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Attachment to Colonel Weaver's Report of Air Force Research:

33. Mensuration Working Paper, with Drawing and Photo

12

New York University
Constant Level Balloons
Section 3, *Summary of Flights*
July 15, 1949

Technical Report No. 93.02

CONSTANT LEVEL BALLOONS
Section 3

SUMMARY OF FLIGHTS

Constant Level Balloon Project
New York University

Prepared in Accordance with provisions of Contract
W28-099-ac-241, between
Watson Laboratories, Red Bank, New Jersey
and
New York University

The research reported in this document has been made possible through support and sponsorship extended by the Geophysical Research Directorate of the Cambridge Field Station, AMC, U. S. Air Force, under Contract No. W28-099 ac-241. It is published for technical information only and does not represent recommendations or conclusions of the sponsoring agency.

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Table of Contents

Introduction

In November, 1946 the Research Division of the College of Engineering of New York University contracted with Watson Laboratories, AMC, to develop and fly constant-level instrument-carrying balloons. This is the third part of the final report on the work accomplished and describes the experimental balloon flights which were made.

In reviewing the flights a number of analytical comments may be made. In most flights one objective was the maintenance of the balloon at a constant pressure level for as long as possible. On many flights balloon behavior was affected by instrumental controls of one kind or another while on some flights no controls at all were used.

Balloons of varying sizes and of different principles of construction have been launched singly, in tandem and in clusters. On some, temperatures were measured and on others the flight path was an object of special study. To explain certain observed flight data a careful analysis of atmospheric stability has been made, while other flights have special significance because they demonstrate the effect of superheat on the lifting gas or some other feature of analytical importance.

Since over 100 flights have been made, it is difficult to tabulate the important results obtained on each specific flight. To present the data which has been collected each significant flight is presented chronologically, with drawings and details where necessary, and a summary of the flight results is given.

To render this information useful, an index has been prepared with reference made to flights which show typical or important results in each category.

Flight 5: Released from Alamogordo, New Mexico, 0517 MST, June 5, 1947
Recovered at Roswell, New Mexico

In this flight, a 55-pound load was lifted with a linear array of 28 350-gram rubber balloons. By attaching the balloons at 20-foot intervals along the load line, a total length of about 600 feet was required. The train is shown in Figure 1. For altitude control, three lifting balloons

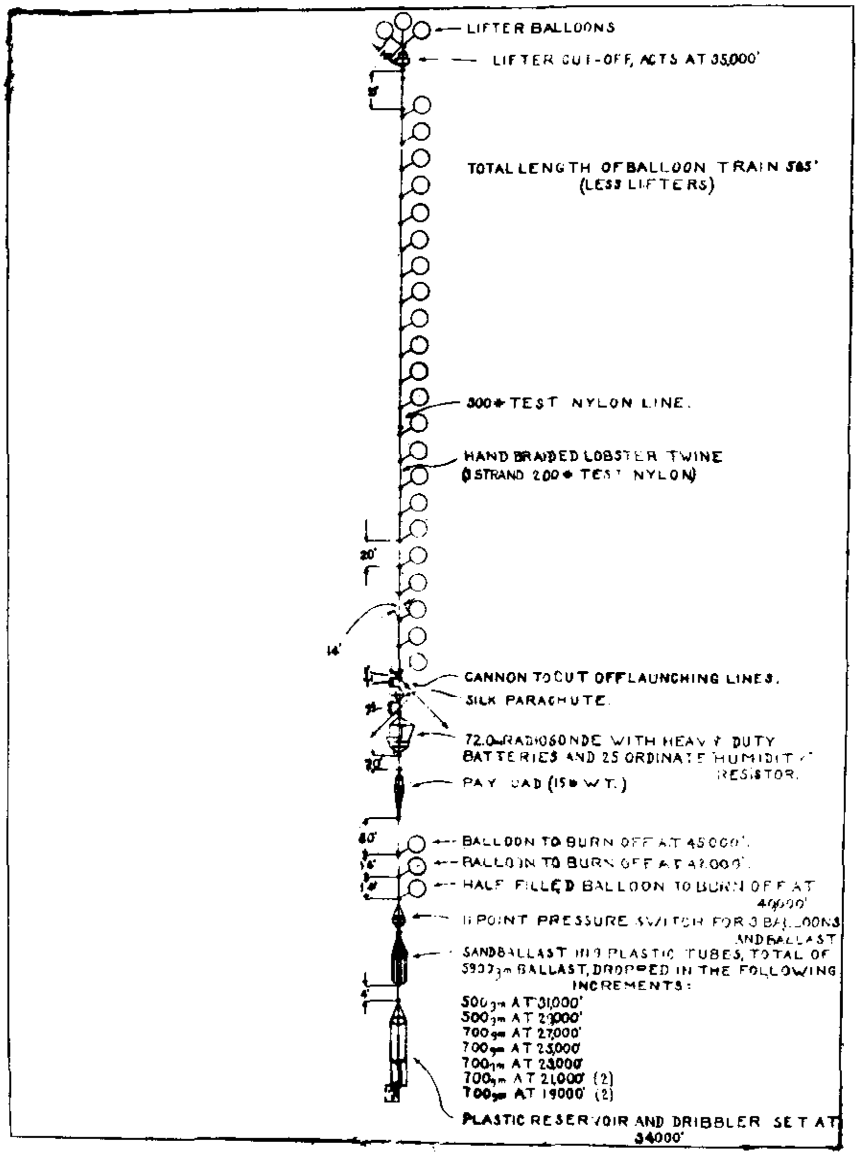


Figure 1: Train, Flight 5

were cut free at 35,000 feet, and the remaining load was weighted to balance at that point. As a precaution against over-buoyancy, three more balloons were to be freed at 40,000, 42,000 and 45,000 feet. The use of sand ballast, to be dropped in increments upon descent to altitudes below 31,000 feet, was supplemented by an early model of the automatic ballast valve set to expend liquid ballast at 34,000 feet.

From the height-time curve of the flight (Figure 2), it will be seen that the maximum altitude reached was much above the predicted 35,000 feet. Also

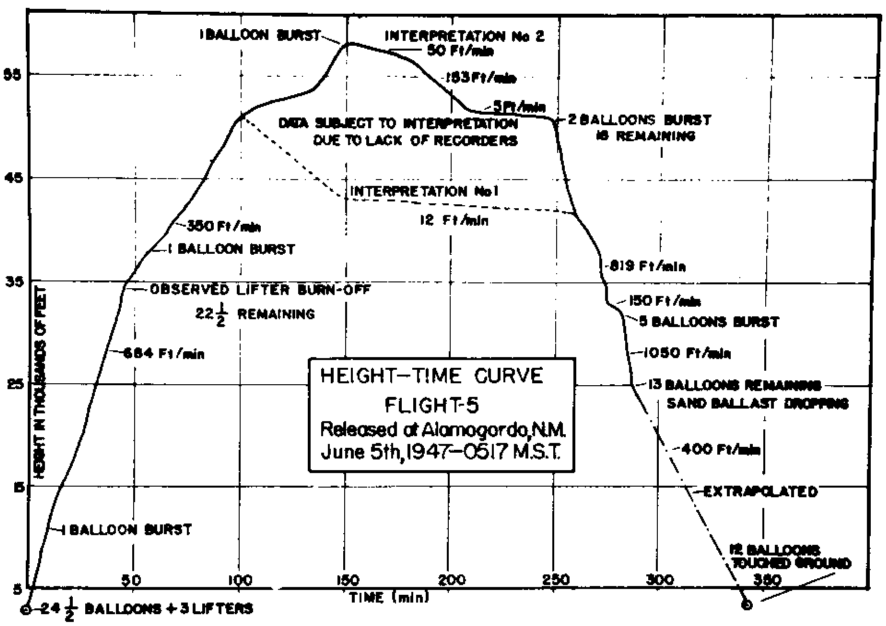


Figure 2

the rate of rise was greater than expected. Both of these evidences of excess buoyancy are attributed to superheating of the balloon by sunshine. The real height is somewhat in doubt because the conventional radiosonde baroswitch (Army type ML-310/)was used, and the pressure signal which was transmitted was ambiguous at some points.

On this flight theodolite readings were taken until the balloon was 90 miles away from release point after 260 minutes of flight. In addition, visual observations were taken from a B-17 aircraft which circled the balloon for most of the flight.

<u>Flight 7</u>: Released from Alamogordo, New Mexico, 0509 MST, July 2, 1947
Descended at Cloudcroft, New Mexico

Using a cluster array (Figure 3) of 13 350-gram rubber balloons and four larger lifting balloons, a 53-pound load was carried aloft on this flight. At 35,000 feet, the desired floating level, the lifter balloons were cut free.

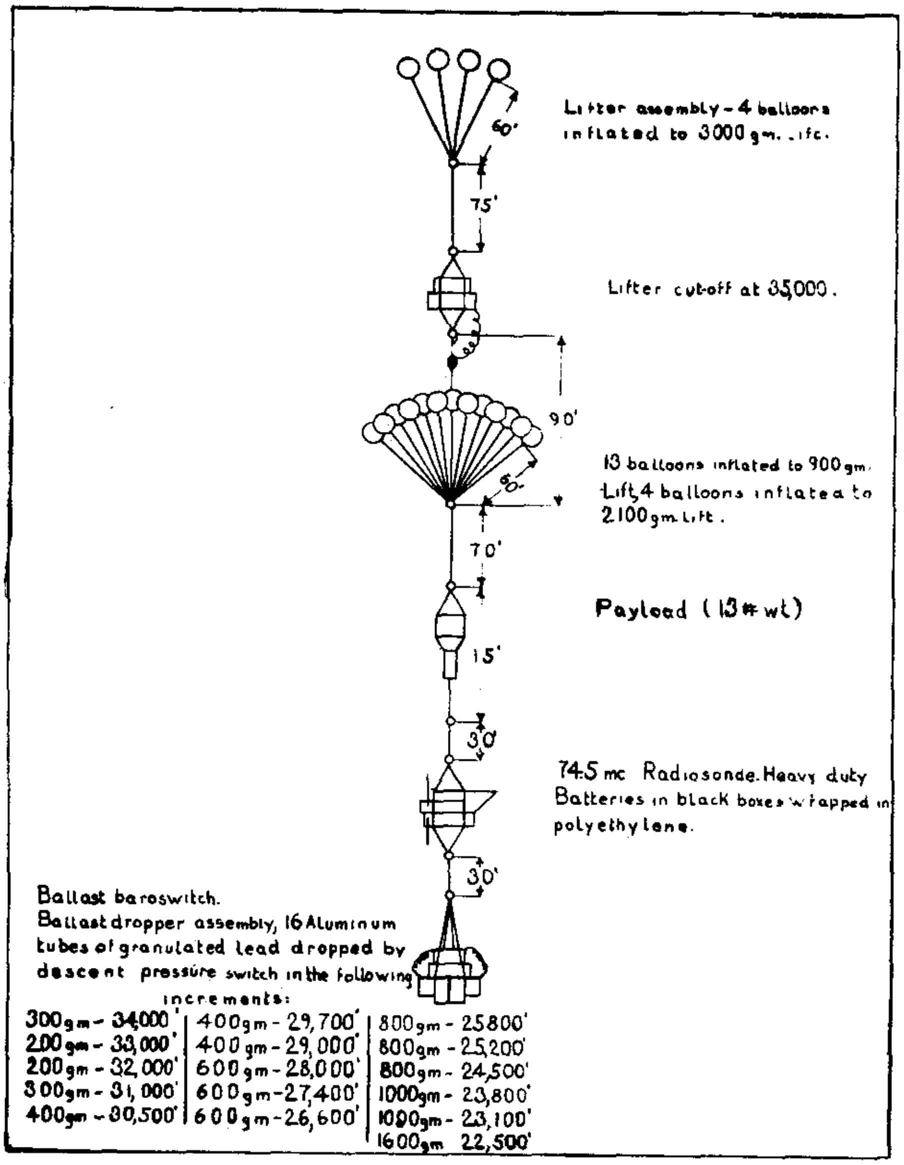


Figure 3: Train, Flight 7

When the train began to descend below 34,000 feet, lead shot was dropped in increments to maintain buoyancy.

This altitude-control system operated well enough to produce a height-time curve (Figure 4) with one descent checked by ballast dropping. Too much weight was lost in this action, and the train rose until some of the balloons were burst. Subsequent descent was not checked.

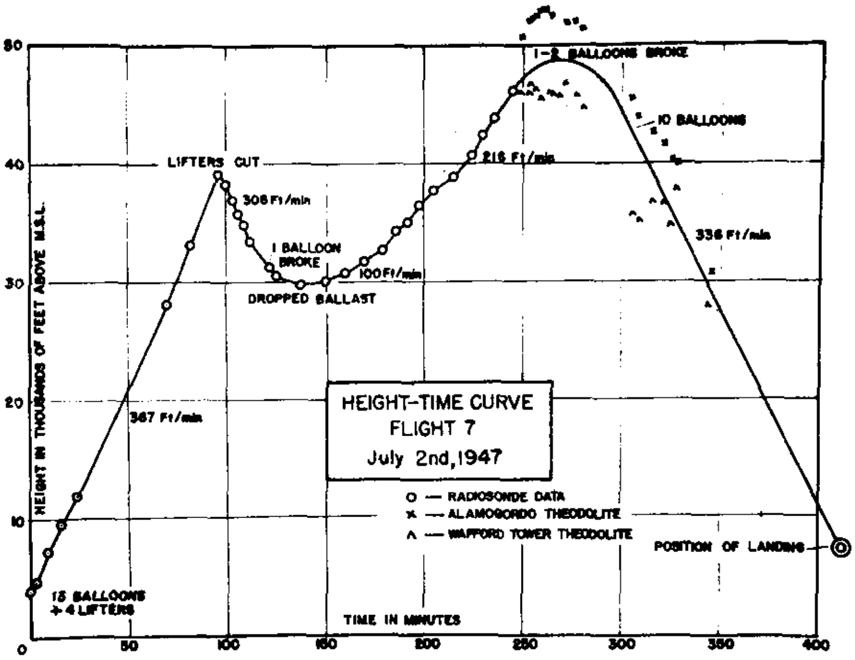


Figure 4

From this flight it appears that the inherent instability of freely extensible balloons is so great that no simple control will cause them to remain at one pressure level.

Tracking for the entire flight period was accomplished with a C-54 aircraft. Two theodolite stations were operated, one at the launching site and one at Wafford Lookout, a fire tower about 20 miles northeast of the release point.

Flight 10: Released from Alamogordo, New Mexico, 0501 MST, July 5, 1947
Not recovered

This flight was the first to use a large plastic balloon as the lifting vehicle. The cell was spherical, 15 feet in diameter, and the walls were .008" polyethylene heat sealed at the seams (made by Harold A. Smith, Inc.). The altitude control was an automatic ballast valve, pressure-triggered to throw off liquid ballast. The equipment train used on this flight is shown in Figure 5.

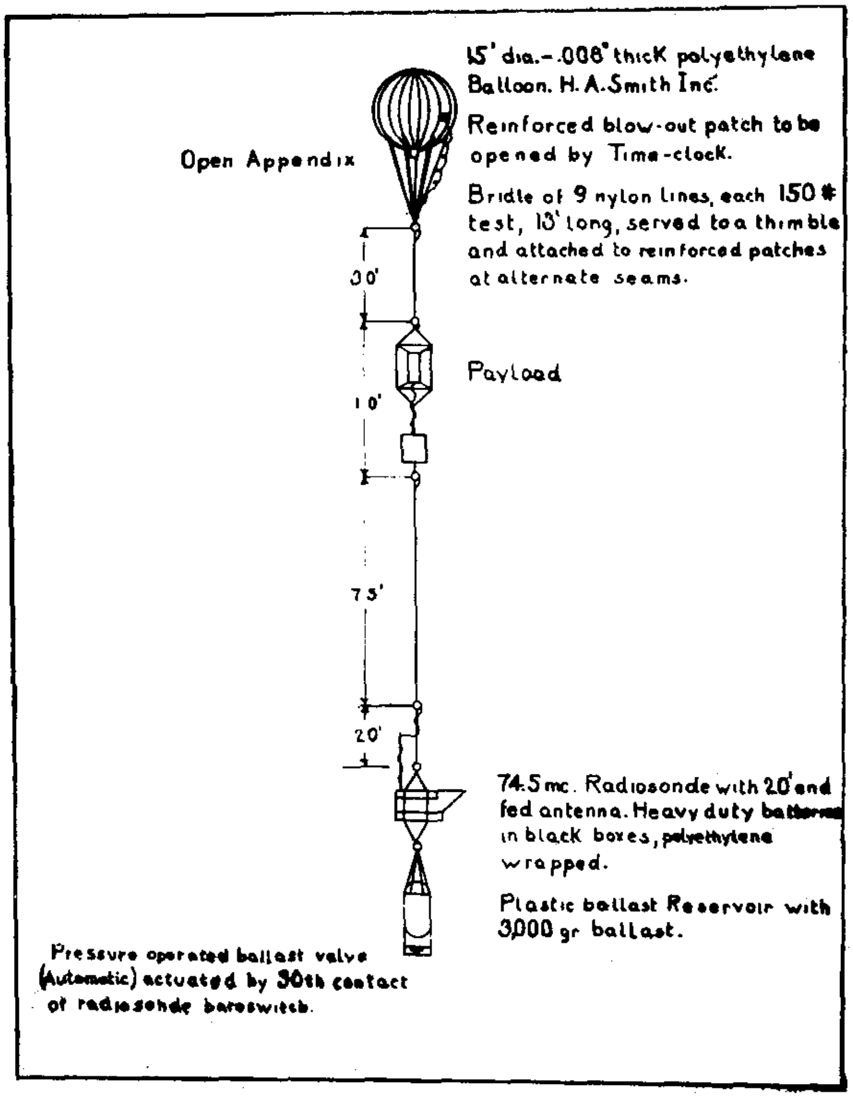


Figure 5: Train, Flight 10

The balloon rose to about 16,000 feet MSL and dropped back to 9000 feet MSL where it "floated" for at least 4 hours, at which time radiosonde reception failed. It is believed that the automatic ballast valve sealed off properly at 12,000 feet, but the air entrapped in its aneroid was heated and caused the operating level to be at the lower value. This would correspond to a superheat of 30°C above the air temperature.

Later flights showed that the type of load attachment used on this balloon was unsatisfactory; however, with proper rigging, cells of .008" thickness were good vehicles as they usually showed very low diffusion and gas leakage.

Near the end of the recorded data, the height-time curve shows large oscillations about a pressure plane (Figure 6). Three factors which probably

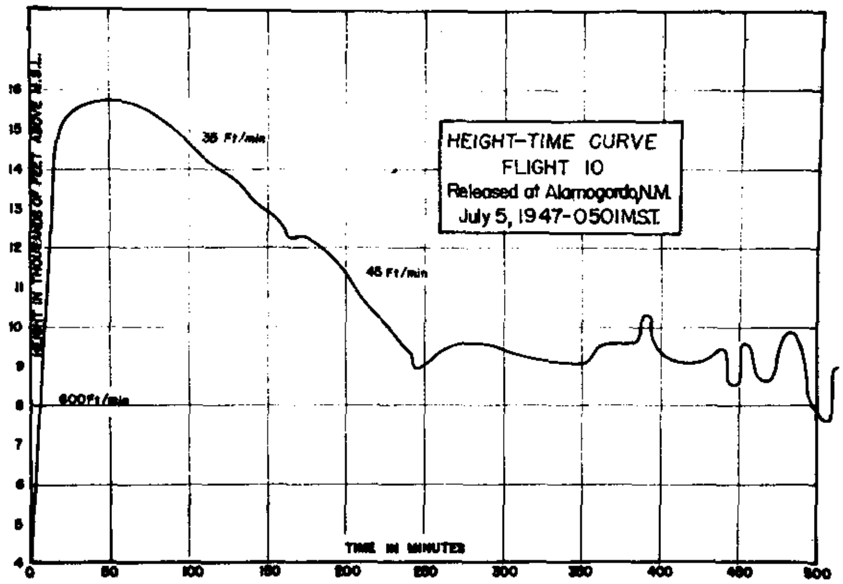


Figure 6

contributed to this instability were: (1) the turbulent motion of the heated air over the desert, (2) the changes in temperature of air in the aneroid valve as intermittent clouds shut off the sun, and (3) the overcompensation caused by the valve-controlled ballast flow.

On this flight the first "destruction device" was used for the purpose of bringing down the balloon after a fixed time to prevent excessive interference in air-traffic lanes. This particular model was a clock-driven device which failed to operate, probably because of low temperatures causing unequal contraction within the movement. Its action was to consist of detonating an inflammable compound taped to the balloon, rupturing its side and permitting a rapid escape of the lifting gas.

Flight 11: Released from Alamogordo, New Mexico, 0508 MST, July 7, 1947
Not recovered

On this flight a 15-foot, .008" wall, polyethylene balloon was combined with a cluster of six small plastic cells (7-foot diameter, .001" wall) to lift a total load of 35 pounds as high as possible (Figure 7). The small

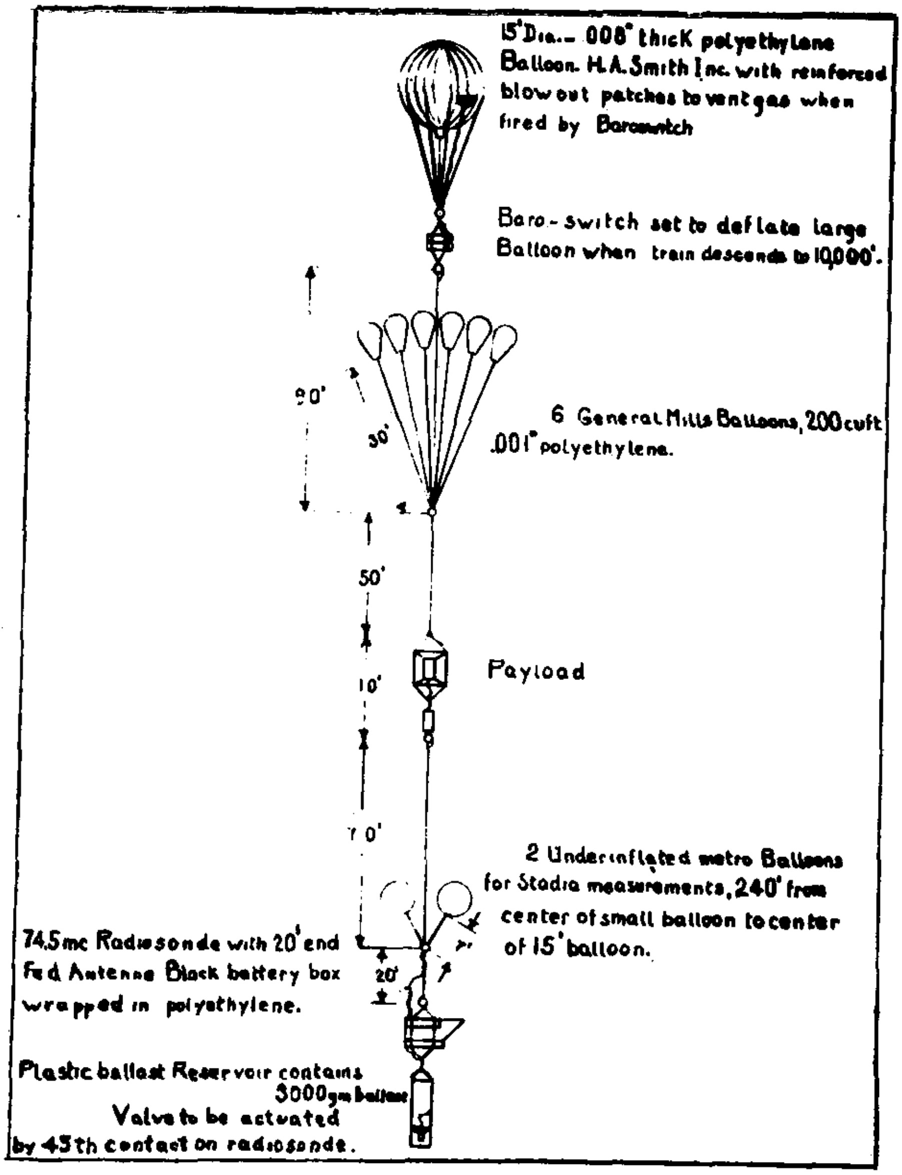


Figure 7: Train, Flight 11

cells did not rise as fast as the large balloon; consequently, three of them were inverted and filled with air.

With this loss of lift, the altitude reached was only about 17,000 feet MSL, and the automatic ballast valve (set to operate at 45,000 feet) was not activated. This flight demonstrated the need for a minimum-pressure switch to activate the ballast valve. A fixed ballast leak of about 400 grams per hour was caused by a defective valve fitting and this was sufficient to maintain the balloon at nearly constant level until all the ballast was exhausted. Following this experience, the use of a preset fixed leak was employed on many flights.

The very unstable "floating" seen on Flight 10, when the automatic ballast valve controlled the flight, is not found on this flight where the vehicle used only a fixed-leak control. This eliminates both the over-compensation and the serious effects of temperature changes on the aneroid capsule, which are found when the automatic ballast valve is used.

The trajectory of this balloon (Figure 8) shows a very interesting deformation at the transit of the Sacramento Mountains. The anti-cyclonic

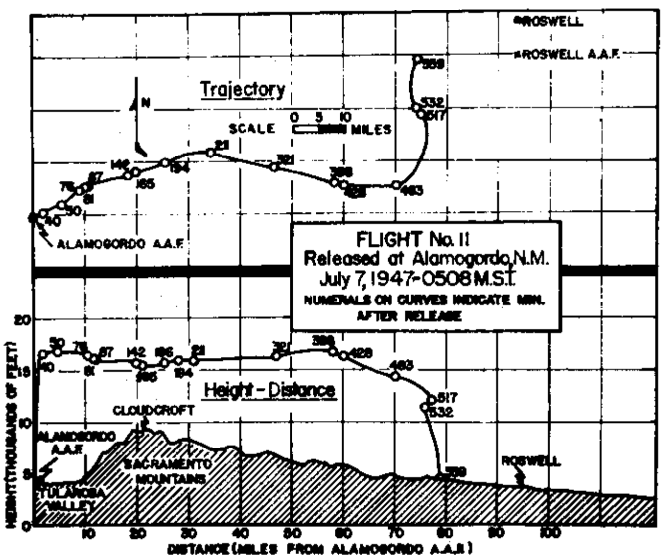


Figure 8

curvature over the eastern slope suggests that the air stream at the floating level was distributed by the terrain, and the deformation predicted by dynamic theory may thus be given a physical illustration. The trajectory was determined by aircraft and theodolite observation.

Another striking feature of the flight is the disagreement between the actual flight path and the trajectory which might have been estimated from routine upper-wind reports. Reports from El Paso, Roswell, Albuquerque and White Sands were used for comparison with the observed trajectory. Except for White Sands, none of these stations reported any wind from the WSW at or near the floating level during the 12-hour period covered by the flight. At White Sands a very shallow current was detected moving in the direction indicated by the balloon flight. This clearly demonstrates the non-representiveness of the ordinary pilot balloon observation.

Flight 12: Released from Lakehurst, New Jersey, 0714 EST, August 5, 1947
Recovered at Smyrna, Delaware

This flight saw the first use of several new items. The balloon was the first .001" polyethylene cell flown; a 397 mc(T-69) transmitter was flown, with radio direction-finding equipment used to track the balloon; a 3 mc (AM-1) transmitter was tested for the first time and the first model of a minimum-pressure switch was provided to activate the automatic ballast valve. The equipment train for this flight is illustrated in Figure 9.

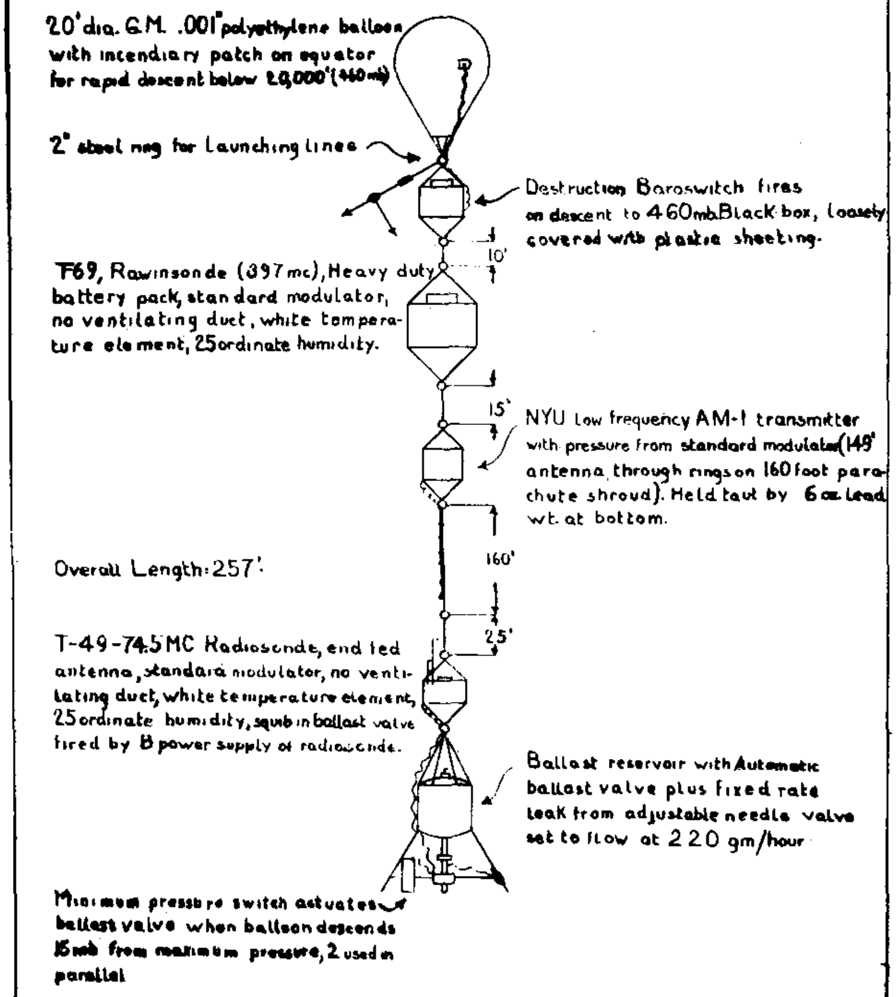


Figure 9: Train, Flight 12

Measurements in the hangar prior to release indicated that lift losses from leakage and diffusion were about 200 grams per hour, and in addition to the automatic ballast valve system, a fixed-flow needle valve was set to discharge ballast slightly in excess of the expected loss. Both systems failed to keep the balloon afloat, and a slow descent from its maximum altitude of 14,000 feet MSL resulted. The expected altitude of 38,000 feet was not reached, and this is believed to be due to mixing of the air with the lifting gas during rising. The bottom of the balloon was open with no protecting skirt or valve to keep out air. Since the thin fabric would rupture with an internal pressure of 0.017 psi, some form of skirt or external appendix was suggested for future flights.

Radio reception with the 3 mc transmitter was excellent and far surpassed the performance of either the 72 mc or 394 mc transmitters which were also flown.

Because of the low elevation angle of the transmitter, the single SCR-658 radio direction-finding equipment was not of much use for positioning. Tracking by aircraft was satisfactory throughout the flight.

Flights 13, 14, 15, 16 and 20: Made in September, 1947, they had as their primary purpose the testing of external balloon appendices to prevent excessive dilution of the lifting gas with air.

On three of these flights the loose polyethylene tubes twisted shut during the balloons' ascent and caused the cell to burst as it became full. The unsatisfactory models tried are seen in Figure 10, as well as the skirt

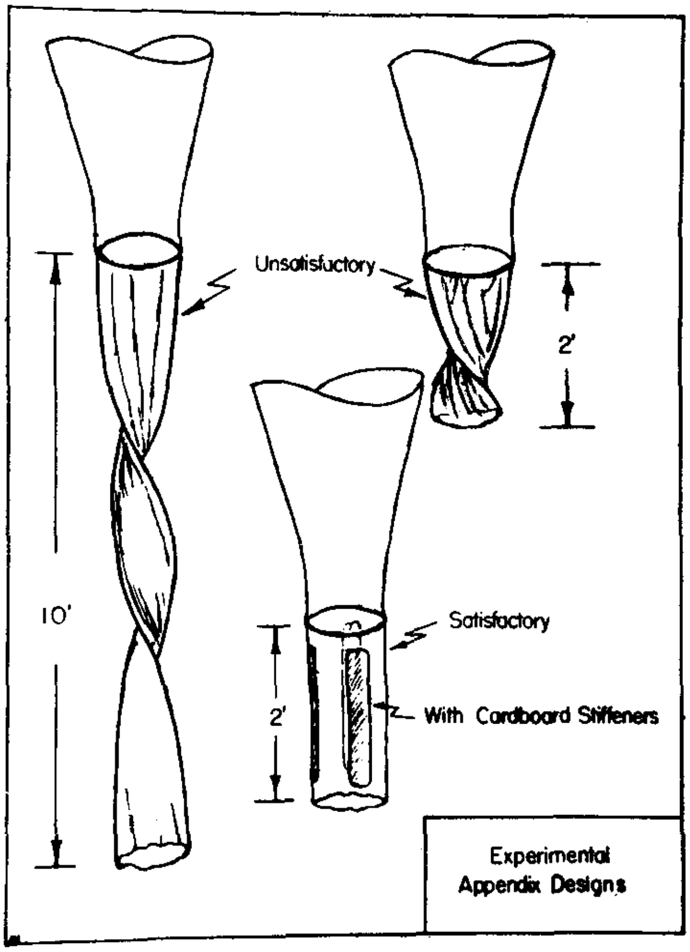


Figure 10

stiffened with external battens which was developed on Flight 20 and used successfully thereafter.

On most of these flights, radio direction-finding equipment (SCR-658) was used, as well as theodolite and aircraft for tracking and positioning the balloons. A system of air reconnaissance and ground recovery was developed using a radio-equipped jeep to move cross-country at the direction of the aircraft observer. Several satisfactory recovery missions were made on these and later flights using this technique.

Flight 17: Released from Alamogordo, New Mexico, 1647 MST, September 9, 1947
Recovered at Croft, Kansas

On this flight the first balloon made of .004" polyethylene was launched. The altitude controls were a fixed-flow needle valve orifice set to leak at 100 grams per hour and an automatic ballast valve activated by a minimum-pressure switch.

This flight reached floating level shortly before sunset, and the balloon took on superheat which was lost when the sun went down. This cooling necessitated the rapid discharge of ballast to maintain buoyancy. The operation of the automatic ballast valve at this time was satisfactory and restored the balloon to a floating level within one hour. Following restoration a satisfactory floating performance was indicated for as long as radio contact was maintained (Figure 11). The need for a balloon-borne

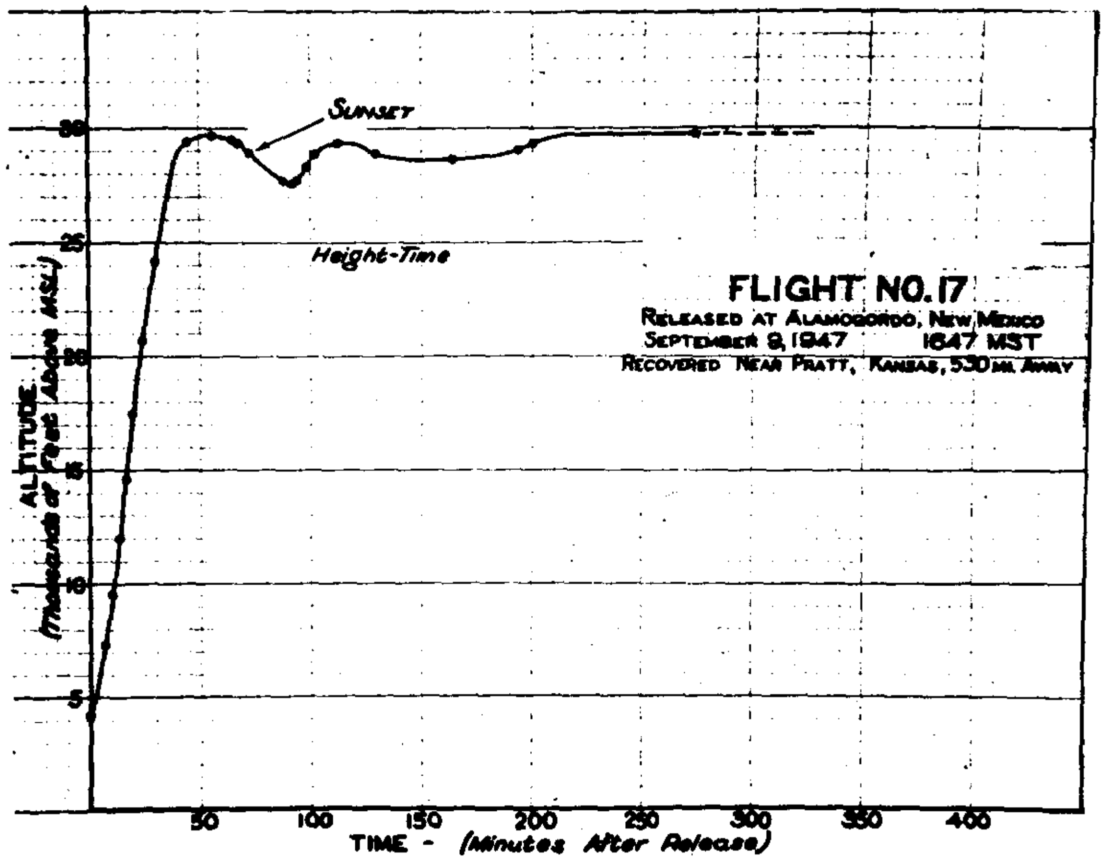


Figure 11: Height-time curve, Flight 17

barograph was demonstrated by this flight which traveled more than 500 miles from the release point.

Flight 23: Released from Alamogordo, New Mexico, 0918 MST, September 12, 1947
Not recovered

A J-2000 neoprene balloon was encased with a nylon shroud and provided with a valve to permit gas to escape after a small superpressure ($\frac{1}{4}$" of water) was exceeded. The balloon in its shroud is shown in Figure 12.

Figure 12: Neoprene balloon encased in a nylon shroud

If a "superpressure" balloon is used, much less ballast is required since, during minor oscillations, the reduction of buoyancy will not cause the balloon to descend as long as the remaining buoyancy is equal to or greater than the load supported.

This balloon, and three similar ones (Flights 38, 66, 87), failed to achieve any constancy of altitude. All four failed during the rising period or soon after the shroud became full. (The balloons were heated prior to release to restore elasticity.)

Flights 29 through 39: They were made from Alamogordo, New Mexico during November and December, 1947 to test ballast controls and to develop a launching technique satisfactory for high winds. The period of data reception by radio was too short in all of these flights to permit much evaluation of the altitude controls. On three flights (33, 35 and 39) a Fergusem meteorograph was added to the train to record flight pressure; of 11 balloons released, only these three were not recovered.

On seven flights the pressure signals received by radiosonde were lost while the balloon was still rising; Flight 38 was a shrouded neoprene balloon which burst as it became full; and Flight 39 was a polyethylene balloon which burst at or near its ceiling following a very rapid rise. (This was the first balloon to burst using a short external appendix with stiffeners.)

On the other two flights (30 and 35) a very short period of level flight was recorded before the balloon-borne radio transmitter passed out of range.

Besides these two, several other .001" polyethylene balloons probably were maintained at constant or near-constant levels for several hours, as can be seen from their points of recovery (Figure 13). One balloon was seen descending 18 hours after release.

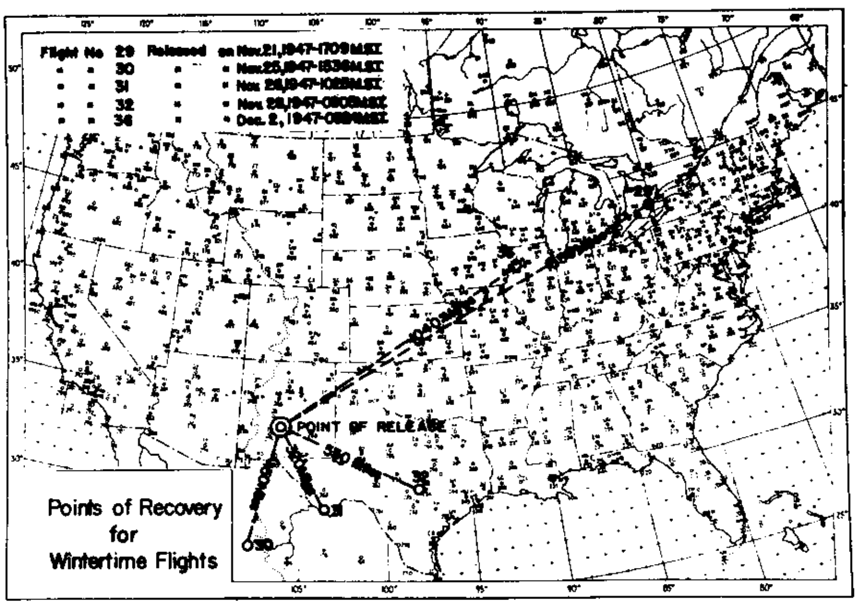


Figure 13

On Flights 29 through 33 only a fixed ballast leak was used, set for flows of from 300 to 600 grams per hour. Other flights used automatic ballast controls. Although these fixed leaks seemed to be sufficient to keep the balloons aloft, there was no clear evidence as to what amount would be needed for most efficient operation. The need for a system of ballast metering was indicated in this series of flights.

Flight 41: Released from Indiantown Gap Military Reservation, Pennsylvania, 0956 EST, February 16, 1948
Not recovered

The balloon was of .001" polyethylene and had a fixed-leak ballast control set to provide a constant flow of 650 grams per hour. The principle objective of this flight was to test aircraft reception from a balloon-borne transmitter. Using RDF equipment, two B-17 planes were able to receive clear signals from the transmitter at least 150 miles away from it and were able to home in on the signal by using the radio compass. There was a questionable zone of about a 15-mile radius beneath the balloon, and it is probable that this represented a cone of silence from the vertical antenna. The balloon was near 40,000 feet with the planes at about 10,000 feet.

On later flights, using a frequency of 1746 kc, reception range was extended to over 400 miles and no cone of silence was encountered. By flying along the bearing indicated by the compass until it abruptly reverses, the position of the balloon may be determined. Visual observations confirmed the presence of the balloon overhead.

On service flights made from this same base during this week, two new pieces of flight gear were added to the train. The first of these was a cloth parachute, mounted upside down in the line to serve as a drag, acting against excessive rates of rise. When mounted above the cloth identification banner, this chute also acts to minimize sway and lateral oscillation of the equipment.

The second unit was a new type of destruction device--a pressure-activated mechanism by which a large hole is ripped in the balloon upon descent into the lanes of air traffic. In this device (Figure 14) the equipment is permitted to fall freely for a few feet, jerking a length of line through the balloon side. After this fall, the equipment again is carried by the main load line, and the ruptured balloon acts as a parachute to lower the gear to the ground at about 1000 feet per minute.

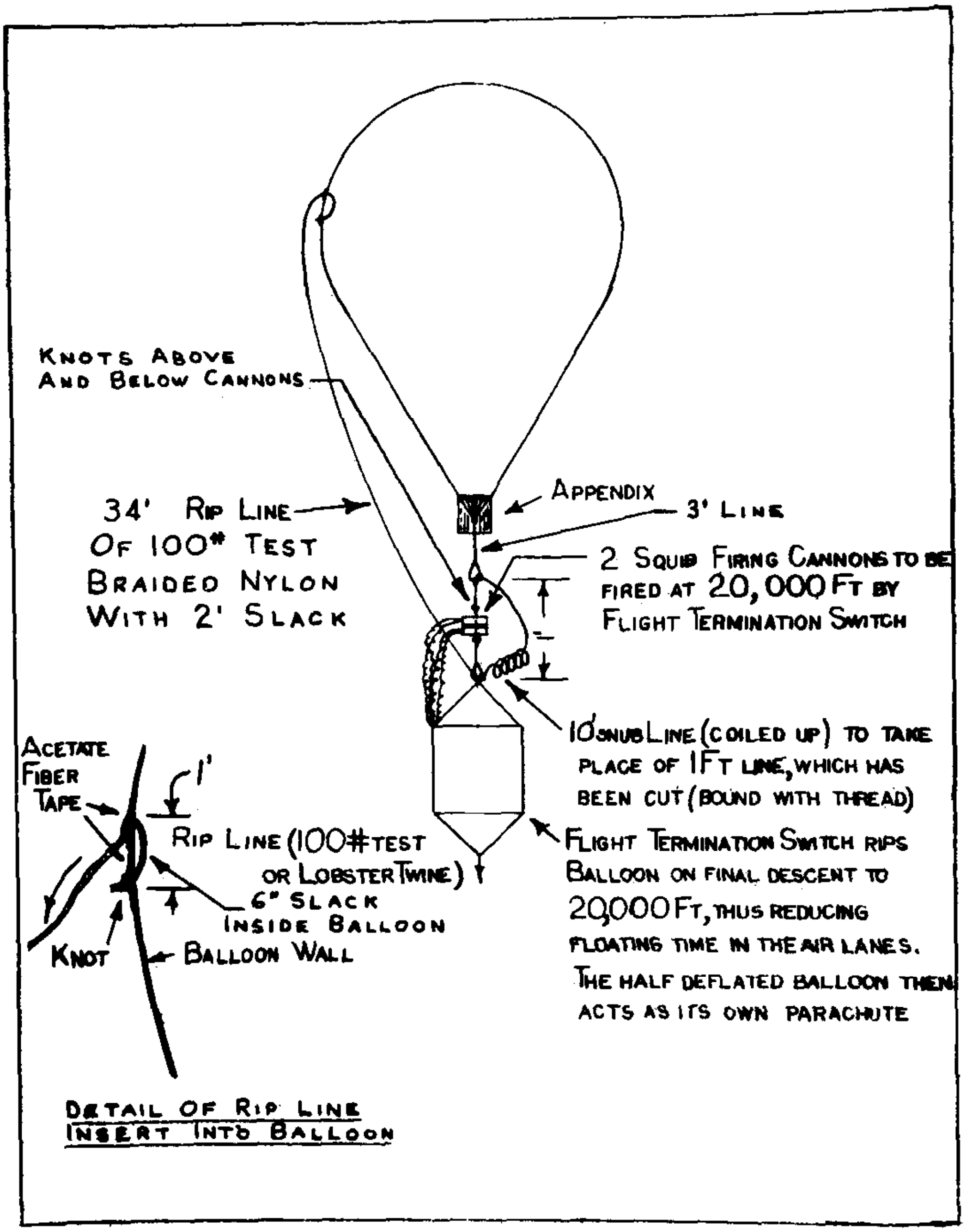


Figure 14: Rip-out line in place on balloon

<u>Flight 43 through 51</u>: In April, 1948 a number of flights were made using <u>.001" polyethylene</u> balloons and fixed-leak ballast controls. Only four of these flights were recovered. The landing points of these are shown in Figure 15.

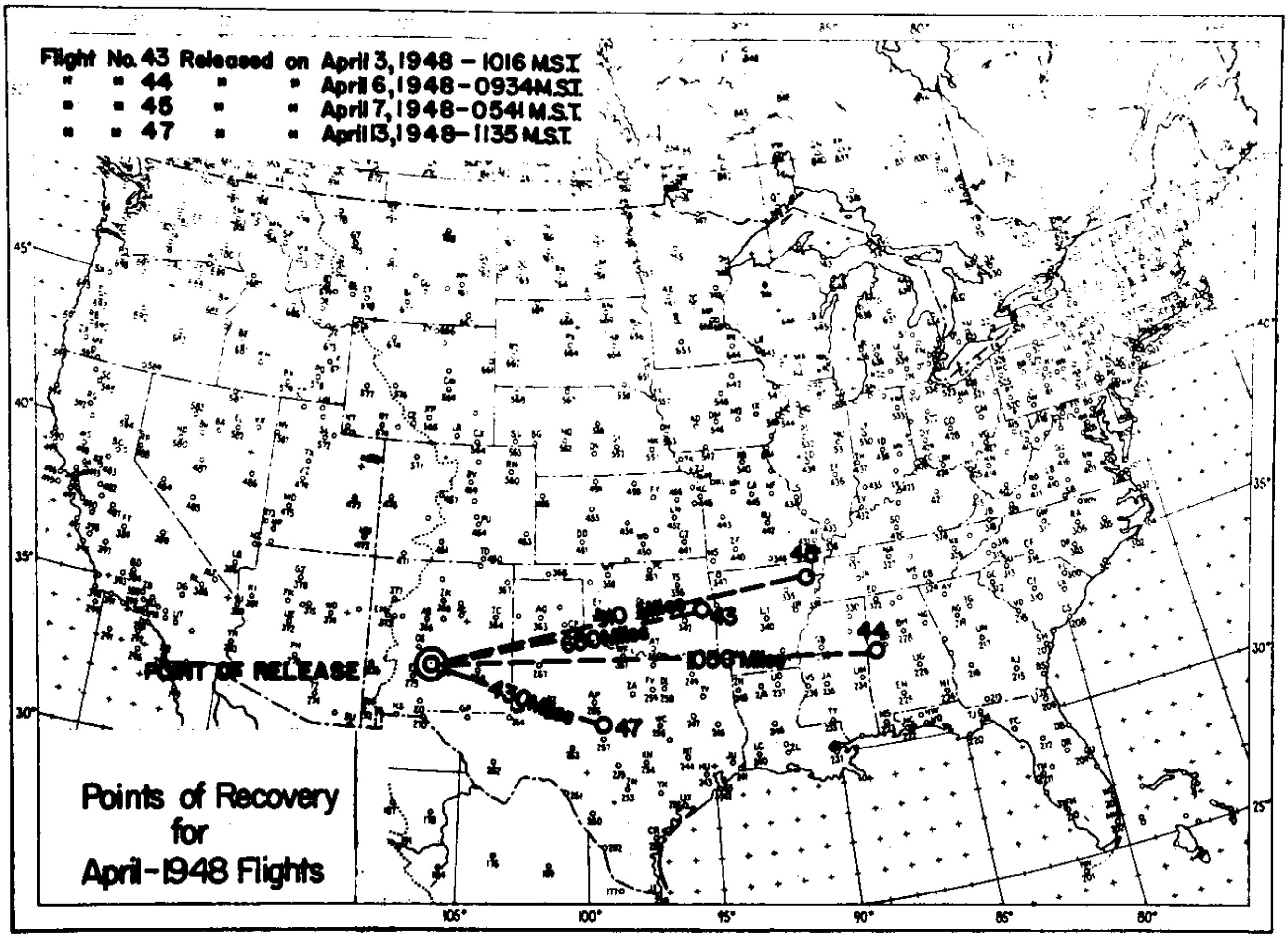


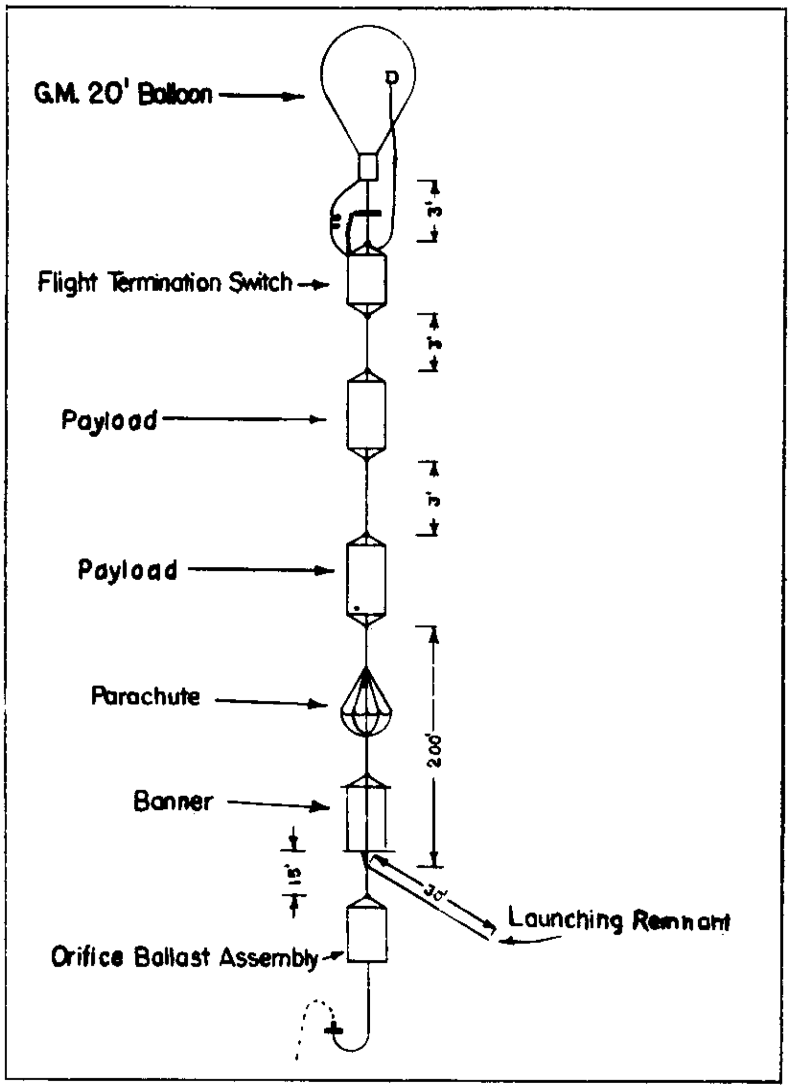
Figure 15

Little is known positively about the floating levels since radiosonde data was not obtained on most flights, and no barographs were available. Three receiving stations at Alamogordo, Roswell and Carlsbad, New Mexico were used to position the balloon with radio direction-finding equipment. By assuming a floating level corresponding to the load, several flight patterns were derived. No aircraft tracking was provided to check these computed trajectories.

On these flights fixed ballast leaks of from 250 to 600 grams per hour were used. These leaks were provided through round orifices rather than through needle valves which had been in use previously. This improvement reduced the possibility of clogging.

On Flight 43 the first model of an Olland-cycle pressure modulator was flown with a modified T-69 (400 mc) radiosonde transmitter. The results obtained on this flight were not satisfactory, but later test proved successful.

The train seen in Figure 16 is typical of those flown during this period. Note the presence of the device to rip the balloon when descending into air lanes and thus speed up its fall.



Flight 16: Train, typical of those flown in April, 1948

Flight 52: Released from Alamogordo, New Mexico, 0958 MST, April 23, 1948
Recovered at Galseburg, Kansas

On this flight a .001" polyethylene balloon carried the first model of the Lange Barograph and an improved Olland-cycle pressure modulator to give improved radiosonde pressure data. The signal from the radiosonde was lost soon after the release, but the barograph was recovered and the altitude record is shown in Figure 17. It will be seen that the balloon rose to a

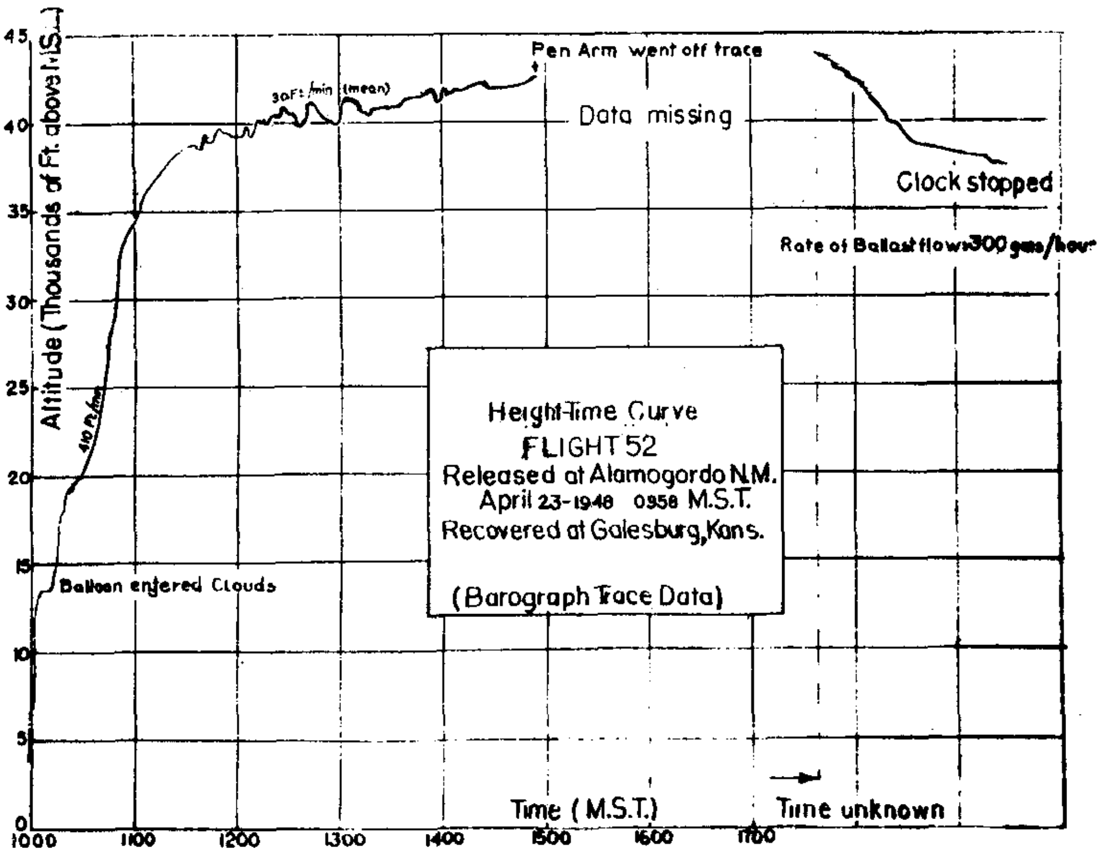


Figure 17

pressure such that the barograph pen passed off the chart, and several hours of flight were not recorded. The slowly rising ceiling seen here was the first long-period confirmation of the expected behavior of a balloon controlled by a constant ballast loss. The flow in this case was set for about 250 grams per hour, and the altitude change was about 400 feet per hour. This rise of "ceiling" is somewhat larger than predicted and heightened the interest in obtaining temperature measurements so that the buoyancy behavior could be more exactly determined.

Three other points of interest may be seen on this barotrace: (1) The two very pronounced step effects found on the rising portion of the flight at about 625 mb and 480 mb correspond to stable layers in the atmosphere as seen from the El Paso radiosonde sounding taken at 0800 MST (Figure 18).

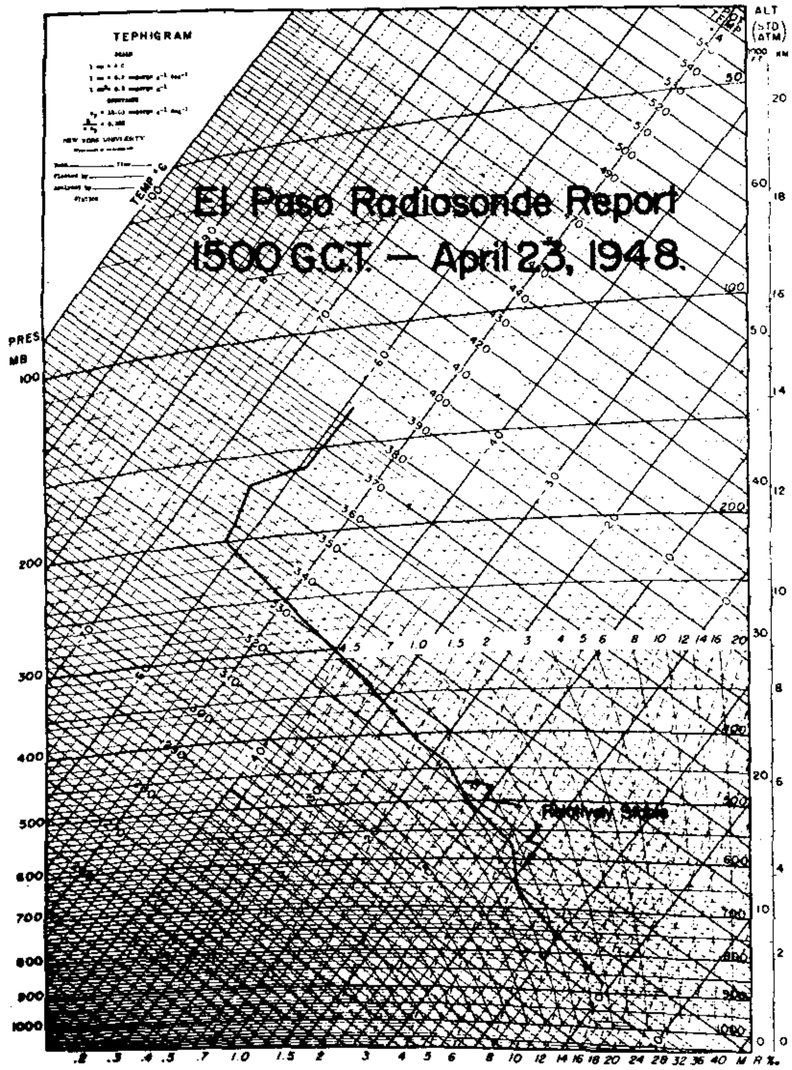


Figure 18

(2) The clock of the barograph stopped after being exposed about 10 hours at cold temperature. (3) During the floating period many small oscillations are seen on the pressure record. Neglecting superheat changes, there is no variation in the forces of the balloon system except the constantly decreasing weight of ballast and the monotonic loss of lifting gas, and these oscillations must, therefore, be attributed to some force in the atmosphere.

Flights 54, 56 and 60: On these three flights, made in April and May, 1948, fixed-leak ballast losses were used to keep a .001" polyethylene balloon aloft, but no barograph record of pressure is available. From the descent points (Figure 19) and the radiosonde data which was received it is believed that the ballast flows of about 300 grams per hour were adequate.

