14

Appendix 14

Controlled Altitude Free Balloons
by Athelstan F. Spilhaus,
C.S. Schneider and C.B. Moore
Journal of Meteorology
Vol. 5, 1948

JOURNAL

OF

METEOROLOGY

VOLUME 5, 1948

Published bimonthly by the

AMERICAN METEOROLOGICAL SOCIETY

CONTROLLED-ALTITUDE FREE BALLOONS

By Athelstan F. Spilhaus, C. S. Schneider, and C. B. Moore

College of Engineering, New York University

(Manuscript received 4 December 1947)

ABSTRACT

The results of an experimental program to develop balloons with associated control devices, which will float at constant pressure in the atmosphere, are given.

Newly developed plastic balloons and automatic ballast equipment are described. Examples of successful controlled-altitude flights are shown, together with a preliminary analysis of their trajectories.

The constant-level balloon may provide data not obtainable from an ordinary pilot-balloon network. Future possibilities and plans for its use are indicated.

1. Purpose

Drift bottles have been used for many years in the study of ocean currents and have provided interesting data. In meteorology, no corresponding device has been available. It is evident, however, that a balloon which is free to move with the air currents, and yet whose altitude can be controlled, has many important applications in meteorology, as well as in other fields, where it may be desired to keep instruments at altitude for considerable lengths of time. An example is in the investigation of cosmic rays; here, clusters of ordinary extensible meteorological balloons have been used, but the constancy of altitude obtained is not sufficient for many meteorological applications. The purpose of the present investigation[1] was to develop a balloon with a control system which would fly at a predetermined constant level for periods of many hours. Such a balloon has wider application than the ocean drift bottle, because, whereas the latter is limited to surface (or near surface) currents, controlled free balloons may be set to drift at any pressure elevation desired, or along other thermodynamically defined surfaces, as long as the element defining the surface changes in a monotone fashion in the vertical.

In addition to the uses for maintaining instruments at high elevations, there are numerous potential applications of these balloons. Direct measurements of air trajectories and of lateral diffusion become possible. The balloons may also be used as vehicles to convey and drop radiosondes over ocean areas. One problem in this application is to obtain an absolute altitude tie-in point, as it will be difficult to identify the point at which the radiosonde reaches the sea surface.

2. Earlier attempts

There have been numerous attempts for various purposes to get a balloon or group of balloons to stay at a fairly constant altitude. Meisinger was interested in the meteorological aspects of this, using a manr balloon. In the investigation of cosmic rays, as example, by Clarke and Korff (1941), clusters ordinary meteorological balloons, 350-gram or 7 gram size, numbering anywhere from twenty to nea seventy, were utilized. No altitude-control dev were used; the balloons were merely given differ amounts of inflation. Thus the whole train ascen to an altitude where certain of the more highly infla balloons burst until the remainder just balanced load; thereafter, the assembly descended slowly to loss of lift by the diffusion of gas. The only provi for having the system regain altitude if it descen too low was by arranging the launching before da so that after the bursting of the first balloon and subsequent descent, superheating of the balloons the rising sun would cause the whole assembly to again, thereby increasing the duration of the fli The system does not have sufficient control for m purposes.

The much-publicized use of balloons by the Japa in the last war represents an attempt which mus considered highly successful from the point of vie the length of time which the balloons stayed in the Here the objective was not to obtain any cri altitude control, but rather to insure that the ball remained floating. The Japanese nonextensible loons were of two types. One type was of heavy pa coated to minimize diffusion, of spherical shape, a 25 to 30 ft in diameter, and containing about 1 cubic feet of gas. A solid-ballast control system utilized and gas was valved at a low internal pre (about two inches of water) to prevent the ball from rupturing due to the increase of the inte pressure by altitude fluctuations or radiation cha Such a valve tends to conserve the lifting gas but as a safety device to prevent damage of the enve due to too great an internal pressure.

The solid-ballast system was complex; app mately 900 pounds of sand was used on each bal distributed in thirty-six bags. The dropping of b

[1] Sponsored by, and in cooperation with the Watson Laboratories of the Air Materiel Command.

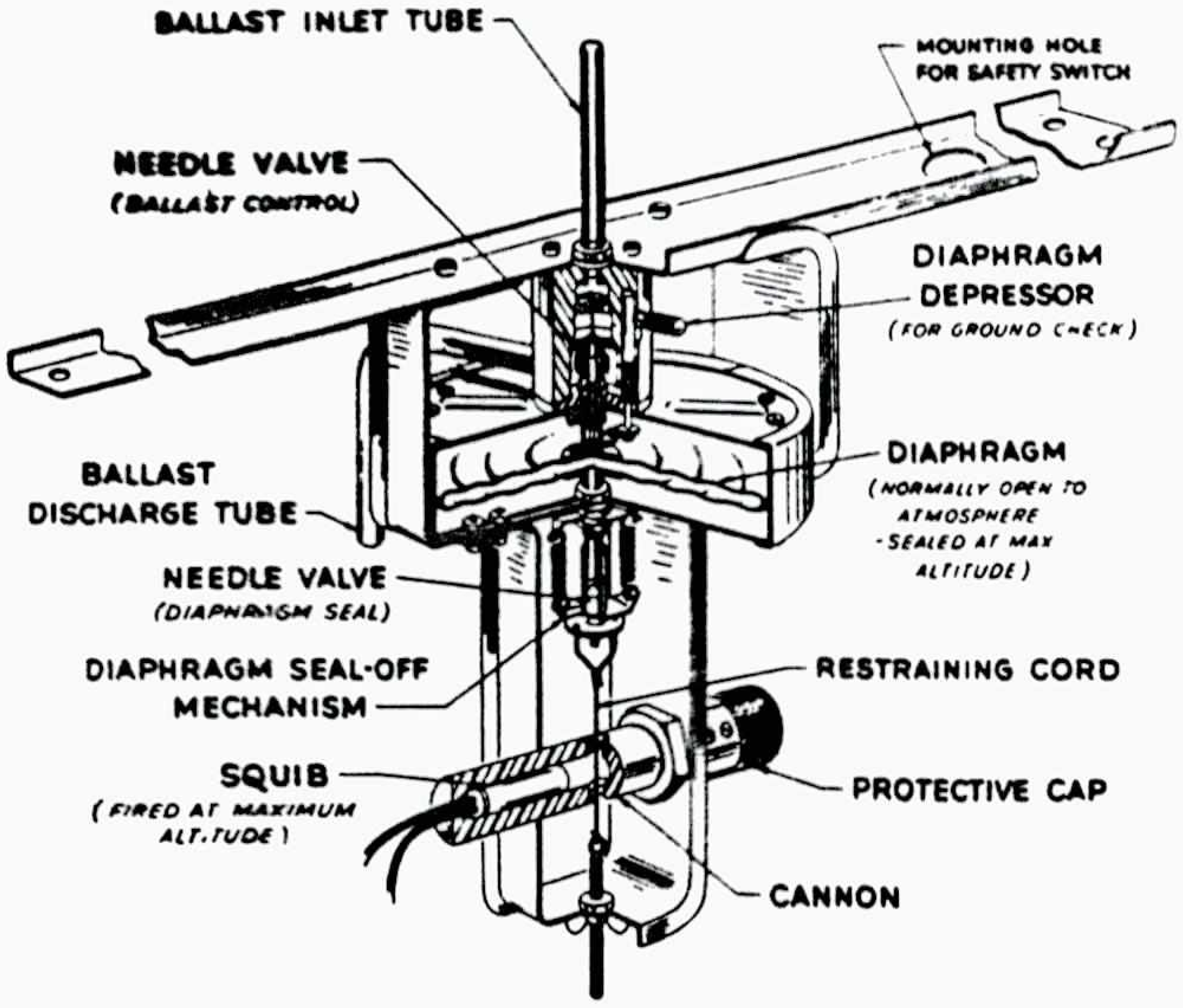


FIG. 2. Automatic ballast valve.

a diaphragm-operated needle valve which jettisons liquid ballast whenever the balloon is below the altitude at which the control is actuated. This is shown in fig. 2. The ballast reservoir (fig. 3), in general, can hold 15 kilograms of the liquid ballast—usually compass fluid, a highly refined kerosene-type petroleum product. When the atmospheric pressure outside the diaphragm is 5 millibars above the internal pressure, 160 grams of ballast per minute flow under a one-foot head. When the automatic ballast valve is wide open, which is after 6.5 millibars increase over the internal pressure, 300 grams per minute flow. These values may be compared with a diffusion loss of lift of the order of magnitude of 10 grams per hour from the thicker 15-ft balloon described below. Quite positive altitude control can be obtained.

Efforts are made to cause the static rate of leakage, *i.e.*, the leakage which proceeds when the automatic ballast valve is closed, to exceed slightly the rate of loss of lift due to the diffusion of the lifting gas from the balloon. To facilitate setting the fixed leak, a manually operated ballast valve, consisting of a leak adjustable by means of a fine needle valve, is added to the ballast-release assembly.[4]

C. Minimum pressure switch.—Obviously, the automatic ballast valve must not be in operation while the balloon is rising, as this would be a waste of ballast. Therefore the automatically operated needle valve is closed until the balloon reaches altitude. This is accomplished by having the loaded diaphragm of the altitude control open to the atmosphere until the balloon descends from a minimum pressure. At this time, an electrical contact is made and a squib[5] cuts a restraining cord and allows a needle valve to seal the diaphragm from any further access to the (fig. 2). The capsule then contains a volume of which has been trapped at the existing pressure a temperature, at the time of operation of the seal switch. Thereafter the aneroid will withdraw ballast-control needle valve when the ambient press increases to the point where the entrapped air is co pressed below this volume.

Fig. 4 shows the minimum pressure switch wh makes the electrical contact at the time of seal-off consists of a trapped volume of air that is allowed escape through a mercury pool as long as the out pressure is decreasing. As soon as the exterior press increases once more, however, mercury is drawn i the tube, making the seal-off contact between electrodes.

4. Height determination

Up to the present time, the standard radiosonde been used in order to determine the altitude at wh the balloon is flying. This permits a regular radioso ascent to be obtained during the period that the loon is rising. Thereafter, as the balloon remain approximately the same altitude, it becomes somew difficult to identify the radiosonde contact, but ut ing both the temperature and pressure indication, is possible. A special radiosonde modulator of Olland type has been designed (fig. 5). The pres

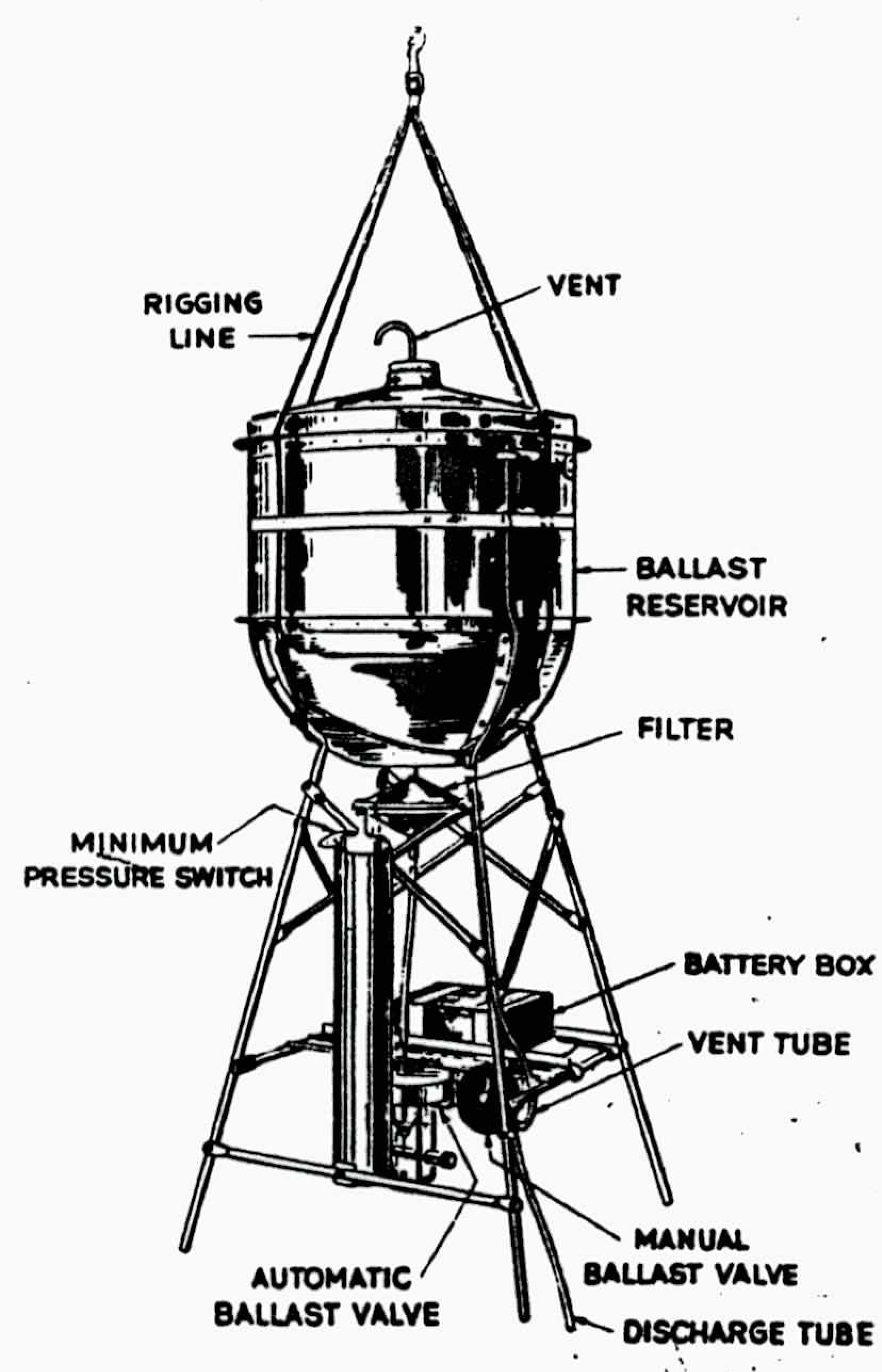


FIG. 3. Ballast-release assembly.

[4] Since this manuscript was written, the procedure has been simplified. Only a simple fixed leak is used for daytime flights. The automatic ballast valve is used alone for flights through sunset or sunrise.

[5] A small electrically detonated charge.

capsule and linkage is of conventional design but in place of the commutator bar, a motor driven helix is employed. This system permits the determination of

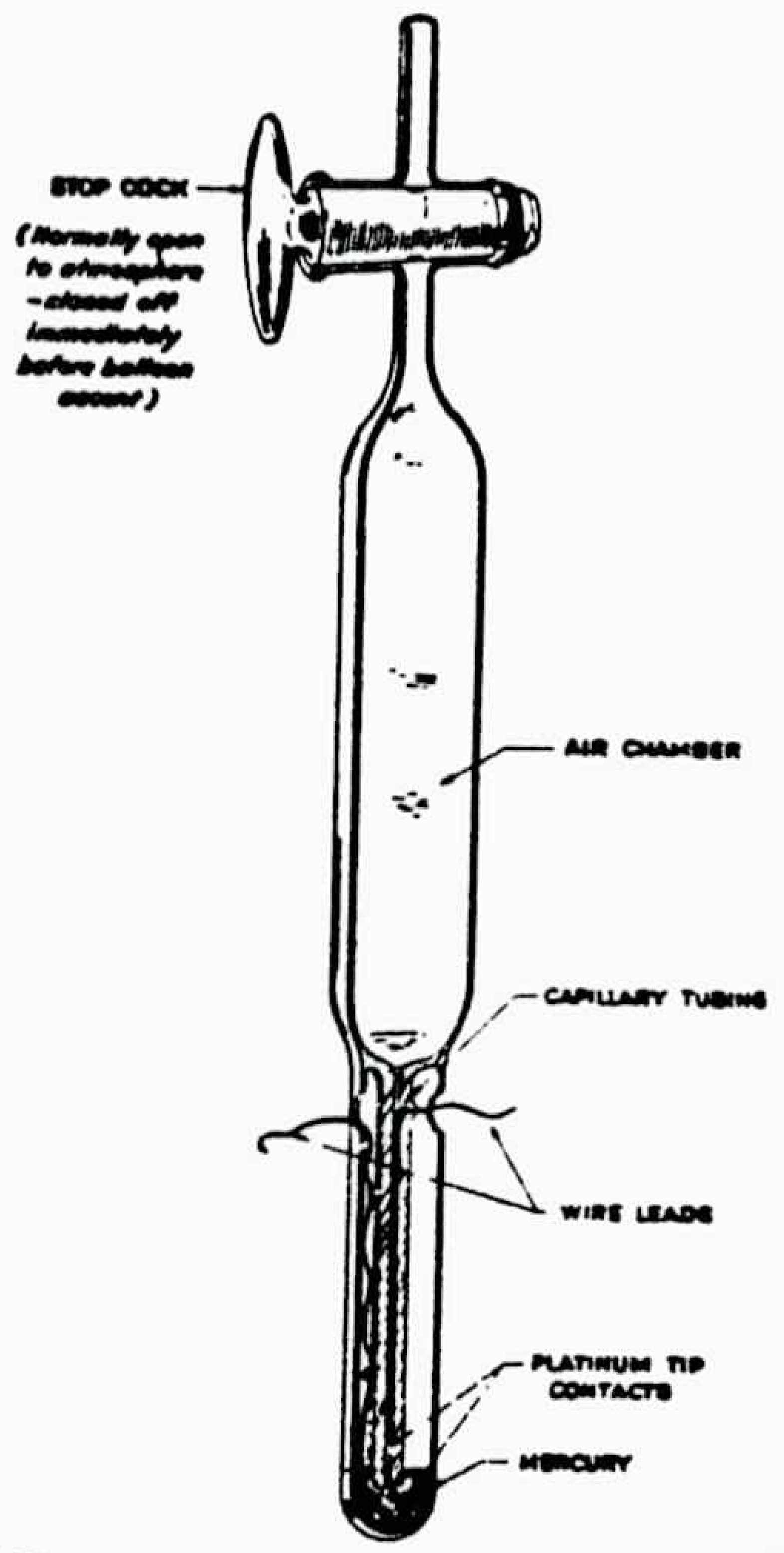


FIG. 4. Minimum pressure switch (mercurial).

.re data without knowledge of the history of contact sequence or of the ascent or descent of the balloon, .s is required in the conventional radiosonde.

;. Tracking of the balloon

The balloons that have been flown by the writers :sually have been tracked by theodolites. Airplanes ıave also been used, to extend the observations. These wo methods require the balloon to be visible and not bscured by cloud cover. When available, ground ıdar has been used in tracking the balloons, with ood results.

A series of SCR 658 radio direction-finders is also sed, arranged in a net along the expected trajectory f the balloon. In addition, aircraft equipped with ıverted search radar have been employed to extend he tracking net.

. Flight results

While the characteristics of various plastics were eing investigated, four preliminary flights were made ith clusters of ordinary meteorological balloons, from 5 to 26 in number, to which two to four towing alloons were attached. The towing balloons were cut ›v a baroswitch at a predetermined altitude. The der of the balloons were inflated so that they cactly balanced the load hung from the cluster. To fset diffusion, sand was dropped from an arrangeent of tubes, 9 to 16 in number, each containing out 200 to 1500 grams of sand ballast. This ballast as dropped by a baroswitch mechanism on descent only. Some of these flights were relatively successful as a beginning method but the dropping of discrete quantities of sand caused too great fluctuation of altitude and therefore was abandoned later. The first successful flight stayed at 51,000 ft, plus or minus 100 ft, for 38 minutes; another remained between 30,000 and 40,000 ft for 147 minutes. The latter shows the same characteristic time-altitude curve as the cosmic-ray clusters, although its altitude control is superior. It is not believed that much improved altitude control can be obtained, utilizing ordinary meteorological balloons. Flight termination was usually due to deterioration of the balloon caused by the sun.

In the first flight utilizing plastic balloons, a cluster of ten seven-foot diameter balloons[6] was used. The load on the cluster was 16.5 kilograms. An altitude control was used. Unfortunately, the maximum altitude reached was not as high as the predetermined altitude which was selected to seal the diaphragm of the automatic ballast valve. As a result, the cluster rose to ceiling and stayed at this altitude for a short while. Diffusion and leakage of helium produced a loss of lift at the rate of 125 feet per minute.

The next flight was made with a single polyethylene balloon, 15 ft in diameter. To insure sealing-off, the ballast-release diaphragm was set to operate at an altitude of 12,000 ft, considerably below the calculated ceiling of the balloon. After a dawn release the balloon continued to ascend to 15,100 ft where it leveled off, then slowly descended to 9000 ft due to diffusion losses. At this altitude the ballast release began to operate and thereafter the balloon maintained its altitude within ±1300 ft for a period of 4½ hours before the radio signal was lost. However, in the first two hours of this period, before the convection currents

[6] Made by General Mills, Inc.

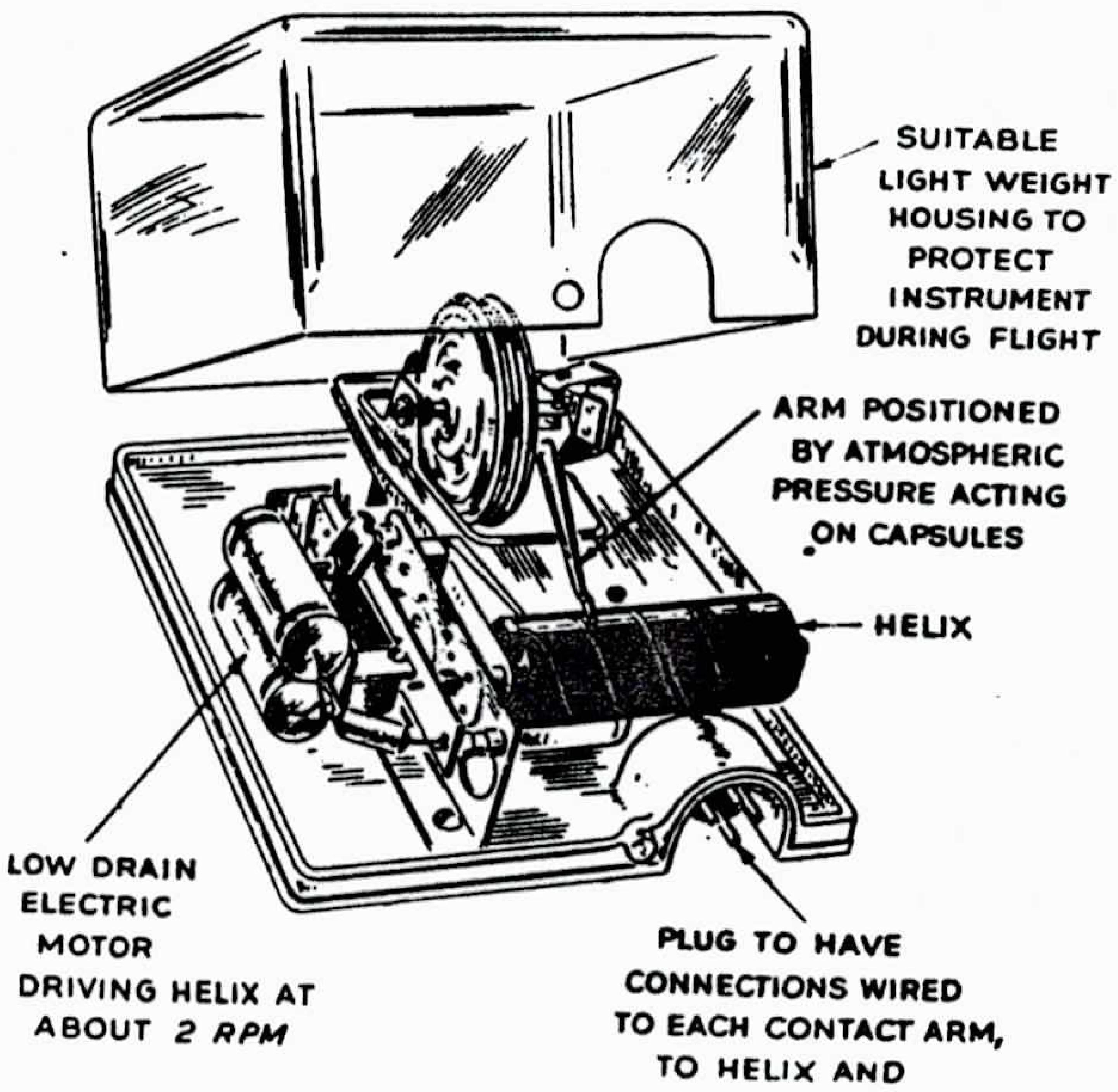


FIG. 5. Olland-cycle pressure modulator.

from the desert set in, the balloon maintained an altitude of 9200 ± 150 ft.

An explanation as to why the ballast release functioned at 9000 ft, although it was set to operate at 12,000 ft, is plain from the following data. The air in the diaphragm was sealed off on the dawn ascent at 12,000 ft, where the pressure was 657 mb and the temperature 9C. However, by the time the balloon passed through this level during the slow descent, the instrument temperature was 19C. This means that the pressure of the air trapped inside the diaphragm was higher than it was at time of seal-off.

For the ballast valve to function, the balloon had to descend to a pressure which would be greater by about 3 mb than the pressure of the trapped air at its now higher temperature. Of course, there was little ventilation past the instrument, and therefore the instrument temperature was about 25C above the ambient temperature after the sun had risen.

The automatic ballast valve operates when the volume inside the sealed diaphragm becomes slightly less than the volume at seal-off. Denoting the altitude at which it can operate by the subscript h, the pressure divided by the temperature at this altitude will equal the pressure at the seal-off altitude divided by the trapped-air temperature at the time of seal-off; in this case

$$p_s = 657 \text{ mb}$$
$$T_s = 9\text{C} = 282\text{A}$$
$$T_h = 39\text{C} = 312\text{A},$$

where the subscript s refers to seal-off. Thus the pressure at altitude h is given by

$$p_h = p_s T_h / T_s = 727 \text{ mb}.$$

This pressure, at which ballast release will begin, corresponds to an altitude of 9000 ft, which is the observed altitude maintained by the balloon for nearly 4½ hours, until the radiosonde tracking signal was lost.

The theodolite lost the balloon in clouds earlier . the airplane observer never succeeded in seeing it the balloon may have remained for a considera longer period at this altitude. Eleven hours after ginning the ascent, the balloon was reported to h been seen over Albuquerque, New Mexico, and ab 26 hours later a report was made from Pue Colorado, which seemed to indicate that the ball was still in the air at that time. The meteorolog situation and wind data for that area at the tim flight support the contention that the latter obse tions were of the same balloon.

The next flight consisted of an assembly of var balloons, as follows:

One 15-ft diameter 0.008-inch polyethylene balloo
Six 7-ft diameter General Mills 0.001-inch pol thene balloons,
Two 350-gm meteorological balloons for stac measurements.

The single balloon had a measured diffusion los lift of 4 grams per hour. The General Mills ballo were observed to lose lift at the rate of about grams per hour per balloon.

Three of the 7-ft balloons were inverted and defl shortly after launching, due to differences in the r of rise of the various balloons in the cluster. Theref the altitude reached was not high enough to ef seal-off. (It is for this reason that the minimum p sure switch was developed for use in later flights.)

Fig. 9 shows the elevation and plan views of track of this flight. The train leveled off at 16,50 The diffusion loss of lift of the remaining balloons approximately 300 grams per hour. The ballast v used had an unusually high rate of static leak which had been measured before release and foun be 310 grams per hour. Thus fortuitously, the los lift was compensated by ballast leakage. This ne

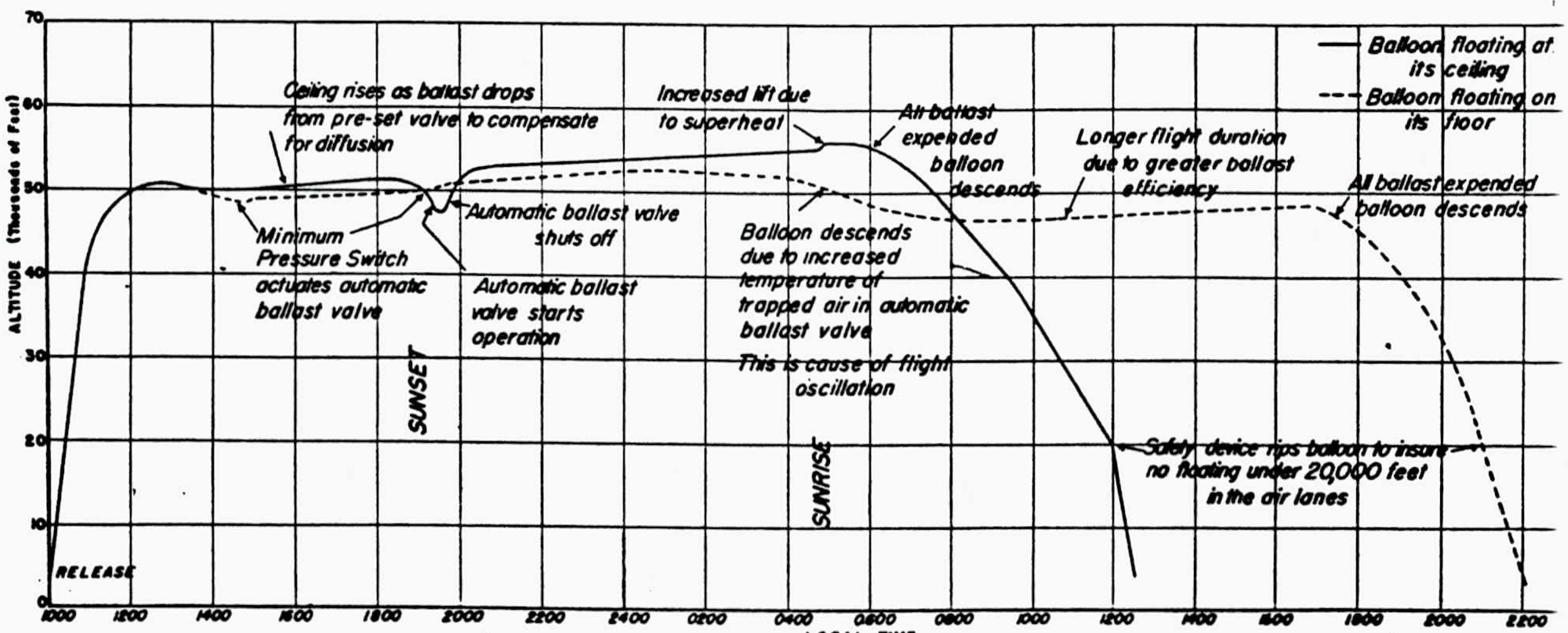


FIG. 6. Idealized time-altitude curves for various balloon-control systems.

