals were recorded after that. The balloon climbed to an altitude of 3,000 feet below theoretical ceiling and exhibited the rounding off of the time-altitude curve characteristic of balloons not equipped with appendices. The balloon remained level until sunset, and was not cut down at 1530 as planned due to a timer failure. Contact was lost with the balloon at about 2130 when the transmitter batteries were discharged. The balloon was found in the sky at daybreak the following morning. As only one theodolite station was available at that time, its altitude was estimated by measuring the subtended angle of the balloon and its elevation angle. The balloon was observed to be full at this time at about 40,000 feet elevation. It was kept in sight during the day in the Twin Cities area, and a second theodolite station was set up on the Physics Building roof. It climbed back up to 78,000 feet and at sunset on May 13 was southwest of Minneapolis. The balloon was not visible the next day, but was later found at Martha's Vineyard, Massachusetts. The balloon top camera was recovered. This camera gave only about a dozen frames during ascent due to a failure. The balloon could not have reached the east coast during the night of May 13th, so the earliest possible impact time must have been during the day or night of May 14th. The latest impact time possible was May 15th, as determined by the recovery. The gondola was recovered from the Atlantic Ocean about 100 miles southeast of the New York harbor by a freight vessel. During the day on May 12th, contact was established between the Beechcraft airplane and the flight center at the University Airport through the balloon, using the re-broadcasting technique. It was found that the balloon receiver had drifted somewhat in frequency after the pre-flight adjustments were made, but good voice communication was obtained at this time. The nylon tape-wrapped girdle was also recovered after it floated ashore on a small island off Cape Cod. The nylon tapes provided a waterproof space which kept the aluminum ring afloat. The barograph and thermograph records were destroyed by sea water, but both the up camera and down camera films gave good quality pictures although the inner parts, film spools, etc., in the down camera were dissolved away by sea water. The up camera used an Ilex lens and was loaded with Kodachrome 3 mm film. The interesting features of this flight are the balloon's ability to remain in the air without ballast for two to three days, and the trajectory executed by the balloon during the time it was observed by the theodolite stations. This trajectory accompanies the time-altitude chart, and exhibits a cusp while floating along at constant level and a spiral motion around the Twin Cities area. The implications of this trajectory will be discussed in detail by Homer Mantis in Section No. 8 of this report.

Conclusions

The command radio circuit showed satisfactory improvement in performance, but careful precautions must be taken to control the stability of the receiver in order to keep its frequency constant. The need for a suitable appendix was again conclusively demonstrated on this flight to prevent the intake of air. There is some evidence that the timer operated the squib, but that the balloon destruction tape either failed to come loose from the balloon or entangled in the balloon load ring assembly in such a way that the load did not fall.

FLIGHT NO. 13

This flight was launched May 15, 1952, at 1815. It was a Winzen 73' 1-mil thick balloon with acetate tapes, and an 8' long tubular appendix was used. The balloon was packed in Williams Arena by the standard method, but the nylon wrapping was omitted from the inside of the aluminum girdle. The aluminum surface was buffed to remove abrasive regions. It was hoped that the correct friction coefficient would be achieved against the polyethylene to make the girdle slip down gradually as the balloon rose, so that the fabric would be controlled better in turbulent regions, and so that the lower portion of the balloon would act as a long appendix to prevent the intake of air. The purpose of this flight was to test balloon performance, to observe the sunset effect on a 1-mil balloon, to attempt level flight by pre-timed ballast dropping, and to carry a major piece of cosmic-ray instrumentation. The planned flight duration was 23 hours, and a unitized gondola was provided which differed from the usual type in that the cameras were omitted and a special ballast dropper was included, with ballast increments distributed throughout the flight at appropriate places. An attempt was made to launch this balloon at a time of day so that sunset would occur before the balloon reached ceiling. The balloon would then lose its superheat before valving and would valve out only the free lift remaining after sunset. Level flight should then be obtained throughout the night. However, to provide for premature settling, a 20-pound ballast drop was scheduled at 2100, and three 10-pound increments scheduled at 0100, 0900, and 1300 on May 16. A beacon light and timer were included for the night operation. The circular girdle catcher Model 2, used in Flights 11 and 12, was included. A stack of postcards with instructions to return to the Physics Department were to be dropped at

30,000 ft. altitude. To save transmitter power and weight, a cycler was provided to turn on the transmitter for three minutes out of 15 beginning at 2100 on May 15. The cosmic-ray equipment was in a sphere. The sphere was balanced against the balloon gondola by a magnesium yoke. This rigging is shown in Appendix 1. Launching was accomplished without difficulty, and the balloon rose at 1,000 feet/minute to 100 millibars, and then accelerated to 1050 up to about 20 millibars. It slightly exceeded the theoretical ceiling of 86,500 feet, and at 87,500 floated level for 15 minutes. It then dropped rapidly with a speed which increased to 900 feet/minute. At 38,000 feet the signal was lost, and the parachute opened after separation from the balloon. The rise rate of the balloon was higher than expected, and consequently it reached ceiling before sunset rather than after, as had been planned. The descent occurred just about at sunset. The load was recovered at Augusta, Wisconsin, in good condition, and the balloon was also found on a nearby farm at Augusta. Altitude records were obtained in this case from a Wallace and Tiernan gauge carried in the cosmic-ray gondola. The altitude chart shows a discrepancy between the records from this instrument and the telemetered data. The telemetering calibration was rechecked as a result of this, and the final value, which is believed to be correct, is that shown on the time-altitude chart. The girdle was observed to slip from the balloon at about 74,000 feet, which indicated that the polished aluminum surface had about the right coefficient of friction to keep the girdle in place during ascent. This balloon displaced 645 pounds of air, and the rather heavy payload also probably contributed to the girdle remaining in place (see the calculations in Section No. 4 on "Miscellaneous Calculations" for girdle slipping behavior). The balloon was returned to

Williams Arena and examined carefully for the cause of failure. The complete crown of the balloon was missing, but most gore sections were intact up to the point where the crown is heat sealed in place. Remnants of the heat seal were found on many gore ends near the balloon top. It is surmised that the balloon failed because of the heavy load, and that the excess pressure opened up a hole near the crown of the balloon. The crown of the balloon itself could have blown off at this time, but this may also have occurred when the load was released by the low-altitude blow-down at 38,000 feet.

Conclusions

The behavior of the girdle was very satisfactory on this flight as a result of obtaining about the right friction coefficient. It is felt that this balloon was definitely overloaded, but the failure may be associated with sunset and tape-chilling. In subsequent flights the tire pressure release was set for a somewhat lower altitude, as it was felt that the residual motion left in the bellows was too small to guarantee proper functioning at high altitudes.

FLIGHT NO. 14

This flight was launched May 22, 1952, at 1419. The balloon was a Winzen 1.5-mil thick, 73' diameter cell made with glass filament tapes No. 890. The balloon number was 150-V-112, and it weighed 180 lbs. It was equipped with an antenna, balloon destruction tape, polished ring, and girdle, and the openings made for packing were heat sealed. Packing was completed on May 19. The purpose of this flight was to determine the flight characteristics with a controlled ballast system and with a balloon equipped with a leakage hole in the top, so that there would be a demand for ballast occasionally. The gondola for this flight contained ballast hopper No. 1 filled with 100 pounds of fine grade steel blasting shot. This gondola was suspended on a spring balance for weighing the remaining ballast head, and the head of ballast was telemetered and also recorded on a section of the barograph. Maas command receiver No. 4 was connected to the ballast drop mechanism and operated on 6420 KC. The usual barograph and thermograph combination was included. A flasher beacon operated by a pressure switch to turn it on if the balloon descended below 30,000 feet. There was an up camera photographing once each minute, a down camera photographing every five minutes, a standard Olland cycle for pressure transmission, and indication of ballast and a one-minute warning that the blow-down timers were activated. The planned duration of the flight was 24-48 hours. The usual Buddy's ball for blow-down below 30,000 feet was also used. The theoretical ceiling was 82,000 feet. This flight displaced 645 pounds of air, the gross lift was 564, and the gross load was 500. The balloon was inflated to approximately the planned pressure in the horizontal position. Wind gusts drove the bag around quite a bit but caused no difficulty. The bubble erected OK. Unfortunately, the anchor rope was cut too long, so that the balloon load ring could not be pulled down low enough with the block and tackle to attach the gondola. The gondola accordingly was lifted by four men off the ground and snapped into the load ring. The measured free lift was about 64 pounds, and after this gas was put into the balloon, the helium trailer was empty. This permitted a close check with a volume calculation made by Ray Dungan of General Mills, who had calculated that there should have been 591 pounds of lift remaining in the helium trailer. We actually found 564 pounds left. The inflation tubing was severely twisted around the anchor line and load ropes and finally ruptured when the inflation was about complete. Launching was held up temporarily because several Northwest Airlines planes were circling in the overcast. The launching sequence proceeded satisfactorily, except that the corset came off just as the balloon was released, without any time interval between, as has been the case in previous flights. It was noticed that the bottom section of the balloon showed a concave shape near the load tapes. The night flasher lamp connection had been broken during transit but was repaired at the wind screen. This balloon had an initial rate of rise of 730 feet/minute to 300 mb. The girdle did not slip down during the ascent, and final- this caused the balloon to level, with the portion above the girdle fully inflated. Calculations showed that the theoretical ceiling for a balloon of the decreased volume experienced in this case should be 64,000 feet. The balloon was observed to level at 64,000 feet, and floated at that altitude for three hours, at which time radio contact was lost. It was believed that the tire deflator which is supposed to release the tire from the girdle was damaged at take-off by the balloon camera, which was hanging from the top ring of the balloon. This assumption was verified upon recovery of the balloon. Despite the fact that the balloon was launched with a 3/8" diameter hole close to the top, level flight was achieved without any noticeable downward drift. It was suspected that the reason for level flight in spite of the hole was that radio noise was dropping ballast steadily. On recovery of the load it was discovered that all of the ballast had been dropped, and the time-altitude curve indicated that all of the ballast had been expended shortly after sunset. It is probable that ballast was dribbled out of the tank and compensated the hole in the top of the balloon. The tracking plane could not follow the balloon during the night because of severe thunderstorm activity. The command ballast operation was not very successful, although when the apparatus was checked out on the ground at the wind screen prior to launching, the command receiver operated the ballast release perfectly. The command receiver was also supposed to operate the blowdown, and was equipped with a cut-in timer to activate this mechanism after the balloon reached ceiling. It was noticed that atmospheric noise operated the resonant relay in the balloon receiver intermittently. It was later determined that the reason why the command receiver did not function properly was that a harmonic of the transmitter was just at the right frequency to produce an image signal in the receiver. Subsequent laboratory tests demonstrated this clearly. It was found necessary to shift from 1638 KC on subsequent flights using command control to 1746 KC, which turned out to be the only other of the available frequencies that gave satisfactory night-time operation.