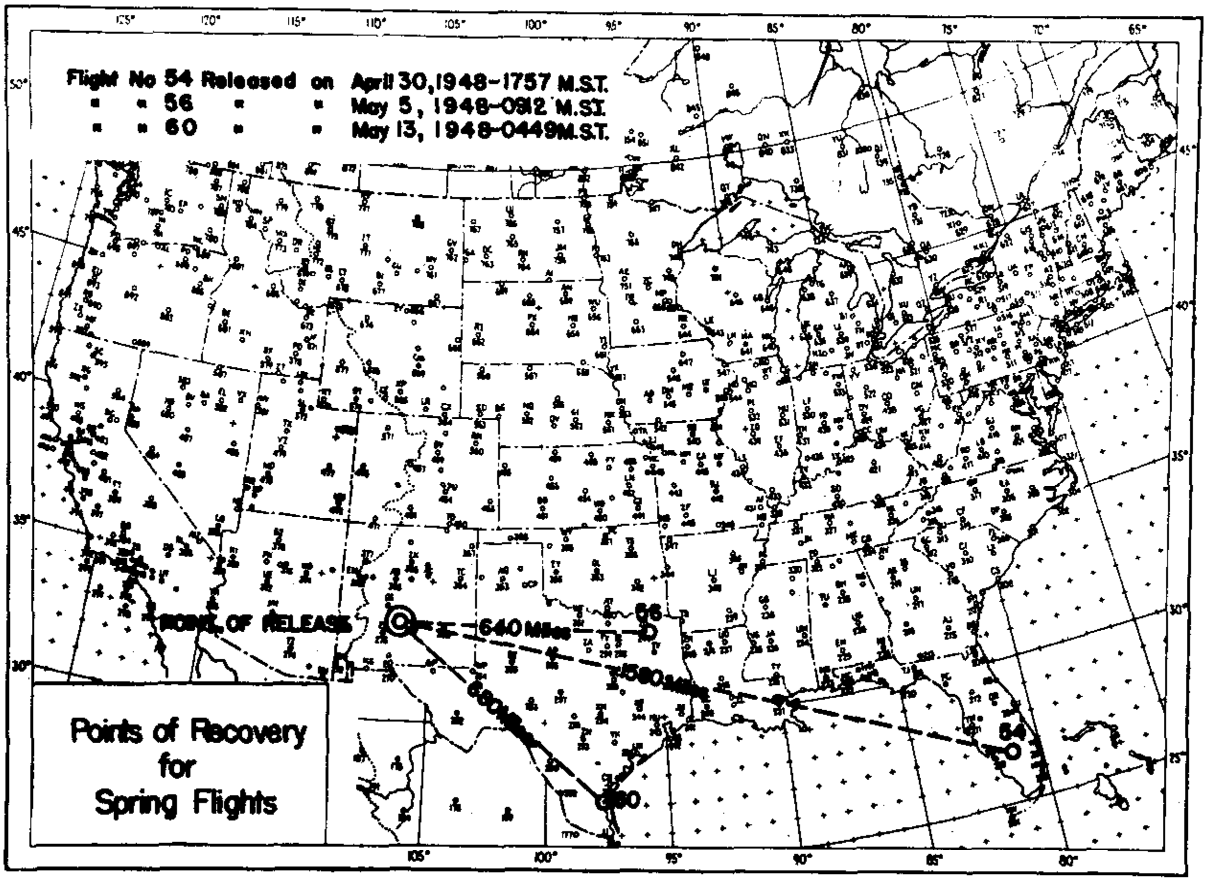


Figure 19

On both Flights 56 and 60 a very light load was lifted, and the floating level in each case was over 60,000 feet MSL. Light winds were encountered in both cases, and a reversal from Westerlies to Easterlies was experienced near the floating level on Flight 60. With a relatively slight change in elevation, the balloon passed from Westerlies (below) to Easterlies (above) with the result that the balloon was still visible from the launching site (Alamogordo, New Mexico) at sunset, 14½ hours after released. The finder reported seeing the balloon descend 35 hours after release.

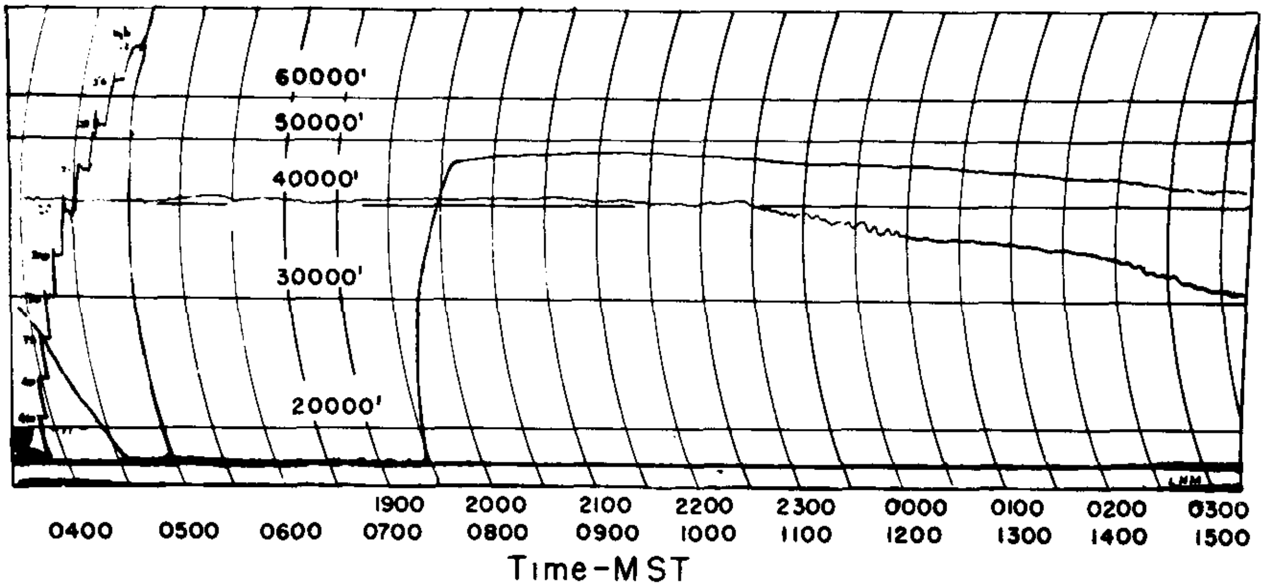
Since the ballast flowing to maintain buoyancy would have been exhausted in only 5 hours, this flight provided the first evidence that such a balloon in the stratosphere maintains buoyancy much longer than at lower levels. The two factors which contribute to this are the heat added to the helium by adiabatic compression when descending and the diminished diffusion of lifting gas at a low pressure.

On Flights 56 and 60, a three-station network was set up to receive pressure signals on radio direction-finding (SCR-658) equipment. In addition, theodolites were used for several hours in each case.

Flight 55: Released from Alamogordo, New Mexico, 1907 MST, May 3, 1948
Recovered at Northeast, Pennsylvania

On this flight a barograph was flown, and a satisfactory Olland-cycle pressure modulator was also used for over 5 hours to give height data. The length of time of signalreception is significant, since the battery box of the transmitter was not insulated, and there was no heat to be gained from the sun during this nighttime flight. The .001" polyethylene balloon was observed descending 22 hours later after traveling more than 1500 miles.

The altitude control used on this flight was an automatic ballast valve, activated by a minimum-pressure switch, and as evidenced by the barogram in Figure 20 (12-hour rotation), the balloon maintained its altitude for over



NYU BALLOON PROJECT FLIGHT 55
Barograph Record Of G.M. 20 Ft. Balloon With
Automatic Ballast Valve
RELEASED AT ALAMOGORDO, N.M., 1907 MST- 3 MAY, 1948
RECOVERED AT NORTHEAST, PA., 4 MAY, 1948
DURATION 23 HOURS

Figure 20

15 hours before beginning its accelerating descent. On this flight record, marked oscillations are observed at three points. Despite the presence of automatic ballast controls which might cause oscillatory motion, these rises and falls must be attributed to atmospheric disturbances since the magnitude of the forces required to produce such accelerations is far greater than any which could be supplied by the control equipment.

A check against the trajectory and end point of the balloon flight was made by a group of graduate students of meteorology at New York University. By constructing constant-pressure maps from the appropriate radiosonde data, the expected trajectory was computed assuming the balloon would move with the geostrophic wind. The results of this comparison (Figure 21) show that the balloon tends to move across the isobars toward lower pressure.

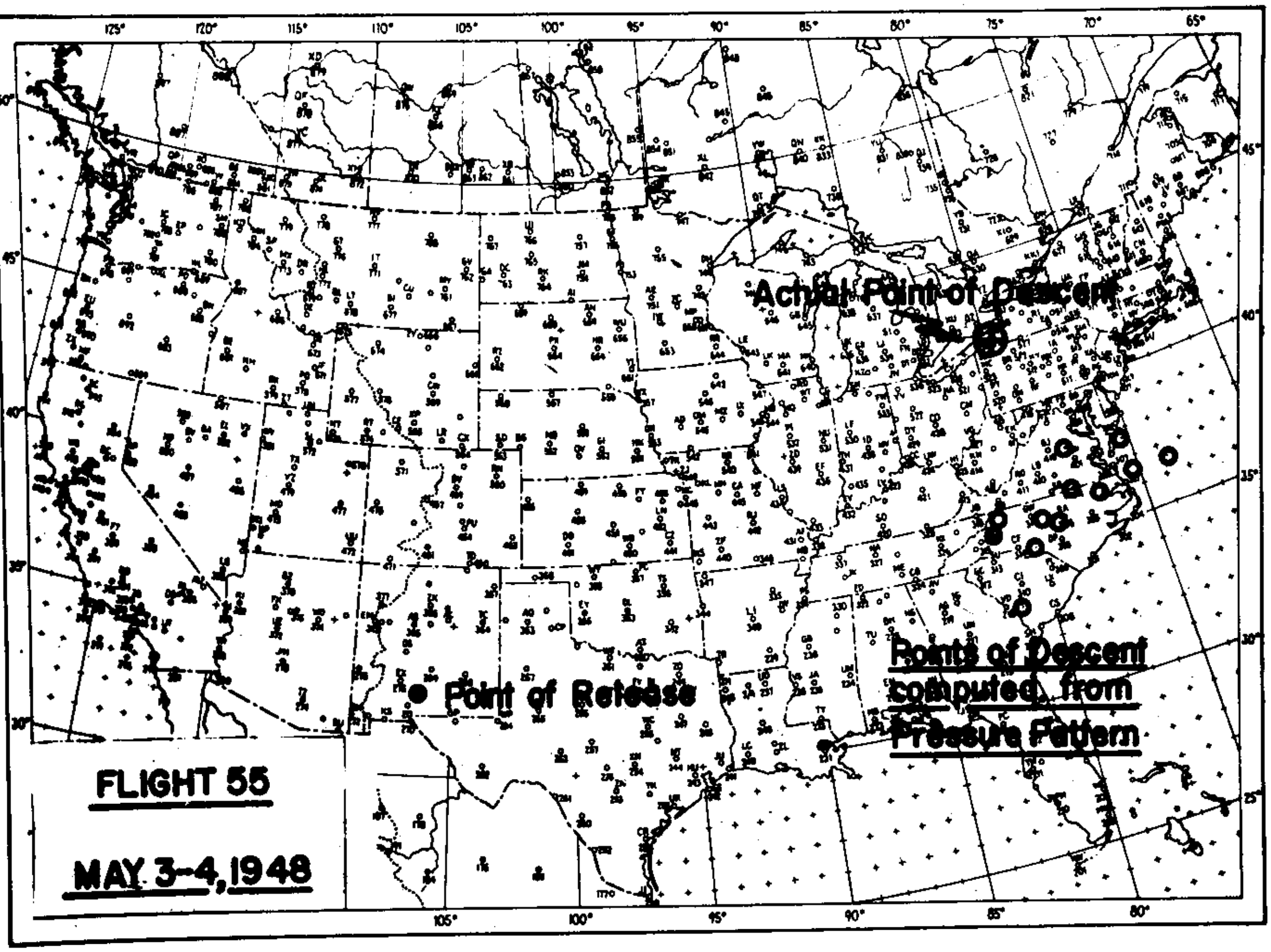
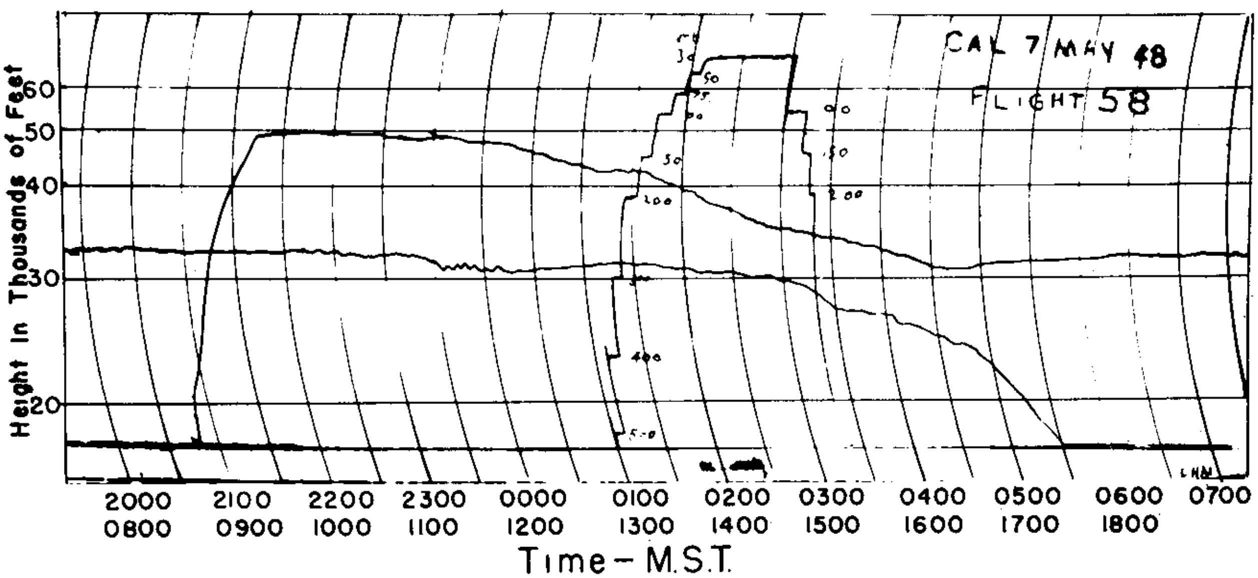


Figure 21

Flight 58: Released from Alamogordo, New Mexico, 2033 MST, May 10, 1948
Recovered at Val D'Or, Quebec

A .001" polyethylene balloon was the vehicle on this flight carrying a barograph as well as an early model of the Olland-cycle pressure modulator. This flight was released at night with a fixed ballast flow of about 300 grams per hour expected to keep the balloon afloat. From the barogram (Figure 22) (12-hour rotation) it appears that the orifice did not permit sufficient (if any) flow to maintain buoyancy during the first several hours (perhaps the orifice was clogged or frozen). After a descent to about 33,000 feet at sunrise a floating level was maintained with 4 kilograms of ballast available. The full flow rate could not have been maintained much more than the 11 hours during which the balloon was at this pressure.



NYU BALLOON PROJECT FLIGHT 58
Barograph Record Of G.M. 20 ft. Plastic Balloon With
300 gm/hr Fixed Ballast Leak
RELEASED AT ALAMOGORDO, N.M. – 2033 MST, 10 MAY, 1948
RECOVERED AT VAL D'OR, QUEBEC, CANADA – 24 MAY, 1948
ESTIMATED DURATION – 24 1/2 hrs.

Figure 22

On this flight, oscillations in the pressure record were seen. With no control system which could cause such behavior, they must be attributed to atmospheric motion.

The descent point was compared with that expected from analyses of the pressure field. The results of a number of such analyses are shown in

Figure 23. As on Flight 55, the balloon appears to have moved across the isobars, toward lower pressure.

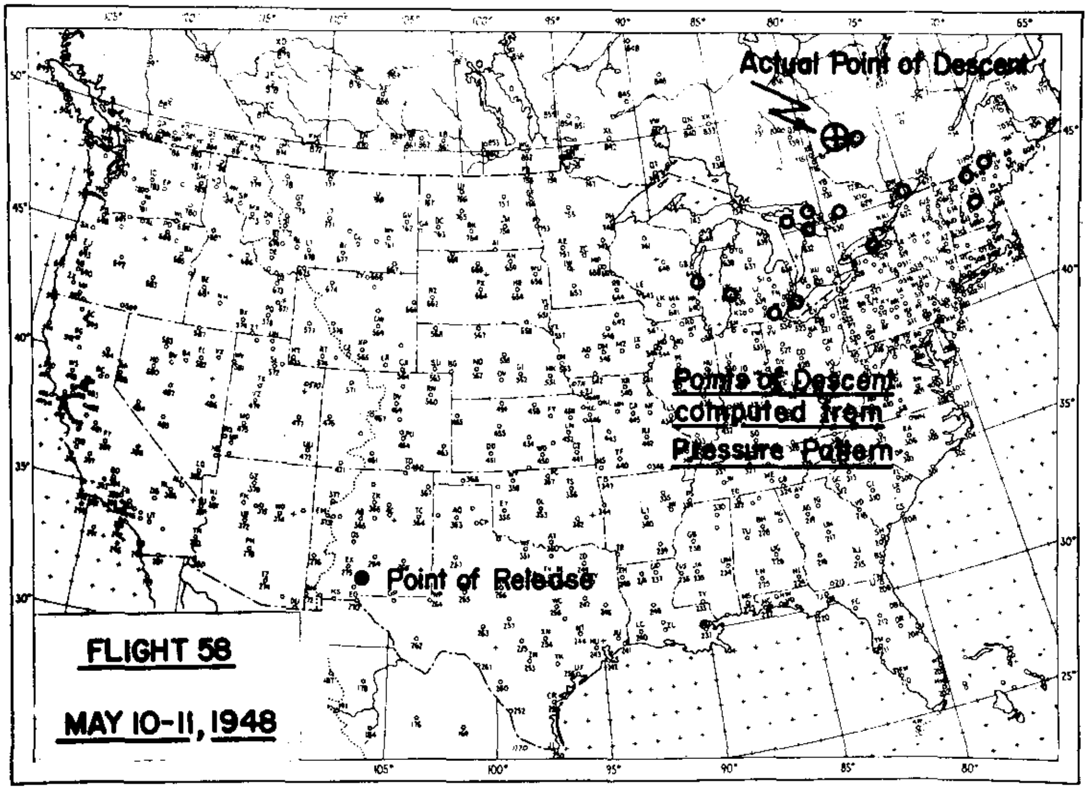


Figure 23

Radio direction-finding tracking (SCR-658) was used during the first 367 minutes of this flight. This was made possible by a strong output from the battery, indicating that no harmful effects were experienced in the cold atmosphere despite the absence of solar radiation. The need for measurements of the temperature of the batteries was suggested by this flight.

Flight 63: Released from Alamogordo, New Mexico, 1116 MST, May 13, 1948
Descended at Alamogordo, New Mexico

On this flight a Seyfang Laboratories balloon, made of neoprene-coated nylon, was flown with a valve in the appendix set to open after an internal pressure of 0.02 psi was built up. On an earlier flight (59) such a balloon was flown with no valve but an appendix held closed with a rubber band; it ruptured upon becoming full.

Both a constant ballast-flow orifice and an automatic ballast control were used to keep this balloon buoyant. In addition to the ballast, a surplus of buoyancy might have been acquired when superpressure was built up inside the cell. Despite these controls, the balloon began to descend after a short period of floating, and its descent was not checked (Figure 24).

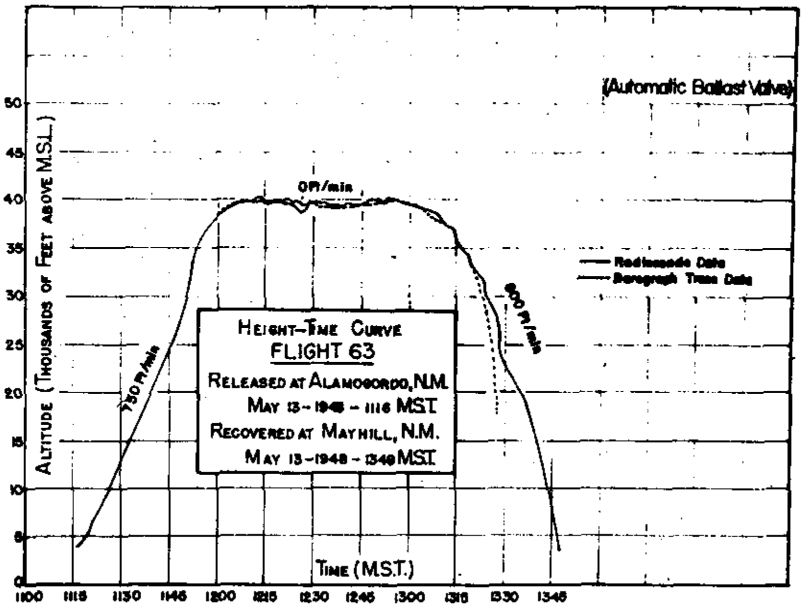
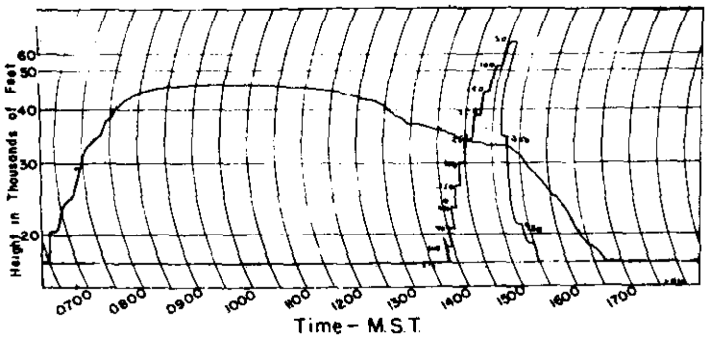


Figure 24

An analysis of the acceleration which could be gained from a loss of superheat indicated that if the coated fabric had absorbed radiation and gained 50°C over the outside air, the superheat thus obtained would be so great that its subsequent rapid loss (as by ventilation) could not be compensated for even with the ballast flowing at full rate. To improve the analysis of balloon flights, a measure of the temperature difference between lifting gas and air temperature was suggested.

Flights 68 through 72: In July, 1948 this series of flights was made without ballast controls to determine the natural buoyancy of the General Mills, Inc. 20-foot .001" polyethylene balloons. Of five such flights, only two good barograph records were obtained, one daytime flight (70) and one night flight (71). In both cases a nearly constant level was maintained for about four hours at the highest altitude reached.

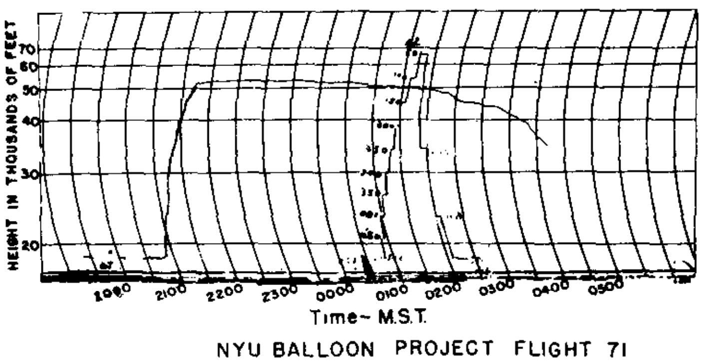
On the barogram of Flight 70 (Figure 25) a section of arrested descent may be noticed, preceded and followed by a nearly constant fall. The cause of this step is not apparent, although a check has been made of the atmospheric structure of that day.



NYU BALLOON PROJECT FLIGHT 70
Showing 20' General Mills Balloon
Performance When No Ballast Was
Dropped
RELEASED AT HOLLOMAN AFB, N.M.–JULY 8, 1948
0633 MST – RECOVERED AT KENT, TEXAS

Figure 25

On Flight 71 marked oscillations are seen at the floating level and also during the descent portion of the barogram (Figure 26). Clearly these must represent atmospheric motions since no controls of any sort were in use. There is no reason to believe that rapid changes in superheat occured, since the floating level was far above the cloud level. Also the flight was made at night and no sunshine was encountered.



NYU BALLOON PROJECT FLIGHT 71
Barograph Record Of G.M. 20 Ft. Plastic Balloon Showing
Balloon Performance When No Ballast Was Dropped.
RELEASED AT ALAMOGORDO N.M., 2042 MST – 9 JULY, 1948
RECOVERED AT VALENTINE TEXAS, 10 JULY, 1948
ESTIMATED DURATION 10 HOURS

Figure 26

Flight 73: Released from Alamogordo, New Mexico, 1948 MST, July 14, 1948
Recovered at Lincoln National Forest, New Mexico

The objective of this nighttime flight was to determine whether a fixed ballast leak of 100 grams per hour would sustain a 20-foot, .001" polyethylene balloon at floating levels near 50,000 feet. From the Olland-cycle pressure record (Figure 27) it appears that loss of buoyancy due to

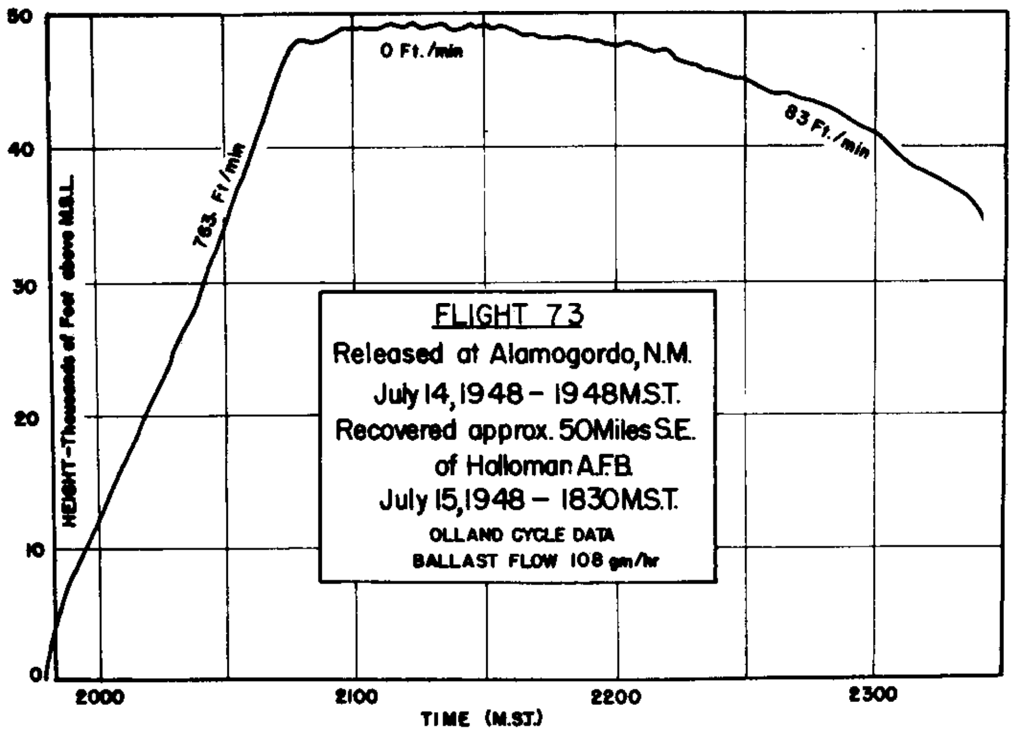


Figure 27

diffusion and leakage is more than this. Indeed, the balloon with this ballast flow did not remain at altitude as long as either Flight 70 and 71 which were without altitude controls.

Flight 74: Released from Alamogordo, New Mexico, 1040 MST, July 19, 1948
Not recovered

This was a test of a single 7-foot balloon made of .001" polyethylene, carrying a 4-kilogram payload. One part of the load was the first model of an automatic ballast siphon used to detect and telemeter the amount of ballast being discharged through an automatic ballast valve.

The balloon flew at 7000 feet MSL across a heated desert area and into a mountain pass whose elevation was about 6000 feet MSL. During the first two hours its behavior was reported by radio, and the accompanying time-height curve (Figure 28) shows how the ballast valve operated successfully

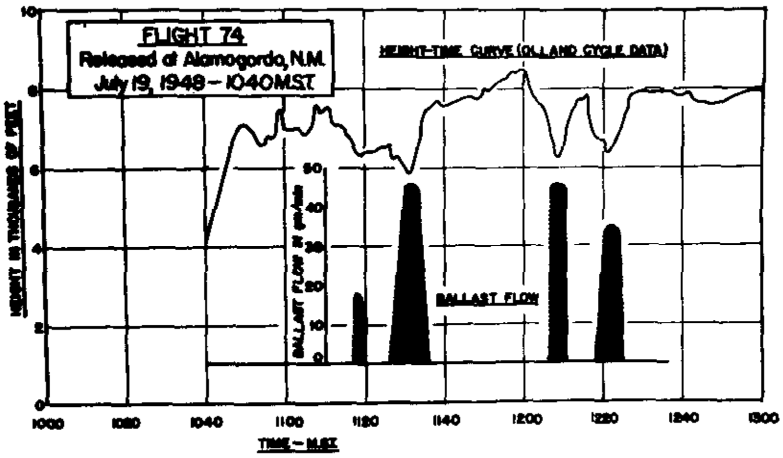


Figure 28

to sustain the balloon. During this turbulent flight about 200 grams of ballast were expended per hour, but the pronounced orographic and convective currents probably necessitated more control than would be required in a more stable atmosphere.

The very useful information about ballast flow was reported clearly, and the principle of the auto-siphon was used repeatedly on later flights. Small variations are seen in the pressure at which the ballast flow began. Since the balloon was floating below the base of clouds, this represents the changes of activation pressure which resulted from changes of superheat of the air entrapped in the aneroid.

Flight 75: Released from Alamogordo, New Mexico, 1010 MST, July 20, 1948
Recovered at Hollister, California

In order to reach higher altitudes than was possible when 20-foot plastic balloons were used, a 70-foot, .001" polyethylene cell was flown on Flight 75. To determine the duration of buoyancy of this type of balloon no controls were used. Despite this, the balloon remained aloft for more than 60 hours and successfully withstood the loss of superheat occasioned by at least two sunsets. From the height-time curve of this flight (Figure 29) the very marked effect of superheat is apparent.

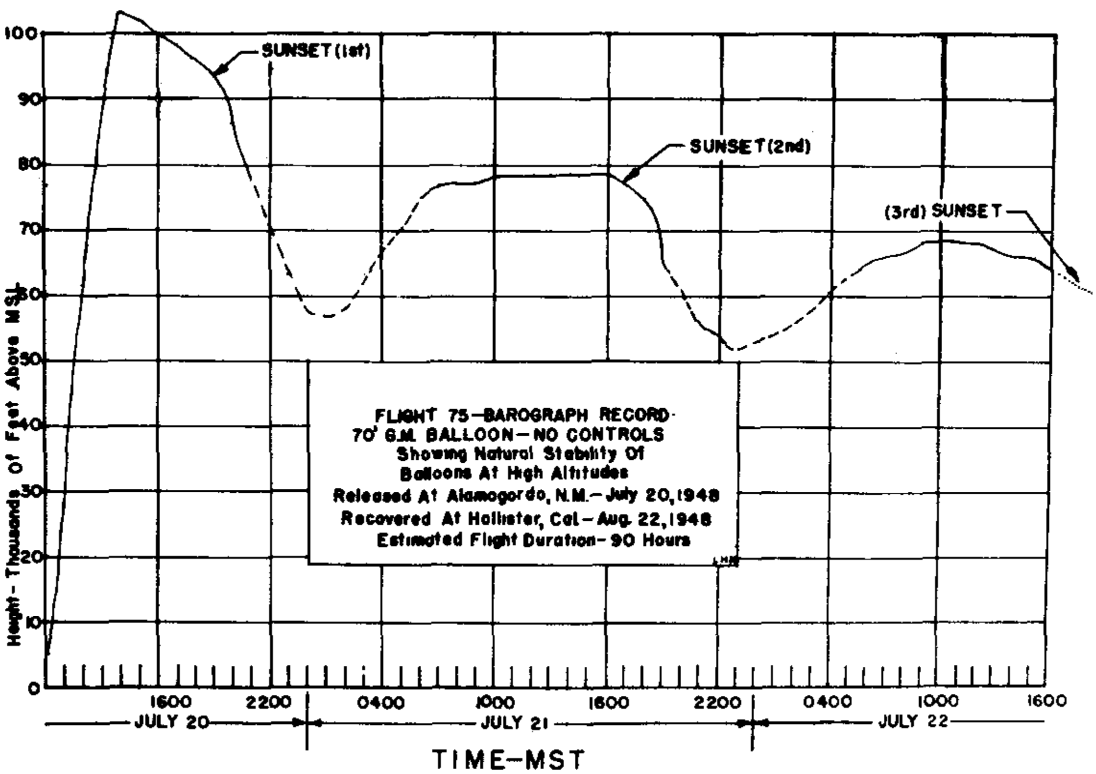


Figure 29

The record of the barograph was not complete since the clock stopped each night (clearly recording the lowest elevation reached, however) and ran down completely after 56 hours.

Since the small external appendix with cardboard stiffeners was not suitable for the large balloon, a new design with aluminum formed stiffeners (Figure 30) was used. This type of appendix closer worked well on later flights, and it is likely that the long duration of this flight may be attributed in part to satisfactory closing off of the aperture. In addition to maintenance of the purity of the lifting gas, this balloon floated in a region of very low pressure, thus reducing the loss of buoyancy by diffusion.

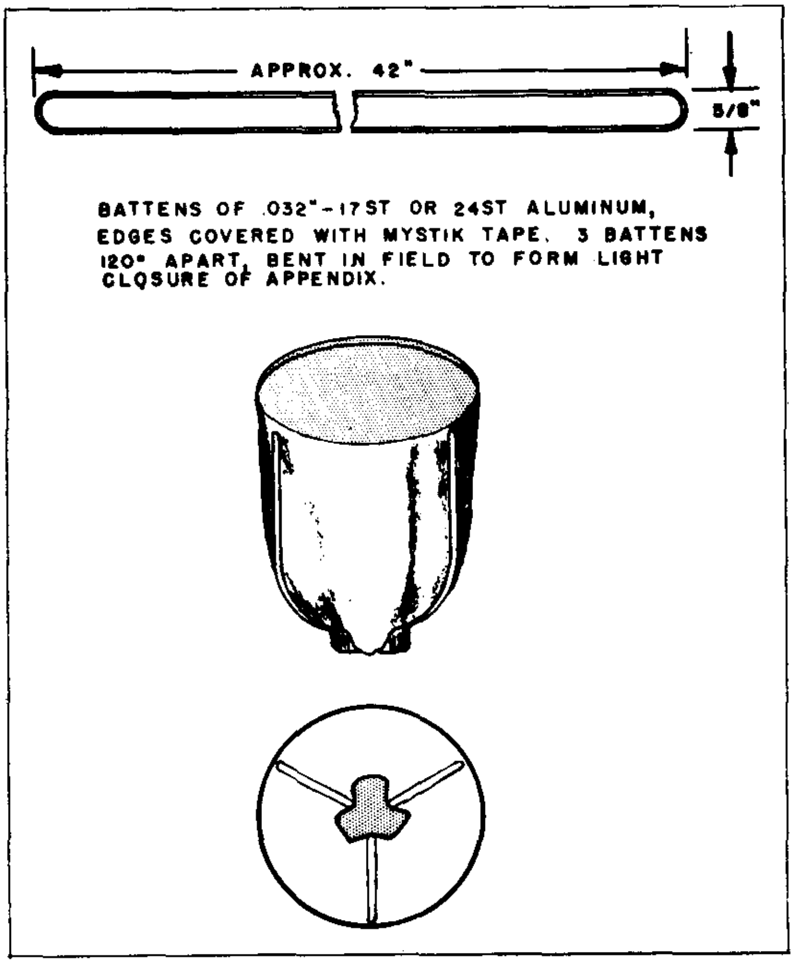


Figure 30: Aluminum battens for balloon appendix

A third factor contributing to the long flight was the heat gained by adiabatic compression of the helium during descent. In the temperature inversion of the stratosphere this adiabatic heating would add to the buoyancy by superheating the lifting gas.

From this flight it becomes apparent that the control required to maintain buoyancy at high levels is much smaller than that at low levels. On the next day, before Flight 75 had ended, a second 70-foot balloon was flown with standard automatic ballast controls, and this flight was never recovered. Presumably the marked easterly flow then observed above 60,000 feet carried this second flight into the Pacific Ocean.

Radar, RDF and theodolite were used to track the balloon.

Flight 78: Released from Alamogordo, New Mexico, 2038 MST, July 22, 1948
Not recovered

This flight was the first to be made with (white) thermistors exposed inside the .001" polyethylene balloon, inside the battery box and exposed to the air. The flight was at night and the balloon temperature was colder than the air temperature by about 5°C during the short period of time that the temperature values were telemetered. The standard SCR-658 receiver and Friez radiosonde ground station were used to record this data which was transmitted by a T-69 radiosonde. A New York University AM-1 transmitter was used to send out pressure data.

An automatic ballast valve, activated by a mercury minimum-pressure switch, was used to control ballast flow but the cold temperature presumably caused the mercury to freeze and no ballast flow was evidenced. (A ballast-metering siphon was part of the equipment.)

On subsequent flights, the minimum-pressure switch used an electrolite which can withstand the cold nighttime temperatures of the upper air.

The evidence of the thermistor in the battery box is very encouraging, since after four hours of flight the temperature remained above 10°C. This was the first measurement obtained on the cooling of batteries and indicated that no special cold temperature batteries were needed if insulation is carefully made. The temperature data and the height-time curve of Flight 78 are shown in Figure 31.

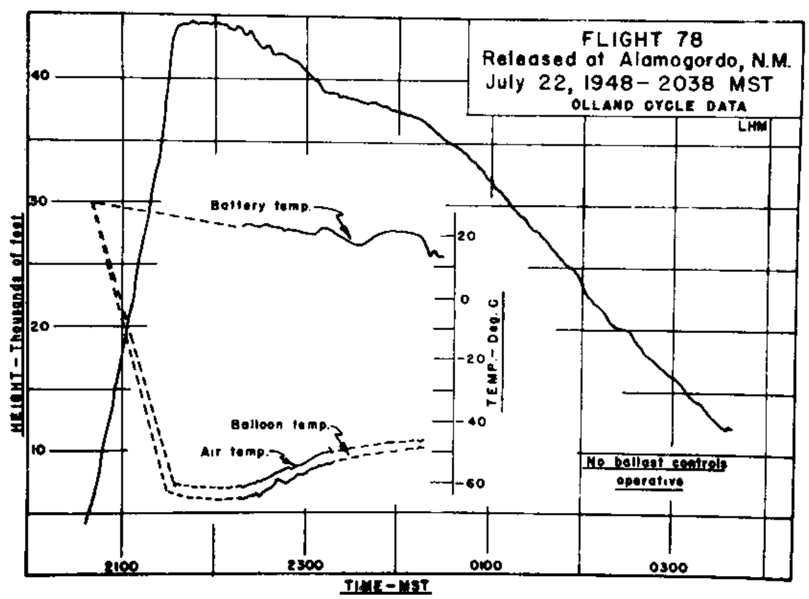


Figure 31

Flight 79: Released from Alamogordo, New Mexico, 1614 MST, July 23, 1948
Recovered at Alamogordo, New Mexico

This was the third attempt to use a coated nylon balloon, sealed off with a valve in the bottom. From Figure 32, the height-time curve, it may be seen

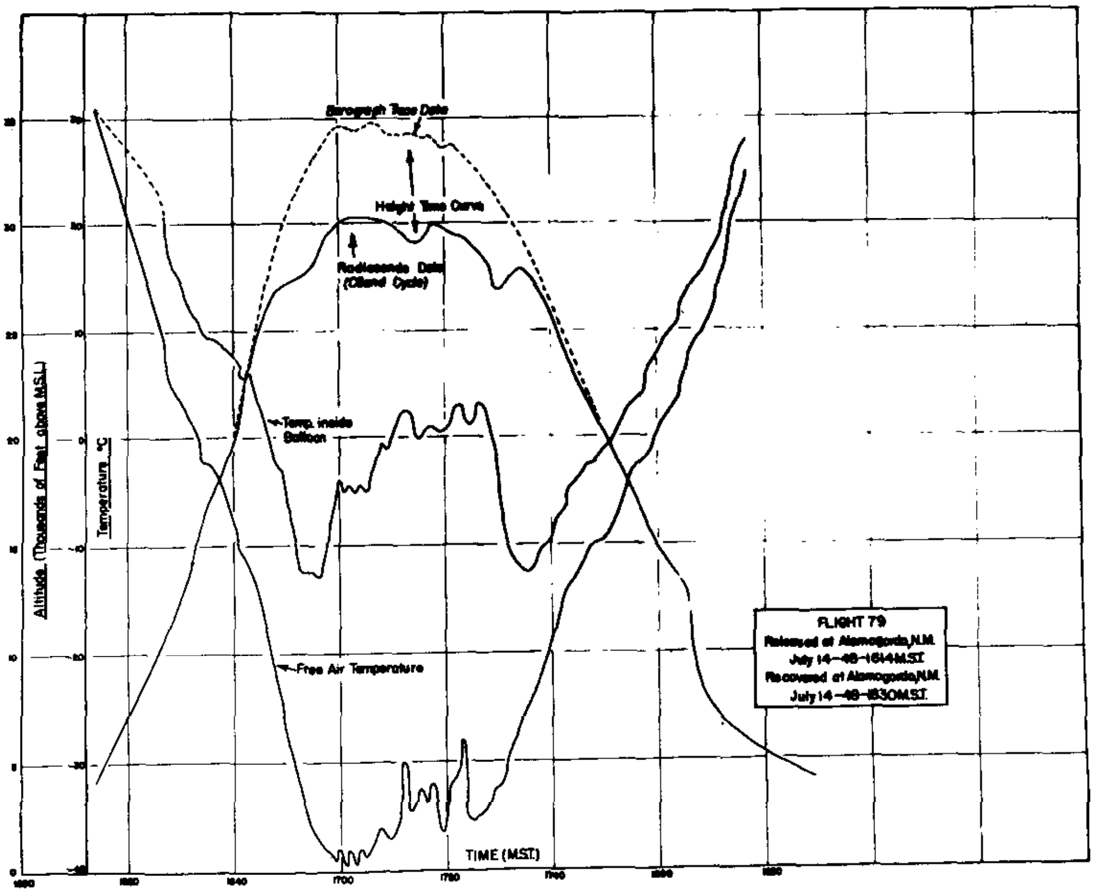


Figure 32

that this balloon did not remain aloft very long but that a high degree of superheat was generated in the lifting gas, despite the aluminum coating of the balloon.

The automatic ballast controls included in the flight equipment were inoperative, and as soon as the balloon lost its initial excess buoyancy (corresponding to the super-pressure maintained behind the safety valve) it descended. From the speed of the descent it was computed that an accelerating force equal to 5% of the gross load (52 kg) was acting to bring the balloon down. This force was in turn derived from the loss of lift encountered when over 30°C of superheat was lost by ventilation.

Flight 80: Released at Alamogordo, New Mexico, 1126 MST, July 24, 1948
Recovered at Rincon, New Mexico

On this flight an automatic ballast valve activated by a minimum-pressure switch was used to support a .001", 20-foot polyethylene balloon. From the height-time curve (Figure 33) it may be seen that the balloon remained at its maximum height for two hours, then began to descend slowly. A ballast meter was in use, and no ballast flow was recorded until the balloon descended to about 30,000 feet. It is likely that the mercury minimum-pressure switch was frozen at the higher levels, or that the squib which the switch controlled failed to detonate until a higher pressure was reached.

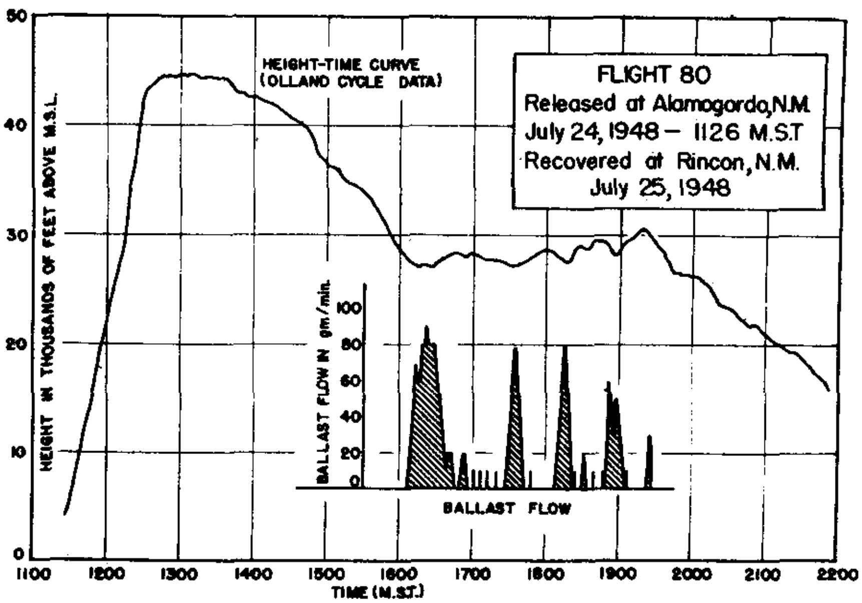


Figure 33

Following the activation of the aneroid capsule of the automatic ballast valve, ballast was released in four separate blocks. With each flow of ballast except the fourth, the balloon was returned to the seal-off pressure of the aneroid with no change in this pressure (321 mb=28,500 feet). The fourth ballast-flow period lasted until the balloon had risen to 300 mb (30,000 feet) and ballast cut off there. Since the sun had set between the third and fourth ballast-flow periods, this rise in "ceiling" is attributed to the cooling of the air entrapped in the aneroid of the automatic ballast valve. This decrease of pressure of 21 mb corresponds to a loss of 8°C of superheat. In each of the four periods of ballast flow, there was enough unnecessary ballast lost to cause an overshoot when the balloon returned to its floating level. This excess ballast was that used during the period when the balloon had begun to rise but was still below activation altitude of the automatic ballast valve. The inefficient use of ballast was one of the major objections to such a control system.

On this flight the ballast load of 3 kilograms was exhausted in only three hours, indicating a large loss of gas from this particular balloon. It is believed that the large initial acceleration provided by the rapid descent of the balloon caused the restoring force, and the subsequent overshoot, to be very large, and the high ballast flow is probably much greater than was the loss of buoyancy on this flight.

Flight 81: Released from Alamogordo, New Mexico, 0548 MST, August 6, 1948
Not recovered

The balloon flown on this flight was made of .004" polyethylene, and it was eggplant shape about 20 feet in diameter and 25 feet long. The first of its kind, this balloon was made by Goodyear Tire & Rubber Company, Inc.

Only a short period of radio reception was obtained, but during this time the balloon rose with predicted speed (500 feet per minute) nearly to its predicted altitude (40,000 feet) and floated within 1500 feet of the 37,000-foot level. Figure 34 is the height-time curve for this flight.

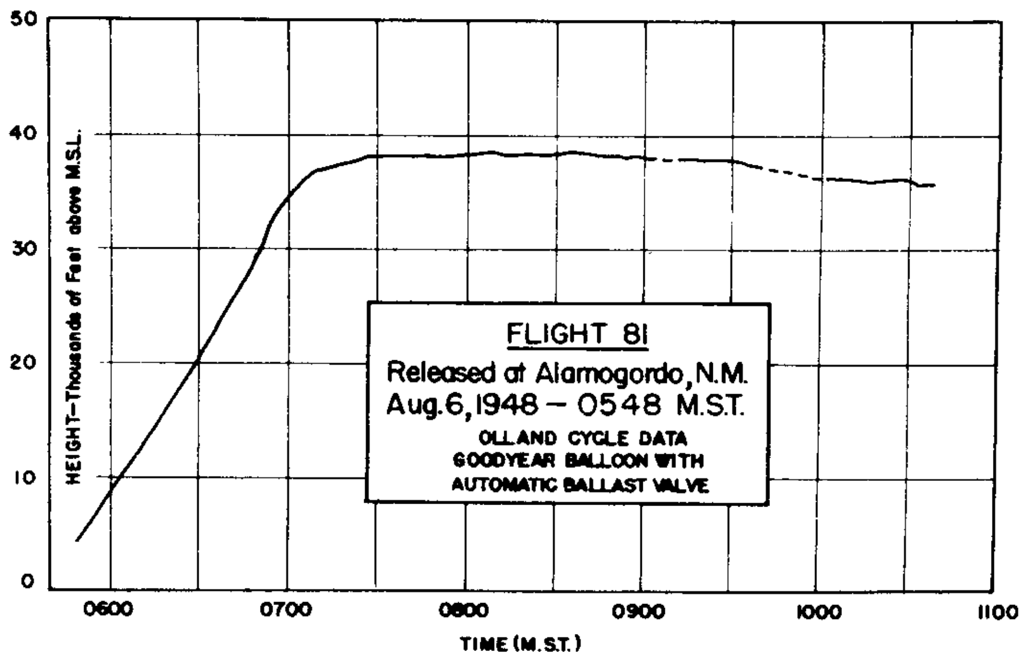
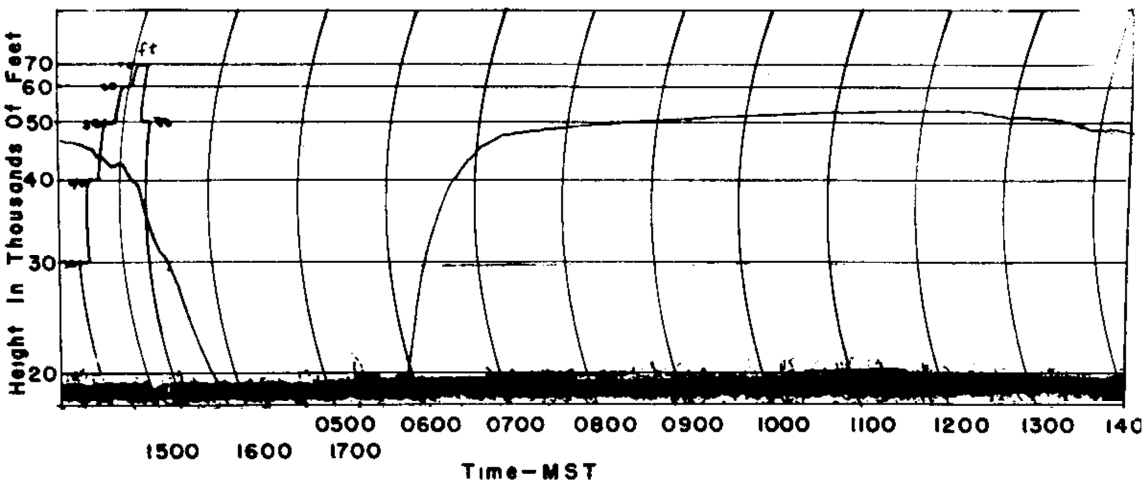


Figure 34

Since the balloon did not descend far enough below its maximum altitude to activate the minimum-pressure switch and the automatic ballast valve, no ballast flow data was telemetered while the balloon was within the radio range. This indicates a very low rate of gas loss through the walls of this balloon.

Flight 82: Released from Alamogordo, New Mexico, 0515 MST, August 10, 1948
Recovered at Roswell, New Mexico

This flight was made with a 20-foot, .001" polyethylene balloon carrying a load to 54,000 feet and sustained by a fixed-leak orifice control, expending ballast at about 525 grams per hour. With 4500 grams of ballast aboard the balloon should have been increasingly buoyant for $8\frac{1}{2}$ hours after release. From the barogram (Figure 35) it may be seen that the "ceiling" did rise, at



NYU BALLOON PROJECT FLIGHT 82
Barograph Record Of G.M. 20' Plastic Balloon With
534 gm/hr Fixed Ballast Leak
RELEASED AT ALAMOGORDO, N.M.– 0511 MST, 10 AUG 1948
DESCENDED AT ROSWELL, N.M.– 1630 MST, 10 AUG 1948
DURATION– $11\frac{1}{2}$ hrs

Figure 35

a rate of 700 feet per hour (525 grams of ballast was lost each hour), for about $7\frac{1}{2}$ hours, and then generally accelerating descent was experienced.

On this flight, radio reception was maintained for the entire air-borne period of 11 hours. Flight 82 is a good example of flight using a single fixed-leak orifice for altitude control by ballast dropping.

Flight 85: Released at Alamogordo, New Mexico, 1542 MST, August 17, 1948
Not recovered

The objective of this flight was to carry a standard radiosonde to a high level; there it was to be released on a parachute and, at the moment of release, the batteries for the transmitter were to be activated. To accomplish this a pressure-triggered switch was rigged on a .001", 20-foot polyethylene balloon. Below the baroswitch a standard T-69 radiosonde was supported with a parachute stuffed into a case also hanging from the parent balloon (Figure 36). Two plugs were set to keep the transmitter circuit

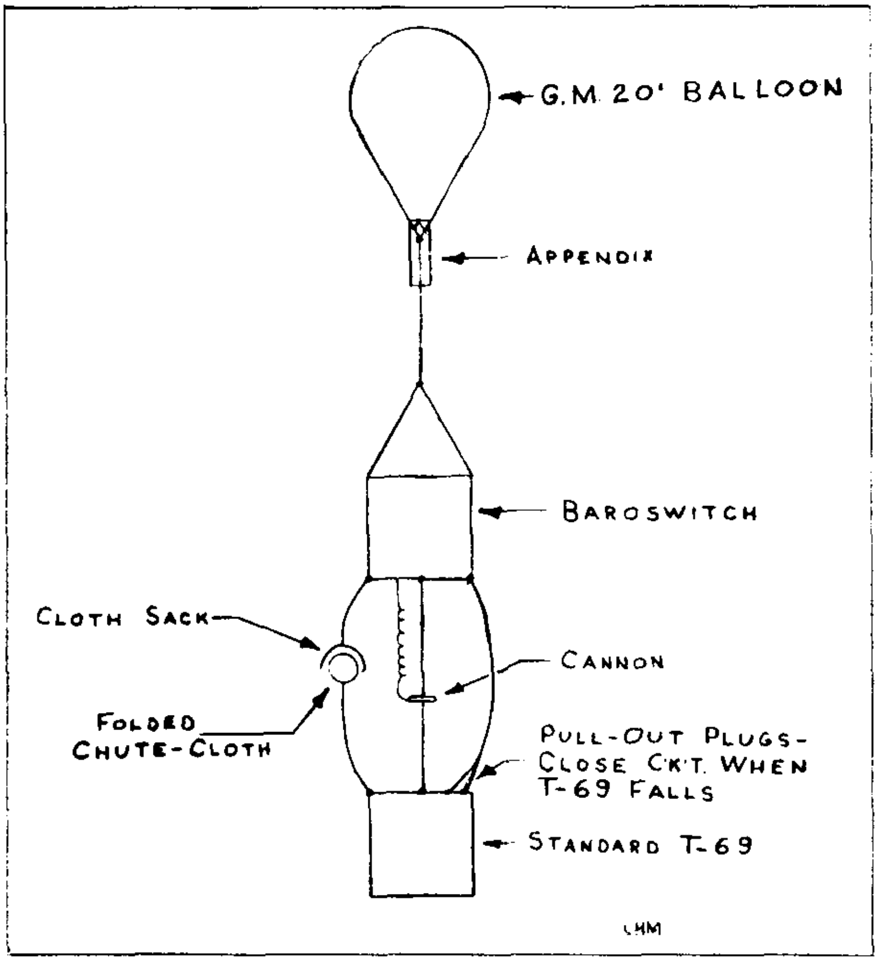


Figure 36: Equipment train, Flight 85

open until the baroswitch fired the "cannon" which severed the supporting line. Then the circuit plugs were to be pulled from their stops, and the parachute was to be pulled from its sock, supporting the radiosonde on its descent.

The failure of this system to act may be attributed to the use of a squib to fire the line-cutter cannon. Subsequent tests at lower levels (where the squibs work better) were made with a satisfactory release and activation of the "dropsonde."

Flight 86: Released from Alamogordo, New Mexico, 0941 MST, August 19, 1948
Recovered at Valmont, New Mexico

This was the fourth flight made with a single, 7-foot, .001" polyethylene balloon (Figure 37), carrying a light load to relatively low altitudes.

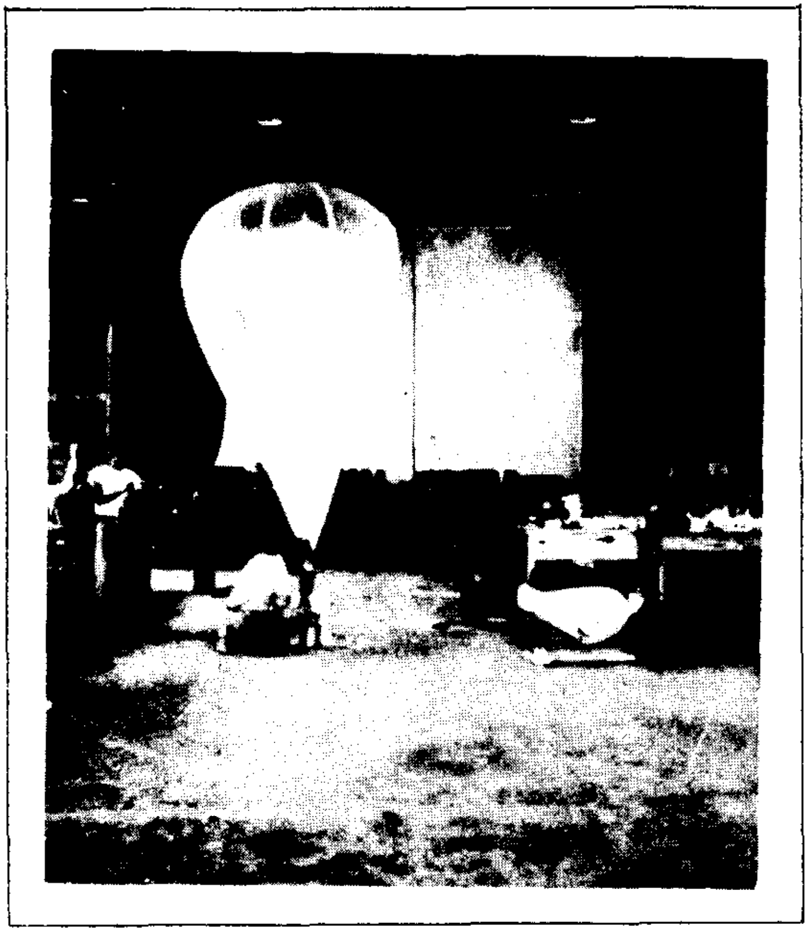


Figure 37: 7-Foot polyethylene balloon

On Flight 74, the automatic ballast meter showed that a ballast flow of 200 grams per hour was required by an automatic ballast valve on such a balloon. Flight 84 was launched in August, 1948 with a low-altitude barograph and no altitude controls to ascertain how long such a balloon would stay up. Using radar and helicopter that balloon was tracked for nearly 2 hours at an altitude of 12,500 feet with a load of 3 kilograms. It was still floating when lost.

On Flight 86, a fixed ballast leak was used, set at 170 grams per hour. After an early failure of the radiosonde transmitter, this balloon was followed with a plane; a floating level of about 14,500 feet was maintained for 4 hours, with a rise of "ceiling" of about 1200 feet per hour.

This balloon was observed during descent and was still distended, indicating that the lifting gas had been replaced by air both before and during descent.

Flight 88: Released from Alamogordo, New Mexico, 1241 MST, August 25, 1948
Recovered at Lovington, Texas

This flight was planned to measure the diffusion and leakage of lifting gas through a 20-foot, .001" polyethylene balloon at 40,000 feet. A fixed-leak orifice was set to flow at 100 grams per hour, and an automatic ballast valve was included to supply more ballast as demanded. This automatic valve broke on release, and the flow of 100 grams per hour was not sufficient to keep the balloon and equipment up.

Temperature data on this flight was obtained from thermistors inside the balloon, inside the battery and in the free air. These data and the height-time curve are shown in Figure 38. During the period from 1400 to 1530 when

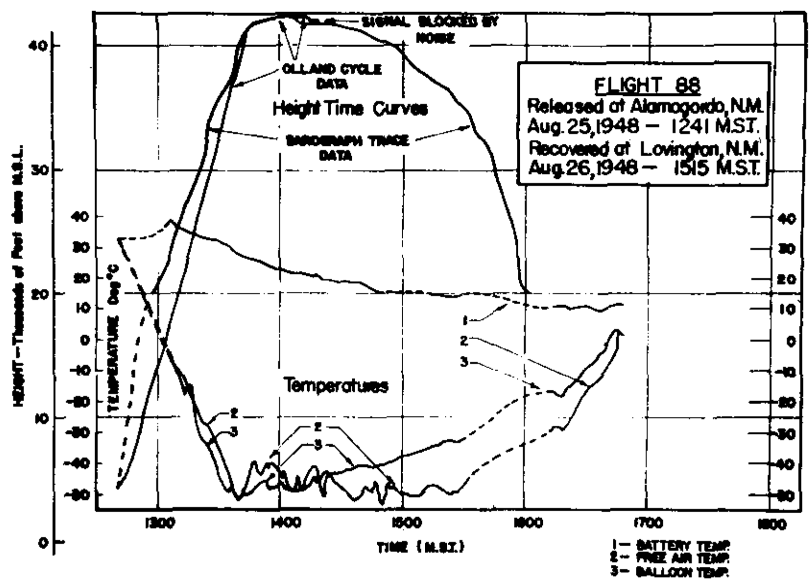


Figure 38

the balloon was slowly descending, the temperature of the gas increased with respect to the free air temperature, and a differential of 15°C was recorded at 1530. With subsequent, more rapid descent, this differential was reduced, presumably by ventilation. The battery box temperature remained above 10°C after four hours aloft.

<u>Flight 89</u>: Released from Alamogordo, New Mexico, 1005 MST, August 26, 1948
Not recovered

On this flight a .001", 20-foot polyethylene balloon was used to carry a ballast meter to about 45,000 feet to determine the ballast requirements at that altitude, using an automatic ballast valve. No record of ballast flow was telemetered during this flight, but it is not known whether the ballast meter was inoperative or the ballast valve itself failed--possibly due to failure of a squib to detonate at the combined low pressure and cold temperatures aloft.