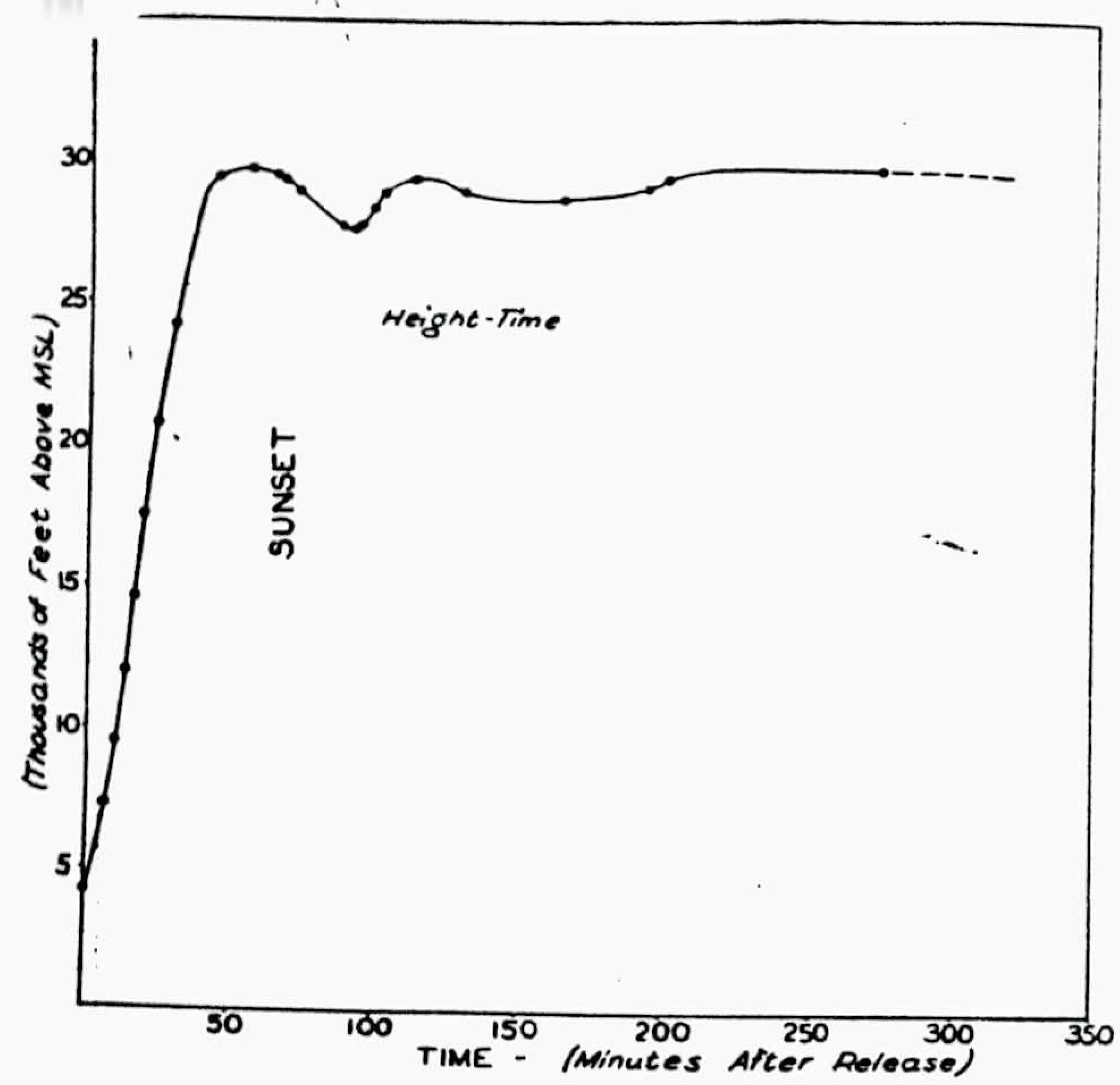


FIG. 7. Height-time curve of balloon Flight 17. Released at lamogordo, New Mexico, on 9 September 1947 at 1647 MST 05th meridian). Recovered near Pratt, Kansas, 530 miles stant.

onstant leakage held the balloon at 16,800 ± 700 ft 7 hours. The duration of the flight was 9¼ hours. the original 2700-gram ballast was expended, ie ualloon descended rapidly. Even had the autoiatic ballast valve been functioning, the constancy of ltitude would have been the same. This seems to indiate that only a minimum of automatic control is eeded, provided that diffusion losses are slightly vercompensated by a constant ballast leak.

Other flights also indicate the importance of a check alve in the balloon appendix to prevent dilution of ie lifting gas with air. If this is not done, the altitude eached is far under the theoretical altitude derined by the displacement and gross load.

. Control systems

Two systems of control are possible with the equipient as described. The balloon is controlled between n upper level (ceiling), where the full balloon buoyncy just equals the load, and a lower level (floor), elow which the automatic ballast valve operates. chematic curves for these two systems of control are hown in fig. 6.

In the first system of control the rate of static ballast eakage is greater than the diffusion loss of lift, and he balloon will stay at the ceiling. If it is displaced ve the ceiling the buoyancy is insufficient to bal-he load and it will descend again. Provided the at of ballast discharge is greater than the rate of lift y loss of gas this ceiling will slowly rise by valving of as, and as gas is lost by diffusion. The less the amount f gas the lower the pressure (higher ceiling) must be r the gas to fully distend the envelope. Unnecessary valving is undesirable and may, in part, be minimized by use of a restraining safety valve set in the appendix, which will allow some slight pressure to be carried in the balloon, preventing gas loss at the peaks of minor oscillations but still valving gas before the balloon ruptures due to too great an internal pressure.

In this system of control, the automatic valve is not sealed off until the balloon starts a descent due to cooling or other changes in lift, as when night falls. Upon descent the valve is activated and starts dropping ballast immediately; this continues until the balloon is no longer losing lift at a rate greater than the diffusion losses. The balloon will then rise above its former ceiling to a height determined by the weight of ballast dropped, and remain there as long as there is ballast to compensate for lift losses. Flight 17, reproduced in fig. 7, used a low-leakage balloon and is an actual case of ceiling control. It may be compared with the idealized time-altitude curves in fig. 6.

In the second system of control the static rate of leakage is less than the diffusion loss of lift. In this case the balloon will descend to the floor, where the automatic control operates and the balloon floats at an equilibrium altitude where the rate of ballast release exactly balances the rate of loss of lift. Floor control conserves ballast, since only that needed for altitude control is released. However, the altitude of the floor varies diurnally as the temperature of the entrapped air in the automatic ballast valve is affected by solar radiation. Two methods are being investigated to circumvent this undesirable feature. One is to

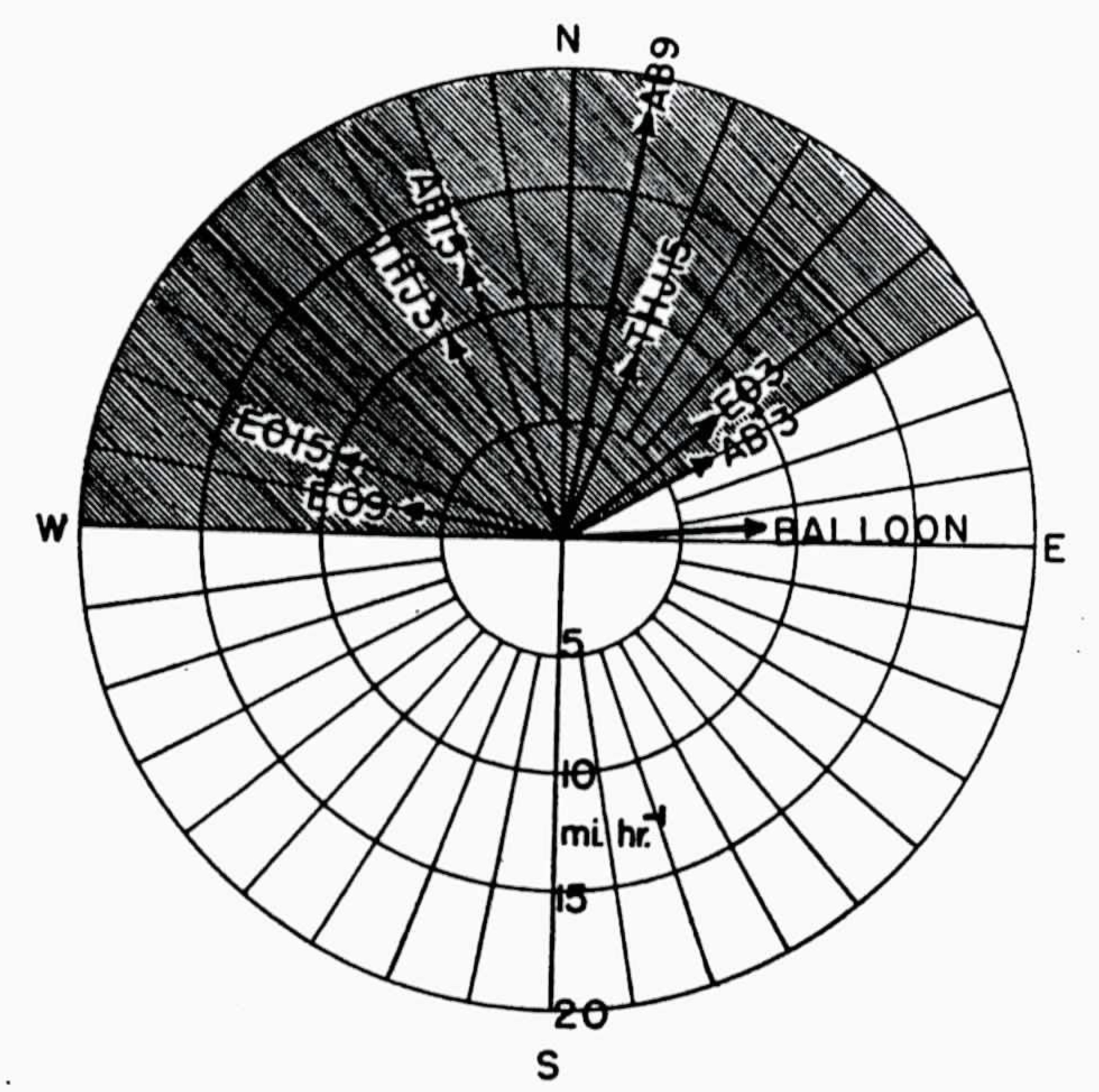


FIG. 8. Wind vectors at 16,000 feet for El Paso (EO), Albuquerque (AB), and Roswell (THJ), at 03^h, 09^h and 15^h (MST) on 7 July 1947, in connection with balloon Flight 11, mean motion of which is shown by the balloon vector. Cross-hatched sector contains all wind vectors at these three stations for the three observation hours and for the three levels, 14,000, 16,000, and 18,000 feet.

temperature-compensate the diaphragm, the other to insulate and shield the valve from radiation.

Using the ceiling-control system, flights of less than 24 hours not passing through sunset, may be held at ceiling by use of a nonextensible balloon and a simple fixed rate of leak to over-compensate diffusion losses. The constancy of level will be better the lower the diffusion and the lower, therefore, the rate of rise of the ceiling. The automatic control is needed for flights lasting through a period in which day changes to night.

8. Preliminary trajectory analysis of two constant-level balloon flights, 7 July 1947[7]

The most striking feature of the constant-level balloon flight (Flight 11, fig. 9) originating at Alamogordo Army Air Base at 05^h08^m MST[8] on 7 July 1947 is the disagreement between the actual trajectory and the trajectory that might have been estimated from routine upper-wind reports. In this connection the observations from the Weather Bureau stations at El Paso, Roswell, and Albuquerque have been examined, since the path of the balloon was contained within the triangle formed by these stations. Over El Paso, the wind directi at 16,000 ft (the approximate average altitude of t balloon during the greater part of the flight) w approximately SW at 03^h, ESE at 09^h, and ESE 15^h. Over Roswell, the apparent average wind directi at 16,000 ft was S during this period. Over Albuquerq which was considerably farther from the path of t balloon than the other two stations, the wind directi at 16,000 ft was variable between WSW and SSE duri the interval from 03^h to 15^h. In contrast with th observations is the fact that the constant-level ballo floated in an essentially steady WSW current betwe 06^h and 09^h.

In fig. 8 the wind observations at 16,000 ft have be plotted for El Paso, Roswell, and Albuquerque for 0 09^h, and 15^h. The wind directions at 14,000 ft, 16,0 ft, and 18,000 ft (only the intermediate level is sho in the figure) are all contained in the 150-degree sect between directions 90° and 240°; yet the mean moti of the balloon (approximately 265°) between 05^h4 and 13^h11^m falls entirely outside this sector.

An indication that this local WSW current was small depth is given by a special upper-wind obser tion made at White Sands at about 13^h. The obser tion in question recorded a wind direction of 250° 16,000 ft, which is in excellent agreement with the fi

[7] The authors are indebted to Prof. G. Emmons for contributing the major part of this section.

[8] Mountain Standard Time—105th meridian civil time. All further time references will be tacitly MST.

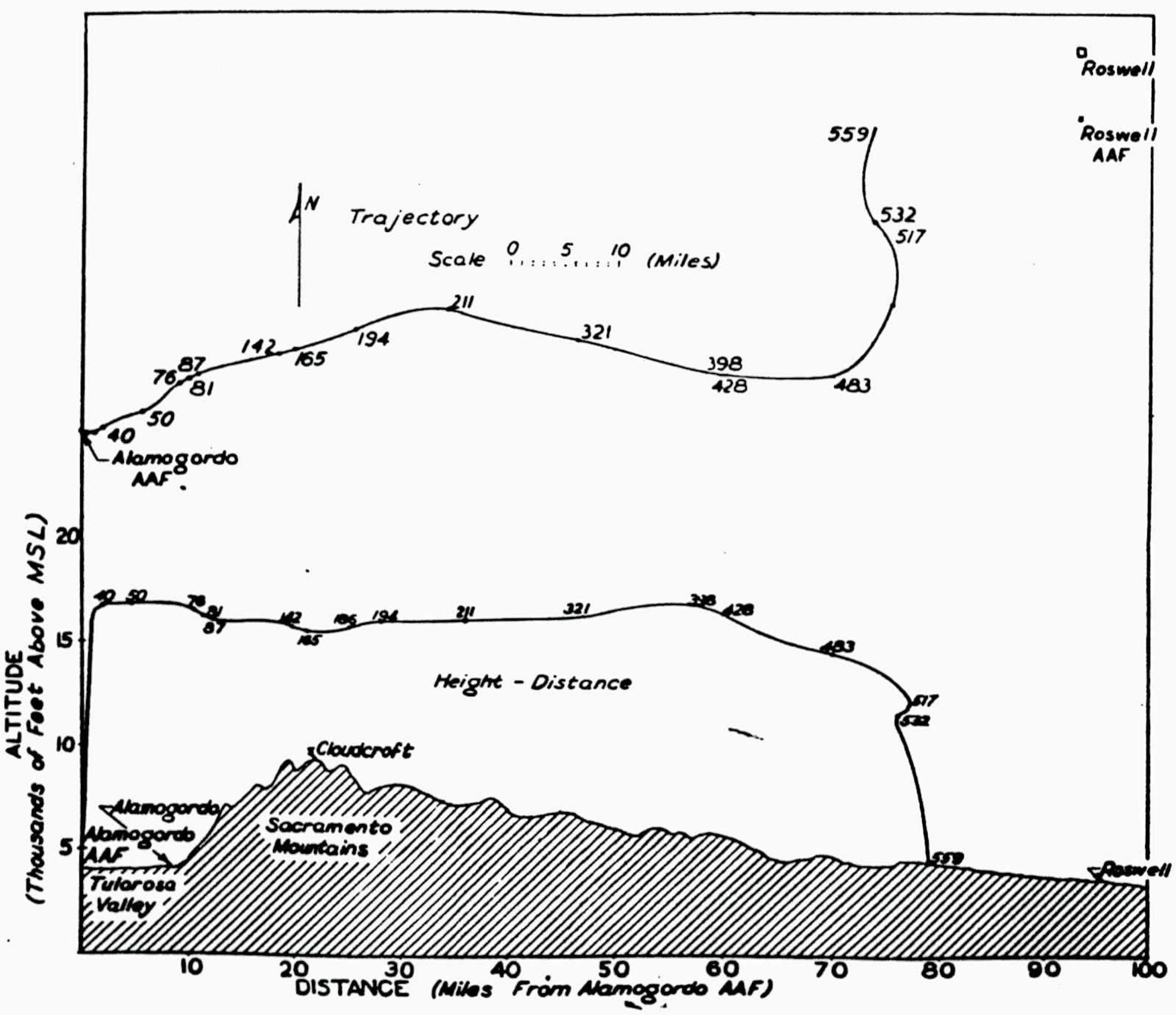


FIG. 9. Height-distance curve and planned trajectory of balloon Flight 11. Released at Alamogordo, New Mexico, 7 July 1947, at 0508 MST. (Numerals on curves indicate minutes after release.)

part of the trajectory of the constant-level balloon. The interesting fact about the White Sands observation is that *at all but one of the other reported altitudes* between the ground and 20,000 ft, the wind directions were from either the NE or SE quadrants.

The trajectory of the balloon curved slightly anticyclonically over the eastern slopes of the Sacramento Mountains. This characteristic is suggestive of the well-known deforming effect of a mountain range on an air current directed toward the axis of the range. In this case, however, the validity of invoking the aforementioned effect to explain the anticyclonic curvature, when the wind at levels below the mountain summits appears to have been blowing approximately parallel to the range, depends on assuming that the air currents parallel to the range themselves constitute a barrier deforming a higher current blowing in a different direction across the mountains. The sharp cyclonic bend that occurred after the balloon had come over relatively flat country occurred at the time that the balloon began its final descent and is due to the fact that the course of the balloon turned toward the north as a result of descent to levels where the wind had maintained a southerly direction throughout the day.

It is of interest to compare this flight with Flight 17 (fig. 10). It may be observed on fig. 10 that no deforming effect of the mountain barrier is apparent. This, however, is to be expected, as the altitude of the balloon above the mountain top is three times that of Flight 11, where this anticyclonic deformation of the trajectory was observed. The balloon was ultimately recovered from Croft, Kansas, a distance of 530 miles from the release point; on the basis of the observed wind speeds a 12-hour flight duration is estimated.

9. Conclusion

Within the coming year it is hoped that a number of meteorological investigations may be attempted, utilizing constant-level balloons. Release of three or more from a single point to float at the same level, release at a number of points to obtain a synoptic presentation of the trajectories in a chosen level, and the dropping of radiosondes from balloons are some of the operations to be attempted. Efforts will be made to simplify the arrangement so that a constant-level flight may be made in a routine fashion and at no greater cost than the ordinary radiosonde flight.

REFERENCE

Clarke, E. T., and S. A. Korff, 1941: The radiosonde: the stratosphere laboratory. *J. Franklin Inst.*, **232**, 217–355.

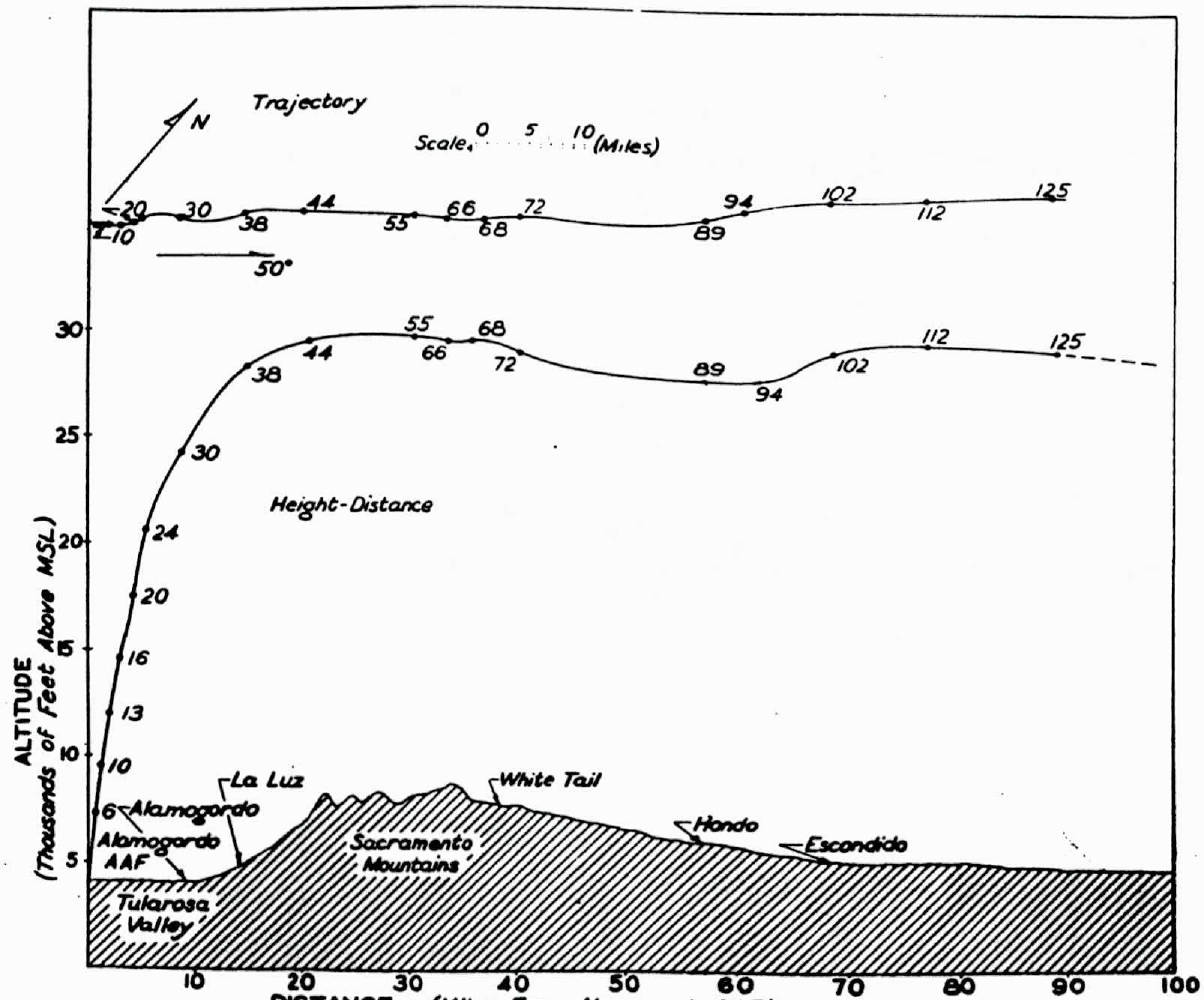


FIG. 10. Height-distance curve and planned trajectory of balloon Flight 17. Released at Alamogordo, New Mexico, 9 September 1947, at 1647 MST. First 125 minutes only are shown. (Numerals on curves indicate minutes after release.)

15

Appendix 15

New York University
Progress Report #6, Section II

PROGRESS REPORT #6

Covering Period from May 1, 1947 to
May 31, 1947

CONSTANT LEVEL BALLOON

Section II

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 S. Schneider

Approved by
Professor Athelstan F. Spilhaus
Director of Research

Research Division
College of Engineering
June, 1947

I. The following new men were employed on the Balloon Project during May:

Name	Duties	Qualifications
J. Richard Smith	Meteorologist (full time)	Former Weather Bureau and Army forecaster. Taught weather equipment at New York University, M.S. in Physics-Meteorology, NYU.
William O. Davis	Balloon Performance Analyst (part time)	B.A. Physics, New York University. Former AAF pilot. Graduate student in Physics.
Fred Barker (rehired)	Equipment Construction (part time)	Undergraduate Aeronautical Engineering Student.

II. The following administrative action was taken during the month of May:

A bid was obtained from Skinner, Cook, & Babcock, Contractors, at 60 E. 42d Street, New York City, for the erection of a prefabricated building for the Balloon Project. The quotation of $4,000 was forwarded to Watson Laboratories.

Correspondence during this period was as follows:

Date of Correspondence	Address	Abstract	Answer
5/1/47	WIRE Dr. Frank Myers Lehigh University Bethlehem, Pa.	Use of football bield requested for balloon launching on 6 May.	Granted.
5/5/47	WIRE Same	Bad weather postponed flight until 9 May.	None needed.
5/6/47	Kollsman Instrument Div. Square D Co. Elmhurst, L.I. Att: Paul Goudy	Request for quotation on diaphragm seal-off for dribbler and for increased quantity of modified dribblers.	Furnished.

5/7/57	WIRE Barney Frank Hightstown, N.J.	Samples of parachute shroud lines requested.	Furnished.
5/6/47	General Mills Minneapolis, Minn. Att: Mr. O. C. Winzen	Request for quotation on sample balloons shown to C.B. Moore on visit.	Awaiting Navy clearance.
5/13/47	Dewey & Almy Chem. Co. Cambridge, Mass. Att: Mr. Isom	Request delivery date on 1000 gm balloons.	Given.
5/14/47	Mr. C.P. Clare 4719 W. Sunnyside Ave. Chicago, 30, Ill.	Request for information and catalogues on rotary switches.	Furnished.
5/14/47	Goodyear Tire & Rubber Akron, Ohio Att: Leonard M. Harb	Delaying action in Goodyear's quotation for balloons.	
5/15/47	Office of the Secretary Fort Worth Sub-Committee on Air Space Civil Aeronautics Authority, (4th Region) Fort Worth, Texas	Request clearance for flight of Balloons from Alamogordo.	Given.
5/27/47	General Mills Minneapolis, Minn. Att: Mr. O.C. Winzen	Repeat request for quotation on plastic balloons.	Awaiting Navy clearance.

IV. Conferences

The following conferences were held during the month of May:

Date	People Present	Where Held	Discussed	Conclusions
5/1/47	O. C. Winzen of General Mills	General Mills Minneapolis, Minn.	Manufacture of balloons by General Mills for this project.	Obtain Navy clearance General Mills balloons look good for our work.
5/8/47	Dr. Peoples, Mr. Ireland, of Watson Laboratories. C.S. Schneider, C.B. Moore	Watson Laboratories Red Bank, N.J.	Bethlehem flight for May 9.	Final details.
5/10/47	Same	Same	New flights at Alamogordo, N.M., where lower winds can be found.	Set up trip to Alamogordo for May 29.
5/13/47	Paul Goudy of Kollsman Instrument C.B. Moore	Kollsman Instrument Div. Square D Co. Elmhurst, L.I.,N.Y.	New dribbler design.	
5/14/47	Representative of Vulcan Proofing Co. C.S. Schneider, C.B. Moore	Vulcan Proofing Co. Brooklyn, N.Y.	Testing of balloon fabrics and films.	Vulcan proofing would make tests.
5/22/47	Dr. Peoples, Messrs: A.H.Mears, John Alden, Charles Ireland, C.S.Schneider, C.B. Moore	Watson Laboratories, Red Bank, N.J.	Final arrangements for Alamogordo trip.	

III C 1. General Work Accomplished

A conference was held on May 1 at Minneapolis with Mr. O. C. Winzen of General Mills concerning the manufacture of balloons by General Mills for this project. At the present time this company cannot supply us with balloons until Navy clearance is obtained, but it is hoped that arrangements can be completed in the near future. The type of balloons manufactured by General Mills seems to be well suited to the needs of this project.

On May 8 a trip was made to Lehigh University, Bethlehem, Pa., to fly a cluster of meteorological balloons carrying Watson Laboratories equipment. Winds developed during launching and the balloons escaped when the restraining lines snapped under the strain, carrying balloons aloft without payload.

As a result of this incident, two conslusions were drawn: first, that a new launching technique was needed; second, that another launching site must be selected offering consistently calm winds during launching. It was decided to make the next flights at Alamogordo, New Mexico, early in June.

On May 14 a conference was held at the Vulcan Proofing Co., in Brooklyn, N.Y. to discuss the possibility of this company testing various types of fabric and film used in the manufacture of balloons. It was agreed that the company would make the desired tests when ordered by us.

The high point of the month's activities was the departure for Alamogordo on May 31, and the balance of the month was spent in the preparation of equipment for the flights to be made there. Departure was made from Olmstead Field, Middletown, Pa. in a C-47 furnished by the Watson Laboratories.

2. Specific Problems

In general, problems remain the same as those discussed in the previous report, namely: the determination of the relative merits of various balloon films and fabrics available; the analysis of the altitude control devices to be used; and the flight testing of the equipment to be used in preliminary work. All of these problems now await further flights and delivery of equipment ordered before solution can be attempted.

3. Limitations.

The greatest hindering factor in the progress of work is the lack of available space. The prefabricated building to be furnished by the government under the terms of the contract is now more urgently needed than before, due to the hiring of more personnel. The joint laboratory and office which this project shares with another is highly inadequate for six men of theirs and eleven of ours -- a total of 17 men in a space approximately 15x15 feet.

d. Methods of Attack

Until plastic balloons can be obtained, we will continue to fly clusters of meteorological balloons.

e. Apparatus and Equipment

The only substantial change in equipment during the period covered by this report, other than general strengthening of flying lines, is the addition of a new main sand ballast dropping device to the equipment train of the flights to be made at Alamogordo.

The device consists of a nest of eight plastic tubes each filled with dry sand and sealed on the bottom with a sturdy paper membrane. At the bottom of each tube, resting against the membrane, is a small detonating squib of sufficient force to rupture the paper and permit the sand to fall. Each squib is connected to a different lead on the baro-switch of a radio-sonde modulator, so that a predetermined weight of sand may be released at eight predetermined altitudes. A small wire "shelf" is placed over the commutator of the modulator in such a way that the pin arm is lifted clear of the contacts during ascent and permitted to drop into place at an altitude above that of the highest firing contact. This is designed to prevent the firing of squibs and consequent dropping of ballast during ascent.

f. Conclusions and Recommendations

It is felt that the use of freely extensible meteorological balloons is unsatisfactory for any final solution of our problem because of their inherent instability and the rapid deterioration of neoprene rubber under the rays of the sun. It is felt that cluster flights of these balloons are a purely stop-gap method of floating Watson Laboratories equipment until plastic non-extensible balloons can be obtained and tested.