Conclusions

Further development was necessary on the command operation, and precautions were obviously necessary to insure that the balloon top camera did not damage the deflation aneroid when the bubble was erected. It was planned to use a long top rope, and instead of cutting the top rope and letting the bubble fly up rapidly, to walk the balloon up and then cut off the rope, on those flights which use a crown camera.

FLIGHT NO. 15

This flight was launched May 26, 1952, at 1553. It was a Winzen 1-mil thick 73' balloon, equipped with acetate tapes, and weighed 115 pounds. The balloon number was 100-V-113. The purpose of the flight was to measure the sunset effect on a balloon inflated with ammonia. A very light-weight balloon was used, and the gondola weight was minimized so that enough inflation volume would be available to lift the gross load using ammonia alone, without helium to supplement it as in a previous flight. The theoretical ceiling was 80,000 feet, and the balloon reached an altitude of 76,000 feet. This balloon was not equipped with an appendix. The flight duration planned was 7 hours and 10 minutes, and the actual time was 7 hours. In this case the flight was terminated by the timers. The gondola included an up camera with Plus X film and an Ilex lens, a down camera with Plus X film and a Bolsey lens, 1638 KC beacon, Olland cycle, antenna dropper, Buddy's ball and timer release unit. The gondola was also equipped with three 6-pound ballast drops set to release after the balloon reached ceiling, and 20 and 40 minutes thereafter, respectively. A strobe-flasher unit was set to turn on four hours after take-off. A baro-thermograph was also included. The gross load was 275 pounds, the free lift 84 pounds, and the gross lift, therefore, 359 pounds. 870 pounds of air were displaced. The ammonia boiled into the balloon, using the heat exchanger described previously, with the heat being supplied by a high-pressure portable steam jenny. The liquid ammonia was carried in tanks on the truck and was bled into the heat exchanger. From thence it was boiled into the balloon. When the inflation was finished and 84 pounds of free lift were acquired, the bubble was very round and tight. It was obvious that very little more volume of gas could have been put in. The launching crew was equipped with gas masks, and the launching took place without incident. The balloon had an initial rise rate of 850 feet/minute, but this increased in the 300-100 mb region to 900 feet/minute, and from 100-40 mb reached 1,200 feet/minute. After reaching ceiling the balloon leveled for one hour and 50 minutes, and began to descend 30 minutes before sunset on the ground at a rate of 400 feet/minute. The balloon descended to 37,000 feet and then leveled. Sunset on the balloon occurred when it had reached about 45,000 feet on the descent. Radio contact was lost at 2110, but the remainder of the record was filled in by the barograph record. The balloon descended to 37,700 feet, and then climbed again during the night a distance of 2,700 feet before the timer release actuated at 2230. The girdle was observed to slip off at about 17,000 feet of altitude. All of the gear from this flight was recovered, including the balloon, all balloon hardware, and the gondola itself. It landed 2 1/4 miles northeast of Marshfield, Wisconsin, and was found the following morning.

Conclusions

This balloon exhibited an acceleration during ascent which was later found to be characteristic of ammonia-filled balloons. The actual ceiling was 4,000 feet short of the theoretical ceiling for ammonia, and this is characteristic of balloons not equipped with appendices which may take in and mix some air on the ascent. The rate of descent at sunset seems higher than that experienced with helium balloons, but if one calculates the percentage loss in lift, taking into account the large weight of the inflation gas, one finds that the sunset effect is actually smaller, or at least not greater, than that experienced with helium. It is clear that a large effect is experienced as the balloon drops to lower levels from the effect of earth radiation. In this case the balloon actually climbed again after sunset at low altitude. It is presumed that this gain in lift is obtained from infrared radiation which is present at these lower levels, but is absorbed at higher altitude by the components of the atmosphere. It was obvious from the launching that the balloon was not suited for this amount of lift in the case of ammonia, as the bubble was too full. The corset at the bottom was under undue strain to contain the bubble of canopy and was not designed for a bubble of this size. The corset would have to be redesigned somewhat to permit further flights with this size balloon. A better solution would be to use a larger balloon.

FLIGHT NO. 16

This flight was launched June 3, 1952, at 1300, for the purpose of measuring the sunset effect on a special double-wall balloon and for further tests on a command receiver. The balloon, No. 2-100-V-119, was a Winzen 72.8' double 1-mil polyethylene wall, equipped with glass filament tapes. It weighed 235 pounds. The planned flight duration was 10 hours, of which 3 hours and 35 minutes was achieved. This flight was released by the Buddy's ball low altitude blow-off. A standard gondola was used, with a 1638 KC transmitter, Olland cycle, antenna dropper, timer release, up and down cameras, balloon top camera, strobe-flasher to be turned on at 1930, and a baro-thermograph combination. Command receiver No. 5, operating on 6420 KC, was included and was arranged to operate a blow-down relay and also put an indicating signal on the telemetering system. The blow-down was operated after a one-minute delay following the beginning of the signal. The inflation medium was helium. This flight also carried a vertical cosmic-ray telescope prepared by Harold Lindgren, and three pounds of nuclear emulsions. The two large assemblies, i.e., the telescope and the balloon gondola, were hung on a magnesium truss equalizer. This balloon was equipped with a line taped to one of the balloon tapes tied on one end to the load ring and on the other end to the top ring to insure that the balloon top camera was retrieved along with the balloon. The gross load was 458 pounds with 70 pounds of free lift and 610 pounds of displaced air. This flight was launched without incident in clear weather at the University Airport. The balloon antenna did not drop as planned, but finally released at 28,000 feet, at which time the telemetering signals began. It was later determined that the cause of this was that the antenna dropper release cam had been twisted when the antenna dropper was adjusted so that there was a lot of friction, and the bellows had to expand further to release the lever. The balloon rose at 830 feet/minute to 300 mb with an average rate of 1,000 feet/minute between 300 and 100 mb, and reached a velocity of 1,200 feet/minute from 100 to 25 mb. The balloon reached its exact theoretical ceiling, which is consistent with the fact that an appendix was used to close off the bottom of the balloon during ascent. However, after reaching ceiling the balloon immediately began to descend with increasing velocity, and the load was released at 1635 by the low-altitude blow-off. Cosmic-ray telemetering was maintained throughout the flight on a high-frequency circuit. The tracking plane followed the chute to the ground and directed the truck in for recovery. The load was recovered near Blair, Wisconsin. The balloon was recovered near Stoughton, Wisconsin, in Bears County, complete with the girdle and the balloon camera. It drifted over a barn, slightly damaging a weather vane. The cosmic-ray telescope was not found with the load, but a report was received on June 9 that it had fallen on a fence on the farm of Mrs. Lloyd Gilbertson of Whitehall, Wisconsin. Cattle broke through the resulting hole and damaged an adjacent oat field. One of the steers subsequently died as a result of eating the oats. The descent of the balloon, i.e., with increasing speed, is characteristic of a leak. It is believed that the appendix used was too tight and built up enough super-pressure to open a leak. The appendix used was a straight tube of polyethylene, long enough to reach the load ring, held closed by wooden slats which were clamped to the load tapes just at the balloon. The tension in the load tapes and the clamp provided a couple to keep the slat in against the load ropes and, therefore, to hold the appendix closed.

Conclusions

The action of the appendix in preventing the intake of air was clearly demonstrated on this flight. The command receiver was operated from the tracking center, but some radio frequency drift of the revolver was encountered, and the relay contact was not positive.