From the height-time curve, Figure 39, it will be noted that the balloon was in a near floating condition for about five hours after reaching its maximum altitude. The total weight available on this flight was 2 kg, so a loss of 400 grams per hour would have been required if the ballast was used during this period.

From Flights 70 and 71 we know that a balloon has remained for about four hours at slightly higher altitudes with no ballast flow to support it; Flight 89, therefore, is not necessarily an example of the action of the automatic ballast valve control.

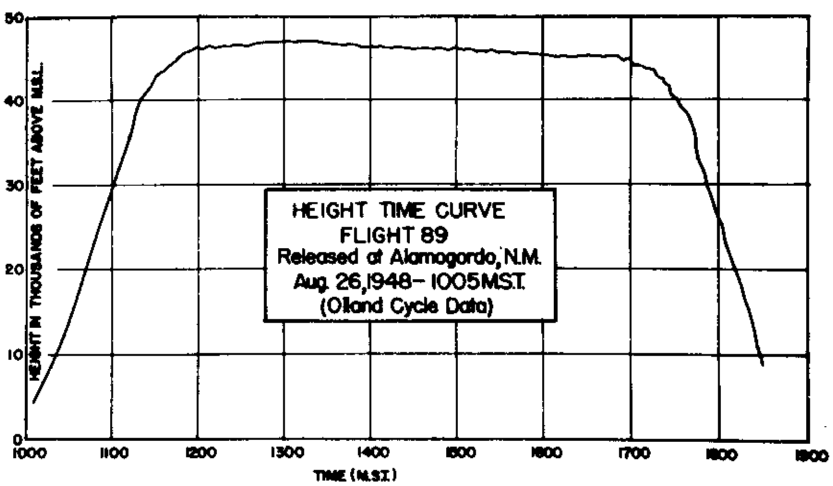


Figure 39

<u>Flight 90:</u> Released from Alamogordo, New Mexico, 1502 MST, August 27, 1948
Recovered at Roswell, New Mexico

The .001", 20-foot polyethylene balloon used on this flight was released in mid-afternoon to provide a test of the sunset effect on a balloon supported by the automatic ballast valve.

From the height-time curve, Figure 40, it may be seen that the balloon had attained a floating altitude shortly before the sunset and that the action of the automatic ballast valve was sufficient to restore the buoyancy

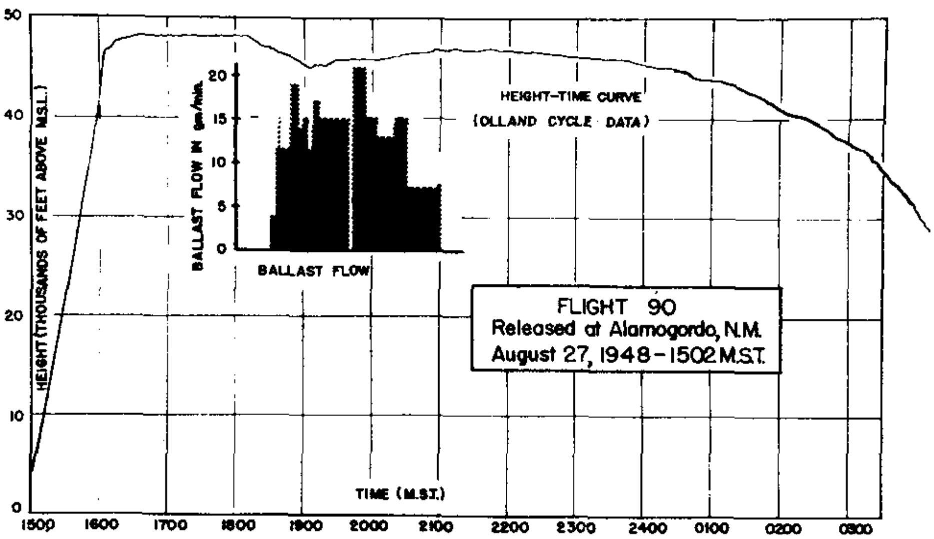


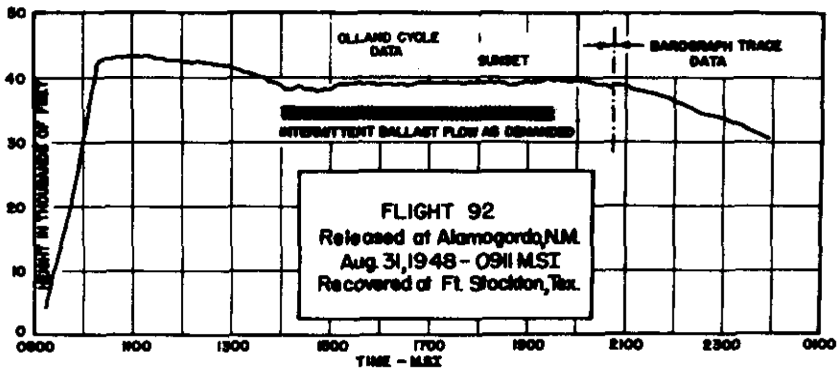
Figure 40

and cause the balloon to again reach a floating condition. The difference between the two floating levels may be explained by a consideration of the automatic ballast valve and the minimum-pressure switch which was used to seal off its aneroid capsule. Since the balloon had not fallen far enough to permit the switch to seal off the valve before sunset, this action was accomplished during the sunset descent (caused when the superheated helium lost the sun's heating effect). A further descent of 5 mb (500 feet at this level) was required to start the flow of ballast. By this time, the balloon had lost considerable lift and in exchange had acquired a downward velocity of about 120 feet per minute. To check this descent a ballast flow was required for about 40 minutes. During the next hour the balloon was buoyant and climbing back to the seal-off pressure of the automatic ballast valve. The inefficiency of this valve system is demonstrated by the ballast which was lost after the balloon had regained its buoyancy and had begun to rise. More ballast was wasted than was required to check the descent. Indeed, the entire 3000 grams available was expended at this time, according to the evidence of the ballast meter.

On this flight there was no apparent change in the activation pressure of the automatic ballast aneroid between the times when ballast flow began and ended. This indicates that the entrapped air had not experienced any significant temperature change during the two hours of ballast operation.

Flight 92: Released from Alamogordo, New Mexico, 0911 MST, August 31, 1948
Recovered at Ft. Stockton, Texas

On this flight an automatic ballast valve (with ballast meter) was used to support a 20-foot, .001" polyethylene balloon. The automatic ballast valve operated properly for about six hours, and 3000 grams of ballast was exhausted soon after sunset. In this case (Figure 41) the floating level of the



GM.20' Balloon with Automatic Ballast Valve

Figure 41

balloon was not seriously affected by sunset as was the case in Flight 90, since the balloon had already descended to the activation level of the automatic ballast valve. This descent followed about three hours of relatively stable flight during which time no ballast was released. The 5000-foot descent represents the delay in operation caused by the activation of the aneroid capsule by a minimum-pressure switch, added to the lag of the aneroid itself. Following the initial activation at about 38,500 feet, small oscillations were introduced into the flight pattern by the action of the automatic ballast valve.

Flight 92 provides a good example of the control of a balloon's altitude by the use of a pressure-set automatic ballast valve. In such a flight there is no tendency to rise to higher and higher levels. The adulteration of the lifting gas with air reduces the buoyancy of the balloon, and through the ballast-valve control, the load is diminished to the same extent so that equilibrium is maintained at the activation pressure of the automatic ballast valve's aneroid. In this flight the altitude constancy achieved was the best of all flights made to date. For seven hours and 35 minutes this balloon was held within 1000 feet at 38,000 feet MSL. (At this altitude 1000 feet corresponds to a pressure difference of 10 millibars.)

The sunset effect resulted in a rise of about 500 feet (5 mb) in the floating level of the balloon at 1830 MST. This seems to be due to a change in the effective seal-off pressure of the aneroid capsule of the automatic ballast valve which was the consequence of a decrease in the temperature of the trapped air inside. The rise in altitude experienced corresponds to a decrease of temperature of about 6°C, the superheat of the aneroid, which was lost at sunset. This valve may be compared with the 30°C found on Flight 10. On the earlier flight a black valve was used while on this flight the equipment was polished aluminum, with a highly reflective surface.

Flight 93: Released from Alamogordo, New Mexico, 0712 MST, September 1, 1948
Recovered at Neuvas Casas Grandes, Chihuahua, Mexico

This daytime flight with a 20-foot, .001" polyethylene balloon went up with defective ballast controls; consequently the flight's main value is in showing the natural stability of such a balloon without any altitude controls. As with Flight 88, which went to about the same height (40,000 feet), this balloon remained at a near-floating level for less than two hours (Figure 42). It is interesting to compare this duration at 40,000 feet with the four-hour duration at 50,000 feet shown on Flight 70 and 71. Probably the effect of reduced pressure on diffusion of the lifting gas is a major factor contributing to the longer floating period at the lower pressure.

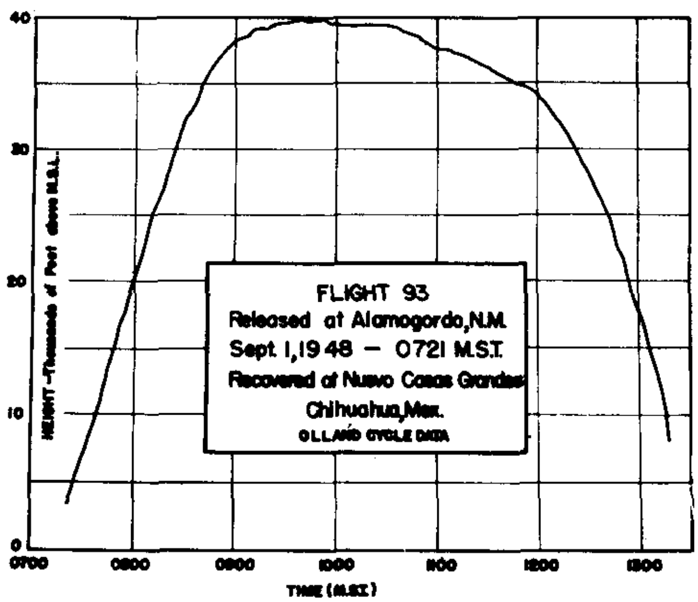


Figure 42

Flight 94: Released from Alamogordo, New Mexico, 1208 MST, September 3, 1948
Recovered At Villa Ahumada, Chihuahua, Mexico

On this flight, a fourth attempt was made to sustain a Seyfang, neoprene-coated nylon balloon. On Flight 79, a previous Seyfang flight, no ballast equipment had been in operation, and so a careful record of ballast flow on Flight 94 was desired. This was provided by a ballast meter. In addition to this and the barograph and Olland pressure-measuring instruments, a thermograph was also part of the equipment train.

The height-time curve (Figure 43) shows that the initial buoyancy surplus of this balloon (for the most part due to superpressure held behind

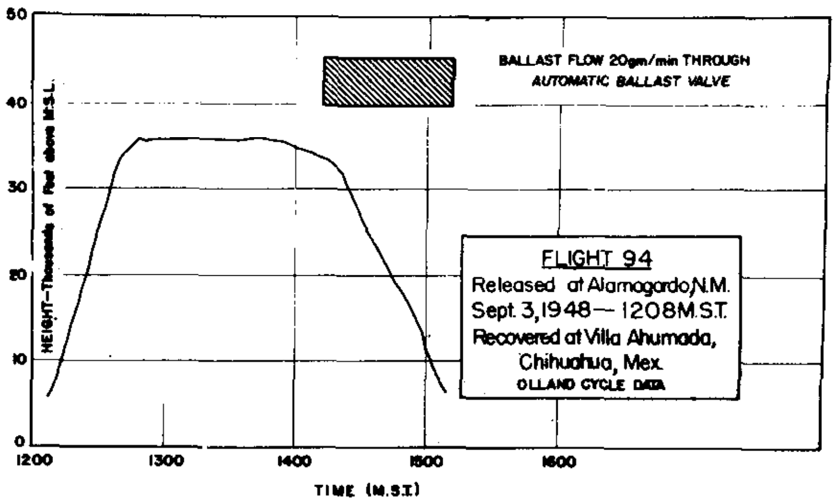


Figure 43

the safety valve) was reduced by diffusion so that after one hour of floating it began to descend at an accelerating rate. After falling about 2000 feet, the automatic ballast valve began to operate, and ballast was discharged at the rate of 20 grams per minute. During the descent, however, the strong superheat which the balloon had acquired was reduced by ventilation.

The adiabatic lapse rate of helium is 2°C per kilometer, whereas air in the troposphere warms up about 6°C with each kilometer of descent. This means that with each kilometer of fall, the lifting gas was cooled relative to the air by an additional 4°C. The combination of inertia, loss of superheat through ventilation, and adiabatic cooling of the gas as it was compressed, proved too great for the limited flow of ballast through the automatic valve, and the balloon fell unchecked to the ground.

From Flight 79, it was determined that superheat of nearly 40°C is built up when Seyfang balloons are flown in the sunshine. If this were lost, the buoyancy of the balloon would be reduced by one-sixth, and no satisfactory control could be achieved by ballast dropping.

Flight 96: Released from Alamogordo, New Mexico, 0733 MST, September 8, 1948
Not recovered

On Flight 96 a .001", 20-foot polyethylene balloon was used to carry a ballast meter to about 45,000 feet to determine the flow required at that altitude using an automatic ballast valve. No record of ballast flow was telemetered during this flight, but it is not known whether the meter was inoperative, or the valve itself failed--possibly due to failure of a squib to detonate at the combined low pressure and cold temperature aloft.

From the height-time curve, Figure 44, it will be noted that the balloon was in a near-floating condition for about four hours when the transmitter

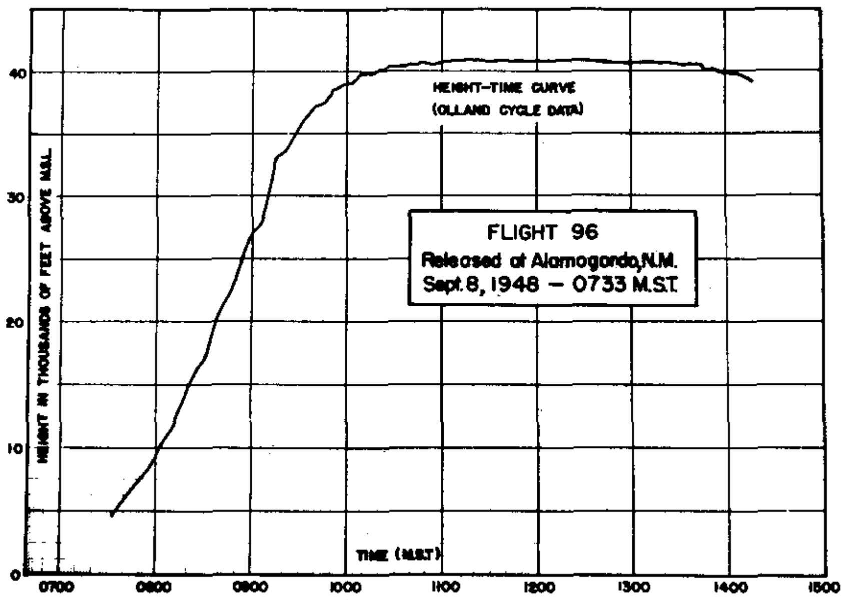


Figure 44

signal gave out. There is no way of telling whether the constant-level flight obtained was due to the natural buoyancy of the balloon or the action of the automatic ballast valve.

Flight 97: Released from Alamogordo, New Mexico, 0856 MST, September 10, 1948
Recovered at Duncan, Oklahoma

On this flight a .001", 20-foot polyethylene balloon was used to test a new type of ballast control. In this system, ballast flow was excited at any altitude if the balloon descended at a rate equal to or greater than 1 millibar in five minutes.

The buoyancy record and the Olland-cycle pressure data obtained from this flight show a disagreement of about 10,000 feet (Figure 45). No explanation has been provided for this difference and the following evidence has been considered. The predicted floating level was about 45,000 feet, in agreement with the Olland-cycle radiosonde data. On the other hand, the balloon rose extremely slowly and may have taken in air to dilute the lifting gas. In this event, the floating level might easily have been reduced by 10,000 feet.

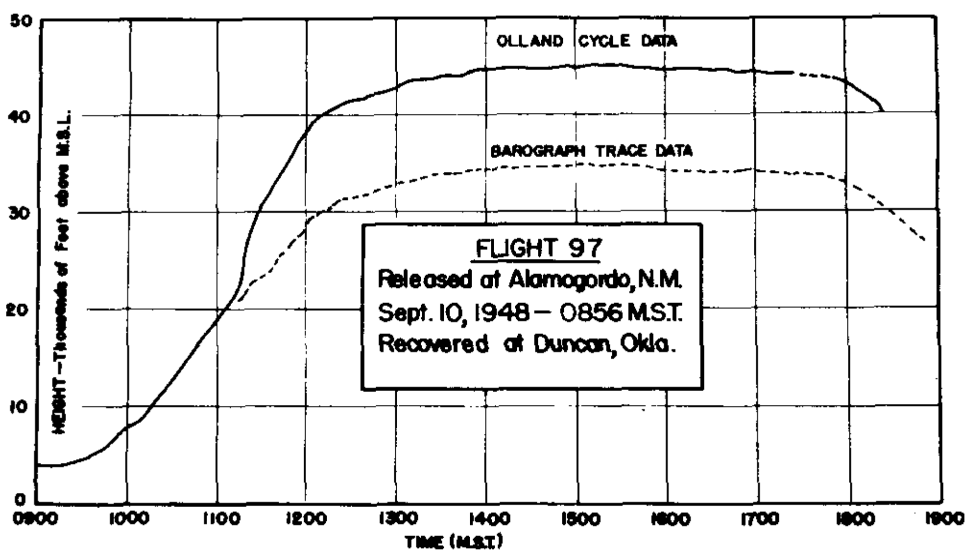


Figure 45

Once at the floating level, however, the balloon was maintained within 1000 feet (or 1200 feet) of a constant level for over four hours. This indicated that the control system was in operation since previous flights (88 and 93) at this altitude descended after about two hours of flight without ballast.

Flight 98: Released from Red Bank, New Jersey, 0948 EST, October 28, 1948
Not recovered

On Flight 98 a 20-foot, .001" polyethylene balloon was used to test radio reception using a new model of the Olland-cycle modulator and a T-69 radiosonde transmitter. Three receiving stations were used, with elevation and azimuth angles as well as the pressure altitude recorded by RDF (SCR-658) equipment. The trajectory of this flight (Figure 46), reconstructed from the data received at the ground station, indicates that the balloon was more than

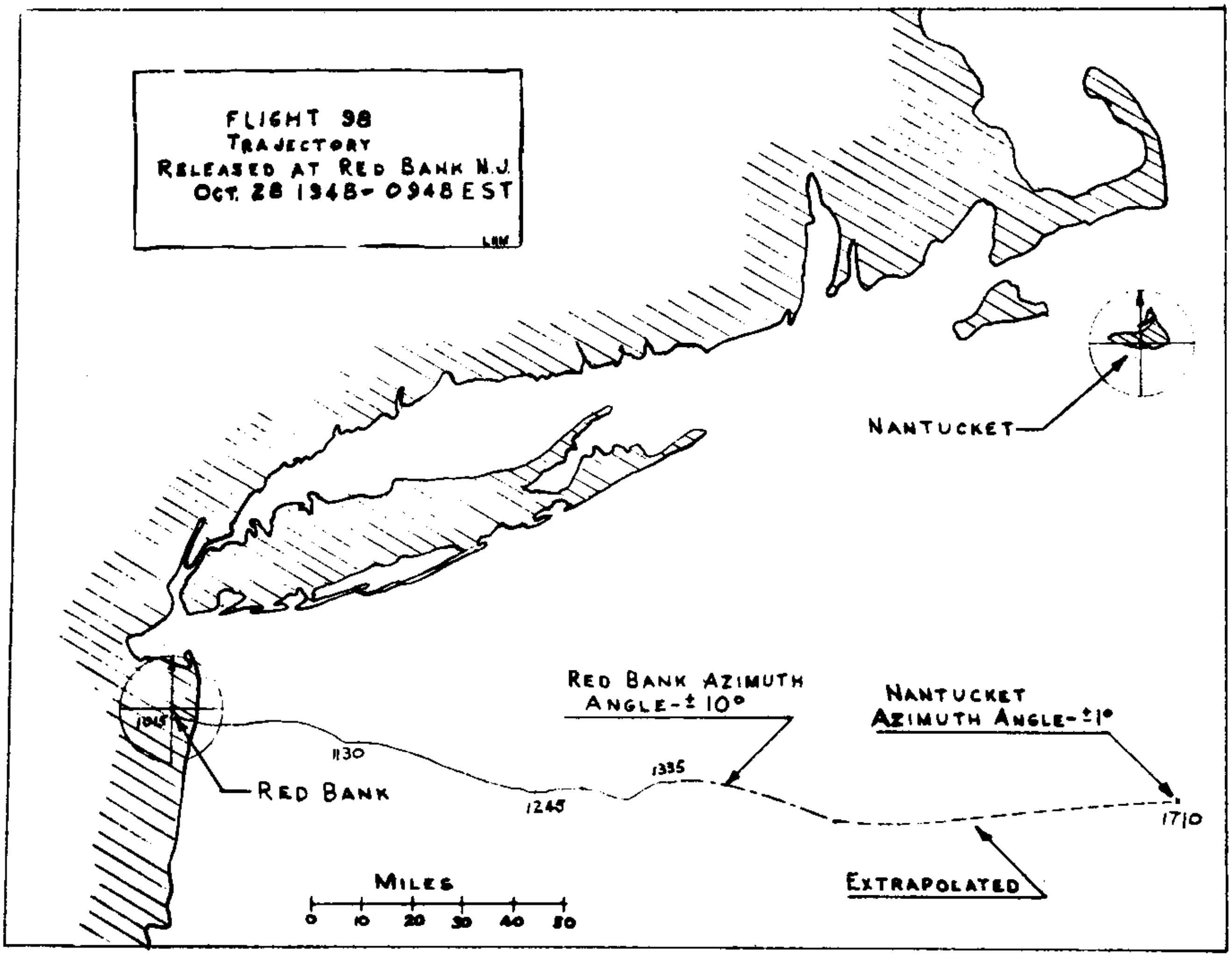


Figure 46

175 miles from the Nantucket station at the time the signal was first received. This reception is much greater than may be expected from most

SCR-658 ground setswhen the T-69 transmitter is used. The signals obtained were not very strong, and there was only an interrupted record of the pressure height. From the height-time curve (Figure 47) it will be seen that a three- to four-hour period of floating was recorded, at an altitude near 50,000 feet MSL. This is in good agreement with the results obtained from earlier flights (70 and 71) at this level when no control apparatus was included.

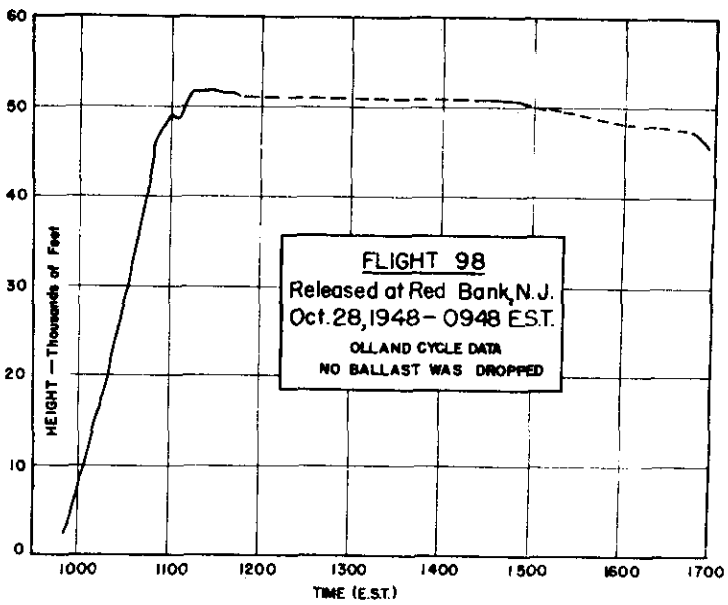


Figure 47

Flight 102: Released from Red Bank, New Jersey, 1023 EST, December 9, 1948
Not recovered

Flight 102 was the first test given to a 30-foot, .001" polyethylene balloon manufactured by General Mills, Inc.; with this balloon a 30-kilogram payload was successfully lifted to 58,000 feet. A combination rate-of-ascent switch and displacement switch was used to control ballast flow, but no record of ballast was made since the ballast meter was broken at launching.

Flight data was received by three ground stations, and the signal from the AM-1 transmitter (with about 10 pounds of batteries) was received for about 400 miles. This was a good test of the distance to which a signal may be transmitted by the AM-1 (N.Y.U) transmitter under daytime conditions. The trajectory of this flight is Figure 48.

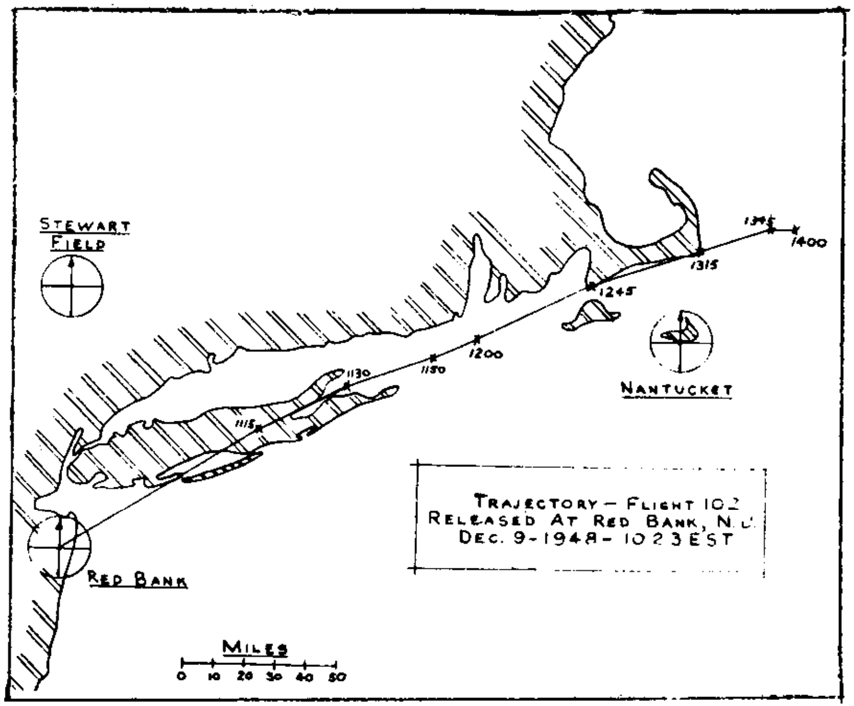


Figure 48

In the height-time curve (Figure 49) it is interesting to note the descent which began shortly before sunset. There is reason to believe that this fall was being checked by ballast flow. The normal descent after a balloon begins to fall is accelerating, while on this flight acceleration is evident. With a loss of 10°C superheat, and a limited flow (900 grams per hours), it would require two hours of flow to restore the buoyancy of the balloon. This is a demonstration that more rapid compensation is required.

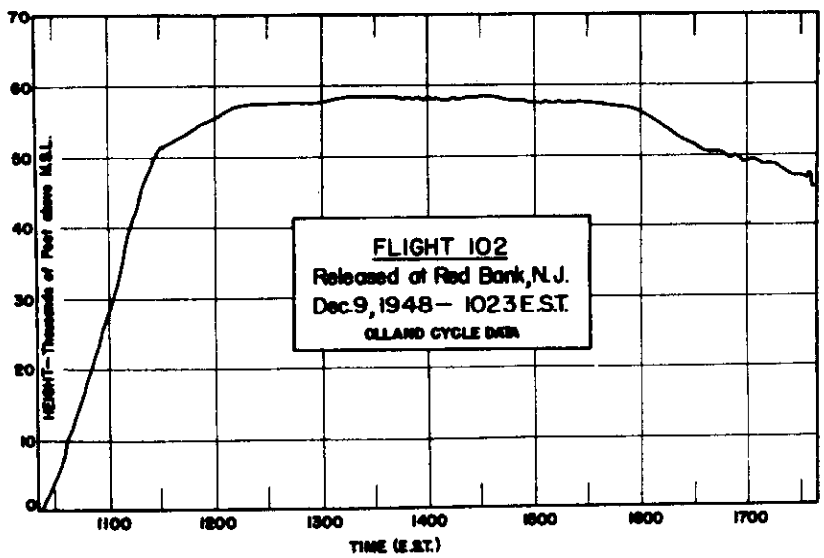


Figure 49

Flight 103 through 111: These flights were released in January and February, 1949 from Alamogordo, New Mexico to test the action of the combined ballast controls (displacement switch and rate-of-ascent switch). Receiving units were stationed at Alamogordo; at Miami, Oklahoma and at Nashville, Tennessee; aircraft were used both to receive the signal and also to track and position the balloon by the use of the radio compass.

For the first time on these flights, a program switch was used to permit a single transmitter to transmit three temperature signals as well as ballast-flow data and pressure information. By interrupting the pressure and ballast data for short intervals of temperature data, all of this information was telemetered with the AM-1 (N.Y.U.) transmitter.

Aircraft reception of 500 miles was reported on these flights, but ground reception was limited to about 250 miles, perhaps due to mountains surrounding the receiving station.

No significant data was obtained on four of these flights, and on two more the principal objective of the flight was defeated by the excessive gas loss from the balloons.

From the height-time curves of Flights 103 and 107 (Figures 50 and 51) may be seen that even with constant ballast flow (at 2400 grams per hour)

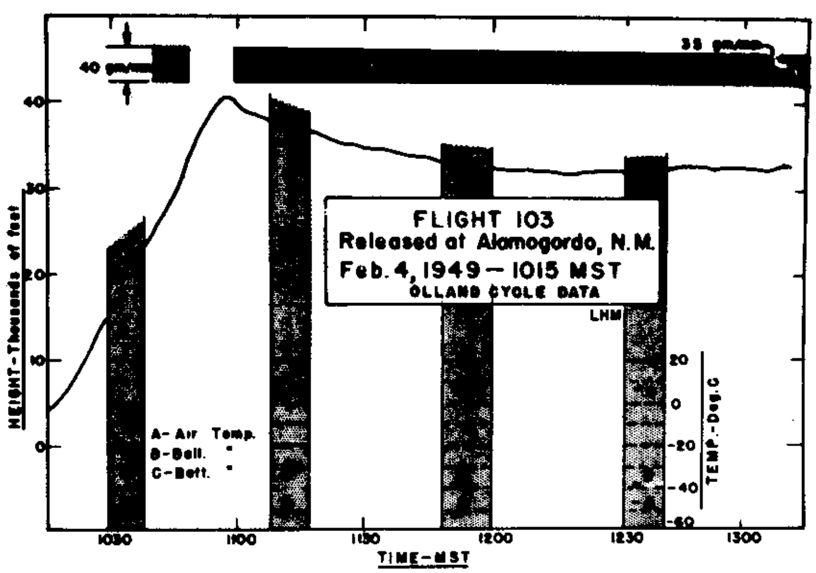


Figure 50

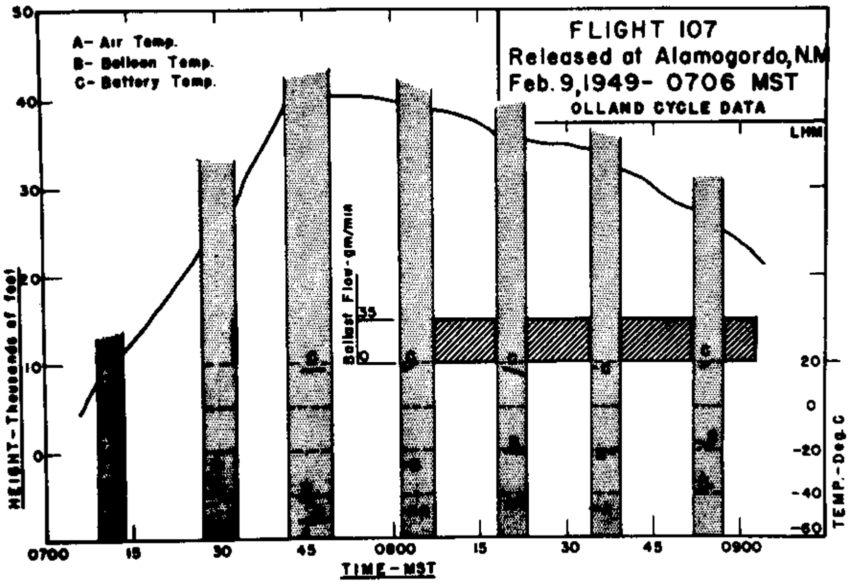


Figure 51

the balloon continued to descend. In both cases the token ballast flow on the ascent portion of the flight indicates that the controls were operative, but there was no test of efficiency since on-off operation was never permitted.

The temperature data of these flights is in generally good agreement with that seen earlier with the balloon gas being warmed by the sun to acquire a superheat of 10° to 20°C.

Flight 103: Released from Alamogordo, New Mexico, 1015 MST, February 4, 1949
Recovered at Mountain View, Oklahoma

On Flight 103 a B-17 airplane was used to follow the balloon, homing in on the signal from the AM-1 transmitter with the radio compass. There were few clouds over the first section of the balloon's path, and very exact positioning was obtainable. The compass needle reversed almost immediately, and no cone of silence was found when the plane passed beneath the balloon. The fixes indicated on the trajectory (Figure 52) show how exactly the path of the balloon may be determined when tracked in such a manner.

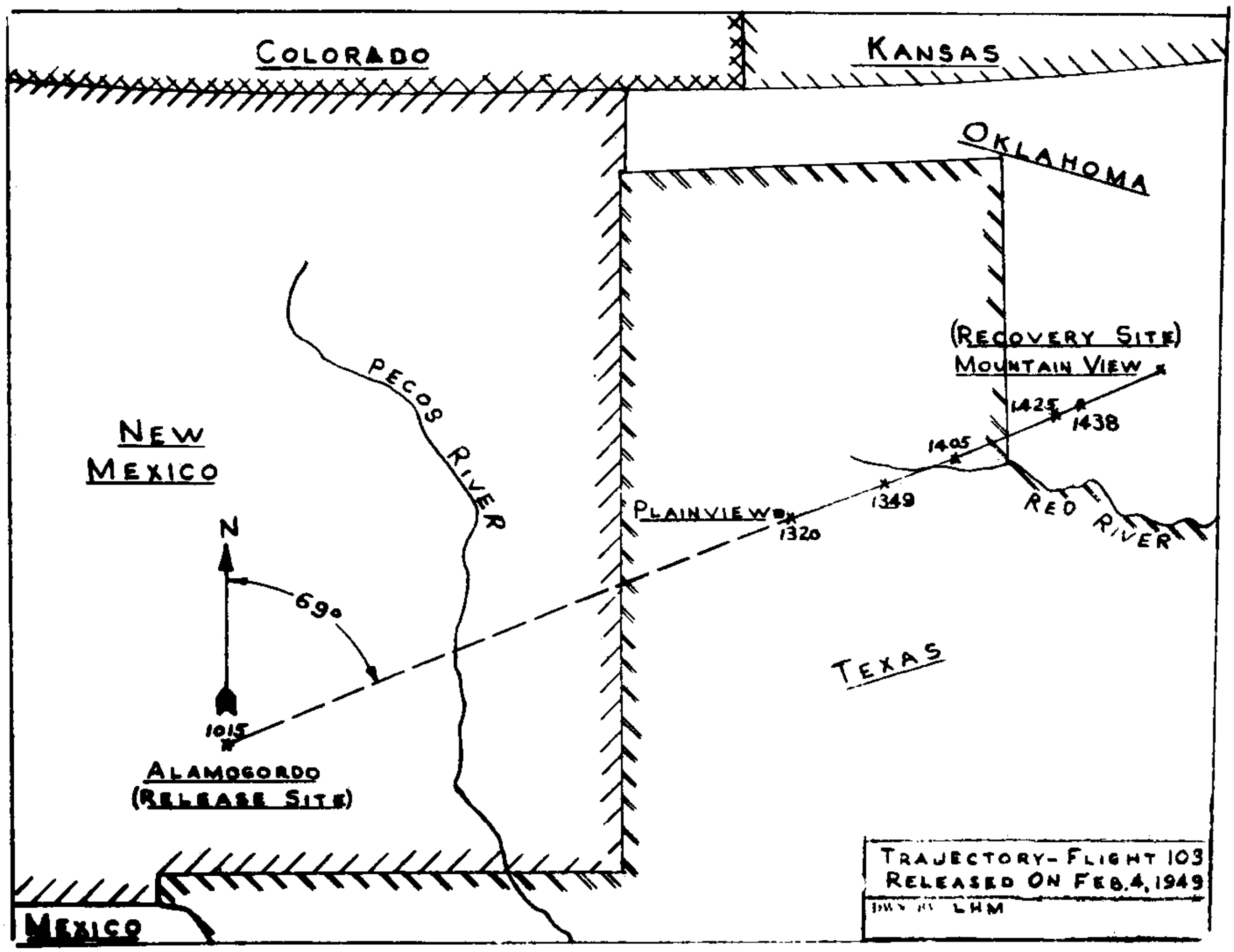


Figure 52

Flight 104: Released from Alamogordo, New Mexico, 1123 MST, Feburary 5, 1949
Recovered at Hale Center, Texas

On this flight a stepwise floating level was achieved by the dropping of weight from the 20-foot, .001" polyethylene balloon. From the height-time curve (Figure 53) the climb from 35,000 feet MSL to 47,000 MSL can be seen. A time clock was used to start the rapid flow of ballast after about one hour at the first level. Following the exhaustion of all ballast, the ballast reservoir itself was released to cause the final rise of the balloon.

By the use of this technique, atmospheric sampling of any kind may be conducted with two or more levels sampled on a single flight. Without using any control to keep the balloon constantly at a given altitude for a long time, the sampling steps should not be expected to be much longer than one hour apiece.

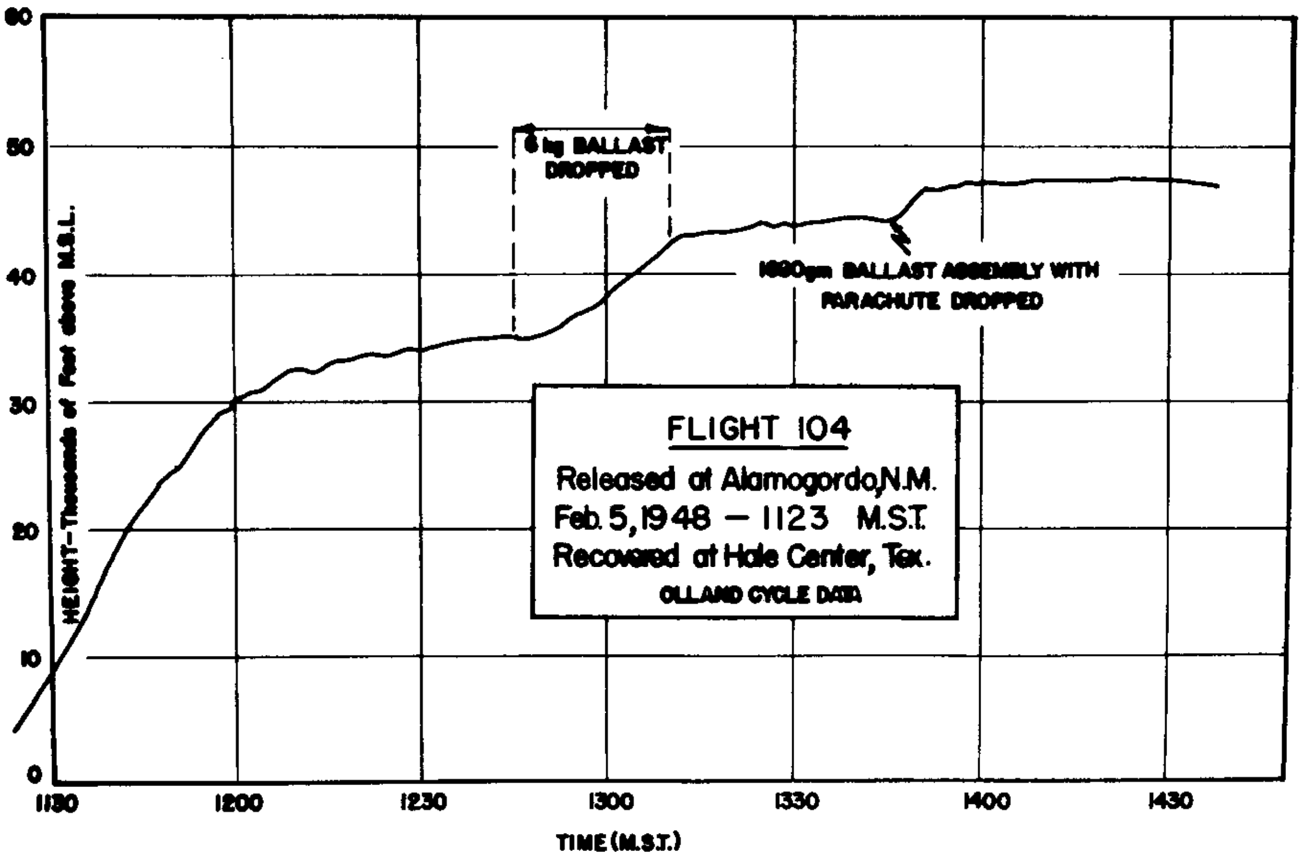


Figure 53

Flight 106: Released from Alamogordo, New Mexico, 0657 MST, February 8, 1949
Recovered at Ellsmore, Kansas

This was the first flight to clearly demonstrate the efficient action of a combination ballast control--displacement switch and rate-of-ascent switch--on a 20-foot, .001" polyethylene balloon. From the height-time curve and ballast-flow record (Figure 54), it will be seen that the ballast control was operating at 41,000 feet MSL during the period of radio reception from Alamogordo, New Mexico. By the time the second receiving station picked up the signal, all of the ballast had been exhausted and the balloon was falling. On this flight a high loss of lifting gas caused the total ballast load of 600 grams to be exhausted in less than five hours. (Average used in first two hours was 1700 grams per hour.)

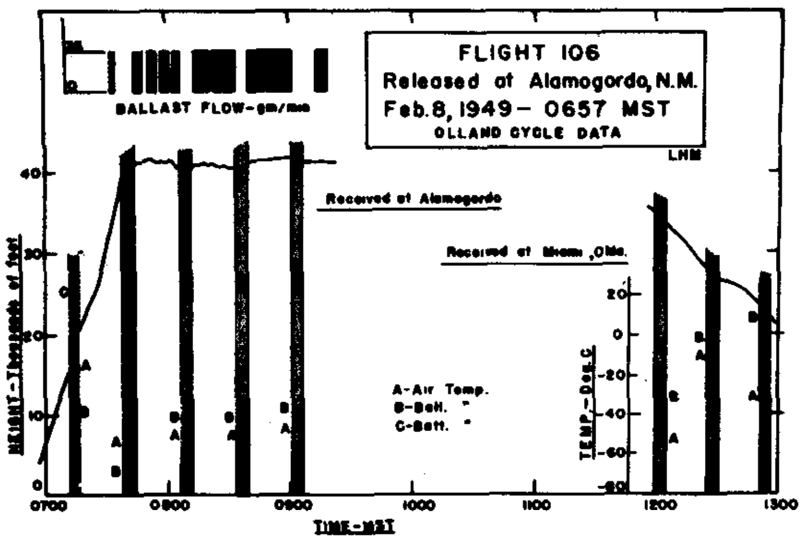


Figure 54

The descent point of this balloon was compared with that predicted from a study of the atmospheric pressure patterns at floating level. Assuming geostrophic flow, members of a graduate class in meteorology at New York

University computed the points of descent seen in Figure 55. As in the cases of Flights 55 and 58, the balloon appears to have moved across the isobars toward lower pressure.

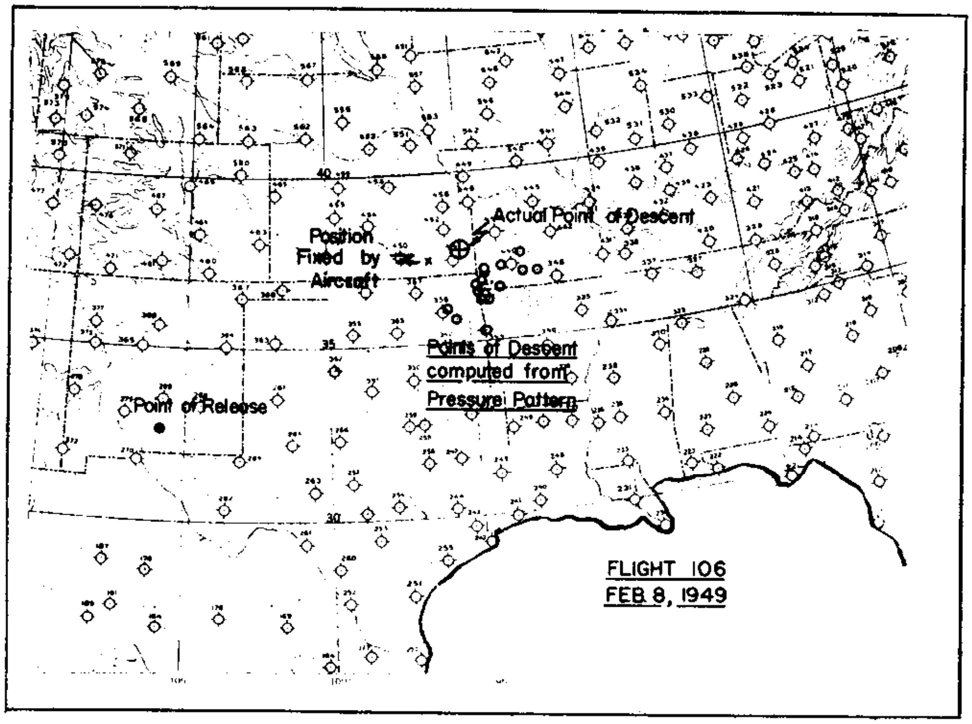


Figure 55

Flight 110: Released from Alamogordo, New Mexico, 0649 MST, February 11, 1949
Recovered at Kershaw, South Carolina

This flight had as its main objectives the testing of a Winzen Research Inc. .0015", 20-foot polyethylene balloon, and further testing of the combination ballast control--displacement switch and rate-of-ascent switch. Following the initial ascent of this flight, a slow descent resulted from loss of lifting gas. Three hours were required for a descent of 2000 feet to the pressure where ballast flow was begun. This and the general flight pattern indicate the satisfactory nature of this Winzen Research Inc. balloon. After ballast started, the valve stuck and a constant flow at 1800 grams per hour followed. The rising ceiling seen in Figure 56 is the typical flight pattern for a balloon whose load is being steadily decreased at a rate in excess of the loss of buoyancy.

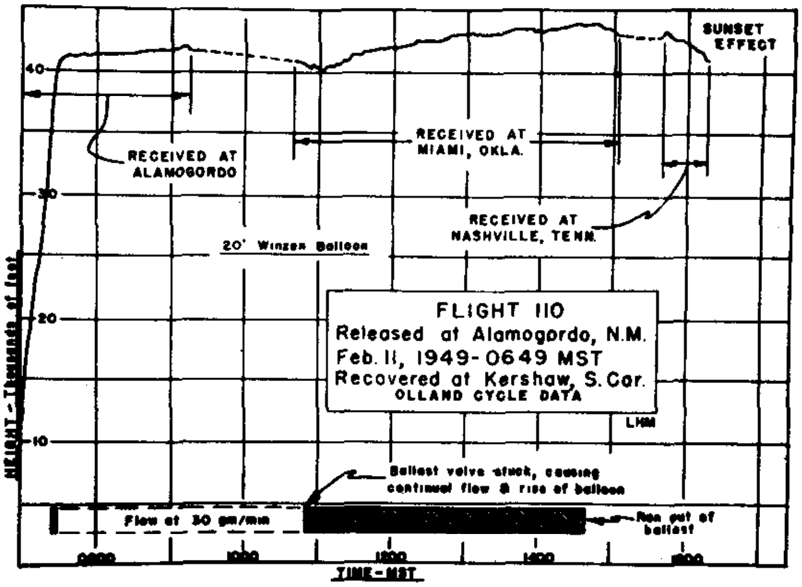


Figure 56

On this flight all three of the receiving stations positioned along the expected path were able to receive and record the pressure and ballast signal. No temperature equipment was flown.

A comparison of the point of descent predicted from geostrophic flow and that actually observed was made by members of a graduate class of meteorology at New York University (Figure 57). Using an airplane fix

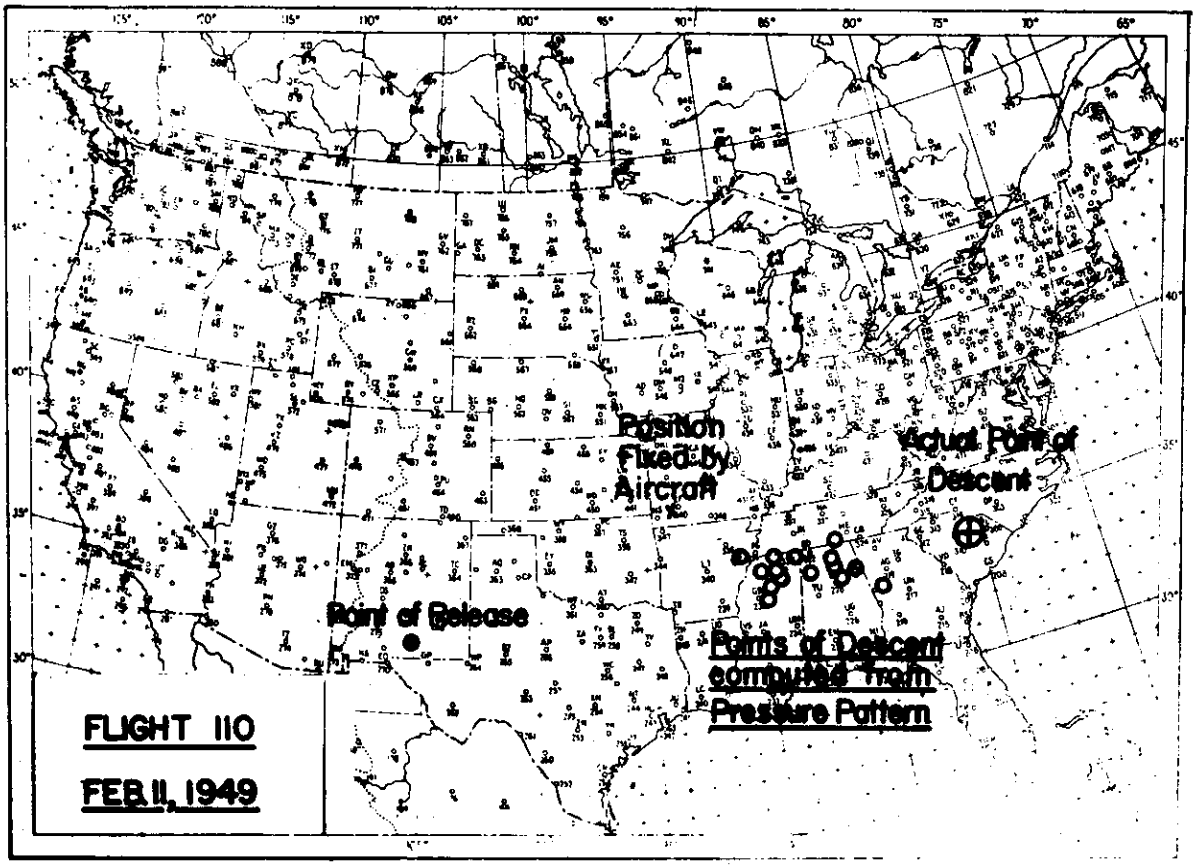


Figure 57

made during the flight the actual trajectory seems to have been well to the north of the "center of gravity" of predicted points of descent, and the actual flight path was considerably longer than that predicted. Since the pressure pattern at the eastern end of the flight was anticyclonic, this seems to be in accordance with the idea of super-geostrophic flow associated with anticyclonic systems. As in all the earlier cases where such a study was made, the balloon apparently moved across the isobars toward lower pressure.

Index

(All references are to flight numbers. The number of the flight on which a particular instrument or principle was first demonstrated is underlined. For example, airborne radio direction finding was first used on Flight 41.)

13

New York University
Technical Report No. 1
Constant Level Balloon
April 1, 1948

TECHNICAL REPORT NO. 1

Balloon Group, Constant Level Balloon Project

New York University

Covering the period Nov. 1, 1946 to Jan. 1, 1948

CONSTANT LEVEL BALLOON

Research Division, Project No. 93

Prepared in Accordance with Provisions of Contract
W28-099-ac-241, between
Watson Laboratories, Red Bank, New Jersey
and
New York University

Prepared by: Charles B. Moore, James R. Smith, and
Seymour Goldstein

Approved by: ıarles S. Schneider, Project Director
and
Prof. Athelstan F. Spilhaus
Director of Research

Research Division, College of Engineering, New York University.

April 1, 1948

New York 53, New York

CONTENTS

List of Figures

List of Figures (cont'd)

List of Figures (cont'd)

List of Tables

THE BALLOON PROJECT TECHNICAL REPORT

Section 1. Introduction to Problem

On 1 November 1946, the Research Division of the College of Engineering of New York University entered into Contract No. W28-099-ac-241 with Watson Laboratories, Air Materiel Command. Under this contract, the University was commissioned to design, develop and fly constant-level balloons to carry instruments to altitudes from 10 to 20 km, adjustable at 2 km intervals.

The following performance was specified:

a. Altitude shall be maintained within 500 meters

b. Duration of constant-level flight to be initially 6 to 8 hours minimum; eventually 48 hours

c. The accuracy of pressure observations shall be comparable to that obtainable with the standard Army radiosonde ($\pm$ 3 to 5 mb)

Monthly reports have been submitted to describe the progress of the project, however, much data and details of technical nature were given only in a qualitative way. It is intended to collect these data in this technical report and to review at the same time the total achievement of this phase of the project.

Section 2. Method of Attack

A. Balloons

A survey was made of previous attempts to produce a constant-level balloon; such as, the experiments by Meisinger[1] with manned balloons, the shrouded meteorological balloon developed by Dewey and Almy[2], the Japanese balloon bombs[3], and the clusters of meteorological balloons which have been used in cosmic ray investigations by Compton, Korff and others[4].

From this survey and a study of aerostatics, [10, 15, 16] it appeared that a non-extensible balloon is highly desirable due to the vertical stability exhibited when such a balloon is full of the lifting gas: A non-extensible balloon with no diffusion or leakage through the walls, which could withstand a high internal pressure, would automatically remain at the density where the buoyancy of the full balloon equaled the load. In practice, control devices are needed to offset the leakage and diffusion of the lifting gas and to correct for the motion of the balloon due to diurnal changes of the balloon's temperature and to correct for vertical wind currents in the atmosphere. It was decided to use a plastic as the balloon fabric, since available plastics have suitable characteristics, and are also relatively inexpensive as compared to coated fabrics.

The desirable properties to be considered in the selection of a plastic balloon material are:

a. Ease of fabrication

b. High tear resistance

c. Light weight

d. High tensile strength

e. Chemical stability

f. Low permeability

g. Low brittle temperature

h. High transparency to heat radiation

Table I is a qualitative-characteristics catalog of the film and fabrics investigated. The data in the table are presented as approximations because of the great variations of a given property with choice of samples and test methods. From this study, polyethylene, nylon, saran, and neoprene-coated nylon seem to be most generally satisfactory. Eighteen plastics and balloon fabrication companies were contacted in an attempt to secure fabricators.

Table I

Fabric	Low Temp. Properties	Permea-bility	Tensile Strength	Tear Resistance	Ease of Fabrica-tion	Stability to Ultraviolet
Polyethylene	Good	Medium	Low	Good	Good	Good
Saran	Fair	Low	High	Poor	Fair	Fair
Nylon	Good	Low	High	Low	Good	Good
Vinylite	Very poor	Medium	Medium	Good	Good	Good
Teflon	Believed good	Low	High	Good	Cannot be fabricated	Good
Ethocellulose	Good	Very high	Low	Fair	Good	Good
Pliofilm	Poor	High	Poor	Fair	Good	Poor
Nylon or silk fabric coated with:						
1. Neoprene	Fair	Low	High	Fair	Fair	Fair
2. Butyl rubber	Good	Low	High	Fair	Fair	Good
3. Polyethylene	Unknown	--				
4. Saran	Unknown	--				

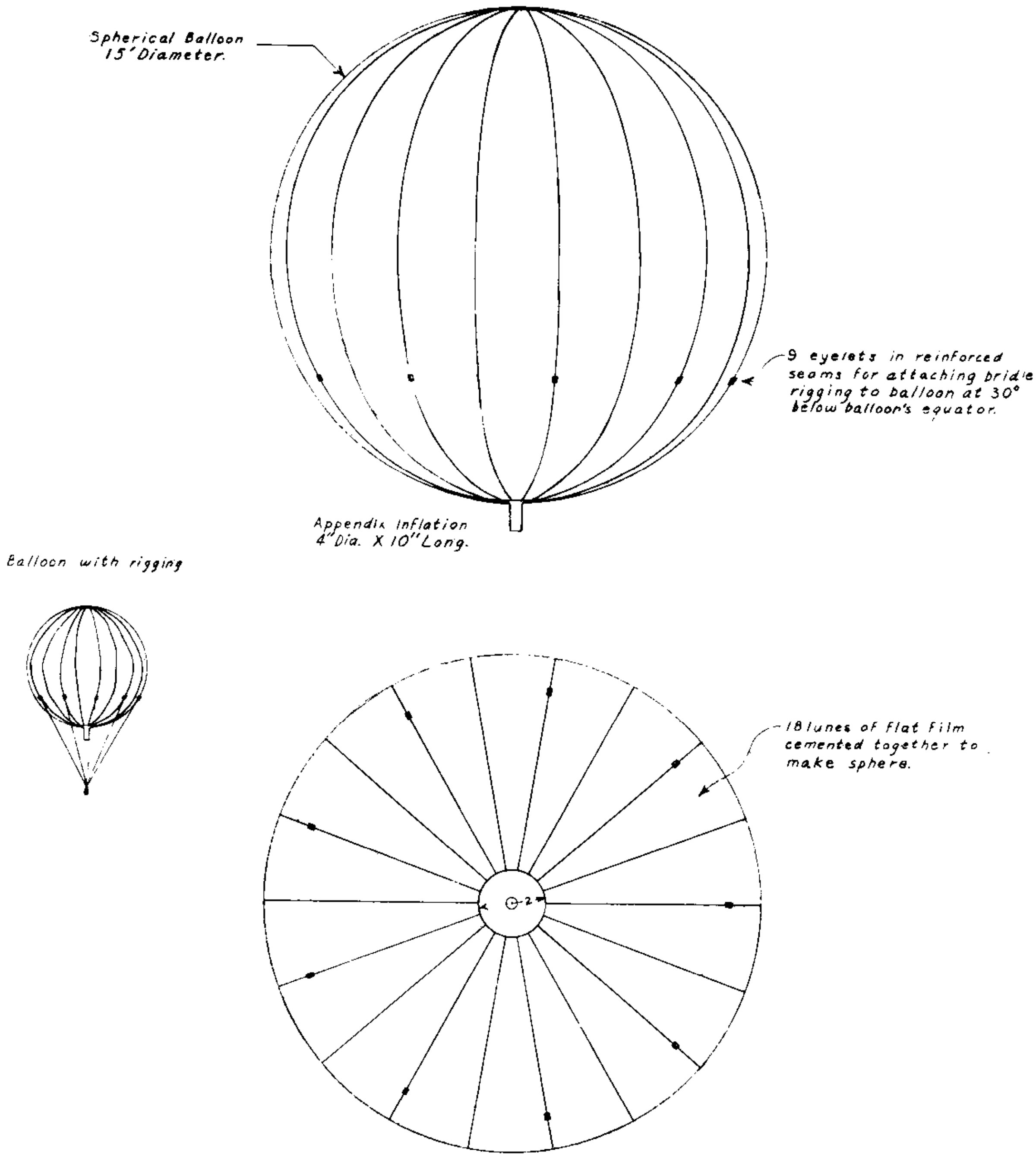
Table II shows the balloons which have been purchased from those manufacturers who expressed an interest in the problem.

Table II

Company	Film type, thickness, diameter, shape	Special Features	Unit Cost	Delivered to date
H. A. Smith Coatings, Inc.	.004 Polyethylene 3 feet diameter spherical	Proto-type	$150.00	4
H. A. Smith Coatings, Inc.	.008 Polyethylene 15 feet diameter spherical	Low Permeability	$530.00	5
H.A. Smith Coatings, Inc.	.004 Polyethylene 15 feet diameter spherical	Low Permeability	$530.00	5
General Mills, Inc.	.001 Polyethylene 7 feet diameter Teardrop.	Stressed tape type seam	$20.00	25
General Mills, Inc.	.001 Polyethylene 20 feet diameter Teardrop.	Stressed tape type seam	$125.00	47
Dewey & Almy Chemical Co.	A spherical nylon cloth shroud around a neoprene balloon.		$339.00	2

Table II is based upon final or modified orders in those cases where the rapid progress of flight technique rendered certain features obsolete before the balloons on order were delivered.

Figure 1 shows the spherical balloon as originally designed. This type of balloon was made of .004 and .008 inch, heat-sealed, polyethylene. It had several good characteristics, such as very low leakage, but the method of load attachment furnished by H.A. Smith, Inc., was not satisfactory. Of the six balloons of this type which were used, two ripped free from the shroud lines during launching.



PLASTIC BALLOON
FOR CONSTANT LEVEL BALLOON PROJECT AT NYU
APRIL 27, 1947
SCALE: 1" = 3'0"

FIG. 1

Figures 2 and 3 show the tear-drop cell of the stressed tape design developed by General Mills, Inc. The film is .001 inch polyethylene, butt-welded, with scotch tape laid along the seam to reinforce the seal and to carry and distribute the load. These strips, which converge to the load ring at the bottom, actually support the load.