The need for greater work space is becoming increasingly urgent as new personnel are added to the project and the extent of the work grows.

It is believed that with present equipment the Alamogordo, New Mexico, area is the most suitable available for launching purposes, since calm winds are consistently present at dawn, and there are a minimum of clouds to impair ground observation of the balloons in flight.

Future Work

It is hoped that in the immediate future satisfactory techniques for the launching and floating of cluster flights may be developed under optimum conditions, and tests made on small plastic balloons to be furnished by H.A. Smith, Coatings, Inc., of Mamaroneck, New York.

Arrangements have been completed with the Vulcan Proofing Co. of Brooklyn, N.Y. to test various balloon fabrics and films available. These tests will probably be conducted in the near future.

As soon as arrangements can be completed to obtain Navy clearance we plan to obtain non-extensible balloons from General Mills in sufficient quantity to make flight tests and commence work on the ultimate objective of this project.

16

Appendix 16

New York University
Special Report #1

SPECIAL REPORT #1

Covering Period from January 1, 1947
to April 30, 1947

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 S. Schneider
Charles S. Schneider
Assistant Project Director

Approved by: Renato Contini
Renato Contini
Acting Director of Research

Research Division
College of Engineering
May, 1947

ABSTRACT

A preliminary survey was made of the problem. Specifications were drawn up for the equipment needed and manufacturers were contacted to construct experimental balloons and altitude controls.

A balloon crew was assembled.

While awaiting delivery on the NYU designed equipment, clusters of meteorological balloons have been flown for experience and as a stop-gap method of carrying a payload to altitude. In addition, two salvaged, racing-type, man-carrying balloons of 35,000 cubic foot size have been procured and are being prepared for flight. Two 19,000 cubic foot Japanese balloons have been made available by the Navy.

Preliminary calculations have been made on balloon buoyancies and families of curves plotting altitude vs. lift for various balloon sizes have been prepared for planning and flight purposes.

Civil Aeronautics Authority has given clearance for flight of large balloons form Lakehurst, New Jersey, and Bethlehem, Pennsylvania, with certain restrictions.

REPORT

I. The personnel working on this project consists of the following full-time employees:

Name	Duties	Qualifications
Charles S. Schneider	Asst. Proj. Director	Former weather equipment officer, Army Air Forces doing similar work during the war. Elec. Engineering, Brooklyn Polytechnic & NYU
Charles B. Moore Jr.	Research Engineer	Former weather equipment officer, Army Air Forces doing similar work during the war. Graduate of Georgia School of Technology in Chemical Engineering.
Richard Hassard	Chief of Flight Detail	Former Signal Corpos Officer, Elec. Engineering at NYU.
Murry Hackman	In charge of the Electronic Weather Equipment.	Former weather equipment Technician, Degree in Mathematics and Statistics City College of New York.

In addition to the above full-time employees, the following part-time personnel are now working on the project:

Name	Duties	Qualifications
Henry Kammenzind	Computations & Equipment Construction	Undergraduate Elec. Engineering Student.
Ralph Morrell	Equipment Construction	Undergraduate Admin. Engineering Student.
James Smith	Weather Observer and Draftsman	Former Weather Observer in Army and Undergraduate Engineering Student.
William Kneer	Machinist	Undergraduate Engineering Student.

The following personnel were hired but later resigned:

Name	Duties	Qualifications
Robert Wisnieff	Equipment Construction	Undergraduate Physicist Student.
Robert Ferris	Equipment Construction	Undergraduate Physics Student.
Fred Barker	Equipment Construction	Undergraduate Aeronautics Engineering Student.

II. The following administrative action has been taken in connection with this contract:

Personnel

1. The assignment of Charles S. Schneider to act as Assistant Project Director.

2. The employment of Charles B. Moore Jr. of Georgia Tech. as a Research Assistant with duties as Engineer.

3. Murry Hackman was engaged to take charge of the Electronic weather equipment due to his past experience as a weather equipment technician and as an instructor of the AAF classes in the maintenance of radiosonde receptor AN/FMQ-1 and radio directional finder SCR-658 at Chanute Field, Illinois.

4. Richard Hassard, a former Signal Corps Officer was hired because of his general knowledge of electrical and radio circuits to handle the construction of special flight equipment.

Equipment

5. As New York University did not possess all the necessary equipment a list of equipment was prepared and submitted to the Government with the request that this equipment be loaned or furnished

by the government. To date most of this equipment has been received with the exception of the AN/FMQ-1, SCR-658 and the prefabricated buildings needed for office and storage space.

6. The list of equipment that was submitted to the government consisted of the major items that were necessary. However, because many small hand tools and radio parts and other equipment were needed periodically a petty cash fund of $100 was set up to facilitate purchase of small items. A further request has been submitted to the Chancellor of the University requesting that this petty cash be increased to $200 and that a travel fund of $100 be established.

Housing

7. The existing inflation shelter at the school for the Meteorological Department's use was not adequate to handle the large diameter plastic balloons that we plan to use. Therefore a request was submitted and approved by the Contracting Officer for the construction of a 27 ft. cube inflation shelter on the campus of New York University. Due to restrictions placed on us by the Air Space Sub-Committee of the Civil Aeronautics Authority, New York Office, it has since been decided not to erect this inflation shelter in the New York area, but rather to use existing facilities at Lakehurst, New Jersey or Olmstead Field, Middletown, New Jersey.

Sub-Contracts

8. Permission was secured from the Contracting Officer of the Watson Laboratories to place two sub-contracts. One was for the fabrication of plastic balloons and was placed with Harold A. Smith Inc., of Mamaroneck, New York. This sub-contract amounted to $7,565. The second sub-contract was placed with Kollsman Instrument Division of

Square D Incorporated at Elmhurst, Long Island, New York. This sub-contract was for the construction of model altitude controls and amounted to $7,446.

Correspondence written during this period is as follows:

Date of Correspondence	Address	Abstract	Answer
11/7/46	Plax Corp Hartford, Conn. Att: Mr. Griffith	Forwarding P.O.#5983 & Requesting price quotation and delivery schedule for 4 diff. thicknesses of 36" wide polyethylene sheet (.001" .00225" .004" and .008".	Not furnished.
11/7/46	Visking Corp. Chicago, Ill. Mr. Cahn	Request to know what maximum width Polyethylene could be supplied in, and what the cost and delivery date would be.	
12/4/46	Visking Corp. Chicago, Ill. E. B. Cahn	Advising interest in securing 300 ft. of 72" circumference polyethylene tubing request information on thickness and price.	72" circumference Polythylene tube could be furnished Request to know quantity and thickness .002 mil thic $1.40/lb. estimate and would need 19 lbs.
12/10/46	Dewey & Almy Chem. Co. Cambridge, Mass. Att: Mr. Langley W. Isom	Acknowledging receipt of material used by Mr. Isom in his constant level balloon work. Also advising that order for single and double neck 1000 gram balloons had been placed.	None required.

12/16/46	Celanese Celluloid Corp. 180 Madison Avenue New York, N. Y.	Advising this company of our desire to fabricate a balloon from plastic film and our interest in ethyl cellulose as a possible plastic film to be used for this construction. Request that literature be supplied showing low temperature characteristics, tensile strength, etc.	Advising they do not believe ethyl cellulose would work secondly that they do not make film only molding powder - no literature available.
12/17/46	Nixon Nitrogen Works Nixon, New Jersey	Same request made of this company as with Celanese Celluloid Corp.	Advising they only make molding powder.
12/17/46	Plax Corp. Hartford, Conn. Att: Mr. Griffith	Advising that E. L. Cournand Co., recommended by Plax, had declined the contract for fabrication of balloons. That Unexcelled Chem. Corp. of New Brunswick had agreed to this fabrication and supplied the necessary shipping address for the polyethylene.	None required.
12/17/46	Dewey & Almy Chem. Co. Cambridge, Mass. Att: Mr. Isom	Acknowledging receipt of single and double neck balloons. Double neck balloons were received with a single neck plus a nub on the top of the balloon. Request to know whether shipment was in error and if so what disposition to be made.	Advising that nub must be cut with scissors in order to get double neck
12/17/46	Dow Chem. Co. Midland, Mich.	Same request made of this company as that made with Celanese Celluloid Corp.	Not received.

12/24/46	Unexcelled Chem. Corp. Harold A. Smith	Advising the Plax Corp. had been supplied with his shipping address and also requesting his technical advice on the feasability of using a 72" wide strip of polyethylene, 2 mil. thickness that Visking Corp. of Chicago could supply.	Advising that .002 mil thickness too thin. Suggested endeavoring to obtain 72" width in .006 mil.
1/3/47	Harold A. Smith	Acknowledge receipt of letter of December 26th containing estimated cost of fabrication of balloon. Advising that the bid could not be accepted on a cost plus basis. Requesting that their quote be resubmitted.	New quotation furnished.
1/3/47	Visking Corp. Chicago, Ill. Att: J. L. Lane	Advising that fabrication of balloons at a 2 mil. thickness polyethylene film would be extremely difficult to handle. Request made that information be supplied on a 72" circumference film 4-6 mils in thickness.	Advising that they only have .004 and .006 15 18" flat width. The 36" width request could be made but price would be prohibitive.
1/8/47	Watson Laboratories Red Bank, N. J. Mr. A. H. Mears	Advising need of radiosonde receptor SCR658 by NYU plus power units and technical publications.	Advising part shipment would be made Feb. 13th.
1/8/47	Watson Laboratories Red Bank, N. J. Mr. A. H. Mears	Returning list of equipment to the government loaned or government furnished with request that certain corrections, additions and deletions be made.	Advising governmen records changed an that catalogues will be sent under separate cover.

1/14/47	Bland Charnas Inc. Yonkers, N. Y.	Requesting to know whether this company would consider fabrication of 15 ft. diameter plastic balloon.	Advising that they could not assist us in fabrication.
1/21/47	Shellmar Projects Corp. Mt. Vernon, Ohio	Request that they quote on delivery and cost of fabrication of 10 ea.15 ft. balloons. Five to be fabricated from Saran (Type M.00225" thick and 5 from polyethylene made from PM-1.004" thick.	Advising plant could not cope wit problem at this time.
1/21/47	Milprint Inc. Milwaukee, Wisc. Mr. Paul B. Hultkrans	Same request as letter to Shellmar 1/21/47.	Verbally informed. Not interested.
1/21/47	Rowe Packaging Co. Ltd. Toronto, Canada	Same request as letter to Shellmar 1/21/47.	Wish to make model and submit same be fore quoting. Nev heard anything.
1/21/47	Western Products Inc. Newark, Ohio	Same request as letter to Shellmar 1/21/47.	Acknowledged receipt of letter and advising quotation would follow Did not arrive.
1/23/47	Kennedy Car Liner & Bag Co., Inc. Shelbyville, Ind.	Same request as letter to Shellmar 1/21/47.	Verbally informed. Not interested.
1/23/47	Unexcelled Chem. Corp. Harold A. Smith	Request for quote on 15-15 ft. diameter balloons and 6-3 ft. diameter balloons to be fabricated from various thicknesses of Saran and Polyethylene.	New quotation furnished.
1/23/47	Watson Laboratories Red Bank, N. J. Mr. A. H. Mears	Advising that tool equipment TE-50A was short a 6" ruler a pr. of tweezers, and a socket wrench. No request for replacement for these items made.	None required.

1/28/47	Kollsman Instrument Co. Elmhurst, L. I. Att: Paul Goudy	Request for quotation of 3 ea. of the following altitude control equipment: 1. Motor switched modulators. 2. Elec. controlled dribblers. 3. Mech. controlled dribblers.	Quotation supplie
2/3/47	Contracting Officer Watson Laboratories Red Bank, New Jersey	Forwarding quote from Unexcelled & requesting approval.	Not approved.
2/7/47	Watson Laboratories Red Bank, New Jersey Att: Mr. D. Rigney	Requesting permission to build a 27 cubic foot inflation shelter.	Permission grante
2/10/47	Contracting Officer Watson Laboratories Red Bank, New Jersey	Forwarding quotation received from Kollsman Instrument Co. for the necessary control devices for the constant level balloon.	Permission grante to place subcontr
2/11/47	Patterson Bros. New York City Att: Mr. H. Carey	Advising that one Ungar electric soldering pencil is being returned under separate cover as it was received in unusable condition. Request for replacement made. Quotation enclosed.	Replacement made.
2/18/47	Contracting Officer Watson Laboratories Red Bank, N. J.	Requesting permission to place subcontract with Unexcelled Chem. Corp. for the fabrication of balloons.	Permission withhel
2/24/47	General Mills Minneapolis, Minn. Mr. O. C. Winzen	Request that quotation be supplied for the fabrication of 15-15 ft. diameter balloons and 6-3 ft. diameter balloons made of various thicknesses of polyethylene and Saran.	Declining to quot until after confe ence with NYU representatives.

2/24/47	Bland Charnas Co. Inc. New York City	Same request as letter to General Mills 2/24/47.	No reply received
2/24/47	Leonard M. Harb Goodyear Tire & Rubber Akron, Ohio	Same request as letter to General Mills 2/24/47.	Quotation supplie 15 April 1947.
3/6/47	Watson Laboratories Red Bank, N. J. Mr. Brophy	Forwarding copy of letter of request that had been sent to Mr. H. A. Smith for the fabrication of balloons.	No answer receive
3/7/47	Contracting Officer Watson Laboratories Red Bank, N. J.	Advising that Unexcelled Chem. Corp. did not wish to proceed with the contract and that instead H. A. Smith of Mamaroneck, N. Y. was willing to undertake the fabrication. Quotation from Mr. Smith enclosed. Request that approval be granted.	Permission grante
3/7/47	Goodyear Tire & Rubber Akron, Ohio Mr. L. M. Harb	Request a quote on the fabrication of 5 ea. balloons made from Nylon covered with suitable neoprene and 5 ea. balloons made from fortisan covered in a similar fashion. Advising that any recommendations concerning balloon fabrics would be appreciated.	Quotation supplie 15 April 1947.
3/7/47	Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Same request as letter to General Mills 2/24.	Advised interest. Ask for conferenc
3/7/47	Unexcelled Chem. Corp. New Brunswick, N. J.	Requesting that polyethylene film that had been shipped to them from Plax Corp. be returned to NYU.	No action taken.
3/7/47	Plax Corp. Hartford, Conn. Mr. R. E. Ames	Request that shipping address for polyethylene film be changed from Unexcelled Chem. Corp., New Brunswick, N.J. to H. A. Smith, 490 Bleecker Ave., Mamaroneck, N.Y.	No answer requi

3/19/47	Unexcelled Chem. Corp. New Brunswick, N. J. Att: Mr. Tegen	Confirming telephone conversation in which authorization was given to ship polyethylene film to NYU and advising once again of correct shipping address.	Film shipped. Quotation supplie[d]
3/21/47	Manne-Knollton Insul. Co., N. Y. C.	Requesting quote and delivery date on fibre screws $1\frac{1}{4}$" long, fillister head and 8-32 thread.	Quotation supplie[d]
3/24/47	General Mills Minneapolis, Minn. Mr. O. C. Winzen	Acknowledge letter of 3/11 and advising that our representatives would be pleased to discuss construction details of the balloons.	Asked for conference in April.
3/24/47	Mr. R. S. Hassard 5 Hollywood Ave. Tuckahoe, N. Y.	Advising him of possibility of full-time position in Research Div. of NYU. Requesting that he make appointment for interview.	Hassard employed
3/25/47	Mr. George E. Weidner Engineer Board Barrage Balloon Branch Ft. Belvoir, Va.	Requesting permission for NYU representatives to visit with him to discuss constant level balloons and safety valves and control devices.	Invited to visit Mr. Weidner.
3/27/47	H. A. Smith Mamaroneck, N. Y.	Requesting quote on valves.	Supplied
3/29/47	H. A. Smith Mamaroneck, N. Y.	Request for quote on balloons fabricated from nylon and fortisan film coated with butyl rubber.	Not received.
3/29/47	Seyfange Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Requesting quote on 3 sets of stabalizer fins.	Received.

3/31/47	J. R. Garvin Douglas Leigh Sky Advertising Co. Lakehurst, N. J.	Requesting quote for the 30,000 cu. ft. balloons that this company received from surplus.	Acknowledged. Asked for definit express ion of interest.
3/31/47	Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Requesting quote on one to five each 15 ft. diameter balloons made of 3 oz. silk cloth coated with neoprene and 2 each 3 ft. diameter balloons made from the same material.	Furnished.
4/1/47	Mr. J. Boyle Air Cruisers Inc. Clifton, N. J.	Requesting quote on 25-15 ft. diameter balloons and 10-3 ft. diameter balloons made from polyethylene .004" polyethylene .008" saran .00225" and a fortisan fabric coated with butyl rubber and from nylon film.	Quote furnished nylon fabric coat with butyl rubber Interested but cost plus basis.
4/1/47	Molded Latex Products Inc. Paterson, N. J.	Identical letter as above request to Air Cruisers Inc.	Furnished.
4/8/47	WIRE H. J. Brailsford & Co. Inc. Rye, N. Y.	Requesting price and delivery date of 3 volt price type relays.	
4/8/47	Capt. Albert C. Trakowski Watson Laboratories Red Bank, N. J.	Forwarding minutes of Air Space Sub-Committee Meeting.	None required.
4/3/47	General Mills Minneapolis, Minn. Mr. O. C. Winzen	Acknowledging receipt of March 31st letter and notifying this company that our representatives would be pleased to come at their convenience.	April date set.
4/10/47	WIRE H. G. Brailsford Rye, N. Y.	Requesting to know how relays ordered were shipped.	Answered.
4/10/47	WIRE Lehigh University Bethlehem, Pa. Prof. Frank Myers	Requesting permission to make balloon release from Lehigh University on 15 April.	Given.

4/10/47	WIRE Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Requesting to know whether April 17th or 18th would be satisfactory to Mr. Frank C. Seyfang to meet NYU representatives to inspect 80,000 cu. ft. and 2-35,000 cu. ft. in Heightstown, N. J.	Date Given.
4/11/47	WIRE Dewey & Almy Cambridge, Mass. Mr. W. L. Dawbarn	Advising that single neck N1000 gram balloons should be furnished on our order 148-48.	None needed.
4/14/47	WIRE Frank Seyfang Seyfang Laboratories Atlantic City, N. J.	Advising NYU representative could not keep engagement for April 17th to inspect balloons and requesting that next best suitable date be furnished.	Furnished.
4/15/47	WIRE Mr. Barney Frank 27 Rochdale Ave. Roosevelt City, N. J.	Advising NYU still interested in purchase of balloons. Requesting that inspection date be changed from 17 Apr. to 23 Apr.	Satisfactory
4/17/47	WIRE Lehigh University Bethlehem, Pa.	Advising time of arrival at Lehigh to release balloons.	None needed.
4/17/47	N. Y. Sub-Committee on Air Space 385 Madison Ave., NYC Att: C. J. Stock	Advising that discrepancies observed in minutes of CAA meeting and requesting that conditions for more suitable flights be granted.	Request refused.
4/21/47	WIRE General Mills Minneaplis, Minn. Mr. O. C. Winzen	Advising that NYU representatives would make definite date for arrival later in week.	

4/21/47	WIRE Barney Frank 27 Rochdale Ave. Roosevelt City, N. J.	Confirming date of Apr. 23 for date inspection of balloons.	None needed.
4/21/47	Seyfang Laboratories Atlantic City, N. J.	Confirming date of 23 Apr. for date inspection of balloons.	Answered.
4/23/47	Kollsman Instrument Division 80-08 45th Avenue Elmhurst, L. I.	Changing details in altitude control purchase order.	None needed.
4/28/47	WIRE Seyfang Laboratories Atlantic City, N. J.	Advising that 2 - 35,000 cu. ft. balloons were purchased from Barney Frank and that these balloons were being shipped to him for repair.	Acknowledged.
4/28/47	Barney Frank 27 Rochdale Ave. Roosevelt City, N. J.	Advising that University would buy 2 - 35,000 cu. ft. balloons and that these balloons should be shipped to Seyfang Laboratories.	Acknowledged.

IV. Conferences

Preliminary conferences were held with plastic packaging companies. However, as trained personnel were not always available at the time of these conferences with the various companies it was necessary to write followup letters. Reference to these letters can be found under communications of this report.

In addition to these preliminary conferences regarding plastics the following conferences were also held:

Date	People Present	Where Held	Discussed	Conclusions
2/11/47	Dr. J. Peoples, C. Ireland, D. Rigney, Capt. Trakowski, Hackman, Moore, Schneider	Watson Laboratories Red Bank, N. J.	Government furnished equipment.	Equipment would be expedited by Watson.
2/21/47	R. Brophy, Dr. J. Peoples, Capt. Trakowski, D. Rigney, Schneider, Moore	Watson Laboratories Red Bank, N. J.	Placement of sub-contracts for balloons with H. A. Smith, Inc.	NYU should visit Goodyear before placing contract.
2/25/47	Lt. Comdr. Harrison, Dr. Peoples, Schneider, Moore, Hackman	Lakehurst Naval Air Station Lakehurst, N. J.	Jap Balloons.	Jap balloons were available for projecture.
2/27/47	J. Sturtevant, L. Harb, Schneider, Moore	Goodyear Tire & Rubber Co. Akron, Ohio	Fabrication of large balloons	Goodyear was interested and would prepare a quote.
3/3/47	Dr. Peoples, D. Rigney, Moore, Schneider	Watson Laboratories Red Bank, N. J.	Placement of sub-contracts for balloons and altitude controls.	Permission granted to place sub-contract.
3/21/47	Mr. Hagen, Dr. Prendergast, Moore	Molded Latex Paterson, N. J.	Fabrication of large balloons.	Await preparation of a quote.

3/25/47	Lt. Gunther, Comdr. Harrison, C. Ireland, Moore	Lakehurst Air Naval Station Lakehurst, N. J.	Use of Lakehurst as a launching site.	Lakehurst would be available to Watson.
3/26/47	F. Seyfang, Mrs. F. Seyfang, Moore, Schneider	Atlantic City, N. J. Seyfang Laboratories	Fabrication of large balloons.	A quotation would be prepared.
4/4/47	Dr. Peoples, D. Rigney, Moore, Schneider	Watson Laboratories Red Bank, N. J.	1st Cluster Flight	Prepare for Second Flight
4/11/47	R. Brophy, Mr. Cambridge R. Contini, M. Giannini Schneider, Moore	New York University	Contract Administration	Housing would be provided by govt.
4/30/47	P. Goudy, Moore	Kollsman Instrument Co. Elmhurst, L. I.	Ballast valve construction.	Change inddetails.

During the period covered by this report, Messrs. Moore and Schneider made repeated trips to Kollsman Instrument Co. and discussed the fabrication of the modulators and other equipment that Kollsman was designing for our use. These meetings have not been considered conferences but for the benefit of this report the same individuals were always present, Messrs. Schneider and Moore of New York University and Paul Goudy, Engineer fo r Kollsman Instrument Co. The material discussed was methods of improving the construction of the modulators and other equipment.

III C 1. General Work Accomplished.

The period was spent in preparatory work which consisted of the following phases:

Phase 1. The designing of a balloon and of altitude controls to be used as tentative solutions to the main problem.

2. The contacting of plastic film fabricators to obtain several sources of supply for large non-extensible balloons. To date, one sub-contract has been let for 15 ft. diameter balloons.

3. The contacting of an instrument company which would construct the altitude control devices. A subcontract has also been let for altitude controls.

4. The designing of a large balloon inflation shelter at N. Y. U. Materials have been procured for it. Due to change in plans the shelter will not be built at N. Y. U. therefore the materials are being held for the government until termination of contract.

5. The repairing and testing of the radiosonde receptor in Department of Meteorology for preliminary flights pending the arrival of Government-loaned equipment.

6. The preliminary flights with clusters of Meteorological balloons as stop-gap methods to attempt constant level balloon flights while awaiting the delivery of N. Y. U. designed equipment.

7. The making of preliminary calculations and requirements on constant level balloon performance.

2. Specific Problems.

Yet to be determined is the relative merits of various balloon films and fabrics available. This is to be handled by test work done by the General Mills and perhaps by the Bureau of Standards in Washington.

The altitude control devices need to be analyzed for determination of optimum settings for initial action and rates of release of the ballast. This problem is awaiting some flights before a full scale, mathematical study is undertaken.

The main problem is the flight testing of the equipment planned as a tentative solution to the desired flight path. This awaits receipt of some large lightweight balloon envelopes and more of the altitude controls.

3. Limitations.

More work would have been accomplished had the equipment to be furnished by the Government arrived. The prefabricated building that is to be supplied by the Government according to the contract is urgently needed, as there is no housing available for the project at N. Y. U. The project personnel has been using work benches occupied by other projects. The project has been using the office space of another research group. This has not been satisfactory as six of their men and four of ours attempt to work in a joint laboratory and office 15 x 15.

Restriction on the project is the Civil Aeronautics Authority requirement that balloon flights be made only on days that are cloudless up to 20,000 feet. This is difficult to meet in the eastern United States but appears less difficult in the New Mexico area.

The pertinent abstract from minutes of the meeting with the Air Space Sub-Committee of CAA on 17 March 1947 are included in the appendix.

d. Methods of Attack

(1) After a survey of available literature in aerostatics and after conferences with various balloon manufacturers and authorities it is believed that the basic problem of maintaining the 15 lbs. of payload at constant altitude can best be solved by using a non-extensible balloon and a device operated by pressure which drops ballast whenever the balloon descends below a preset altitude.

The specifications for the equipment are as follows:

The balloon should be of large known volume, light in weight, non-extensible, either transparent or highly reflective to solar radiation. Rigging should be used to distribute the load evenly about the balloon.

A safety valve should be used to hold the inflation appendix of the balloon normally closed (as any hydrogen lost decreses the time possible at nominal constant altitude). The valve would act as a safety vent if the balloon should rise appreciably above the altitude where it is fully inflated, as there is danger of rupturing the envelope unless the excess pressure is relieved The safety valve should be set to release pressure before the limit of the working stress of the balloon fabric is reached.

If the exact volume of the balloon is known and the air density vs. altitude relationship is determined on the day of flight, it is possible to compute the total lift of the gas in the balloon at any altitude. By adjusting the gross load to be supported by the gas to equal the total lift at the desired altitude of flight, the balloon will level off at the desired altitude as it has no further buoyancy. This altitude stability exists only as long as the balloon is in the fully inflated or "taut" state. Once the balloon starts descending (due to loss of hydrogen by diffusion or by other loss) it becomes flabby and is no longer stable. It will continue descending until corrective action is taken or until it reaches the earth.

The altitude control is to be used is the ballast valve. When correctly set it will determine the lower limit of the balloon's oscillation as it would release a free flowing liquid ballast from a reservoir whenever the balloon descends a short distance below a preset altitude.

To test this tentative solution to the basic problem, intermediate sizes of balloon made of suitable fabric or films are needed in addition to the altitude controls.

Balloons

Balloon manufacturers and fabricators of plastic films were contacted to locate a suitable balloon material. The following materials were suggested:

Material	Advantages	Disadvantages	Disposition
Plastic Film			
Polyethylene	Good low temperature properties (Gen.Mills desires to fabricate Picard's balloons from this).	Low tensile strength, Milky-translucent, Medium permeability.	10 ea. 15 ft. balloons being fabricated from it.
Saran	Transparent, low permeability, high tensile strength.	Tears easily, fair low temperature properties (?), weak at seams if heat sealed.	5 large balloon being fabricate

Nylon	Good low temperature properties, easily fabricated, strong.	Not available, low tear resistance (?)	Awaiting sample
Vinylite	Easily fabricated. Almost transparent.	Very poor low temperature properties.	Discarded.
Teflon	Strong	Can not be fabricated.	Discarded.
Ethocel	Easily fabricated. Good low temperature characteristics.	Very high permeability.	Discarded.
Pliofilm	Easily fabricated.	Poor ultra violet properties, poor low temperature properties.	Discarded.
<u>Coated Fabrics</u>			
Nylon coated with neoprene butyl rubber polyethylene saran	Strong, easily fabricated.	Heavy, expensive opaque, nylon cloth has relative high elongation.	Awaiting Investigation.
Fortasin (regenerated celulose rayon) coated with neoprene butyl rubber polyethylene saran			Awaiting Investigation.
Silk coated with neoprene butyl rubber			Awaiting Investigation.

As a result of this preliminary study a sub-contract was given to H. A. Smith, Coatings Inc. of Mamaroneck, New York, to fabricate balloons with the following specifications for test purposes:

3 foot diameter balloons, no attachments excepting an inflation tube or appendix made of the balloon film about 10 inches long and 1.4" diameter.

2 each made from Polyethylene PM-1 film .004" thick
2 each made from Polyethylene PM-1 film .008" thick
2 each made from Saran type M film .00225" thick

15 foot diameter balloons with inflation tube 4" in diameter and 12" long, also means for attaching rigging lines supporting a 25-pound load to bottom of balloon and means for attaching auxiliary lifting balloons to top of balloon. If possible, balloon should be capable of withstanding internal pressure equivalent to 2" water.

5 each made from Polyethylene PM-1 film .004" thick
5 each made from Polyethylene PM-1 film .008" thick
5 each made from Saran Type M film .00225" thick

(1) The balloon film should be treated before or after manufacture in such a way as to seal all pinholes.

(2) A patching kit should be furnished for use of the balloon flight personnel.

(3) It is desired that either the volume of the 15 foot balloons be known to within 10 to 20 cubic feet when fully inflated or that the volume, though unknown, be nearly the same for each of the balloons of this size (differences in volume should not exceed ±1% of the total volume of a mean balloon).

Delivery was made 20 April 1947 on the first 3 foot balloons, two 15 foot balloons are expected by the end of May.

In an attempt to interest another manufacturer in the problem, the following companies were contacted.