FLIGHT NO. 17

This flight was launched on June 5, 1952, at 1234. It was a Winzen 72.8' diameter, 1-mil thick balloon No. 100-V-128, and was constructed with acetate fiber tapes. This balloon was packed June 4 and weighed 123 pounds. The purpose of the flight was to measure the sunset effect on ammonia and to test an appendix design. The light-weight balloon was used to reduce the ammonia inflation to a volume which could be contained by the 73'-type balloon when packaged by this method. The planned flight duration was 23 hours, and the theoretical ceiling was 75,900 feet. The gondola carried a 1638 KC beacon, Olland cycle No. 7, antenna dropper, low-altitude release, timers, up and down cameras, flasher, barograph-thermograph, and a low voltage blow-down as a safety. In case of timer failure the low altitude blow-down would operate when the storage battery ran down. This flight was laid out in the northeast sector of the wind screen. The ammonia inflation proceeded without difficulty, with the exception that the engine in the steam jenny had a dirty fuel line which had to be cleaned out. It was planned to put 200 pounds plus the balloon of lift before erecting the balloon, but due to the fact that the bubble was a little small as a result of a packaging error in measurement, the necessary amount of ammonia could not be vaporized into the balloon. The bubble became very round and tight, and at this point it was erected. With the gondola the free lift was only about half the planned value, namely about 32 pounds. The gross load was 295 pounds and air displaced was 790 pounds. A reinforced corset was used, and no difficulty was encountered in constraining the bottom of the balloon with this corset. When the balloon was launched, it rose about 6 feet and momentarily leveled as it drifted out horizontally from the wind screen.

Once clear of the eddy, however, it rose with an initial rate of about 400 feet/minute. During the course of the ascent the upward velocity increased, and above the 300 mb level had a rate of rise of 1060 feet/minute, i.e., the same as Flight 16. The girdle slipped down at 380 mb. The balloon was observed to burst at about 72,000 feet, i.e., about 4,000 feet below the theoretical ceiling. Jim Magnus reported that the vehicle disappeared to his view in the plane for a little while, and then he picked it up again. The plane followed the load all the way to the ground and directed the Navy truck into the impact point by radio. The load was returned to the lab about 6:00 PM, and preparations were started for a repeat of the experiment. When the gondola was unloaded from the truck, the antenna ball rolled out of the antenna dropper. This was caused by improper clamping of the ball, which on this flight was made of wire with thinner insulation so that the size of the ball was smaller. The difference was made up of two blocks of Styrofoam which loosened during transit. This was corrected on the field, but resulted in a change in the antenna drop adjustment so that the antenna came down from an altitude of about 1,500 feet. Attempts were made immediately after launching to operate the command receiver from the radio shack. A new 100-watt radio transmitter was in use, but it was not found possible to close the relay in the balloon by radio control and make a mark on the telemetering record. Further attempts were made, but only occasional "flicking" of the relay was achieved. The plane reported improved signals from the radio shack with the new transmitter, and contact was established as far as Red Wing, Minnesota, with the plane at very low level when directing in the truck for load recovery. The 1 r.p.m. Olland cycle was used again on this flight. Bob Howard reported that pressure signals were received about one minute after balloon burst was reported, and that it seemed as though altitude was still increasing during that period. Handy-talkies were used for communication between theodolite, the wind screen, and the radio shack. Examination of the up camera record showed that balloon burst was probably caused by the girdle slipping down and catching the lower end of the plastic appendix valve in the girdle catcher, thereby preventing the appendix valve from opening. It is clear from the pictures that the balloon was filling out very rapidly and in the last frame before burst was almost full. There is then an interval of three frames before the parachute could be seen, showing that probably the equipment free fell from 72,000 feet down to 30,000 feet, at which point Buddy's ball fired the squibs with the load. Balloon destruction tape snap was missing, although the nylon line was still tied to the gondola.

Conclusions

It was demonstrated again that a large size balloon was necessary for ammonia inflation if the regular gondola is used. The bubble just barely contains the necessary lifting gas. The great increase in upward velocity is interesting, and is probably caused by earth radiation on the balloon which produces a relatively greater superheat as the balloon gets higher because of the cooling of the atmosphere with height. The fouling of the appendix by the balloon girdle must be corrected by lengthening the ropes on the catcher ring so that the girdle hangs clear of the appendix. The failure of the command receiver was subsequently found to be image interference from the transmitter as discussed in Flight No. 16. The low battery blow-down needed re-designing, and a few simple precautions should be taken to insure that the rolled up antenna fitted properly into the antenna dropper. The low altitude release successfully opened the chute following a balloon failure and during a free fall. Evidently a stronger snap is necessary on the balloon destruction tape.

FLIGHT NO. 18

This flight, scheduled for June 6, 1952, was to have been a repeat of Flight No. 17. A Winzen balloon equipped with acetate tapes, 72.8' in diameter and 1-mil thick, No. 100-V-124 was used. It weighed 123 pounds and was packed June 6. The theoretical ceiling was 76,000 feet with ammonia, and the same gondola, No. 2, was prepared for this flight. This contained the same instrumentation as Flight No. 17 except that the low voltage blow-down was omitted. Inflation was begun without complication except that difficulty was encountered with the steam jenny. A bypass valve had been added to the ammonia heat exchanger so that the excess pressure could be bled off into a side hose instead of into the balloon. When the bubble was erected, the free lift without the gondola was about 175 pounds which would have given a free lift with the load of about 25 pounds. It was thought necessary to get a higher free lift to insure rising, but the steam jenny was started only after a delay of about 1/2 hour. During this time a large tear about 8" in length was discovered near the bottom of the balloon. This tear was patched with polyethylene tape. About 10 pounds more free lift was added to the balloon, and immediately the inner bubble collapsed. It was thought that the diaphragm ruptured so the gondola was quickly tied in place and the inflation tube pulled. The canopy immediately lifted, and it was discovered that the lower bubble had ruptured almost over its full length. Ammonia was released from the remainder of the balloon on the ground by making knife cuts. The ammonia gas which escaped was very warm. It was discovered that the acetate tapes were melted apart where they passed under the aluminum girdle. The polyethylene was also damaged. The girdle itself was too hot to touch. Evidently the failure started at this point. The corset, which had been strengthened by metal bands, did not release properly when the first quick release was pulled. This corset constricted the fabric in the wrong way and possibly could produce damage to the canopy at that point. The bubble was so round and tight that a large amount of stress was exerted at the corset, and parts of the balloon at this point were under large tension. Checkout of the equipment proceeded in a routine way, and the command receiver could be operated satisfactorily in front of the radio shack using the portable oscillator. The 6420 KC antenna was altered to a simple quarter-wave vertical instead of the half-wave Zepp type used on all other flights. The gondola was not damaged in any way and was returned for use on a future flight. Operations were concluded about 1500.

Conclusions

This operation revealed another weak point in the launching technique; namely, that some insulating layer must be put over the aluminum surface of the girdle so that in hot weather the aluminum temperature would not get high enough to damage the balloon. Probably the use of glass filament tapes instead of the acetate tapes would greatly reduce the hazard. Very probably the use of a completely nylon taped aluminum girdle would eliminate this difficulty.

FLIGHT NO. 19

This flight was launched June 10, 1952, at 1313, and utilized a Winzen 72.8' double 1-mil balloon, No. 2-100-V-89, with glass filament tapes. It was equipped with an antenna, taped aluminum girdle and contained a top camera to photograph the inside lower portion of the balloon during flight. The balloon weighed 232 lbs. The purpose of the flight was to measure the sunset effect on the double thickness balloon, and to test the operation of the appendix. The flight was scheduled for 10 hours, but was released after 9 hours by the low altitude blow-down. The theoretical ceiling was 89,500 ft. The gondola contained the same instrumentation as Flight No. 18 except that the command receiver was omitted. The balloon was inflated with helium to a free lift of 96 lbs. The gross load was 362 lbs., and 523 lbs. of air were displaced. This flight was launched in the open with an 8-knot wind and scattered to broken clouds. The balloon had a rather large free lift, and accelerated from 1,100 ft. per minute up to 300 mb level to 1,200 ft. per minute between 300 and 100 mb, and reached 1,500 ft. per minute as it approached ceiling. The balloon reached the theoretical ceiling of 89,500 ft., and after 35 minutes of approximately level flight began descending and developed a rate of 90 ft. per minute downward. At sunset this rate increased to 270 ft. per minute. The load was released by the low altitude blow-off, and was recovered two miles due west of Lone Rock, Wisconsin. The balloon itself drifted considerably further and dropped on an airport at Elgin, Illinois. The balloon and all accessories were recovered in good shape. In this flight it was observed, while examining the up-camera pictures, that a loose flap of plastic appeared at about the position of the equator of the balloon and opposite to the position of the ripcord tape. On examining the balloon Williams Arena after its return, it was found that this flap of plastic was actually the outer thickness of the 2-ply material, and should not have contributed in any way to the balloon performance. It was convenient in this case to make a measurement of size of the balloon equator. The balloon has nominally a 73' diameter, so the equator should be 36 1/2' from the top of the balloon on a radius. The distance along the gores is then 57.5'. A strip of plastic 3' wide with its center at 57.5' was cut from the balloon equator. This strip was laid out on the floor, pulled tight, and measured. The measured length was 232'4", which corresponds to a balloon diameter of 73.95'. The design diameter is 72.9', giving a circumference of 229'. It is believed that it would be impossible to stretch the balloon equator in its present condition by 3.3' at room temperature without destroying it. Subsequently, two other balloons which had never been flown were measured at the equator, and gave a circumference of 229'4" and 229', respectively; that is, just exactly the design value. It therefore appears that the increase in the size of the balloon on Flight No. 19 is to be due to plastic creep. It is very possible that a balloon which does not have the natural shape will try to acquire this shape through the mechanism of creep.

Conclusions

The change in dimensions may produce a decrease in volume with a resulting loss in lift which could account for the balloon's settling. Since the decent curve of this flight is not characteristic of a leak, one must invoke some explanation like this to account for the descent of the flight.