The overloading of a General Mills 20-foot balloon on Flight 12 at Lakehurst kept the lower end of the balloon open during ascent. The ceiling was greatly reduced by the resulting dilution of the helium with air. On later flights an unsuccessful attempt to minimize this mixing was made, using a 10-foot external appendix passing through the shroud lines. This appendix fouled in the rigging and twisted completely shut, causing the balloon to burst at pressure-altitude. A modification with a 10-foot appendix outside the shroud lines also failed in actual flight. Figure 4 shows this appendix construction on a General Mills balloon which is being inflated. The final style is shown in Figures 5 and 6. It consists of a 2-foot external appendix stiffened with cardboard battens. This is taped on the outside of the load ring. It serves as a one-way valve which excludes air during ascent but allows the extra helium to valve freely when the balloon is full. No external appendix can be used whenever the rate of rise exceeds 600 feet per minute. For optimum balloon performance, it has been determined that: 1) the equipment load for the General Mills 20-foot balloon should be held under 30 pounds; 2) rates of rise should be less than 900 feet per minute; and 3) for maximum altitudes an external appendix is needed; hence the limiting rate of rise is about 600 feet per minute in this case.

Several experimental flights have been made using shrouded Dewey and Almy neoprene balloons, as well as small and large experimental cells in

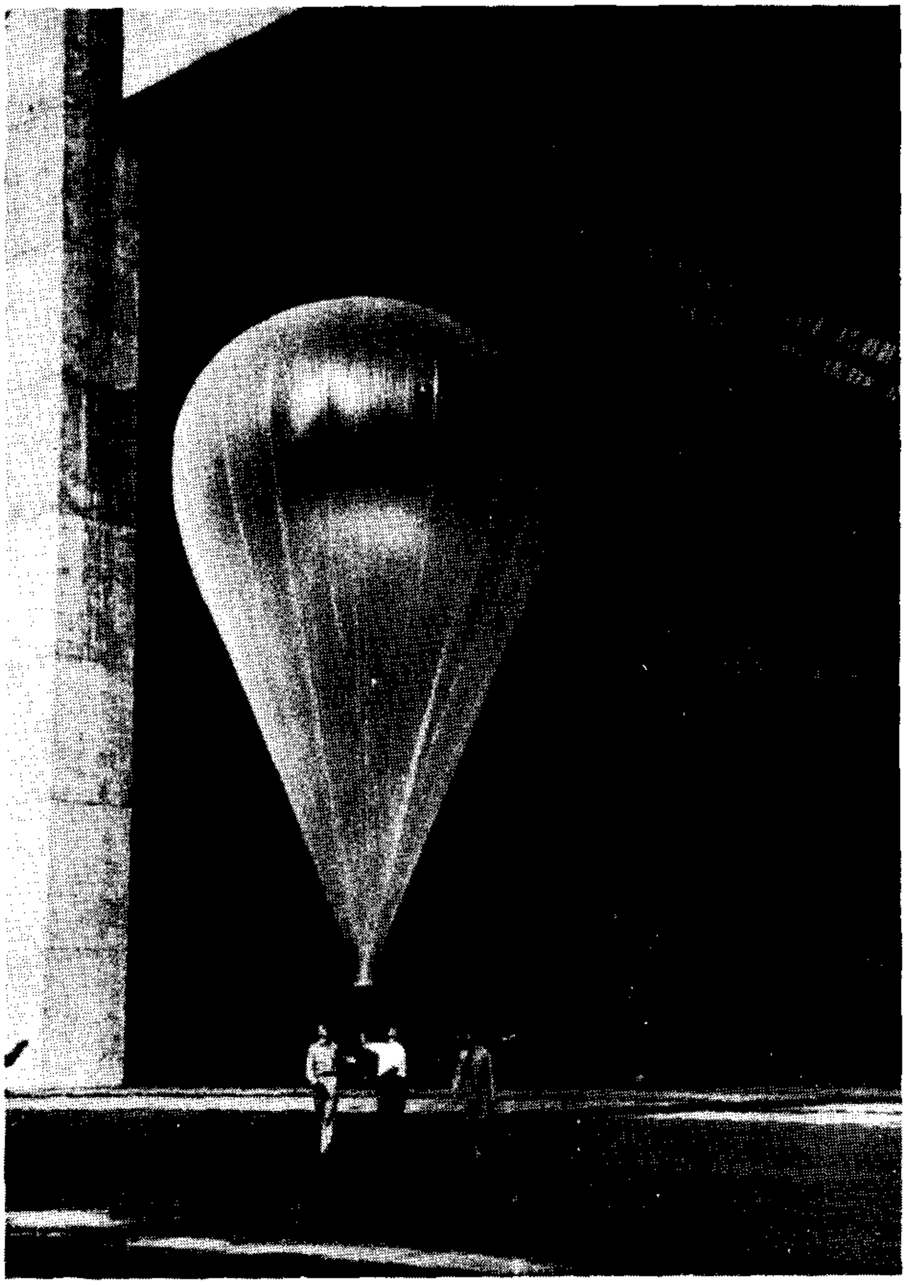


Figure 2
Teardrop, .001" polyethylene balloon, 20 foot in diameter, designed by General Mills, Inc.

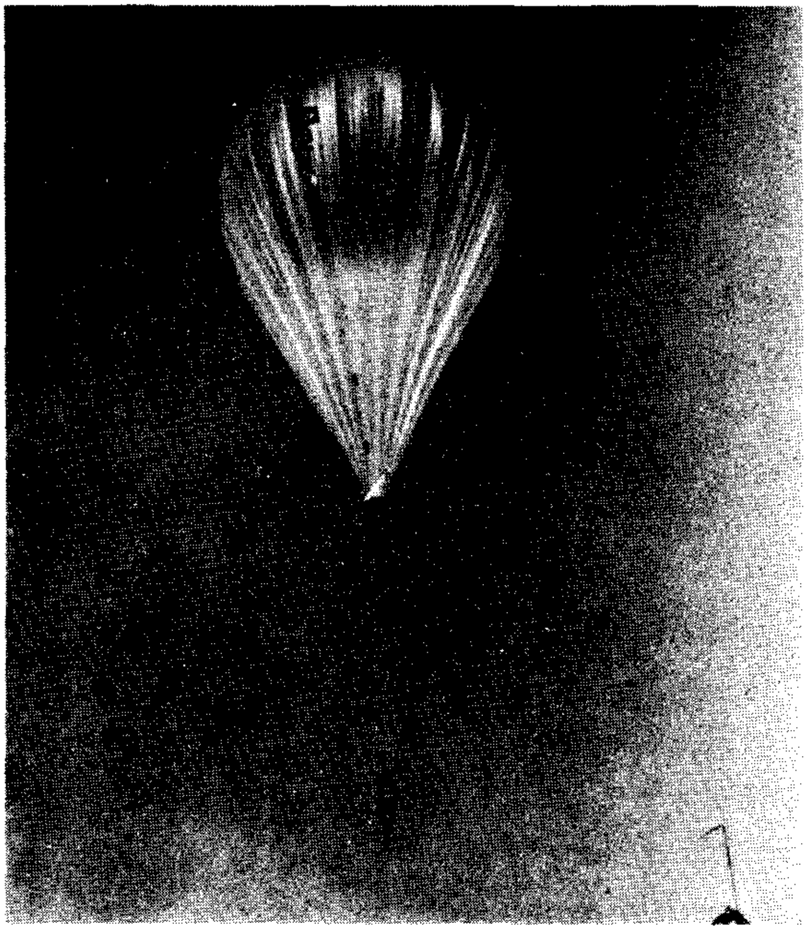


Figure 3
Twenty ft. balloon, showing
burn-out patch in place.

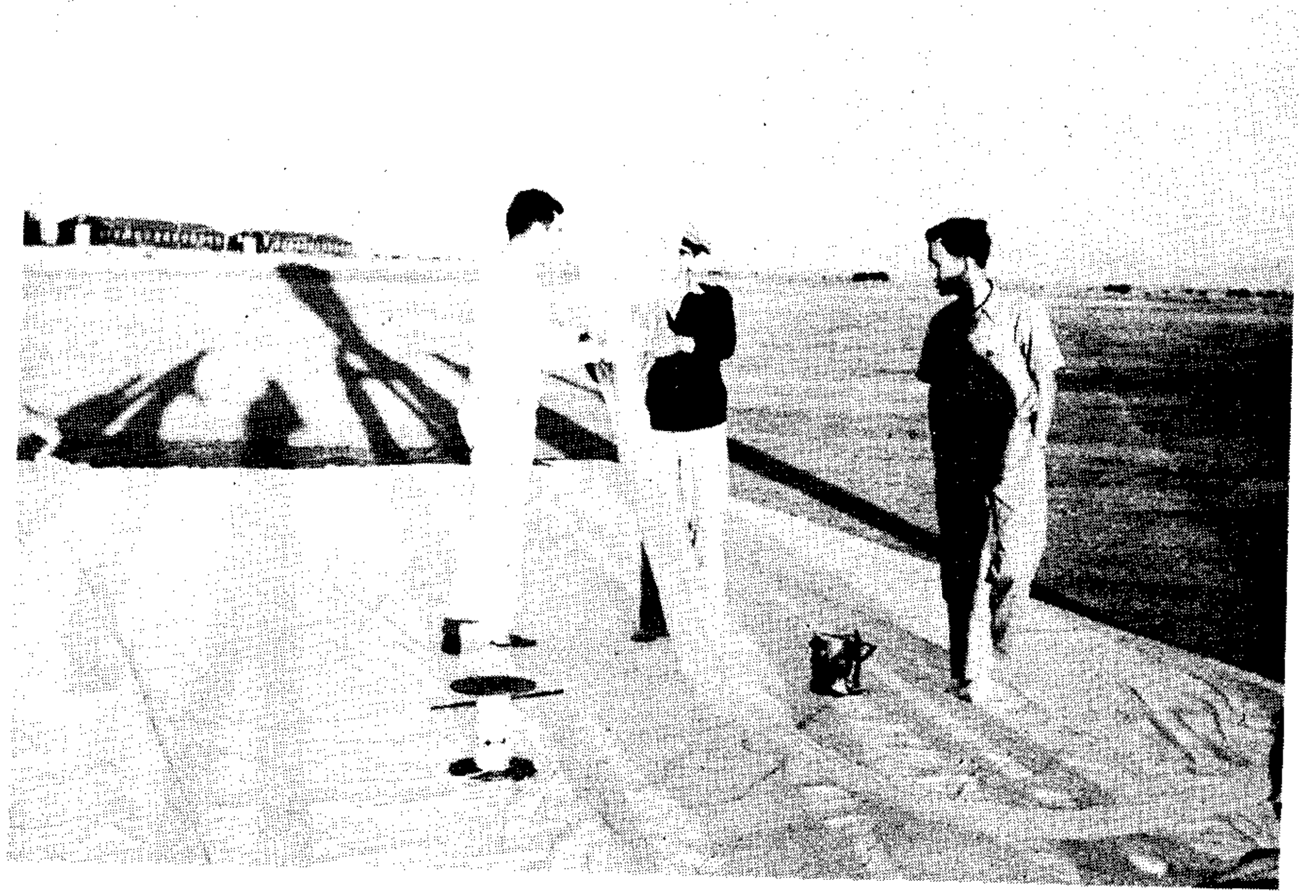


Figure 4
General Mills 20 foot balloon with 10 foot appendix.

Figure 5
Two foot appendix, stiffened, shown on a General Mills ballon. The swollen inflation tube indicates that the balloon is being filled.

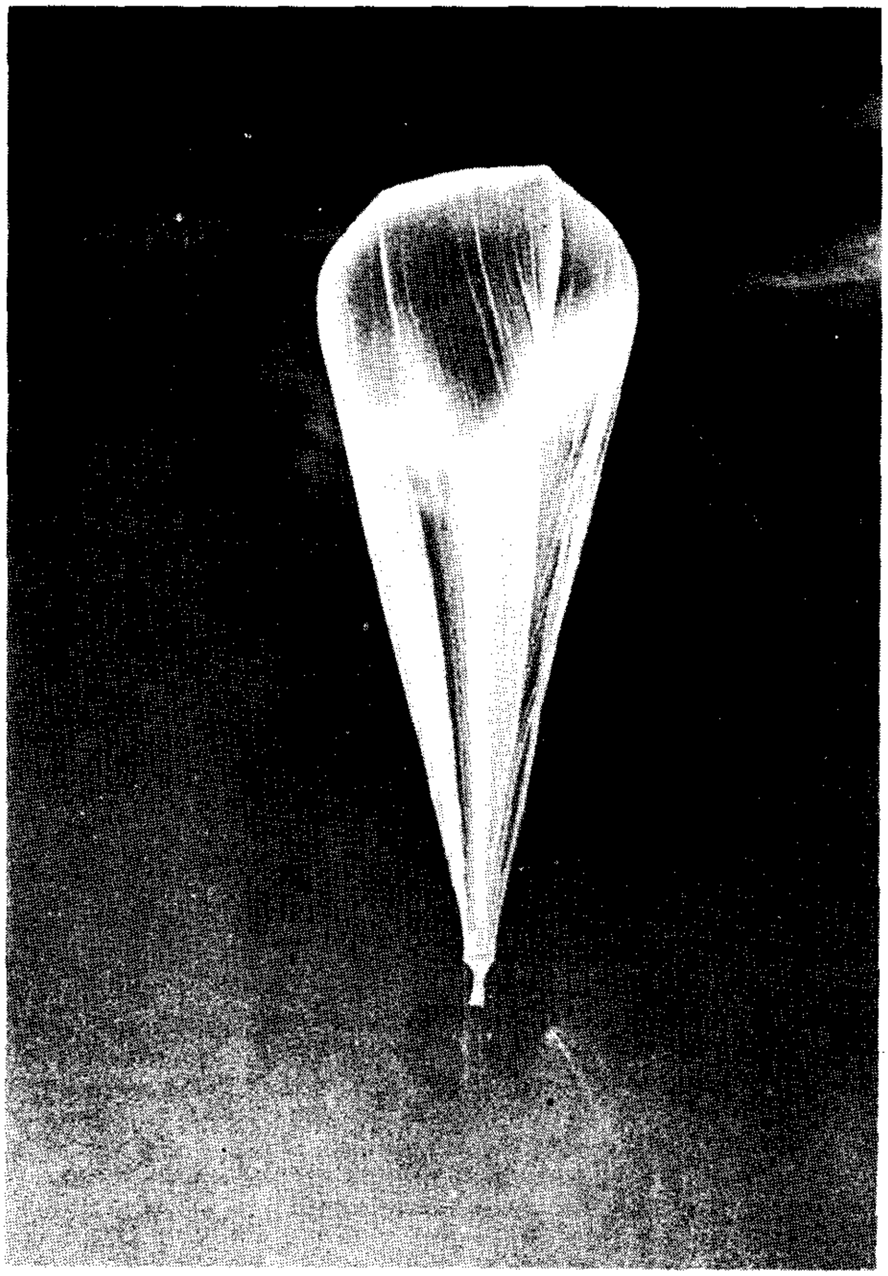


Figure 6
General Mills 20 foot balloon in
flight with 2 foot stiffened appendix.

various cluster arrangements. None of these have been too satisfactory but further investigation will be made in the field of shrouded or coated films.

B. Altitude Controls

Given a balloon capable of carrying the instruments to a desired altitude (the theory and computations involved are discussed in Section 3), there remains the problem of maintaining the cell at a constant level. The buoyancy of a gas-filled cell will decrease as the gas leaks or diffuses through the balloon wall. To hold an absolutely constant altitude, the volume of lifting gas entrapped must be maintained in an atmosphere of unvarying horizontal density, with no change in the total weight supported by the balloon and with no fluctuations of the temperature of the gas with respect to the air. The best approximation to these conditions may possibly be achieved through the use of liquified hydrogen, which would be permitted to evaporate at a rate in excess of gas leakage. The weight of equipment required to control this evaporation rate appears to be prohibitive. Liquid hydrogen, also, is not safe to handle.

Two practical methods of keeping a balloon at nominally constant altitude have been devised, both using the liquid ballast dropping technique. (Solid ballast, such as sand, does not flow well and is liable to absorb moisture which will freeze at the temperatures experienced at high altitudes. Although a few preliminary flights were made with desiccated sand, a highly refined water-free kerosene-type petroleum product, compass fluid, was found to be more satisfactory).

In the simpler control system, ballast is dropped at a pre-determined rate, aimed to slightly exceed the loss of lift of the balloon due to leakage and diffusion. If this method is successfully used, the balloon stays full because the remaining gas in the balloon has less load to support; therefore, the balloon can rise slowly until the balloon is again full and the equilibrium is again reached between the buoyancy and the load. In the General Mills 20-foot balloon, for example, diffusion losses equal about 300 grams per hour; the balloon at its ceiling of 50,000 feet, with a 30-pound payload, risea about 900 feet with each kilogram of ballast dropped. This means that a balloon, using the simple ballast-dropping technique, will float at a ceiling which rises at the rate of about 360 feet per hour. An idealized flight of this type is shown in the solid curve of Fig. 7., neglecting the oscillation shown at sunset.

The "manual ballast valve" which was developed for this simple control system is shown in Fig. 8. This valve can be adjusted prior to balloon release to allow any predetermined flow of compass fluid up to 2000 grams per hour. The filter housing and ballast reservoir used with this valve are shown in Figures 9 and 10. This method is good where 1) a slowly rising ceiling can be tolerated, and 2) the flight does not have to go through a sunset while at its ceiling.

For economy of ballast, hence longer flight duration, it is desirable to keep the constant flow as close as possible to the total loss of buoyancy resulting from diffusion and leakage. This means that whenever rapid loss of buoyancy occurs, due to changes in solar radiation, the manual ballast valve alone will not sustain the balloon. When the balloon is suddenly cooled, due to sunset or clouds cutting off insolation (loss of superheat), the heavy loss will start the balloon downward and only a rapid expenditure of ballast will check its fall and restore its stability.

The second type of ballast dropping control has been devised to operate on a demand basis, when such a descent occurs. This control is called the automatic ballast valve. Figures 11, 12 and 13 show the appearance and design of this pressure-actuated needle valve.

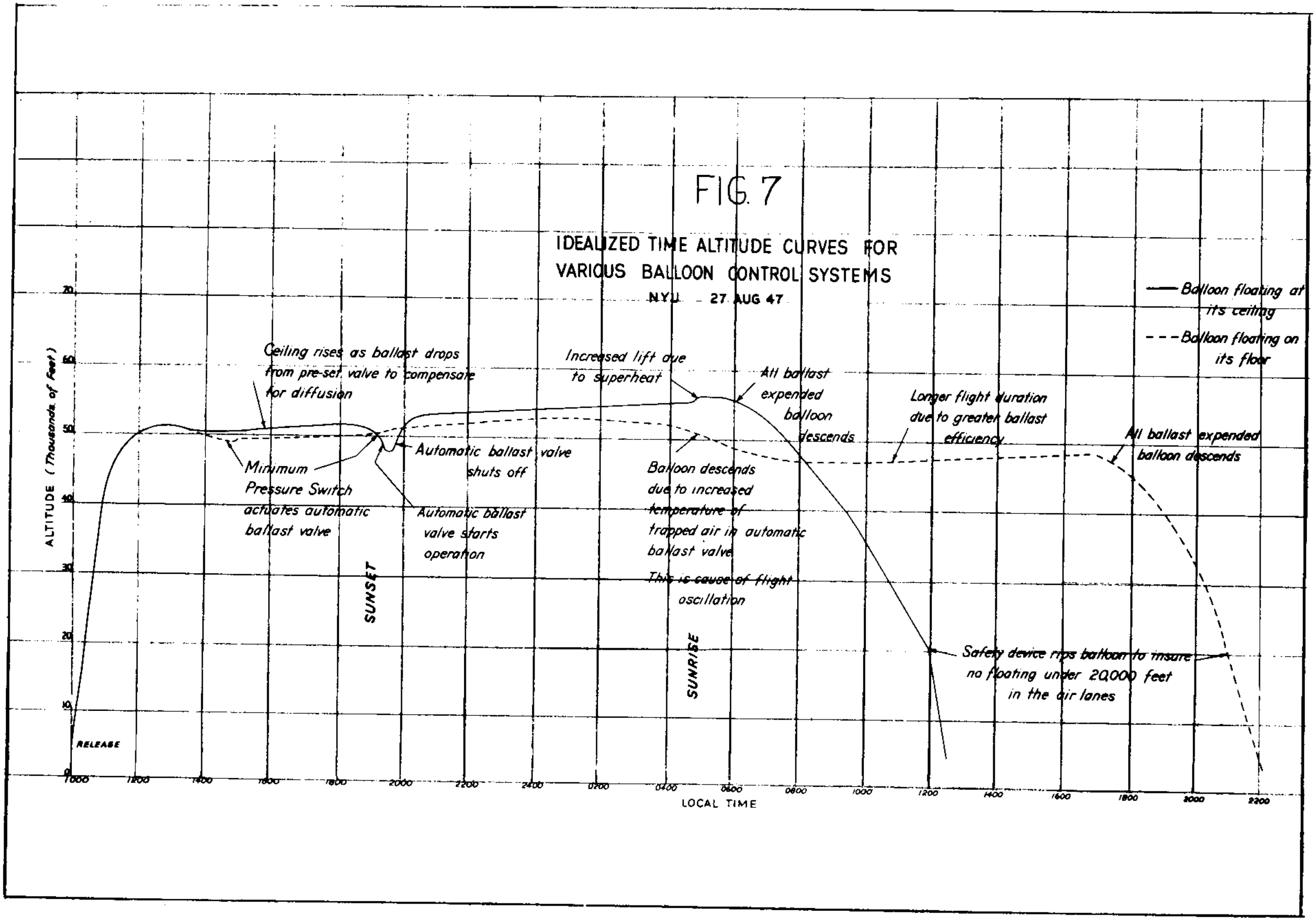
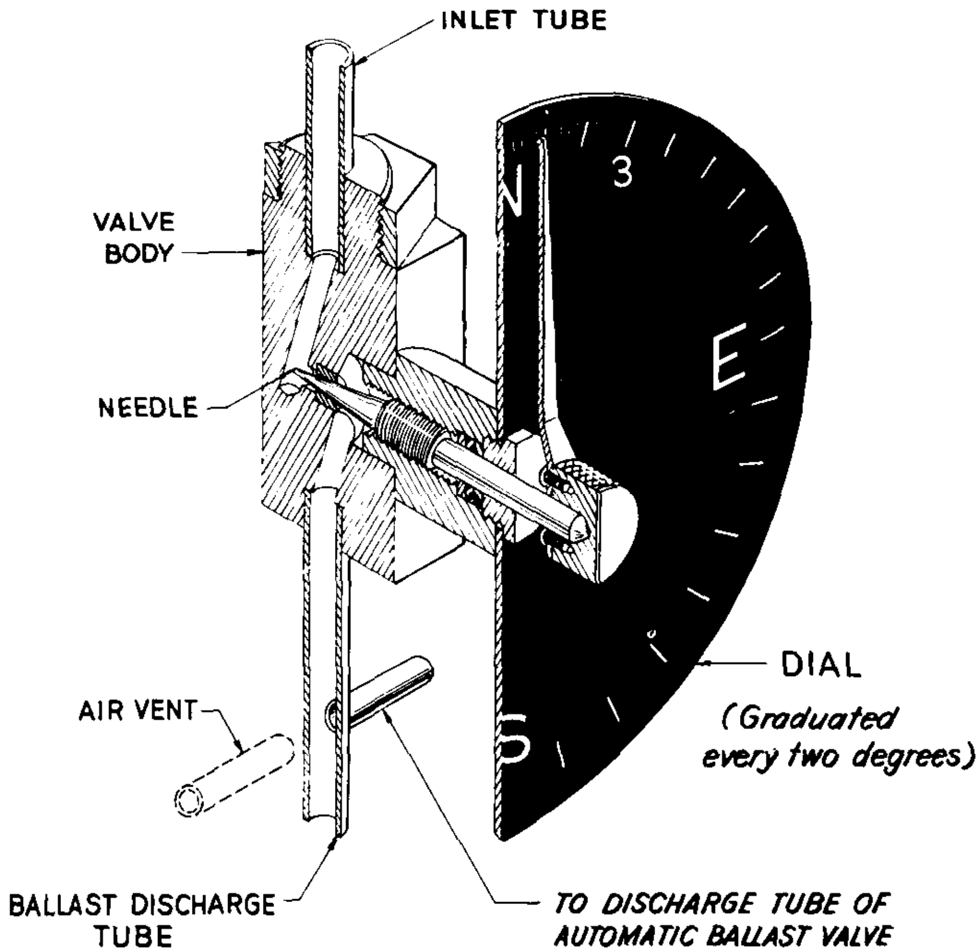


FIG. 7

IDEALIZED TIME ALTITUDE CURVES FOR VARIOUS BALLOON CONTROL SYSTEMS

NYU 27 AUG 47



MANUAL BALLAST VALVE

FIG. 8

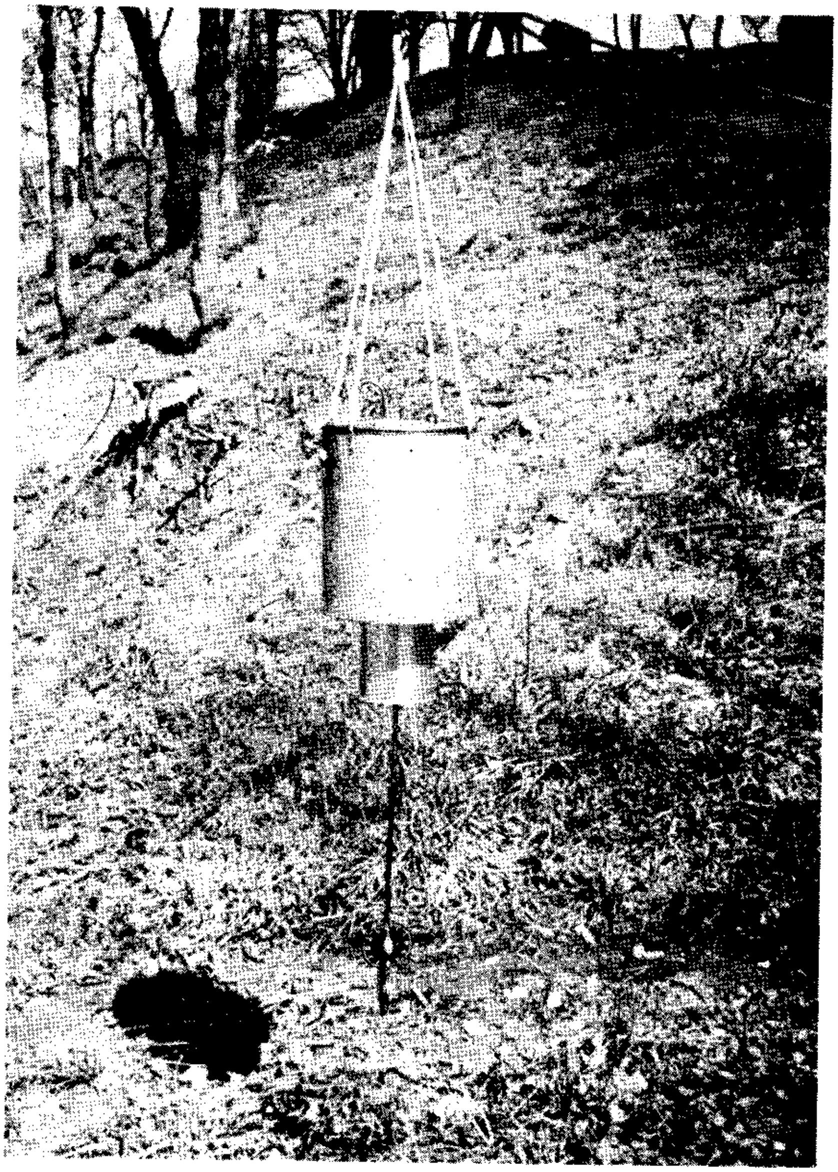


Figure 9
Fixed rate, manually operated ballast release assembly.

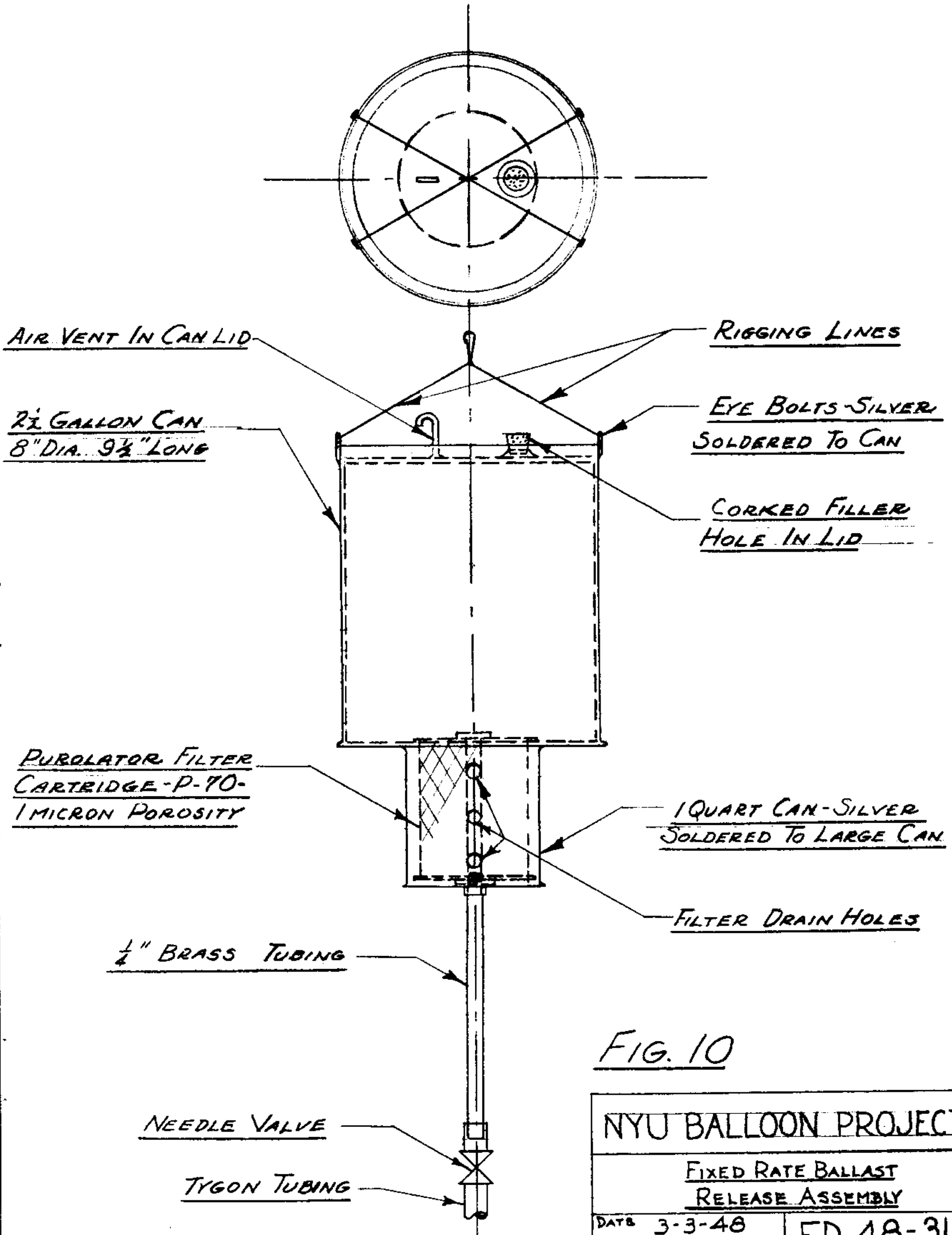


FIG. 10

NYU BALLOON PROJECT	
FIXED RATE BALLAST RELEASE ASSEMBLY	
DATE 3-3-48 DWN. BY S G.	ED 48-31

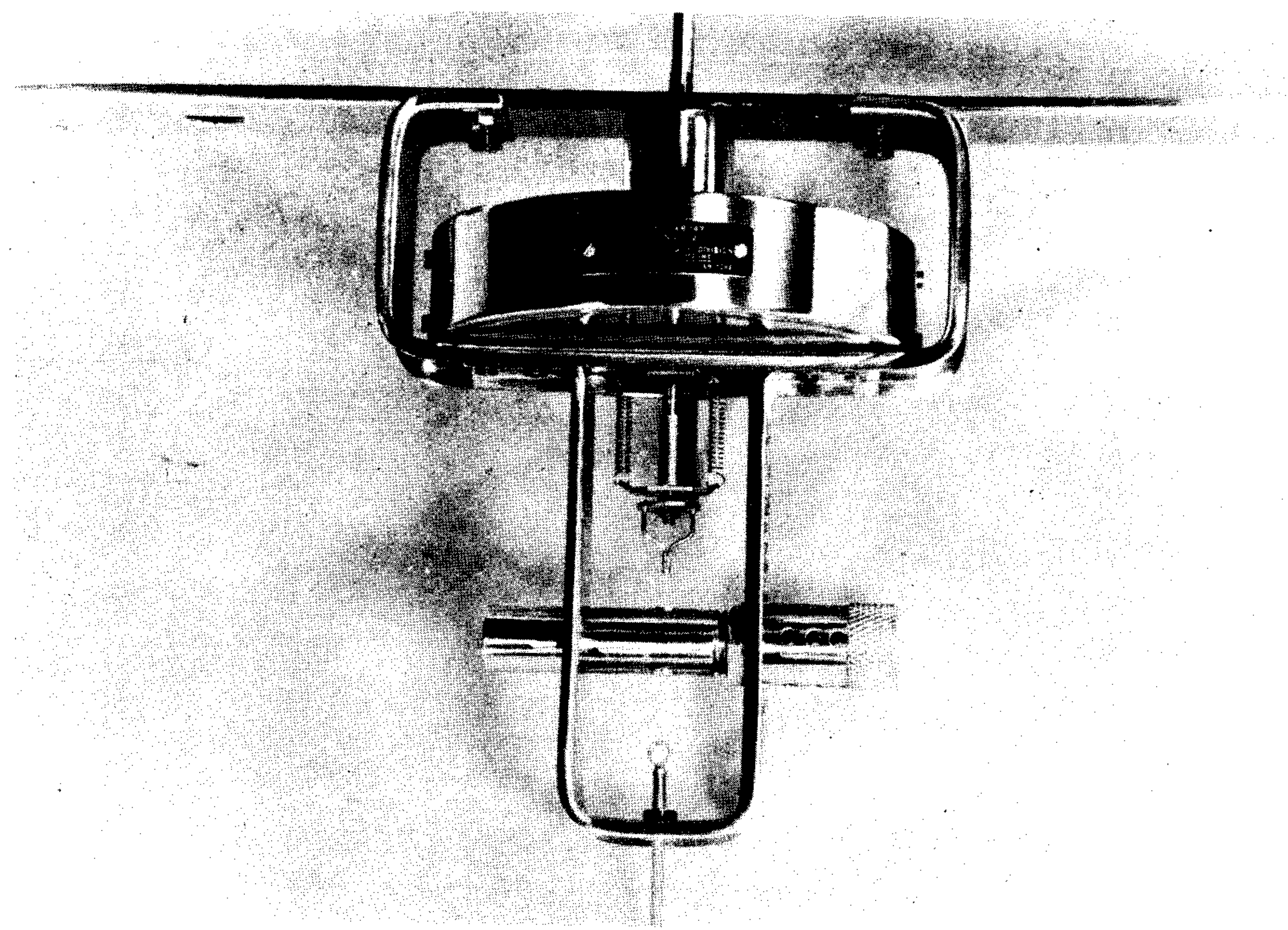


Figure 11
Automatic ballast valve.

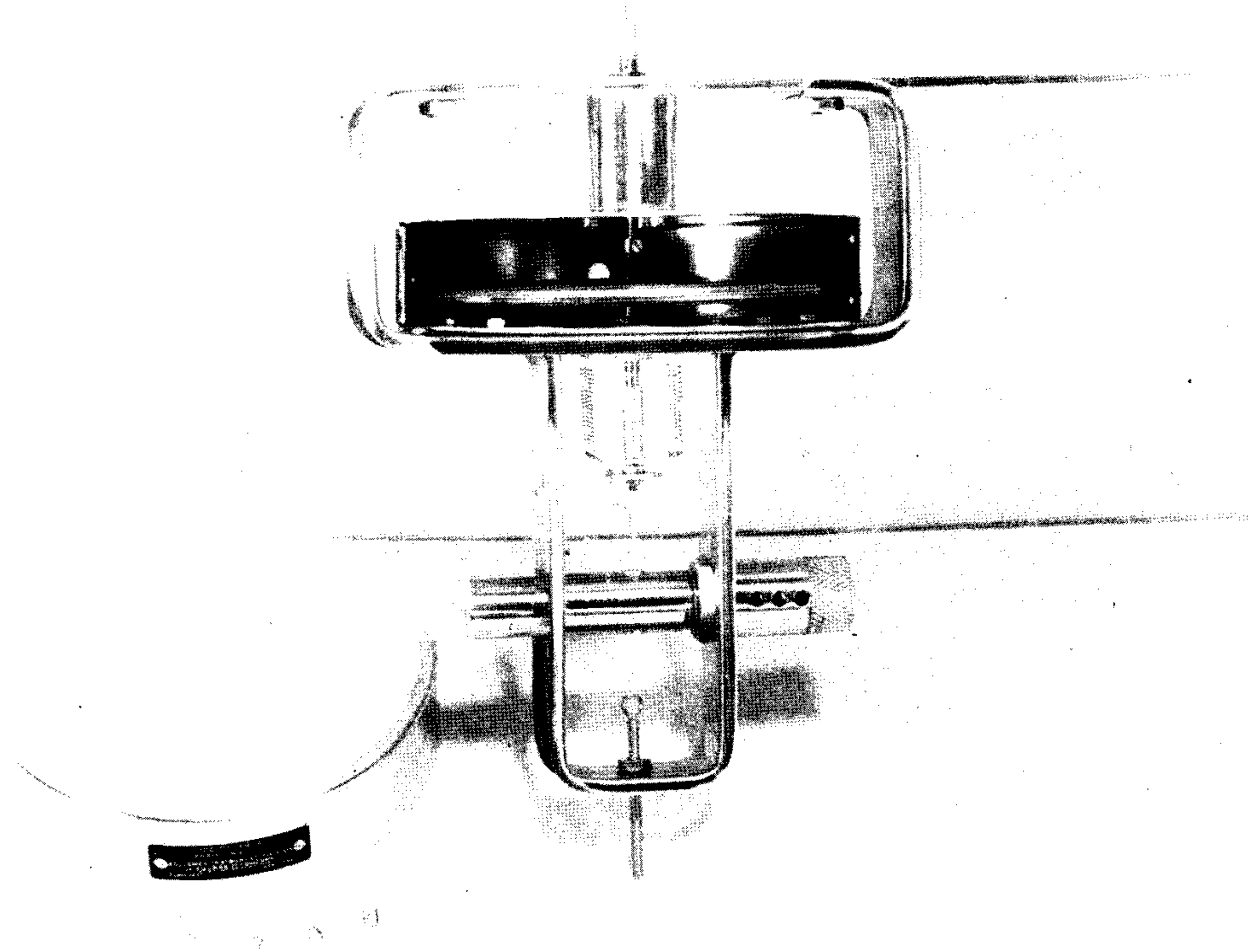


Figure 12
Automatic ballast valve, showing loading diaphragm.

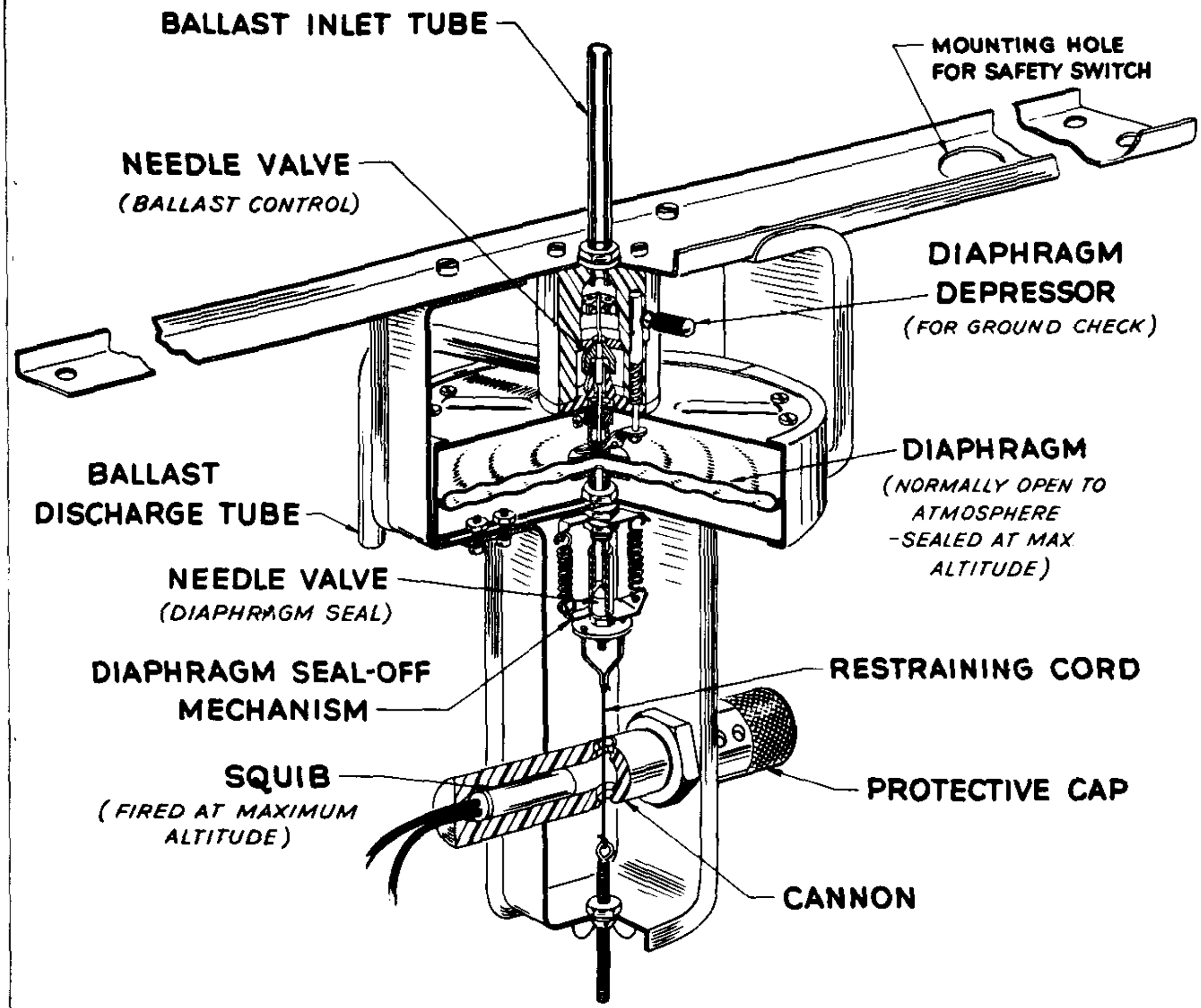


FIG. 13

AUTOMATIC BALLAST VALVE

N.Y.U. - 19 JANUARY 1948 - PINCUS

When the atmospheric pressure outside the diaphragm increases to 5 mb. above the internal pressure, compass fluid will be discharged at the rate of 160 grams per minute under a 1-foot head. When the automatic ballast valve is completely open (at 6.5 mb. pressure differential), 300 grams per minute will flow.

The automatically operated needle valve is held closed by a loaded diaphragm until the balloon reaches altitude. This diaphragm is open to the atmosphere until the balloon descends from the minimum atmospheric pressure attained. At that time, an electrical contact is made, firing a squib which seals the diaphragm mechanically from any further access to the external air. Thereafter, the capsule contains a volume of air which has been trapped at the pressure and temperature existing at the time of operation of the sealing switch. When the ambient pressure increases to the point where the entrapped air is compressed below this original volume, the diaphragm will withdraw the ballast control needle valve allowing ballast discharge to occur.

Figure 14 shows the minimum pressure switch which makes the electrical contact at the time of seal-off. It consists of a trapped volume of air that is allowed to escape through a mercury pool as long as the outside pressure is decreasing. As soon as the exterior pressure increases, mercury is drawn into the tube making the seal off contact between two electrodes.

The dimensions of the air chamber and capillary tubing are chosen so that during operation the change in the volume of the air would be less than one one-thousandth of the original volume. The distance between the two electrodes (one under mercury, the other within the capillary tubing) was influenced by considerations of safety and sensitivity. If the distance is less than 6 mm., shaking during launching is likely to move the mercury

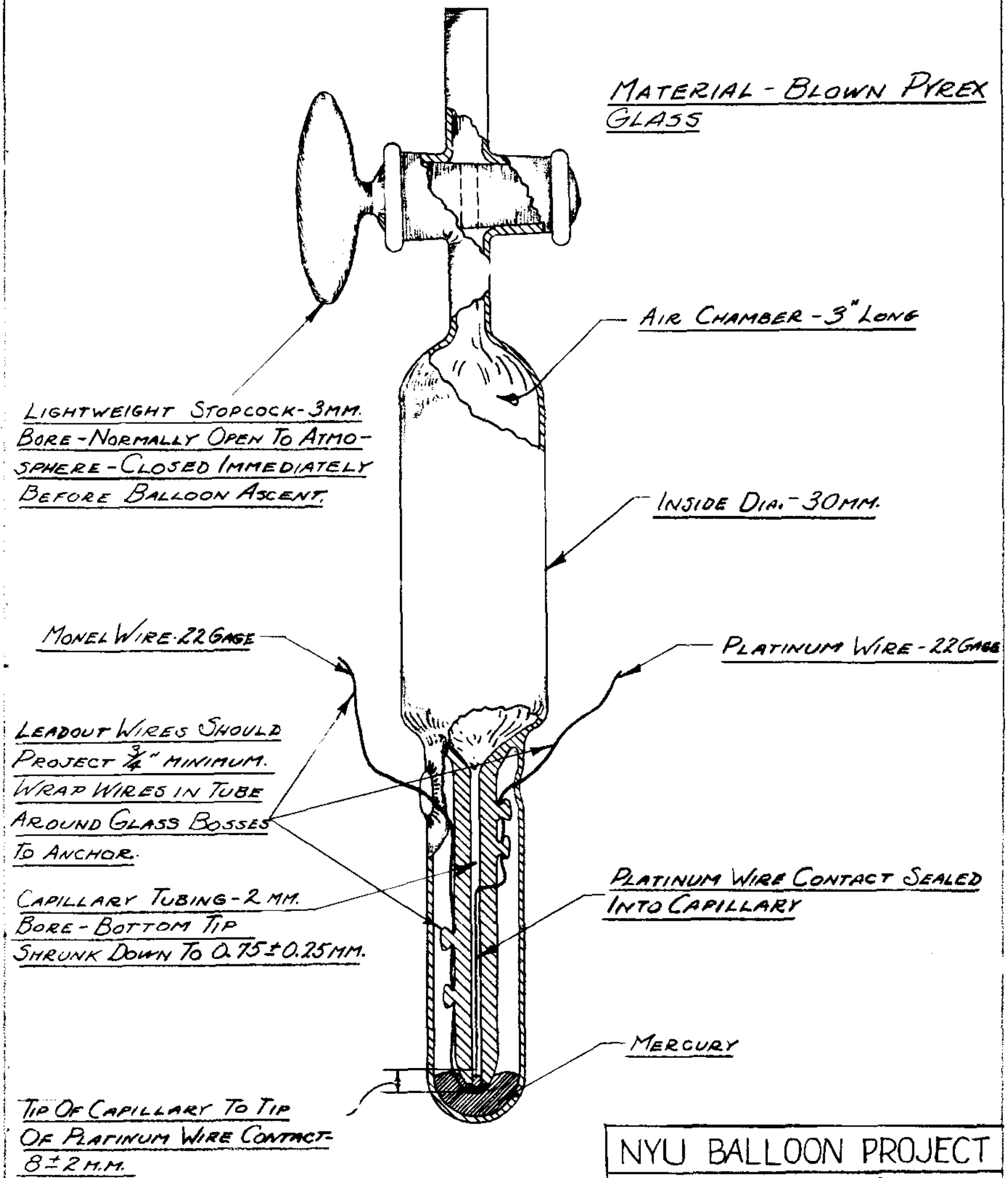


FIG. 14

NYU BALLOON PROJECT	
MINIMUM PRESSURE SWITCH (MERCURIAL)	
DATE: 3-9-48 SCALE: FULL DWN. BY: J. G.	ED 48-33

sufficiently to cause a short between the electrodes, firing the squib prematurely. If the distance is too large, however, there will be too great a height difference between the time of minimum pressure and the time the electrodes are shorted. For instance, a spacing of 10 mm. would delay the firing of the squib until the pressure reached 13.3 mb. above the minimum pressure. At an altitude of 50,000 feet, the equivalent height (standard atmosphere) would be about 2300 feet. It is obvious that for high level flights, a less dense and lower freezing electrolyte for the minimum pressure switch will be needed to obtain the desired sensitivity of 2000 feet.

By adding the pressure-activated automatic ballast valve to the manual ballast valve, the complete pattern of the solid curve in Figure 7 may be achieved ideally. At sunset the rapid cooling causes descent which cannot be compensated for by the manual ballast valve. As soon as the seal-off pressure of the automatic ballast valve is exceeded by the atmospheric pressure, ballast flow is begun, which restores the balloon to its ceiling.

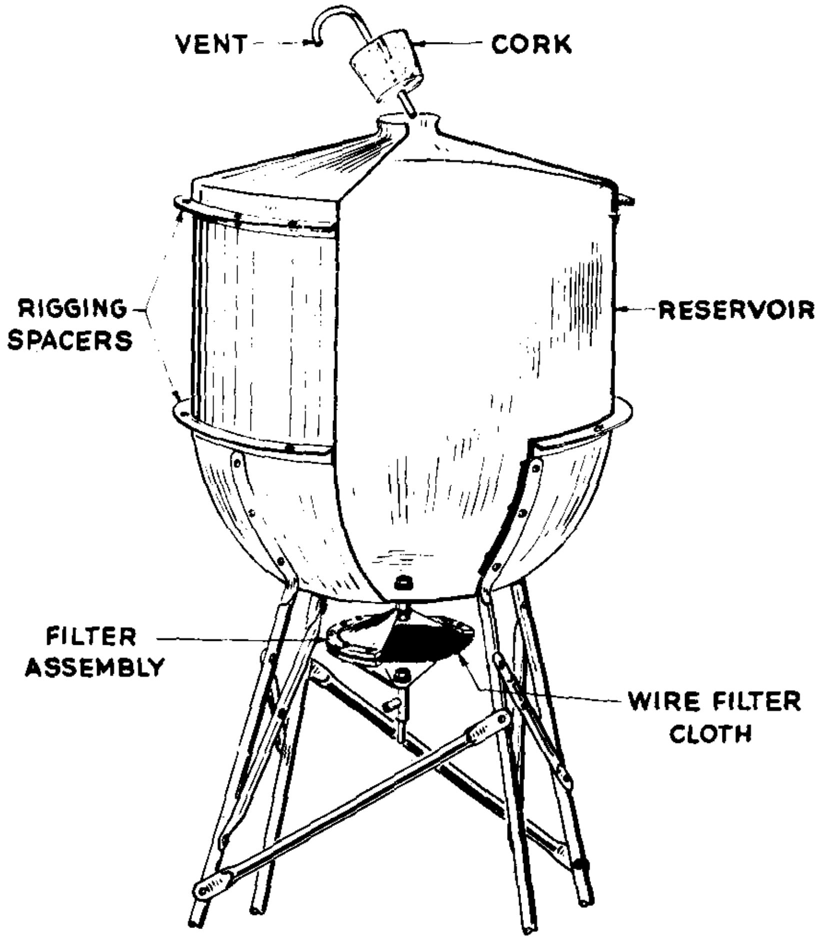
The dashed curve in Figure 7 shows the action of a balloon when the automatic ballast valve alone is used for control purposes. In this case the balloon will sink slowly from its ceiling (where full buoyancy just equals the load) to the level where the automatic ballast valve drops ballast at a rate equal to the diffusion (the floor). It will be noted that a flight which is controlled in this manner is less wasteful of ballast and results in a correspondingly longer flight. The "floor" determined by this valve varies diurnally as the temperature (hence pressure) of the air entrapped in the diaphragm is affected by solar radiation. The amplitude of this diurnal oscillation may be as much as 6000 feet, the night level being higher than the day level.

To reduce the effect of varying fluid heads and a corresponding variation in valve calibration, a ballast reservoir mounting was devised to limit the head values. This ballast reservoir, after several modifications, consists of a spun aluminum tank with filter, mounted on 18-inch legs. It is shown in Figure 15. The legs serve as supports for the other control units and a head of at least one foot is provided by tubing to the automatic ballast valve. The capacity of the reservoir is approximately five gallons. Figures 16 and 17 show the complete ballast release assembly.

One other system of altitude control may be mentioned. This is the method used by Korff and others[4] to roughly approximate constant level flights for cosmic ray investigations. A number of meteorological balloons are inflated until they will just support the flight load. A few other balloons are added to the train to give a free lift appropriate for the desired rate of rise (see Computations, Section 3). At some time after release these "lifter" balloons burst due to over-inflation, or are released by a pressure or time-activated mechanism. If the original balance was correct, and the effects of superheat and diffusion cancel each other, the cluster of cells may float. When one or more of the balloons breaks, or leaks excessively, the train will descend. Although this method was used in early experimental flights it proved to be useful only as a stop-gap method of carrying gear aloft for test purposes. No modification of this basic technique seems likely to produce even a consistant flight pattern due to the uncertainty of properties and behavior of these inherently unstable balloons.

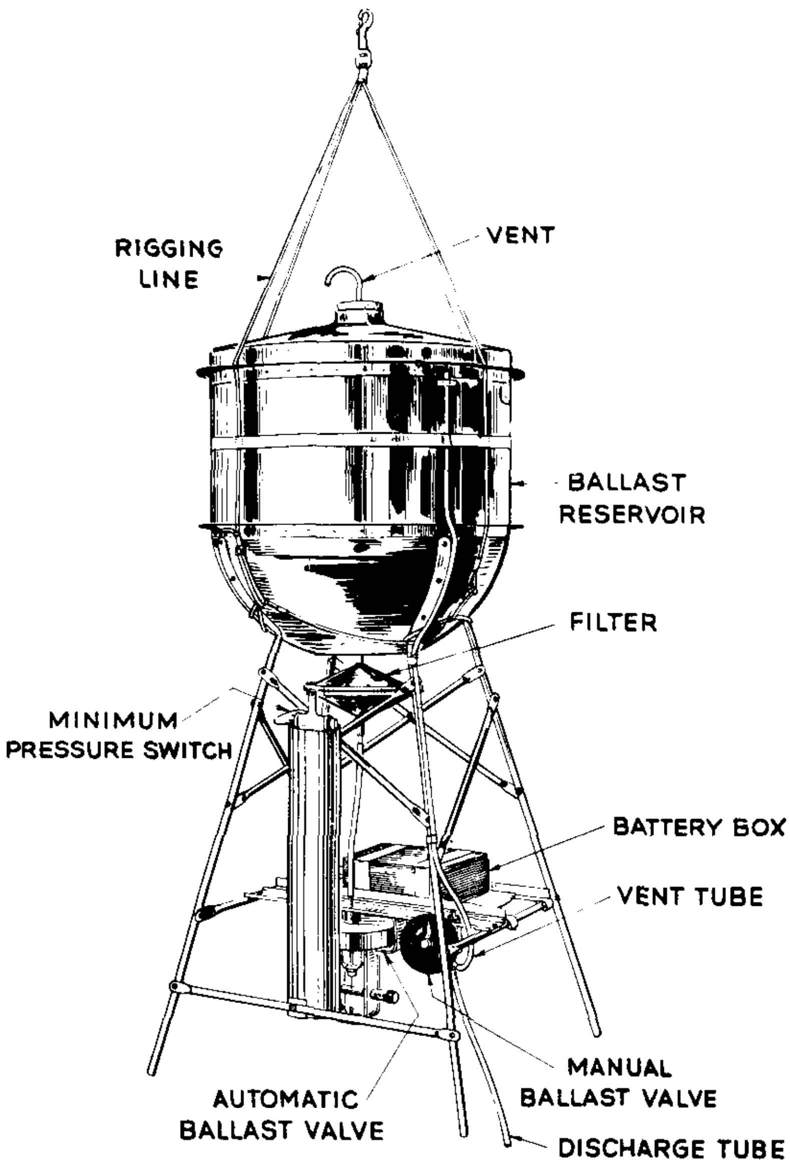
C. Altitude Determination

In order to evaluate the performance of the basic control apparatus, an investigation of pressure-measuring equipment and telemetering gear has been made. The problems of measuring upper-air conditions in general



BALLAST RESERVOIR

FIG. 15



BALLAST RELEASE ASSEMBLY

FIG. 16

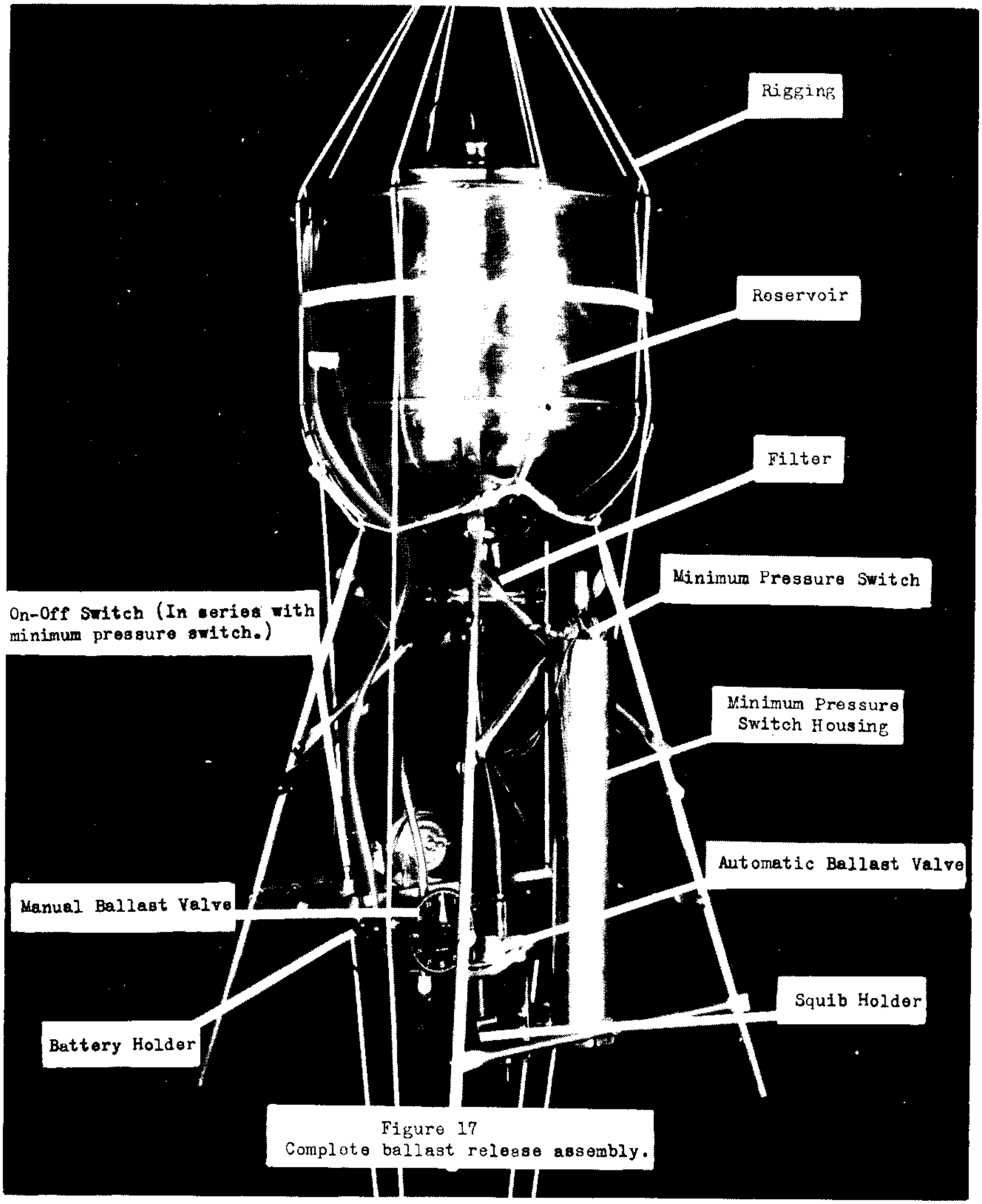


Figure 17
Complete ballast release assembly.

may differ markedly from the problems of surface measurement. For example; for any instrument used on a floating balloon, some consideration must be given to the effect of solar radiation on its behavior. As mentioned in the discussion of the automatic ballast valve, this effect is especially important in the action of any aneroid or other capsule which is not completely temperature compensated. Since the floating balloon will remain within one parcel of air, rising and falling and moving sidewise as the air does, temperature extremes will result from radiation effects and lack of ventilation. One investigator[9] has estimated that the temperatures to be experienced by such a body range from -60°C after a night of radiation to a maximum of +50°C in direct sunlight. Two ways of partially circumventing the undesirable results of this feature are:

1. Temperature compensation of the pressure capsule for some pre-set pressure. This compensation is only complete at one pressure.[5]
2. A second method of reducing insolation effects is the use of highly reflective shields.

The methods of height determination used so far are not completely satisfactory. Pressure-heights have been obtained by 72 mc. and 397 mc. radiosonde transmitters with long-life battery packs. Difficulties have been experienced in all long flights due to:

1. Signals being lost due to excessive range or to power failure.
2. When the balloon begins to float and height oscillations result from the action of the automatic ballast valve, it is impossible to identify the radiosonde contact (hence the pressure) using the conventional baroswitch of the Diamond-Hinman type radiosonde.

These steps are now being taken to improve height measurements:

1. The addition to the flight train of a light-weight barograph.

This could provide up to 40 hours of pressure-time data if recovered. At present, about 60 percent of the flights have been recovered.