Company	Type of Company	Interested?	Disposition
Dobeckman Co. 500 Fifth Avenue, NYC	Plastics & Packaging	No	None
Kennedy Car Liner & Bag Co., Shelbyville, Ind.	Plastics & Packaging	No	None

Plextron Inc. 55 Tremont Ave., Bx 57	Beach Balls	No	None
DuPage Plastics Co. 475 Fifth Ave., NYC	Beach Balls	No	None
Shellmar Products Inc. Empire State Bldg., NYC	Plastics & Packaging	No	None
Millprint Inc. Milwaukee 1, Wisconsin	Plastics & Packaging	No	None
Celanese Plastics Corp. 180 Madison Ave., NYC	Plastics & Packaging	No	None
E. L. Cournand Co. 2835 9th Ave., NYC	Plastics & Packaging	No	None
Bland Charnas Co. 24 Ashburton Ave,Yonkers	Toys, Beach Balls	No	None
Western Products Inc. Newark, Ohio	Plastics & Packaging	No	None
Rowe Packaging Co. 26 Queens St. E. Toronto 1, Ontario Canada	Plastics & Packaging	No	None
Goodyear Tire & Rubber Co., Akron 16, Ohio	Blimps & Balloons	Yes	Awaiting final decision.
Molded Latex Products Inc., 27 Kentucky Ave. Paterson 3, N. J.	Balloons (Meteorological)	Not very.	None
Air Cruisers Inc. Clifton, N. J.	Balloons (Meteorological)	Yes	Awaiting final decision.
General Mills Inc. 1837 Pierce St. N.E. Minneapolis 13, Minn.	Balloons (Picard's)	Yes	Awaiting visit.
Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Barrage Captive & Other Balloons	Yes	Awaiting final decision.
Dewey & Almy Company Cambridge 40, Mass.	Meteorological Balloons	No	None

On completion of the survey of balloon materials other orders will be placed for experimental intermediate balloons.

As soon as a series of successful flights are obtained, it is planned to procure balloons of about 8 times the displacement of the intermediate size for tests as the model to solve the problem. These larger balloons would be about 30 feet in diameter.

Altitude Control

Mr. Goudy of the Kollsman Instrument Division of Square D Corporation was contacted to determine the feasibility of:

(1) An accurate pressure-actuated liquid ballast dropping device.

(2) A motor-switched modulator for the standard Army radiosonde AN/SMT-1. The standard pressure-switched modulator would be of little value in determining the height of the constant level balloon after it leveled off on a constant pressure surface.

On a subcontract Kollsman undertook to build a pressure actuated "dribbler" or ballast dropping device as follows:

Mechanically Controlled Dribbler

To consist of a diaphragm operated needle valve which will allow no flow for a 2 mb. increase in pressure on the diaphragm over pressure of which diaphragm is sealed but will allow a flow of 40 grams/minute under 1 foot of lead for a 5 mb. increase in pressure. Petroleum ballast with a density of about .775 gm/cc is to be used.

Diaphragm to be open to the atmosphere until it is sealed off by the radiosonde pressure switch at a preset altitude.

An electrically operated needle valve was included in the order, however it is to be cancelled as the mechanical valve appears more feasible to the manufacturer.

As the motor switched modulator was already in experimental state of manufacture for the Signal Corps and Evans Signal Laboratories an order was placed for 3 of them with these characteristics:

To have a motor-driven commutator to contain 4 contacts alternately switching two different temperatures, pressure and a reference. Rate of switching will complete one cycle per minute. To report pressure accurately between 150 and 500 mb. with a pressure resistor to be of such a valve that with a large radiosonde frequency variation for a small change in pressure.

To have an adjustable contact variable between 250 mb and 400 mb with a factory adjustment of 300 mb. When the pressure arm reached this contact, a squib will cut a thread that holds the ballast diaphragm open.

The first mechanical dribbler was received on 20 April 1947 and is undergoing modification and tests before being flown on Cluster Flight #2. If it is successful, an order for improved models will be placed.

Another method maintaining a balloon at constant altitude is by replenishing the hydrogen in the non-extensible envelope as it is valved or as it diffuses. This might be accomplished by use of liquid hydrogen but not by use of chemicals due to their great weight relative to the small volume of hydrogen generated. The liquid hydrogen method is being investigated with a long range view. It does not seem too feasible, however, due to the difficulties of keeping the rate of evaporation of the liquid hydrogen low at the high altitudes, without extensive and heavy guard flasks of liquid air.

A third method of holding the equipment at a nominal constant altitude is to fly a cluster of standard meteorological balloons equipped with ballast dropping devices and a device for releasing lifting balloons should the cluster depart from the altitude limits desired. This method is inherently unstable, as there are no proportional restoring forces which will act on the flabby, freely extensible meteorological balloons. The success of this procedure depends on very careful balancing of the load against the variable lift of the balloons.

This cluster method is of use and interest only as a stop-gap method of lifting the Army equipment to altitude now, and has been the method used while awaiting delivery of the non-extensible plastic balloons.

III d) e. A flight was made on 3 April 1947 using this method. A cluster of 12 balloons meteorological carrying a radiosonde, a 15 lb. dummy load and a series of ballast dropping devices was released from the football field at Lehigh University, Bethlehem, Pa. The train was to be towed to 30,000 ft. by 2 lifting balloons which would then be cut loose. The weight of the equipment was adjusted to equal the lift of the balloons and presumably the train should have floated after the towing balloons were cut off. Actually, due to lack of experience in the difficulty of handling long balloon trains, auxiliary rigging lines were needed to take up launching stresses. These lines fouled the main flying line and the ballast which was to be dropped on parachutes. As a result, the balloon train went to 50,000 ft. where the tow balloons worked themselves free. The remaining train thereupon descended as fast as it had climbed (1,000 ft. per minute), landing in the ocean near Sandy Hook,

N. J. The flight was of value in training personnel, establishing a net for reception of the 74 megacyle radiosonde data, and in obtaining familiarity with the type of operation peculiar to all large balloon flights. The actual layout of the train used is sketched in the appendix.

Using the lessons learned on the dummy flight, improved equipment was built for a flight with a payload. Release was attempted on 18 April. Due to the high wind at 0830 EST, the time of release, and due to malfunctioning of the Army receiver in the plane that was to follow the balloons, release was not made. The already-inflated balloons were cut free and the equipment was brought back to New York University. It is expected that this equipment will be flown about 8 May. A description of the final flight equipment will be given in the report for May. A sketch of the layout of equipment built for the second cluster flight is given in the appendix. As this is a stop-gap method using modified standard components, no detailed report is being prepared on the equipment. Preliminary altitude controls used in both flights consist of standard radiosonde modulators ML-310 which have had leads taken off of the desired contacts of the commutator. The modulator thus acts as a pressure actuated control that releases ballast or balloons. In the first flight small radiosonde relays were used to close circuits to burn off cans filled with ballast. In the improved, second flight, a nest of plastic tubes were filled with dried sand. The bottom of the tube was covered with paper and a DuPont type S64 Squib was placed on the paper under the sand. On firing the squib, a hole is torn in the paper, permitting the sand to trickle out. This method permits dropping of more ballast and yet, in smaller increments. In the second cluster flight, provision was also made to release balloons if the train rose above 40,000 ft. The flying line in the second train was approximately 500 ft. long.

This cluster flight is tedious to prepare and difficult to launch, and is a greater hazard to aircraft than the plastic balloons will be because of the great length of the cluster train.

III e) Apparatus and Equipment.

A detailed explanation is not given on the equipment of the Cluster Flight. However, a layout sketch is enclosed in the appendix. An important piece of new apparatus for this project is the ballast valve or dribbler, a photograph and drawings of which appears in the appendix. It consists of a special diaphragm which operates a needle valve. Normally the valve is closed as the diaphragm is open to the air before the balloon reaches the desired altitude. This allows the pressure inside the diaphragm to be the same as the outside pressure. The diaphragm is sealed electrically by the baroswitch of the flight radiosonde when the balloon train passes a predetermined altitude. Whenever the balloon train descends below this preset altitude, the increase of pressure on the sealed diaphragm causes the needle valve to be opened. The greater the excess in pressure on the diaphragm the more ballast there is released through the valve. Thus a proportional restoring force is applied to the train. The ballast that is to be used is a petroleum cut boiling from 300° to 400°F with a density of about .78 and a minimum change of viscosity with temperature. Two different type fluids that may meet this specification are the Army type compass fluid and a Sinclair paint solvent. The ballast valve or dribbler essentially perform the same function as the Japanese altitude control on the balloon bombs yet it is simpler and permits use of a liquid ballast for better control

Another piece of equipment that is under construction by Kollsman Instrument Company is a motor-switched radiosonde modulator. It presents pressure data to the radiosonde transmitter as a variable resistance. The meteorological data is programmed by a samll Brailsford Electric motor. This modulator will provide the contact that seals off the diaphragm in the ballast valve. A complete discussion of this equipment will be furnished upon its delivery.

Sketches of balloon and rigging of the balloon to be used on to the main problem are given in the appendix and are self-explanatory.

Computations

A chart showing the relation between altitude, gross lift, and balloon size has been found necessary.

Data for it was computed using mean aerological soundings as reported in the Monthly Weather review for 1943.

A chemical term, molar volume (in cubic feet) was used as a term relating the sounding data with buoyancies of the balloons at various altitudes.

Using the simple gas laws, the molar volume of dry air was computed thus:

I. (1) Molar volume of any gas at standard conditions is 359 $ft.^3$

(2) From Monthly Weather Review Jan. 1943, the mean sounding data at 15 km for Lakehurst, N. J. is: Temperature $-59.5^{\circ}C$

Pressure 120 mb.

$$359 \times \frac{273.2 - 59.5}{273.2} \times \frac{1013.3}{120} = 2370 \text{ ft.}^3$$ (the mean molar volume at 15 km for Jan.1943 over Lakehurst,N.J.

This volume data was computed for all lovels given. Data was "borrowed" from other stations in the same latitude to piece out the 20 km soundings as needed.

II. Lifts were computed for various molor volumes for balloons between 7.5 and 75 feet diameter in the following manner:

Given

purity of Hydrogen	99.7%
impurity as oxygen	0.3%
computed molecular wt.	2.11 #1 mol

Molecular weight of dry air as computed from data reported at 10 km. in Handbook of Chemistry and Physics. 28.764 #1 mol

To find the lift of a 20'D balloon at an altitude where the molar volume is 1000 ft.^{3}:
Volume 20 ft.D Balloon = 4190 ft.^{3}

$$\text{Lift/Balloon} = \frac{\text{Balloon Volume X(Difference in molecular wgts.of air\#h}}{\text{Molar Volume at a given altitude}}$$

or

$$\text{Total Lift of gas in \#/Balloon} = \frac{\text{ft.}^3\text{/Balloon X (}\quad\text{\#/mol)}}{\text{ft.}^3\text{/mol}}$$

for the 20 foot diameter balloon:

$$\text{Lift} = \frac{4190\ (28.76 - 2.11)}{1000} = 111.7\#$$ lift from a 20 foot diameter sphere of hydrogen at an altitude where the molar volume is 1000 ft.^{3}.

The lifts were plotted against molar volume for each size balloon. The altitudes corresponding to various molar volumes for Lakehurst and Albuquerque in January and in August 1943 as computed above were plotted on the left margin of the chart.

The family of curves was plotted on log paper and is included in the appendix with the basic sounding data.

III g) Conclusions and Recommendations.

It is believed that a balloon can be kept at nominal constant altitude between 10 and 20 km. for six hours using a non-extensible envelope with the addition of a ballast valve to keep the balloon near its pressure altitude. The flying of a balloon thus equipped is our main objective. The work to date has been primarily preparatory but it is believed that plastic balloons can be flown in the early summer with a payload.

Additional work space is urgently needed at New York University if significant work is to come from this group.

It is believed that the ideal launching area for balloons of this type is Lehigh University, Bethlehem, Pa. as long as this is feasible, For large balloons it is believed that the Navy people at Lakehurst can best facilitate the launching. Calm winds are essential for actual launching.

Future Work

General Mills is making large balloons from lightweight films that would meet our specifications with the exception that they cannot take any internal pressure. It is believed that their balloons should be investigated as General Mills appear to be the best source of supply for large balloons. An order will be placed with them as soon as they furnish a quotation.

As a stop-gap device before these might arrive it is planned to fly two 35,000 cu.ft. racing type as well as the 2 Japanese balloons from Lakehurst, N. J. carrying payloads with heavy duty power supplies for the radio transmitters.

In the meantime, improved clusters of meteorological balloons will be flown until larger balloons are available.

COPY

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.

N.Y. Meeting No. 12 — 20 March 1947

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 nylong 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 wife 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 bebetween 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 furnished 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.

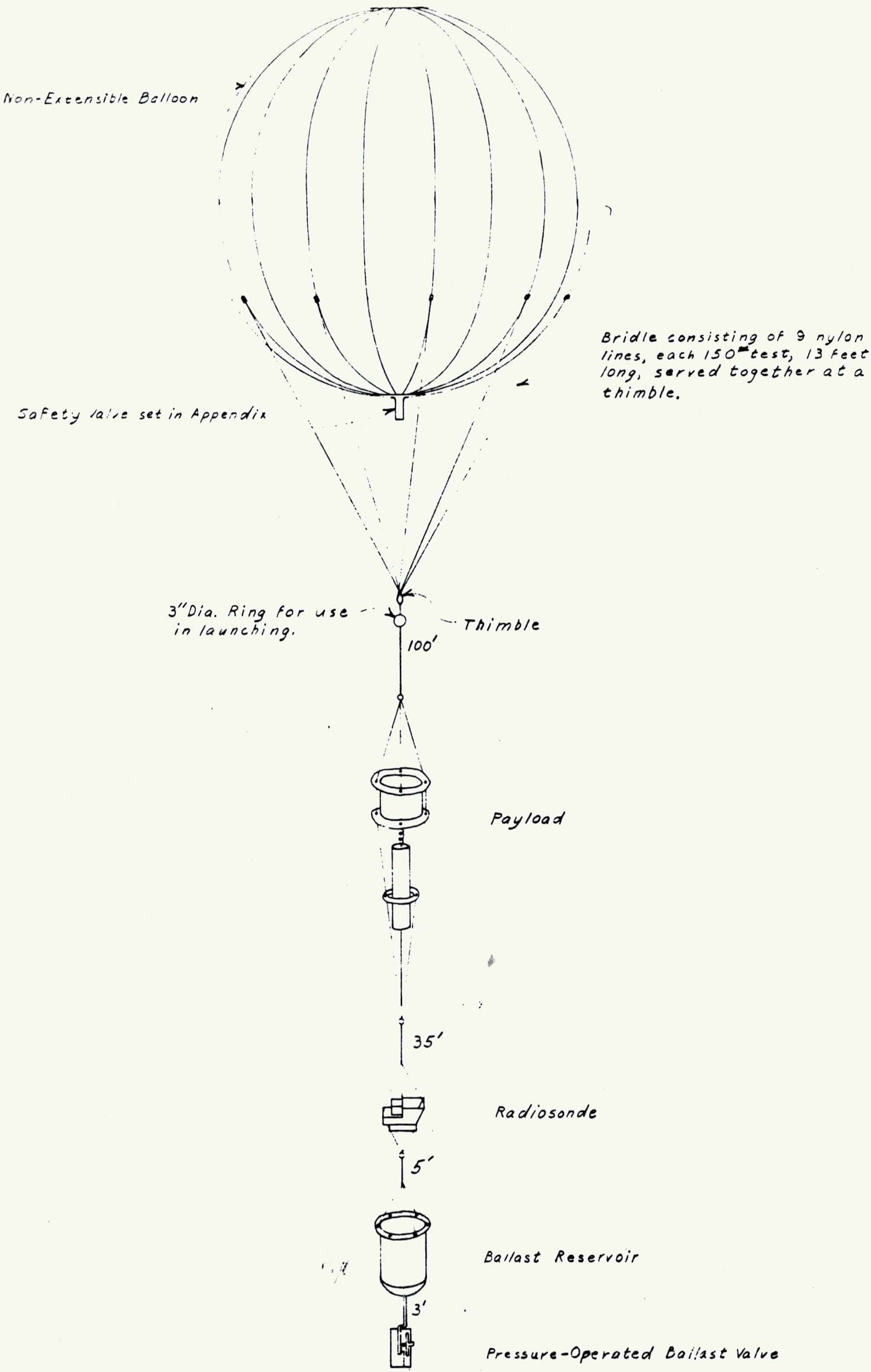
3. The War Department member requests that balloon operations along the lines of Phase II be presented to the Washington Subcommittee for clearance with all other Regional Airspace Subcommittees, in consideration of War Department plans to continue the Phase II type of operation from White Sands, New 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.

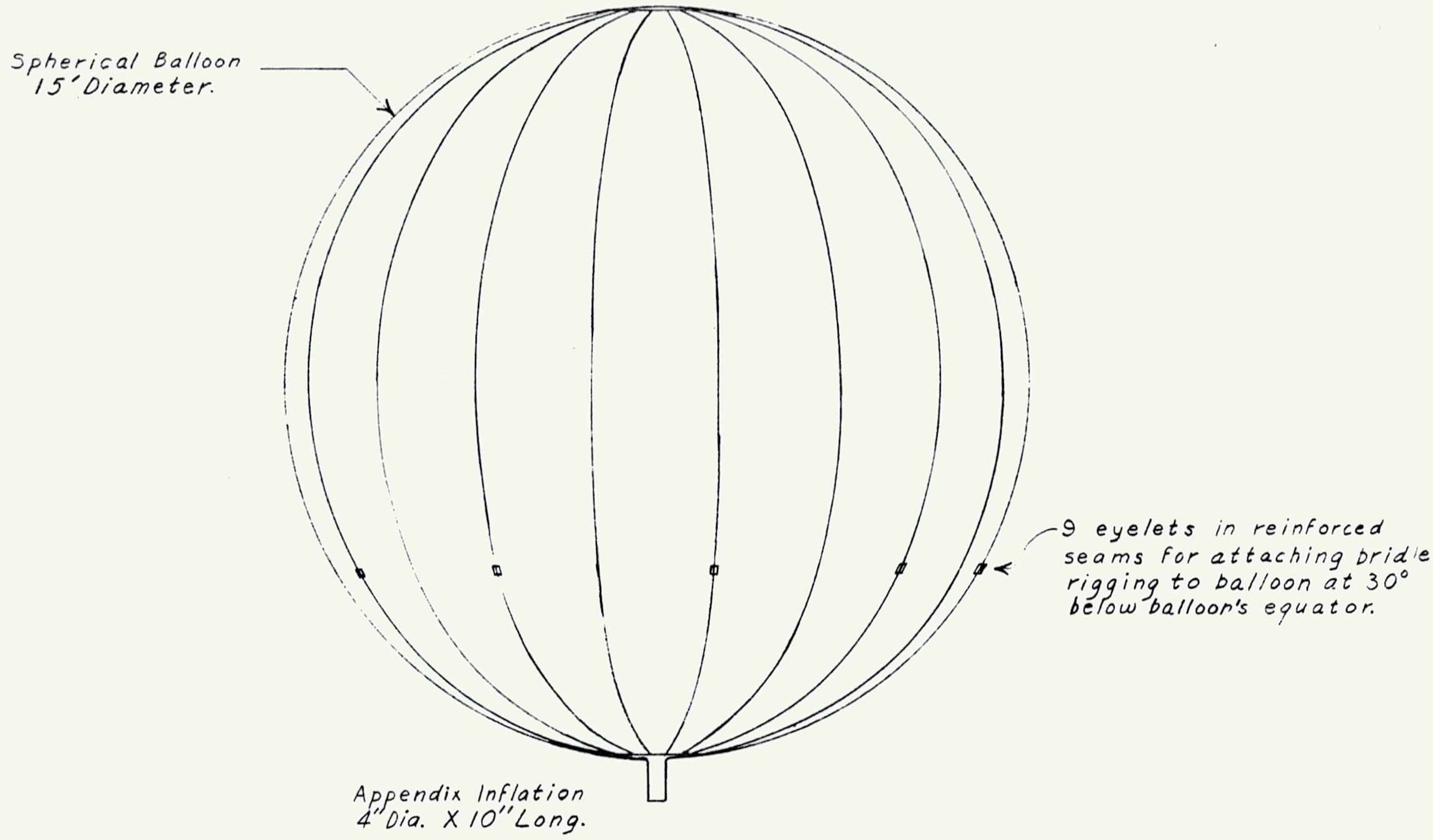
5. That the release of free balloons by New York University as described above in Paragraph 2-B (Phase II), Subparagraphs (1) - (6) inclusive, be approved.

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.

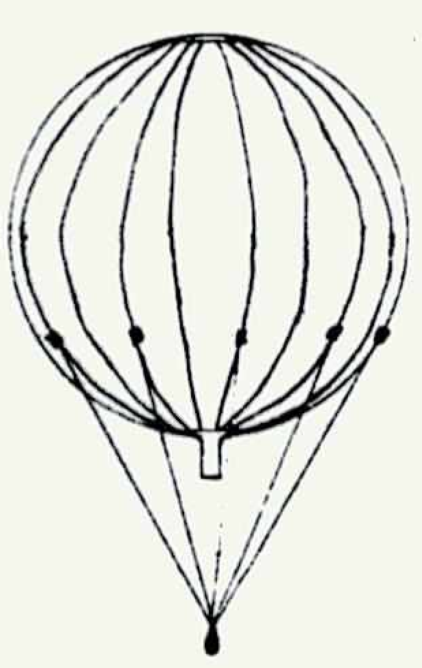


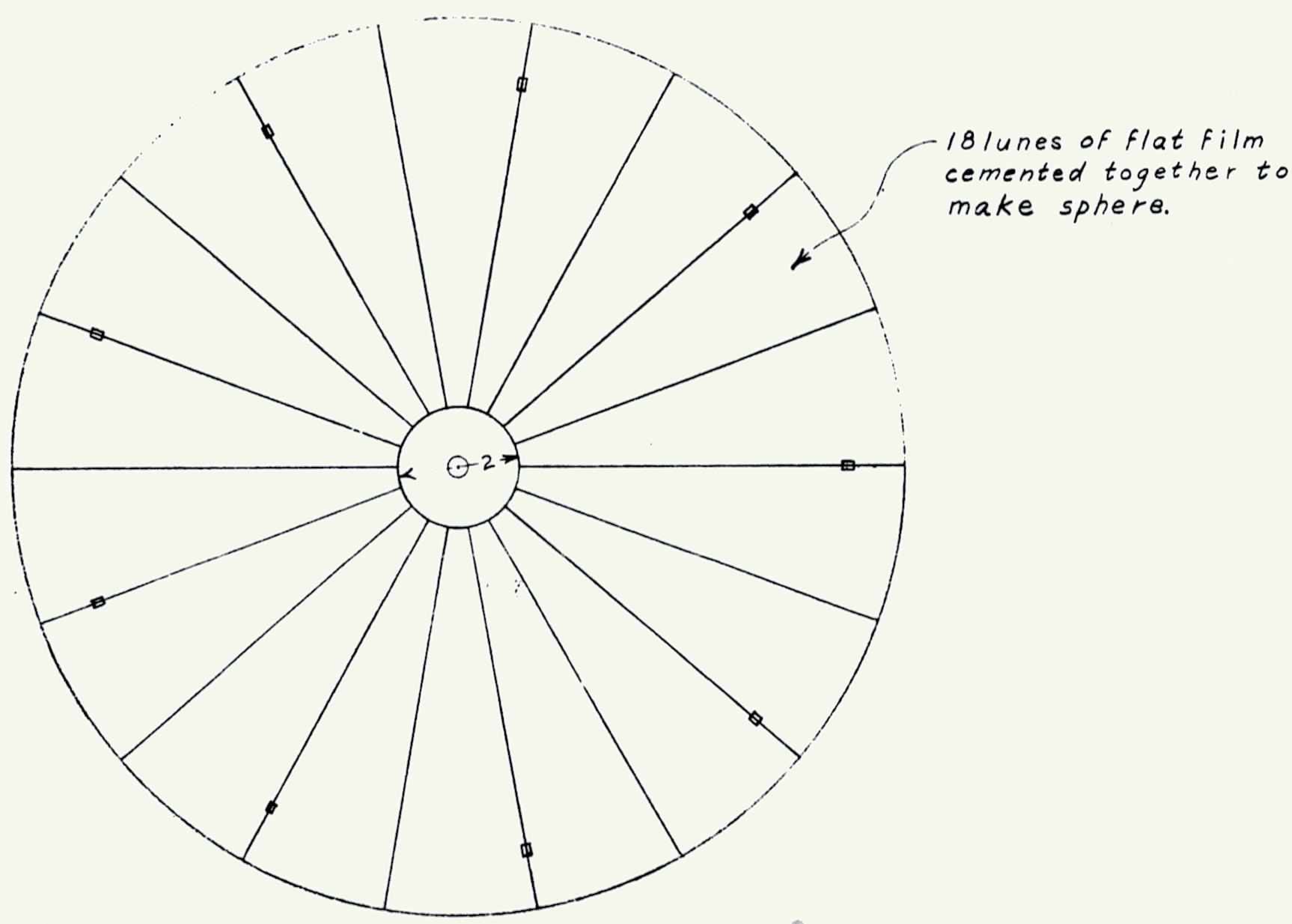
PROPOSED ASSEMBLY OF
TRAIN FOR CONSTANT LEVEL BALLOON

APRIL 27, 1947 SMITH, JAMES F.



alloon with rigging





PLASTIC BALLOON

FOR CONSTANT LEVEL BALLOON PROJECT AT NYU

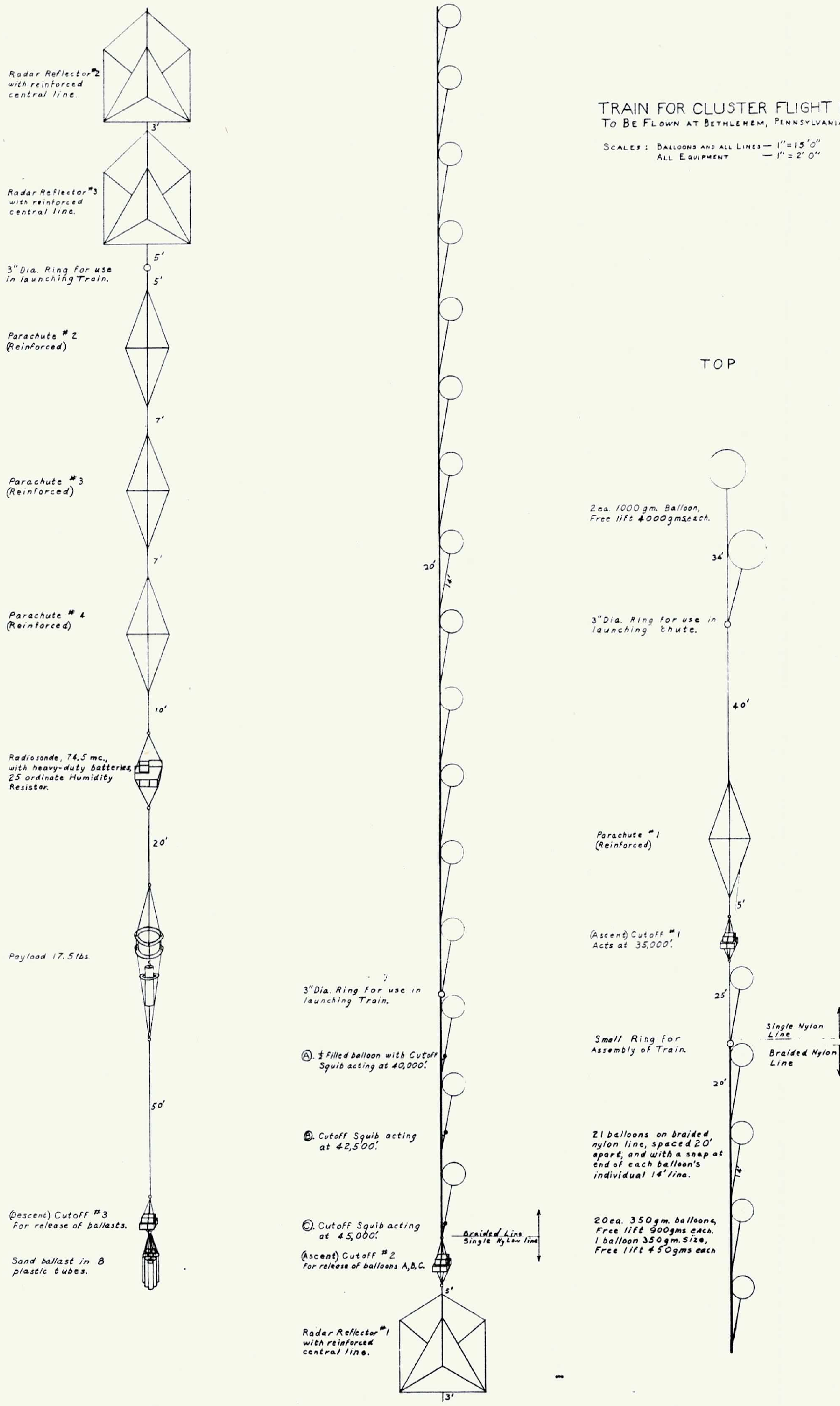
APRIL 27, 1947

SCALE: 1" = 3' 0"

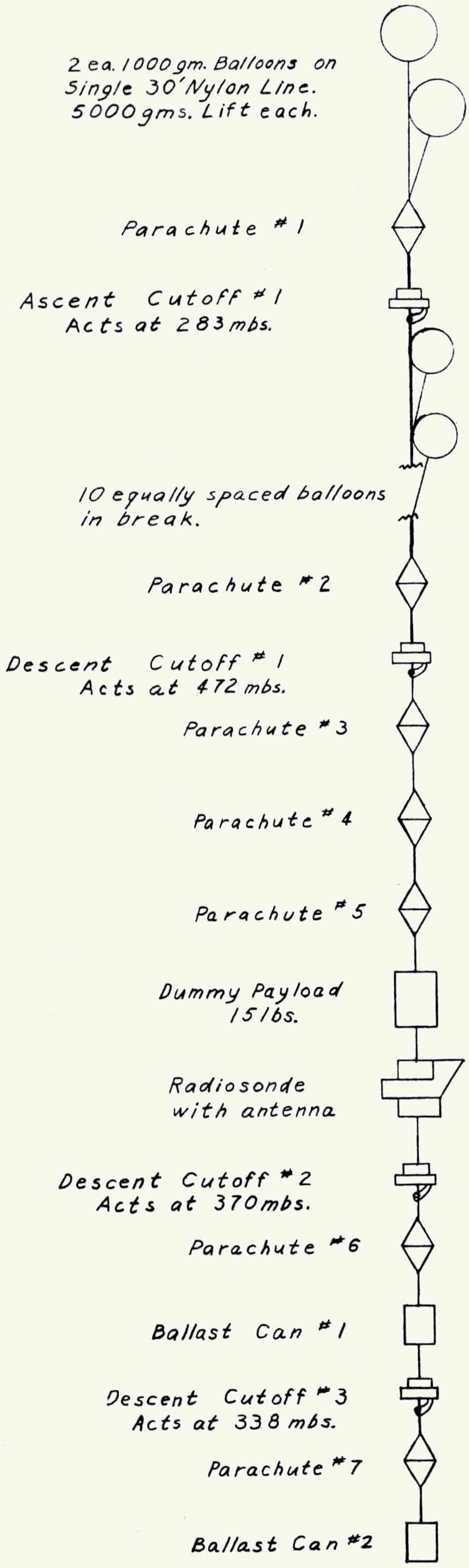
TRAIN FOR CLUSTER FLIGHT NO. 2

To Be Flown at Bethlehem, Pennsylvania

Scales: Balloons and all Lines — 1" = 15' 0"
All Equipment — 1" = 2' 0"



os E. Smiza



All individual balloons on single 15' Nylon lines and tied onto Main Line at 20' intervals.