FLIGHT NO. 20

This flight was launched June 12, 1952, at 1300. A Winzen double wall 1-mil 72.8' balloon, equipped with glass filament tapes, and numbered 2-100-v-120, was used. This balloon weighed 235 lbs. and was packed (or at least the packing was completed) the morning of June 12. The purpose of this flight was to measure the sunset effect on the double wall balloon, and to test the appendix. It was essentially a repeat of Flight No. 19 with the addition of radio control equipment. The planned duration was 10 hours, and the release occurred after 10 hours by means of the timers. Gondola No. 5 was prepared for the flight. It contained a 1746 kc transmitter, as it had been learned just previously that the cause of the command receiver failure was an image produced by the 1638 kc frequency. Olland cycle No. 5, regular antenna drop, low altitude blow-off, timers, up and down cameras, flasher, barograph-thermograph, and a command ballast, drop consisting of 30 lbs. of ballast in bags which could be dropped as a whole when desired, were also included. The balloon was equipped with an 11-meter antenna. The appendix was the type used in recent flights of this series, and it consisted of a straight tubular section of 2-mil polyethylene against the load lines. The inflation was carried out to a free lift of 64 lbs., the gross load was 406 lbs., and the displaced air 549 lbs. This balloon was launched on a clear day in a 10-knot wind in an open field near the windscreen at the University of Minnesota Airport. The balloon climbed all the way to theoretical ceiling with an accelerated upward velocity much like that in Flight No. 19. It floated level for 60 minutes, then established a rate of descent at about 1550 of 160' per minute. At 1730 the 30 lbs. of ballast were dropped by command operation. This constituted 5.5% of the displaced air of the flight. The balloon them climbed again from 72,000' to 78,000', and floated level until sunset at this height, which was 10,000' below the theoretical ceiling. Because of the ballast drop, theoretical ceiling was now about 87,300'. The initial theoretical ceiling was 86,000'. At sunset the balloon began to descend at 160' per minute, and had reached a level of 53,000' when the timers released the load. The load was recovered near Chaska, Minnesota, the next day.

Conclusions

A very successful operation of the command receiver was achieved now that the image interference difficulty had been eliminated. Evidence for a large shape factor or for intake of air was given by the failure of the balloon to rise again to its theoretical ceiling after ballasting. The new ceiling after the ba ast drop corresponded to a balloon volume two-thirds of that of the original balloon. It was thought that the balloon did not take in air because of the closed appendix, and this was also indicated by photographs which show the appendix remaining closed in this region. A systematic examination of the up-camera pictures further showed that the balloon slacked off as it descended for the first time, and the bottom became concave. After the ballast drop and the subsequent rise, the balloon was still slack and never filled out and valved as it did in the initial rise after launching. It is not clear at this time why the balloon, which was given an upward velocity, did not continue until full, but rather leveled off in a slack condition.

FLIGHT OPERATIONS CHART

The flight operations charts show the details of each individual balloon flight. The information included ranges from the comparison of theoretical to actually achieved altitude, to information about the recovery of the load. These charts are helpful in determining at a glance the purpose and approximate performance and principal characteristics of a flight. As can be seen from the first chart, the gondolas from the first twenty flights were all recovered, and in many cases, the balloons were also reported in. We believe the reason for this rather remarkable recovery record is that almost all of these flights were made in Minnesota in the summer months, during which time the upper winds are relatively light. A rather interesting recovery is Flight #12, in which all of the balloon gear, the balloon itself, and the gondola were recovered, in spite of the fact that the load was released over the Atlantic Ocean. The gondola was recovered 100 miles southeast of New York harbor by a molasses boat. The balloon was found at Martha's Vineyard, Massachusetts, and the gondola was recovered after floating ashore on an uninhabited island off Cape Cod. It should be noted that in this flight, although immersed in salt water from 24-36 hours, both cameras gave good records. In one camera, the corrosion was so bad that the inner part of the film spool was completely dissolved.