2. The adoption of a time-interval or Olland-cycle radiosonde system for telemetering pressure data.

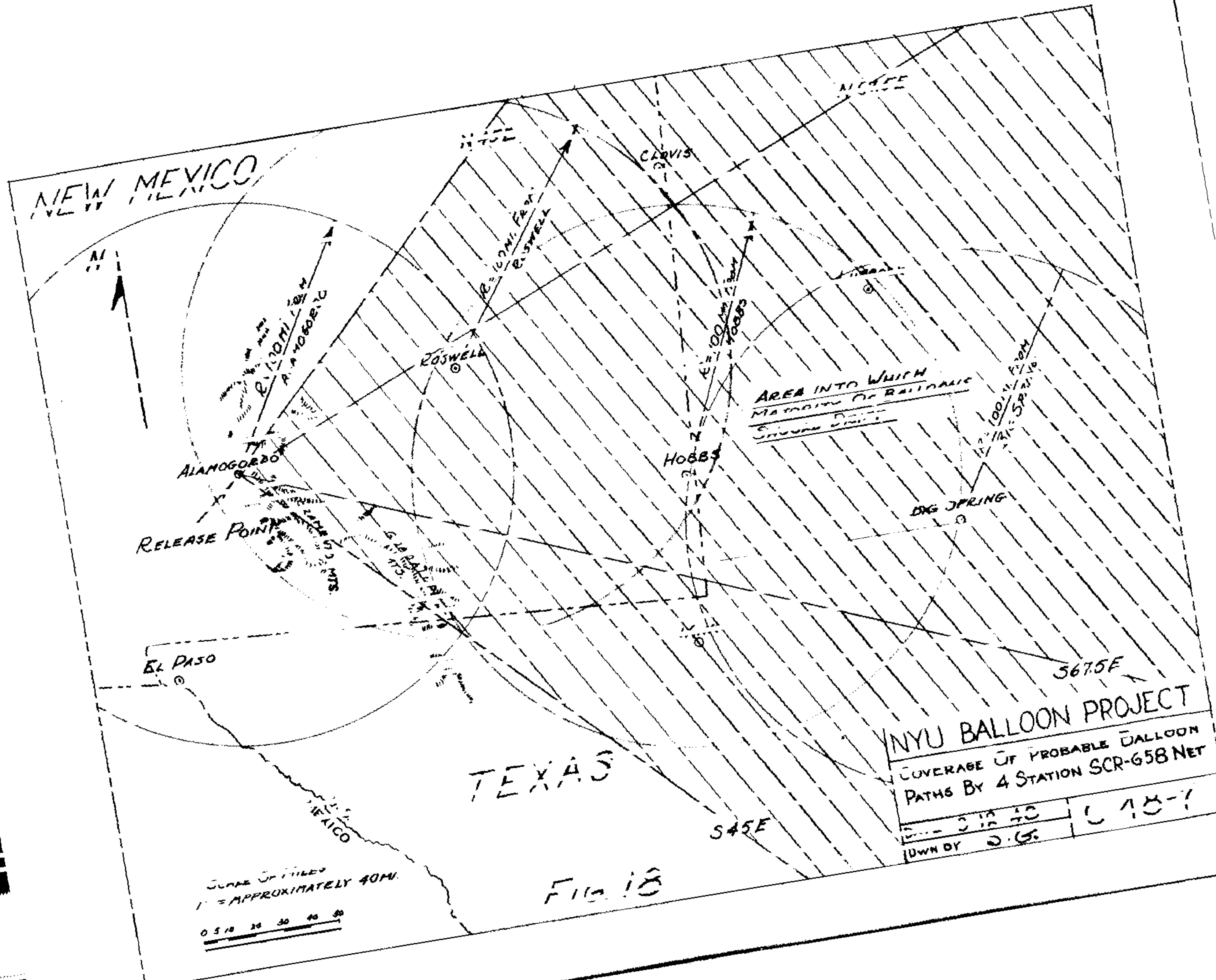
3. Expansion of the network of ground tracking stations equipped with SCR-658 direction finding sets to increase reception of data telemetered. Figure 18 shows the area to the east of Alamogordo, New Mexico, and the probable boundaries of flight paths following release from the Alamogordo Army Air Base. Table III shows the prevailing wind data on which these probable boundaries are based. Also shown in Figure 18 are the desirable locations for SCR-658 sets and the overlap of reception ranges which could be expected, using stations at Alamogordo, Roswell, New Mexico; Hobbs, N.Mex.; and Big Springs, Texas.

TABLE III

AVERAGE WIND INTENSITIES IN BEAUFORT SCALE AND WIND DIRECTIONS AT ELEVATIONS TO 10,000 METERS FOR NOVEMBER AND DECEMBER 1944 AND 1945

NOVEMBER

	Year	Surface	1,500 M	3,000 M	5,000 M	10,000 M
El Paso	1944	N-3	NE-1	WSW-5	W-7	--
	1945	N-3	WSW-3	WSW-5	W-7	--
Roswell	1944	S-1	WNW-3	W-4	--	--
	1945	S-3	SW-1	WNW-5	W-7	--
Albuquerque	1944	SE-3	--	W-3	W-6	W-9
	1945	N-3	--	WNW-5	W-8	W-9
Amarillo	1944	SSW-4	W-4	WSW-5	W-7	WSW-11
	1945	SW-4	SW-4	W-6	WNW-9	--
Big Spring	1944	--	WSW-4	WNW-4	W-7	WSW-9
	1945	--	SW-3	W-6	WNW-7	--
Abilene	1944	--	--	--	--	--
	1945	--	--	--	--	W-10



NEW MEXICO
N
ALAMOGORDO
RELEASE POINT
ROSWELL
CLOVIS
HOBBS
BIG SPRING
EL PASO
TEXAS
S45E
S67.5E
AREA INTO WHICH
NYU BALLOON PROJECT
COVERAGE OF PROBABLE BALLOON PATHS BY 4 STATION SCR-658 NET
DWN BY

Fig. 18

DECEMBER

	Year	Surface	1,500 M	3,000 M	5,000 M	10,000 M
El Paso	1944	N-3	NNE-1	W-2	NW-1	--
	1945	NNE-3	W-3	WNW-6	WNW-6	--
Roswell	1944	S-1	NW-3	NW-4	WNW-6	--
	1945	SSE-3	WSW-2	WNW-5	WNW-8	--
Albuquerque	1944	N-3	--	WNW-4	WNW-6	W-10
	1945	N-3	--	NW-6	WNW-8	WNW-9
Amarillo	1944	NW-4	NW-4	WNW-5	WNW-6	WNW-8
	1945	SW-3	W-2	WNW-5	WNW-9	--
Big Spring	1944	--	NW-4	NW-5	WNW-6	--
	1945	--	WSW-3	W-6	WNW-7	--

D. Tracking Devices: Horizontal

The flights made in the early part of this program were tracked optically with theodolites. Coupled with the height data, theodolite readings provide a fairly reliable horizontal locus of the balloon. However, even in the clear air of New Mexico, this method is useful for not more than 100 miles and, unless accurate height data are available, theodolite stations provide useful data for not more than 40 miles.

Aircraft observations have been used with some success when the ceiling of the balloon is not too great. It is expected that an inverted AN/APQ-13 radar, mounted atop a B-17, will greatly augment the horizontal tracking and will be of some value in determining height.

The most useful equipment for determining horizontal movement of the balloons has been the SCR-658 radio direction finding set. Long after the vertical angles registered by this gear are questionable (due to reflections off intervening terrain), the horizontal angles are useable. Used in sets of two or more, or coupled with height data, these observations give good positions with distances up to 150 miles. Figure 18 shows the coverage a network of four of these sets would provide. In contrast to the theodolites and aircraft observations, these instruments are perfectly operative when the balloon is not visible due to haze, cloud cover, etc. Ground radar has been used, when available, with fair results, particularly when radar targets are added to the flight train.

E. Flight Termination Control

Due to the size and weight of the balloons and the flight gear, the Civil Aeronautics Authority was advised of the testing program. At a meeting in New York on 20 March 1947, the New York Air Space Sub-Committee prescribed a procedure which was designed to minimize the hazard to air traffic. Similarly, the Fort Worth Sub-Committee established a procedure for flights made within the Fort Worth region of the CAA. Pertinent correspondence with the CAA is included in the Appendix, Part 2. Owing to the size of these cells, a very slow rate of descent should be expected after all ballast has been expended and the flight control devices have ceased to operate. Thus a large balloon and several heavy pieces of equipment might take an hour or more to descend through the levels of air travel. Despite the extreme improbability of midair collision, it is obviously desirable to take all possible precautions against such mishap and current flights have the following safeguards: (1) Flights are released on days when cloud cover is forecast to be light, thus permitting visual contact. (2) Notices to airmen are to be issued if the balloon is descending within designated regions of dense air traffic. (3) To reduce the time involved in a final descent, a special device called the "blowout patch" has been developed. This is an igniting squib which is fastened to the side of the cell, on the equator. Sealed in with the squib, which is fired electrically when the cell descends below 20,000 feet, is a quantity of gunpowder and magnesium. When the squib is fired, the incendiary patch blows out, allowing a rapid escape of gas through the opening. Since the patch is on the equator, the cell does not collapse but serves as a parachute to prevent extremely rapid fall and damage to the instruments. Figure 3 shows this patch in position on a balloon. Due to premature firings, a time switch has been built into the circuit to prevent misfiring in launching. A rip device will be developed to replace the incendiary on all future flights.

Section 3. Theoretical Relationships and Computations

A. Altitude-Density Relationships

An investigation into the relationship between density of the atmosphere and altitude, with the seasonal and geographical variations experienced, was made. The basic data, mean aerological soundings, were taken from the Monthly Weather Review, 1943[6]. These basic data consisted of observed temperatures, pressures, and humidities for altitudes from the surface up to the bursting height of balloons, normally 50,000 to 60,000 feet. For altitude above this height, the highest reported temperatures for the stations under consideration were used and the pressure data were taken for the remaining altitudes up to 100,000 feet, from the N.A.C.A. Standard Atmosphere[7].

Density was expressed inversely in terms of pound molar volumes, as this relates volume in cubic feet to buoyancies of gases of varying purity, using fundamental data. Using the simple gas laws, the molar volume of dry air at each altitude was computed in the following manner:

Given: (1) The pound molar volume of any gas at standard conditions=359 $ft.^3$

(2) From the mean sounding data at 49,200 ft. (15 km.) over Lakehurst, N.J. (Jan. 1943).

Temperature = -59.5°C.

Pressure = 120 mb.

$$\text{Molar volume}_{(\text{standard})} \times \frac{\text{Temperature}_{(\text{observed})}}{\text{Temperature}_{(\text{standard})}} \times \frac{\text{Pressure}_{(\text{standard})}}{\text{Pressure}_{(\text{observed})}}$$

= Molar volume at observed conditions.

$$359 \times \frac{273.2 - 59.5}{273.2} \times \frac{1013.3}{120} = 2370 \text{ ft.}^3$$

This is the mean pound molar volume at 15 km for Jan. 1943 over Lakehurst, N. J. This volume data was computed for levels up to 100,000 ft. over several stations and may be found in Appendix 3, plotted on the left hand side of figures 19 and 20.

B. Load-Diameter Maximum Altitude Relationships

Molar volume is related to buoyancy in the following fashion. Using 98% hydrogen of molecular weight, 2.11 lb./mol. and dry air of molecular weight 28.76 lb./mol., a buoyancy equal to the difference, 26.65 lb/mol. (See Table IV) is available whenever one pound molecular weight of hydrogen displaces one pound molecular weight of dry air under the same conditions of temperature and pressure.

TABLE IV

Buoyancy per Pound-Mol.

Helium (98%)	24.6 #/#mol, or 11.1 kg/#mol
Hydrogen (98%)	26.6#/#mol, or 12.1 kg/#mol

The number of mols in a balloon volume may be readily computed by dividing the air density, expressed in molar volume, at a given altitude into the balloon volume. The lift of the gas filling the balloon at any altitude is then equal to the number of mols multiplied by the buoyancy per mol. For example: To find the lift of the gas in a completely inflated (hydrogen filled) balloon of 20-foot diameter, at an altitude where the pound molar volume is 1000 $ft.^3$ (This is equivalent to about 30,000 ft.):

Volume of a 20-foot diameter sphere = 4190 ft^3.

Number of mols in sphere at this altitude = $\frac{4190}{1000}$ = 4.19 mols

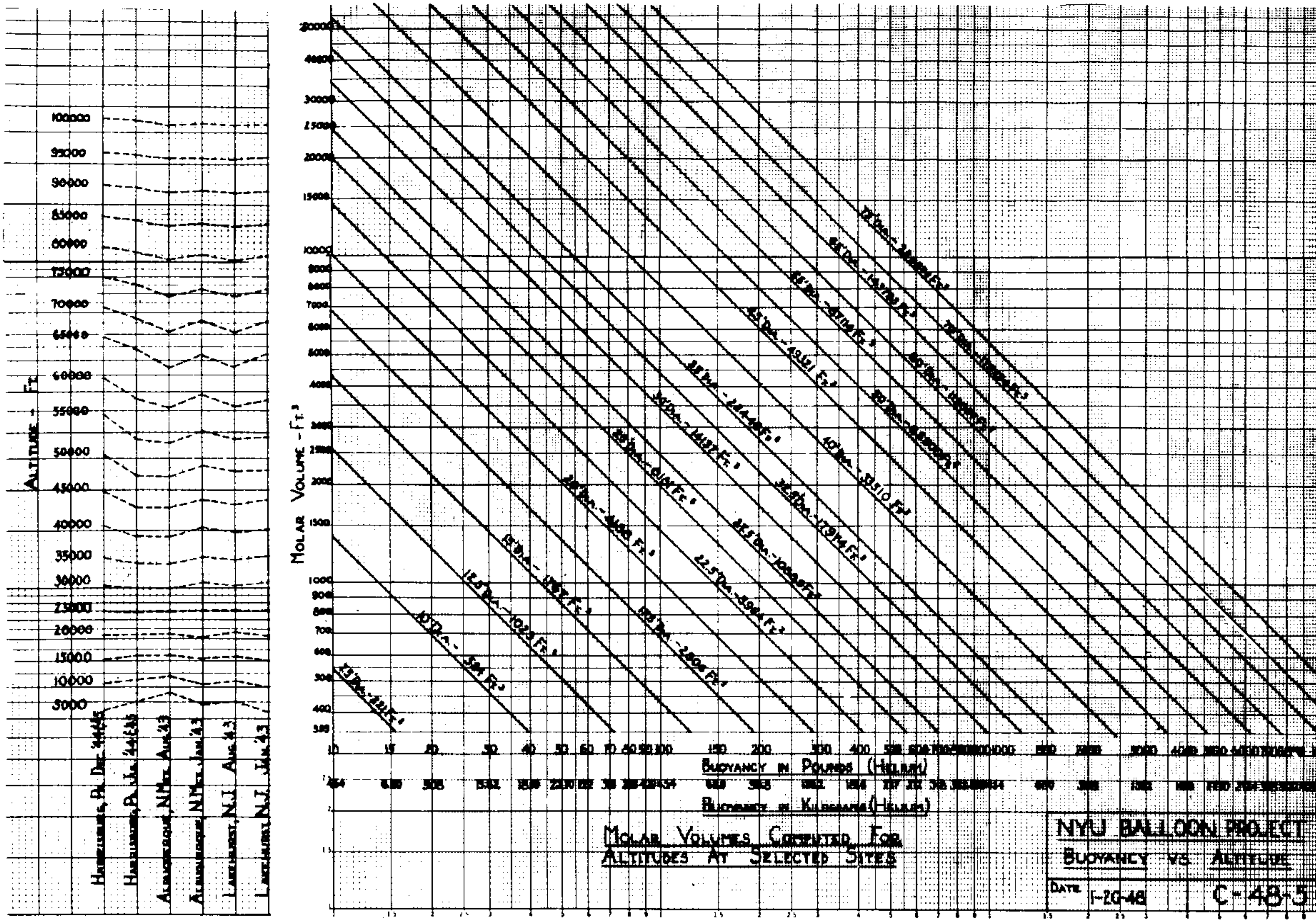
Buoyancy = 4.19 mols x 26.65 #buoyancy/mol = 111.7 # lift given by the gas at 30,000 feet.

In one step, this becomes:

$$\text{Gross Lift/Balloon} = \frac{(\text{Balloon Volume}) \times (\text{Difference in molecular weights of air and lifting gas})}{\text{Molar Volume at a given altitude}}$$

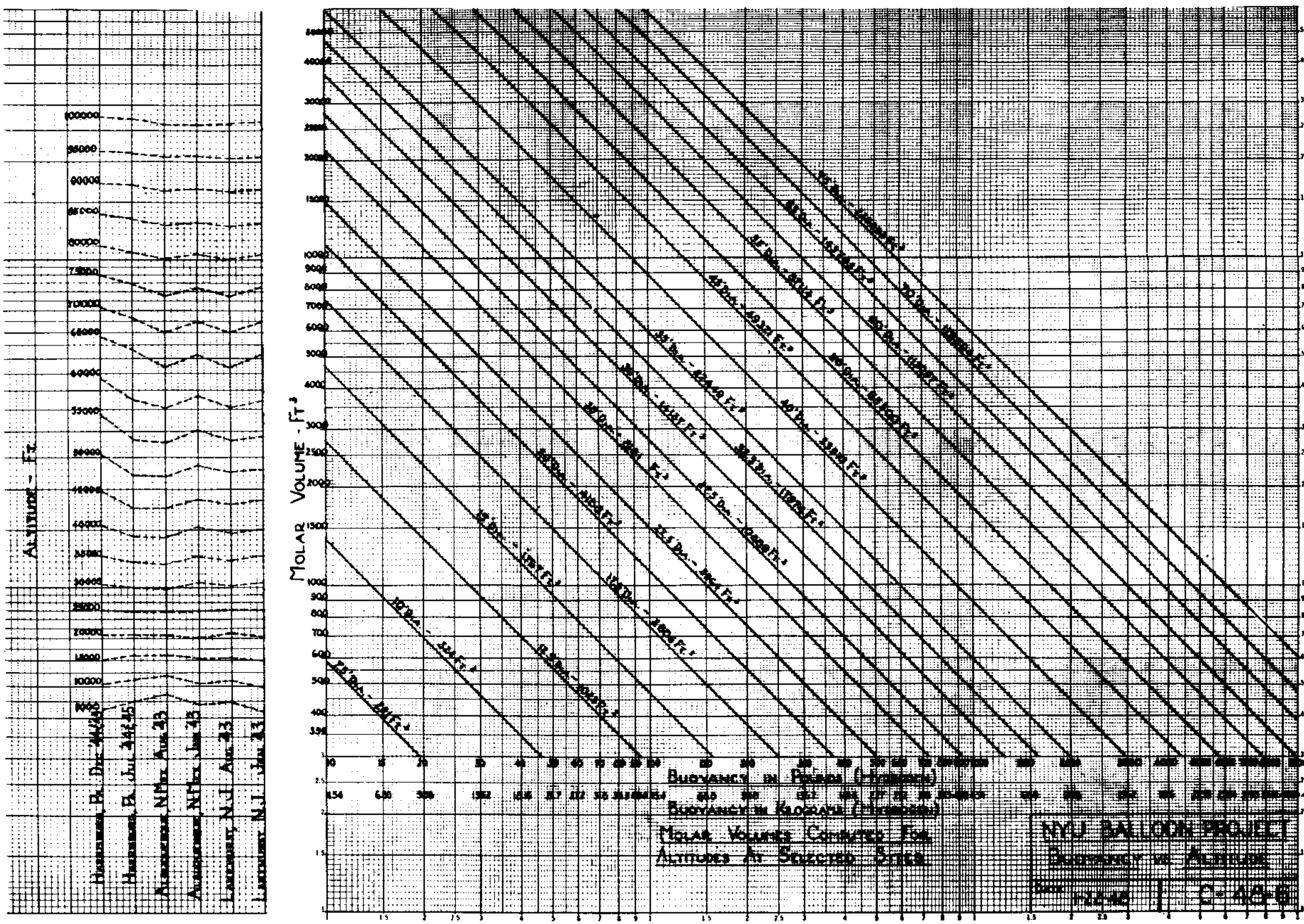
Conversely, the maximum altitude to which a given size balloon will carry itself and a specified load can be determined, as a molar volume, which may be evaluated from a graph of altitude versus molar volume. Such graphs, computed as in Part A of this Section, are given in Figures 19 and 20, at the left hand edge.

Hydrogen and helium lifts were computed for various molar volumes for spheres of lifting gas with diameters from 7.5 to 75 feet. Figures 19 and 20 were plotted using the values computed. To use these figures to determine the maximum altitude of a balloon with a specified pay load, enter the table with required buoyancy (balloon weight plus payload). Go vertically to the diagonal line representing the balloon's size, and then read horizontally on the left hand edge, either the molar volume or the equivalent altitude over



Altitude - Ft.
Molar Volume - Ft.³
Buoyancy in Pounds (Helium)
Buoyancy in Kilograms (Helium)
Molar Volumes Computed For Altitudes At Selected Sites
NYU BALLOON PROJECT
BUOYANCY VS. ALTITUDE
DATE 1-20-48
C-48-5

FIG. 19



Altitude - Ft.
Molar Volume - Ft³
Buoyancy in Pounds (Hydrogen)
Buoyancy in Kilograms (Hydrogen)
Molar Volumes Computed For Altitudes At Selected Sites
NYU Balloon Project
Buoyancy vs. Altitude
C-48-6

Fig. 20

sample stations. Figure 21 shows the calculated net lift of the General Mills balloons.

C. Balloon Diameter-Weight Relationships

To facilitate design discussions, charts have been drawn up relating the approximate weight of a balloon to its size and the unit weight of the balloon fabric. A ten percent increase is added to the weight over that determined from the surface area to account for seams and shroud lines. Figures 22 and 23 are these charts.

D. Rate of Rise

It is important that the rate of rise of a balloon be neither too fast nor too slow. For example, if a General Mills' 20-foot balloon rises faster than 900 feet per minute, there is danger of rupturing the balloon when pressure altitude is reached. On the other hand, if rates of rise under 400 feet per minute are chosen, since the free lift will be quite low, there is danger of: 1) a slight error in inflation resulting in the balloon's being unable to lift the equipment, or 2) with a wind much in excess of the rate of rise, the up-wind release failing due to the dragging of the equipment prior to its being lifted by the balloon.

To compute the free lift necessary for a given rate of rise, the equation developed by Korff[4] is used. This equation is:

$$V = 412 \frac{(F)^{\frac{1}{2}}}{(G)^{\frac{1}{3}}}$$

where F = free lift in grams

V = rate of rise in feet per minute

G = gross lift in grams

For our purposes, we wish to find F and have modified the equation to read:

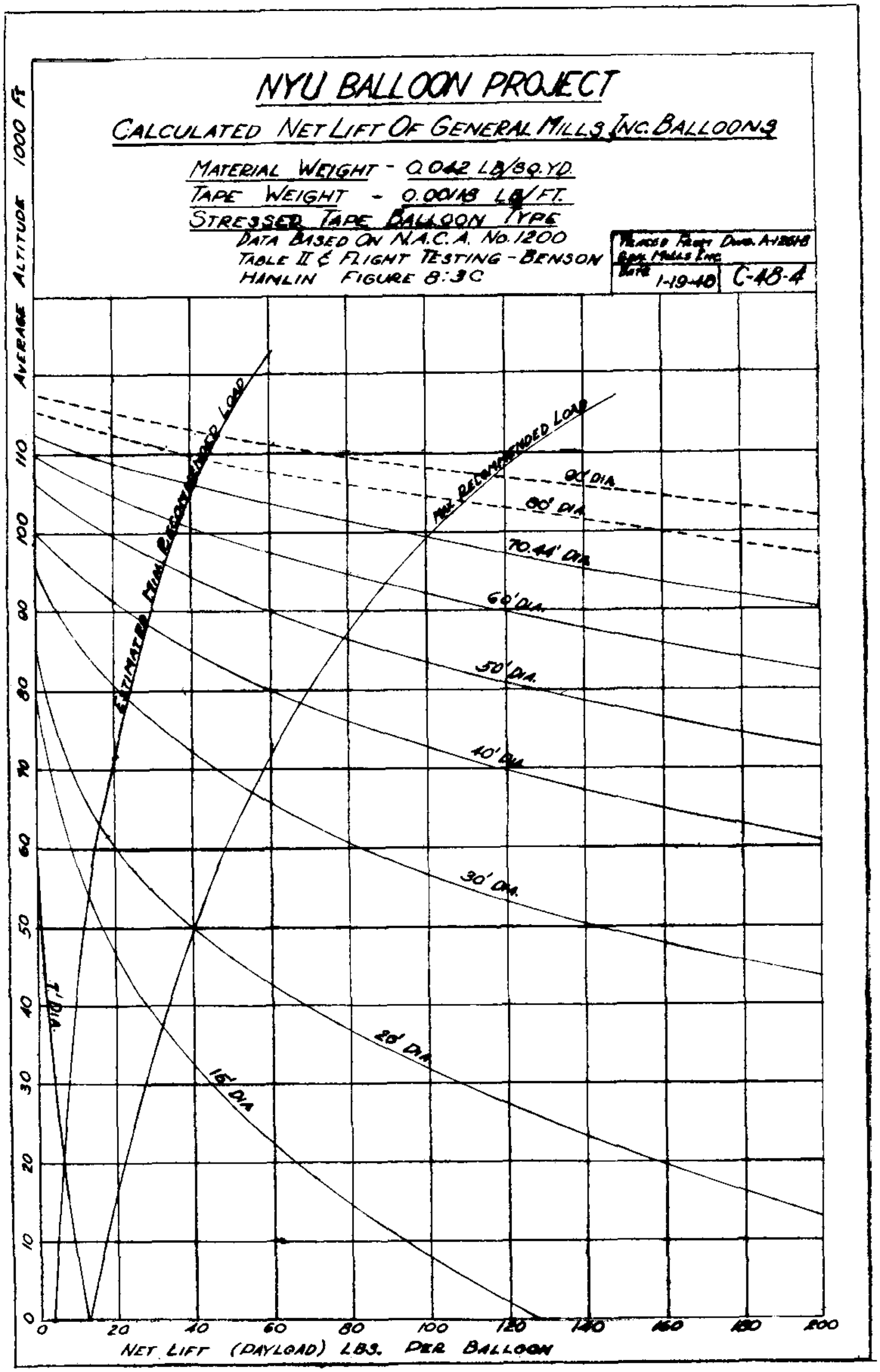
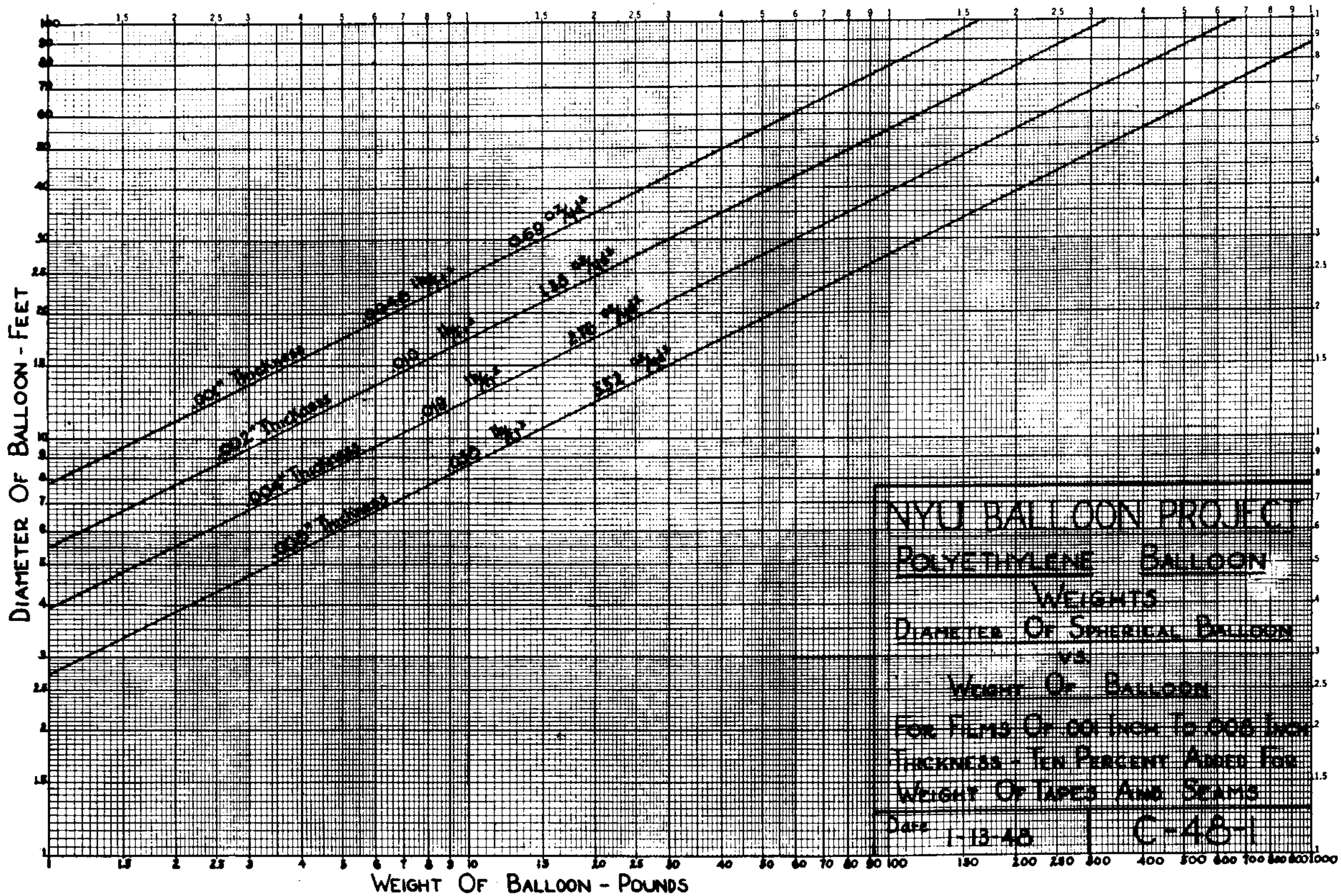
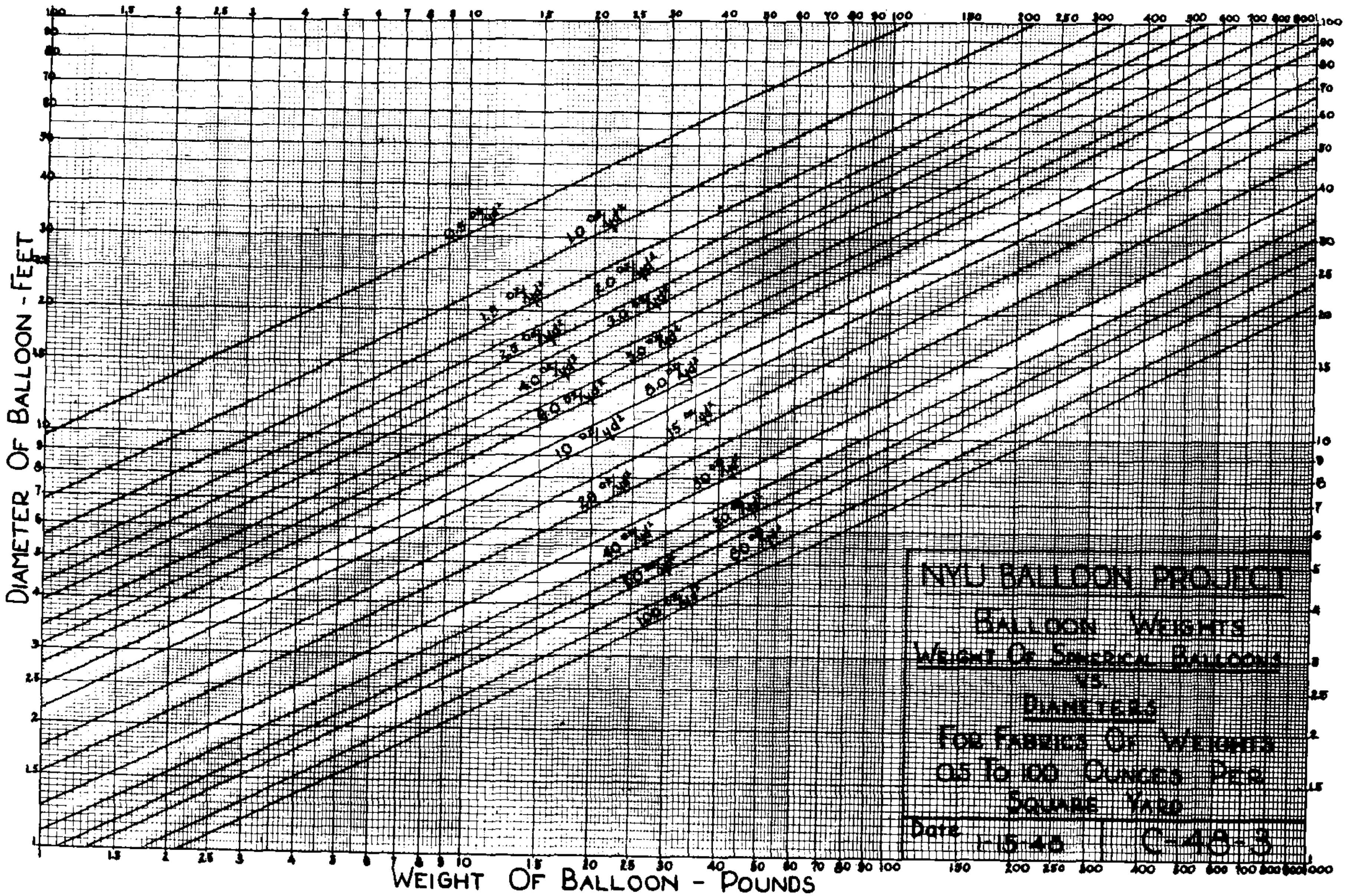

NYU BALLOON PROJECT
CALCULATED NET LIFT OF GENERAL MILLS INC. BALLOONS
MATERIAL WEIGHT - 0.042 LB/SQ.YD.
TAPE WEIGHT - 0.00148 LB/FT.
STRESSED TAPE BALLOON TYPE
DATA BASED ON N.A.C.A. No. 1200
TABLE II & FLIGHT TESTING - BENSON
HANLIN FIGURE 8:3C
1-19-48
C-48-4
AVERAGE ALTITUDE 1000 FT
ESTIMATED MIN. RECOMMENDED LOAD
MAX. RECOMMENDED LOAD
90' DIA.
80' DIA.
70.44' DIA.
60' DIA.
50' DIA.
40' DIA.
30' DIA.
20' DIA.
15' DIA.
7' DIA.
0
10
20
30
40
50
60
70
80
90
100
110
0
20
40
60
80
100
120
140
160
180
200
NET LIFT (PAYLOAD) LBS. PER BALLOON

FIG. 21



Diameter Of Balloon - Feet
Weight Of Balloon - Pounds
.001" Thickness
.002" Thickness
.004" Thickness
.008" Thickness
NYU BALLOON PROJECT
Polyethylene Balloon
Weights
Diameter Of Spherical Balloon
vs.
Weight Of Balloon
For Films Of .001 Inch To .008 Inch
Thickness - Ten Percent Added For
Weight Of Tapes And Seams
Date 1-13-48
C-48-1

FIG 22



Diameter Of Balloon - Feet
Weight Of Balloon - Pounds
NYU Balloon Project
Balloon Weights
Weight Of Spherical Balloons
vs.
Diameters
For Fabrics Of Weights
0.5 To 100 Ounces Per
Square Yard
Date 1-15-48
C-48-3

FIG 23

$$F = \left(\frac{V}{412}\right)^2 \times \left(G\right)^{\frac{2}{3}} \quad \text{(Approximate)}$$

where G = gross load

A chart, Figure 24, has beendrawn up, based on this equation, expressing free lift as a percentage of gross load, allowing the rate of rise to be approximately predetermined.

E. Ballast Requirements

The amount of ballast which must be dropped through the manual ballast valve to keep the balloon at its ceiling, can be approximately determined by the following measurements: a balloon of similar size and construction is inflated and its loss of lift with time is measured with correction for variation of temperature. This inflation is not complete, but is of the same magnitude as that of a balloon ready for release, approximately 14% of full inflation in the case of a General Mills balloon. The loss of lift per hour, multiplied by a factor representing the increase of the surface which results from total inflation, is thus obtained. This factor is the reciprocal of the fraction of inflation raised to the two-thirds power for a spherical balloon, and is approximately the same for the tear-drop shaped General Mills balloons.

Field experience has shown that ballast leak pre-set to slightly exceed the computed loss of lift is insufficient. A ballast leak of double the computed loss of lift has usually been adequate. It is believed that increased liquid viscosity and valve closure caused by the colder temperatures of the high atmosphere are responsible for the need for this higher ballast setting. An investigation into temperature effects on the ballast release systems has been started.

The amount of ballast which must be released at sunset to compensate for the loss of superheat, may be computed as follows:

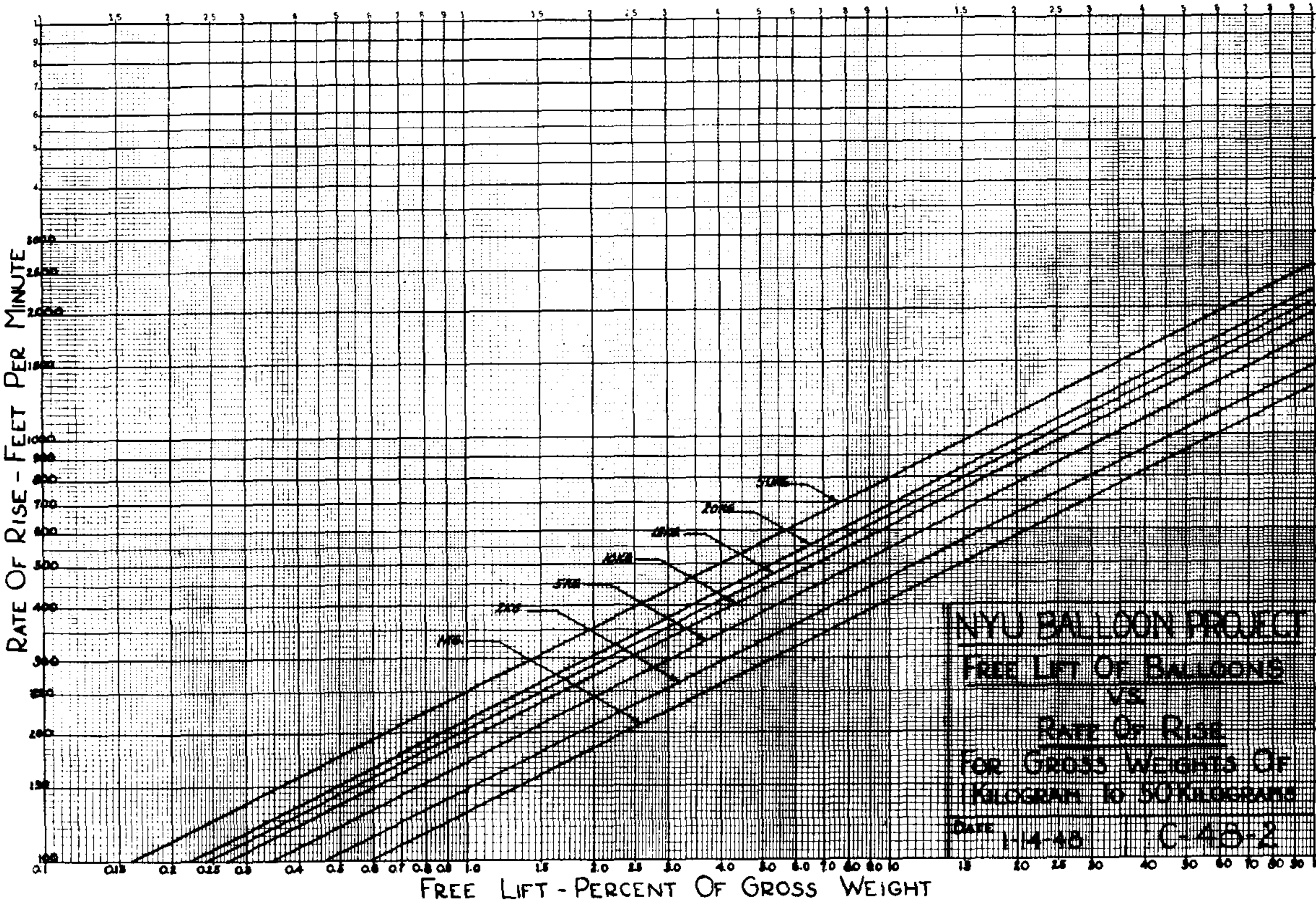

NYU BALLOON PROJECT
FREE LIFT OF BALLOONS
VS
RATE OF RISE
FOR GROSS WEIGHTS OF
1 KILOGRAM TO 50 KILOGRAMS
DATE 1-14-48
C-48-2
RATE OF RISE - FEET PER MINUTE
FREE LIFT - PERCENT OF GROSS WEIGHT

FIG 24

$$\Delta G = G \times \frac{\Delta T}{T} \times (1 + K)\ K$$

where ΔG = loss of lift

G = gross load (balloon weight plus equipment load)

ΔT = mean temperature difference in lifting gas before and after sunset

T = free air temperature

K = specific gravity of lifting gas, relative to air

The specific gravity of 98% helium, diluted with air, and with respect to air, is 0.157. It may be noted that with a lower specific gravity of a gas, lower ballast corrections are required. Hydrogen, for example, requires half the ballast which helium requires for the same temperature differential. At high altitudes, a difference of 40°C may be expected in the temperature of the lifting helium from day to night. This would correspond to a loss of lift at sunset, on a General Mills 20-foot balloon, of about 550 grams.

F. Internal Pressure

The maximum internal pressure which can be held within a spherical container is given by Timoshenko[8]:

$$P = \frac{2S_u \times t}{r}$$

where S_u is the ultimate strength of the material in tension, t is thickness of the material and r is the radius of the spherical shape. Applying this equation to a polyethylene film, such as used in the General Mills 20-foot balloons, S_u at room temperature = 1900 psi., t = 0.001", and r = 10 ft., giving the maximum pressure, P = 0.032 psi. This pressure is equivalent to about 1.1 inches of water, or 2.5 mb. This small bursting pressure necessitates proper inflation and load values to prevent the balloon's bursting at pressure altitude.

A series of forms which have been used to facilitate computations have been drawn up. They are included in Appendix 3, together with a table of altitudes based on the N.A.C.A. Standard Atmosphere[6], and other useful reference tables.

TABLE V

Glossary

Equipment load: Weight of all equipment, rigging, and ballast hung from the balloon shrouds not including balloon or its integral parts.

Gross load: Load on the gas at release (Balloon plus equipment load weight).

Free lift: Net lift of the balloon with the equipment load attached.

Gross lift: Lift of all of the gas in the balloon at release (Equals weight of the balloon, equipment load plus the free lift).

Balloon inflation: Gas inflation to be given the balloon in terms of initial lift of the balloon (equals weight of equipment load plus free lift plus allowance for gas losses before launching).

Floor: The locus of altitudes at which a balloon will float when lift losses are exactly compensated for on a demand basis by ballast dropping. In practice, this is determined by the operation of the automatic ballast release and is some altitude below the ceiling.

Ceiling: The locus of pressure altitudes at which a non-extensible balloon will float when gas losses are slightly over-compensated for by ballast losses.

Pressure Altitude: The altitude at which a non-extensible balloon becomes fully inflated.

Pressure Height: The height above mean sea level as determined from pressure measurements used in this work with the N.A.C.A. Standard Atmosphere.

Section 4. Flight Techniques

The general techniques of preparing and launching controlled altitude balloons are patterned after those of the smaller radiosonde balloons. The treatment of large, manned balloons has been studied, however, and information of considerable value has been gleaned; as from the National Geographic Society reports of the flights of Explorer I and Explorer II[11,12], and from the book by Upson and Chandler[15]. From these and other studies[13, 14], and from original experimentation with General Mills advice, a satisfactory technique of handling controlled-altitude balloons has been developed.

A. Inflation

The lifting gas used for these large balloons has been helium. The choice of gas was made on safety considerations. Hydrogen, however, has several advantages over helium. It will lift 9% more than helium and, due to its lower specific gravity, requires but 50% of the ballast release that helium requires to correct for disappearance of superheat at sunset. Helium, on the other hand, leaks and diffuses at a rate but 70% that of hydrogen. However, for long flights, hydrogen would probably have more over-all economy of ballast.

Inflation has been made through a low-pressure, diffusing manifold, feeding from a number of helium tanks simultaneously to the balloon. The smaller balloons have been inflated inside a hangar, permitting very exact weigh-off of the balloon's free lift, thus predetermining the rate of rise fairly well. The plastic balloons larger than 15 feet in diameter have generally been inflated out-of-doors, as no hangar large enough for interior inflation has been available.

The 20-foot General Mills balloons are inflated through a tube in such a fashion that the gas collects in a bubble at the top of the balloon. The tube is inserted by the manufacturer and is shown in Figure 5. If this bubble is restricted, the wind cannot catch and make a sail of it. (See figure 25 for the sail effect.) The actual technique of inflation is as follows:

In actual inflation the balloon is spread out on a ground cloth which covers the launching table and a balance. The balloon is arranged so the upper 18 feet projects beyond the balance. Two heavy (80#) elliptical shot bags (see Figure 26) are covered with polyethylene and placed on top of the balloon on either side of the inflation tube. The platform is then made to balance. The lower end of the balloon is weighed and then stretched out again down wind, held down with sand bags and polyethylene strips. A weight equal to the weight of the lower half of the balloon, plus the equipment weight and the desired free lift is placed on the balance. Inflation is started, taking care to get all twists out of the inflation tube before allowing full gas flow. When the balance beam falls, inflation is complete (care must be exercised to guard against under-inflation due to wind moving the balloon on the balance). The inflation tube is carefully removed, and the helium truck is moved clear. All personnel are now positioned for release.

B. Release

During the early portion of the experimental period, flights of meteorological balloons in clusters were launched. The first flights were made with balloons hitched one above another along a single strong load line.

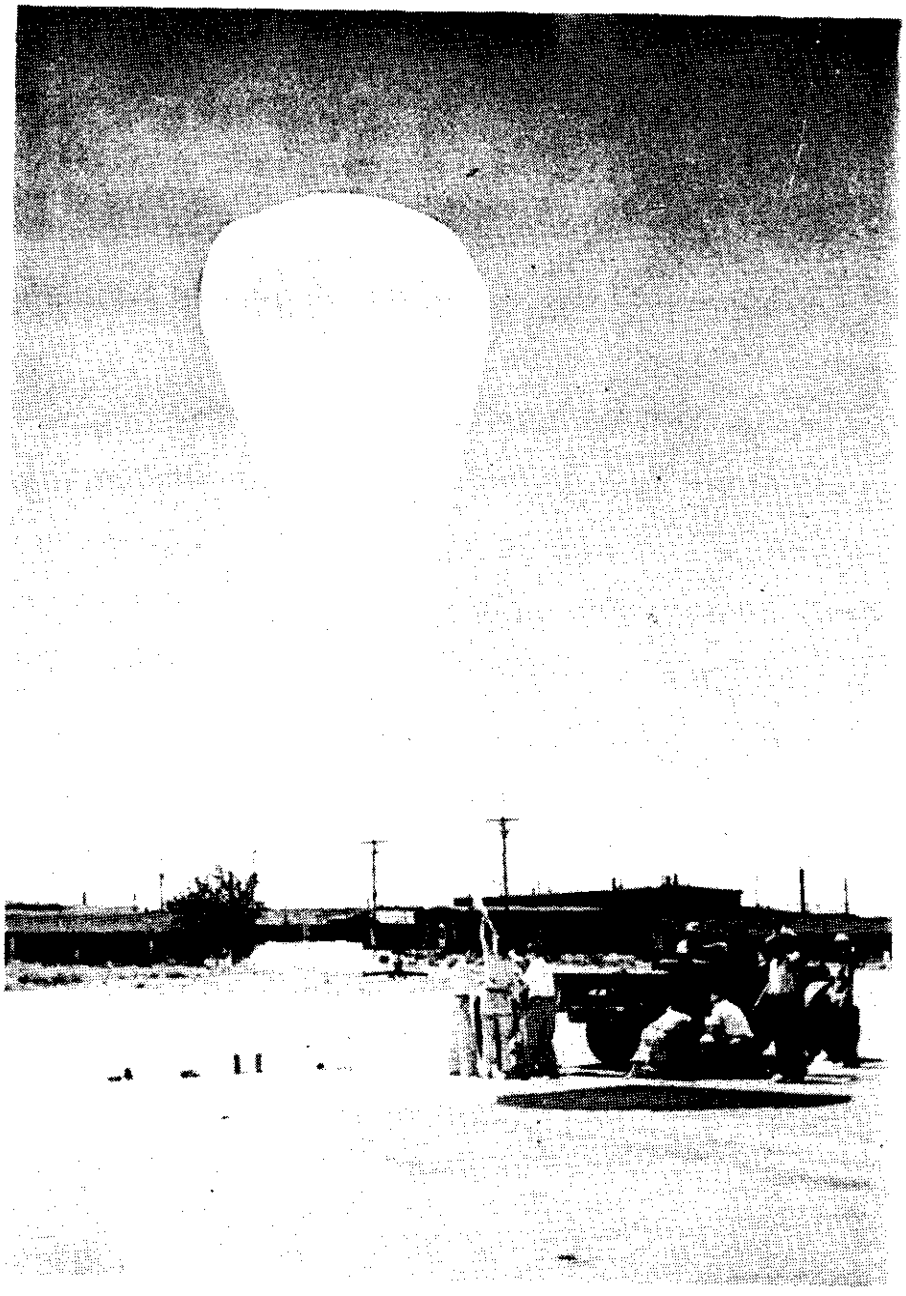
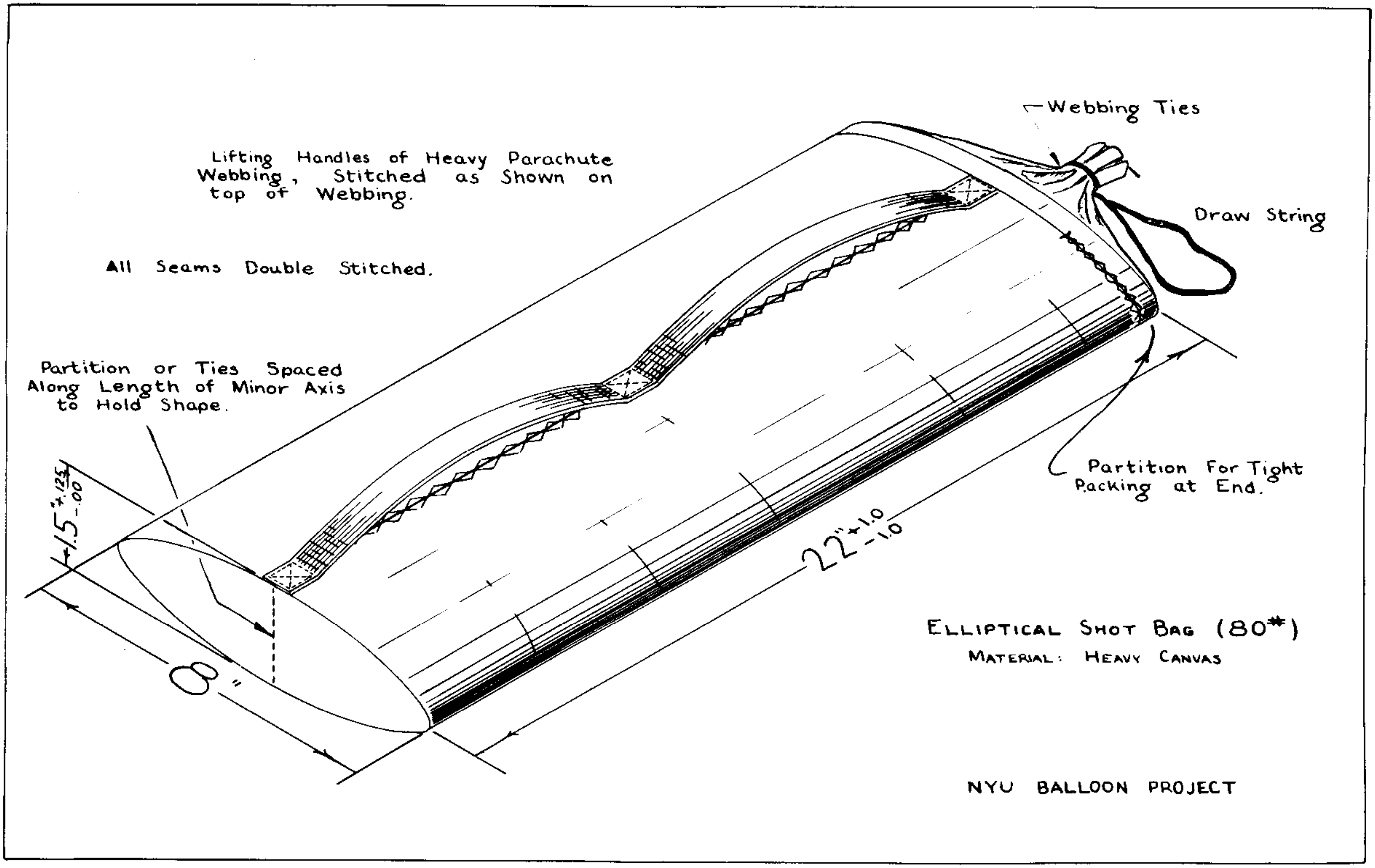


Figure 25
General Mills 20 foot balloon
billowing in a five knot wind.



Webbing Ties
Lifting Handles of Heavy Parachute Webbing, Stitched as Shown on top of Webbing.
Draw String
All Seams Double Stitched.
Partition or Ties Spaced Along Length of Minor Axis to Hold Shape.
Partition For Tight Packing at End.
1.5" +.125 -.00
22" +1.0 -1.0
8"
ELLIPTICAL SHOT BAG (80#)
MATERIAL: HEAVY CANVAS
NYU BALLOON PROJECT

FIG. 26

With these and subsequent rigging lines the following technique was used: on all lines a strength test was made and a safety factor of at least ten to one was demanded. Most of the lines used are of braided or woven nylon, chosen for its low weight-strength ratio. To facilitate handling of the line segments each length is prepared with a small hook on either end. The knots employed are double carrick bends.

The total length of the early trains reached as much as eight hundred feet, making them extremely difficult to release. A system of restraining the load line was evolved with two winches paying out restraining lines while balloons and equipment were added to the load line. In this way the pull of the balloons themselves and the much greater strain caused by even light winds was held by winches. When the final piece of equipment was clear of the ground (or when the entire flight line was under tension with the lowest element being held back) a gunpowder squib was electrically fired to sever the restraining lines near the bottom of the balloon. Figure 27 shows the aluminum "cannon" holding the gunpowder, the two winch lines and a light line used to pull the restraining lines away from the load line after firing. The load line has not yet been attached in Figure 27, but will be fixed just above the "cannon".

When the restraining line is severed, there is danger of a pendulum swing of the train causing the lower components to be dashed into the ground. To avoid this action, the lowest piece of equipment is usually held by a member of the crew on the back of a truck. By driving downwind faster than the surface wind speed, the pull of the balloon can be resolved into only a vertical component and the equipment may be safely released when the truck gets under the balloon.

With later plastic cell flights, this method of launching was also used in cases of light wind. When winds of about 5 knots are encountered,

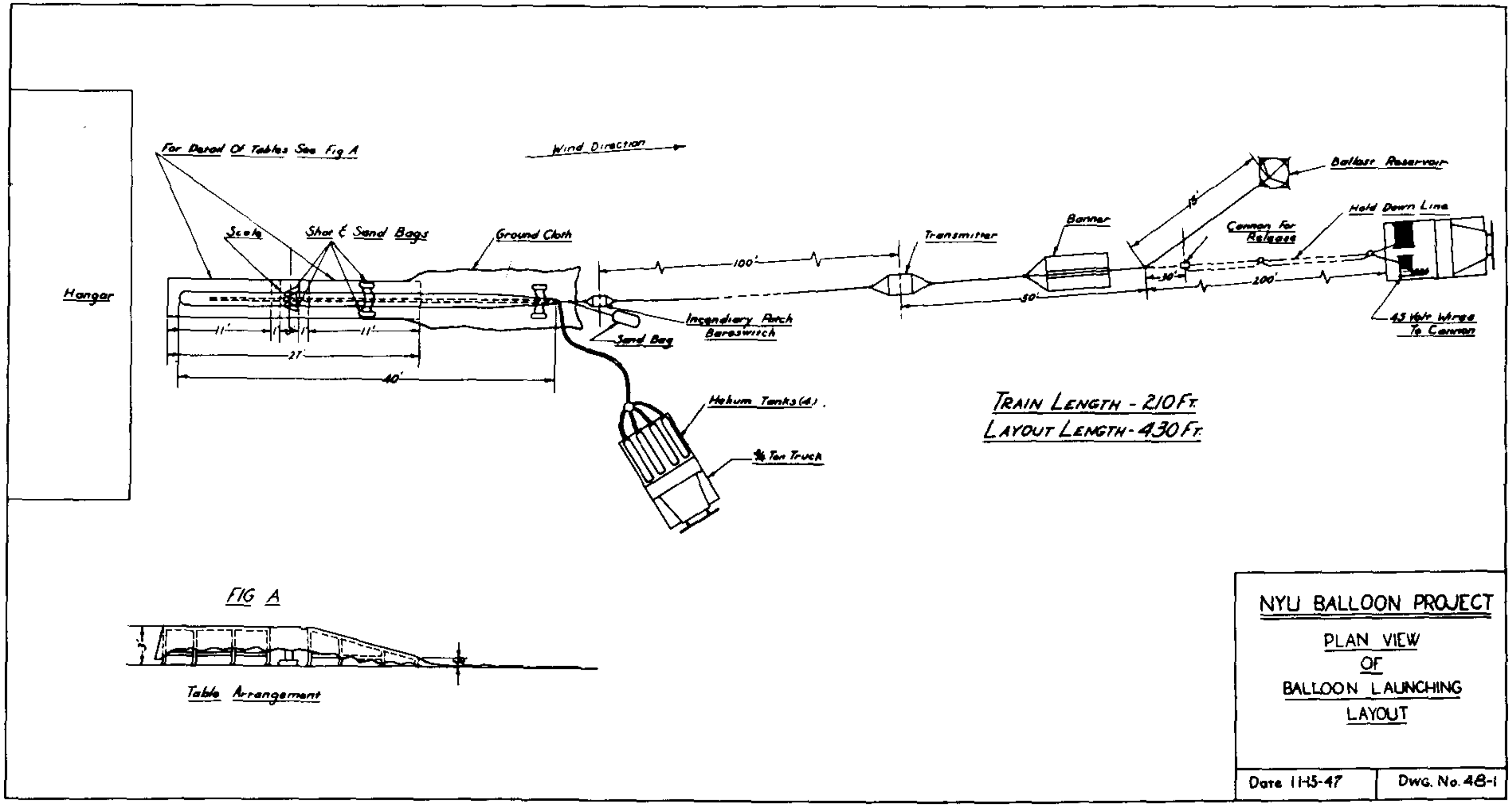
Figure 27
Aluminum "cannon" and launching lines used to restrain balloon while load is being attached.

the total strain on rigging lines and even on the balloon itself becomes excessive. With the thin polyethylene film of the General Mills' balloons, such a wind force causes the balloon first to billow, sail-like, as in Figure 25, then to tear.

To eliminate surface failures on days when the wind is not calm, the following release technique is employed: The equipment train is laid out parallel to the wind direction, with the balloon in the lee of a large building and the other components stretched out downwind. The central portion of the balloon rests on a platform balance and the lower portion rests on a sloping eleven-foot table whose top is level with the platform and whose bottom rests upon the ground. The upper portion of the balloon usually lies on another table, level with the platform. Except for this upper portion, the balloon is held down on the scales and sloping table by bags of sand and lead shot. In addition, one sand bag is fastened to the lead thimble of the balloon by a short line which is kept taut during inflation. This layout is shown in Figure 28.

When the balloon is inflated, it is held down at the weighing-off scales by the shot bags. Personnel required for the launching consist of two men at the hold-down shot bags (who lift the bags at the release signal), one man near the large sand bag (who cuts the line to the load thimble when the balloon rises above him), one man at each piece of sensitive equipment on the train (to support and protect the equipment until it is airborne), one man at the lower end of the hold down line (who fires the cannon severing the last line when the gear is all safely lifted).

If each operation is performed when the balloon is directly overhead and if the train has been accurately laid out downwind, the entire train is sent off with a minimum of oscillation of the load. Figure 29 shows successive positions of the balloon and gear during release.