Flying line from Cutoff #1 to Parachute #2 is braided for added strength.

There is a distance of 5' between each piece of equipment, except the 20' between balloons on the Main Flying Line.

The 12 balloons on the braided line are each 350 gm. balloons with a lift of 1550 gms. each.

BALLOON TRAIN FOR CLUSTER FLIGHT NO. 1
BETHLEHEM, PENNA.
3 APRIL 47.

LAKEHURST (39 meters)

	JANUARY 43				AUGUST 43				
Alt.Ft.	Temp.°C	Press mb	Humidity%	Molar Vol. ft.^{3}	Temp.°C	Press mb	Humidity%	Molar Vol.ft^3	Alt.Ft.
65,617	-58	53	--	5410	- 64	58	--	4850	65,617
62,336	--	--	--	--	--	--	--	--	62,336
59,055	--	--	--	--	212.0 - 61.2	79	--	3585	59,055
55,774	--	--	--	--	337.2 - 64.2	94	--	2962	55,774
52,493	--	--	--	--	338.6 - 65.6	110	--	2370	52,493
49,212	213.7 -59.5	120	--	2370	337.1 - 64.1	130	--	2150	49,212
45,931	215.8 -57.4	140	--	2050	333.7 - 60.7	153	--	1845	45,931
42,651	216.3 -56.9	164	--	1808	329.4 - 56.9	179	--	1630	42,651
39,370	217.2 -56.0	192	--	1506	304.0 - 51.2	209	--	1440	39,370
36,089	-54.1	224	--	1339	318.0 - 45.3	243	--	1250	36,089
32,808	-51.0	262	--	1130	311.2 - 38.2	282	--	1115	32,808
28,527	-45.5	304	--	995	303.4 - 30.4	325	--	1000	28,527
26,247	-38.8	352	--	888	296.0 - 23.8	374	--	890	26,247
22,966	1 -32.1	408	--	788	290.0 - 17.0	428	--	800	22,966
19,685	248.2 -25.0	469	--	705	283.1 - 10.1	488	31	718	19,685
16,409	254.3 -18.9	536	60	632	276.9 - 3.9	555	28	650	16,409
13,123	-13.0	611	59	566	1.5	629	38	582	13,123
9,843	- 8.5	696	60	507	6.4	711	49	523	9,853
8,202	- 6.4	742	61	478	9.0	756	51	499	8,202
6,561	- 4.5	791	65	453	11.9	802	55	474	6,561
4,921	- 3.2	843	69	427	15.0	852	63	452	4,921
3,281	- 2.5	898	68	401	18.6	903	58	432	3,281
1,640	- 1.7	956	69	378	21.7	956	60	413	1,640
0	- 1.0	1013	76	359	21.5	1008	76	385.9	0

ALBUQUERQUE (1620 meters)

	- JANUARY 43				- AUGUST 43 -				
Alt.Ft.	Temp.°C	Press mb	Humidity%	Molar Vol.ft.³	Temp.°C	Press mb	Humidity%	Molar Vol.ft.³	Alt.Ft
65,617	-63	54	--	5410	-58.1	58	--	4960	65,617
62,336	--	--	--	--	--	--	--	--	62,336
59,055	-65.1	75	--	3701	--	--	--	--	59,055
55,774	-64.3	88	--	3170	-70.0	96	--	2830	55,774
52,493	-63.0	104	--	2700	-69.8	114	--	2430	52,493
49,212	-61.6	122	--	2320	-66.4	134	--	2060	49,212
45,932	-60.2	143	--	1990	-61.5	138	--	1780	45,932
47,651	-54.1	168	--	1690	-54.7	186	--	1560	47,641
39,370	-57.2	197	--	1450	-47.0	217	--	1390	39,370
36,089	-54.7	230	--	1250	-39.4	251	--	1250	36,089
32,808	-49.7	269	--	1140	-31.6	290	--	1110	32,808
29,527	-43.0	312	--	983	-24.2	333	45	980	29,527
26,247	-35.7	362	39	872	-17.1	382	45	895	26,247
22,966	-28.3	416	45	786	-11.0	436	56	803	22,966
19,685	-21.2	477	48	704	- 5.6	495	72	715	19,685
16,404	-14.6	546	50	631	1.1	562	79	652	16,404
13,123	- 8.3	622	51	567	3.8	634	66	594	13,123
9,843	- 2.6	706	48	522	16.6	715	48	541	9,843
8,202	.6	752	45	486	20,4	758	42	517	8,202
6,562	3.4	800	46	463	23.3	803	39	492	6,562
0	3.8	838	45	449	25.2	838	44	480	0

5fc 1620 meters = 5315 feet

M E A N   S O U N D I N G S

Fiscal Report As of April 30th, 1947

Total amount expended	$20,067.96
Available Balance	97,632.04
Total	$117,700.00

17

Appendix 17

Personal Journal of Albert P. Crary

NOTE: Albert P. Crary, Project Mogul Field Operations Director, maintained a daily journal of his activities from 1939 until his death in 1987. While preparing a book based on his career, Crary personally transcribed the following periods:

April 2,1946 - May 8, 1946
December 2, 1946 - August 16, 1947

Following the transcription is the untranscribed journal in its entirety for the period of March 19, 1946 - March 7, 1948.

PERSONAL JOURNAL OF ALBERT P. CRARY

Albert P Crary, Project MOGUL Field Operations Director, maintained a journal of his activities throughout his career. The following transcription was made personally by A.P. Crary before his death. The periods which have been transcribed are:

April 2, 1946 - May 8, 1946
December 2, 1946 - August 16, 1947

Pages 13 through 16 contain information concerning the Alamogordo I and Alamogordo II field trips during June and July of 1947. Following the transcription is the complete untranscribed journal from April 1946 , when Crary began working for Watson Laboratories until the end of the journal, February 1948.

1946

April 2 Tues D & I left caracas Pan Am bus 9 pm. Arrived Miami 10 pm on Pan Am. through customs and caught 1 am National Airlines plane for Newark

April 3 Wed Arrived Newark 730 am and took airline bus to NYC. D left for Providence 9 am. Called up Ewing but he was in Chicago - due back tomorrow. Left on 1040 sleeper for Canton tonight.

April 6 Sat At home. Over to Ogdensburg to see Steve this pm

April 7 Sun. Left Canton on 805 sleeper. Saw Bob Foster '31, also on way to NYC

April 8 Mon. Arrived NYC 730 am. Up to Columbia University to see Ewing 130 pm. Wycko and Dove on way to Los Angeles by plane this pm. Crane and Morrison in also from Wats Labs. Went back to Red Bank with them in AWS car to Officer's Club near Watson Lab. Crane, Morrison and I went up tonight to see Reinnegle at office. Met Gifford who has 80' sea rescue boat this project is planning to use. Stayed at Officer's Club tonight

April 9 Tues. At Watson Labs all day. Went through all processes necessary for employment under Civil Service. Warrant Officer Gifford transferred to WHERI-4 today. McCur already in and started work. Talked with Reinnagle and Gallo re Columbia contract. Gifford left pm for Washington, Major Crane for Camp Dix and Morrison for NYC. Reinna and I went down to CO this pm to meet group from Cornell extension at Buffalo - Aeron ical research wanting to get contracts. Stayed at Molly Pitcher Hotel in Red Bank ton

April 10 Wed Checked out of Molly Pitcher Hotel and caught 730 am train out of Red Ba NYC. Checked in at Hotel Webster and then up to Ewings at Columbia University. Mr Gal of Watson Labs in at 10 am and we went over contract questions regarding Watson Lab c with Columbia until 1 PM. Went over all parts of work with Doc from 2 to 530 pm. John Ewing in from Missouri.

April 11 Thurs. Worked on rough outline of Eglin Field and SOFAR project Am. Up to se Ewing at Columbia PM. Doc and I went over contract with Watson Lab & Columbia tonight Caught 1205 sleeper to Boston.

April 12 Fri. Arrived Woods Hole about 11. Joe Worzel went over all sound transmissio work at WHOI this pm.

April 13 Sat. Talked with Columbus Iselin this Am regarding Watson Lab work and needs. Crane and Gifford up pm and Joe and I went up to lab with them.

April 14 Sun. Down to lab this am with Joe looking for G9A files. Jim Peoples over abo noon for awhile. Joe and I went golfing pm. Took 600 pm train to Boston and 1230 sleep to NYC. Up to Boston with Lt Frank Ryder with Navy and WHOI

April 15 Mon. Contacted Doc Ewing in NYC and rode down to Red Bank with him. Talked o instrumentation of upper atmosphere investigations. Out to Oakhurst this pm. Conferenc with Col. Cole and Col. Crough re Project 188-5 and regarding microseisms. Doc and I back to Molly Pitcher Hotel in Red Bank tonight.

April 16 Tues. Rode out to Watson Labs with Ewing. Went over to Evans Labs with Harry Watson Lab navigation man, and saw newly developed ranging apparatus and talked to Lt Rydetor? re Spherics, location of lightning and thunderstorm data collected during pas few years. Saw Col. Duffy of Meteorological Division AAF and back to Watson Labs. Doc on through to NYC. Went over program with Dove and Crane this pm. Back to lab tonight Crane and Gifford, discussing Project 185-7-1. Back to Myrtle Hotel at 1045 pm.

April 17 Wed. Rode out to Watson Labs with McCurdy. Worked with Major Crane on report regarding underwater work, Eglin Field and deep water. Took this in to Colonal Cole th pm. Acceptance probable. Got room in private house in Red Bank. Moved out of Molly Pit Hotel.

April 18 Thurs. Caught bus out to Watson Lab. Col Cole up this am and advised writing Cost Expenditure for and revising the R. & R. Major Crane left about noon for Phila and Woods Hole. Made arrangements to meet him in NYC Monday. Wrote out new R & R and Cost Expenditure ready to take to Col Cole.

April 19, Fri. Talked over work with Dove and we wrote up 2nd EC covering all ocean wo Talked to Ewing on phone this am. Dove and I went down to see Col Cole and then wrote new EC for deep water work. Saw Hincke? regarding this EC and A for P processed this p and ready to go out to Wright Field.

April 20 Sat. Caught 710 train to NYC, cashed check at Chase Natl Bank, talked to Ewin phone. Back to Red Bank about 4 pm.

April 22 Mon. At Watson Labs this am. Got final physical exams. Down to Supply to see Morris with Reinnagle re getting equipment out that came from WHOI without paper cover Got travel order back and authority to use it. Caught 342 pm out of Red Bank and arri in Newark about 430. Reservations to Dayton on Spirit of St. Louis had been cancelled. Called Watson Labs. Got roomette on Spirit about 530. Called Mrs Ewing in NYC. Left Newark on Spirit of St Louis at 620 pm.

April 23 Tues. Arrived Dayton, Ohio about 830 am. Tried to get return ticket for tonig but coach car only open. Took bus out to Wright Field, Bldg 28. Saw Mr Drexler and turn over 2 of the A for P to him. Colonel Maier on leave. Went down to Colonel Winter's of and found Major Crane there. We talked to Colonel Winters regarding the need for plane and about new TO on extended long ranges of the 189-7-1 program which he approved and marked up to 1-? & sent on for higher approval. Went over with Crane & saw Colonel Lin gard in the plane assignment division and talked about planes. Had lunch with him and went back to talk to Colonel Eaton regarding planes to 189-9-1. Went over to look at C- converted B-29 for transport. Back to Bldg 28 & talked with General Rives. Request for planes agrred upon and B-29 will be available near the 1st of June. 189-7-1 required b Rives. A for Ps in Drexler's office not yet signed. - will be sent on to Watson Labs la Crane had reservations for me on the Spirit of St Louis and we left Dayton at 8 pm.

April 24 Wed. Discussed with Crane possibilities of getting sound through the ground pa of the ocean sound channel and about the possibilities of a balloon such as Piccards. Arrived in NYC about 1030. Called Watson Labs and then we took a taxi up to Ewing's of at Columbia. After Ewing 1-2 class we discussed plans for 188-5 and 189-7-1, both Egli Field and long range channel program. Left Ewings office about 6. Crane registered at Lexington and I caught 740 out of Penn Station and arrived at Red Bank at 845 pm

April 25 Thurs. Up to Watson Labs. Worked over notes of conference with Ewing yesterday Wrote up both travel blanks and sent them down to Travel Order Section. Talked with Pal about HQ travel forms. Wrote up letter to Wright Field requesting use of second crash b Wrote R&R for Mark 2 hydrophone. Talked to Lt. Hungerford regarding request of this. Stepanoff, new physicist for WLERL in this pm. Crane left for Wright Field tonight.

April 26 Fri. Up to Watson Labs. Went over purchases already applied for with Reinnagle Wyckoff in this am. McCurdy in pm for radio parts. Went back to Oakhurst with McCurdy this PM

April 27 Sat. Left Red Bank about 730 AM with McCurdy in his car. Drove through NJ at TRenton & down to Philadelphia. Mac left me off at Olney at subway station. Contacted Marion at Bankers Security and went by train with her to Newton, Pa at 100 PM . Stayed with Flaggs.

Apr 28 Sun. Wayne & Marion drove me over to Trenton, NJ & I caught 1030 am train into N Went up to Ewings about 1215. Joe Worzel there & Hilly Barbour. They left for Woods Hol about 2 PM. I caught 550 train out of Penn Station to Red Bank, NJ

April 29 Mon. Up to Watson Labs. Checked over at library to have some periodicals obtai Went over water work with McCurdy regarding what is needed in way of purchases. Went ov to Oahhurst with Roke, new engineer, former Lt. Commander in Navy. Talked to Cha Ireland regarding Eglin Field work.

April 30, Tues. Up to Oakhurst. Went over equipment that would be left there and what we might do when rest of people gone to Whitesands with Wyckoff. Wyckoff and I took car t Watsom Labs to conference with Col Duffy of Weather Bureau, Capt Kellogg and Col Gault. Discussed weather problems - on eqpt? and S658s & aerography neede in coming work. Disc equipment with McCurdy pm and tried to find where demolition cable could be located.

May 1 Wed. Up to Watson Labs. Talked with Stepanoff and Wyckoff regarding work to be do while crew was recording White Sands in New Mexico. Commander Navy arrived about 1130 a and we held a conference - Gault, Compton?, Dove Crane, Wyckoff, Hungerfield, Vaux and myself regarding Navy participation with us in Crossroads. Captain Kellogg of Weather Service over pm and talked with Crane and I regarding 658s, airgraphs, etc. Got travel orders etc to Columbia tomorrow. Wyckoff and about 11 others leaving for White Sands by plane tomorrow morning. Up to lab tonight with Crane.

May 2 Thursday. Left Red Bank on 8 am train, off at Elizabeth and took ferry to NYC. Up to GCT and then up to Docs. Too late for talk with Kellogg but in time for conferenc with Ewing, Lane of Columbia, Gallo, Bradford, Dove and Crane of Watson Labs. Conferenc went over contracts with Columbia and WL. Crane and I talked to Dove for short time afte dinner. Caught 1130 sleeper to Boston tonight.

May 3 Fri. Arrived Woods Hole 1045 am . Went over to Falmouth with Dorothy. Up to lab I with Joe W. Talked to Jim Peoples re his amplifier and level recorder. Bump and Kit ove tonight. Saw Columbus PM.

~~May 4 Sat~~

1946

May 4 Sat. Up at WHCI this am. Out with John Ewing taking bottom shots in water. Wor with Joe on his boat this pm. Over to Jim and Rowes tonight and to Buzzards Bay bowl
May 5 Sun. Up to WHCI about 11. Went over deep water equipment with Joe Worzel and J Peoples. Jim and I caught 600 pm train to Boston tonight, got 1130 pm Owl to NYC
May 6 Mon. Caught 625 train out of Penn Station to Red Bank. Arrived Red Bank 730 am bus out to Watson Labs. Checked at library for caps?military info. Called up Morris of and wrote supply request. Stepanoff in fm Oakhurst. Wrote up weekly report to Watson for 189-7-1. Arranged truck to take fathometer to Nyack, N.Y. for 104' boat and brin microbaragraph from Columbia. Went out to Oakhurst and saw Rooke who is working on f meter, and got fathometer NMB-1 ready to send to Nyack. Went over list of parts need 189-7-1 with Peoples. Peoples signed in at Watson Labs today. Capt Kellogg in from E Labs re how they can help- rough draft of letter of request to be written by Col Gra Got travel orders to NYC tomorrow and to Nyack.
May 7 Tues. Jim Peoples and I caught 608 train out of Red Bank and arrived Ewing's o about 850 am. Conference at Ewing's office Gallo, Bradley, Crane, Peoples and I fro Labs, Lane and Ewing of Columbia and Iselin and McCrory? of WHCI regarding 189-7-1 of WHCI with Columbia. Conference later Iselin, Crane, Ewing, Peoples and myself rega technical procedure and plan for Atlantis, Anton Dohrn and two boats of Watson Lab f summer and next winter. Crane, Peoples and I left about 240 pm for Nyack, NY in Arm Arrived in Nyack at Peterson's Shipbuilding Co, new 104' boat P778 docked about the time. Went over all changes and additions to the boat with Gifford and made plans for version to our needs. Left Nyack about 6. Jim Peoples and I caught 740 train out of P Station and arrived in Red Bank 9 pm.
May 8 Wed. Jim Peoples and I went up to Watson Labs this am

Dec 2 Mon. Oakhurst. Cold wave hit about midnight - temperature down to 15° - strong wind. Started preparations for Alamogordo trip; getting Rubicon drums and galvanomete ready.

Dec 3 Tues. Oakhurst. Worked on Rubicon drums and galvanometers for Alamogordo trip - Stepanoff on August 9 data - Vivian working up cruise tabulations. Oliva setting up GR3 for Alamogordo. Got oscillograph operating with 3 T-21 microphones.

Dec 4 Wed. Oakhurst. Set up 20 sec galvos and operated for several hours. In with to safety meeting, Vl. Chantz set up Rubicon in dark box and took several records wi 1 sec galv. Made up list for Alamogordo.

Dec 5 Thurs Oakhurst. Worked on relays for setup at Alamogordo. McCurdy & his group c T-21 operations. Woodruff and Chantz getting motors,etc ready for trip. Went over work at Oakhurst with Vivian.

Dec 6 Fri. Oakhurst. Worked on equipment for Alamogordo. Left at noon, caught 135 to New York City. Contacted Carl Gerdes and Ed Schempf at United Geophysical office. Cur also in NY office. Went out to eat with Carl and Ed and discussed future work. They job open for me in Alaska and also later possibilities in Turkey. Ed caught plane out about 745. Left on 1215 tonight for Asbury Park.

Dec 7 Sat. Went to Oakhurst 10 - 3. Woody and Phil there getting ready for Alamogordo. Peoples up for awhile pm.

Dec 8 Sun. Worked about 7 - 8 hours at Oakhurst. Chantz and Peoples there - getting re etc ready for Alamogordo. Went over all theoretical work on flights, etc with Peoples.

Dec 9 Mon. Oakhurst. Finished getting all equipment ready for Alamogordo. Chantz, Wood went to Watson Labs. Got checks and travel orders. All equipment loaded on trucks and to Watson late pm. Talked to Colonel Duffy a while about future plans.

Dec10 Tues. Woody, Chantz and I left Oakhurst in staff car about 9 am. Arrived at Newa airport 10. C-54 in from Middletown about 11, bringing Ball and Oakes from Wright Fiel Loaded up all equipment on C-54 and left Newark about 145 pm. Lewis, pilot; Clowry, co pilot. Arrived Oklahoma City about 945 pm EST. Got rooms at Air Base Hotel. Went into homa City for dinner tonight.

Dec 11 Wed. Oklahoma City. Waited for weather to lift. Unable to leave in time to reac Alamogordo before dark. At Air Base hotel tonight. Equipment from Johns Hopkins Univers transferred to MOGUL plane, including warhead of V-2. 4 scientists & crew, including De gano? . Called Jimmie at Fairview, Okla.

Dec 12 Thurs. Left Oklahoma City in C-54 at 0800 CST. Arrived at Alamogordo about 11 R Met Major Pritchard at air base. C-54 unloaded warhead material first then all MOGUL eq which went to North Hanger. Went over to Prichard's office, met Major Maguire? and talk over prospects of serûps. Woody and Phil worked on equipment pm. Went up in L-3 with Sg Mack looking over country of proposed sites. WAC corporal launched at 4 pm. Worked on equipment tonight. Staying at BOQ.

Dec 13 Fri. Woody and I left Alamogordo Air Base in weapon carrier and scouted out area of White Sands and Turoro Lake. Got lost on ordnance map we had. Located Tower and K st Went to Proving Ground. Saw Karsh and Major Grant and got good locations and one of goo maps. Left Proving Grounds about 2 and went up west side of sand area to site A Arrived there at 4 but over very rough roads. Back to Alamogordo Air Base at 620. Chant Alamogordo working on T-21s, BST and Brush equipment.

Dec 14 Sat. Went out Hwy 70 this am toward Proving Grounds. Turned off at White Sands N Monument and drove to end of 9 mile road in park, about half in white sand area. Found ation for #2 site which is about 30 miles north and a little east of launching site. Ba Air Base at noon. Went out north looking for Site 3. Tried to get through Ordnance Gate needed key. Went back and around by Alamogordo and Tularosa but couldn't get in there. to base, got key from Provost Marshal and went out to Ordnance Gate. Found it did not le in right Came back to North Hanger and took road out from there, finally landing bombing area about 35 mi from base. Left all Rubicon equipment there. Back at Base 645

Dec 15 Sun. Got all GR3 recording units and went up to site 3. Set up both Rubicon in te and GR3 in small building. Got recordings on both. Back through Tularosa and Alamogordo.

Dec 16 Mon. Signal Corps people, Dr.Kane and Dr Crenshaw in this am. They are planning measure time interval between bursts of meteorites at 60, 70, 80 seconds after launching Went over our plans with them. Packed eqpt for Site #2 in White Sands. Chantz and I stay setting up apparatus and Woody went back for equipment for Site #1. Left Site 2 about 3 and went to site 1. Set up equipment there. Finished about 7. To Alamogordo for dinner.

Dec 17 Tues. Got Chantz a Jeep to use on Station 3. Went out to #3 made final checks - Chantz stayed there. Woodruff and I went to Station 1 and made final checks there. Woo drove me to Station 2 and then went back to 1. V-2 rocket went up at about 1015 pm. Got B recording - 1 trace & Rubicon at 2. Woodruff got BCT & Rubicon at 1 -though had interf ence with other group. Chantz got GR 3 & Rubicon record at #3. Back to DC about 12. R icon & BCT recordings not yet developed.

Dec 18 Wed. Chantz and I went out to Sta 3 and got all equipment together and back to about 1 - went in borrowed weapon carrier. Woody and Jeff Fowler took other weapon car and collected all equipment from Sites 1 and 2. Packed all equipment at north hanger a loaded it into truck, which was then put on plane. Got data from V-2 firings from Brit office. Left Alamogordo about 730 pm in C-54 and went to El Paso Biggs Field.

Dec 19 Thurs. Went down to El Paso this morning and then across to Juarez. Back to Big Field about 230 pm. C-54 left El Paso 400 pm , landed in Patterson Field, Dayton, Ohio

Dec 20 Fri. Left Dayton about 9 am & arrived in Olmsted Field near Harrisburg, Pa abou noon. Lt Carroll and Clowry drove us down to Pa RR station. Got 150 out of Harrisburg arrived in Newark 6 pm. Caught train to Asbury Park.

Dec 21 Sat. Chantz went down to Oakhurst and developed 3 Rubicon recordings from White and BCT recording at Site # 1. Site #1 recording poor, possibly NG. Looked over record obtained at Oakhurst on bombing run of 19 Dec.

Dec 22 Sun. Out to Peoples this evening in Marlsboro.

Dec 23 Mon. Oakhurst. Worked on Alamogordo and Flight 13. Had flight # 14 this pm. - 2 bombs starting at 2 pm. Ran GR-3, Brush and Rubicon at lab. Woodruff went out to Farm with van and Rubicon but results NG. No shots apparent on recordings.

Dec 24 Tues. Oakhurst. Closed down about 1130. Worked on Flight # 14 and work from NYU. Started Stepanoff on extension of Aug 8 flight. Into NYC PM and caught 1045 sleeper to

Dec 28 Sat. Cold NE winds and storms all day. Unable to get roads cleared out. Cancell reservations for this evening to NYC.

Dec 29 Sun. Caught 805 sleeper to NYC this evening.

Dec 30 Mon. Arrived NYC about 915 am - caught 1040 out of Penn Sta, arrived Asbury Park about 1 pm. Worked on Alamogordo results. Went over work with McCurdy who proposed new type instrument and wants authority to go ahead with it.

Dec 31 Tues. Oakhurst. Flight # 15 this morning at 1040 - 1105. Woody went out to Farm and recorded on Rubicon drum. Recorded also on Rubicon drum T-9- Brush and GR3-T-8. Se sonobuoy 1000 ft ± west of T-8-0. Times Square tonight.

1947

Jan 1 Wed Asbury Park. Snowstorm pm

Jan 2 Thurs. Oakhurst. Worked with V on flights 12, 13 and part of 14. Got Alamogordo results together. Conference this pm with Colonel Duffy and showed him my results with flights and with Alamogordo.

Jan 3 Fri. Oakhurst. Worked with V on Flights 14 and 15 and started NYU data of Sept 12 Stepanoff on extension of August 9 results. Conference pm: Dr. Ewing, Spilhaus, Dr Fer of Evans, Duffy. Discussed Evans program and air flight and Alaomgordo results. Made ar angements for cooperation with Evans in coming tests.

Jan 4 Sat. At Oakhurst about 3 hours. Finished getting velocities for Sept 17 flight a started work on data of Oct 4 cruise.

Jan 6 Mon. Oakhurst. Finished velocity data for Oct 4 and Oct 16 from NYU meteorologic studies. Stepanoff finished Aug 9 data and started on # 1 of Sept 12. Moved into new bu ing next to T-8-0 today.

Jan 7 Tues. Oakhurst. Vivian worked up ray paths, time and distance for Vel #2 of Sept Started on Aug 8 data to get Stepanoff's figures together for study above 15 kms. Went scouting for location of sono buoy west of Oakhurst Arm about 3000 ft. Chantz and Wood on calibration of Alamogordo instruments and fixing up of equipment for field uses.

Jan 8 Wed. Oakhurst. Worked on Aug 8 cruise, making final calculations for sky wave. Vel #3, Sept 12 cruise. Woody and I went over to high ridge 2900 ft west of Oakhurst sonobuoy which worked into GR3.

Jan 9 Thurs. Oakhurst. Worked on sky wave data. Vivian and Stepanoff on Sept 12 ray pa Flight # 16 at 1200 to 1220 pm. No noticeable results. Used sonobuoy at 160' hill back labs.