SECRET

FLIGHT NUMBER	1	2	3	4	5	6	7	8	9
FLIGHT DATA									
Date Flown	December 8, 1951	January 18, 1952	February 8, 1952	March 1, 1952	March 15, 1952	March 29, 1952	April 7, 1952	April 10, 1952	April 23, 1952
Time	Approx. 0900	Approx. 0900	1630	0922	0926	0858	Not launched	0926	0934
Balloon Type	General Mills 853 1.5 mil Viking DB-2400	73' x 1.5 mil General Mills	General Mills 851 80' x 1 mil No top ring	General Mills 73' x 2 mil. No top ring. Balloon dropped in elevator shaft.	Winzen 73' x 1 mil 100-V-68	Winzen 73' x 1 mil 100-V-69	Winzen 73' x 1 mil DE 2500 100-V-66	Winzen 73' x 1.5 mil 150-D-73	Winzen 73' x 1 mil 100-V-71
Date Packed and Packers			January 9, 1952. Whole gang. El shaft packing.	February 15, 1952 Whole gang	March 11, 1952, Whole gang Williams Arena	March 28, 1952 Winckler Edwards, Smith, Hansen, Ney	March 28, 1952 Edwards, Hansen, Smith	April 8, 1952 Edwards, Hansen, Smith	April 19, 1952 Edwards, Hansen, Smith
Balloon Weight	204 lb	180 lb	142 lb	265 lb	108 lb	120 lb	108 lb	152 lb	115 lb
Altitude Theoretical Maximum	500 to 1000 ft	96,000 1,000	85,500 Unknown	85,000 28,300	96,000 68,000	95,000 ~95,000	Not launched	91,000 81,800	88,500 87,000
Purpose	Launching test	Launching test	Balloon performance launching method	Balloon performance launching method	Balloon performance launching method	Balloon performance	Balloon performance	Balloon performance	Sunset effect and effect dropped at night. Receiv
Duration Planned	6 hours	4 hours	2½ hours	3½ hours	3½ hours	5 hours	6 hours	6 hours	27 hours
Actual Duration	2 minutes	Approx. 5 hours	Unknown	Unknown	3½ hours	5 hours	Not launched	6 hours	16½ hours
How Released	Jerked apart	Floated down	Aneroid blowdown	Unknown	Timers	Timers		Timers	Aneroid blowdown
GONDOLA DATA									
Gondola No.			No standard gondola	1	2	2	2	2	1
Radio Gear	1746 beacon	None		1746 transmitter Baroswitch modulator	1724 XMTR #5. Baroswitch modulator. Pneumatic delay ant. drop.	1724 XMTR #5. Baroswitch modulator. 218 MC XMTR #1. Vibrapack #3. Antenna drop #1.		1746 XMTR #23. Modified Olland cycle #1. Vibrapack #2. Antenna dropper #2.	5 watt beacon #1. Olland 6420 modified Sentinal re Expanding type antenna dr
Blow Down	Timers	Timers	Chevrolet timers Aneroid blowdown	Timers Aneroid blowdown did not fire squib	Timers #1 Aneroid blowdown #1	Timers #2 Aneroid blowdown #1		Timers #4 Aneroid blowdown #2	Timer #1. Aneroid blowdown altitude release, #4 balla
Cameras	None	None	None	None	Up #1 Bolsey f-8 1/100 0 filter + X film	Up #1 Bolsey f-11 1/100.0 filter + X film Down #2 Bolsey f-8 1/100 0 filter + X film		Up #1 Ilex f-11 1/150 Down #2 Bolsey f-11 1/300	Up #6 Bolsey f-9 1/50 Down #7 Bolsey f-11 1/20 + X film
Ballast	None	None	10 gal of kerosene	None	None	None		None	30 lb
Cosmic Ray	60 lb photo plates	None	Telescope K. Anderson Plates 9.5 lb	Single counter No. 5. Photo plates.	Lead enclosed photo plates 60 lb	None		Geiger counter telescope Four single counters	Lead block plates
Light	None	None	Blinker (wooden box)	Blinker	None	None		None	None
Barograph	None	None	None	None	Barograph #1	Barograph #1. Thermograph gave good records.		Barograph #1B. Thermograph gave good records.	Barograph #2. Thermograph gave good re
Miscellaneous		(Appendix tied off to make balloon burst)	Beacon timer parachute. Ballast control rate proportional to altitude error Reel for dropping antenna fouled.	Weigh off with spring balances. Balloon to carry antenna	Poly wrapped canvas girdle Antenna dropped 0917 First flight with torque wrenches	2 man launch. Tire came off 0907. Cloth girdle rigged with squibs.		No appendix ripcord	Girdle deflector Mod. 1. No appendix. Rip cord. Cornstarch bomb. Recovered gear showed tha was never dropped.
LAUNCHING									
Inflation Medium	Helium	Helium	Helium	Helium	Helium	Helium	Balloon destroyed on ground	Helium	Helium
Displaced Air	Unknown	Unknown	Approx. 523	591	356	311		482	506
Gross Lift	Unknown	Unknown	Approx. 447	505	304	267		413	434
Gross Load	310	260	347	409	251	213		345	354
Free Lift	Unknown	Unknown	Approx. 100	96	53	54		68	80
Percentage Free Lift of Gross Load Lift Air Displaced	Uncertain	Uncertain	Uncertain	23.5 19.0 16.2	21 17.5 14.9	25.4 20.2 17.3		19.8 16.5 14.2	22.6 18.5 15.8
Rate of Rise 1000-300 mb 300-100 mb 100 mb-ceiling	No data	No data	No data	280 ft/min to 320 mb	700 ft/min 340 ft/min 165 ft/min, 100 to 50 mb	940 ft/min 930 950		1000 ft/min 800 350 100 to 30 mb	810 ft/min 730 370 100 to 25 mb
Weather Clouds Ground Wind Other	Clear Very low	Clear No wind	Overcast 20 kt Jet stream	Clear No wind	Clear No record	Broken to scattered 12 to 18 kt	Clear 21 kt	Clear 14 kt N NW	Murky Broken 18 kt
Launching Site	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport	New Brighton Arms Plant
TRACKING									
Radio Frequency	1746	None	1746	1746 95 mc 220 mc	1724	1724 KC 218 MC	Balloon destroyed on ground	1746	1724
Time in Contact				1746 failed (antenna) Data 220 mc none	Complete	Lost at Knapp, Wisconsin		6 hours	16½ hours
Miscellaneous				Data came from counter sonde					
Airplane Type	None	O-2	O-2 MAN	None	O-2 MAN	O-2 MAN		O-2 MAN	O-2 MAN
Hours in Contact		Took off late and could not contact balloon	No contact (overcast)		Followed to impact	5		6 hours	No Contact
Theodolite Stations on	None	None	None	None	U of Minnesota Airport	U of Minnesota Airport		U of Minnesota Airport	U of Minnesota Airport
Hours in Contact					But no data	1042 to 1109		6 hours	7 hr 10 min
Truck When Dispatched	None	Followed by car	None	None	None	None		None	None
Hours in Contact									
RECOVERY IMPACT									
Estimate Before Flight								La Crosse, Wisconsin	Unknown
Actual Impact Balloon		Forest Lake power line	Chippewa Lake, Michigan					Medford, Wisconsin Victor Stendel	Not found
Load	U of Minnesota Airport	Attached to balloon	Reed City, Michigan Sgt. Grant, Michigan State Police	15 miles N. E. Bay City, Michigan Saginaw Bay.	2 miles N, 2 miles E St. Charles, Minnesota Lester Plotz	4 miles W of Chippewa Falls, Wisc. Mrs. Edna Gunderson		1 mile E of balloon	25 miles from Sturgeon Chamberlain Is. and St in Lake Michigan. Four brothers.
Dates and Time Balloon		January 18, 1952	February 8. 1952					April 23, 1952	Not found
Load			April 7, 1952		March 16, 1952 1900	March 29 1600		Found by air search near balloon	May 9 (15 days in lak
Notified of Position, How		Telephone	Telephone	Telephone	Plane Telephone	Telephone		Balloon by telephone	Telephone
When			April 9, 1952	March 1, 1952 1700	March 15, 1952				May 11, 1952
Recovered by Balloon		Wilenski	A. Metcalf, Jr.					Smith	
Load			Shipped in		Ney, Thorness			Byrne, Kruse	Smith
Gear Recovered		Balloon and load	All gear and balloon	Gondola Claire Meninch Counter Sonde free fell on farm Joe Waible, Pinconning, Michigan	Gondola	Gondola		Load Balloon	May 12, 1952
Miscellaneous	Balloon was packed into parachute like ice cream cone. Parachute was released by timers. It was hoped that the parachute would bring the balloon tail down slowly enough to avoid damage to the balloon.		Corset (same as Flight 4) came off prematurely. No torque wrench, only very rough weigh-off. Standard appendix for GMI balloons.	Used canvas girdle with hand grips instead of the corset developed for later flights. Standard appendix furnished with balloon (straight tube). Mod 1 tie downs.		2 man launch 39 minutes from time started to unload truck.	Inadequate bottom corset allowed balloon to slip out. Tape was folded under top ring and ripped a hole. Balloon slipped off at both ends. No appendix.	Conducted three air searches. Finally found load by air search near balloon which had been found by Stendel in the northeast corner of our search area. No appendix.	Established intermit Radio shack-balloon O-2MAN: 1724. Able via the balloon whe impossible. Receive with Olland cycle e No appendix.
C. A. A. CONTACTS									
Preflight					Spud, Erlewein	0848 Spud, Brill.		0826 Spud, Dripps	0910 Byrne to Buss
Take Off					0945 Spud, Erlewein	0906 Spud, Brill.		0930 Omally, Dripps	0949 Byrne
In Flight					1145 1242	O-2 MAN during flight.		1200 Gave estimated descent	1215 Byrne, 1515 Byr 1945 Byrne, Jones
Termination					1340 release Ney			1449 Spud	1000 April 24 Winckl
GONDOLA RECORDS									
Up Camera		None	None	None	20 ft good pictures, slightly overexposed	Operated throughout flight.		50 ft ok	50 ft Kodachrome ok day submersion in La
Down Camera		None	None	None	None	Operated throughout flight. Overexposed.		50 ft ok	Test pictures ok in mersion. Camera fail
Inside Camera		None	None	None	None	None		None	None
Barograph Thermograph		None	None	None	Good records	Good records		Good record Good record	Good records in spit in Lake Michigan
COURSE CHART	None	None	None	None	None	None	None	Single theodolite Down pictures	Single theodolite
PRINCIPLE CHARACTERISTICS OF FLIGHT	Parachute did not effectively slow descent of balloon tail and load snapped the 1000 lb line.	Gas was trapped under canopy. When canopy erected balloon lost its free lift and slowly settled.	Balloon disappeared into overcast. No data obtained because of antenna trouble.	Balloon weighed off incorrectly. Leaked or failed at 28,000 ft. Travelled in jet stream.	Canvas girdle slipped at too large balloon angle causing valving or gas during ascent. By release time girdle had come half way down the balloon tail.	Climbed to ceiling. Floated level until release by timers. Canvas girdle blown off at 8,500 ft.	Because of failure of the rigging at both ends we made a critical study of the packing and the launching hardware. The balloon was not launched. Measured the equator circumference 229' 4".	Climbed to altitude 10,000 ft below theoretical. Floated level until release by timers 3 hours later.	Climbed to altitude theoretical. Floated for 3 hr. Began desc developed a rate of sunset. Rate increas ft/min at sunset. Sl 40,000 ft, then bega more rapidly.