For Detail Of Tables See Fig A
Wind Direction
Ballast Reservoir
Hold Down Line
Scale
Shot & Sand Bags
Ground Cloth
Transmitter
Banner
Cannon For Release
Hangar
100'
30'
200'
50'
11'
27'
40'
Incendiary Patch
Bareswitch
Sand Bag
45 Volt Wires To Cannon
Helium Tanks (4)
3/4 Ton Truck
TRAIN LENGTH - 210 FT.
LAYOUT LENGTH - 430 FT.
FIG A
Table Arrangement
NYU BALLOON PROJECT
PLAN VIEW OF BALLOON LAUNCHING LAYOUT
Date 11-15-47
DWG. No. 48-1

FIG 28

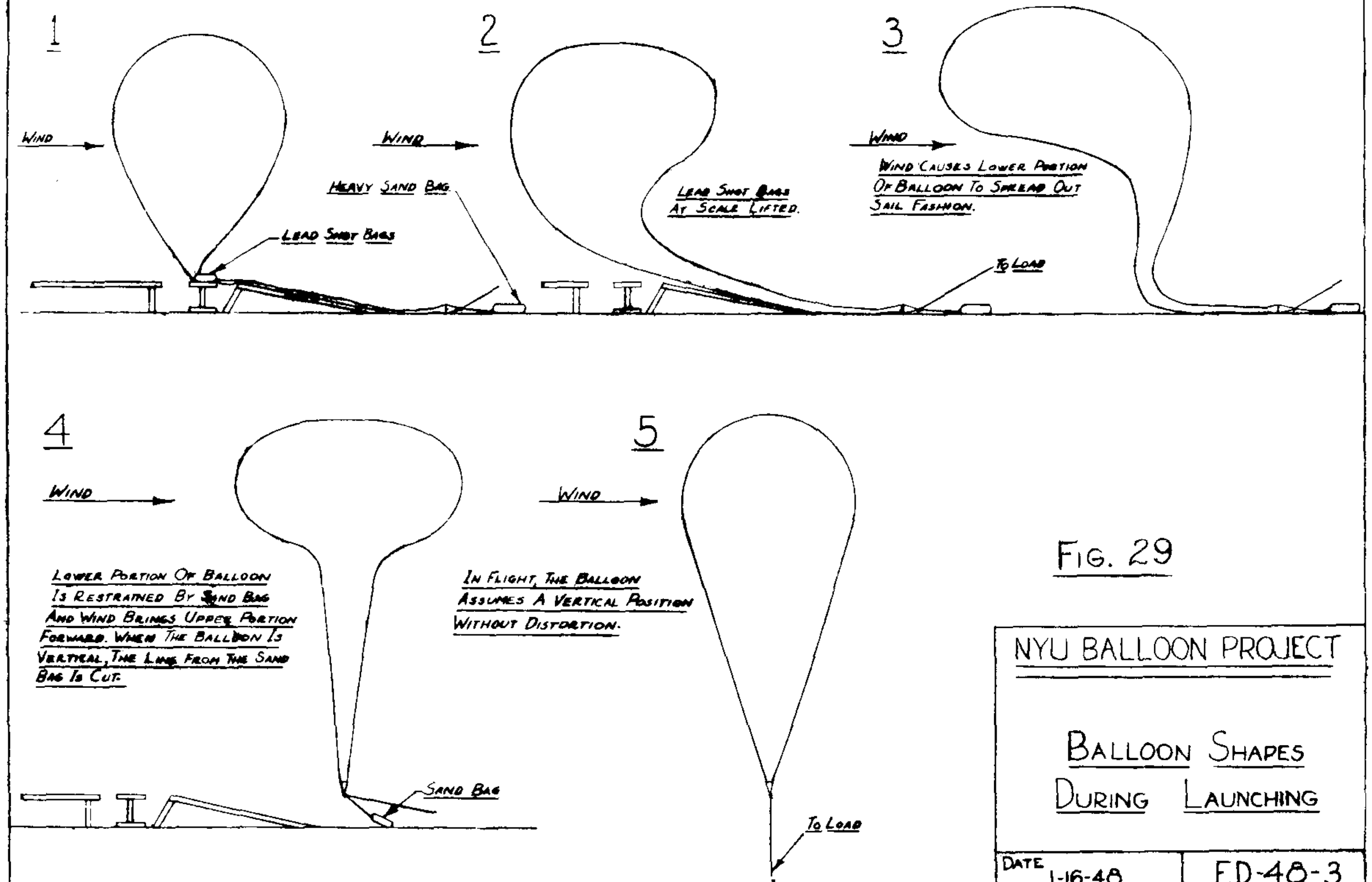


FIG. 29

NYU BALLOON PROJECT

BALLOON SHAPES DURING LAUNCHING

DATE 1-16-48

ED-48-3

This method of release is a development of the upwind release used in radiosonde flights in the U.S. Weather Bureau, with refinements first used by General Mills Aeronautical Research Laboratories and necessitated by the larger balloon size and the number of components on each flight.

Using this method, successful releases were made at Alamogordo in winds of 20 miles per hour with gusts up to 30 miles per hour.

C. Recovery

Much additional information on the behavior of the train components can be gained if they are recovered. Two methods of recovery are employed: 1) reward tags and 2) recovery by the balloon crew tracking the flight.

Reward tags attached to several components have encouraged the finders to protect the equipment and report its location. The tag and associated questionnaire are included in Appendix 3. Total recovery of flights to date is about 60% of those released.

When the location of the balloon is known by visual observation from an airplane, or the landing area is indicated by direction-finding gear, recovery is attempted by truck by the balloon crew or the crew at one of the downwind stations. Several successful recoveries have been made of flights of relatively short range. It was found in earlier attempts that the balloon equipment was a difficult target both in the air and on the ground. Consequently a colored cheesecloth banner (6 by 12 ft., stiffened top and bottom) was added to the train. It also is a convenient marker for theodolite stadia measurements. A banner may be seen in Figure 30. White banners seem to be the most generally useful.

Section 5. Flight Summary

A summary of pertinent information on all flights made to date is included in Appendix 1 as table VII. Also shown there are flight train

Figure 30
General Mills 20 foot balloon
in flight, showing banner and other
flight train components.

diagrams, time-height curves, trajectories and photographs of significant flights, grouped by flight numbers. The flight numbering system has been revised since its inception and now only those flights in which an attempt was made to control the altitude of the balloon are included in the summary. Excluded are flights made to test special gear and launchings which were not successful.

Flights A, B, 1, 5, 6 and 7 all made use of meteorological balloons in various arrangements and combinations. Each flight included one or more "lifting balloons" which were to be released from the train when the desired altitude was reached, the other balloons then theoretically supporting the load at the constant altitude.

Figures 31 and 36 show the two methods used to group the balloons in clusters. Figure 31 shows the linear array borrowed from cosmic ray flight techniques; figure 36 shows the modified "Helios Cluster" in which lines from the balloons are joined at a central ring at the top of the load line.

The Helios cluster was by far the easier to handle because of the simpler rigging and the reduced launching strains.

Flight 7 was the only one of this group in which anything approaching a controlled altitude was attained. The previous flights failed to level off when the lifting balloons broke loose. In flights 1, 5 and 6, where ballast dropping devices were included, the ballast either did not drop, or the dropping did not have the desired effect. In flight 7, however, the cluster rose till the lifters were cut off, descended until sufficient ballast was dropped to cause the cluster to rise to a still higher altitude. There several balloons burst, resulting in a final descent. The time-height curve for this flight is shown as figure 38.

This flight pattern represents the best approximation to constant level flight that we have obtained with meteorological clusters.

Flights 8 and 11 each employed more than one polyethylene balloon in an attempt to reach higher altitude than possible with the single balloons then available. Figure 39, 40, 41, 44 and 45 show the type and arrangement of balloons and their flight behavior. In both flights, the maximum altitude was not high enough to cause activation of the automatic ballast valve. Consequently, there was no compensation for diffusion other than the steady leakage of ballast through the imperfect seating of the valve. In flight 8, after one hour, this leak was not sufficient to maintain a constant altitude, so the flight terminated. However, in flight 11, constant altitude was maintained at 16,000 ft. $\pm$ 1500 feet for 7 hours until all of the ballast was expended.

Flight 10, in contrast to flights 8 and 11, did reach an altitude at which the automatic ballast control was actuated, resulting in a flight of perhaps more than 26 hours. Although the maximum altitude reached by this heavy spherical cell was 15,000 feet, the ballast control was effective at a level of 9000 feet. The expected difference between activation level and operation level was probably exceeded because of the temperature effect of the air entrapped in the pressure capsule.

Figure 42 shows the train, and figure 43 shows the time-altitude curve for the 512 minutes of radiosonde data.

The oscillations around 9000 feet during the last two hours of data may be attributed to the changing buoyancy of the balloon as cloud masses intermittently shielded it from the sun's rays. An unconfirmed report was received to the effect that this balloon was still floating 26 hours later over Pueblo, Colorado.

Flight 12 was designed to overcome the difficulties encountered in flights 8 and 11, and, by the use of a thin tear-drop balloon (General Mills balloon) to carry the load to a higher altitude than flight 10. To guarantee a predetermined constant ballast flow, the manual ballast valve was added to the flight train. The minimum pressure switch replaced the fixed pressure switch to activate the automatic ballast valve, whether or not a predetermined activation altitude was reached. Figure 46 shows the train; figure 47 shows the time-altitude curve, which exhibits a marked departure from the ideal. The minimum pressure switch failed to operate or operated near surface pressure, effectively preventing the operation of the automatic ballast valve. The manual ballast valve did not provide sufficient flow to prevent the gradual descent of the balloon. Finally, the heavy load necessitated almost complete inflation of the balloon at the surface. This distention permitted continual mixing of air through the open bottom of the balloon. Instead of reaching the pre-calculated 38,000 feet maximum altitude, this flight had a peak of 14,000 feet from which it slowly descended. Since the blowout patch was set to act upon descent to 20,000 feet, it also failed to operate.

Five of the succeeding flights (nos. 13, 14, 15, 16 and 20) had as a prime objective the development of a satisfactory appendix to overcome the loss of buoyancy due to mixing during launching and ascent. The types considered have been discussed in Section II, Part A of this report and the (two foot) appendix stiffened with battens, which was finally evolved, is shown in figure 5. Figures 48, 49 and 50 show the time-altitude curves for these flights. Either short flight or limited radio reception curtailed the trajectory data.

In flight 19, the danger to personnel of the blowout patch was dramatically demonstrated by its firing 30 seconds after release. Launching shocks caused the baroswitch pen-arm to fall off its shelf, completing contact prematurely. In later flights, a time delay switch was placed in series with the baroswitch to prevent a recurrence of this action.

Flights 21, 22, 24, 26 and 27, although carrying altitude control devices, were flown to test gear for associated projects. Either no pressure reporting gear was carried or the data from modified gear proved unreliable. Hence few performance data charts are presented.

Flight 21, using a late-model General Mills 20 foot thin cell and an automatic ballast valve, is known to have lasted for ten hours, descending at Marietta, Oklahoma.

Flight 22, included an earlier model General Mills balloon with a high rate of gas leakage, and an automatic ballast valve. The ballast control kept the balloon aloft, but for only six hours.

Flight 24, including an automatic ballast valve, is believed to have maintained constant level, $\pm$ 1,000 feet, for 122 minutes. It stayed aloft for at least $3\frac{1}{2}$ hours, when transmission ceased. The time-altitude curve is shown in figure 51.

Flignt 27 employed a fixed rate of leak rather than an automatic ballast valve. The manual control did not provide sufficient ballast flow, accounting for the time-altitude curve shown in figure 52.

Flights 29 through 37 and flight 39 were undertaken to test the downwind launching procedure, to try for higher constant level altitudes, and to determine the feasibility of using the General Mills thin cells for frequent service flights. Flights 37 and 39 burst early. The former was released during a rainstorm and balloon failure occured at the seams.

Flight 29, with a manual ballast valve, was released just before sunset on 22 November. It was observed descending 50 miles north of Toronto, Ontario, Canada, 14 hours later. The average wind was 130 mph. Radio receiption was for 69 minutes.

Of the other recent flights, satisfactory radio performance was enjoyed only on flight 36. Before any more flights are made, a better transmitter and battery pack will be needed. Even on this flight the signal was lost after 135 minutes, due to excessive range. The last plotted position was northeast of Tucumcari, N.M. This flight was recovered from Burlington, Iowa.

Time-height curves of this series are included in figures 53, 54 and 55. Despite the limited data, some results can be determined. For example, flight 32 is believed to have floated for at least 70 minutes within 1,000 feet of a constant level above 40,000 feet MSL.

Flight 35 also exhibited 32 minutes of constant-level flight before the radio signal was lost. From the remarkable distances that some of the otners traveled (See flight summary Table VI, Appendix I) it is almost certain that they floated for long periods.

These flights included a simple-filter manual ballast valve assembly (Figure 9) designed to reduce equipment weight and cost. The performance of this equipment justifies its continued use for relatively short flights.

Considerable difficulty was experienced with the type of filter used. Experiments are now being conducted to improve the filter.

Because of limited data received from earlier flights, modified Fergusson meteorographs were added to the equipment train on flights 33, 35 and 39. As of January 1, 1948 none of these instruments have been recovered.

Flight 17, using a fifteen-foot balloon of .004 Polyethylene is worthy of special consideration. The thickness of this type of cell eliminates much of the próblem of appendix design since more internal pressure can be withstood. Despite this factor, and the low permeability of the fabric, balloons of this type are too heavy and costly to be used for high altitude flights.

The trajectory and time-altitude curve of this flight are shown in figure 56 and 57. This controlled-altitude flight demonstrates that the automatic ballast valve combined with a fixed leak, will successfully maintain constant altitude through a sunset. The balloon floated at 29,000 feet $\pm$ 500 feet for at least three hours, after which the excessive range prevented further radio reception. Here again the necessity of a barograph was demonstrated as the balloon was recovered from Pratt, Kansas, 530 miles away. Two flights, 23 and 38, were made using the shrouded Dewey and Almy J-2000 Neoprene balloon. Both of these flights were failures. Flight 23 (see figure 48) attained a maximum altitude at 50,700 feet and began to descend immediately. Flight 38 (see figure 55) was observed from a B-25, and the balloon was seen to burst within the shroud.

Section 6. Current Objectives

In order to meet the requirements for future flights, improvement must be made in three phases:

1. Performance data for too many flights have been either uncertain or of too short duration. Before more flights are undertaken, altitude-measuring instruments must be improved and increased. To this end, four specific improvements are being undertaken:

    A. To supplement the pressure data received by radio, a lightweight barograph will be added to those flight trains in the future when flights of more than a few hours' duration are attempted.

B. The improvement of radio transmitter gear; it is planned to utilize the three megacycle transmitter developed in the Electrical Engineering Laboratories at New York University. In previous tests, this has provided clearer reception and a longer range for comparable weight than either the 72 megacycle or 397 megacycle units previously used. To provide direction finding, 397 megacycle carrier signal will also be transmitted which will be tracked by SCR-658 sets. It is also hoped that a better light weight battery pack can be developed for airborne use.

C. The Olland cycle time-interval method of presssure measuring and data presentation is being adapted, with the following advantages anticipated:

(1) The direct interpretation of pressure data in terms of the time interval eliminates the ambiguities inherent in counting pressure contacts in the Diamond-Hinman system. Used in conjunction with the Brush recorder operating at medium speed, and with four turns on a helix rotating once a minute, the pressure readability of this system will be better than one millibar.

(2) Under noisy conditions the recorded data obtained with this system will be more readable than the audio signal now being employed. When only pressure data is being transmitted, this system can be more economical of power than is a system of modulated audio frequencies.

(3) In cases where data other than pressure is also to be transmitted on the same radio channel, the pressure

signals may be arranged so as to consume a very small portion of transmission time.

D. The duration of radio reception and of positioning data may be greatly extended by appropriately equipped aircraft. It is intended to utilize a B-17 with top-mounted radar to search above the plane for tracking. Depending upon the noise-level encountered, it may be possible to acquire pressure data with a receiver in the plane. It may be necessary to provide at least two aircraft for continuous reception over long periods.

2. It is very desirable that the simplified light-weight ballast control system for flights of less than 24 hours' duration be perfected. The elaborate ballast assembly with the automatic ballast valve will not be needed for the many contemplated flights which will be made with a useful life of less than eight hours. A lower-capacity reservoir with manual ballast valve and filter provides a light-weight, inexpensive unit. Tests are now being conducted to find the best design for these components.

3. In order to float a balloon at a pre-selected maximum altitude it is necessary to supplement the variation-of-ballast with a new height control system.

A. With a given balloon, and given total load, it is possible to forecast the maximum height. (See Section III for the computation.) If various maximum heights are desired, this maximum height may be varied by varying the total load, or varying the bouyancy of the balloon through variation in balloon volume.

The method used heretofore is variation of balloon load through changes in the amount of ballast used. However, there are upper and lower limits on the amount of ballast that can be used, due to the strength limitations of the fabric. Also, the "height sensitivity"; that is, the ratio of change in altitude to change in load, is not great enough to provide suitable choice of heights.

B. Another attack is to effect a change of volume by making openings below the equator of the balloon. The volume of gas contained in the balloon envelope is then obviously limited.

C. If this method of height control proves to be unsatisfactory, still other control mechanisms will be sought.

The three objectives, with their indicated subdivisions, will be pursued to better effect control of the balloon altitude. A parallel pursuit will be the investigation of other balloon types and sizes, in addition to the satisfactory General Mills Polyethylene models now in use. Thus, plans for the future include both the development of control devices currently under test and also a broad, general study of the basic components of constant-level balloon trains from the theoretical as well as the operational viewpoint.

APPENDIX 1

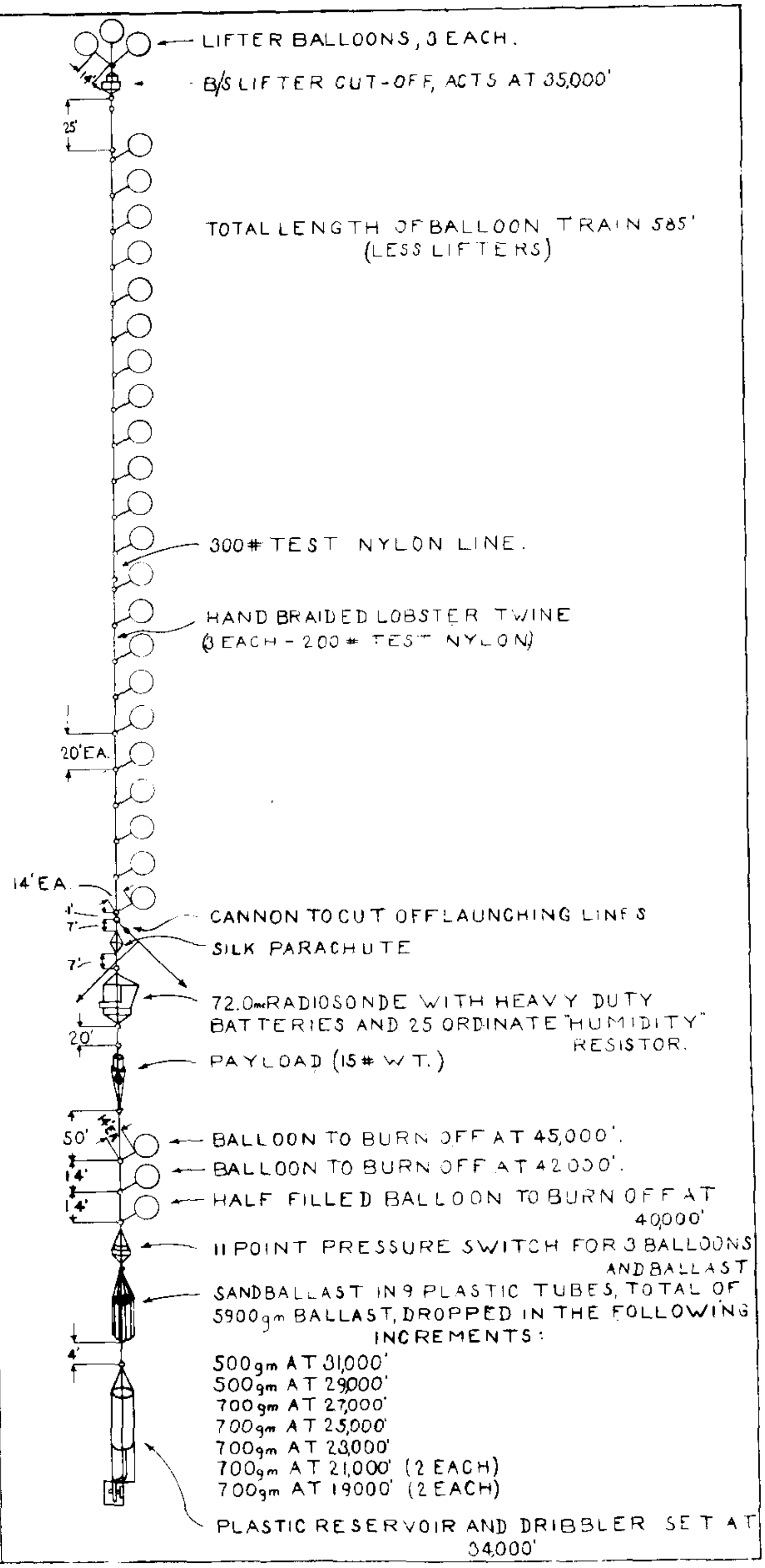


FIG 31

NYU BALLOON PROJECT

Flight 5

DATE 6-5-47 | ED 48-39

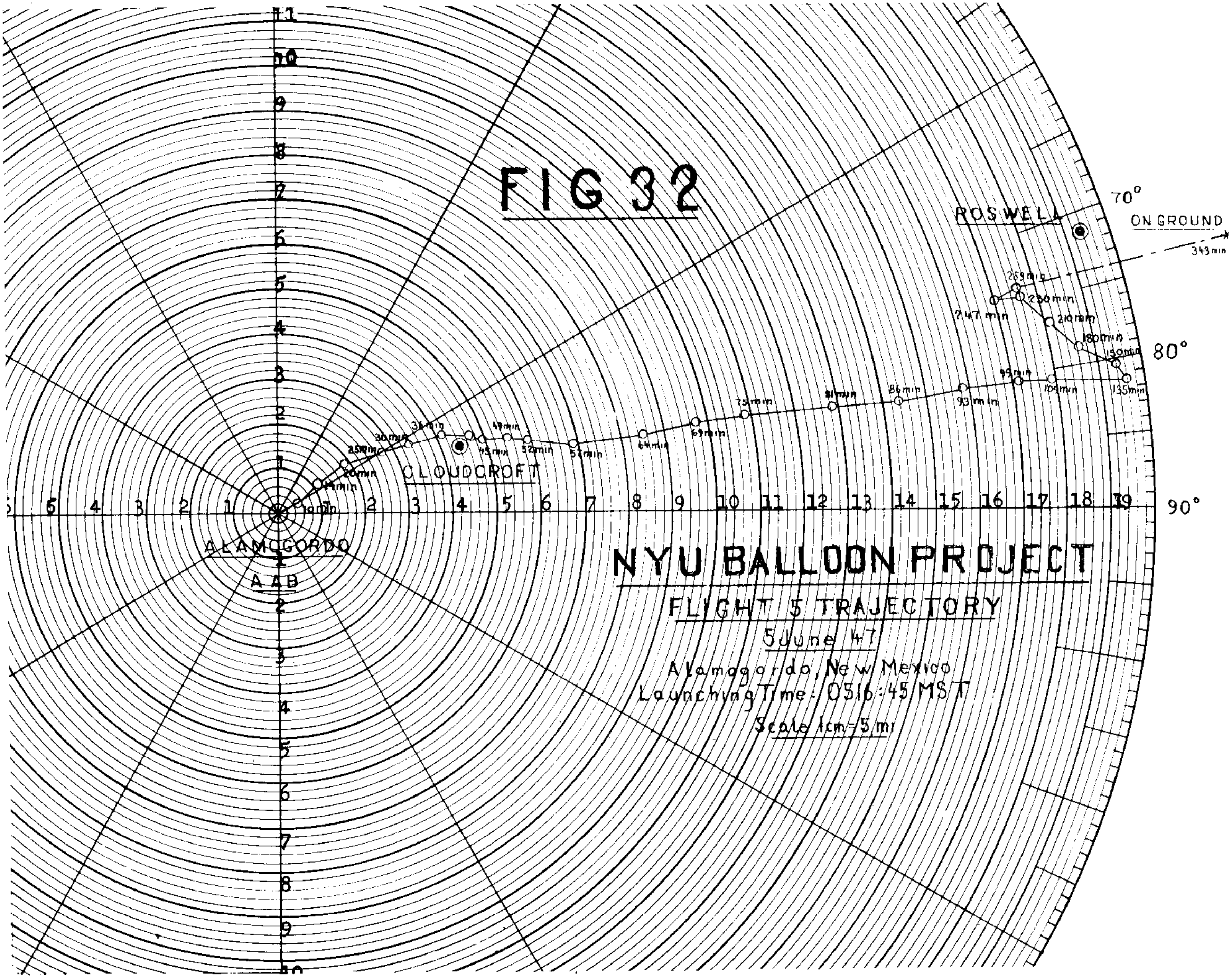


FIG 32
ROSWELL
70°
ON GROUND
343 min
80°
90°
CLOUDCROFT
ALAMOGORDO
AAB
NYU BALLOON PROJECT
FLIGHT 5 TRAJECTORY
5 June 47
Alamogordo, New Mexico
Launching Time: 0516:45 MST
Scale 1cm=5 mi
247 min
259 min
230 min
210 min
180 min
150 min
135 min
109 min
99 min
93 min
86 min
81 min
75 min
69 min
64 min
57 min
52 min
49 min
45 min
36 min
30 min
25 min
20 min
14 min
10 min

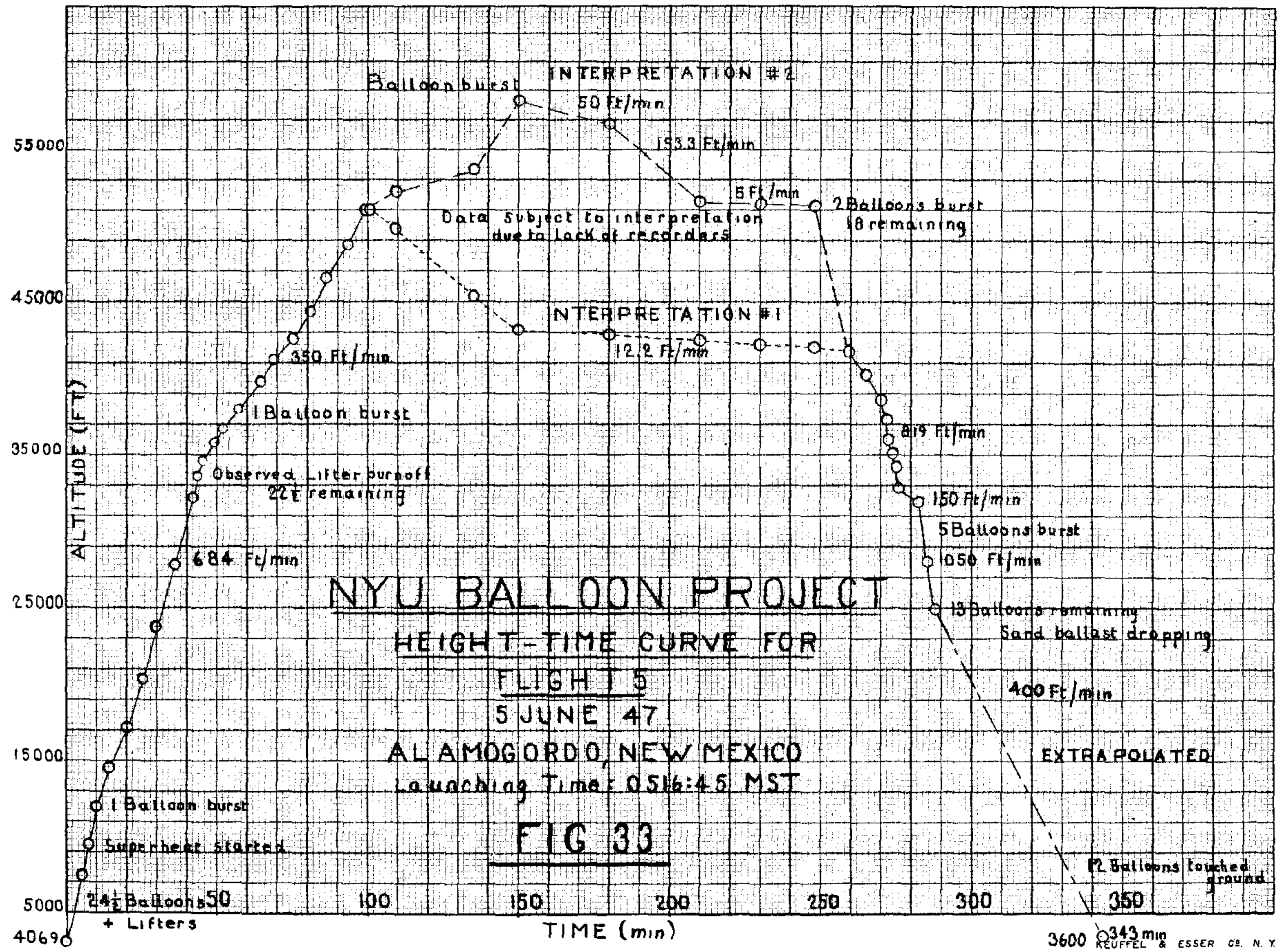

NYU BALLOON PROJECT
HEIGHT-TIME CURVE FOR
FLIGHT 5
5 JUNE 47
ALAMOGORDO, NEW MEXICO
Launching Time: 0516:45 MST
INTERPRETATION #2
INTERPRETATION #1
Balloon burst
50 Ft/min
153.3 Ft/min
5 Ft/min
2 Balloons burst
18 remaining
Data subject to interpretation
due to lack of recorders
12.2 Ft/min
350 Ft/min
1 Balloon burst
Observed Lifter burnoff
22½ remaining
684 Ft/min
819 Ft/min
150 Ft/min
5 Balloons burst
1050 Ft/min
13 Balloons remaining
Sand ballast dropping
400 Ft/min
EXTRAPOLATED
12 Balloons touched ground
1 Balloon burst
Superheat started
24½ Balloons
+ Lifters
ALTITUDE (FT)
55000
45000
35000
25000
15000
5000
4069
TIME (min)
50
100
150
200
250
300
350
3600
343 min
KEUFFEL & ESSER CO. N.Y.

FIG 33

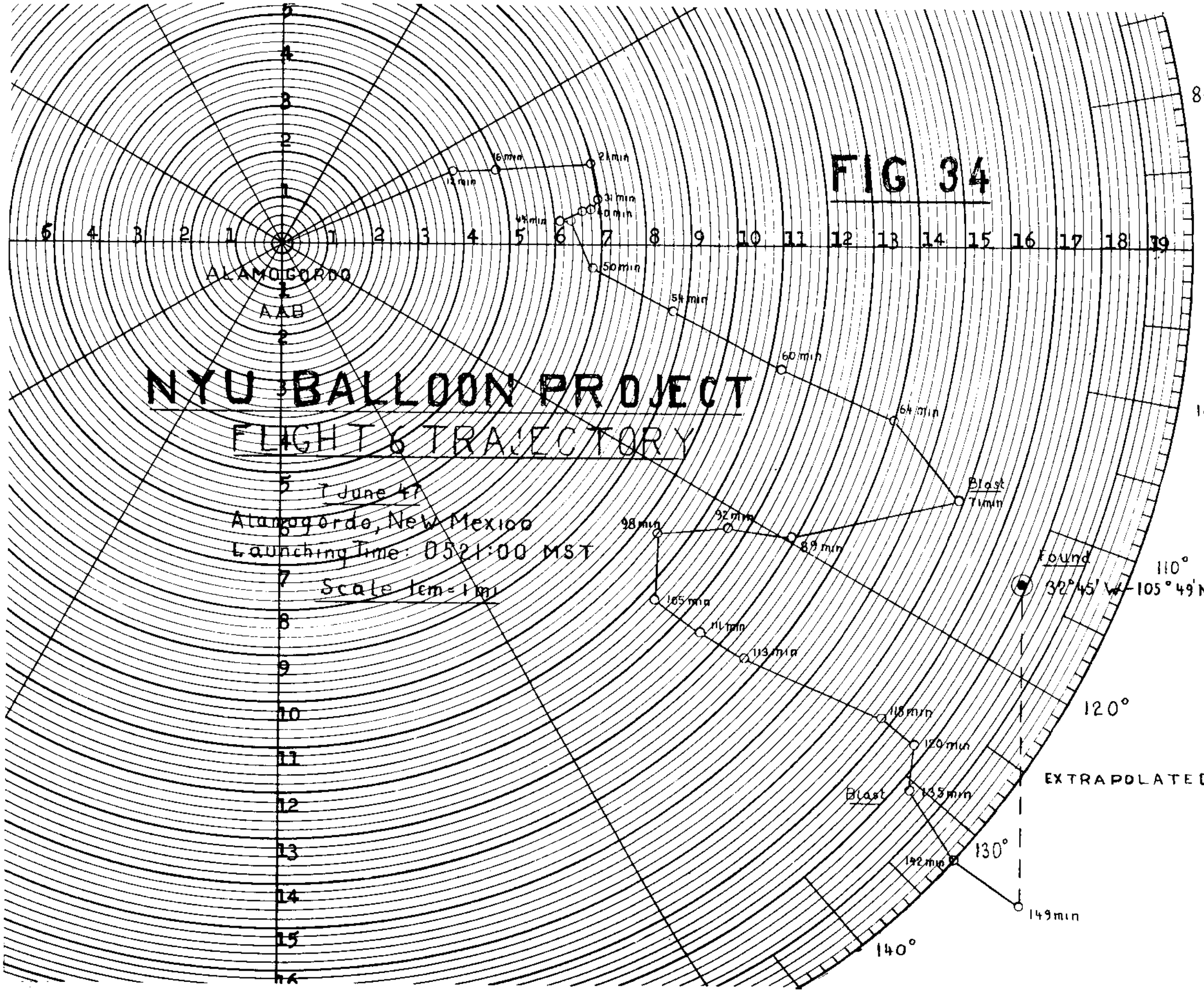

NYU BALLOON PROJECT
FLIGHT 6 TRAJECTORY
7 June 47
Alamogordo, New Mexico
Launching Time: 0521:00 MST
Scale 1cm = 1 mi
ALAMOGORDO
AAB
12 min
16 min
21 min
31 min
40 min
45 min
50 min
54 min
60 min
64 min
Blast
71 min
89 min
92 min
98 min
105 min
111 min
113 min
118 min
120 min
Blast
135 min
142 min
149 min
Found
32°45' W - 105°49' N
EXTRAPOLATED
80°
90°
100°
110°
120°
130°
140°

FIG 34

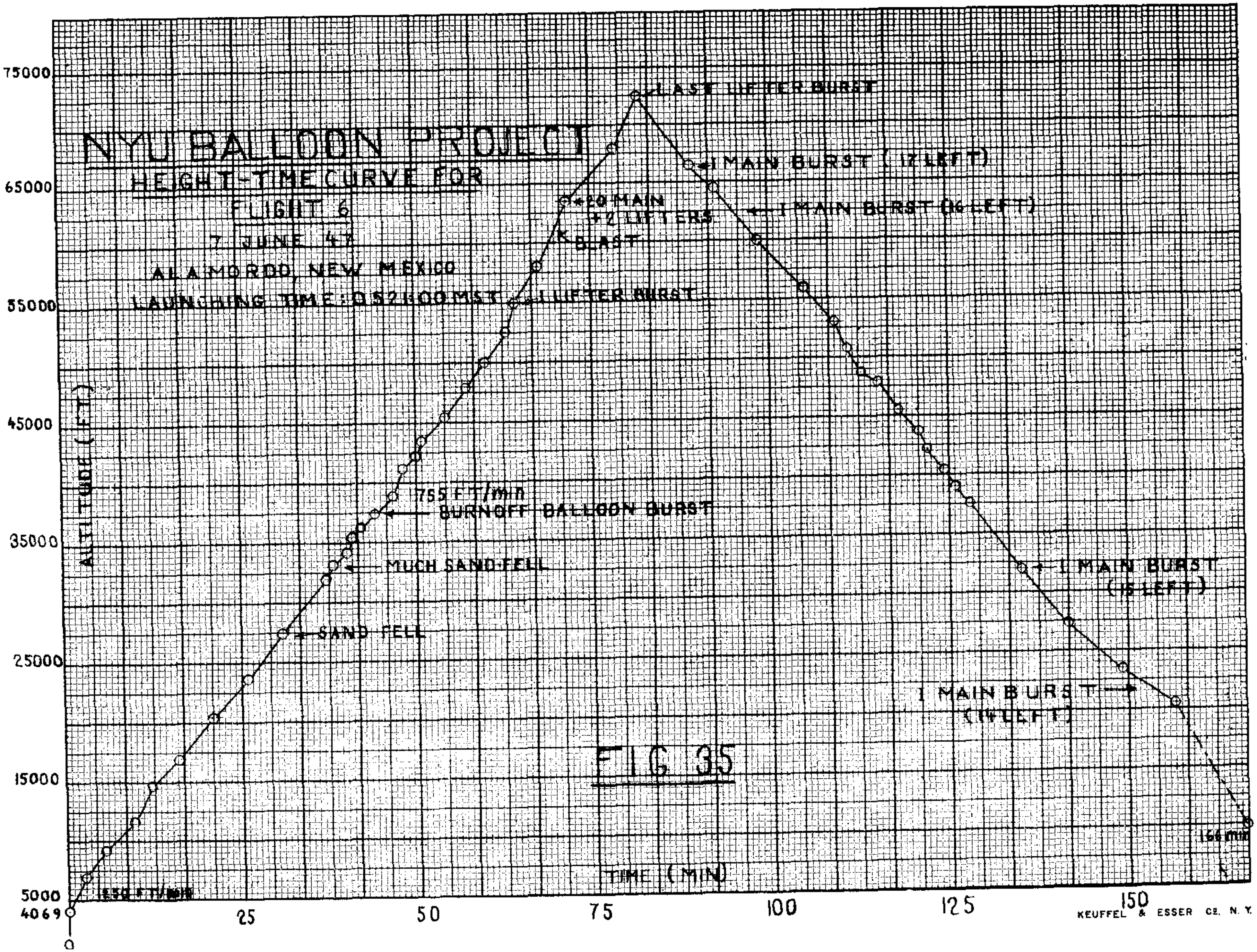
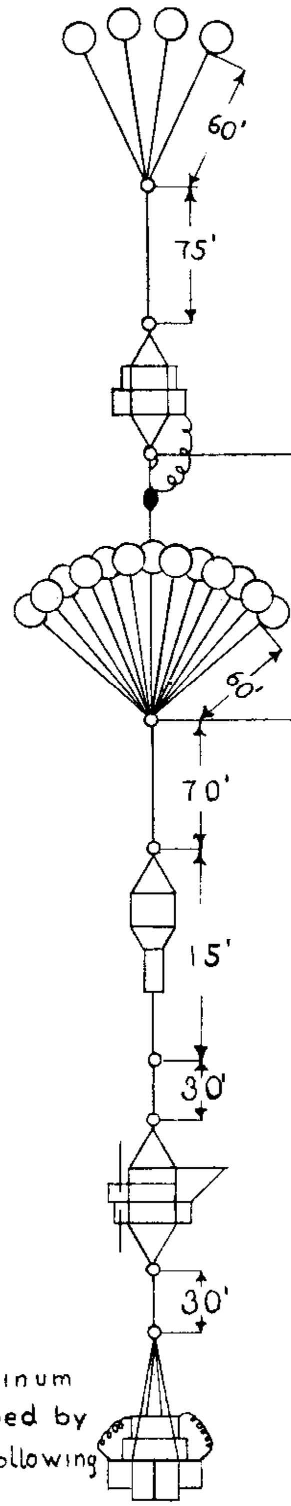

NYU BALLOON PROJECT
HEIGHT-TIME CURVE FOR
FLIGHT 6
7 JUNE 47
ALAMORDO, NEW MEXICO
LAUNCHING TIME: 052100 MST
LAST LIFTER BURST
1 MAIN BURST (17 LEFT)
1 MAIN BURST (16 LEFT)
20 MAIN
+2 LIFTERS
BLAST
1 LIFTER BURST
755 FT/min
BURNOFF BALLOON BURST
MUCH SAND FELL
SAND FELL
1 MAIN BURST
(15 LEFT)
1 MAIN BURST
(14 LEFT)
166 min
1250 FT/MIN
ALTITUDE (FT)
TIME (MIN)
75000
65000
55000
45000
35000
25000
15000
5000
4069
0
25
50
75
100
125
150
KEUFFEL & ESSER CO. N. Y.

FIG 35



Lifter assembly - 4 balloons inflated to 3000 gm. Lift.

B/S lifter cut-off at 35,000'.

12 ea. balloons inflated to 900 gm. Lift, 4 ea. balloons inflated to 2100 gm. Lift.

Payload in picture frame mount and transmitter. (13 # wt.)

74.5 mc Radiosonde. Heavy duty Batteries in black boxes wrapped in polyethylene.

Ballast baroswitch.

Ballast dropper assembly, 16 Aluminum tubes of granulated lead dropped by descent pressure switch in the following increments:

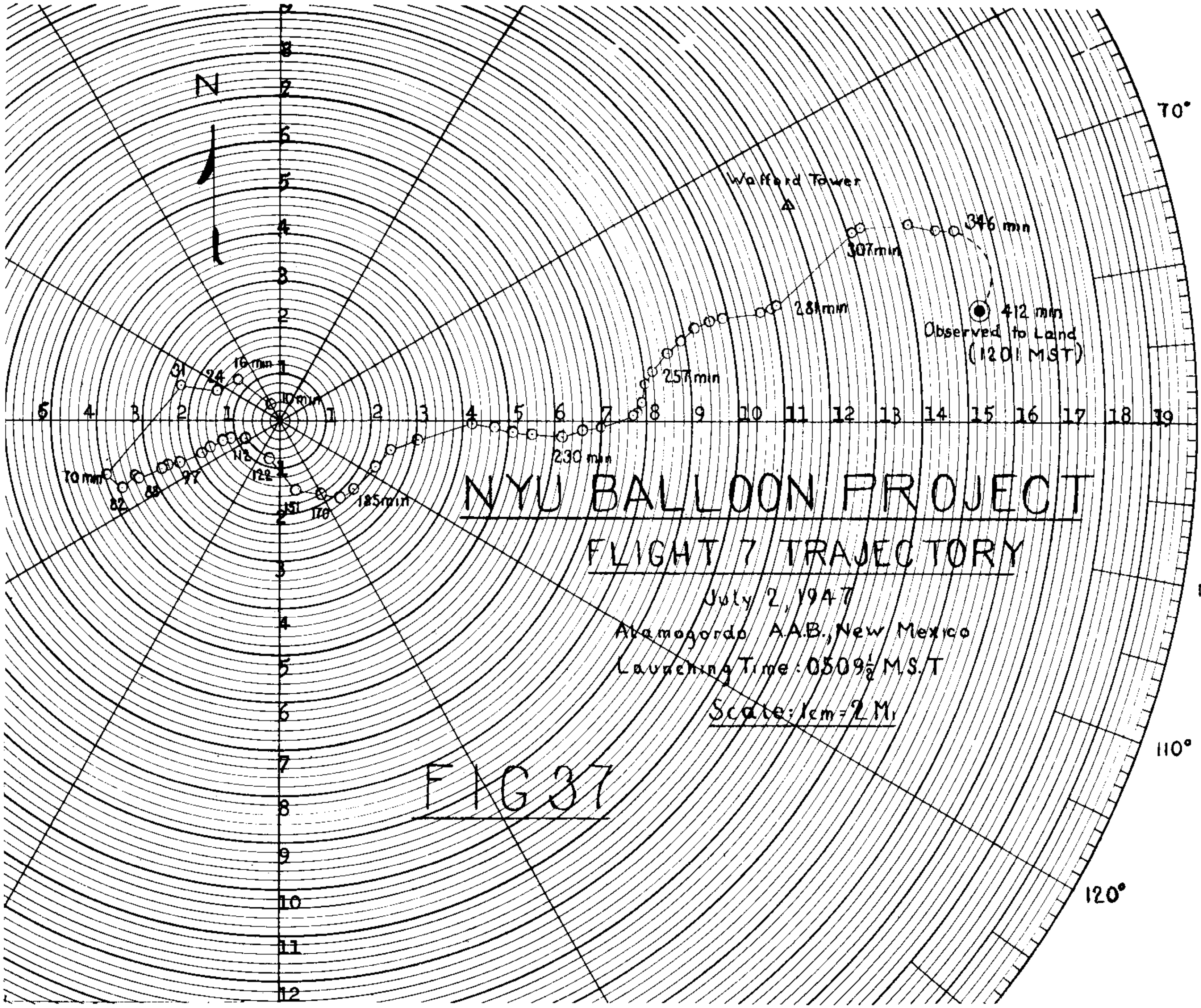
300 gm - 34,000'	400 gm - 29,700'	800 gm - 25800'
200 gm - 33,000'	400 gm - 29,000'	800 gm - 25,200'
200 gm - 32,000'	600 gm - 28,000'	800 gm - 24,500'
300 gm - 31,000'	600 gm - 27,400'	1000 gm - 23,800'
400 gm - 30,500'	600 gm - 26,600'	1000 gm - 23,100'
		1600 gm 22,500'

FIG 36

NYU BALLOON PROJECT

FLIGHT 7

Date: 7-2-47 | ED-48-44



N
Walford Tower
346 min
307 min
281 min
412 min
Observed to Land
(1201 MST)
257 min
230 min
185 min
10 min
70 min
82
85
97
112
122
151
170
31
24
16 min
70°
80°
90°
100°
110°
120°
NYU BALLOON PROJECT
FLIGHT 7 TRAJECTORY
July 2, 1947
Alamogordo A.A.B., New Mexico
Launching Time: 0509½ M.S.T
Scale: 1cm = 2 Mi

FIG 37

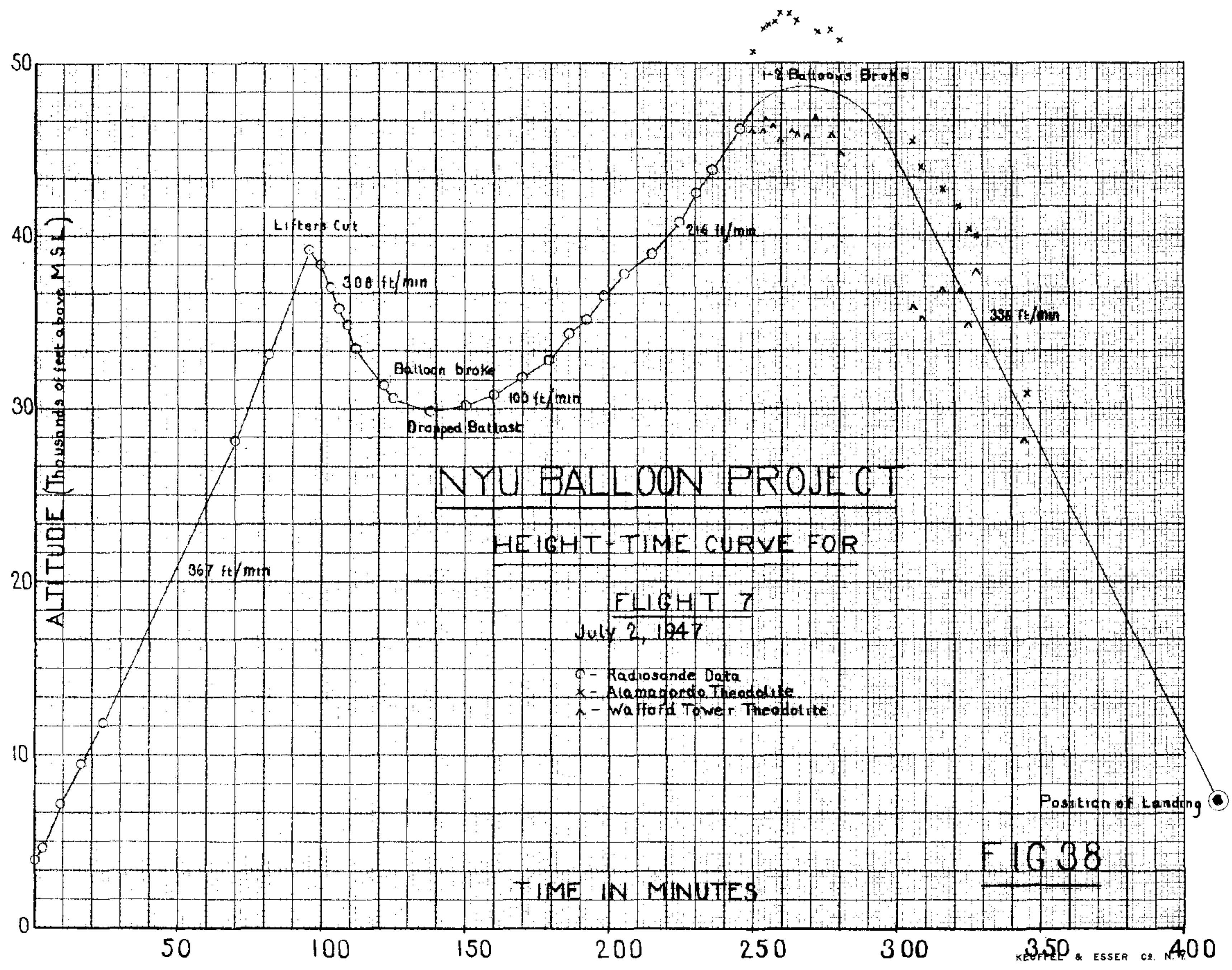

NYU BALLOON PROJECT
HEIGHT-TIME CURVE FOR
FLIGHT 7
July 2, 1947
○ - Radiosonde Data
x - Alamogordo Theodolite
^ - Walford Tower Theodolite
Lifters Cut
308 ft/min
Balloon broke
Dropped Ballast
100 ft/min
216 ft/min
1-2 Balloons Broke
336 ft/min
367 ft/min
Position of Landing
ALTITUDE (Thousands of feet above M S L)
TIME IN MINUTES
0
10
20
30
40
50
50
100
150
200
250
300
350
400
KEUFFEL & ESSER CO. N.Y.

FIG 38

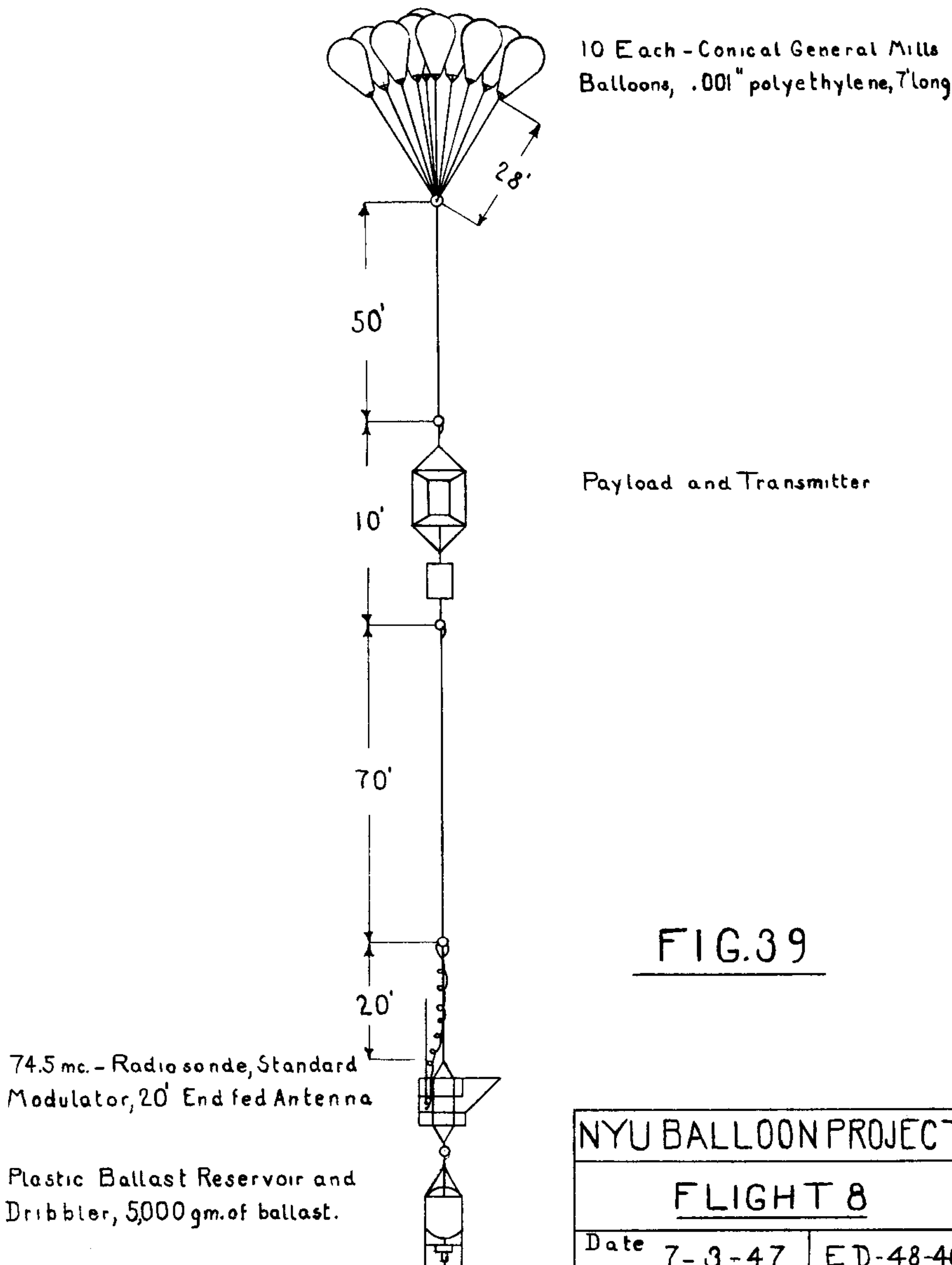
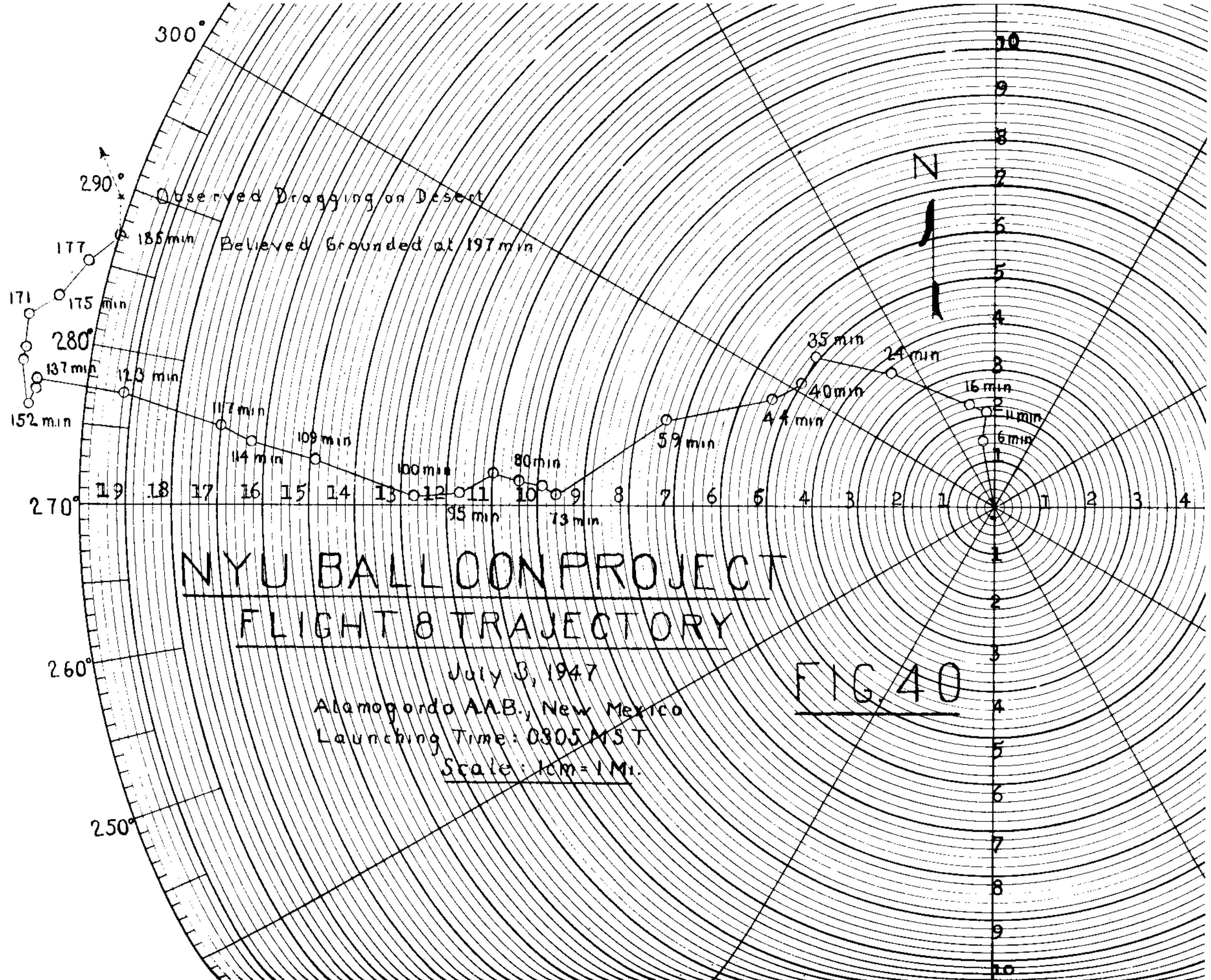


FIG. 39

NYU BALLOON PROJECT

FLIGHT 8

Date 7-3-47	ED-48-40


NYU BALLOON PROJECT
FLIGHT 8 TRAJECTORY
July 3, 1947
Alamogordo A.A.B., New Mexico
Launching Time: 0305 MST
Scale: 1cm = 1 Mi.
Observed Dragging on Desert
Believed Grounded at 197 min
N
300°
290°
280°
270°
260°
250°
6 min
11 min
16 min
24 min
35 min
40 min
44 min
59 min
73 min
80 min
95 min
100 min
109 min
114 min
117 min
123 min
137 min
152 min
171
175 min
177
185 min
FIG 40

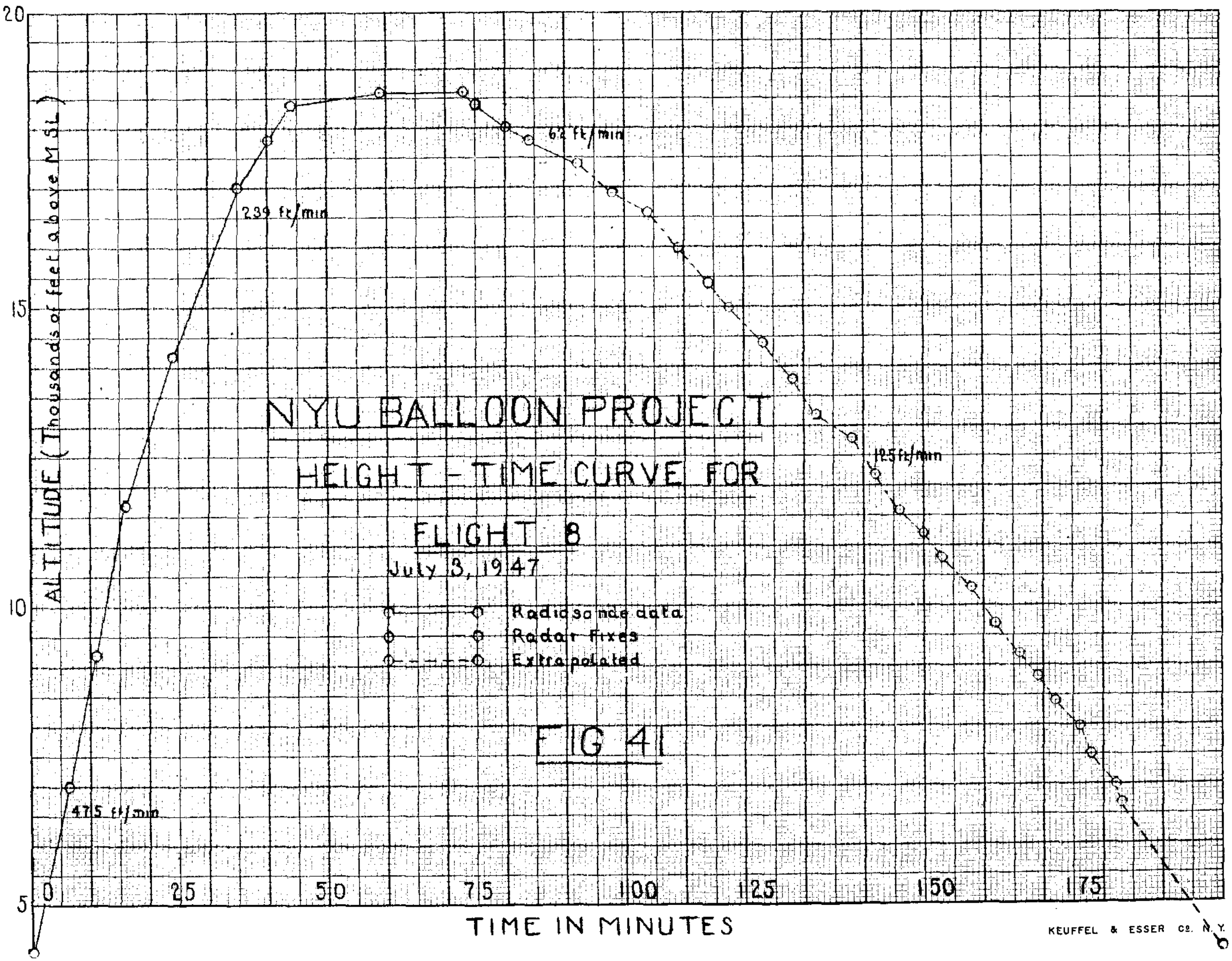

NYU BALLOON PROJECT
HEIGHT - TIME CURVE FOR
FLIGHT 8
July 3, 1947
Radiosonde data
Radar Fixes
Extrapolated
475 ft/min
239 ft/min
62 ft/min
12.5 ft/min
ALTITUDE (Thousands of feet above MSL)
20
15
10
5
0
25
50
75
100
125
150
175
TIME IN MINUTES
KEUFFEL & ESSER CO. N.Y.