Jan 10 Fri. Oakhurst. Into Watson Labs at 9 to take supervisor's test. Trakowski, Peopl I went to Camp Evans and discussed results of V2 rocket recordings informally. Flight this PM 1600 to 1620. Worked on sky wave data

Jan 11 Sat. Oakhurst. Worked on sky wave data of Aug 9. Drew up curves for lower and stratosphere. Regunz? brought in calculator from Wright Field.
Jan 12 Sun. Oakhurst. Worked on sky waves Aug 8th and 9th. Got out letter to Gutenberg pertaining to those two days.
Jan 13 Mon. Oakhurst. Working on sky wave curves. Made plans for Alamogordo this Thurs
Jan 14 Tues. Oakhurst. Calibrated instruments A-21 to take to Alamogorso. Raining
Jan 15 Wed. Oakhurst. Started writep of V-2 rocket work. Dr O'Day in from Watson and went over V-2 rocket program with him. Finished calibration of T-21s on GR 8. Vivian finished sky wave curves. Worked on Dec 31 Woods Hole recordings.
Jan 16 Thurs. Oakhurst. All equipment for Alamogordo packed and loaded on truck pm. Wo with Vivian on sky waves of Aug 8th and 9th.
Jan 17 Fri. Oakhurst. Conference with Capts Lewis, Clowry and Duff of Olmstead Field a NOCUI at 1230 regarding bombs, future flights, etc. Mathematecian from Newman's group started work this noon - for two weeks. - working with Vivian. Woodruff and Chantz wer up to Newark with equipment and loaded on P-47. Went up at 2 pm by staff car. P-47 le Newark 333 pm, landed at Patterson for fuel, landed at Tinker Field, Okla City 120 am. Stayed there overnight, Officers Manjak and Layden.
Jan 18 Sat. Left Oklahoma City about noon and went as far as Amarillo. Stayed at Amari at Clinton Hotel
Jan 19 Sun Left Amarillo about 1130 CST - arrived Alamogordo 1230 pm RMST. Unloaded e ment off plane and put in north hanger. Unpacked GR-8s, T-21 galvanometers. 3 T-21s an galvanometers broken. Repairing tonight
Jan 20 Mon Alamogordo. Tested out T-21s at north hanger with GR-8s. Loaded up all equi for GR-3 and Rubicon drum and went out to A1 tower. Set up house along road about 3/4 southeast of the tower. Ran out 3 1000' lines for the at 120° radii. Set up dark tent and 2 galv L&N broken suspensions. Worked on timing circuits, T-21s and galv at Alamogordo Air Base.
Jan 21 Tues Alamogordo. Tried out more T-21s with GR-8. All OK but one. Set out Site 2 Hwy 70, C&GS marker 'Dona'. Laid out 1000'cables, set up Rubicon. Went out to end of D line to station G but could not find C&GS marker 'Town'. Went back along line toward b house & set up site #1, cables and Rubicon drum at intersection of G line and C line. Sites now set up 6, 13, 19 mi from blockhouse, all about 2 mi east of N line from boun site
Jan 22 Wed Alamogordo. Made rounds of all 3 sites. Set up L&N at Site #3, & surveyed t tower. Took T-21s and GR-8s to Sites 1 and 2 and set them up ready to operate. Took Rubicon recordings at Site 1 and 3 to check galvanometers.
Jan 23 Thurs. Alamogordo. Left air base about 900am. Bombing postponed from 11 am to 3 Went out to Site 3, surveyed to tower. Got GR-3 recordings. Left Chantz at Site 3 and to Site 2. Woody left Site 2 and went to site 1. Bombing delayed by 15-30 minute inter from 3 pm to 519 pm. Got good recordings at Site 2 . Both other stations lost to trian ulation acc't radio communication though Woody had GR-8 operating but without directio instrumnets.
Jan 24 Fri. Alamogordo. Checked with Major Pritchard at base. Left about 830 and picke all equipment from 3 sites. Surveyed Site #2 and made rough survey of Site #1
Jan 25 Sat. Alamogordo. Sorted out all equipment at north hanger. Left GR3, Rubicons a Sprengnethers. Packed up GR8's and other equipment and loaded in C-47. Carroll and Sho in C-47 from Middletown. ready to leave tomorrow. Worked on Site 2 recordings pm. got azimuths and angles of ascent for 2 main explosions. Have high angle of ascent.
Jan 26 Sun. Left Alamogordo about 830 am in C-47, Lt Sherry of Alamogordo pilot. Lande at Scott Field, St Louis for gas & eats, and then to Patterson Field, Dayton, Ohio whe we stayed overnight acct bad weather east of Pittsburg.
Jan 27 Mon. Left Patterson Field about 930 am, arrived in Newark near noon. Chantz and Woodruff left by train. I went to Oakhurst with truck and equipment.Arrived about 330 Peoples going to Washington tomorrow to V-2 panel meeting with Trakowski.
Jan 28 Tues. Oakhurst. Worked up diagrams for azimuth and offset distances, also angle descent from Site 2, Alamogordo. Went over recording, got about 20 recordings on first part but only 2 on down part.
Jan 29 Wed. Oakhurst. Worked on latter part of V-2 recording of Alamogordo. Got 2 recor besides 2 large ones, but very poor. Worked up possible trajectory of V-2 rocket. Work up future program for Alamogordo - Chantz & Oliva leaving about 10 February for semi-permanent work there. We are passing up Feb 6 rocket but starting on definite program following that.

Jan 30 Thurs. Plotted up angle of azimuth against angle of descent for V-2 recordings. Set aside this work for bombing runs. Worked on Flight 18 with Vivian. Started Eileen on calculations with Aug 8 and 9 data, reworking calculations doe before. Checked pick on Flight 18 - they appear to be sky waves though angle of descent is not regular.
Jan 31 Fri Oakhurst. Worked with Eileen on Aug 8 calculations. Finished up for both di and reflected possibilities. Went over Flight 19 records. Found that all of these are waves.
Feb 1 Sat. Left A.P. for Philly on 940 bus, arrived at Marions apt about 1. Wayne back work about 5. After dinner we went out to Newtown and stayed overnight.
Feb 2 Sun. Drove up to Sparta NJ with Marion and Wayne. Saw Dorothy, Joe and family. V Steenland & family living there with them. Saw Worzels pm. Ed Douglas in tonight for f minutes. Joe took me over to Dover & caught 958 train, then 1120 out of Penn Station, Newark. Arrived AP about 1230
Feb 3 Mon Oakhurst. Peoples in Washington regarding balloon ascention in June. Made pl for flight 20 which was made this pm 1300 to 1320 in conjunction with instruments in Bl Route just south of east, no results. Worked on sky waves from Flights 18-19.
Feb 4-5-6, Tues, Wed, Thurs. Oakhurst. Checked over all sky wave picks on Flights 19 - Went over Loran data and plotted up to get accurate plane speed. Plotted T - X curve u these figures. Worked up Oakhurst corrcetions for elevations and replotted all values velocity - Flights 18 - 19. Received Gutenberg letter in which he had worked out Aug 8, data. Went over this method and worked over thae data again. Unique solution not obtai Went over possible experiments in 'Helios' balloon June with Peoples.
Feb 7 Fri Oakhurst. Worked on 23, 24 Jan T-X curves. V files 23,24 Jan forms, started NYU data. Eileen worked on least squares-Va , then on Gutenberg's method applied to Au data.
Feb 8 Sat Oakhurst. Worked on V-2 rocket information 23 Jan. Used meteorological infor for 2 explosions. Tried to get $\bar{V}$ at height of explosions but seems too low.
Feb 9 Sun Asbury Park - worked on calculations of flights, setup? and calculations for rockets.
Feb 10 Mon Oakhurst. Worked over Alamogordo Radar Hueco stations for 23 Jan 1947 record and made plot of V-2 rocket D - H using all radar data. Went over all equipment to go t Alamogordo. Made plans for departure Thurs. Set up 8 sec galv in T-9. Vivian checked velocity from caps with temperatures and continued on Oct 22-23, Flights 12-13, Cruises NYU data. Eileen in pm - worked on formulas of seismic refraction using straight line f line - Aug 8 - 9. Finished this and went back to least square solutions of Jan 23 -24 d
Feb 11 Tues Oakhurst. Flight 21 scheduled for 8 tonight postponed until tomorrow. Worke Oct 22 data with sky waves to Highland Lights. Went over all records. Have 2? consecuti shots to H.L. Oliva left by train tonight for Alamogordo.
Feb 12 Wed Oakhurst. Vivian & Eileen worked on temperatures and winds Oct 22 & 23 and w up ray paths for sky waves to Highland Lights. All equipment for Alamogordo assembled a loaded on trucks for Watson Labs this pm. Flight 21 at midnight tonight. McCurdy, Chant Woodruff, Ball, Hom?, Rigny present. Dropped 20 bombs 1200 to 1237. No signals received either sky or direct waves.
Feb 13 Thurs. Got special instruments for 1 cycle from McCurdy this AM. Drove up to New in staff car- Chantz & myself. Loaded B-25 this pm but could not get all equipment on - 5 reels and box of equipment ? . Left Newark about 330, stopped in Middletown, Olmsted Field for 1 1/2 hrs to eat and gas plane, then left and landed at Godman Field side Fort Knox, Louisville, Ky. Stayed at Officers Club tonight.
Feb 14 Fri Left Louisvilleabout 930 am. Stopped at Tinker Field, Ok City for eats and re then to Alamogordo. Arrived Alamogordo 430 pm - contacted Watson Lab and got truck. Unlo all equipment from B-25 & took part of it to North hanger. B-25 crew:Lt Mosher, Lt Alte Sgt ? Oliva arrived Alamo. by train this am
Feb 15 Sat. Moved eqpt from north hanger across runway to stowage building. Checked T-2 GR 8, Checked galvanometers, etc
Feb 16 Sun Alamogordo.Out to Tower and Dona sites & surveyed in instrument locations - be station(ed) in shape. Ran out field wire at Dona station.
Feb 17 Mon Alamogordo. Went out to Tower site and set up Springnether and GR3 equipment. Rubicon 500 ft from GR3. Took trial recordings on both equipments
Feb 18 Tues Alamogordo. Went out to Dona Site this morning. Set up GR8 then Phil took tr and went over to GR3 Tower site. WAC corporal shot off about 215 but with little signa recorded at Dona but Phil at Tower site never saw rocket. Waited at Dona until ? pm. Ph

not come so got rideinto Army base. Phil in later. Very windy for recording.

Feb 19 Wed. Alamogordo. Got radios from Vatrus of Signal Corps and got trip tickets tomorrow. Ran test records on Rubicon at both sites and checked everything ready for tomorrow.

Feb 20 Thurs. Alamogordo. Out early to station at Tower. Left Phil off there and went to Dona Site. Rocket delayed from 10 to 1119. Both stations got good recordings except 1 97-MS on both MS. Worked on GR8 records tonight.

Feb 21 Fri. Alamogordo. Went to White Sands Proving Grounds with Fritchard, Magnir?, & Phil this morning for V-2 critiques, 0930 to 1100. Canister from rocket unpacked? at 40 miles up and finally found this pm between El Paso and Alamogordo. No transportation back to NJ yet. Worked on GR-3 records today

Feb 22 Sat. Alamogordo. Worked on data all day today. Correlated between the Tower and sites for several sources. Worked total travel times for ascents both Dora and Tower and got average velocities up to about 65 kms, velocity increases from about 40 kms up to 60. Average velocity at 65 kms is about 320 meters per sec.

Feb 23 Sun. Worked on detailing record from GR3. Added more and made T-D move up 75 kms, giving velocity of about 420 m/sec at top. Phil and Sal went out and picked up ment - T-791s and GR8 and checked all pickups.

Feb 24 Mon. Alamogordo. Waited for air transportation today but none available and may be any until Thurs at latest. Worked on V-2 recordings, frequency and characteristic ysis - T-3. Sal and Phil out to Site at Dona and recorded WAC Corporal at 1400. Got so waves in about 7 minutes after it had left ground.

Feb 25 Tues. Alamogordo. Went out to Tower Site, surveyed in #6, took down shelter. To Site, set up GR3 in shelter, surveyed in #6, went to launching site, about 2 -3 miles launching area. Phil went in to WSPR and got permission, Sal and I surveyed 1 site for with WAC Corporal.

Feb 26 Wed. Alamogordo. Worked on GR8 records of 20 Feb V-2 rocket. This am Phil and up Sounding? site for tomorrow's W.A.C. I left 7 pm - C-47 Hoffman, Missinger: Pilot, pilot. arrived in Newark 9am.

Feb 27 Thurs. Arrived Newark 9 am. Lewis, Duff,Mosher a request? in from Middletown - way to WL to conference and I rode in with them. Conference re future missions. Confer PM Trakowski, Peoples, Ewing & myself regarding future operations

Feb 28 Fri. Oakhurst. Ewing in from NYC. Went over Alamogordo results with Ewing, Peop and Trakowski. Out to Peoples tonight

March 1 Saturday. Asbury Park

March 2 Sunday Oakhurst. worked on calculations for wind translations.

March 3 Monday.Oakhurst. Postponed Alamogordo trip until tomorrow. getting together eq ment for Alamogordo. Thompson going also to get information on bombing runs? there. Wo on calculations from V-2

March 4 Tuesday. Thompson and I left staff car about 930, arrived at Newark 1040. Load B-25 with equipment and left about 1230. Stopped at Middletown and picked up radio. St at Scott Field & Tinker Field for gas. Arrived at Alamogordo 2 am. Crew B-25:Hoffman, DeTurk, Hancock

March 6 .Thursday. Alamogordo. Snowing - rocket flight called off until tomorrow. Chan out to Tower Site and brought in batteries. Sal and I checked low frequency equipment went out to Tularosa site with it this pm. Ready to use on 1 sec galv on Rubicon drum

March 5 Wednesday. Alamogordo. Chantz, Thompson and myself out to Tulerosa site and su eyed out X setup and ran out wires. Back about 2. Oliva working on check of T21s. Wor on radio and T21s until tonight

March 7 Friday. Alamogordo. At 8 am Fritchard got word rocket would go off between 10 and 1200. Phil and Sal went out to Dona and Launching Sites with weapon carrier. Hoffm DeTurk and Thompson out with them in staff car. I took Jeep and went out to Tularosa s Rocket off at 1123. Got recording on GR8 but not time for Rubicon record. Phil and Sal OK records from their sites. Thompson reported on bombing sites for runs and met and t with Ordnance Officer. Left Alamogordo 845 pm , B-25 with Hoffman, DeTurck. Motor trou on way and reached? Tinker Field 1200 with cylinder broken.

March 8 Sat. Hoffman wired Alamogordo and caught Manjak & Schneider (P4)? before leavi for Florida. They changed their route and landed at Tinker Field, O.C. 535. Trouble wi their oil gauge and the trouble not repaired until 10 am. Left Tinker Field 10 and lan at Patterson. Off from patterson to Olmsted, Olmsted at 9pm. I stayed there overnight.

March 9 Sun. Left Olmsted 0934 am - C47, Manjak and Schneider and landed at Newark 113
Thompson and I took train to Asbury Park from Pa station. In Asbury Park 3 pm
March 10 Mon Oakhurst. Vivian and I worked on Flight 25, Parts 1 and 2. Started Eileen on V-2 rocket recordings.
March 11 Tues Oakhurst. Vivian and I worked on Flights 25, 24. Flight 26 off today, Pa 1 at 9, part 2 at 2 pm. Good results! Eileen on V2 rocket March 7, Dona Site.
March 12 Wed Oakhurst. Vivian and I worked on records - Flight 26, and started Flight 2 Eileen worked on Dona site , V-2. Thompson and I went over Alamogordo plans.
March 13 Thurs Oakhurst. Worked with Vivian some on Flight 23 and 22. Worked on Tularo site of V2 - 7 March. Eileen worked on Launching Site, V-2. Flight 27 today - at 12 noo and at 4 pm. Probably last of flights.
March 14 Fri Oakhurst. Vivian worked on identification of returns, last 4-5 cruises. ga good sky waves. Trakowski, Peoples and myselfwrote up report for General Reves on overa program to be hand carried by Thompson to Washington. Eileen worked on V-2 records, #21
March 15 Sat Oakhurst. Worked up survey of Launching Area and Tuleroso sites & plotted sites on air map. Worked on V2 rocket March 7 records.
March 16 Sun Oakhurst. Worked on formula for sound correction until 2 pm - went over to McCurdys tonight.
March 17 Mon Oakhurst.Vivian plotted up all last sky waves. Worked on eqpt list for Ala gordo. Worked on formulas for wind correction.
March 18 Tues Oakhurst. Worked with V. Checked through all March 13 records. Worked on Woods Hole recordings pm. Eileen working on V-2 rockets.
March 19 Wed Oakhurst. Reviewed Flight 24A trying to get some azimuths from Oakhurst bu records very poor. Reviewed records of Jan 23rd and started on stratosphere calculatior Eileen working on corrections Jan 20 V2 rocket from meteorological data. Baten? in from Florida Field Station, ready to go to Alamogordo next Tuesday.
March20 Thursday, Oakhurst. Went over final calculations for stratosphere data using seismic methods, of Jan 23 data with Vivian. Got V=325 at 3 kms. Studied azimuths on th data and got w = 10 m/sec coming from south on June 23rd. Worked with Eileen on rocket Jan 20thcorrecting for met data and plotting final H against X in kms from surface for up data.
March 21 Friday Oakhurst. Worked on Alamogordo plans - Lewis & Clowry over this pm and went over all future plans including bombing for Alamogordo. Worked on rocket data with Eileen and on flight data with V. Stepanoff on ray paths of Dec 13
March 22 Saturday Oakhurst. Went over all V2 rocket data. Studied azimuth - elevation graphs & studied WAC Corporal of 3 March. Caught 534 train from Asbury Park - 1045 sleeper out of NYC
March 23 Sunday. At home. Arrived Canton about 9. Left on sleeper tonight about 8 pm
March 24 Monday. Arrived NYC about 7. At 0930 went up to Math Department at NYU - Washi Square. Met Mr Bennett of WL. Found that Dr. Courant would not be in until late and dec not to wait but caught 1040 train to Asbury Park. Went over shipment ready for Alamogor and over work for Vivian and Eileen. Packing tonight.
March 25 Tuesday Truck at Oakhurst at 9 with scales - all equipment weighed - about 35 total including TORRID. Edmonton, Reynolds, Thompson, Porter, Godbie? and I left about and went through to Mitchell Field in staff car. B-17, Carroll, pilot -- co-pilot. Left Mitchel Field about 3 pm. High level winds - went southern route - stayed at Maxwell Fi Alabama tonight. Thompson stayed behind waiting for B-45
March 26 Wednesday. Left Maxwell Field, Ala. about 9 and landed in Alamorgoro 3 pm
March 27 Thursday Alamogordo. Phil, Reynolds and I went out to Tower site, took in all Pulled down tent and Rubicon equipment and took it over to new site west of Lake Lucero Strung out wire, surveyed in site & set up Rubicon tent. Sal, Edmonson, Godbie?, Porter weighing in equipment in Alamogordo air base.
March 28 Friday. Alamogordo. Went out with Godlers, Porter to White Sands west of air b Located site and surveyed it, put up shelter and set up GR3. Phil and Reynolds went up Tularosa site, Sal and Edmondson worked on GR8 and low frequency equipment. Thompson in with B-45 from Newark.
March 29 Sat Alamogordo
March 30 Sun Alamogordo. Phil and I went out to Dona site and picked up some equipment then out to Lucero site. Set up Rubicon and took a record. Tried to get through to Tula site west of White Sands but couldnt find road.

March 31 Monday. Alamogordo. Chantz, Bill Godbee and Ace went out to E. White Sands ar Tularosa sites to make final setups. Sal, Edmondson, Peoples and I went out to Dona s: this pm and moved tent and Rubicon to #3 position and set up low frequency apparatus

April 1 Tues V2 Rocket #22 went off at 1310 this pm. Chantz and Don at Tularosa, Godbe and Peoples at East White Sands, Sal and Edmondson at Dona, Porter and I at Lucero. A: 4 stations got good recordings though low frequency instrument at Dona did not work o

April 2 Wed. Peoples, Major Magnur?, Thompson and myself went over to Lt Col McKenson' office this am regarding bombing runs. There are many difficulties with the bombing he mostly that so many new groups have moved in and are setting up on the northern? range Thompson and I went overto see Major Mitchell this pm regarding same matter. Wrote mer regarding proposed work to take to CO tomorrow. Peoples left on B-17 today. Don and B: went to Dona and Launching Area sites am and got all loose wires. Don and Bill E went East White Sands and Tularosa pm and got inventory and brought back Rubicon and tent Tularosa. Worked on East White Sands record. V2 made 85 peaks - down course. Porter wc on calculations pm. Sal and Edmondson took complete inventory and this pm worked on lc frequency equipment.

April 3 Thurs. Oliva and Edmondston on low frequency equipment. All T-21s changed over Stds. Edmonton and Bill G went out to Lucero and Dona, got inventory and brought back tent from Lucero.

April 4 Fri. Reynolds and I went out to Osurso? Range and located PB1 bombing range. S up wires and did surveying. Chantz and Porter on computations April 1

April 5 Sat Alamogordo.

April 6 Sun. Checked clocks. Cleaned out hanger and emptied trash out at East White Sa

April 7 Mon Talked to Pritchard re 3rd car for tomorrow. Gave him memo of progress rep for MOGUL project to date, talked to Lt Dyer of Signal Corps regarding for tc firing. Chantz and Bill went out to Tularosa and got that site ready. All equipment ch for tomorrow. Edmondston and Reynolds ran drum recording of McCurdy low frequency equi ment at base. Porter and I worked on amplitudes and frequencys of all recordings Apri: firing and started calculations. Olive worked on calibration of GR8 recorder attenuati Got 3rd vehicle and all trip tickets for tomorrow.

April 8 Tues. Ace and I went out 7 am to Osarco site. Arrived 9 and set up radio and T Rocket due at 11, delayed until 1710. Very windy then, all settings at 8. Ran 3 rolls nothing came in. Chantz at Tulerosa alone - Godbee and Reynolds at East White Sands - and Edmonston at Dona - all sites windy but 3 closest ones got some signals.

April 9 Wed. Worked on yesterday's records. Made picks on Dona, East White Sands and T Found nothing on Oscuro site recordings. Don and Bill G went out to East White Sands s and took recordings with pistonphone to get GR3 attenuation calibration. Sal Olive lef pm for San Diego. Wrote letters to Vivian and Jim P tonight.

April 10 Thurs. Ace and Phil worked on rocket recordings. - azimuths vs elevation angl Don and I went out to Tulaarosa Range and checked bombing sites - bombing range just n of Range Camp and another site between that and our Tularosa site. Triangulated in wit Tularoas Peak, etc. Thompson left in 45 for East. Godbee and Edmondson went with him.

April 11 Fri. Don and I went out past Tularosa Site looking for bombing sites. Went ba to Air to Ground Range and to air strip. Chantz and Porter working on calculations V2 and T-21 calibrations.

April 12 Sat. Alamogordo Air Base

April 13 Sun. Worked on formula for triangulation without using compass - Alamogordo A

April 14 Mon. Porter, Chantz and I worked on GR3 and GR8 calibration curves for freque and attenuation settings. Don worked around equipment - Don, Ace and Bill got apartmen at air base. Wrote letters to Vivian and Eileen tonight.

April 15 Tues Alamogordo. B-29 arrived today - Lt Ball, McCurdy, Woodruff and MOGUL pe onnel - 41493: Lewis, Wolk, Burnhoff, Adams, Duff . Worked some on instrument calibrat Lewis, Ball and I checked with Major Pritchard, then to Major Mitchell's office regard bombing sites. Mitchell said CO had turned down bombing from air, but we could have su charges along Tularosa road. Went up in AT-6, light plane with Capt Runcraft and looke area west of Tularosa as far as the mountains, where bombing sites are to be located.

April 16 Wed. Alamogordo. Chantz and Reynolds out to East White Sands and Tularosa sit to check GR3 equipment for tomorrow. Porter and McCurdy working on low frequency equip: for V2 tomorrow. Woodruff, Ball, Work and I went out to Dona site then to Launching Ar site. Strung out wires and left equipment for tomorrow's firing. McCurdy working tonig on low freq. Oliva in from San Diego this pm

April 17 Thurs. V2 firing #24 scheduled for 11 am. Chantz - Porter at Tulerosa Range; Reynolds - Woodruff at East White Sands, Woodruff with low frequency equipment for 1 trace GR3;Oliva - Kabassa?, radio operator on B-29 at Dona Site, Bill Edmonston arrivec by car from Florida about 11 and went out to Dona -- Captain Lewis and myself at Launch Area site. V-2 postponed from 11 to 1610. 9 explosives supposed to go off, SCEL, only 1 worked. Tularosa site - had bad instruments - had 3 working but in line; East White San - one short roll, then paper jammed; Dona Site OK; Launching Area site - OK for first 2 rolls, paper jammed on third roll. McCurdy set up low frequency in hanger, north side, on Rubicon drum but recordings questionable - as SCEL radio transmitter interfered.

April 18 Fri. B-29 took off for Middletown and Newark about 730 from Alamogordo with al personnel that came down with it. Wrote Peoples a letter regarding split-up of equipmer so that bombing runs could be continued on East Coast. Plans are to have Edmonston, Reynolds here with 2 sets and take Oliva, Chantz w 2 sites for the East. Set up equipments Sprengnether & L&N galvanometers for Helgoland experiment & run equipment 1030 to 3 Pm. Checked over all recordings. Oliva and Reynolds out to Dona and brought in all equipmen except wire.

April 19 Sat. Into El Paso with Bill E this am. Got reservations to Houston next weeker

April 20 Sun. Worked on plans for bombing runs and V2 monitoring.

April 21 Mon. Alamogordo Air Base. Bill Edmonston and I went out to Tularosa Range and checked 2 bombing targets, and located third bombing site 7-8 miles west of A1, near al flats. Chantz and Porter worked on calculations V2 -#24. Sal worked on equipment. Don off today.

April 22 Tues. Alamogordo. Reynolds - Oliva out to East White Sands. Brought GR3 there for overhaul. Worked up calibration of GR 8. Got curves for settings of 8 and for chang in attenuation. Talked to St. James, Ordnance Supply, re 500# bombs. Wire from Peoples Godbee ready to come back - plane ready to come down this week. Sent return wire to hol plane off until after 1 May.

April 23 Wed. Alamogordo. Bill E. and I left Air Base at 0930 and drove to Roswell. Scc out area between Roswell and Donali? but all irrigated farm lands. Finally back with fi ing suitable site, 129 miles from Air Base to Roswell. Chantz went Tularosa range GR3 t Oliva and Reynolds checking GR3 in base, Datn?on calculations April 1 rocket

April 24 Thurs. Phil and Ace working on V-2 recordings April 1 and 8 getting and amplitudes. Sal and Don on GR3, Bill E. on clock checks. Saw Pritchard about Roswell tr bombing. Saw Post Engineers and Major Mitchell.

April 25 Fri. Sal and I went to Motor Pool and got our driving licenses. Worked up suns for Tower and Dona sites, OK within 10 minutes. Bill E and Phil got timbers from scrap and went out on Tularosa Bombing Range to build shelters. Sal and Don working on GR3. Air Base 130 and left Alamogordo 3 pm. Got room in El Paso at Hotel McCoy.

April 26 Sat. Left El Paso on Continental Air Lines about 0930, went by way of Hobbs, M land, Odessa, San Angelo to San Antonio. Waited there about 2 hrs and caught Eastern Ai Lines out to Houston. Got in about 0630, took bus to Houston and taxi to see Donnie.

April 27 Sun. Houston with Donnie and family

April 28 Mon. Down to Sohio Geophysical office with Donnie and Roy Bennett. Went up to Abbott and Stansell about a car. Caught bus out to airfield 1020 and caught Eastern Air Lines to San Antonio, and Continental Air Lines to El Paso. Arrived El Paso 730 and cau train to Alamogordo, then bus to Air Base. Chantz, Oliva and Bill E. checked over L&Ns, got driving licenses and worked on calibration curves.

April 29 Tues. Alamogordo Air Base. Delayed trip to Silver City to talk over Signal Cor Communication with Peoples, Ball this PM. Went out with Don to East White Sands to set GR3 and get it working. Lt Thompson in pm. Lt Stevens in on vacation trip. Sal and Bill got low frequency equipment together and ran test with it at hanger. Possibility rocket will not be fired until Monday acct weather

April 30 Wed. Alamogordo. Phil and Don out to East White Sands and Tularose sites to ge equipment ready for test tomorrow. Set up Rubicon at Tularosa. Sal and Bill E. went to and Launching Area sites to set up equipment. All mikes got out ready for firing.

May 1 Thurs. Out at 2 am. Put up equipment for low frequency run at the north hanger. C to stations in field - Thompson with Phil at Tularosa - Don and Ace to East White Sands Sal and Bill E. to Dona and I went to Launching Area site. Rocket misfired at 050009 an all equipment of Signal Corps 'explosions' lost. Picked up equipment from Dona, Launchi Area and East White Sands this pm. C-47 in this pm: Dubell, Mosher and Duff. Duff broug in 2 100# bombs with some TNT charges. Bill Godbee in from R.B.

May 2 Friday. Alamogordo. Assembled apparatus to go back to Watson Labs. Phil and Bill Godbee out to Tularosa and picked up all GR3 equipment. Duff, Mosher, Dubell and I wen out to Tularosa Bombing Site #2 and shot off 2 100# bombs, using the TNT blocks alongs: All went off OK. Duff got box caps for use. Will cancel 500# bomb order and use just T: blocks if possible. All equipment loaded on plane this pm.

May 3-4 Sat, Sun. Left Alamogordo about 9 am, Chantz, Porter and myself, 2 Signal Corp: men along. Stopped at El Paso and went over to Juarez for pm. Left El Paso about 8 pm. Landed in Scott Field about 4 and found weather bad in East. Stayed at BOQ until 10. Le about 11 and arrived in Middletown, Olmsted Field, about 6. Weather bad in Newark. Sta in Olmsted Field BOQ

May 5 Mon. Left Olmsted Field at 7 am. In Newark about 8. Trucks in about 11. Loaded ec ment and sent to Oakhurst. Arrived Oakhurst about 230. Chantz left for Frenchtown fm Ne

May 6 Tues. Oakhurst. Worked with Vivian and Eileen on their calculations. Eileen work: on several? Feb 20 rocket and Vivian on last flights from Oakhurst.

May 7 Wed Oakhurst. Conference am - Dr Delassos? and Leonard from UCLA. Went over T-21 calibration they had - also the results from Alamogordo. Conference pm with Mr--- from AMC Wright Field. Flight scheduled for tomorrow, balloons with instruments going up at Bethlehem - B-17 following balloons with recording equipment and B-29 dropping bombs ea ward from Atlantic City.

May 8 Thurs. Oakhurst. Scheduled balloon flight this morning at 730. Mears and men fron NYU at Bethlehem with balloons. Trouble with winds and instruments did not go up. Peopl Moulton over to Middletown with recording equipment on B-17 following balloons. Had no trouble following them. B-29 started dropping bombs near Atlantic City about 8. Trouble with oil leak in a motor and B-29 had to jettison the bombs and return. Recorded at Oak hurst with Brush and GR3. Working today with Eileen on Feb 20 rocket - final ave veloci data

May 9 Fri Oakhurst. Worked on calculations - bombing runs and V2 tests Feb 20. Took sle out of NYC for Canton tonight.

May 10 Sat. Canton. Steve and Esther up from Syracuse for weekend.

May 11 Sun. At home. Took sleeper out of Canton for NYC

May 12 Mon. Arrived NYC and caught 0940 out to Asbury Park - then to Oakhurst. Saw Mr E of NYU this pm regarding future flights both here and in Alamogordo.

May 13 Tues. Chantz and I went down to Cape May today with staff car and driver. Locate suitable site for bomb recordings on road between Cape May Court House and Goshen. Surv out 5 pickup locations and took solar observations. Back in AP about 0800 pm

May 14 Wed - Finished checking up with Chantz and Oliva in regard to bombing runs on e coast. Run scheduled for 9 and 12 on Friday. Packed up all equipment from computing off to go to Alamogordo. Checked transit and rod to go to Alamogordo. Jappett?, new compute in today. Started him out on work Stepanoff was doing.

May 15 Thurs Oakes, Stevens?, Oliva and myself to Fort Dix this am early. Loaded up C-5 when it arrived, with 229 boxes of TNT, about 12,000#. Carroll - pilot and Hoffman- cop: Mears, Vivian and Eileen arrived laterand we took off Fort Dix about 1130, EDST. Arrive Fort Worth about 9 EDST. Off again to Big Springs, Texas, where forced to stop account weather conditions. Stayed overnight at Hotel Supples.