SECRET SECURITY INFORMATION

SECRET

FLIGHT OPERATIONS CHART

7	8	9	10	11	12	13	14	15	16
April 7, 1952	April 10, 1952	April 23, 1952	April 29, 1952	May 8, 1952	May 12, 1952	May 15, 1952	May 22, 1952	May 26, 1952	June 3, 1952
Not launched	0800	0934	1506	1510	0929	1815	1419 (delayed, airplanes in vicinity)	1553	1300
Winsen 73' x 1 mil DB 2500	Winsen 73' x 1.5 mil 150-B-73	Winsen 73' x 1 mil 100-V-71	DB-2500 Winsen 73' x 1 mil 100-V-67	72.8 ft 1 mil Poly. Winsen acetate 100-V-70 Antenna	72.8' x 1.5 mil Poly. Winsen 150-V-110 (Antenna) Glass filament	72.9' x 1 mil Winsen acetate 100-V-114 (Antenna) 8' standard appendix	73' x 1.5 mil Winsen 150-V-112 Glass filament	73' x 1 mil Winsen acetate tapes 100-V-113	72.8' x 2 x 1 mil W... 2(100-V-119) Glass f...
Edwards, Hansen, Smith	April 8, 1952 Edwards, Hansen, Smith	April 19, 1952 Edwards, Hansen, Smith	April 25, 1952 Edwards, Hansen, Smith	April 26, 1952 Hansen, Edwards, Smith	May 6, 1952 Hansen, Smith, Edwards	May 14 Polished girdle Hansen, Edwards, Smith	May 19, 1952 Hansen, Edwards, Smith	May 20, 1952 Smith, Hansen, Edwards	May 28, 1952 Smith, Hansen, Edwards
Not launched	152 lb	115 lb	110 lb	110 lb	177 lb	115 lb	180 lb	115 lb	235 lb
	91,000 81,800	88,500 87,000	97,000 86,000	73,500 80,900	93,000 90,000	86,500 87,700	82,000 64,000 (Girdle in starting position)	80,000 76,000	83,000 83,600
Balloon performance	Balloon performance	Sunset effect and effect of ballast dropped at night. Receiver test.	Sunset effect with helium and 1 mil balloon. No ballast.	Ammonia test #1	Test round trip radio link Second model command receiver	0. Anderson plate mover	Control system test and balloon leakage with 3/8" dia. hole 1 top	Ammonia sunset	Sunset effect on double balloon. Command receiver
6 hours	6 hours	27 hours	Approx. 6 hours	6½ hours	6 hours	23 hours	24 to 48 hours	7 hours 10 minutes	10 hours
Not launched	6 hours	16½ hours	6½ hours (to release)	6½ hours	60 to 72 hours	3 1/3 hours	Unknown	7 hours	3 hours 35 minutes
	Timers	Aneroid blowdown	Timers	Aneroid blowdown	Aneroid blowdown	Aneroid blowdown	Unknown	Timers	Aneroid blowdown
2	2	1	4	4	2	6	3	4	4
	1746 XMTR #23. Modified Olland cycle #1. Vibrapack #2. Antenna dropper #2.	5 watt beacon #1. Olland cycle #2. 6420 modified Sentinel receiver #1. Expanding type antenna dropper #2.	1 watt beacon #21. Olland cycle (Amico).	1638 XMTR #21 Vibrapack #3 Batt. #13 Olland cycle #5	1724 KC XMTR #26. Drop #4. Vibrapack #15. Olland cycle #6. 6420 KC RCVR #1. Timer motor.2 min 25 sec Telemeter. 2 min receiving.	1638 XMTR #23 Drop #5 Vibrapack #2 Olland cycle #7	MAAS RCVR #4. Olland cycle with indication of ballast and 1 min blow down.	Standard 1638 Vibrapack #2 Olland cycle #7 XMTR #23 Antenna dropper #7 (4800 ft)	Standard 1638 KC XMTR #2... cycle #5 recalibrated. ... dropper #7 (4700). Vibra...
	Timers #1. Aneroid blowdown #7	Timer #1. Aneroid blowdown #3 low altitude release, #4 ballast blowoff	Timers #5 (operated) Aneroid blowdown #5 (operated)	Flight timer #5 Aneroid blowdown #5	Flight timer #6. Aneroid blowdown #2. Fires 33,000 ft.	Flight timer #2 (long). Aneroid blowdown #6 (cocks 57,000, fires 31,000).	Aneroid blowdown #5	Timer #5. Aneroid blowdown #7.	Aneroid blowdown #1 (co... fires-30,000). Timer #5 ... at 1222.
	Up #1 Ilex f-11 1/150 Down #2 Bolsey f-11 1/300	Up #6 Bolsey f-9 1/50 Kodachrome Down #7 Bolsey f-11 1/200 G filter + X film	Up #9 Ilex f-9 1/50 Anglo daylight Kodachrome. Operated ok but tilted. Down #8 f-11 1/200 G filter Anglo + X. Stopped transporting film after 30 frames.	Up Ilex 1/150 f-13 G filter + X Graydon motor Down #8 Bolsey 1/200 f-16 G filter Graydon Rate of rise #10 Lina. Ortho.	Up #12 (+ X) Ilex 1/150 f-11 G filter Down #11 (+ X) Bolsey 1/200 at f-16 G filter Balloon top camera #9 mount #1 Ilex 1/150 f-11 G filter	None	Up camera Haydon 1 min Down camera Anglo 5 min	Up #15 (+ X) Ilex Anglo 1 min Down #14 (+ X) Bolsey Anglo 1 min	Up #15. Down #14. Balloon top camera #4. No...
	None	30 lb	None	None	None	Ballast dropper #1 set as follows: 2100 - 20 lb 0900 - 10 lb 2100 - 10 1300 - 10	100 lb	3 six lb increments dropped after reaching ceiling	None
	Geiger counter telescope Four single counters	Lead block plates	Plates	None	None	Sphere containing plate mover Weight 125 lb.	Plates for Anderson	None	Vertical telescope. H. Lin... 3 lb nuclear emulsions.
	None	None	Blinker unit—motor cycled. Headlight bulb #1.	Strob-light #1 490 v dry cell	None	Beacon light and Timer #2	Flasher beacon Pressure switch operated	Strob flasher unit #1 Turns on four hours after take off	Strob flash #1 (same as Fl... Turns on 1930.
	Barograph #1B. Thermograph gave good records.	Barograph #2. Thermograph gave good records.	Barograph #3 and thermograph gave good records.	Barograph #1	Barograph #3.	Barograph #1.	Barograph #4. Thermograph and ballastograph.	Barograph #1 Thermograph Two baro discs	Barograph #4. Thermograph
	No appendix ripcord	Girdle deflector Mod. 1. No appendix. Rip cord. Cornstarch bomb. Recovered gear showed that ballast was never dropped.	Girdle deflector Mod. 1. No appendix. 48" appendix hole. Rip cord.	Girdle catcher model 2	Had mike in balloon throat. Listened through 1724 on way up every 2 min. Then listen to 6420 receiver. Resonant relay keys sub-carrier. Made contact with plane on 6420-1724 link through balloon after detuning NCA1 transmitter.	Girdle catcher Mod. 2. Magnesium yoke. Post cards in special drop (30,000 ft) RPD #1. Timer on XMTR starts cycling 3 min on out of 15 at 2100.	3/8" dia. hole in top of balloon Ballast telemetering failed at 1743		Magnesium truss equalizer. 50 post cards in chute. Blowdown relay #1. Balloon had 1000 lb line up top to save camera.
Balloon destroyed on ground	Helium	Helium	Helium	Ammonia + Balloon + 50 lb Helium + 150 lb more	Helium	Helium	Helium	Ammonia (100%)	Helium
	452	506	334	633	418	589	645	870	610
	413	434	292	326	357	503	564	359	528
	345	354	244	262	287	419	[illegible]	275	458
	68	80	48	64	70	84	84	84	70
	19.8 16.5 14.2	22.6 18.5 15.8	19.6 16.4 14.4	24.0 20.0 16.0	24.4 19.6 16.8	20.3 16.9 14.4	17.8 14.4 10.0	30.5 23.3 9.7	15.3 13.2 11.5
	1000 ft/min 800 350 100 to 30 mb	810 ft/min 730 370 100 to 25 mb	910 ft/min 1060 840 (100 to 30 mb)	960 ft/min 860 760 100-35 mb	910 ft/min 780 610 100-25 mb	1200 ft/min 1000 1250 100 to 20 mb	730 ft/min 650 420	750 ft/min 900 1200 100 to 40 mb	830 ft/min 1000 1200 100 to 25 mb
	Clear 14 kt N NW	Murky Broken 18 kt	Clear Gusty 10 kt (Launched in wind screen eddy)	Overcast Gusty 5 mph	10,000 Layer scattered 10-25 mph gusty	Overcast 5-10 kts.	N. S. for balloons Broken 20-30 mph Gusty Definite no jet stream	Scattered to broken 10-12. Gusts to 20, 170°. Gusty 45 mph at 40,000	Clear Little cirrus and cumulus Light, variable 50 mph at 40,000 Definite no jet
U of Minnesota Airport	U of Minnesota Airport	New Brighton Arms Plant	U of Minnesota Airport	U of Minnesota Airport Behind screen	U of Minnesota Airport	U of Minnesota Airport Behind screen	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport
Balloon destroyed on ground	1746	1724	1638 KC	1638 KC beacon	1724 beacon	1638 KC beacon	6420 Receiver 1638 Beacon	1638 beacon	1638 beacon theodolite
	6 hours	16½ hours	6 hr 46 min	4½ hours	10 1/3 hr	7 hr 40 min until 2355	Until 1900 at center	Until 2110 (5½ hr)	until 1635
	O-2 MAN	O-2 MAN	O-2N						Was able to operate command rcvr from NCA-1 R. F. drift. Relay contact not positive.
	6 hours	No Contact	No Contact	Beechcraft	Beechcraft Kay, Winckler, Thorness	Beechcraft	Beechcraft	Beechcraft	Beechcraft
				7 hr 10 min	0930-1630 May 12 0630-0730 May 13	Take off to 2020	In contact until 2030 Had to leave because of weather		Until on ground
	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport	U of Minnesota Airport No data	1st day U of Minnesota Airport 2nd day Airport and Campus	U of Minnesota Airport		U of Minnesota Airport	U of Minnesota Airport