FIG 41

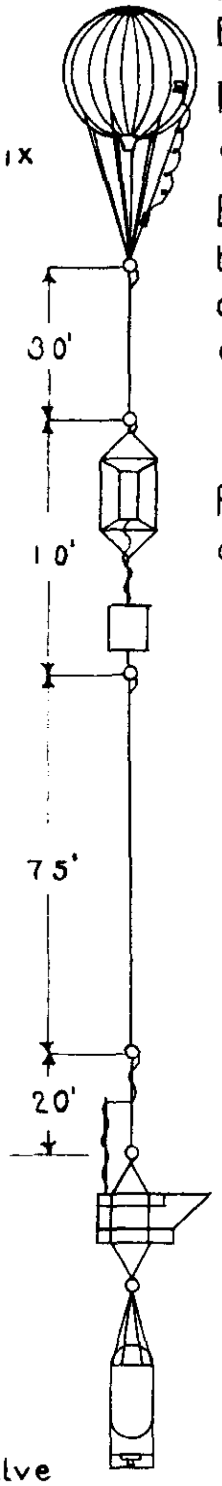
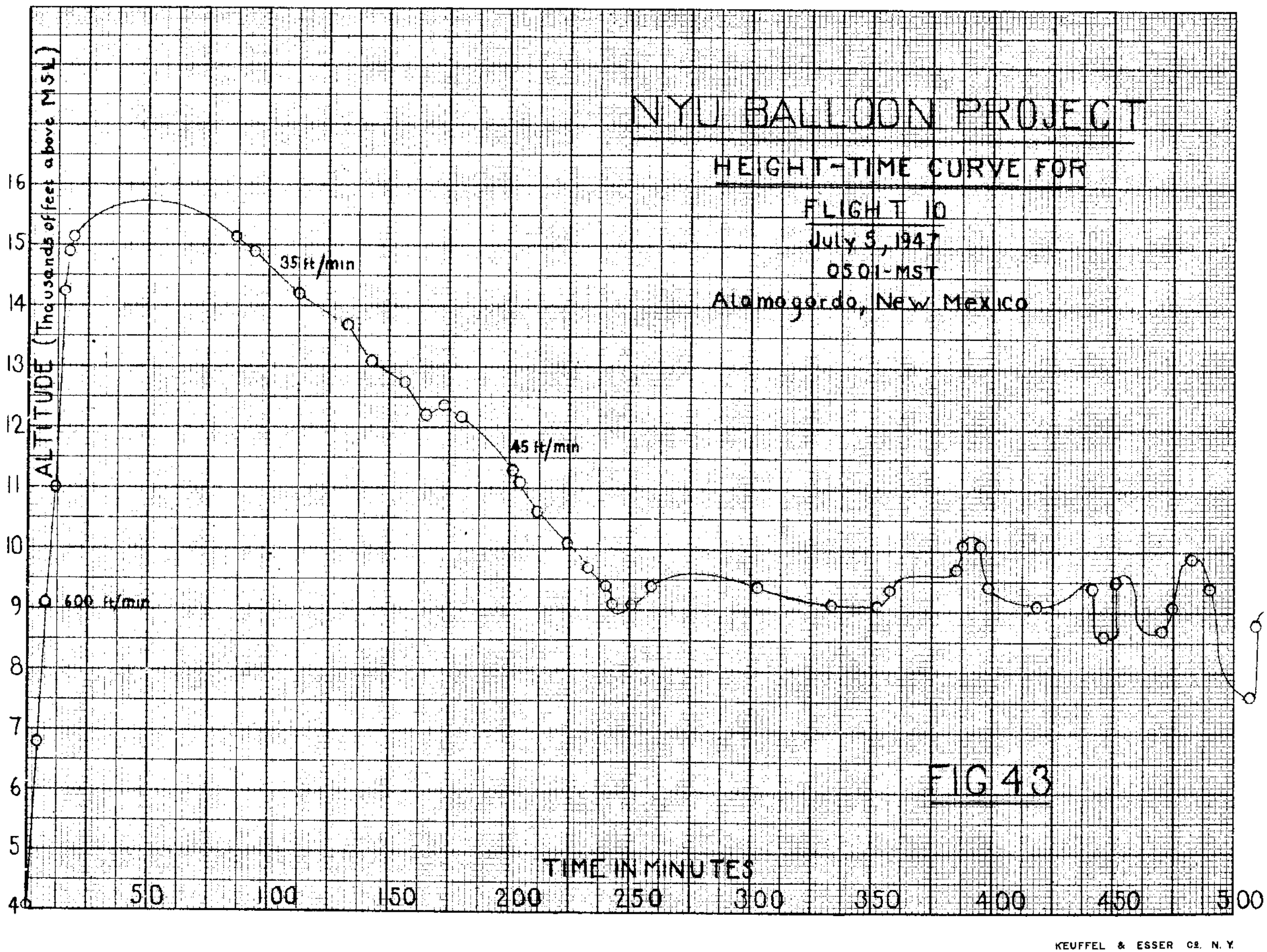


FIG. 42

NYU BALLOON PROJECT	
FLIGHT 10	
Date 7-5-47	ED-48-42



NYU BALLOON PROJECT
HEIGHT-TIME CURVE FOR
FLIGHT 10
July 5, 1947
0501-MST
Alamogordo, New Mexico
ALTITUDE (Thousands of feet above MSL)
TIME IN MINUTES
600 ft/min
35 ft/min
45 ft/min
4
5
6
7
8
9
10
11
12
13
14
15
16
50
100
150
200
250
300
350
400
450
500
KEUFFEL & ESSER Co. N. Y.

FIG 43

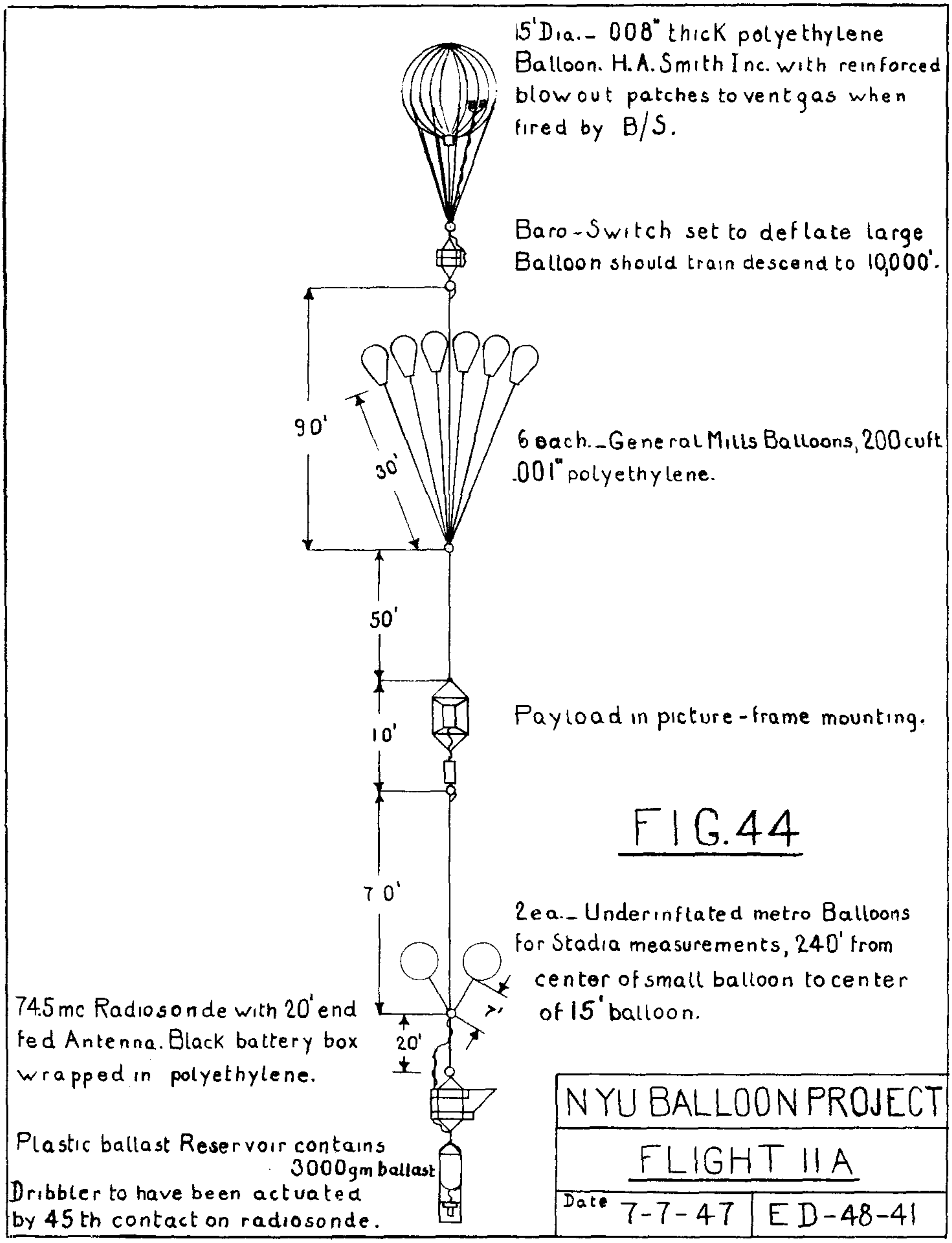

15' Dia. - 008" thick polyethylene Balloon. H.A. Smith Inc. with reinforced blowout patches to vent gas when fired by B/S.
Baro-Switch set to deflate large Balloon should train descend to 10,000'.
90'
30'
6 each. - General Mills Balloons, 200 cuft .001" polyethylene.
50'
Payload in picture-frame mounting.
10'
70'
2 ea. - Underinflated metro Balloons for Stadia measurements, 240' from center of small balloon to center of 15' balloon.
74.5 mc Radiosonde with 20' end fed Antenna. Black battery box wrapped in polyethylene.
20'
Plastic ballast Reservoir contains 3000 gm ballast
Dribbler to have been actuated by 45th contact on radiosonde.
NYU BALLOON PROJECT
FLIGHT 11A
Date 7-7-47
ED-48-41

FIG. 44

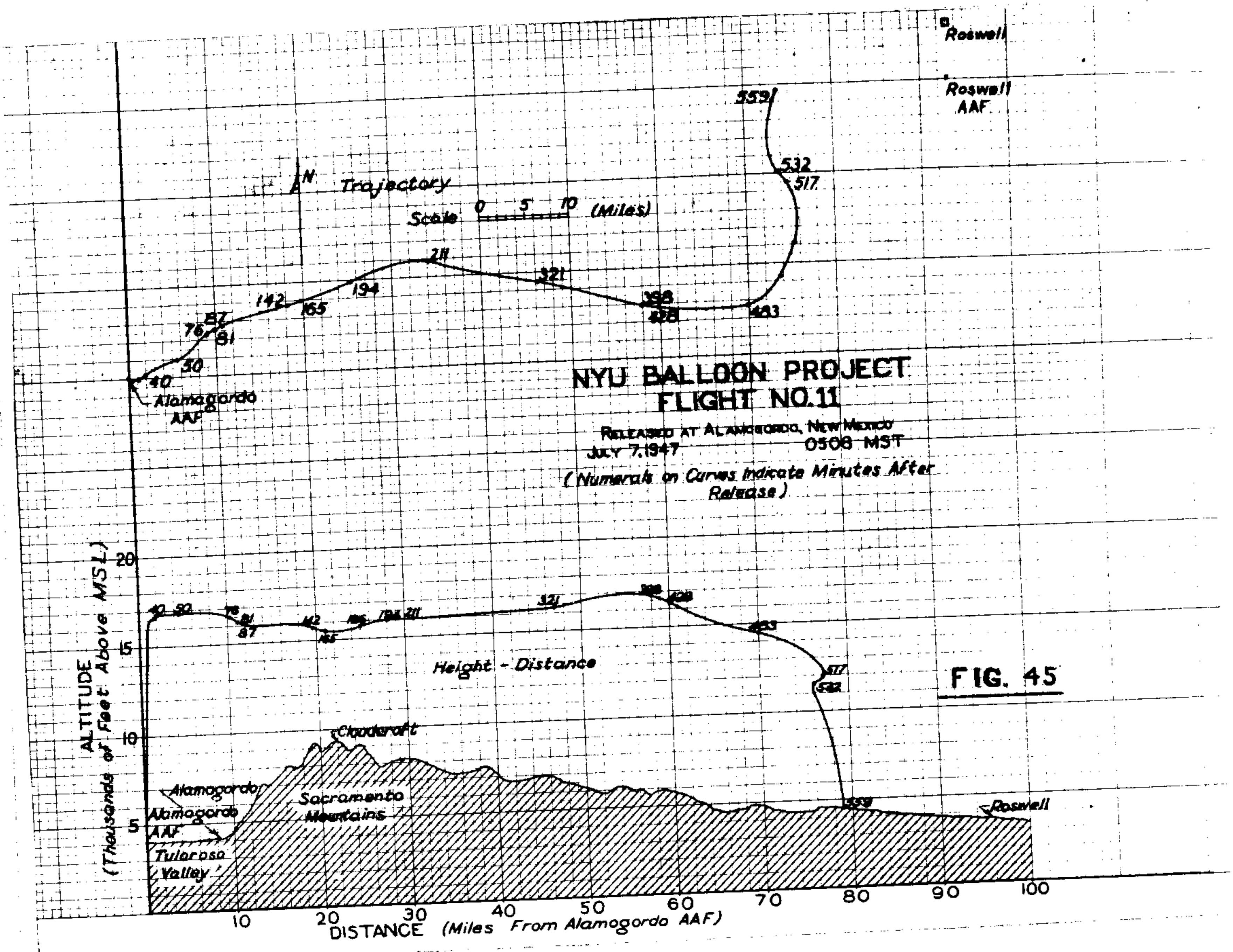

NYU BALLOON PROJECT
FLIGHT NO.11
RELEASED AT ALAMOGORDO, NEW MEXICO
JULY 7, 1947 0508 MST
(Numerals on Curves Indicate Minutes After Release)
Trajectory
N
Scale 0 5 10 (Miles)
Roswell
Roswell AAF
Alamogordo AAF
Height - Distance
Cloudcroft
Sacramento Mountains
Alamogordo
Alamogordo AAF
Tularosa Valley
Roswell
40
50
76
81
87
142
165
194
211
321
398
408
483
517
532
559
ALTITUDE (Thousands of Feet Above MSL)
5
10
15
20
DISTANCE (Miles From Alamogordo AAF)
10
20
30
40
50
60
70
80
90
100

FIG. 45

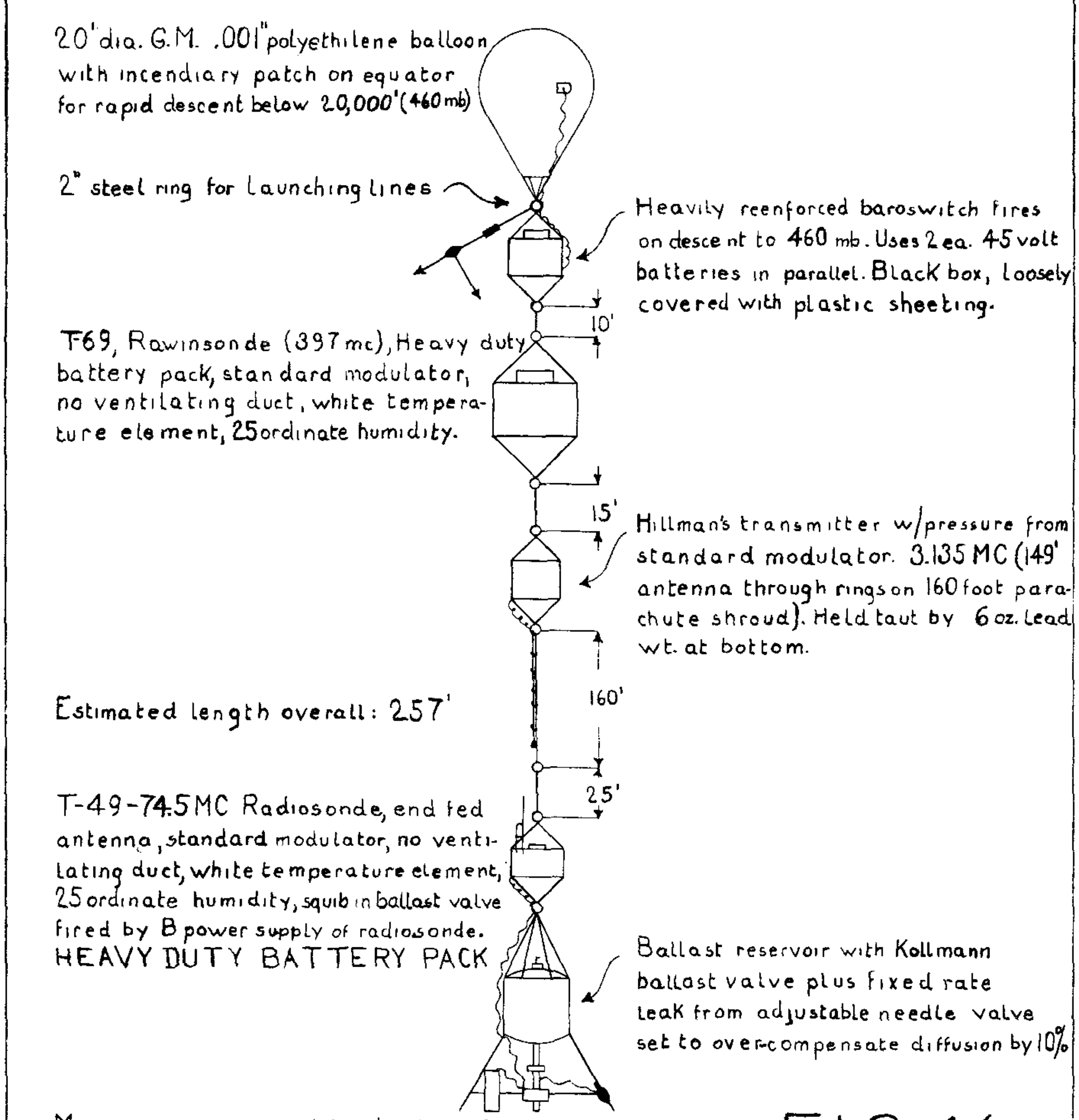


FIG. 46

NYU BALLOON PROJECT	
FLIGHT 12	
Date 8-5-47	ED-48-43

[redacted]

NYU BALLOON PROJECT

HEIGHT-TIME CURVE FOR

FLIGHT #12
LAKEHURST N.A.S.
NEW JERSEY 5 AUG 1947

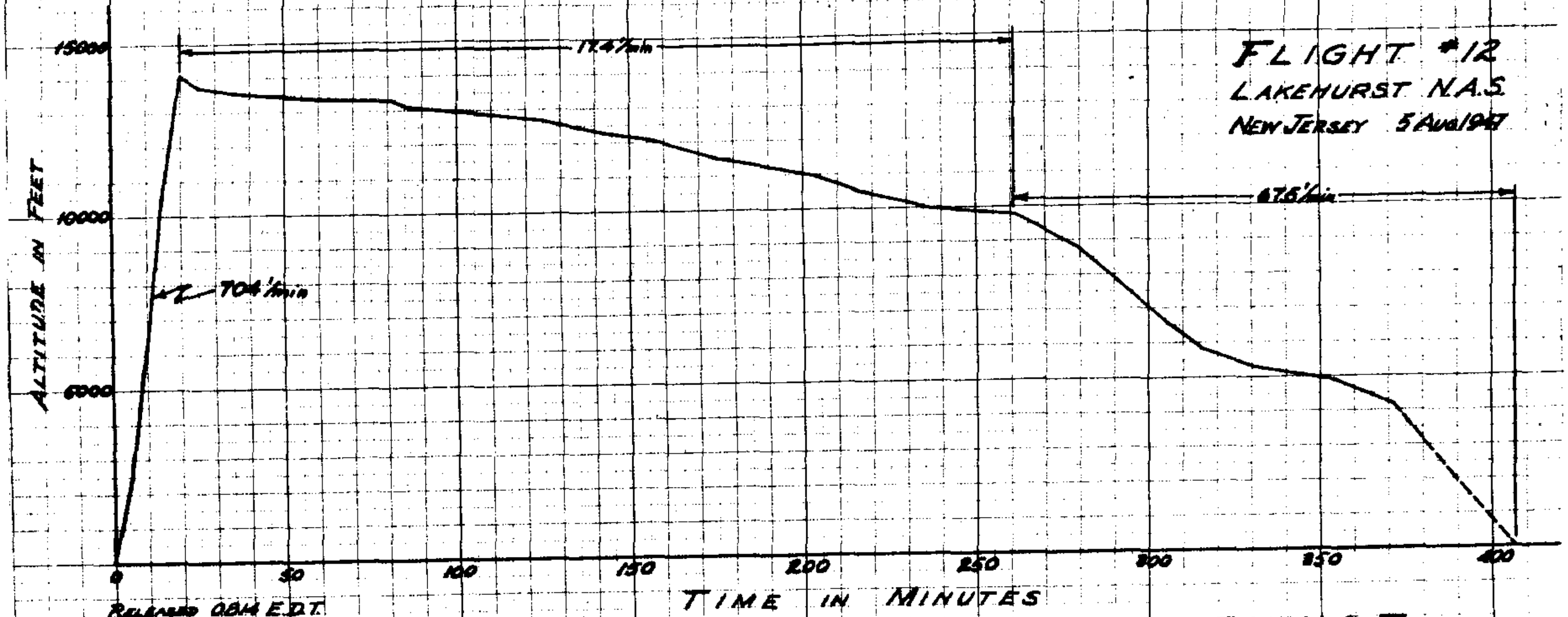
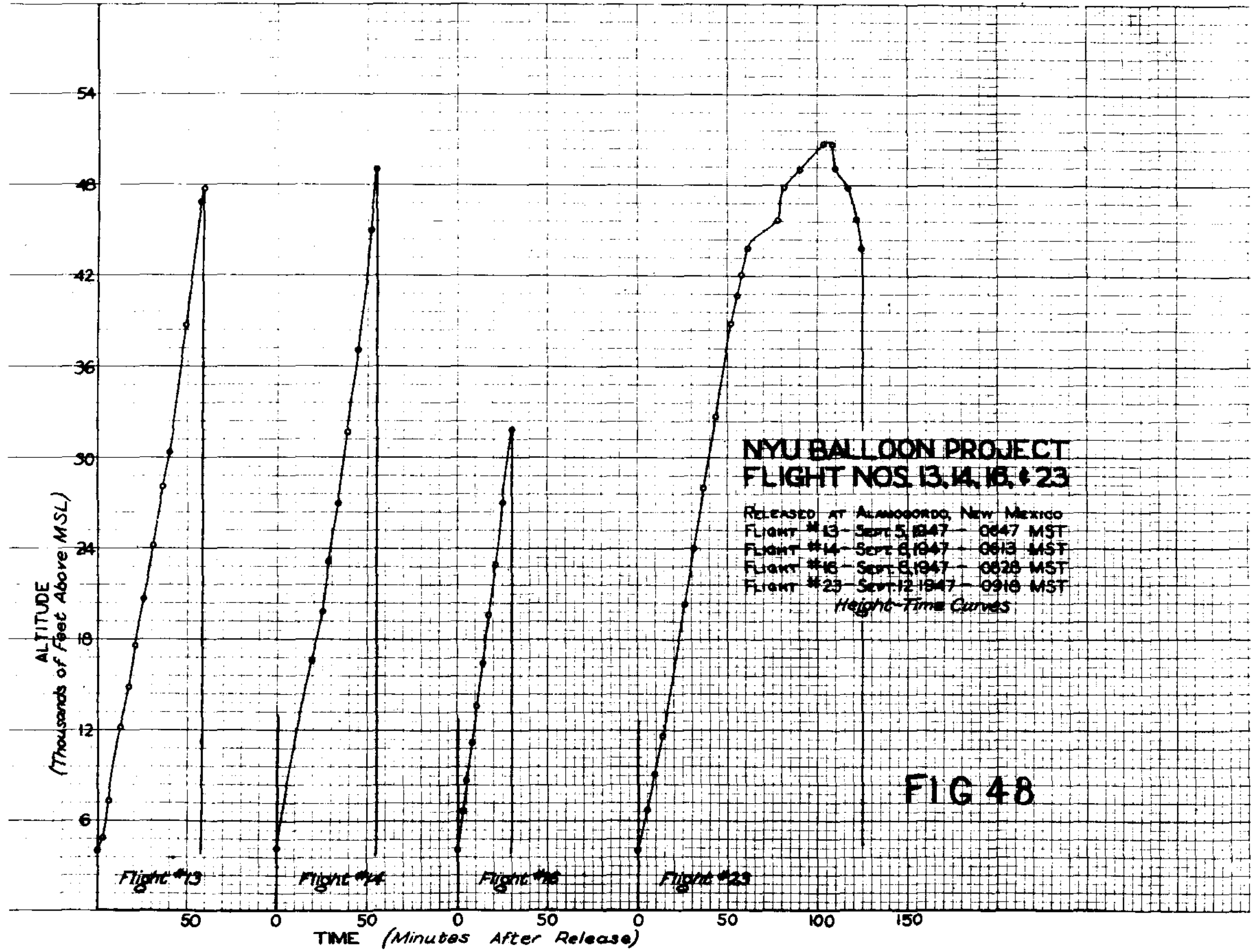
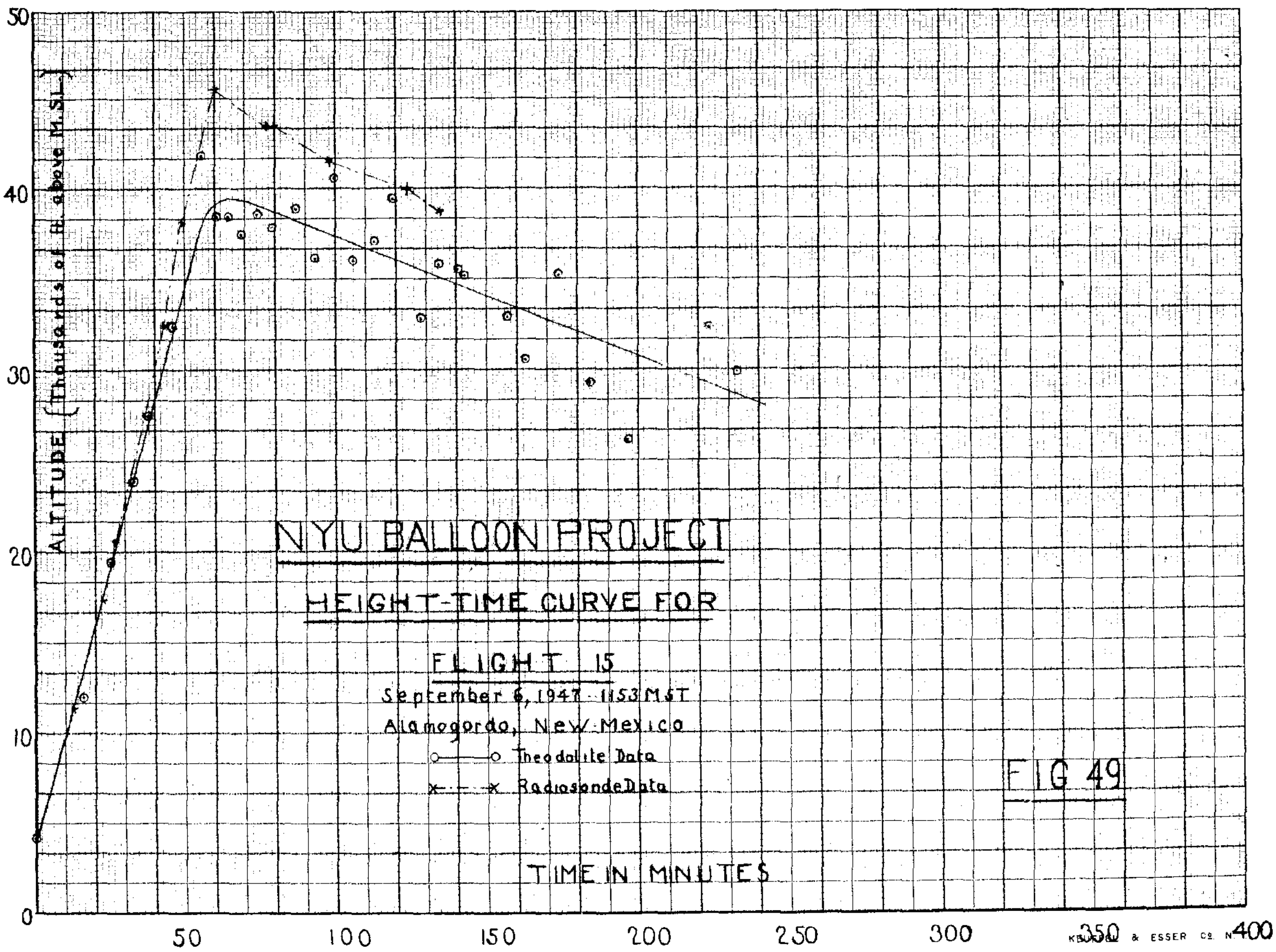


FIG 47



NYU BALLOON PROJECT
FLIGHT NOS. 13, 14, 16, & 23
RELEASED AT ALAMOGORDO, NEW MEXICO
FLIGHT #13 - SEPT. 5, 1947 - 0647 MST
FLIGHT #14 - SEPT. 6, 1947 - 0613 MST
FLIGHT #16 - SEPT. 8, 1947 - 0628 MST
FLIGHT #23 - SEPT. 12 1947 - 0916 MST
Height-Time Curves
ALTITUDE
(Thousands of Feet Above MSL)
54
48
42
36
30
24
18
12
6
Flight #13
Flight #14
Flight #16
Flight #23
50
0
50
0
50
0
50
100
150
TIME (Minutes After Release)

FIG 48



NYU BALLOON PROJECT
HEIGHT-TIME CURVE FOR
FLIGHT 15
September 6, 1947 1153 MST
Alamogordo, New Mexico
Theodolite Data
Radiosonde Data
ALTITUDE (Thousands of ft. above M.S.L.)
TIME IN MINUTES
0
10
20
30
40
50
100
150
200
250
300
350
400

FIG 49

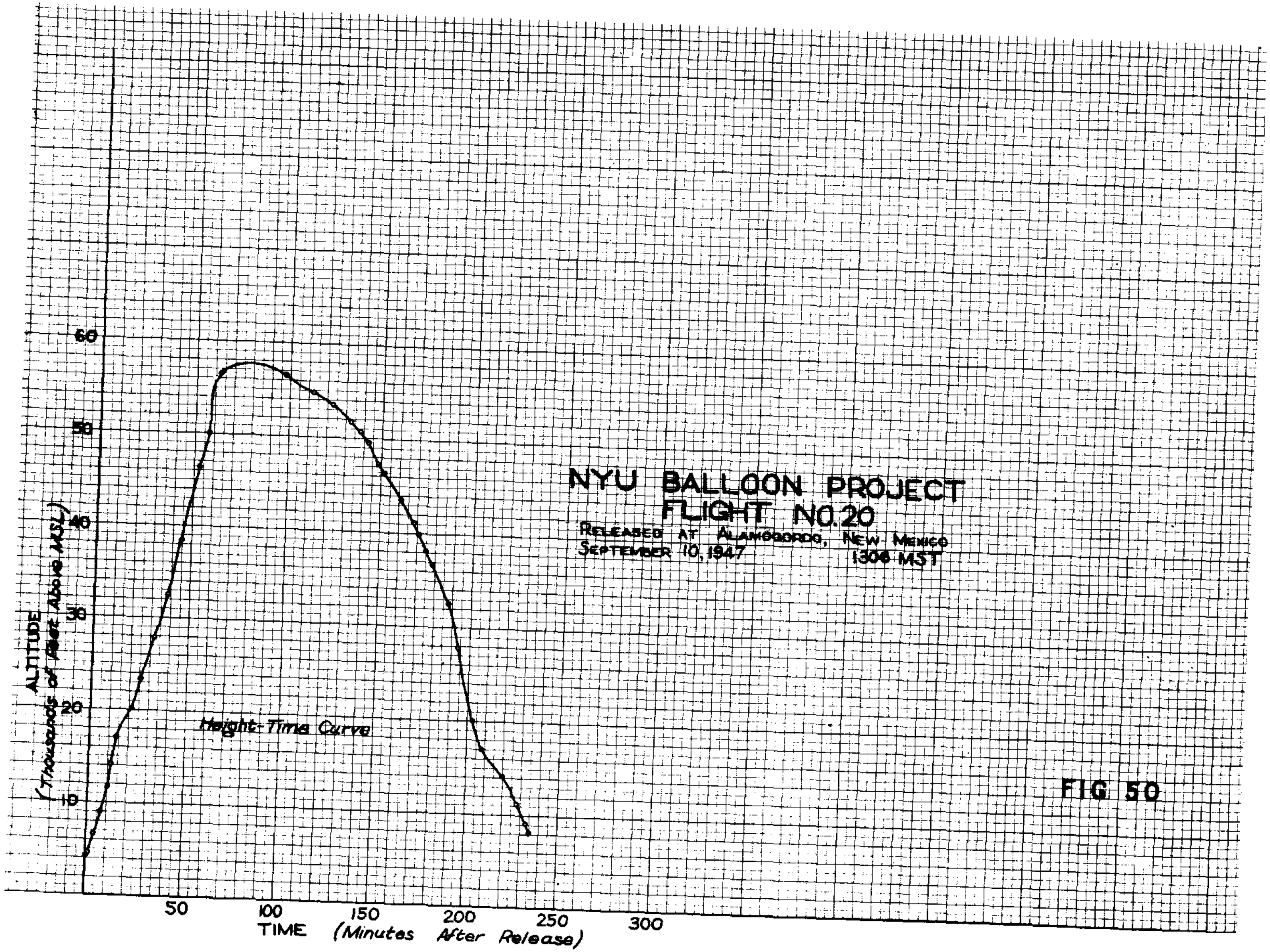
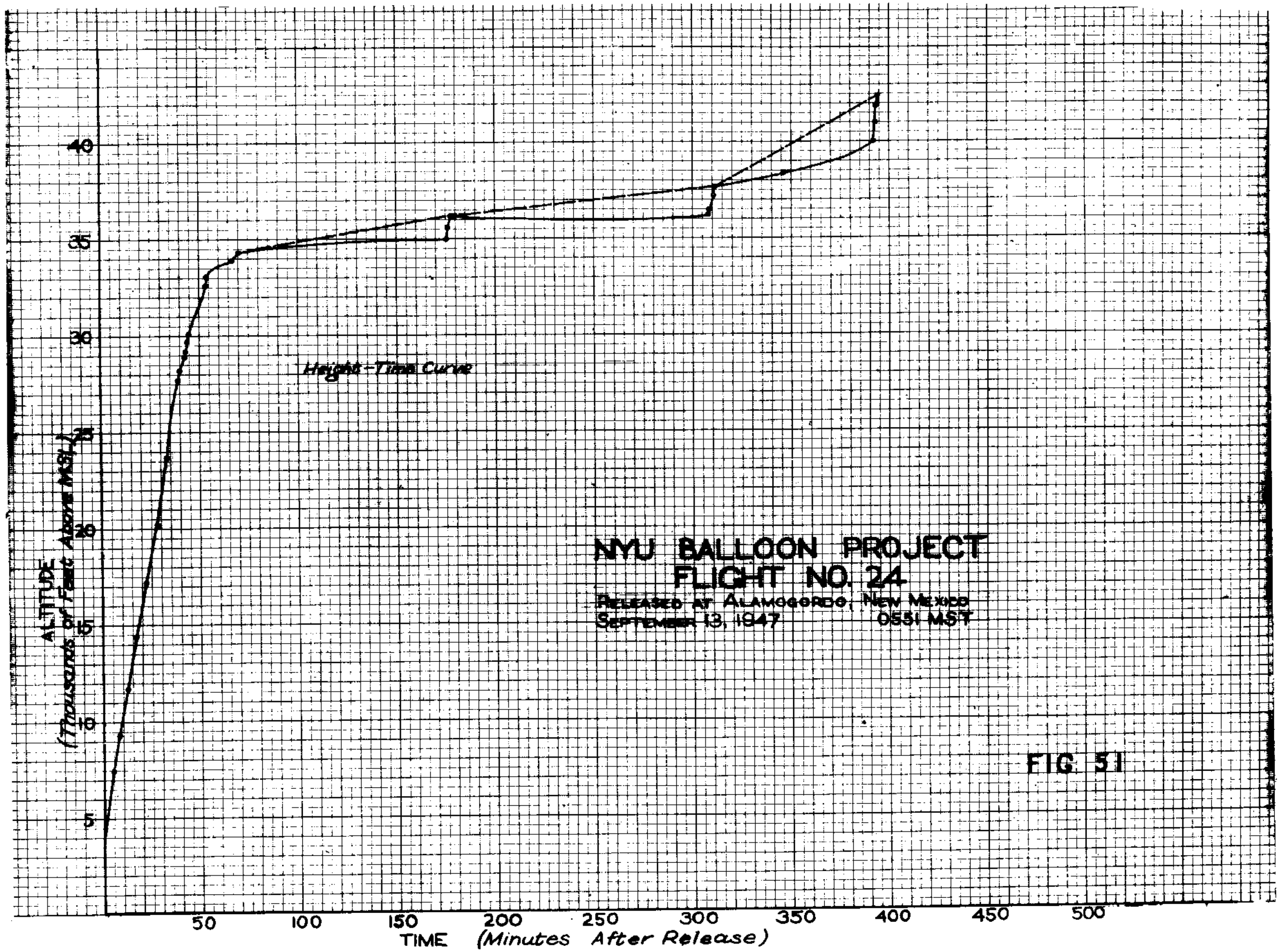

NYU BALLOON PROJECT
FLIGHT NO.20
RELEASED AT ALAMOGORDO, NEW MEXICO
SEPTEMBER 10, 1947 1306 MST
Height-Time Curve
ALTITUDE (Thousands of Feet Above MSL)
10
20
30
40
50
60
50
100
150
200
250
300
TIME (Minutes After Release)

FIG 50



ALTITUDE
(Thousands of Feet Above MSL)
5
10
15
20
25
30
35
40
Height-Time Curve
50
100
150
200
250
300
350
400
450
500
TIME (Minutes After Release)
NYU BALLOON PROJECT
FLIGHT NO. 24
RELEASED AT ALAMOGORDO, NEW MEXICO
SEPTEMBER 13, 1947 0551 MST

FIG. 51

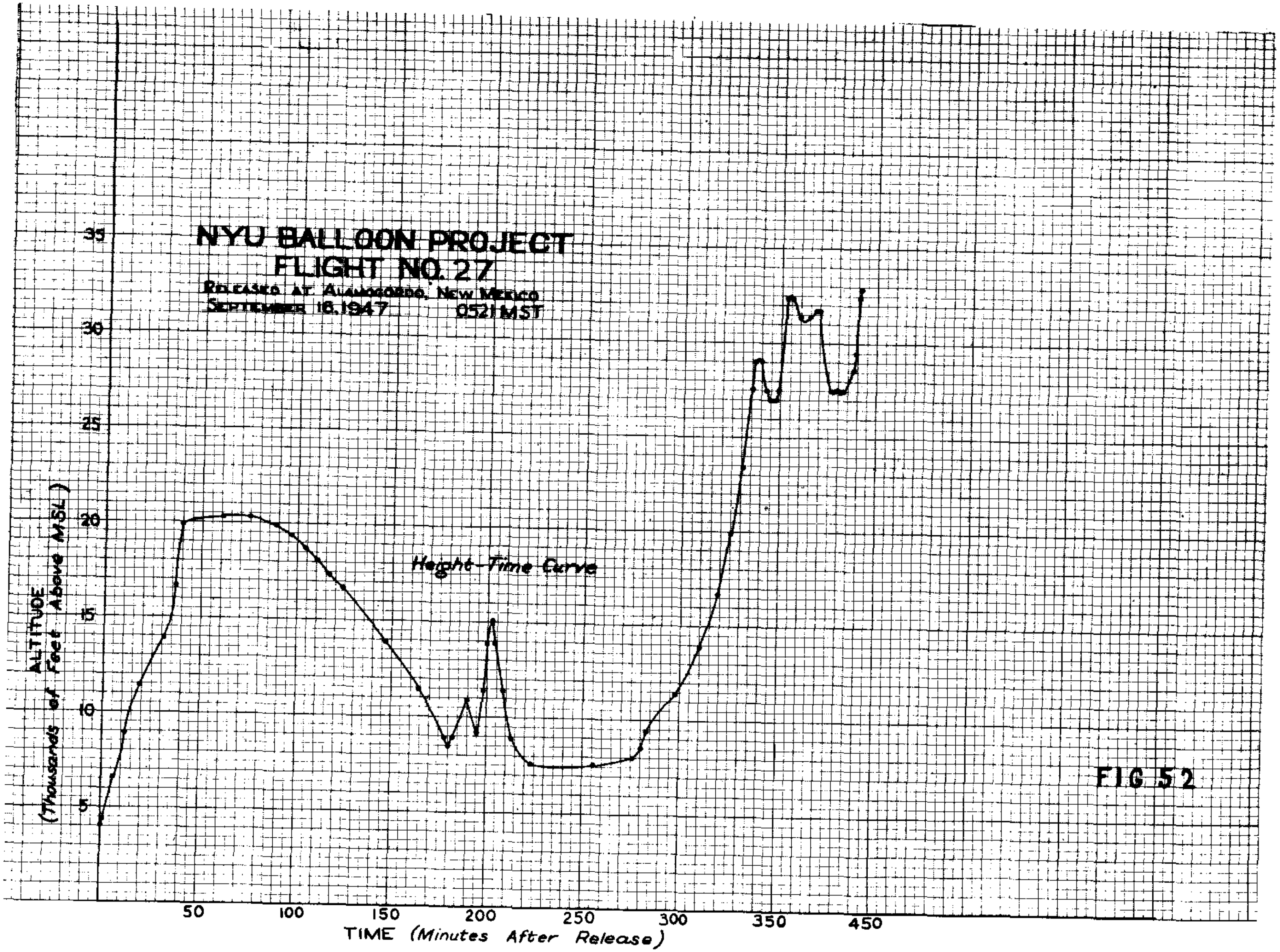

NYU BALLOON PROJECT
FLIGHT NO. 27
RELEASED AT ALAMOGORDO, NEW MEXICO
SEPTEMBER 18, 1947 0521 MST
Height-Time Curve
ALTITUDE
(Thousands of Feet Above MSL)
5
10
15
20
25
30
35
50
100
150
200
250
300
350
450
TIME (Minutes After Release)

FIG 52

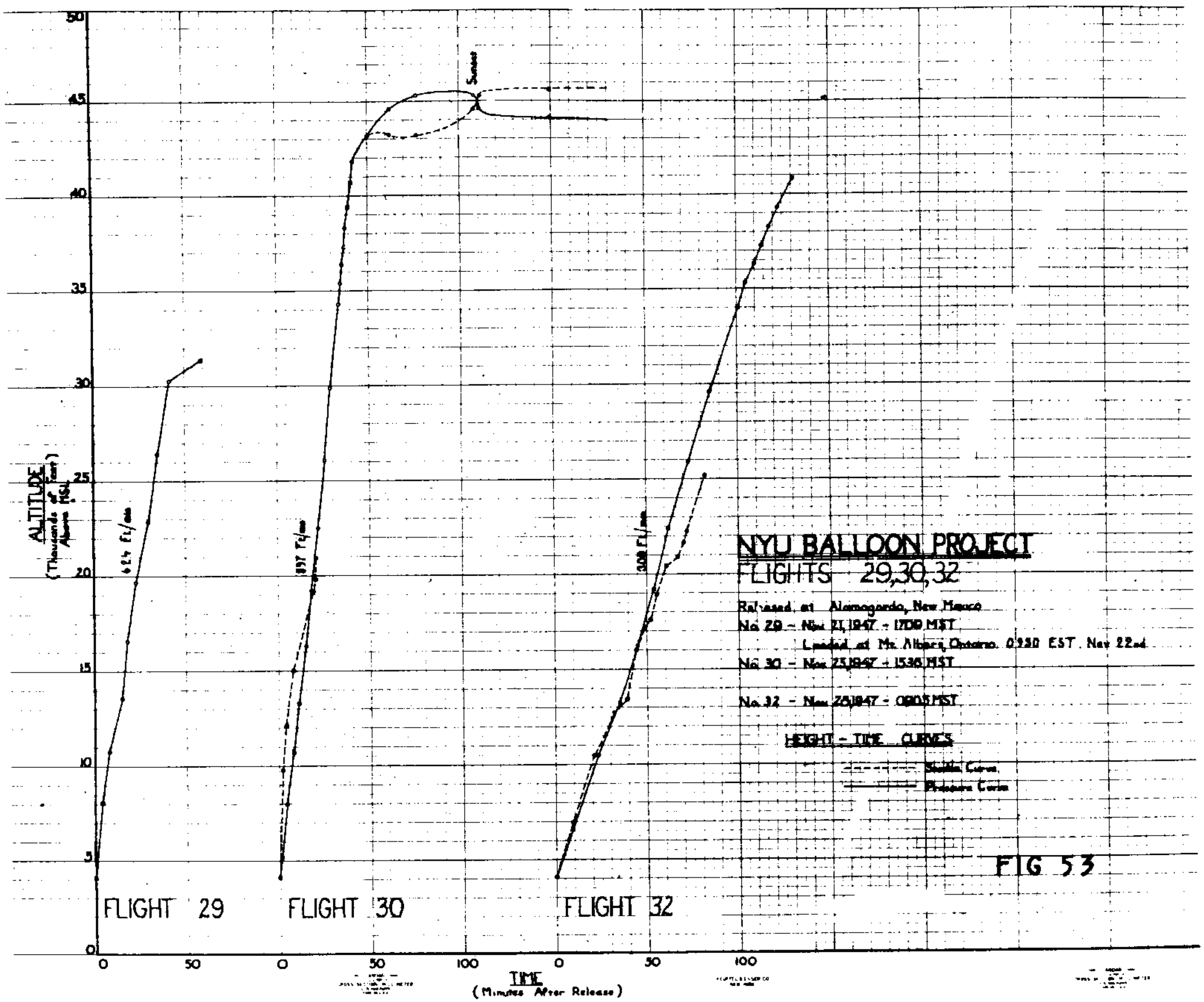

NYU BALLOON PROJECT
FLIGHTS 29,30,32
Released at Alamogordo, New Mexico
No. 29 - Nov 21, 1947 - 1700 MST
Landed at Mt. Albert, Ontario 0930 EST Nov 22nd
No. 30 - Nov 25, 1947 - 1536 MST
No. 32 - Nov 28, 1947 - 0805 MST
HEIGHT - TIME CURVES
Shaded Curve
Pressure Curve
ALTITUDE
(Thousands of feet)
Above MSL
TIME
(Minutes After Release)
FLIGHT 29
FLIGHT 30
FLIGHT 32
624 Ft/min
897 Ft/min
308 Ft/min
Sunset

FIG 53

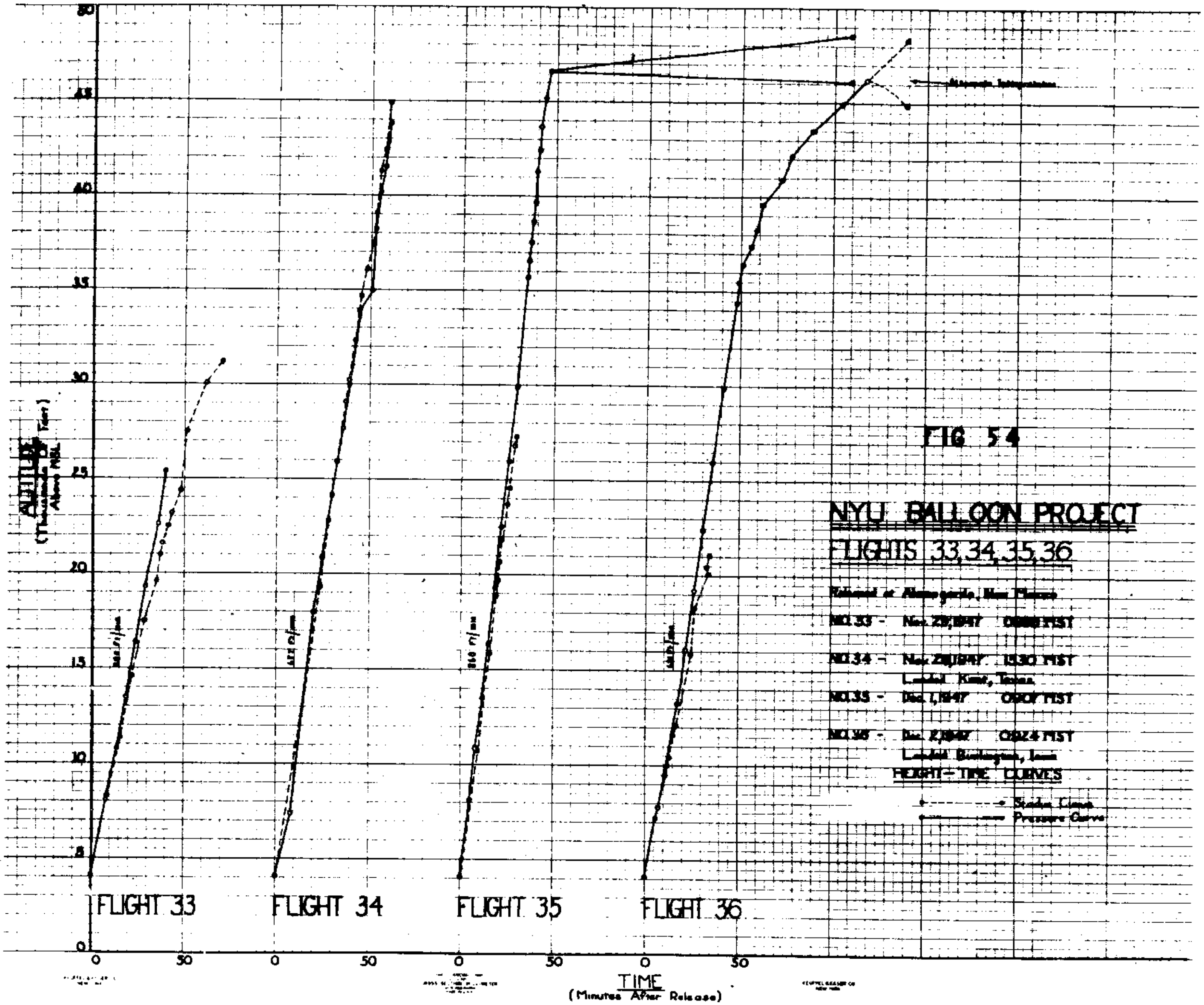
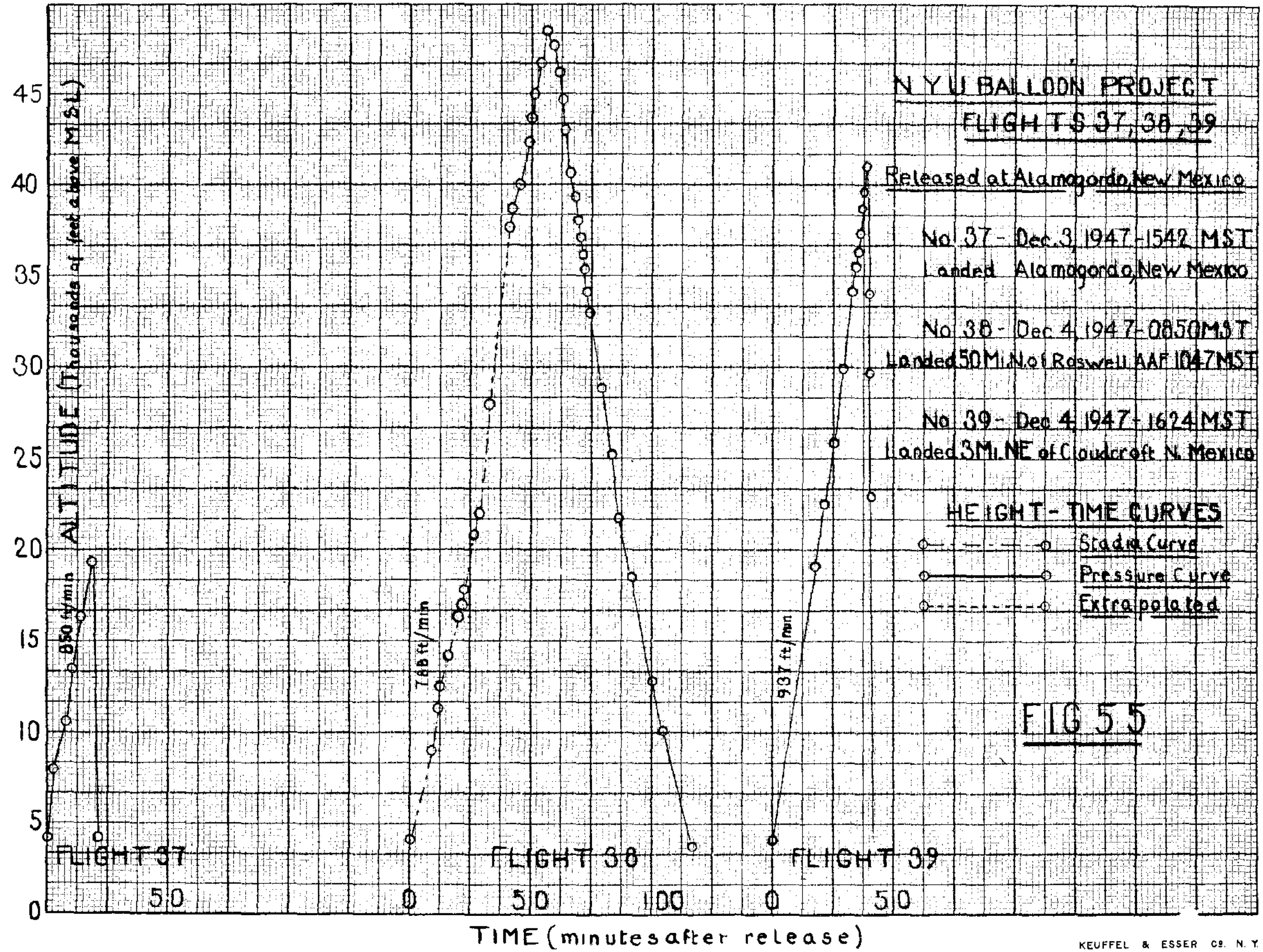
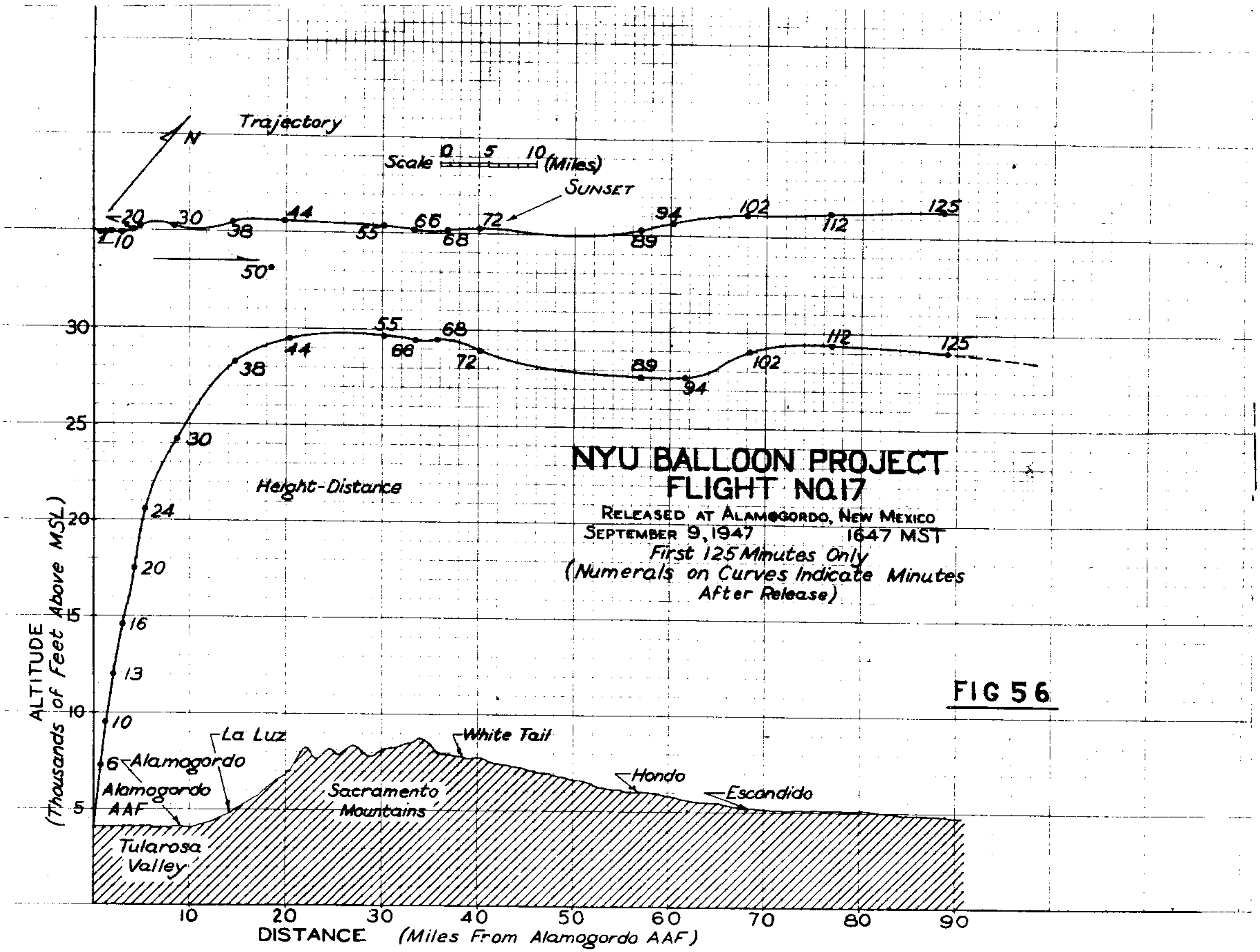


FIG 54
NYU BALLOON PROJECT
FLIGHTS 33,34,35,36
NO.34 - 1530 MST
NO.35 - Dec. 1,1947
NO.36 - Dec. 2,1947 0824 MST
HEIGHT-TIME CURVES
Pressure Curve
ALTITUDE
Above MSL
FLIGHT 33
FLIGHT 34
FLIGHT 35
FLIGHT 36
TIME
(Minutes After Release)



N Y U BALLOON PROJECT
FLIGHTS 37, 38, 39
Released at Alamogordo, New Mexico
No 37 - Dec. 3, 1947 - 1542 MST
Landed Alamogordo, New Mexico
No 38 - Dec 4, 1947 - 0850 MST
Landed 50 Mi. N. of Roswell AAF 1047 MST
No 39 - Dec 4, 1947 - 1624 MST
Landed 3 Mi. NE of Cloudcroft N. Mexico
HEIGHT - TIME CURVES
Stadia Curve
Pressure Curve
Extrapolated
ALTITUDE (Thousands of feet above M S L)
850 ft/min
768 ft/min
937 ft/min
FLIGHT 37
FLIGHT 38
FLIGHT 39
TIME (minutes after release)
0
5
10
15
20
25
30
35
40
45
50
100

FIG 55



Trajectory
N
Scale 0 5 10 (Miles)
Sunset
20
10
30
38
44
55
66
68
72
89
94
102
112
125
50°
Height-Distance
30
38
44
55
66
68
72
89
94
102
112
125
24
20
16
13
10
6
30
25
20
15
10
5
ALTITUDE (Thousands of Feet Above MSL)
La Luz
Alamogordo
Alamogordo AAF
Tularosa Valley
Sacramento Mountains
White Tail
Hondo
Escandido
10
20
30
40
50
60
70
80
90
DISTANCE (Miles From Alamogordo AAF)
NYU BALLOON PROJECT
FLIGHT NO.17
Released at Alamogordo, New Mexico
September 9, 1947 1647 MST
First 125 Minutes Only
(Numerals on Curves Indicate Minutes After Release)

FIG 56

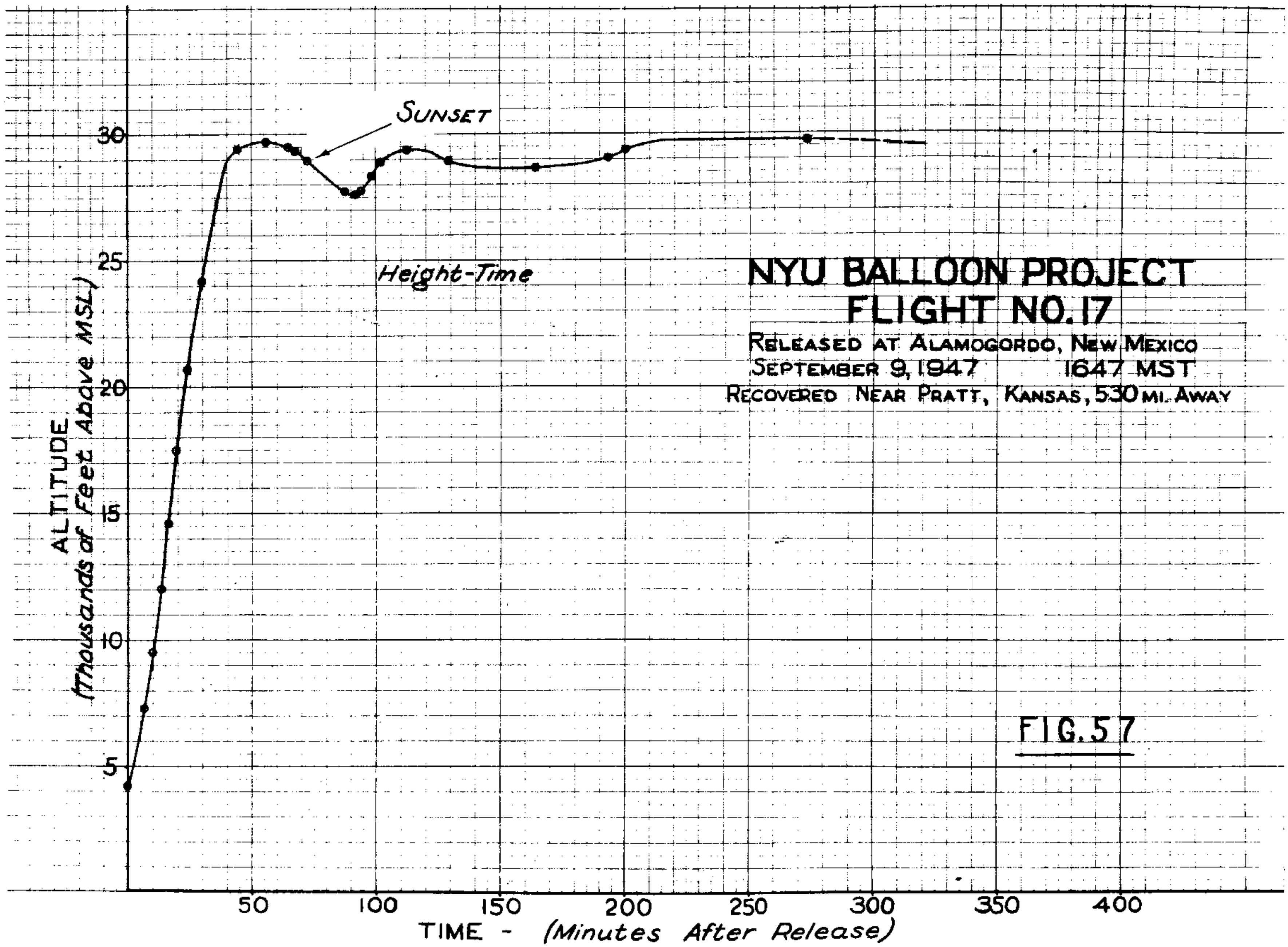

SUNSET
Height-Time
NYU BALLOON PROJECT
FLIGHT NO. 17
RELEASED AT ALAMOGORDO, NEW MEXICO
SEPTEMBER 9, 1947 1647 MST
RECOVERED NEAR PRATT, KANSAS, 530 MI. AWAY
ALTITUDE
(Thousands of Feet Above MSL)
5
10
15
20
25
30
50
100
150
200
250
300
350
400
TIME - (Minutes After Release)

FIG. 57

TABLE VII

SUMMARY OF NYU CONSTANT-LEVEL BALLOON FLIGHTS

FLIGHT NUMBER	DATE AND RELEASE TIME	LAUNCHING SITE	DESCRIPTION OF BALLOONS	BALLOON WEIGHT	DESCRIPTION OF EQUIPMENT	TOTAL WEIGHT ON BALLOON INCLUDING BALLAST	DESCRIPTION OF ALTITUDE CONTROL	BALLAST WEIGHT	FREE LIFT	BALLOON LIFT	RADIOSONDE RECEPTION %	TRACKING %	AIRCRAFT OBSERVATION %	FLIGHT DURATION	TIME CONSTANCY	MAXIMUM + CONSTANT LEVELS MSL	RECOVERY + LANDING SITE	CRITIQUE
A	20 Nov. 1946 1438 EST	NYU, N.Y.	2 - 350 gram meteorological	0.7 kg	72.2 mc Radiosonde	1.8 kg	None	0	Not known	Not known	80%	0%	0%	70 min.	4 min. ± 1000'	Max. 37000' Const. 37000'	0%	Balloon balancing load. Free lift from 350 gram meteorological balloon. Successful cutting free of lifter balloon. Balloon did not level off.
B	18 Dec. 1946 1219 EST	NYU, N.Y.	2 - 350 gram meteorological	0.7 kg	72.2 mc Radiosonde	1.8 kg	None	0	Not known	Not known	80%	Theodolite 50%	0%	31 min.	6 min. ± 1000'	Max. 15000' Const. 15000'	0%	Balloon balancing load. Free lift from 350 gram meteorological balloon. Successful cutting free of lifter balloon. Balloon did not level off.
1	3 April 1947 1412 EST	Bethlehem Pennsylvania	14 - 350 gram meteorological balloons. Long cosmic ray train	4.9 kg	72.2 mc Radiosonde Sand ballast	13.0 kg	3 cans of ballast to be dropped on descent	6.8 kg	Not known	Not known	60% with recorder 50% without recorder	Theodolite 66%	0%	115 min.	None	Max. 46000'	0%	Failure due to poor rigging, poor launching technique. 2 lifter balloons. 12 main balloons. Train rose until some balloons burst then descended rapidly.
5	5 June 1947 1517 MST	Alamogordo New Mexico	29 - 350 gram meteorological balloons. Long cosmic ray train	10.2 kg	72.2 mc Radiosonde Data gear Sand ballast Liquid ballast	26.4 kg	Balloons to cut off above 40000' 5 kg sand and 5 kg liquid to fall under 32000'	10.0 kg	9.9 kg	36.3 kg	100% without recorder	Theodolite 90%	90% B-17	343 min.	38 min. ± 200'	Max. 58000' Const. 51000'	100% E. of Roswell N. M.	First successful flight carrying a heavy load. 3 lifter balloons, 26 main balloons.
6	7 June 1947 0509 MST	Alamogordo New Mexico	28 - 350 gram meteorological balloons. Long cosmic ray train	9.8 kg	74.5 mc Radiosonde. 69.3 mc transmitter. Ballast assembly	28.3 kg	Balloons to cut off above 40000' 5 kg sand and 5 kg liquid to fall under 32000'	10 kg	1.9	30.2 kg	95% without recorder	Theodolite 90%	40% B-17	166 min.	None	Max. 72000'	50%	Flight unsuccessful. Altitude control damaged on launching. 4 lifter balloons, 24 main balloons.
7	2 July 1947 0521 MST	Alamogordo New Mexico	20 - 350 gram meteorological balloons in 2 Helios clusters	7.0 kg	74.5 mc Radiosonde Ballast assembly	25.7 kg	4 over inflated balloons. 10 kg lead shot to fall under 34000'	10 kg	10.5 kg	36.2 kg	60% without recorder	Theodolite 100%	100% C-54	412 min.	147 min. ± 5000'	Max. 48500' Const. 35000'	1% (1 balloon) neck	Best flight thought possible with flabby neoprene balloons. 4 lifter balloons, 16 main balloons.
8	3 July 1947 0303 MST	Alamogordo New Mexico	10 General Mills 7' .001" polyethylene	4.6 kg	74.5 mc Radiosonde Ballast assembly	16.7 kg	Dribbler, compass fluid Fixed leak 160 gm/hr	3 kg	3.5 kg	20.2 kg	100% with recorder	Theodolite 33% Radar - last 55%	Last 15% C-45	195 min.	62 min. ± 1500'	Max. 18500' Const. 18000'	0%	First non-extensible balloon flight. Due to lack of information on volume the altitude control was not actuated. However, flight shows excellent stability of non-extensible balloons. Loss of lift due to balloon leakage 1000 gm/hr.
10	5 July 1947 05[illegible]1 MST	Alamogordo New Mexico	1 H.A. Smith 15' .008" polyethylene	14.2 kg	74.5 mc Radiosonde Ballast assembly	16.3 kg	Dribbler Compass fluid	3 kg	5.6 kg	21.9 kg	512 min. with recorder	Theodolite 82 min.	0%	Over 512 min.	130 min. ± 300' 282 min. ± 2700'	Max. 15100' Const. 9000'	0%	Successful flight with altitude control working. Balloon reported over Albuquerque after 11 hours; Pueblo, Colorado after 26 hours. Fluctuations toward end of transmission believed due to convection currents over desert. Balloon diffusion 10 gm/hr.