May 16 Fri C-54 arrived at Alamogordo from Big Spring about 930 MST. All TNT unloaded a put in dump. Vivian and Eileen got rooms at girls dorm, Mears and I at BOQ 25. Went ove: future program with Edmondson, Reynolds and Godbee. Vivian and Eileen in office this pm Have office in Watson Lab Bldg. Checked out ready to go to Silver City Monday. Got car and gas for car. Checked transit and made from field wire chain for 125 meters. Mears a Thompson down to critique at White Sands and to see Capt Smith of Weather Service.

May 17 Sta. Alamogordo. Vivian, Eileen and I worked on May 15 rocket data. Plotted up a uth angle against elevation angle for Dona and White Sands stations. Plotted azimuth ag time for Dona site.

May 18 Sun. Alaomgordo. Worked on Dona record, May 15 rocket. Checked through picks - p elevation angle against time, calculated elevation and distance from bombing site using straight line plane between launching site and point of impact.

May 19 Mon Reynolds and I left about 0745 in weapon carrier for Silver City. Arrived at Giles National Forest Station about 1230. Got permission for site there and went along valley 16 miles, then back 5 and located site. Surveyed location, dug holes and strung Back to ranger station and located ourselves on range map. Left Bayard about 630 pm. Ba at Alamogordo about 1045 pm. Edmondson and Godbee out to record WAC Corporal at Dona si but it was postponed until Thursday.

May 20 Tues. Edmondson and I left about 0845 in weapon carrier for Roswell. Arrived at Hagerman about 12. Went across Pecos R and found site. Surveyed in locations, dug holes and strung wires. Went over to Roswell Army Air Field, filled up with gas. Checked for r for Bill for Wed and Thurs. Back to Alamogordo about 730 pm. Godbee and Reynolds loaded one weapon carrier, ready to leave tomorrow. Vivian working on weather data to send back to Watson. Eileen working on March 7 azimuth - elevation plots and checking picks.

May 21 Wed. Reynolds and Godbee left about 800 in loaded weapon carrier. Stopped at gate by SC Lt and had to unload on motor pool weapon carrier acc't bad tires and heavy load o other one. Left about noon for Silver City. Bill Edmondson picked up GR8 and left for Ro well in weapon carrier SC about noon. Got all equipment together for shooting tomorrow. Worked with V and E this pm. Eileen finished checking original data 7 March and started checking April 1 azimuths and elevation angles. V finished azimuths direct waves and sta extension of weather data to 288, 18 kms fm sky wave data.

May 22 Thurs. Thompson and I out at 0730 to Ordnance dump. Sgt Rand met us there and let in area. Picked up 17 boxes of TNT. Shot 1000 at Site 1, 1100 at Site 3, 1200 at Site 3 1300 at Site 1 again. Thompson left for El Paso to meet his family, in from Corpus Chris Worked a little in office PM. Called up Silver City and Roswell tonight, changed schedul of tomorrow from 1100 last one to 1115. Checked AAF clocks over telephone.

May 23 Fri. Went out at 0530 and got sgt Rand. We went out to ammunition dump, picked up 16 boxes of TNT. Sgt Rand to field with me. Shot 0800 Site 1, 0900 Site 2, 1000 Site 3 and 1115 Site 1. Worked on theoretical calculations pm. Bill E in from Roswell about 5 a and Reynolds & Godbee in about 800

May 24 Sat. Went over with Godbee and unloaded his truck, hung his recordings to dry. We over GR8 records too but didn't see any signals there. GR3 from Silver City has some goo sky waves.

May 25 Sun. Tried to get into El Paso to catch train to Houston but Alamogordo train too late to make connections. Back to Alamogordo Air Base.

May 26 Mon. Worked on Tests 1 and 2 records today. No signals from Roswell - some thunde on 2 shots. 5 sky waves from Silver City. Vivian worked on records, Eileen on thunder recordings. Godbee worked am, Bill and Don off today.

May 27 Tues. Worked with V on tests 1 and 2, E back on rocket of April 1. Bill Godbee and Don out to Dona and set up GR3 for Thursday firing.

May 28 Wed. B-17 in from Watson with Mears, Hackman, NYU and Alden. They plan to fly test balloon tomorrow. Other gang with recording equipment, due to leave Watson Sat. Got every thing ready for HERMES rocket tomorrow, Dona & White Sands. Finished theoretical calculations of T-X solution of sky waves.

May 29 Thurs. Mears and Hackman got balloon ascension off about 1 PM today with B-17 plan to follow it. Don and Godbee out to Dona, Bill and I to East White Sands to record HERMES Set for 1100 am, postponed repeatedly, finally fired at 0730 PM. Rocket off course, lande near Juarez, Mexico.

May 30 Fri. Memorial Day. Got 330 bus out of Alamogordo, 1030 train out of El Paso to Hou

May 31 Sat. Arrived Houston 715, went up to bank 900, then to Abbott - Stansell and picke up car - '42 Chrysler. Went up to Sohio and talked to Donnie and Roy Bennett for an hour. Left Houston about 1145, stayed overnight past Post, Texas.

June 1 Sun. Left 0400, arrived in Alamogordo about 0930 - 800 miles to base from Houston. C-47 with Moore, Schneider and others from NYU. Also Ireland, Minton, Olsen. NYU men worked on balloons today in north hanger.

June 2 Mon. Changed shooting plans to coordinate with balloon flights. Balloon all ready to go. Receiver in plane and receiver on ground. Edmondson with GR8 to Roswell pm, Godbee and Reynolds with GR3 to Silver City. Vivian working on amplitudes of flights - Eileen on April 7 rocket.

Jun 3 Tues. Up at 0230 am ready to fly balloon but abandoned due to cloudy skies. I went out to Tularosa Range and fired charges from 6 on to 12, missed 530 shot - trouble getti ordnance man.

Jun 4 Wed. Out to Tularosa Range and fired charges between 00 and 06 this am. No balloon flights again on account of clouds. Flew regular sono buoy up in cluster of balloons and had good luck on receiver on ground but poor on plane. Out with Thompson pm. Shot charges from 1800 to 2400.

June 5 Thurs. Up at 4 to shoot 2 charges for balloon flight. Whole assembly of constant-altitude balloons set up at 0500. Fired charges at 0537 and 0552, then soon buzzed by pla to return. Receiver at plane did not work at all. Ground receiver worked for a short time but did not receive explosions. B-17 and most of personnel out to Roswell - recov equipment some 25 mi east of Roswell. Out at 10 this morning, got TNT and went out to range. Fired shots 12 to 18 every hour. Last of bombing tests this week.

June 6 Fri. NYU personnel getting ready for flight tomorrow. Conference about noon, Hac with radiosonde, Olsen and Godbee with receiver to Roswell - also Smith on theodolite. Regular equipment in plane.Edmundson and Reynolds to operate equipment at labs - recei with GR8. Worked on adopting GR8 this pm and this evening. Fired some shots pm at site but no transmitter for sonobuoy. This pm put McCurdy low frequency amplifier in circuit before GR8 and have plenty of signal.

Jmne 7 Sat. Balloon flight off about 530. Dribbler? broken on takeoff. Balloon was to 60,000'±, broke left balloons then train came down somewhere in mountains. Recordings a north hanger, and at Roswell but plane did not receive. Shot at 6, 630, 7, 730, 8 and 8 at site #4. Plane out to find balloons but no luck. All NYU personnel and John Adden of on B-17 - Lewis, Gallagher. Went over to Alamogordo with Ireland, Minton, Olsen and Mea but no train today - making reservations for tomorrow.

June 8, Sun. Rancher, Sid West, found balloon train 25 mi south of High Rolls in mounta Contacted him and made arragements to recover equipment Monday. Got all recordings of balloon flights. Took Ireland, Mears, Winton, Olsen to Alamogordo to catch train this p

June 9 Mon. Bill Godbee and Don Reynolds went out to Sid West's ranch south of High Rol and broughtback recovered balloons- clock, 2 radiosondes, sonobuoy and microphone and l part of dribbler. Bill Edmondson cleaning up hanger and sorting out equipment of NYU. W today on balloon records (GR8) from north hanger. No definite signals obtained. Took in entory MRs.

June 10 Tues. Bill G , Bill E and Don worked on equipment, repairing GR8, T21 mikes, et Getting ready for rocket Thursday. Worked on GR8 recordings from Hagerman, Tests 3,4,5, No signals obtained. Worked on balloon tests from Roswell - no signals. V on Gila R tes 3,4,5,6, Eileen on V2 amplitudes.

June 11 Wed. Bill Godbee and I went out to Tuleresa Range and located Site #5 for bombi 24 mi N of Site #3 - roads bad. Laid out wire for shooting, Don and Bill E getting read for rocket. Checked Rubicon records, all 3 sites.

June 12 Thurs. All rockets postponed until July 3 rocket of S.C.E.L. Bill E, Don, Bill (went down to El Paso and then SE along Rio Grande. Located listening site south of Clin Texas and layed out wires and dug holes. Worked on bombing flights from Oakhurst.

June 13 Fri. Men off today. V worked on tests 3,4,5,6 Tularosa bombing. E on V-2 rocket amplitudes. I plotted T-X all sky waves and started reviewing March 11 and 17 records.

June 14 Sat. Bill E and family, Don R and family, V, E and I to Carlsbad.

June 15 Sun. Through Carlsbad Caverns and back to Alamogordo.

June 16 Mon. Men off today. Worked on eastern shore cruises, plotting T-X corrected to 6 kms & worked on apparent velocities and differences in azimuth.

June 17 Tues. Men left for Silver City and Febrero? near El Paso for bombing tests. Work on Cruises.

June 18 Wed. Test 7 of Tularosa Bombing Program, Shots at 7, 930 and 1230. Men called in from field to check clocks. Weather poor - raining at all sites. E on V2 rockets, V Crui

June 19 Thurs. Test 8 of Tularosa bombing program, shots at 1600, 1830, 2100 , 2400. Weather poor - rainy at Alamogordo.

June 20 Fri Finish of Test 8. Shots at 0000 and 0230, Sites 1,3,5. Men back today. Godbe Reynolds at Silver City got all shots, Edmondson at El Paso got 1 possibly 2. Looked ove all Fabens records today. E on weather data, rocket firings,V on Tests 3,4,7 and Flights

June 21 Sat Worked on GR8 records from Fabens - calculated azimuth and elevation angles Fabens recordings and some of Silver City.

June 22 Sun. On trip with V & E - San Cruzes, Hot Springs, Carizzo

Week of Jan 23-28 Alamogordo Air Base. Men worked on equipment for sound ranging Monday and made arrangements for off base transportation, had to get some from Base Motor Pool; Bill G, Don R left am for Gila Valley and Bill E went to Fabens. Tests 9, 10 Wednesday 2 and Thurs, Fri 26-27. Test 9: 7-10-13-16-18 Sites 1-3-5-3-1. Went out with Sgt Rand. Contacted by telephone Wed night and Thursday. Shot 10 Thurs, Fri at 18-21-00-03-05. Out with Sgt Rand again. Men in Fri pm. Good results from west, but poor or nothing from Fab Looked over some of Fabens records Sat. V worked on Tests 7-8 getting all data, includin amplitudes, then worked on Flights 1-27. Got met data for all flights up to 18 kms excep Oct ones. Found one whole minute error in timing on 24A flight which now checks with oth in March. E on new weather calculations 20 Feb. Found adding wind directly to velocit from temp gives accurate enough results. Changed 20 Feb rocket and plotted up altituc against signal Strength - shows nothing significant & started on 1 April rocket. Have 4 station azimuths about finished. Phil Chantz and Wiggett in by train Friday night. brought in records of Flights 28, 29 and 30 on east coast - 1 of May and 2 in June. W over records Saturday and identified signals of 28 -29. Balloon expedition personnel ived Saturday evening - Peoples, Trakowski, Mears, Ireland, Olsen, Moulton, Alden frc and Moore, Schneider, Hackman, Smith, Hazzard, 2 others and a Lt Smith from Navy NYU.

29 June (Sun) NYU personnel and some of Watson Lab men working today with equipment i north hanger. Went to Ruidoso with Mears, Trakowski, Godbee, V & E

Week of 30 June - 5 July '47 Alamogordo. Vivian worked on Tests 9 and 10, finishing a upward data on GR3 recordings. Eileen worked on 1 April rocket, getting signal streng vs altitude (corrected for weather data) and started on time calculations to get time signal for correlation purposes. Appears likely that strength of signal is dependent station factors rather than anything about rocket.

Balloon tests? 7, 8, 9, and 10 off this week. Test 7, slated for 1 July postponed u 2 July as equipment was not ready. 100 tanks Helium obtained from Amarillo Monday eve Also radiosonde receivers set up by NYU personnel Monday but were not operable. Test at dawn on July 2 with pibal 1 hr first following with theodlite. Winds were very lig and balloons up between A air base and mountains most of time. Included cluster of me balloons. Followed by C-54? for several hours & finally landed in mountains near road Cloudcroft. Before gear could be recovered, most of it had been stolen. Stations opera at north hanger, Cloudcroft and Roswell. Shots made unfortunately at Site #4 and picke good from north hanger and from Cloudcroft for awhile. Nothing from Roswell. On Thurs morning 3 July, a cluster of GM plastic balloons sent up for V2 recording but V2 was fired. No shots fired. Balloons up for some time. No recordings from Roswell as pibal no W winds. Balloons picked up by radar WL and hunted by Manjak C-45. Located on Tula Range by air. Out pm with several NYU by weapon carrier but we never located it. Rocke postponed until 730 Thursday night but at last minute before balloon went up, V2 was off on account of accident at White Sands. Sent up cluster balloons with dummy load. Ba flight #10 at dawn on July 5th. Had gone out in C-45 again with Moser and Dubell to hu for balloon from Flight 8 but not since? we found them. C-54 went to El Paso and picke single Smith plastic balloon and GM cluster plastic balloons. Flight 10 with single plastic followed from Alamogordo and Cloudcroft. Shot 8 shots from Site 4. Picked up and lost signal at 845. Balloons ? more than 6 hrs although time clock had been put i to bring them down after 5 hrs. ? were picked up by ? C-45 as first flight out delayed. Had special balloon at 7 with explosice charge which went off at 35,000 ft an 745 but by that time the receiver had lost the signal. Followed by radiosonde series u after 1300. Cloudcroft off at 8 and doubtful about signals received.

Peoples and Trakowski up 4 July with Dr. O'Day of CFS to Alamo Tower ---- ? Solar Ob vatory the SCEL station. Schneider up with O'Day to check use as NYU station.

Alamoggrdo crew helped get helium, and did ground shooting of 2 July. Out July 3 at and Launching sites at 2 pm and later at night.

Finished identification on Flights 28, 29 and 30 on east coast and made plans for Be flights.

Unable to leave for home on 3 July as was planned and wired Donnie first part of wee if he could change his schedule and go home folloeing week. Got wire back that he had decided not to make the trip.

July 6(Sun). Worked at office on flights and rocket data. Started on plans for speech 1 meeting NYU - Getting ready for Flight 11. Plans are to put up Smith balloon with GM plasties + simple met balloon sonobuoy + balloon bomb.

July 7 (Mon) Alamogordo. Balloon Flight 11 A off at 0503. Big plastic with small auxil plastics. WL gear - radiosonde and dribbler. Followed with theodolite and receiver unt about 11. Picked up on radiosonde receiver at Roswell and followed then. Finally came d (at 10,000 ' cap should have punctured plastic) near Hwy 70 between Roswell and Tularo Second balloon - met balloons with radio sonde up about 630. Third balloon with 2 1/2 stick TNTand caps set by pressure element to fire at 35,000' up at 0630. Surface bombi at Site 4 from 545 to 845 at 15 min intervals. Ireland followed main receiver only abou 3/4 hr but followed radio sonde about 3 hrs. 35,000' explosion off about 655.

Vivian got all instructions for completing work on Flights 1-30 and picked all recorc and filed. Sent off TWX re Bermuda Flight and wrote up memo on it. Worked with Eileen

April 1 rocket plotting H-SS, H-T, SS-T.
July 8(Tues) Alamogordo. C-54 off about 1030 with 23 people - all NYU, WL including /, Godbee. Lt Thompson, Edmondson, Reynolds and myself left. Wote up report on East Coast Flights for Peoples.
July 9(Wed) Alamogordo. Worked today on balloon flights. Studied WL records of them bri and wrote a memorandum to Peoples about results. Left in car this PM late. Flat tire be Roswell and Tularosa and stayed there.
July 10 Thurs. Changed tire and went into Roswell. Bought new tire. On to El Reno, Okla today. Stopped in cafe in Hereford, Texas and met Dannie Harns from UGC. Went up to off and saw Bob Cowder?, PC and Gene Conant, supervisor.
July 11 Fri. From El Rosa to Cherokee. Got note at Cherokee that Jimmie was at Tonkawa a went over there. Stayed tonight with J & family.
July 12 Sat. Jim, Pat , Vanessa along with me on way home. Got to Doolittle, Ark tonigh
July 13 Sun. to cabins in Ohio just out of Springfield.
July 14 Mon. To cabins near Geneva, N.Y.
July 15 Tues. Stopped at Syracuse. Got home about 230. Marion & her baby there.
July 16, 17, 18 At home. Drew in 4 or 5 loads of hay but land very wet and rains intermittently.
July 19 Sat. Marion and I left in Chrysler for Woods Hole to see Dorothy & family. Throu Albany, Springfield, Providence. 463 miles 12 hours. Doc Ewing on Atlantic cruise. Worze working on gravity at sea. Saw Geo Woollard and the Ryders. Woollard after Guggenheim fellowship for next year - positions at WHOI and Princeton are ? very satisfactory.
July 20 Sun. Saw men working with Worzel at WHOI, Pollak, went over to Vine's new house, Kit and Bump at their house, then out to Ewings, saw Midge & children, Anne and Mikey.
July 21 Mon. Went down to WHOI, saw Pollak, Bumpus, Worthington. Up 3rd floor and saw Em of NYU, who is finishing up some research work there under Ray Montgomery. Talked with C umbus Iselin for short time. Saw Gil Oakley. Marion & I left about 11 am. Went through Providence, Hartford. Crossed river at Hudson. Met rain last part of trip, not home unt 130. Jim & family spent weekend with Steve and Esther in Syracuse.
July 22,23,24 At home. Drew in a little more hay from lot in front of barn but still rai ing quite often. Jimmie & family took Thursday PM train to Syracuse to catch tomorrow's plane to Wichita, Kansas.
July 25, 26,27 At hôme. Steve and Esther came up Sat night. Marion and I went to Waterto to pick them up at bus station at midnight. They left again Sun pm on bus from Canton. Ch Crary up from Canton Sunday PM
July 28,29,30,31,Aug 1. At home. Chrysle to Canton, change plugs, reline wheels - Rainec hard first part of week then clear. Got in lots in back of barn, north of road and front house.
Aug 2 Sat. Marion - Bunny and I left 1230 PM, arrived Marcellus about 5 PM. Ate dinner wi Steve and Esther, left Marcellus 730 PM. Through Binghamton, Scranton, Stroudsburg, Easto Arrived in Newtown about 245 am.
Aug 3 Sun. In Newton with Flaggs for dinner. Left Newtown about 5 PM. Arrived Jersey Coas Got room on Hwy 35 near White Bite Shop.
Aug 4 Mon. Up to Oakhurst. Went over developments to date with Jim Peoples. Out to lunch Lt Ball. This PM Chantz and I surveyed to Sonobuoy site.
Aug 5 Tues. Oakhurst. Worked on Aberdeen results - 2 failures - 1 direct wave. - Worked o Bermuda run # 2 - Oakhurst and started Bermuda #2 C.N.C.H., Peoples on vacation startin today.
Aug 6, 7, 8 Wed, Thurs, Fri. Oakhurst. Worked on Cruises 1 -28 with Vivian and Epstein. Checked over all recordings of Bermuda #2, Flight 32. Got sonobuoy survey calculated and worked up results of Flight 25 B which depended on sonobuoy signal. Started Epstein on we ther data which Wiggett is working on. Wrote letter to Emmons with remaining work to be done there. Conference Wed pm with Clowry, Carroll, Dubell, Bernhoff of Olmsted regardin Bermuda and Alamogordo plans. Mr Mears put up balloons with equipment on here at Oakhurst Reynolds and Edmondson in and working around lab. Worked some with Eileen on rockets.
Aug 9,10 Asbury Park
Aug 11, 12,13,14,15,16 Oakhurst. Wrote memo regarding Alaskan work and had copies typed up Worked most of week on rockets. Plotted altitude against time of origin for April 1, 8 rockets but did not get identical graphs. Tried to vary distance to obtain similiar curves but this was not possible. Made plots of time vs SS and altitude vs SS in effort to correlate signals between stations. Correlated fairly good on 1 April but poor on 8 April.

18

Appendix 18

New York University
Progress Report [No. 7]
Constant Level Balloon, Section II
July 1947

PROGRESS REPORT

Covering Period from June 1, 1947 to
June 31, 1947

CONSTANT LEVEL BALLOON

Section II

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 S. Schneider

Approved by
Professor Athelstan F. Spilhaus
Director of Research

Research Division
College of Engineering
July, 1947

II. ABSTRACT

The first successful, though nominal, constant level flight was made in a series of launchings at Alamogordo, New Mexico. Navy permission was given for New York University to purchase the Navy-sponsored polyethylene balloons from General Mills. This opens up the first source of large, light-weight plastic balloons. First delivery was made on the subcontract with H. A. Smith Coatings, Inc. for the 15-foot diameter heavy polyethylene balloons. Improved type ballast reservoir was designed and procurement started. Equipment was prepared for a second series of flights at Alamogordo in July.

III. a. PERSONNEL

The following men were hired:

Name	Duties	Qualifications
Dorion, Richard	Navigator, Draftsman	Former B-17 Radar Navigator. Undergraduate Mechanical Engineering Student.
Higgins, Robert L.	Equipment Construction	Undergraduate Mechanical Engineering Student. Army Instrument Mechanic at Oak Ridge.
Morrell, Paul	Equipment Construction	Undergraduate Engineering Student. Merchant Marine Engineer.

ADMINISTRATIVE ACTION

Clearance was obtained from the U. S. Navy for the purchase of plastic balloons from General Mills, Inc., Minneapolis, Minnesota.

b. COMMUNICATIONS

(1) Correspondence during this period was as follows:

Date of Correspondence	Address	Abstract	Answer
6/16/47	Mr. A. P. Crary, Watson Labs., AMC, Alamogordo AAF, N.M.	Forwarding check for equipment recovery reward	None required

Date of Corres- pondence	Address	Abstract	Answer
6/16/47	Mr. F. M. Cooper 959 Whittier Ave. Akron 2, Ohio	Specification of large balloon sent and appointment requested to discuss manufacture	Considering problem before mailing bid.
6/19/47	Contracting Officer, Watson Laboratories Red Bank, N. J.	Enclosing copies of Special Report #1	None required.
6/19/47	Mr. Douglas Rigney Watson Laboratories Red Bank, N. J.	Request for additional Army weather equipment	Being procured.
6/23/47	Chief of U. S. Weather Bureau Washington 25, D. C. Att: Mr. B. C. Haynes	Request for Big Springs radiosonde station to monitor Alamogordo flights	Active cooperation received.
6/23/47	Kollsman Instrument Div. Square D Company Elmhurst, N. Y. Att: Mr. Paul Goudy	Order to modify dribble mounting and rate of flow.	Complied with.
6/24/47	WIRE Mr. O. C. Winzen General Mills Minneapolis, Minn.	Request 7 foot balloons have means of attaching shroud lines to carry load.	Complied with.
6/26/47	Mr. O. C. Winzen General Mills Minneapolis, Minn.	Order to ship remaining 7-foot balloons to El Paso. Request for estimate on ballast gripping devices.	Complied with. General Mills awaiting ballast - sample.

(2) **Conferences**

The following conferences were held during the month of June:

Date	People Present	Where Held	Discussed	Conclusions
6/12/47	H. A. Smith, Messrs. Schneider, Moore	New York University	Manufacture of Poly-ethylene balloons for this project.	2 each 15 ft. dia-meter balloons would be completed by 1 July.
6/13/47	Dr. Peoples, Messrs. Ireland, Mears, of Watson Laboratories, Messrs, Schneider, Moore, J. R. Smith, Hackman of N.Y.U.	Watson Laboratories Red Bank, N. J.	Results of Alamogordo flights	Communications will be improved, next flight's set-up accomplished.
6/17/47	Mr. Paul Goudy, C. B. Moore	Kollsman Instrument Co.	Modification of the Ballast valve	
6/20/47	H. A. Smith, Messrs. Moore, J. R. Smith	New York University	Different types of solid ballast	Granular lead is better than sand or various powders.
6/23/47	Mr. Gordon Vaeth, Commander G. W. Hoover, J. R. Smith, C. B. Moore	Sands Point Office of Naval Research, Port Washington, L. I., N. Y.	Request for clearance on General Mills Bal-loons. Request f r Lt. H. F. Smith (USNR) to accompany project to Alamogordo.	Granted.

1151

A

c. 1. GENERAL WORK ACCOMPLISHED

Field tests were conducted at Alamogordo Army Air Base during the week of June 1, using clusters of meteorological balloons. The primary object of these tests was to perfect handling and launching techniques for large flights and to check the operation of the various altitude controlling devices developed for this project. At the same time, the tests afforded the opportunity to carry aloft payloads of Watson Laboratories equipment. In general, while the flights were successful in the sense of carrying Watson Laboratory gear aloft for an extended period of time, difficulties and materiel failures encountered served to emphasize the unsatisfactory characteristics of meteorological balloon clusters. A technical report under preparation will contain discussion of the flights.

After the return from Alamogordo, the remainder of the month was occupied with preparations for a second field trip to Alamogordo Army Air Base for tests to be conducted in July.

Twenty-five seven-foot diameter 1 mil. thick polyethylene balloons were received from General Mills. One each fifteen-foot diameter 8 mil. thick polyethylene balloons was received from H. A. Smith, Inc.

A seven-man balloon crew departed for Alamogordo Army Air Base on June 27 to make the second series of launchings there.

The plastic ballast reservoir used for the first flights in New Mexico was too fragile to take launching stresses. An aluminum reservoir, mounted on legs containing a built-in filter was designed and a supplier was located. The capacity of the new reservoir is 5 gallons (30#) though it will weigh only 2 pounds. It is believed that the aluminum reservoirs if recovered may be used repeatedly.

2. Specific Problems

The greatest problem encountered during the field tests at Alamogordo was the unpredictable and highly variable effect of superheat on meteorological balloons. The unpredictable increase in lift of the cluster under the rays of the sun was as much as 25% higher than the initial lift. This in several instances resulted in the inability of altitude control balloon cut-offs to stop the ascent of the balloon train at the desired altitude.

The extreme low temperatures encountered at high altitudes apparently has considerable effect on the operation of electrial equipment used in altitude control.

In several cases squibs used for altitude control failed to fire at extremely high altitudes. It is believed that placing a small load on batteries may help keep cells warm enough to produce the necessary voltage at high altitude on future flights.

3. Limitations

The greatest factor hindering the progress of work is still the lack of available space at New York University.

d. METHODS OF ATTACK

Field tests at Alamogordo indicated that a Helios-type cluster is much superior to a long cosmic-ray type flying line in case of fabrication, handling and launching when it is necessary to use clusters. Therefore, this type of cluster where the balloons are all at the same level, will be used on all future multiple balloon flights.

Large plastic balloons have been obtained and will be flown at Alamogordo during the tests to be conducted in July.

e. APPARATUS AND EQUIPMENT

The main sand ballast-dropping device was improved as a result of experiments at Alamogordo by constructing the ballast tubes of aluminum rather than plastic, and by using stronger paper diaphragms as the frangible support for the ballast.

f. CONCLUSIONS AND RECOMMENDATIONS

Opinion has been strengthened that clusters of meteorological balloons will never be a satisfactory method of achieving constant altitude for long period flights. Various factors which weigh against the success of such flights are: the inherent vertical instability of extensible balloons; the rapid deterioration of neoprene under the rays of the sun (average 6 hour life); the complex set of ballast and lifting equipment required; the variable and indeterminate effects of superheat; and the difficulty of launching a long train assembly, even under the best conditions.

In general, equipment must be strengthened and higher safety factors must be used to withstand the strains of launching and the oscillations of the balloon train in flight.

One or more observation posts, downwind, are needed for Alamogordo releases; each post should have theodolite and radiosonde observers and equipment. Better communications between, and coordination of observation posts is vital for satisfactory tracking of balloons in flight. Aerial observation of the balloons greatly assists interpretation of performance data. Better radio transmission of data is needed from the balloon.

IV. FUTURE WORK

Plastic balloons have been obtained from both General Mills and H. A. Smith, Inc. and will be flown on the next field trip to Alamogordo in July. Arrangements have been completed to obtain as large a supply as is necessary of these balloons and tests will be conducted frequently to perfect a technique of maintaining a balloon at nominal constant altitude.

19

Appendix 19

New York University
Progress Report #4

Rpt 3 (i.e. 4)

COLLEGE OF ENGINEERING
NEW YORK UNIVERSITY

REPORT BY THE
ENGINEERING RESEARCH DIVISION

PROGRESS REPORT NO. 4

Covering Period from March 1, 1947 to March 31, 1947

RADIO TRANSMITTING, RECEIVING AND RECORDING SYSTEM FOR 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

Prof. Philip Greenstein
Project Director
Department of Electrical Engineering

Approved by Renato Contini

Renato Contini
Acting Director of Research

Research Division
College of Engineering
April 2, 1947

ABSTRACT

During the period covered by this report, work was continued on developing an FM transmitter. Tests were made on FM Radio Receiver R-2a/ARR-3 and Radio Transmitter T-1B/CRT-1 to determine their performance characteristics, and compare the results with the transmitter system under development.

Necessary field equipment was constructed and an antenna was erected in preparation for field testing of the completed AM transmitter. A duplicate model of the AM transmitter was constructed and built into a container with a battery pack and simulated signal circuit.