	6 hours	7 hr 10 min	1520 to 2000	4½ hr	1st day 0930-2100 2nd day 0500-2000	1835 - 2000			Until 1635
	None	None	No track	Left for Stillwater 1606	Left 1300 returned soon	2230 at Eau Claire	1645 to Taylors Falls	1700	1540
	La Crosse, Wisconsin	Unknown	Anoka	Eau Claire, Wisconsin		None	None		None
	Medford, Wisconsin Victor Standel	Not found	Rock Falls (near Eau Claire)	Lost	Martha's Vineyard, Massachusetts	Farm of Laurence Zingsheim Route #2, Augusta, Wisconsin	Fifield, Wisconsin. Found by Peary Hansen, Jr.		Balloon did not rip but ascended again.
	1 mile E of balloon	25 miles from Sturgeon Bay between Chamberlain Is. and Strawberry Is. in Lake Michigan. Found by Allie brothers.	Rock Falls	Farm of John Chapek, Route 1, Jim Falls, Wisconsin	100 miles Southeast of New York harbor	Farm of Archie Strader Route #2, Augusta, Wisconsin	Fifield, Wisconsin. Found by Lloyd Kilgren, Jr.	2 1/4 miles N. E. of Marshfield, Wisconsin (Adam Emig)	Blair, Wisconsin 1700
	April 23, 1952	Not Found	April 30, 1952	Lost	May 15, 1952 afternoon	2100	Approx. June 19 (found)	0530 May 27	
	Found by air search near balloon	May 9 (15 days in lake)	April 30, 1952 0700	Morning, May 9	May 16, 1952 1830 EST	2106	July 16 (found)	0430 May 27	
	Balloon by telephone	Telephone	Finder telephoned	Telephone	Telephone	Telephone	Telephone	Telephone	Plane and Mr. Chal, Blair, Wisconsin, phone
	Smith	May 11, 1952	April 30 0900 balloon, 1000 load	May 9, 1952	May 16 Balloon May 19 Gondola	May 16	July 3	May 27	1715
	Byrne, Kraus	Smith	Smith	Lost	Camera detached and shipped	Don Hansen	Don Hansen	Edwards, Smith	Navy truck recovered
	Load Balloon	May 12, 1952	Smith	Hansen	Shipped	Don Hansen	Hansen-Edwards	Edwards, Smith	Gondola
			April 30, 1952	Girdle—Chippewa Falls, Wisconsin C. A. Bronsted, May 9 Gondola	Girdle: Island off Cape Cod May 25. Called May 26. Received June 6. Gondola inside camera.	No top plate but girdle with balloon Gondola Balloon	All gear. Balloon and all rigging gear	All Gear Balloon All balloon hardware	
...uate bottom corset allowed ...n to slip out. Tape was ... under top ring and ripped a ... balloon slipped off at both ...endix.	Conducted three air searches. Finally found load by air search near balloon which had been found by Standel in the northeast corner of our search area. No appendix.	Established intermittent contact. Radio check—balloon: 6420. Balloon-O-7MAN: 1724. Able to communicate via the balloon when direct 6420 impossible. Receiver was cycled with Olland cycle each on 1 min. No appendix.	The girdle was not with load. Balloon and load recovered near each other. Girdle was recovered. Ring in top of balloon recovered. Three pieces of balloon scattered over 3 acres (tapes all loose). No appendix.	Tire deflator 1½ turns. No appendix. Rate of rise indicator gave data during ascent.	Tire deflator 1½ turns. No appendix. Timers failed, balloon and load up 2 nights at least and 3 days. Load may have hung on ripcord. Altoo mike worked on take off. No disturbance was heard on the ascent. May be malfunction.	Tire deflator 1½ turns. Girdle remained on to 1930 (≈ 75,000 ft). Appendix: 8 ft standard 1 mil tube size of balloon bottom. No stiffeners. Girdle probably acted as an automatic appendix since it was last observed to slip at 74,000 ft.	At 1600 girdle had not slipped. Balloon reached theoretical ceiling for girdle at take off position. No appendix, but girdle in position acted as appendix. Believe tire deflator was damaged, during take off by inside camera. Reason for girdle not slipping. Hole was placed in top of balloon.	Girdle came all the way down 20 min after take off. Tire deflator set for 14,000 ft. This balloon descended at sunset and rose again during the night. No appendix.	Plane co-pilot and finder of gear (Chal) said only one box. Girdle came off 29,000 ft 1345 (1 1/4 turns tire deflator). Winckler appendix with 8 slats, 3" clips. Girdle tore hole in balloon when girdle was released (plastic heat-sealed to girdle by sun).
	0826 Spud, Dripps	0910 Byrne to Bussey	1500 (Thorness)	1425—initial Spud, Dripps	Initial 0840 Spud, Dripps	1722 Initial Brill, Spud	1245, 1320 Spud Also conversation with Hart of Northwest.	1405, 1500 Spud	1225 Spud
	0930 Cmally, Dripps	0949 Byrne	1512 (Thorness)	1520 Manna	0942 Robinson, Spud	1833 Brill, Spud	1422 Beech, Magnus	1600 Magnus 1610 Spud	1310 CAA called. Stoddard notified of release. 1310 Magnus from plane.
	1200 Gave estimated descent	1215 Byrne, 1515 Byrne, Bussey 1945 Byrne, Jones	None		Plane during day	Plane			
	1600 Spud	1000 April 24 Winckler	2200 (Ray)		1605 Dripps, Spud. Notif. of no release. 2000 Lerner, Winckler.	2215 Brill, Winckler		Plane	Plane at release.
	50 ft ok	50 ft Kodachrome ok in spite of 15 day submersion in Lake Michigan	50 ft Kodachrome ok	Entire film ran through. Two film before sunset.	50 ft Kodachrome ok (24 to 36 hr in Atlantic).	None flown	50 ft ok	38 ft of good film before sunset	38 ft ran through. Good pictures
	50 ft ok	Test pictures ok in spite of submersion. Camera failed in flight.	Camera failed after 30 frames.	Entire film ran through pictures show clouds	45 ft out of 50 ft good pictures (24 to 36 hr in Atlantic). Inner part of spool dissolved.	None flown	50 ft ok	12 ft ran through	35 ft good pictures
	None	None	None	Rate of rise camera ok 50 ft	None	None flown			All but 4 ft ran through
	Good record Good record	Good records in spite of 15 days in Lake Michigan	Good record Not readable	Failed to run Not started properly	Both corroded by sea water. No record obtained	Good record Good record	Good record Good record	Both gave records but clock stopped time	
	Single theodolite Down pictures	Single theodolite	Single theodolite	None	Double theodolite	Single theodolite	Single theodolite	Single theodolite	Single theodolite
...failure of the rigging ...s we made a critical ... packing and the ...ardware. ...was not launched. ... equator circumference	Climbed to altitude 10,000 ft below theoretical. Floated level until release by timers 3 hours later.	Climbed to altitude 2000 ft below theoretical. Floated approx. level for 3 hr. Began descending and developed a rate of 60 ft/min by sunset. Rate increased to 120 ft/min at sunset. Slowed down at 40,000 ft, then began descending more rapidly.	Climbed to altitude of 96,000 ft (3000 ft below theoretical). Floated level for 2½ hr until sunset. In 2½ hr after sunset the balloon only lost 6000 ft of altitude.	Balloon rose to altitude 7000 ft above theoretical for the mixture (probably due to valving pure ammonia). After reaching altitude it descended at 260 ft/min almost 2 hours maintaining this constant rate. Reached release altitude at sunset.	Climbed to altitude 3000 ft below theoretical and stayed level until sunset. Descended during night to approx. 40,000 ft. Climbed back up to 78,000 ft the next day (May 13). At sunset of May 13 was southwest of Mpls. Could not have reached east coast during night so the earliest release time would be during the day or night of May 14. Latest release May 15.	Climbed to theoretical ceiling. Floated level 15 min and then descended at an ever increasing rate (beginning at sunset). A large hole must have opened up at sunset. Balloon was recovered but the top was missing. The girdle probably acted as an automatic appendix.	Climbed to theoretical ceiling for girdle in original position (64,000 ft). This is a factor of 2.38 in pressure below the full theoretical ceiling. Floated level for 3 hours then radio contact was lost. Barograph was not recovered.	Climbed to altitude with steadily increasing rate of rise. Reached altitude 4000 ft below theoretical. Stayed level until sunset. Descended at 400 ft/min. Leveled off during night at 37,000 ft. Climbed 2700 ft before release.	Climbed to theoretical ceiling. Began descending almost immediately with ever increasing rate typical of a leak. Believe the appendix was too tight and opened a hole during valving.