TABLE VII

SUMMARY OF NYU CONSTANT-LEVEL BALLOON FLIGHTS

FLIGHT NUMBER	DATE AND RELEASE TIME	LAUNCHING SITE	DESCRIPTION OF BALLOONS	BALLOON WEIGHT	DESCRIPTION OF EQUIPMENT	TOTAL WEIGHT OF BALLOON INCLUDING BALLAST	DESCRIPTION OF ALTITUDE CONTROL	BALLAST WEIGHT	FREE LIFT	BALLOON LIFT	RADIOSONDE RECEPTION %	TRACKING %	AIRCRAFT OBSERVATION %	FLIGHT DURATION	OPTIMUM CONSTANCY	MAXIMUM & CONSTANT LEVELS MSL	RECOVERY & LANDING SITE	CRITIQUE
11	7 July 1947 0508 MST	Alamogordo New Mexico	7 - General Mills 1 - 15' .008" Polyethylene 6 - 7' .001" Polyethylene in Helios cluster below 15' balloon	17.1 kg	74.5 mc Radiosonde Ballast assembly	15.9 kg	Dribbler Compass fluid Fixed leak 300 gm/hr	3 kg	11.3 kg	27.2 kg	97% with recorder	Theodolite 38%	100% C-54	550 min.	423 min. ± 1500'	Max. 1[illegible]800' Const. 16000'	0%	Balloons used in cluster to obtain higher altitude. In high wind at launching 3 small balloons deflated. Therefore cluster did not rise high enough to actuate altitude control. Dribbler leak and balloon diffusion both 300 gm/hr. Therefore balloon remained at ceiling until ballast was expended.
12	5 Aug. 1947 0714 EST	Lakehurst New Jersey	1- General Mills - 20' .001 Polyethylene	4.1 kg	3 mc transmitters 39.7 mc Radiosonde 72.2 mc Radiosonde Ballast assembly	28.0 kg	Automatic and manual ballast valves and minimum pressure switch	5 kg	3.8 kg	31.8 kg	100% Hillman	Theodolite 15% SCR-658 80%	85%	407 min.	60 min. ± 400'	Max. 14100'	95% Smyrna, Delaware 85 mi.	First flight with large thin balloon. Open appendix caused helium dilution with air-cover over appendix thought to have caused balloon rupture, terminating flight early and low. Flight not successful as balloon test or altitude control test.
13	5 Sept. 1947 0647 MST	Alamogordo New Mexico	2 General Mills 20'.001" Polyethylene. 10' appendices inside shroud lines	8.4 kg	397 mc Radiosonde Data Gear Ballast release	24.2 kg	Automatic Ballast release assembly	10.0 kg	3.8 kg	28.0 kg	100%	Theodolite 100% SCR-658 100%	Not required Burst over desert	58 min.	None (burst)	Max. 47600'	0% White Sands, N. M.	Appendices twisted around shroud lines, preventing valving of gas at pressure altitude. Both balloons burst within 2 minutes and gear fell free to desert. Recovery not attempted.
14	6 Sept. 1947 0613 MST	Alamogordo New Mexico	1 General Mills 20' .001" Polyethylene. 10' appendix outside shroud lines	4.0 kg	397 mc Radiosonde Banner, Ballast release	15.1 kg	Automatic Ballast release assembly	5.0 kg	2.2 kg	17.3 kg	100%	Theodolite 100% SCR-658 100%	Last 10% (L-5)	55 min.	None (burst)	Max. 49000'	100% 6 mi. north of Alamogordo AAF	Appendix again twisted around shroud lines, preventing valving of gas at pressure altitude, where balloon burst. Descent retarded by banner.
15	6 Sept. 1947 1153 MST	Alamogordo New Mexico	1 General Mills 20' .001" Polyethylene. 1' appendix outside shroud lines.	4.0 kg	397 mc Radiosonde Banner, Ballast release	15.1 kg	Manual ballast valve. Fixed rate of leak 1000 gm/hr	5.0 kg	2.6 kg	17.7 kg	364 min.	Theodolite 175 min. SCR-658 364 min.	Not required Accurate data not required	More than 364 min.	71 min. ± 900'	Max. 45800' Const. 34000'	0%	First flight with large G. M. balloon which did not burst due to appendix. Believe holes in balloon due to high wind at launching caused slow descent after pressure height was reached. Shows need of short appendix and automatic ballast valve.
16	8 Sept. 1947 0828 MST	Alamogordo New Mexico	1 General Mills 20' .001 Polyethylene. 2' appendix outside shroud lines	4.4 kg	397 mc Radiosonde Data gear Banner Ballast release	16.1 kg	Automatic Ballast Release assembly	3.2 kg	2.4 kg	18.5 kg	100%	Theodolite 100% SCR-658 100%	Not required A/c used to search for gear	30 min.	None (burst)	Max. 31700'	0% 6 miles NE Alamogordo AAF	Heavily loaded balloon with too much free lift (inflated by volume estimate in wind). High oscillations observed after release. Balloon burst due to blowing off top well below pressure altitude. Balloon came down with free falling gear but was not found.
17	9 Sept. 1947 1647 MST	Alamogordo New Mexico	1 H. A. Smith 15' .004" Polyethylene with 18 load points	6.4 kg	397 mc Radiosonde Banner Ballast release	11.3 kg	Automatic Ballast release assembly 100 gm/hr fixed leak	4.0 kg	2.1 kg	13.4 kg	281 min.	281 min.	Not required night flight	estimated 10 hrs.	181 min. ± 500'	Max. 29700' Const. 29100'	Croft, Kansas 555 miles	Successful controlled altitude flight demonstrating altitude controls maintaining height through a sunset. Balloon descended near Croft, Kansas long after passing out of Roswell's reception range. Need for a barograph shown.

TABLE VII

SUMMARY OF NYU CONSTANT-LEVEL BALLOON FLIGHTS

FLIGHT NUMBER	DATE AND RELEASE TIME	LAUNCHING SITE	DESCRIPTION OF BALLOONS	BALLOON WEIGHT	DESCRIPTION OF EQUIPMENT	TOTAL WEIGHT ON BALLOON INCLUDING BALLAST	DESCRIPTION OF ALTITUDE CONTROL	BALLAST WEIGHT	FREE LIFT	BALLOON LIFT	RADIOSONDE RECEPTION %	TRACKING %	AIRCRAFT OBSERVATION %	FLIGHT DURATION	OPTIMUM CONSTANCY	MAXIMUM ± CONSTANT LEVELS MSL	RECOVERY ± LANDING SITE	CRITIQUE
19	10 Sept. 1947 0859 MST	Alamogordo New Mexico	1 H. A. Smith 15' .004" Polyethylene with 18 load points	6.3 kg	Data gear Ballast release	13.2 kg	Automatic Ballast release assembly	2.4 kg	2.3 kg	15.5 kg	100%	Theodolite 100% SCR-658 100%	Used on search for grounded gear	20 min.	None	--	100% Alamogordo	Premature activation of burnoff baroswitch, caused by jerking in high surface wind. Hole blown in balloon after ascent of 200 feet. Balloon descended slowly, landing 2 miles away. Excellent demonstration of blowout patch and that only. Two hour delay switch needed in burnout circuit.
20	10 Sept. 1947 1306 MST	Alamogordo New Mexico	1 General Mills 20' .001" Polyethylene 2' appendix with battens outside shroude	4.1 kg	397 mc Radiosonde Banner Ballast assembly	9.0 kg	Manual ballast valve Fixed rate of leak 1000 gm/hr	4.7 kg	1.5 kg	10.5 kg	235 min.	Theodolite 145 min. SCR-658 235 min.	Not required data not essential	Over 235 min.	50 min. ± 1000'	Max. 56400' Const. 56000'	0%	Successful upwind release (GM type). Successful appendix design shown. Need of automatic ballast valve demonstrated as high fixed rate of ballast leak did not keep ball on floating after reaching ceiling.
21	12 Sept. 1947 0716 MST	Alamogordo New Mexico	1 General Mills 20' .001" Polyethylene 2' appendix with battens outside shrouds	4.1 kg	Data gear Banner Ballast assembly	12.8 kg	Automatic Ballast release assembly	5.0 kg	0.2 kg	13.0 kg	Not provided for	Theodolite 57 min.	Not available	About 600 min.	No data	Max. 58000' Estimated	100% Marietta, Okla. 535 mi.	Flight for Watson. No pressure reporting gear due to weight limitations. Very successful flight due to improved low leakage General Mills balloon, in spite of complete disabling of ballast release on launching. Low initial ascent observed. Descent observed by finder.
22	12 Sept. 1947 0538 MST	Alamogordo New Mexico	1 General Mills 20' .001" Polyethylene 2' appendix with battens outside shrouds	4.1 kg	Data gear Banner Ballast assembly	12.8 kg	Automatic Ballast release assembly	4.8 kg	1.1 kg	13.9 kg	Not provided for	Theodolite 37 min. 10%	1 hour Balloon climbed above range of plane	About 382 min.	No data	Max. 54000' Estimated	100% Carlsbad, N. M. 105 mi.	Flight for Watson. No pressure reporting gear due to weight limitations. Successful flight. Old style balloon had high leakage but was kept in air due to automatic ballast release. Descent observed by finder.
23	12 Sept. 1947 0918 MST	Alamogordo New Mexico	1 shrouded Dewey & Almy	6.0 kg	397 mc Radiosonde Banner, ballast assembly	9.8 kg	Automatic Ballast release assembly	3.1 kg	0.97 kg	10.8 kg	125 min.	Theodolite 125 min. SCR-658 125 min.	Not required Only L-5 available	Over 125 min.	20 min. ± 1000'	Max. 50700' Const. 50000'	0%	Foot ropes of shrouded balloon believed to have tangled, pulling out balloon valve. Uncertain performance. Perhaps the neoprene balloon burst inside of shroud due to friction.
24	13 Sept. 1947 0551 MST	Alamogordo New Mexico	1 General Mills 20' .001" Polyethylene 2' appendix with battens, outside shrouds	4.1 kg	3 mc transmitter, banner, ballast assembly	13.7 kg	Automatic Ballast release assembly	3.2 kg	1.1 kg	13.8 kg	394 min.	Theodolite 230 min.	Middle 2 hours	Over 394 min.	122 min. ± 1000'	Max. Unknown Const. 43000'	Graham, Texas 440 mi.	Radiosonde modulator defective. Good balloon climbed to its rising ceiling and remained there until transmitter failed.
25	15 Sept. 1947 0607 MST	Alamogordo New Mexico	11 Meteorological balloons 350 gm each	3.9 kg	Data gear Banner	7.3 kg	None	None	1.8 kg	9.3 kg	210 min.	Theodolite 73 min. SCR-658 210 min.	Not required	Over 210 min.	20 min. ± 1000'	Max. Unknown Const. 27000'	0%	Cluster of meteorological balloons for Watson. No altitude control or radiosonde provided.
26	15 Sept. 1947 1008 MST	Alamogordo New Mexico	1 General Mills 20' .001" Polyethylene 2' appendix with battens outside shrouds	4.2 kg	3 mc transmitter, banner, ballast assembly	13.6 kg	Automatic Ballast release assembly	5.0 kg	0.2 kg	13.8 kg	508 min.	Theodolite 94 min.	2 hours	Over 508 min.	Unknown	Unknown	Ozona, Texas 325 mi.	Operational flight for NYU transmitter test. Pressure data which was received proved to be incorrect when gear was recovered.

TABLE VII

S U M M A R Y   O F   N Y U   C O N S T A N T - L E V E L   B A L L O O N   F L I G H T S

FLIGHT NUMBER	DATE AND RELEASE TIME	LAUNCHING SITE	DESCRIPTION OF BALLOONS	BALLOON WEIGHT	DESCRIPTION OF EQUIPMENT	TOTAL WEIGHT ON BALLOON INCLUDING BALLAST	DESCRIPTION OF ALTITUDE CONTROL	BALLAST WEIGHT	FREE LIFT	BALLOON LIFT	RADIOSONDE RECEPTION ✗	TRACKING ✗	AIRCRAFT OBSERVATION ✗	FLIGHT DURATION	OPTIMUM CONSTANCY	MAXIMUM + CONSTANT LEVELS MSL	RECOVERY + LANDING SITE	CRITIQUE
27	16 Sept. 1947 0521 MST	Alamogordo New Mexico	1 H. A. Smith 15' .004" Polyethylene with 18 load points	12.5 kg	3 mc transmitter, banner, ballast assembly	12.1 kg	Manual ballast valve. Fixed rate of leak 200 gm/hr	4.1 kg-	2.5 kg	14.6 kg	392 min.	None	None required	Over 392 min.		Max. 32900'	0✗	Another flight showing necessity of automatic ballast valve. Balloon went to pressure height, descended to ground where some gear was dropped. Balloon then oscillated between ground and successively higher ceilings. Radiosonde modulator believed defective.
28	16 Sept. 1947 0542 MST	Alamogordo New Mexico	11 meteorological balloons 350 gm each	3.9 kg	Data gear banner	7.1 kg	None	None	2.0 kg	9.1 kg	Not provided	Theodolite Alamogordo 52 min. Tularosa Peak 223 min.	None required	Over 223 min.	No data	No data	0✗	Cluster of meteorological balloons for Watson Labs. No altitude control or radiosonde provided.
29	21 Nov. 1947 1709 MST	Alamogordo New Mexico	1 GM 8' appendix with battens	4.1 kg	T-69, burn-out baroswitch banner, ballast assembly	13.1 kg	2 1/2 gal. can purolator filter. Manual ballast valve	5.5 kg	857 g	14.4 kg	69 min.	658 - 69 Theodolite 12 min. 1✗	None	14 hours 21 min.	Rising when lost	51,000' est.	Mt. Albert, Ontario	Excellent flight presumed from duration and distance. Manual ballast valve kept flight in air. Observed landing 9:30 AM, Nov. 22, 1947. Rawin stations downwind not in operation. Tracking only by Alamogordo receiver. Average wind less than 100 mph. Flight shows need of barograph.
30	25 Nov. 1947 1536 MST	Alamogordo New Mexico	1 GM, no appendix	3.7 kg	T-69, burn-out baroswitch ballast assembly, banner	13.1 kg	2 1/2 gal. can purolator filter. Manual ballast valve	5.5 kg	2900 g	14.1 kg	148 min.	658-148 min. theodolite 26 min.	Not found by tracking plane L-5	Over 3 hours.	Over 70 min. at ± 1000 ft.	45,000' const.	Chinipas Chihuahua Mexico	Good flight presumed though data not available. Maximum altitude 6000 feet lower than computed due to lack of appendix.
31	26 Nov. 1947 1025 MST	Alamogordo New Mexico	1 GM	4.1 kg	T-69, burn-out baroswitch ballast assembly, banner	12.6 kg	2 1/2 gal. can purolator filter. Manual ballast valve	5.0 kg	1480 g	14.1 kg		658 theodolite 200 min.	Not found by tracking plane L-5	Unknown	Rising when lost	Unknown	Presidio Texas	Transmitter failed shortly after release.
32	28 Nov. 1947 0905 MST	Alamogordo New Mexico	1 GM 8' appendix w/battens	4.0 kg	T-69 burn-out baroswitch ballast assembly, banner	12.7 kg	2 1/2 gal. can purolator filter. Manual ballast valve	5.0 kg	1480 g	14.3 kg	148 min.	658-148 min. theodolite 146 min Roswell 155 min	None	Unknown	Rising when lost	Unknown	Blanco, Texas	658 tracking 93 miles from Alamogordo, about 70 miles from Roswell. Transmitter apparently failed after 155 min. of flight. 490 miles from Alamogordo
33	29 Nov. 1947 0934 MST	Alamogordo New Mexico	1 GM 8' appendix	4.0 kg	T-69 Watson batteries, Ferguson meteorograph, burnout baroswitch, ballast assembly, banner	14.2 kg	Reservoir #108, automatic ballast valve #109, no manual valve	5.0 kg	2160 g	16.5 kg	38 min.	658-38 min. theodolite 115 min	None	Unknown	Rising when lost	Unknown	Not recovered	Transmitter failure. Elevation angle 13° when lost. Distance about 15 miles.

TABLE XII

SUMMARY OF NYU CONSTANT-LEVEL BALLOON FLIGHTS

FLIGHT NUMBER	DATE AND RELEASE TIME	LAUNCHING SITE	DESCRIPTION OF BALLOONS	BALLOON WEIGHT	DESCRIPTION OF EQUIPMENT	TOTAL WEIGHT ON BALLOON INCLUDING BALLAST	DESCRIPTION OF ALTITUDE CONTROL	BALLAST WEIGHT	FREE LIFT	BALLOON LIFT	RADIOSONDE RECEPTION %	TRACKING %	AIRCRAFT OBSERVATION %	FLIGHT DURATION	OPTIMUM CONSTANCY	MAXIMUM + CONSTANT LEVELS MSL	RECOVERY + LANDING SITE	CRITIQUE
34	29 Nov. 1947 1530 MST	Alamogordo New Mexico	1 GM 2'appendix	4.1 kg	Cool water, burnout baro-switch, ballast assembly, banner	15.6 kg	Reservoir #105 Automatic ballast valve #107, no manual valve	5.0 kg	738 g	16.3 kg	132 min.	658-132 min. theodolite - 78 min. Roswell - 182 min.	None	Unknown	Rising when lost	Unknown	Kent, Texas	Burnout patch activated before release. New balloon filled and flight released with difficulty due to wind shift. Signal strength reduced when balloon moved behind hangar. Cause for end of tracking.
35	1 Dec. 1947 0807 MST	Alamogordo New Mexico	1 GM 2' appendix	4.0 kg	Cool water, Ferguson meteorograph, burnout baro-switch, ballast assembly, banner	15.7 kg	Reservoir #111 Automatic ballast valve #111, no manual valve	5.0 kg	710 g	16.4 kg	169 min.	658-169 min. theodolite - 46 min. Roswell - 130 min.	None	Unknown	32 min. at ± 300'	46,000' const.	Not recovered	A constant level flight. No data due to transmitter or battery failure over Roswell.
36	2 Dec. 1947 0924 MST	Alamogordo New Mexico	1 GM 2' appendix	4.3 kg	T-49 Watson batteries, burnout baro-switch, GM automatic pilot, banner	12.7 kg	GM automatic pilot with gypsum dune sand ballast	5.6 kg	682 g	12.3 kg	135 min.	658-135 min. theodolite-34 min.	Not found by tracking plane B-25	Unknown	Rising when lost	Unknown	Blandinsville, Ill.	Flight with General Mills automatic pilot. High winds aloft carried balloon rapidly to NE. Signal lost over Tucumcari.
37	3 Dec. 1947 1548 MST	Alamogordo New Mexico	1 GM no appendix	4.0 kg	T-49, burnout baro-switch, ballast assembly	12.8 kg	Constant leak, 2 1/2 gal. can, manual valve	5.0 kg	2040 g	14.9 kg	38 min. 100%	658-38 min. 100%	None	38 min.	None	19,300' maximum	Alamogordo New Mexico	Released in rain shower. Burst and fell 8 miles NE of Field due to soaking and failure of tapes holding balloon fabric.
38	4 Dec. 1947 0850 MST	Alamogordo New Mexico	1 DAA J-2000 with nylon shroud	6.6 kg	cool water, ballast assembly, banner	10.9 kg	Reservoir #100 2 manual valves, no automatic valve	3.0 kg	484 g	11.4 kg	80 min. 67%	658-117 min. theodolite-81 min. plane-117 min. 100%	last 75% B-25	117 min.	None	48,500 maximum	50 mi. N of Roswell AAF, 1047 AM, 12/4/47	Neoprene balloon burst in shroud and was observed to parachute down. Tracking by 3-658 receivers and B-25 plane. Balloon heated on radiator 3 days. Filled about 20 hours before release.
39	4 Dec. 1947 1634 MST	Alamogordo New Mexico	1 GM 2' appendix	4.0 kg	T-69, Ferguson meteorograph, burnout baro-switch, automatic ballast assy.	13.6 kg	Reservoir #101, automatic valve #108, no manual valve	5.0 kg	648 g	14.3 kg	40 min. 100%	658-40 min. theodolite-40 min. 100%	None	40 min.	None	41,100 maximum	3 mi. NE of Cloudcroft, N.M.	Inflation error with resulting high free lift and rate of rise (1000 ft/min) caused balloon to burst at pressure altitude. Fell in mountains near Cloudcroft. Recovery not attempted. Strong signals received by 658's at Alamogordo, Roswell and Hobbs.

APPENDIX 2

Correspondence

C O P Y

Abstract from:

AIR COORDINATING COMMITTEE
NEW YORK SUBCOMMITTEE ON AIRSPACE
RULES OF THE AIR AND AIR TRAFFIC CONTROL
385 Madison Avenue
New York 17, N. Y.

20 March 1947

N. Y. Meeting No. 12

PROBLEM:

1. The Secretary of the Subcommittee presented a request from the War Department member in behalf of New York University for approval to release free balloons from Allentown, Pa. and Lakehurst, N. J.

DISCUSSION

2. The subject project is broken down into two phases as described below:

A. PHASE I.

(1) The type balloon to be used in this phase of the project will be 6 ft. in diameter, hydrogen filled, encompassed by a nylon shroud with black and white panels 24" wide. Radio instruments weighing approximately 3 lbs. will be suspended approximately 50 ft. below the balloon and equipped with parachute device so that upon separation from the balloon, the attached equipment will float down towards the earth rather than become a freely falling body.

(2) It is anticipated that two flights will be required in this phase of operation, the release to be made during weather conditions in which the sky is free of clouds and the visibility at least three miles at all altitudes up to 20,000 feet., within a four hour cruising radius from Allentown, Pa.

(3) The balloon, during these flights, shall be convoyed by suitable aircraft to maintain air-ground communications on the balloon trajectory and equipped to effect destruction of the balloon at the termination of four hours flight or at such time that the balloon may become hazardous either to aircraft flight operations or the persons or property of others on the surface.

(4) New York University will file a Notice to Airmen at least twelve (12) hours in advance of balloon release and a second notice will be filed at the time of release with the Allentown, Pa. Airways Communications Station.

B. PHASE II.

(1) The type balloon to be used in this phase of the project will be a 15 to 40 ft. diameter plastic balloon, hydrogen filled. Radio equipment weighing approximately 25 lbs., will be suspended approximately 100 ft. below the balloon. The balloon will be towed to high altitude levels (above 20,000 feet) by three auxilliary lifting balloons fastened together with a 4 lb. weight. All equipment attached to the balloon will be equipped with parachute device so that upon separation from the balloon, the attached equipment will float down towards the earth rather than become a freely falling body. Upon attaining the desired altitude, the auxilliary lifting balloons will be released from the main balloon.

(2) It is anticipated that a maximum of ten flights will be required in this phase of operation, 2 to 5 releases to be made from Allentown, Pa. and 2 to 5 releases to be made from Lakehurst, N. J. Release will be made during weather conditions in which the sky is free of clouds and the visibility at least three miles at all altitudes up to 20,000 feet.

(3) The range of flight during this phase of operation will be between 30,000 and 60,000 feet. A period of six hours will be the maximum duration of flight.

(4) New York University will provide an operator for tracking of the balloon during period of flight and will furnish information on its position to the N.Y. Air Traffic Control Center during period of flight.

(5) New York University will file a Notice to Airmen at least twelve (12) hours in advance of balloon release and a second notice will be filed at time of release with either the Allentown, Pa. or Lakehurst, N.J. Communications Stations.

(6) Destruction of the balloon will be predetermined to be effected over water where hazards are not present. Aerial convoy will not be effected during this phase of operation inasmuch as balloon flights will be conducted in excess of 20,000 feet.

3. The War Department member requests that balloon operations along the lines of Phase II be presented to the Washington Subcommittee for clearance with all other Regional Airspace Subcommittees, in consideration of War Department plans to continue the Phase II type of operation from White Sands, New Mexico, upon completion of the 12 proposed releases described herein. The type of balloon releases proposed out of White Sands, N. Mex., will involve flight through other regions.

RECOMMENDED ACTION

4. That the release of free balloons by New York University as described above in Paragraph 2-A (Phase I), Subparagraphs (1) - (4) inclusive, be approved.

5. That the release of free balloons by New York University as described above in Paragraph 2-B (Phase II), Subparagraphs (1) - (6) inclusive, be approved.

6. That the Washington Airspace Subcommittee present the Phase II operation to other Regional Airspace Subcommittees for clearance, in view of War Department plans to continue the Phase II type of operation from White Sands, New Mexico.

April 17, 1947

Mr. C. J. Stock, Secretary
New York Subcommittee on Air Space
385 Madison Avenue
New York 17, N. Y.

Reference: New York Meeting No. 12 Subject No. 26, New York Case #156

Dear Sir:

Receipt of the minutes of the above meeting are acknowledged with thanks. However, on reading them, a discrepancy was noted. We believe the weather conditions agreed upon for Phase 2 operations were not a cloudless sky, but no ceiling under 20,000 ft.

We realize that there might be occasions when the clouds present would not constitute a ceiling. Yet, due to chaotic or unstable sky conditions, our balloons might be considered an unseen hazard to aircraft.

It is therefore requested that we be permitted to fly these rapidly rising, high altitude balloons after obtaining clearance on days when there are no more than scattered clouds in thin layers up to 20,000 ft. and visibility greater than three miles.

This is an important point, as the phenomena which we hope to measure is not a frequent one and our chances to investigate the remote phenomena are markedly reduced if we have to wait for cloudless skies and the phenomena to coincide.

This would have been brought to your attention earlier. However, we are unable, until yesterday, to confirm our impressions with the representatives of the Army Air Forces who were present at the meeting.

Yours very truly,

C. S. Schneider
Research Assistant

CSS:gm

DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION

385 Madison Ave.
New York 17, N. Y.

New York University
College of Engineering
Research Division
University Heights
New York 53, N. Y.

Attention: Mr. C. S. Schneider, Research Assistant

Dear Mr. Schneider:

This is in reply to your letter of April 17th.

It is true that at N.Y. Airspace Subcommittee Meeting #12, we advised you that the Phase II operations would be restricted to weather conditions in which the sky was clear of clouds below 20,000 feet and the visibility at least three miles at all altitudes up to and including 20,000 ft. However, it was indicated that these conditions were subject to concurrence and approval by the Washington Airspace Subcommittee.

In order to expedite final approval of this case, coordination was effected with the Washington Airspace Subcommittee immediately subsequent to our Meeting #12. It was revealed as a result of such coordination that the Washington Committee felt that the ceiling restriction was inadequate in the interests of air safety and required that a cloudless sky condition be specified.

This information was relayed to the members of the N.Y. Airspace Subcommittee and they in turn concurred with this amendment in the interest of air safety. The minutes of New York Meeting #12 were amended accordingly.

Yours very truly,

C. J. Stock
Secretary, N. Y. Airspace Subcommittee

AIR COORDINATING COMMITTEE
FORT WORTH REGIONAL AIRSPACE SUBCOMMITTEE
P. O. BOX 1689
FORT WORTH 1, TEXAS

August 21, 1947

Meeting No. 30

Time:	August 21, 1947 - 10:00 a.m. to 1:30 p.m.
Place:	Regional Office, CAA, Ft. Worth, Texas
Members Present:	L. C. Elliott, Chairman Lt. Col. Hall F. Smith, War Dept. Member Major Williams, War Dept. Alternate Member Perry Hodgden, CAB Member Commander James Douglas Arbes, Navy Dept. Member Tracy Walsh, ATA Coordinator
Secretary:	Paul H. Boatman

EXTRACT COPY

PROBLEM

1. The Secretary of the Subcommittee presented a request received from the New York University through the Department of Commerce Member for approval of releases of free balloons at the White Sands Proving Ground in Phase II operation as outlined in New York Subcommittee Meeting No. 12, dated March 20, 1947.

DISCUSSION

2. It was first thought that balloons would ascend and descend within the confines of the White Sands presently assigned danger area and that no further authorization would be required; however the Subcommittee was advised by the University that balloons have been descending outside of the area in the vicinity of Roswell, New Mexico. It, therefore, appeared that there was a certain amount of hazard to aircraft encountered in the descent of this equipment.

3. The Subcommittee did not have full information on the number of releases anticipated and other pertinent details; however it appeared the chances of collision of aircraft with this equipment was very remote and due to the fact prevailing winds in this area would ordinarily carry the equipment eastward, which would tend to carry it away from heavy travelled already established civil airways, that this activity might not be too objectionable.

4. The Department of Commerce Member stated that he felt it may be necessary to effect some coordination with air traffic in the local El Paso area but that due to the meager information available, this could not be determined without a discussion of methods and procedures with the people who were actually going to do the work.

5. Thw War Department Member stated that he felt it desirable to stipulate that local coordination should be effected with the Commanding Officer at Biggs Field.

(NOTE: At a meeting held in El Paso, Texas, on August 27, 1947, between representatives of the CAA and the New York University, procedures satisfactory to the Commerce Member and the Commanding Officer at Biggs Field were established).

RECOMMENDED ACTION

6. That release of free balloons by the New York University within the confines of the White Sands Proving area be approved provided that:

(a) Local coordination be effected to the satisfaction of the Department of Commerce Member and the Commanding Officer at Biggs Field to assure all precautions are taken to prevent collision of aircraft with this airborne equipment.

COPY

AIR COORDINATING COMMITTEE
FORT WORTH REGIONAL AIRSPACE SUBCOMMITTEE
P. O. BOX 1689
FORT WORTH 1, TEXAS

September 2, 1947

MEMORANDUM

TO: L. C. Elliott
Chairman, Ft. Worth Regional Airspace Subcommittee

Lt. Col. Hall F. Smith, War Dept. Member, Ft. Worth Regional Airspace Subcommittee

FROM: Secretary, Ft. Worth Regional Airspace Subcommittee

SUBJECT: Procedure for Release of Free Balloons in the White Sands Danger Area

The writer met with Mr. James R. Smith of New York University and Lt. V. D. Thompson of Alamogordo AAF, at El Paso, Texas, on August 27 to discuss procedures to be followed during the descent of free balloons released within the White Sands Danger Area.

Mr. Smith advised that he had met with the Commanding Officer at Biggs Field who had stated he desired no further coordination other than what the Civil Aeronautics Administration might require and that he would write a letter to Mr. Smith to this effect. Mr. Smith will forward this to the Chairman of the Subcommittee for the record.

Mr. Smith outlined their program, which consists for the most part of testing various types of balloons. Their program will probably be of 5 flights per month for the next 6 months, the first flight to be released on Sept. 6, weather permitting. Weather minimums were agreed on as not more than 4/10 of the sky covered or forecasted to be covered within the expected descent area (60 mile radius).

Balloons are tracked by VHF DF stations at Alamogordo and Roswell for the present plus an aircraft. When the balloon descends to 20,000 feet, if not in the clear, positions will be given every hour or so and will be put out as notams on Schedule "A" from the Roswell AAF. This will serve to advise the Army Fields, the airlines, and some itinerant traffic. In any case if the balloon is outside the assigned danger area, notams will be issued when the balloons descend below 15,000 feet.

The balloons are for the most part 15 feet in diameter and plastic. Suspended from the balloon is a 100 foot one thousand pound test nylon line which carries the airborne equipment. Releases are usually made at dawn and the flight terminates in an average of 8 hours time; it may be from 6 to 12 hours duration.

It is believed the notam procedure will serve to advise pilots of this activity effectively enough to provide the desired amount of caution. It is understood the airlines have some instrument flights through this area at 20,000 feet; however these are for the most part at night and to the north of the expected balloon track.

/s/ Paul H. Boatman
PAUL H. BOATMAN
Secretary, Ft. Worth Regional Airspace
Subcommittee

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APPENDIX 3

Flight Forms and Tables

Page

PRESSURE IN STANDARD ATMOSPHERE

(Accurate to .001 mm of Hq, .0001 in. of Hg and .002 of millibar)

Thermal Layer					Isothermal Layer				
Altitude (feet)	Pressure (mm Hg)	Pressure (In. Hq)*	Pressure (mb)	ft.per (mb)	Altitude (feet)	(mm Hq)*	(In.Hq)*	(mb)	ft per (mb)
-5,000	907.809	35.7404	1210.312		35,332	175.899	6.9251	234.513	
-4,000	876.533	34.5091	1168.615		36,000	170.375	6.7077	227.148	
-3,000	846.130	33.3121	1128.081		37,000	162.430	6.3949	216.556	
-2,000	816.582	32.1488	1088.686		38,000	154.854	6.0966	206.455	
-1,000	787.879	31.0188	1050.419		39,000	147.632	5.8123	196.826	
0	760.000	29.9212	1013.250	27	40,000	140.747	5.5412	187.647	110
1,000	732.923	28.8552	977.150		41,000	134.183	5.2828	178.896	
2,000	706.634	27.8202	942.101		42,000	127.925	5.0364	170.553	
3,000	681.114	26.8155	908.077		43,000	121.959	4.8015	162.599	
4,000	656.344	25.8403	875.053		44,000	116.271	4.5776	155.015	
5,000	632.308	24.8940	843.008	31	45,000	110.848	4.3641	147.785	140
6,000	608.991	23.9760	811.921		46,000	105.678	4.1605	140.892	
7,000	586.375	23.0856	781.769		47,000	100.750	3.9665	134.322	
8,000	564.444	22.2222	752.530		48,000	96.051	3.7815	128.057	
9,000	543.180	21.3850	724.180		49,000	91.571	3.6052	122.085	
10,000	522.571	20.5736	696.704	36	50,000	87.301	3.4370	116.392	175
11,000	502.600	19.7874	670.078		51,000	83.229	3.2767	110.963	
12,000	483.251	19.0256	644.282		52,000	79.348	3.1239	105.789	
13,000	464.511	18.2878	619.297		53,000	75.647	2.9782	100.854	
14,000	446.362	17.5733	595.100		54,000	72.119	2.8393	96.151	
15,000	428.793	16.8816	571.677	43	55,000	68.755	2.7069	91.666	225
16,000	411.786	16.2120	549.003		56,000	65.549	2.5807	87.391	
17,000	395.332	15.5642	527.066		57,000	62.492	2.4603	83.316	
18,000	379.412	14.9375	505.841		58,000	59.577	2.3455	79.429	
19,000	364.018	14.3314	485.317		59,000	56.799	2.2362	75.726	
20,000	349.132	13.7453	465.471	50	60,000	54.150	2.1319	72.194	285
21,000	334.742	13.1788	446.286		61,000	51.624	2.0324	68.826	
22,000	320.836	12.6313	427.746		62,000	49.217	1.9377	65.617	
23,000	307.403	12.1025	409.837		63,000	46,921	1.8473	62.556	
24,000	294.429	11.5917	392.540		64,000	44,733	1.7611	59.639	
25,000	281.901	11.0984	375.837	60	65,000	42.647	1.6790	56.858	360
26,000	269.808	10.6223	359.714		66,000	40.658	1.6007	54.206	
27,000	258.140	10.1630	344.158		67,000	38.762	1.5261	51.678	
28,000	246.883	9.7198	329.150		68,000	36.954	1.4549	49.268	
29,000	236.027	9.2924	314.677		69,000	35.230	1.3870	46.969	
30,000	225.561	8.8803	300.723	72	70,000	33,587	1.3223	44.779	455
31,000	215.473	8.4832	287.274		71,000	32,021	1.2607	42.691	
32,000	205.754	8.1005	274.316		72,000	30,528	1.2019	40.701	
33,000	196.394	7.7320	261.837		73,000	29,104	1.1458	38.802	
34,000	187.381	7.3772	249.821		74,000	27.746	1.0924	36.992	
35,000	178.705	7.0356	238.254	86	75,000	26,452	1.0414	35.266	580
					76,000	25.219	.9929	33.623	
					77,000	24,043	.9466	32,055	

* Mercury column at 0° C.

PRESSURE IN STANDARD ATMOSPHERE

(Accurate to .001 mm of Hq, .0001 in. of Hg and .002 of millibar)

Isothermal Layer

Altitude (feet)	Pressure (mm Hq)*	(in.Hq)*	(mb)	Ft. per (mb)
78,000	22.921	.9024	30.559	
79,000	21.852	.8603	29.134	
80,000	20.833	.8202	27.775	735
81,000	19.862	.7820	26.480	
82,000	18.935	.7455	25.245	
83,000	18.052	.7107	24.067	
84,000	17.210	.6776	22.945	
85,000	16.408	.6460	21.876	935
86,000	15.642	.6158	20.854	
87,000	14.913	.5871	19.882	
88,000	14.217	.5597	18.954	
89,000	13.554	.5336	18.071	
90,000	12.922	.5087	17.228	1190
91,000	12.319	.4850	16.424	
92,000	11.745	.4624	15.659	
93,000	11.197	.4408	14.928	
94,000	10.675	.4203	14.232	
95,000	10.177	.4007	13.568	1510
96,000	9.702	.3820	12.935	
97,000	9.250	.3642	12.332	
98,000	8.819	.3472	11.758	
99,000	8.407	.3310	11.208	
100,000	8.015	.3156	10.686	1920

Diam.	Volume	Surface
1/64	0.00002	0.003068
1/32	.00013	.012272
3/64	.00043	.027612
1/16	.00102	.049087
5/64	.00200	.076699
3/32	.00345	.110447
7/64	.00548	.150330
1/8	.00818	.196349
9/64	.01165	.248505
5/32	.01598	.306796
11/64	.02127	.371223
3/16	.02761	.441786
13/64	.03511	.518485
7/32	.04385	.601321
15/64	.05393	.690291
1/4	.06545	.785398
9/32	.09319	.994019
5/16	.12783	1.22718
11/32	.17014	1.48489
3/8	.22089	1.76714
13/32	.28085	2.07394
7/16	.35077	2.40528
15/32	.43143	2.76116
1	.52360	3.14159
1/16	.62804	3.54656
1/8	.74551	3.97607
3/16	.87681	4.43013
1/4	1.0227	4.90873
5/16	1.1838	5.41188
3/8	1.3612	5.93957
7/16	1.5553	6.49180
1/2	1.7671	7.06858
9/16	1.9974	7.66990
5/8	2.2468	8.29576
11/16	2.5161	8.94617
3/4	2.8062	9.62112
13/16	3.1177	10.32061
7/8	3.4515	11.04465
15/16	3.8082	11.79323
2	4.1888	12.56636
1/16	4.5939	13.36403
1/8	5.0243	14.18624
3/16	5.4808	15.03300
1/4	5.9641	15.90430
5/16	6.4751	16.80014
3/8	7.0144	17.72053
7/16	7.5828	18.66546

Diam.	Volume	Surface
1/2	8.1812	19.63494
9/16	8.8103	20.62896
5/8	9.4708	21.64752
11/16	10.1635	22.69062
3/4	10.8892	23.75827
13/16	11.6486	24.85047
7/8	12.4426	25.96720
15/16	13.2719	27.10849
3	14.1371	28.27431
1/16	15.0393	29.46468
1/8	15.9789	30.67959
3/16	16.9570	31.91905
1/4	17.9741	33.18704
5/16	19.0312	34.47159
3/8	20.1289	35.78467
7/16	21.2680	37.12230
1/2	22.4493	38.48448
9/16	23.6735	39.87120
5/8	24.9415	41.28246
11/16	26.2539	42.71826
3/4	27.6116	44.17861
13/16	29.0153	45.66350
7/8	30.4658	47.17294
15/16	31.9639	48.70692
4	33.5103	50.26544
1/8	36.7511	53.45612
1/4	40.1943	56.74497
3/8	43.8462	60.13200
1/2	47.7129	63.61720
5/8	51.8004	67.20057
3/4	56.1150	70.88212
7/8	60.6627	74.66185
5	65.4497	78.53975
1/8	70.4822	82.51582
1/4	75.7663	86.59007
3/8	81.3080	90.76250
1/2	87.1136	95.03310
5/8	93.1892	99.40187
3/4	99.5409	103.86882
7/8	106.175	108.43394
6	113.097	113.0972
1/8	120.314	117.8587
1/4	127.832	122.7184
3/8	135.656	127.6762
1/2	143.793	132.7322
5/8	152.249	137.8863
3/4	161.031	143.1387
7/8	170.144	148.4892

Diam.	Volume	Surface
7	179.594	153.9379
1/8	189.368	159.4846
1/4	199.532	165.1298
3/8	210.031	170.8730
1/2	220.893	176.7144
5/8	232.123	182.6540
3/4	243.727	188.6917
7/8	255.711	194.8277
8	268.082	201.0618
1/8	280.846	207.3940
1/4	294.008	213.8245
3/8	307.576	220.3531
1/2	321.555	226.9799
5/8	335.950	233.7048
3/4	350.770	240.5280
7/8	366.019	247.4493
9	381.703	254.4688
1/8	397.829	261.5865
1/4	414.403	268.8023
3/8	431.431	276.1163
1/2	448.920	283.5285
5/8	466.875	291.0389
3/4	485.302	298.6474
7/8	504.207	306.3541
10	523.598	314.1590
1/8	543.479	322.0621
1/4	563.858	330.0633
3/8	584.739	338.1627
1/2	606.130	346.3603
5/8	628.036	354.6561
3/4	650.464	363.0500
7/8	673.420	371.5421
11	696.909	380.1324
1/8	720.938	388.8208
1/4	745.514	397.6075
3/8	770.641	406.4923
1/2	796.327	415.4753
5/8	822.578	424.5564
3/4	849.399	433.7358
7/8	876.797	443.0133
12	904.777	452.3890
1/4	962.512	471.4348
1/2	1022.65	490.8734
3/4	1085.25	510.7047
13	1150.34	530.9287
1/4	1218.00	551.5454
1/2	1288.25	572.5548
3/4	1361.15	593.9569

Diam.	Volume	Surface
14	1436.75	615.7516
1/4	1515.10	637.9391
1/2	1596.25	660.5193
3/4	1680.25	683.4922
15	1767.14	706.8578
1/4	1856.98	730.6160
1/2	1949.81	754.7670
3/4	2045.69	779.3107
16	2144.66	804.2470
1/4	2246.77	829.5761
1/2	2352.07	855.2979
3/4	2460.61	881.4123
17	2572.44	907.9195
1/4	2687.60	934.8194
1/2	2806.16	962.1119
3/4	2928.15	989.7972
18	3053.62	1017.875
1/4	3182.63	1046.346
1/2	3315.23	1075.209
3/4	3451.45	1104.465
19	3591.36	1134.114
1/4	3735.00	1164.155
1/2	3882.41	1194.589
3/4	4033.66	1225.416
20	4188.78	1256.636
1/4	4347.83	1288.248
1/2	4510.86	1320.253
3/4	4677.91	1352.651
21	4849.04	1385.441
1/4	5024.29	1418.624
1/2	5203.71	1452.200
3/4	5387.36	1486.168
22	5575.27	1520.530
1/4	5767.51	1555.283
1/2	5964.11	1590.430
3/4	6165.13	1625.969
23	6370.62	1661.901
1/4	6580.62	1698.226
1/2	6795.19	1734.943
3/4	7014.37	1772.053
24	7238.22	1809.556
1/4	7466.78	1847.451
1/2	7700.10	1885.739
3/4	7938.23	1924.420
25	8181.22	1963.49
1/4	8429.12	2002.96
1/2	8681.97	2042.82
3/4	8939.84	2083.07

Diam.	Volume	Surface
26	9202.76	2123.71
1/4	9470.78	2164.75
1/2	9743.96	2206.18
3/4	10022.3	2248.00
27	10306.0	2290.22
1/4	10594.9	2332.83
1/2	10889.2	2375.83
3/4	11188.9	2419.22
28	11494.0	2463.01
1/4	11804.7	2507.19
1/2	12120.8	2551.76
3/4	12442.6	2596.72
29	12770.0	2642.08
1/4	13103.1	2687.83
1/2	13442.0	2733.97
3/4	13786.7	2780.50
30	14137.1	2827.43
1/4	14493.5	2874.75
1/2	14855.9	2922.46
3/4	15224.2	2970.57
31	15598.5	3019.07
1/4	15978.9	3067.96
1/2	16365.5	3117.24
3/4	16758.3	3166.92
32	17157.3	3216.99
1/4	17562.5	3267.45
1/2	17974.1	3318.30
3/4	18392.1	3369.55
33	18816.5	3421.19
1/4	19247.4	3473.22
1/2	19684.9	3525.65
3/4	20128.9	3578.47
34	20579.5	3631.68
1/4	21036.8	3685.28
1/2	21500.8	3739.28
35	22449.3	3848.45
1/2	23425.2	3959.19
36	24429.0	4071.50
1/2	25461.1	4185.38
37	26521.8	4300.84
1/2	27611.6	4417.86
38	28730.9	4536.46
1/2	29880.0	4656.62
39	31059.3	4778.36
1/2	32269.3	4901.67
40	33510.3	5026.54
1/2	34782.7	5152.99

Diam.	Volume	Surface
41	36086.9	5281.01
1/2	37423.3	5410.60
42	38792.3	5541.76
1/2	40194.3	5674.50
43	41629.7	5808.80
1/2	43098.9	5944.67
44	44602.2	6082.12
1/2	46140.0	6221.13
45	47712.9	6361.72
1/2	49321.0	6503.88
46	50964.9	6647.60
1/2	52645.0	6792.90
47	54361.5	6939.77
1/2	56115.0	7088.21
48	57905.8	7238.22
1/2	59734.2	7389.81
49	61600.8	7542.96
1/2	63505.8	7697.68
50	65449.8	7853.98
1/2	67432.9	8011.84
51	69455.8	8171.28
1/2	71518.7	8332.28
52	73622.1	8494.86
1/2	75766.3	8659.01
53	77951.7	8824.73
1/2	80178.8	8992.02
54	82447.8	9160.88
1/2	84759.3	9331.31
55	87113.6	9503.31
1/2	89511.1	9676.88
56	91952.2	9852.03
1/2	94437.2	10028.7
57	96966.7	10207.0
1/2	99540.9	10386.9
58	102160	10568.3
1/2	104825	10751.3
59	107536	10935.9
1/2	110293	11122.0
60	113097	11309.7
1/2	115948	11499.0
61	118847	11690
1/2	121793	11882
62	124788	12076
1/2	127832	12272
63	130924	12469
1/2	134066	12668
64	137258	12868
1/2	140500	13070

Diam.	Volume	Surface
65	143793	13273
1/2	147137	13478
66	150532	13685
1/2	153980	13893
67	157479	14103
1/2	161031	14314
68	164636	14527
1/2	168294	14741
69	172007	14957
1/2	175773	15175
70	179594	15394
1/2	183470	15615
71	187401	15837
1/2	191389	16061
72	195432	16286
1/2	199532	16513
73	203689	16742
1/2	207903	16972
74	212174	17204
1/2	216504	17437
75	220893	17672
1/2	225340	17908
76	229847	18146
1/2	234413	18386

Diam.	Volume	Surface
77	239040	18626
1/2	243727	18869
78	248474	19114
1/2	253284	19360
79	258154	19607
1/2	263087	19856
80	268082	20106
1/2	273140	20358
81	278261	20612
1/2	283446	20867
82	288695	21124
1/2	294008	21382
83	299387	21642
1/2	304830	21904
84	310339	22167
1/2	315913	22432
85	321555	22698
1/2	327263	22966
86	333038	23235
1/2	338880	23506
87	344791	23779
1/2	350770	24053
88	356817	24328
1/2	362934	24606

Diam.	Volume	Surface
89	369120	24885
1/2	375377	25165
90	381703	25447
1/2	388100	25730
91	394568	26016
1/2	401108	26302
92	407719	26590
1/2	414403	26880
93	421160	27172
1/2	427989	27464
94	434892	27759
1/2	441869	28055
95	448920	28353
1/2	456045	28652
96	463246	28953
1/2	470522	29255
97	477874	29559
1/2	485302	29865
98	492806	30172
1/2	500388	30481
99	508047	30791
1/2	515783	31103
100	523598	31416

Table 20. Diameters of Circles with Sides of Squares of Equal Areas

Diameter of circle = 1.12838 × side of square of equal area
Side of square = 0.88623 × diameter of circle of same area

Table 21. Spheres: Diameters, Volumes, Surfaces

Diameters by fractions
Surface = 3.14159 × (diameter)^2
Volume = 0.523598 × (diameter)^3

Basic Data for Computation of Molar Volume

ALBUQUERQUE, NEW MEXICO

January 1943

(Mean Sounding)

Altitude (KM)	Temp. (°C)	Pressure (Mb)	Humidity %	Molar Volume ft.³
1.620 (Surface)	+ 3.8	838	45	449
2	3.4	800	46	463
2.5	.6	752	45	486
3	- 2.6	706	48	522
4	- 8.3	622	51	567
5	-14.6	546	50	631
6	-21.2	477	48	704
7	-28.3	416	45	786
8	-35.7	332	39	872
9	-43.0	312	-	983
10	-49.7	269	-	1140
11	-54.7	230	-	1250
12	-57.2	197	-	1450
13	-58.1	168	-	1690
14	-60.2	143	-	1990
15	-61.6	122	-	2320
16	-63.0	104	-	2700
17	-64.3	88	-	3170
18	-65.1	75	-	3700
PHOENIX, ARIZONA				
20	-63	54	-	5410

Basic Data for Computation of Molar Volume

ALBUQUERQUE, NEW MEXICO

(Mean Sounding)

August 1943

Altitude (KM)	Temp. (°C)	Pressure (Mb)	Humidity %	Molar Volume $ft.^3$
1.620 (Surface)	25.2	838	44	480
2	23.3	803	39	492
2.5	20.4	758	42	517
3	16.6	715	48	541
4	8.8	634	66	594
5	1.1	562	79	652
6	- 5.6	495	72	715
7	-11.0	436	56	803
8	-17.1	382	45	895
9	-24.2	333	45	980
10	-31.6	290	-	1110
11	-39.4	251	-	1250
12	-47.0	217	-	1390
13	- 54.7	186	-	1560
14	-61.5	158	-	1780
15	-66.4	134	-	2060
16	-69.8	114	-	2460
17	-70.0	96	-	2830
		SANTA MARIA, CALIFORNIA		
20	-58.1	58	-	4960

Data for Molar Volume-Altitude Graph

Altitude, ft.	Molar Volume, ft.^{3}	Altitude, ft.	Molar Volume, ft.^{3}
5,000	420	50,000	2200
10,000	490	55,000	2850
15,000	590	60,000	3700
20,000	680	65,000	4900
25,000	820	70,000	6200
30,000	980	75,000	7800
35,000	1230	80,000	10,000
40,000	1410	85,000	12,600
45,000	1750	90,000	15,900
		95,000	20,200
		100,000	25,600

This data assumes a constant temperature (-60°C) above 65,000 ft., and below that altitude is based on representative pressures and temperatures taken from Washington, Albuquerque, Pittsburgh and Lakehurst soundings.

Individual variations from season to season, and from station to station may be noted in the graphs at the left of Figures 19 and 20. These variations are at most about 10%.

Remuneracion

La materia ha volado con este globo desde la New York University para hacer investigaciones meteorologicas. Se desea que esta materia se vuelva para estudiarle nuevamente.

Con este motivo, se dara una remuneracion de ________ dolares norteamericanos y una suma proporcional para devolver todos los aparatos en buen estado. Para recibir instrucciones de embarque, comuniquense con la persona siguiente por telegrafo, gastos pagados por el recipiente, refiriendo al numero del globo ________.

CUIDADO!
PELIGRO DE FLAMA. HAY KEROSEN EN EL TANQUE.

C.S. Schneider
Research Division
New York University
University Heights
Bronx 53, N. Y.

NOTICE

This is special weather equipment sent aloft on research by New York University. It is important that the equipment be recovered. The finder is requested to protect the equipment from damage or theft, and to telegraph collect to: Mr. C. S. Schneider, New York University, 181st St. & University Heights, West Hall, New York City, U.S.A. Phone: LUdlow 4-0700, Extension 63 or 27. REFER TO FLIGHT #

A   dollar ($) reward and reasonable reimbursement for recovery expenses will be paid if the above instructions are followed before September 1948.

KEEP AWAY FROM FIRE. THERE IS KEROSENE IN THE TANK.

CUESTIONARIO

Tenga la bondad de contestar lo siguiente y enviarlonos para que podamos mandarle a Ud. la remuneracion.

1. En que fecha y a que hora se descubrio el globo?

2. Donde se descubrio? Indique la distancia y direccion aproximada del pueblo mas cercano que se encuentra en el mapa del sitio de descubrimiento.

3. Se observo bajar? Cuando?

4. Se bajo despacio o se cayo rapidamente?

QUESTIONNAIRE

Please answer this and send to us so that we may pay you the reward.

1. On what date and at what hour was the balloon discovered?

2. Where was it discovered? (Approximate distance and direction from nearest town on map?)

3. Was it observed descending? If so, when?

4. Did it float down slowly or fall rapidly?

WEIGHT SHEET

Flight No. ____________ Date ____________

Time ____________

Balloon Manufacturer ____________

Number ____________ Quantity ____________

Burnout Patch and Wires. . . . ____________

Shrouds . . . . ____________

Total Balloon Weight . . . . ____________

Launching Remnant . . . . . ____________

1st Unit. Serial No. ____________

description ____________ ____________

Line length ____________ ____________

2nd Unit. Serial No. ____________

description ____________ ____________

Line length ____________ ____________

3d Unit Serial No. ____________

description ____________ ____________

Line length ____________ ____________

4th Unit Serial No. ____________

description ____________ ____________

Line length ____________ ____________

Banner description ____________ ____________

Ballast assembly - description ____________ ____________

____

____

____

Ballast . . . . ____________

Total Equipment Weight. . . . . ____________

Gross Load . . . . ____________

RATE OF RISE AND MAXIMUM ALTITUDE COMPUTATIONS

Flight No. ____________________ Date ________________

Time ________________

BALLOON INFLATION

Desired Rate of Rise . . . . ________________ ft./min.

Gross Load . . . ____________

Assumed Gross Lift (Gross Load + 10%) G ________________

G 2/3 ________________

Free Lift - $F = (\frac{V}{412})^2 G^{2/3}$ . . . ________________

Equipment Weight. . . . . ________________

Desired Balloon Inflation = Free Lift + Equipment Total ______________ grams

Allowance for Leakage @ ________ gm/hr, ______ hrs. waiting ______________ "

Actual Balloon Inflation . . . . ______________ "

MAXIMUM ALTITUDE

Balloon Volume. . . . . . ________________ cu. ft.

Gas Lift/mol . . . . . . Helium 11.1 kg/mol; Hydrogen 12.0 kg/mol

Molar Volume = $\frac{\text{Balloon volume x gas lift/mol}}{\text{gross load}}$

________________ cu. ft.

Maximum Altitude . . . . . ________________ ft. m.s.l.

Altitude Sensitivity . . . . ________________ ft./kg.

BALLAST COMPUTATIONS

Flight No. ____________________ Date ____________________

Time ____________________

Surface Balloon Diffusion (measured) (estimated) . . . ____________________ gms/hr

Percent Inflation. . . . . . . ____________________

Full Balloon Diffusion: Surface Diffusion x $\left(\frac{1}{\%\ \text{inflation}}\right)^{2/3}$

____

Ballast Leak (120% Full Balloon Diffusion). . ____________________

Automatic Ballast Valve Calibration

____

Estimated Ballast Duration. . . . . ____________________

New York University
Research Division
Balloon Project

Supplementary Information for Flight No. __________

Release: Site ____________________ date ________________ time _________________

Encoded Sounding Data:

Encoded Upper Winds

Release Weather

In-Flight Hourly Weather

Train Sketch in Folder _____________________ Films Sent Out ____________________

List Flight Records in Folder:

Remarks

Checked by ______________________________

Transmitter Performance for Flight No. ______________________________.

Release: Date __________ Time __________________ Site ________________.

Transmitter Type and Serial No. __________________________________.
Batteries: ' Type and Number ______________________________________.

Open Circuit Voltages:

Voltages Under Load:

Reception at Station #1

Reception at Station #2

Reception at Station #3

Critique

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