2

[illegible]	[illegible]	[illegible]	May 26, 1952	June 3, 1952	June [illegible], 1952	[illegible]	[illegible]	[illegible]	
	1[illegible]	1419 (delayed, airplanes in vicinity)	1553	1300	123[illegible]	[illegible]	[illegible]	[illegible]	
[illegible].5 mil Poly. [illegible] [illegible] (Antenna) [illegible]	72.8' x 1 mil Winzen acetate 100-V-114 (Antenna) 8" standard appendix	73' x 1.5 mil Winzen 150-V-112 Glass filament	73' x 1 mil Winzen acetate tapes 100-V-113	72.8' x 2 x 1 mil Winzen 2(100-V-119) Glass filament	72.8' x [illegible] 100-V-123 [illegible]	[illegible]	[illegible]	[illegible]	
[illegible]52 Smith, Edwards	May 14 Polished girdle Hansen, Edwards, Smith	May 19, 1952 Hansen, Edwards, Smith	May 20, 1952 Smith, Hansen, Edwards	May 28, 1952 Smith, Hansen, Edwards	June [illegible] Smith, [illegible]	[illegible]	[illegible]	[illegible]	
	115 lb	180 lb	115 lb	235 lb	[illegible]				
	86,500 87,700	82,000 64,000 (Girdle in starting position)	80,000 76,000	83,000 83,600	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible] trip radio link [illegible] command receiver	G. Anderson plate mover	Control system test and balloon leakage with 3/8" dia. hole in top	Ammonia sunset	Sunset effect on double wall balloon. Command receiver test.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	23 hours	24 to 48 hours	7 hours 10 minutes	12 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]hours	3 1/3 hours	Unknown	7 hours	3 hours 35 minutes	[illegible]	[illegible]	[illegible]	[illegible]	Actual Duration
[illegible]blowdown	Aneroid blowdown	Unknown	Timers	Aneroid blowdown	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Released
									CONTROL DATA
	6	3	4	4			[illegible]		Gondola No.
[illegible]XMTR #26. Drop #4. [illegible]#15. Olland cycle #6. [illegible]VR #1. Timer motor. 2 min [illegible]ometer. 2 min receiving.	1638 XMTR #23 Drop #5 Vibrapack #2 Olland cycle #7	NRAS RCVR #4. Olland cycle with indication of ballast and 1 min blow down.	Standard 1638 Vibrapack #2 Olland cycle #7 XMTR #23 Antenna dropper #7 (1,500 ft)	Standard 1638 [illegible] XMTR #[illegible]. Olland cycle #6 [illegible]. Antenna dropper #7 [illegible]. Vibrapack [illegible]	[illegible]	[illegible]	[illegible]	Standard [illegible] XMTR #[illegible], Olland cycle [illegible] minute [illegible], Antenna dropper #[illegible]	Radio Gear
[illegible]r #6. Aneroid blowdown [illegible]3,000 ft.	Flight timer #2 (long). Aneroid blowdown #6 (cocks 57,000, fires 31,000).	Aneroid blowdown #5	Timer #5. Aneroid blowdown #7.	Aneroid blowdown #[illegible] [illegible]	[illegible]		[illegible]	Aneroid blowdown. Timer #5 and [illegible]	Blow [illegible]
[illegible]X) Ilex 1/150 f-11 [illegible]ilter [illegible]X) Bolsey 1/200 at f-16 [illegible]ilter [illegible] camera #9 mount #1 [illegible] 1/150 f-11 G filter	None	Up camera Haydon 1 min Down camera Anglo 5 min	Up #15 (+ X) Ilex Anglo 1 min Down #14 (+ X) Bolsey Anglo 1 [illegible]	Up #[illegible] Down #[illegible] [illegible]	Up #[illegible] Down #[illegible]	[illegible]	Up #[illegible] Down #[illegible] [illegible]	Up camera #15. Down camera #[illegible].	Cameras
	Ballast dropper #1 set as follows: 2100 – 20 lb 0900 – 10 lb 0100 – 10 1300 – 10	100 lb	3 six lb increments reaching ceiling [illegible]	None	None		None	30 lb ballast. Operated [illegible] relay on command.	Ballast
	Sphere containing plate mover Weight 125 lb.	Plates for Anderson	None	[illegible]	None		None	Cosmic [illegible]	Cosmic Ray
	Beacon light and Timer #2	Flasher beacon Pressure switch operated	Strobe flasher [illegible] Turns [illegible]	[illegible]	Flasher #[illegible]	[illegible]	Flasher #[illegible]	Truck [illegible] flasher #[illegible]	Light
[illegible]9.	Barograph #1.	Barograph #4. Thermograph and ballastograph.	Barograph #[illegible]. Thermograph [illegible]	Barograph #[illegible]. Thermograph	Barograph #[illegible]. Thermograph	Barograph [illegible] Thermograph	Barograph #[illegible]. Thermograph	Barograph Thermograph	Barograph
[illegible] balloon throat. [illegible]ough 1724 on way up [illegible] Then listen to 6420 [illegible]sonant relay keys sub- [illegible] with plane on 6420- [illegible]rough balloon after [illegible] transmitter.	Girdle catcher Mod. 2. Magnesium yoke. Post cards in special drop (30,000 ft) RFD #1. Timer on XMTR starts cycling 3 min on out of 15 at 2100.	3/8" dia. hole in top of balloon Ballast telemetering failed at 171[illegible]		[illegible] 50 post cards [illegible]	[illegible]	[illegible]	50 post cards Camera [illegible] top of balloon	50 post cards	Miscellaneous
									LAUNCHING
	Helium	Helium	[illegible]	Helium	[illegible]	[illegible]	Helium	Helium	Inflation Medium
	589	645	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Displaced Air
	503	564	[illegible]	[illegible]			[illegible]	[illegible]	Gross Lift
	419	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	Gross Load
	84	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	Free Lift
	20.3 16.9 14.4	[illegible]	[illegible]	[illegible]			[illegible]	15.8 13.6 11.6	Percentage Free Lift of Gross Load Lift Air Displaced
[illegible]0–25 mb	1700 ft/min 1[illegible] 1350	[illegible]	[illegible]	[illegible]	[illegible]		[illegible] ft/min	811 ft/min 930 1200	Rate of Rise 1000–300 mb 300–100 mb 100 mb-ceiling
[illegible]scattered [illegible]sty	Overcast 5–10 kts.	[illegible]	[illegible]	[illegible]	[illegible]		Scattered [illegible] cirrus cumulus [illegible] [illegible] mph (between 36,000 and [illegible] ft)	Clear (slight haze) 10 kt in open	Weather Clouds Ground Wind Other
[illegible] Airport	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		U of Minnesota Airport	U of Minnesota Airport	Launching Site
									TRACKING
	[illegible]	[illegible]	[illegible]	[illegible]	1638 beacon Theodolite (observed burst)	Balloon not released.	1638 beacon Theodolite	1638 beacon	Radio Frequency
	[illegible]	[illegible]	[illegible]	[illegible]	Until burst				Time in Contact
				[illegible]	See below				Miscellaneous
[illegible]	Beechcraft	Beechcraft	[illegible]	[illegible]	Beechcraft		Beechcraft	O2N	Airplane
[illegible]	[illegible]	[illegible]		[illegible]	Tracked it to ground		Until release. Reported release 15 miles west of Lone Rock		Hours in Contact
[illegible]	[illegible]		[illegible]	[illegible]	U of Minnesota Airport		U of Minnesota Airport	U of Minnesota Airport	Theodolite Stations on
[illegible]	[illegible]	[illegible]		[illegible]	Until after burst		From launch until sunset		Hours in Contact
				[illegible]	1300		1345	1320 for Red Wing	Truck When Dispatched
	None			None	Continuously			1320 to 2330	Hours in Contact
									RECOVERY IMPACT
	None				[illegible], Lone Rock, Wisconsin				Estimate Before Flight
[illegible]	[illegible]	[illegible]		[illegible]			Elgin, Illinois Airport Farmer Collins. Kieth Wade		Actual Impact Balloon
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	John Barfield called in. Magnus followed to ground		Keith Hardy, Route #2, Muscoda. 13 miles due west of Lone Rock.	Sheriff Melchert Chaska, Minnesota	Load
[illegible]	[illegible]	[illegible]	[illegible]				June 11 0700		Dates and Time Balloon
[illegible]	[illegible]	[illegible]	[illegible]				June 11 during day	June 13, 1952	Load
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] by Mr. [illegible]	Magnus and telephone		Telephone	Telephone	Notified of Position, How
[illegible]	[illegible]	[illegible]	[illegible]		June 5		June 11 balloon, June 12 load	June 13, 1952	When
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Lewis, Bales. Navy truck recovered within an hour after impact.		Bales, Farger, Navy truck (left at Lone Rock)	Hansen	Recovered by, Balloon
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Load and bottom and top of balloon		Balloon, camera, girdle, girdle catcher. Gondola.	Gondola	Load, Gear Recovered
[illegible]	[illegible]	[illegible]	[illegible]	Plane re-girdled and finder of gear [illegible] only one box. [illegible] Girdle tore hole in balloon when girdle was released (plastic heat-sealed to girdle by sun).	This balloon showed a faster and faster rate of rise as it ascended. It appears to be an inverse of Flight 15. Girdle came down 1324 to 1328. Winckler appendix with 4 slats, 2" clips.		Girdle came off 1337—23,500 ft (1 1/4 turns tire deflator). Winckler appendix with 4 slats, 2" clips. Load released 2135 by aneroid blowdown.	Girdle off 1336, 27,000 ft. Winckler appendix with 4 slats, 2" clips. Command receiver worked well. Ballast was released by command.	Miscellaneous
									CAA CONTACTS
[illegible]	[illegible]	[illegible]	[illegible] Spud	1225 Spud	1045 Spud, Lerner 1138 (delay) Spud, Lerner		1230 Spud, Brill	1230 Spud, Lerner	Preflight
[illegible]	[illegible]	[illegible]	[illegible] Spud	1310 CAA called. Stoddard notified of release. 1310 Magnus from plane.	1245 Spud, Lerner		1313 Spud, Brill	1309 Spud, Lerner	Takeoff
									In Flight
[illegible]	[illegible]		[illegible]	Plane at release.	Plane notified of burst		Plane notified of release	2325 Ney. Notified CAA of timer failure	Termination
									GONDOLA RECORDS
			[illegible] before sunset	38 ft ran through. Good pictures	25 ft ran through. Good pictures		50 ft Super X ok	50 ft Super X ok	Up Camera
	[illegible]		[illegible] ran through	35 ft good pictures	25 ft ran through. Good pictures		50 ft Super X ok	50 ft Super X ok	Down Camera
				All but 4 ft ran through			50 ft Super X ok	None	Inside Camera
[illegible]	[illegible]	[illegible]	Both good records but clock stopped [illegible]		Good record Good record		Clock apparently stopped after reaching altitude. Started during descent.	Good record Good record	Barograph Thermograph
	[illegible]	[illegible]	Single theodolite	Single theodolite	Single theodolite		Single theodolite	Single theodolite	COURSE CHART
[illegible]	[illegible]	Climbed to theoretical ceiling [illegible]	[illegible] altitude with steadily [illegible] rate of rise. Reached [illegible] 3000 ft below theoretical. [illegible] Leveled off during [illegible] at 37,000 ft. Climbed 2700 ft before release.	Climbed to theoretical ceiling. Began descending almost immediately with ever increasing rate typical of a leak. Believe the appendix was too tight and opened a hole during valving.	Balloon climbed to an altitude 3000 ft below theoretical and burst. (This was the altitude at which valving commenced.) The up pictures showed the appendix was fouled by the girdle, causing the failure.	Sun heated girdle and melted acetate tapes during inflation. When inner bubble was filled to capacity it blew a seam. Balloon was not launched.	Climbed to theoretical ceiling. After 35 min of approximately level flight began descending and developed a rate of 90 ft/min. At sunset this rate increased to 270 ft/min.	Climbed to theoretical ceiling. Floated level 60 min. Established rate of descent of 160 ft/min. At 1730 30 lb ballast dropped (5.5% of displaced air). Balloon climbed from 72,000 to 78,000 ft (10,000 ft below theoretical) and floated level until sunset when it began to descend at 160 ft/min. New ceiling corresponds to 2/3 original balloon volume.	PRINCIPLE CHARACTERISTICS OF FLIGHT

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