II. a. PERSONNEL AND ADMINISTRATION

No change

b. COMMUNICATIONS

None

c. GENERAL WORK UNDERTAKEN DURING THIS PERIOD

It was called to our attention by the Watson Laboratories, Oakhurst Field Station, that the FM radio transmitter T 1-b/CRT, which is a unit of Sonobuoy equipment AN/CRT-1, might have application in this project. Five of these transmitters were purchased from a surplus radio supply house. These units were tested for frequency stability under conditions of variation in plate and filament voltages. Deviation measurements were made at several values of plate voltage. These tests indicated that this transmitter would probably be unsatisfactory without a system of automatic frequency control. The receiver used with transmitter, R-2a/ARR-3, has an a.f.c. circuit incorporated. A receiver of this type was borrowed from the Oakhurst Field Station. Tests were conducted to determine the overall frequency drift which could be tolerated in the transmitter before returning became necessary. It was observed that as great as a ± 0.35 mc shift could be tolerated at the transmitter. Further tests on the transmitter showed that the frequency deviation varied with input plate voltage and that as the battery depreciated, an error would be introduced in any amplitude measurement. For a plate voltage change from 135 to 90 volts, a variation in detected amplitude of over 20% was observed.

Further tests on the FM transmitter being devéoped at this laboratory showed that the deviation was likewise a function of the applied plate supply voltage. This problem will have to be solved by improved circuit design before a suitable FM transmitter can be evolved.

In addition to the AM transmitter model already constructed, a second unit was built. This duplicate was installed in a cardboard container which also houses the storage battery supply and a blocking oscillator to supply an audio-frequency which modulates the carrier at 30 c.p.s. Plans and arrangements were made for testing this unit on a captive balloon.

d. APPARATUS

A battery box containing a metered circuit for constant monitoring of transmitter currents were constructed for field or blimp transmission tests.

An antenna approximately 150 ft. in length was erected on poles twenty feet above the roof of the Electrical Engineering Building for use in receiving signals during test flights.

e. FUTURE WORK

In view of the excellent characteristics of the automatic frequency control of the Radio Receiver R-2a/ARR-3, an attempt will be made to secure the circuit diagram of this equipment and employ its use in any FM receiver which might be used.

Further circuit investigation will be carried out to develop an FM transmitter which is free of the undesirable effects introduced by input voltage variations.

Field tests will be carried out on the AM transmitter using a tethered balloon and a blimp, if available. It is desired to obtain information about the operating range and difficulties which might develop with this transmitter.

Philip Greenstein
Philip Greenstein
Project Director

20

Appendix 20

Interview
Col Jeffrey Butler and
1st Lt James McAndrew with
Professor Charles B. Moore
June 8, 1994

Transcript from 8 June 94, Interview with
Professor Charles Moore

(A) Professor Charles Moore
Project Engineer - Project Mogul
(Q) Colonel Jeff Butler
(Q) Lieutenant Jim McAndrew
8 June 1994

A: ...Dr. Spilhaus, who you may have met, was really the Director of the project.

Q: We talked with him last week. He sends you his regards. He's a very interesting man to chat with.

A: But I was essentially the project engineer and a graduate student, whereas he was Director of Research at New York University at that time.

Q: We have gone through many of the various technical documents related to Project Mogul and some of the other work that you and Dr. Spilhaus and others have done with the Constant Altitude balloon projects. According to Dr. Spilhaus, he said you would be the technical expert as it related to those types of projects in terms of the materials involved, the instrumentation, that sort of thing. Is that a pretty accurate statement?

A: I think that's correct.

Q: What we're really here for is to discuss this that came out in the newspaper and the General Accounting Office's investigation of how we deal with records, the acquisition, and ultimately disposition. There is an allegation that the Government is involved in a conspiracy and coverup of something that occurred in 1947, which is the allegation of their being some sort of flying disk, flying saucer, UFO, what have you.

A: That's correct.

Q: Of course the people who put out things such as this journal, MUFON, Mutual UFO Network, the books that have been written by William Moore, and Randall Schmidt, and others, a lot of the popular television shows, they've just exacerbated the situation where a lot of things, quotations, some of your quotations taken out of context. One of the individuals, Sheridan Cavitt, who at that time was a Counter-Intelligence Corps officer at [Roswell] Army Airfield who actually went out with Jesse Marcel to recover some material that has been alleged to be the results of a UFO which Colonel Cavitt specifically states looked like a weather balloon to him.

A: I'm aware that he had been there, but I'd understood that other quotations had been attributed to him.

Q: Yes, sir. As we go through this, I believe I've got a copy of essentially a statement he made to Colonel Weaver, whom you've talked with also. Colonel Weaver talked with Sheridan Cavitt two weeks ago. So a lot of the statements that have been attributed to Sheridan Cavitt, he says they're taken out of context. He refutes a lot of the information that appears in these various books.

What I'd like to do, even though this is out of a popular UFO type of magazine, is there are some statements attributed to individuals concerning the material that was found, supposedly by Mac Brazel, somewhere northwest of Roswell, New Mexico. They talk in terms of materials that look like metallic foil, and specifically that "could not be bent or broken."

As we've gone through the various research, what we believe to be Project Mogul was probably involved in this incident. The materials that were being used in Mogul included, of course, not only the polyethylene balloons, but included the neoprene balloons at some point, the various types of radar reflectors, the instrumentation that was being used. Is there any type of material from that project that you can think of that would be pliable, would be bendable, but could not be torn? Could any of the polyethylene or the foil-like radar reflectors, could that be the case?

A: Let me get a picture for you. This is a radar reflector manufactured in 1953. It's the ML-307C.

Q: Which is a little different from the B model that was used in 1947?

A: Where this looks like a pine stick, the material on the ones we had, this was all balsa and somewhat smaller in diameter, but the configuration, with one exception... This configuration of corners, these corners were the same thing. Here's a picture of this sort of target being used in 1948, and you can see we are launching multiple targets beneath this balloon.

Q: Is this the same type of target as this, or is this the B model?

A: This is the B model we flew in 1947 and 1948. Those are pictures of the B model. If you look, faintly along here you can see a sort of a discoloration, and that's where my memory of the reinforcing tape was that they talked about. The B models, as I remember, did not have these three vanes up here. You don't see particularly any suggestion in other photographs I have, I don't remember these which would make the thing rotate in flight.

But this, in the B models was more like an aluminum foil with a heavy laminated paper. So the material they talk about, I think, was derived from some version of this.

Q: They talk in terms of the material, being able to crumple it and releasing it, and it would unfold by itself and not leave any creases. This material looks like it would almost be like aluminum foil, would crease and remain creased.

A: It does have this paper laminate, and the paper, I think, was maybe a bit tougher on the earlier thing. But I have no explanation for the fact that it couldn't be bent with a sledge hammer, as one of the people said, and couldn't be...

Q: Burned?

A: I think some of the balsa wood was dipped in something like Elmer's glue, and as a result had some sort of a glue coating on it which would make it somewhat resistant to burning.

Q: I know in Colonel Weaver's discussions with Sheridan Cavitt, they talked about the aspect of burning. He did not recall burning anything, but then his wife indicated that there had been one night they'd been out and had a barbecue and had a few beers and that Jesse Marcel just took a piece and stuck it in the barbecue and then pulled it back out. So if that's what they're using to say it wouldn't burn, that's what we consider typically testing a material for burning or not.

A: I need to say here, you need to qualify everything I say with the memory of almost 50 years ago. I will say things that are to the best of my memory, but on the other hand, should other evidence indicate my memory is faulty, I readily accept that. So I'll state things to the best of my memory, but...

I have a memory that there was something like Elmer's glue... There was a problem in attaching this to the paper behind.

Q: Going back to the reinforcing tape and things, there were discussions concerning unusual symbols and almost like hieroglyphics -- purple, pinkish in nature, that sort of thing.

A: I don't know if I sent Colonel Weaver a copy of the sketch.

Q: No, we did not see that.

A: Robert Todd, who has been a person very interested in trying to get to the truth of this, asked me to make a sketch of what I remember. A couple of years ago, or a year or so ago, I made this sketch, and this is my memory of what was there.

I do remember every time I prepared one of these targets for flight, I always wondered why these figures were on the tape. There was always a question of why they were there. When this purplish-pink marking on the debris came up, I immediately remembered this sort of marking. Other people, I have a letter here from one of my technicians, who says oddly he remembers the same marking. You, perhaps, have talked to Albert Trakowski...

Q: We have tried to reach Colonel Trakowski, and he has not returned our calls. We've left messages on his answering machine, and there's been no response.

A: He may be out of town. I did visit him last October, and he made the point that... He was our project officer. He and I served together under Colonel Duffy in the Air Force Liaison Office in 1943 to... Well, I went overseas in '44 but Trakowski stayed and took a commission in the Air Force when it was offered and was the project officer on Mogul. I have some paperwork here from General LeMay's files in which after the war a number of people were to be sent overseas because they had not had overseas duty. There is a history of Colonel Trakowski. Perhaps you have it from the Pentagon files already, from the AG files.

Q: We have some records, yes.

A: Anyway, Albert Trakowski was the Watson Laboratory project officer on this. When I raised this question to him he said he had talked to John Peterson, one of Colonel Duffy's procurement men, and they were joking about these markings on the tape. I have a letter that I can give you a copy of in which I quote Trakowski in saying, "What do you expect when you have your targets made by a toy factory in Manhattan?"

Q: So essentially, the original targets were made by a toy company?

A: Well, it's either a toy company or a garment manufacturer in the garment district in Manhattan, or it was by a novelty company. I talked to Ed Istvan who was another one of the Air Force liaison office people who stayed in. Istvan lives in your area. I can give you documentation on these things. Istvan says that it was some outfit that extruded toothpaste tubes and he got involved with them because they made radar chaff. In the early days of this effort, there were a number of different targets made. I don't have them here, I have them downstairs, there were a number of different forms the targets were made. One idea was just the inside of a meteorological balloon, to put radar chaff and adhere it with glycerine. Just wet the inside of the balloon with glycerine and then shake in dipoles cut to the proper half wave length. When the balloons were inflated, these would be all on the inside, coating the inside of the balloon. This didn't give nearly the sort of target that the corner reflector gave.

But anyway, Istvan initially went to New York hunting for a source of supply and came across a company.

(Pause)

A: ...much of which we can copy and make it easier for you. These are balloon fragments, things that held balloons [up] after they'd been exposed to the sun.

Q: Is this the neoprene type or the...

A: That's the neoprene type. I have the polyethylene type...

Q: Is this from the '47 era?

A: That's a balloon probably from the '50s. That's a K-San balloon. The kind of balloons we used then were the (inaudible) derricks balloons, and that's the way they look after they've been out in the sun. That's about three weeks' exposure to sunlight here in New Mexico.

Q: So the polyethylene really is degraded by sunlight.

A: That's neoprene. All that's neoprene.

Q: This almost looks like ashes of paper.

A: That's right. And there's a big point in some of the recovery that the material was black...

Here is the list of the people who were assigned under Colonel Duffy in the Air Force liaison office. Istvan's name you'll find in there. He ended up being in the Titan program and, I think, retired as a lieutenant colonel maybe back in the '70s.

Schneider was the administrative director of our project. He and I worked together. He was in Maine, and was not really technically involved. I have letters from him if you're interested in seeing them. He says he has no memory of this.

A person who was heavily involved in developing this whole radar thing was Colonel Joe Fletcher. I wrote him a letter asking for his help and he essentially says he doesn't remember much.

Q: He's also been hounded by some of these UFO...

A: And by Todd and by me.

Q: So it appears as though you, yourself, have done some extensive research into this particular incident.

A: Until two years ago, I was quite convinced one of our polyethylene balloons we didn't recover caused it. Then I got this newspaper, Todd sent me this, and I immediately saw there's no way that could be a polyethylene balloon.

Q: W.W. Brazel mentions eyelets which appear in the reflectors. There's also, on the polyethylene balloons, the shroud however you had it hooked on there. There's eyelets around the base. There was a ring at the neck of the balloon and then there were attach points to that ring, were there not?

A: But there were no eyelets.

Q: I believe there were. I've reviewed the New York University documents and there's a very clear depiction in one of them of eyelets.

A: Okay, I was thinking of the later... Here are the NYU reports, the originals of them.

Q: In one of the configurations they clearly show eyelets in the drawing.

Q: Going back to Brazel, you state that you think it could not be one of the polyethylene balloons. He indicates in this newspaper article that he actually found the debris in mid-June, however it didn't subsequently come out until July.

A: You're right. That is in one of the polyethylene balloons, you're correct. I fall back on my plea that my memory isn't...

Q: It comes into depending on what Brazel was speaking about.

A: There are clearly eyelets here. In fact there's a little swivel.

He talks about the smoky gray rubber...

Q: Which these samples here, as you say, if they'd only been out for a short time, a matter of days, smoky gray, that's a very good description of what they looked like.

A: And when you first retrieve it has a bad odor. And people talked about there being a burned odor.

We need to talk about these neoprene balloons because they came in different... There were two manufacturers -- one, Dewey & Olney in Cambridge manufactured with a dip process and they had very much the appearance, if you will, of a condom. They were an ivory colored jell. The Kaysam company in Patterson made a cast neoprene emulsion into a mold, and then they inflated the mold. They had to put a lot of plasticizers so they could take this wet jell and inflate it and make it into a meteorologic balloon. This is a Kaysam balloon here, which I think is not a good candidate.

Q: Kaysam?

A: A guy named Sam Kay formed a company and it was called Kaysam. In fact I have, and you're welcome to them...

(Pause)

A: Kaysam balloons because of the way they were made, and this jell that had to be inflated had this ring, cardboard ring put in them. That's the neck of a Kaysam balloon, and here are more modern Kaysam balloons, the sort that are still being flown.

Q: These are just used for the typical meteorological type balloons.

A: Carry radio (inaudible), that's correct.

Dewey & Olney have gone out of the business and Kaysam bought them out. Here's a Kaysam balloon that is made by a dip mold. This is somewhat indicative, I think, of the way one of those balloons of the type we're using. As you can see on exposure just to ordinary light, they discolor. But these are balloons that were made probably in the '70s. As they change with plasticizer and anti-oxidants for ozone, they certainly change in appearance. The balloons we...

I have pictures here, pictures in the hangar. There, as you can see, these are the ivory colored balloons of the sort we were flying. This is the balloon you just found the eyelets on in the hangar. These are pictures from the 1947 era where we're getting ready to fly the 15 foot H.A. Smith balloon.

Q: The reinforcing tape on these balloons, these polyethylene balloons, we were told is a type of acetate. It had none of this symbology, is that correct?

A: None at all.

Q: So the symbology on the tape was only related to the radar reflectors.

A: That's correct. Here is a later model polyethylene balloon, and it's a little thinner than the ones we were flying, but there's a polyethylene balloon.

Q: It looks like polyethylene sheeting that I would use to cover up...

Q: I've also heard the early balloons described as carrot bag quality. Material they would use in a carrot bag. Dry cleaner bags.

Q: Dry cleaner bags. We think of them as being very fragile, but materials from this time frame have been described as durable -- something you couldn't tear with your hands.

A: That's about two mil polyethylene here.

Q: Obviously, you could tear this.

A: This was four mil. These balloons that we had... That's Flight 8. These are the little balloons here that are seen from the air.

Q: From a B-17?

A: I think this was a C-45. We did, indeed, have B-17's attached to us, and C-54's. But I think this was trying to chase Flight 8 down. This was one of the candidate flights that I thought might have been, until two years ago, I thought might have been an explanation for what occurred.

Q: Why did you change your mind at that point?

A: Because of that newspaper report right there.

Q: Because of him saying that he actually found the material in mid-June?

A: No, because he said it was balsa sticks and smoky rubber and had those curious markings on that. That's a very vivid memory I have of these markings on the radar targets we flew.

Q: You said you often wondered why those markings were on there. Had you ever resolved that for yourself?

A: Only what Albert Trakowski told me, that our friend John Peterson, the procurement man, was just joking, "What else do you expect when you have your targets made by a toy factory?"

Let me go back, if I may. Colonel Duffy was assigned to extract meteorological equipment out of the Signal Corps in 1943. There was a great argument that went on between the Army Air Force and the Signal Corps. The Signal Corps didn't want to let any meteorological equipment out until he thought it was perfect. At the same time, General Arnold was expanding for a global war, and was trying to get meteorological equipment all around the earth. So Colonel Duffy got assigned to expedite the equipment. As various of us graduated from the meteorological cadet schools, he took those of us with engineering backgrounds and assigned us to bird dog various things within the Signal Corps engineering laboratories. I got assigned to... I ended up with some appendicitis and got pulled off of an overseas shipment, and while I was recovering I got assigned to prepare this manual that Colonel Duffy, he was unhappy with the rate at which Signal manuals were coming out so he wanted a loose leaf arrangement to send things out. So I got assigned to prepare this manual.

At the same time, then Captain Fletcher was assigned... Duffy had heard that weather was giving trouble to radar, so Colonel Duffy just turned around and said, "Gee, you mean radar can pick up weather?" And ended up with Captain Fletcher being assigned to both convert this for looking at storm clouds and also to make wind measurements. There was a big problem, the Weather Bureau prior to World War II determined upper winds merely by releasing a pilot balloon, following with the (inaudible), and estimating the rate of rise, and then from the elevation and azimuth angles and the assumed height after a certain time, to calculate what the winds were.

Q: Is that the Boford Scale?

A: Well, Boford was Navy, that was the Navy...

Q: Like taking a Pi Ball reading now.

A: Exactly. It was called a Pi Ball then and it is now. Colonel Duffy pushed very heavily to get electronic means for measuring winds aloft. There were two approaches. One, use a radar target, and the SCR-584 with which you may be familiar -- the early gun-laying radar. Colonel Duffy talked to the field artillery that was procuring through the Signal Corps, gun-laying radar, the SCR-584, which is, that's this radar right here.

Q: We've seen that photo before.

A: This is Spilhaus's book. So Fletcher ended up with a whole bunch of his own 2nd lieutenants around. There was a Jud Tibbett from whom I have a photograph showing an earlier model target, the A Model target. Istvan was one. There are a bunch of them listed. This listing is for you if you'd like to have it.

Tibbetts ended up being the big installer of radar and, in fact, was assigned down to the Tulerosa Range Camp to make wind measurements for the Trinity shot, the test in 1945. As far as I know, that was the first time these targets had been used in New Mexico. Tibbetts, who until recently lived in Albuquerque, he's now moved to Scottsdale, Arizona. Tibbetts says that he did not ever fly this kind of target in New Mexico, which will be of interest with you when they talk about, that people should have known what a target looked like.

Q: Right. There were discussions concerning having radar targets, but supposedly the B Model and subsequent models were brand new, had never flown anything like that in this area.

A: According to Tibbetts, the A Model had bit aerodynamic drag. It was a flat plane of aluminum foil and had two triangles coming down that made a corner reflector. The A Model looked like... Then across here was that. This is one surface, this is another surface, and this is yet another, and they were held by strings from these four corners. Obviously, trying to take something that's almost a meter in cross section, a meter on a side, take it sideways up through, gave a lot of drag, and it took a lot of lift to make the balloons rise very rapidly.

So instead, somebody came up with this smart idea of this other arrangement of a corner reflector that had much less drag. These, according to Tibbetts, weren't distributed until something like November of 1945. As far as I know, as you will see in the various correspondence, there were no SCR-584s which were required to track them, issued to the weather services here in New Mexico. Obviously, after the Trinity shot, there was no bit military operation that required wind determination in New Mexico.

Q: So essentially you'd say there were no radar reflectors in New Mexico until 1947 until this appeared?

A: That's my opinion.

Q: Was Major Pritchard doing any kind of balloon project?

A: No. He and Dyvad and others were at Watson Laboratories. I understand from Trakowski that Alamagordo Army Air Field was about to be closed down as surplus. The people at Watson Laboratories seized on it and were able to keep it on active status for two projects -- one, the radar project from Watson Laboratories that was set to track the V-2 being flown from the proving ground across the Tulerosa Valley; and Project Mogul.

I joined the NYU group in January of '47, and while I was finishing up at Georgia Tech I had talked to my chemical engineering professors, I'd already been recruited by Duffy and Spilhaus, and I asked if you wanted to make a balloon of non-extensible material, what plastic would you use. My professor named Grubb told me you ought to consider polyethylene. It's a new plastic just now becoming available. You can heat seal it. It has a lot of desirable properties.

So as soon as I got to NYU, I began talking to everybody I could find in Manhattan -- DuPont, all the sales offices...

Q: We saw your listing.

A: I was concerned with where we could get the plastic and who we could get to manufacture the balloons. I was in my 20's, just a recent graduate. I knew nothing about manufacturing. But we did try to get a manufacturing company that would fabricate balloons for us.

During that period we heard of the Navy project that was going on at General Mills where Jean Get was planning to make a flight to 100,000 feet. General Mills at that time was making balloons out of a Goodyear film called pliofilm. It was a vinyl chloride that just went to hell when exposed to sunlight. It really came apart. So I'm very proud that we began pushing them for polyethylene balloons. With some difficulty we got Otto Winzen who was the entrepreneur and promoter, working with Get, and we got him to make these balloons you see here in the design that was being planned for Project Helios, with the pliofilm balloons. At the same time we got an entrepreneur who was even faster acting, and that was this fellow A.J. Smith. A one-man shop. He would do anything for money. He, indeed, did. With no great technical background, he made a number of these balloons for us.

Q: Kind of a garage type of affair where he would sit down and make them one by one and...

A: I don't know. He got some girls and got some assembly workers, for a contract from us. Anyway, we got these balloons going, made visits to Minneapolis to push General Mills. The pressure from the Air Force was enormous. There was a similar problem, of course, in developing microphones that would pick up low frequency sound waves with Columbia. There was much enthusiasm, in testing these microphones.

Q: How did you come to join the Army Air Force?

A: When World War II broke out I applied for pilot training, and so did everybody else. Because I was a senior at Georgia Tech in a chemical engineering course with a fair amount of thermodynamics and other things, I got diverted into the meteorological cadet program. I still wanted to be a pilot but I got diverted into the meteorological cadet program, and the next class that I could join didn't start until December of '42. I joined up sometime in '42. So I went through the meteorological cadet program and found I was a lousy forecaster, but I did end up, when Spilhaus came recruiting for people with engineering background, I got recruited into Colonel Duffy's liaison office.

Q: Was that directly for General Arnold's staff?

A: I was assigned, believe it or not, to Headquarters, Air Force... I still have the Headquarters Air Force [rondelles]. I ended up being assigned to Headquarters, Army Air Force. I was a second lieutenant.

Q: So you got recruited by, at that time, Captain Spilhaus.

A: Right, and I got sent to the Weather Equipment Technician School in Spring Lake, New Jersey, essentially Fort Monmouth. When I finished the training course for radiosonde and for maintenance of equipment, I was headed for North Africa, and I had a medical problem. When I got out of the hospital, I was assigned back to Colonel Duffy. I remained there. I finished this manual in '44. I was commissioned in September of '43, finally, and then finished the school in November, was assigned to write this manual which was finished in the summer of '44, and then I got an assignment to China.

Q: With Dr. Spilhaus?

A: No. I ended up being the weather equipment officer for CBI and the Spilhaus came over later. At that time the war was going very much better. Spilhaus and Duffy had a long range storm detection system, the spheric system, the predecessor of what's used now for lightning detection, the storm scopes, and the LLP. If you're familiar with LLP, the lightning location system...

Q: Used by the Weather Service.

A: We have one of the stations here on campus. And we actually have, if you're interested later on we'll go over and show you, we have a map of the lightning strokes over the entire U.S. as they occur. We have a read-out right here in our laboratory.

Q: So you're doing that work from China?

A: Spilhaus came over with the spherics net, it was called, and got a station installed in Chianting, China to work, of course, for the bombing of Japan. So Spilhaus came over I think the summer of '45 is when he came over. We had the radio wind, the ra-win, the SCR-658s, we had a number of them that were being installed. We had one up in Yunan in the communist area; we had several of them in China for getting good wind measurements. Spilhaus had been involved in that. I think by '45 it was clear that things would be over relatively soon. We thought we'd be back in '48. In any event, he got an assignment over to 10th Weather in the summer of '45 and came over.

Q: At what point did you ever hear the term long range detection?

A: That's a good question. I didn't know the name Mogul until Robert Todd told me two years ago. I'd never heard the name Mogul -- the classification was that high. I knew what we were doing. When "Helgoland" was exploded in April of '47, we had balloons in the air. We launched balloons out of the Watson Laboratory, actually Eatontown, what had been the Eatontown Signal Laboratory, but I think it was now Watson Laboratory. In any event, we launched a string of balloons, even though we didn't have [constant-level] balloons, we still carried microphones aloft and a C-54 orbited overhead and followed the balloons out to sea. I have no idea about the results that they got.

Q: Did you number that balloon flight?

A: No, we didn't.

Q: Not a letter or a number?

A: Wait a minute. The answer is, I don't know.

Q: If you did give it a letter or a number would it be on... There are some of these flights that appeared to have no sequence number and they were talking in terms of being service flights and the impression that we got was that the service flights were either test flights just to check the balloons out or they were the highly classified flights where the information was not being logged into essentially an unclassified document.

A: You notice that Flight 1 was made from Bethlehem, Pennsylvania.

Q: The football field there?

A: LeHigh, exactly. That's where we did it, from the football field. And we did this because a professor at NYU had just gone to head up the physics department at LeHigh and he invited us over. His name was Frank, Butler keeps coming to mind, but I'm not sure that's the right name. Anyway, we went there and that was for an early, early attempt for Helgoland. I think the Helgoland explosion got scrubbed, but we had balloons in the air from this and we were woefully not ready. We had all sorts of problems. We adopted the balloon technique that a cosmic ray investigator at NYU, a fellow named Sergei Korf, we adopted his technique and we had a lot to learn. We got our hands torn up with nylon line being pulled through it as we couldn't hold the balloons down in the wind...

Q: Speaking of nylon line, were these braided type lines or were they monofilament type lines?

A: Neither. I think initially we used either parachute cord, which was braided. I don't remember the details of what we used, but we rapidly used that the radiosonde cord we used was not strong enough at all to hold the forces that came, so we went to what was called lobster twine. We used a lot of lobster twine that was twisted, a laid line that was used in lobster nets.

Q: Do you recall there ever having been some sort of monofilament similar to the monofilament fishing line in any of the projects?

A: I think there was none available at that time. My memory, the answer is yes, we've used an awful lot of monofilament and we use it now all the time.

Q: But at that time you don't think it was available?

A: I think it was not available.

Q: The early nylon line, would it have degraded, such as the balloon material degraded, and maybe fused in the hot sun?

A: I doubt it. If we had any it would have been white, which would have been a high (inaudible), would not have absorbed a lot of sunlight.

Q: There were discussions about what appeared to be unbraided or unstranded fiber type lines. It's been alluded to that was the precursors to what we use for fiber optics today. The materials that were found. That's why I asked about the monofilament line.

A: A lot of what we used early was a linen cord, not twisted, and it was indeed, a brown, a dull brown color. But because it was designed just for radiosonde balloons, and we rapidly exceeded its strength. So very quickly, and I don't know when, but we very quickly went over to this twisted lobster twine.

To answer your question, there are three flights that are missing here -- two, three, and four. I've identified Flight 4. Flight 4 was a flight we made, and you don't have it there, but Flight 4 we made in Alamagordo something like June 2nd or 3rd of 1947. The reason I have it identified is I have Albert Crary's diary. The scientific end of the group was heavily based from Columbia University. It was Dr. James Peoples who was an employee of Watson Laboratory, and there was an Albert Crary who had been a graduate student under Dr. Ewing.

Q: Who later also was an employee of...

A: Who was then an employee of Watson Laboratory. I have Crary's diary. Here is a translation...

(END OF SIDE)

A: ...Here is the diary starting May 24, '47, and on May 28 he has "B-17 from Watson with Mirs, Hackman, NYU and Alden, they plan to test fly balloons tomorrow. Other gang with recording equipment due to leave Watson Laboratories Saturday. Got everything ready for Hermes Rocket today."

May 29th. "Mirs and Hackman got balloon ascension off at 1:00 p.m. today without plane to follow it. Don and Godby out to Donyo. Bill and I out to E. White Sands to record Hermes."

I've marked the key things here with red, and then I've given you a page without my red if you have any need for that.

June 1st, "C-47 with Moore, Schneider and others from NYU, also Irewin, Minton, Olson, NYU men worked on balloons, north hangar."

June 4th, "Out to Tulerosa Range and fired charges between 0-0 and 0-6" something. "No balloon flight again on account of clouds. Flew regular sonobuoy mike with cluster balloons and had good luck with receiver on ground but poor on plane." I think that's Flight 4 right there.

Q: So that's June 4th.

A: As to that flight made by Mirs and Hackman earlier, we have no record of it here in the NYU summary.

Q: If he flew that on June 4th and it carried the microphones, the radar reflectors, that would have been with a neoprene type balloon.

A: There were no plastic balloons delivered until the 28th or 29th of June that year. So everything as evidenced on the Helgeland flight that we made and the other flight, they were all meteorological balloons prior to late June.

Q: That would have also had the B Model reflector, this type of reflector, but the B Model?

A: My memory is that Jim Peoples, because we were being sent down by B-17 and by air, didn't let us take the radiosonde receiving equipment which at that time was very heavy. It was like a 500 pound rack with a receiver, frequency meter, recorder, etc., and we weren't allowed to use that. Instead, the idea was that Peoples would provide tracking on the balloons with radar targets and so on. So this is where I think the radar targets come in. If you look in these reports you'll find here statements, radiosonde reception, and you'll see 60 percent with recorder, 50 percent without recorder, 100 percent without recorder for June 5th. A hundred percent without recorder.

So I think we tried the radar targets, as I remember, our contact who was a Captain Larry Dyvad found that they weren't able to track our flights at all. They had a radar that was entirely aimed at looking at the missiles. To look at slow moving balloons with poor signal return was difficult for them. So we started off with making single target flights. I think we went to multiple target flights, and still didn't have any success, so I began putting radiosondes and then just audibly, as the tones would change, I would log it on a piece of paper. I'd count the pressure... Are you familiar with radiosondes?

Q: Somewhat.

A: The commutator with the pressure contacts, etc. I would count contacts and record it and you'll see in some of these flight reports, there's two different interpretations possible, depending on what the contact sequence was. An ordinary radiosonde is very good for something that's going one way. But for something that's going to go up and float, you can have ambiguities. You don't know if it went up or down when you get the next pressure contact switch. You'll find that sort of uncertainty in describing the report.

So I'm quite sure that as a result of the failure of the radar tracking, I went back and started using radiosondes even though I didn't have the right equipment.

Q: You mentioned a few moments ago the Watson Laboratory gear, the microphones, and it was also Columbia that was developing the low frequency microphones. You had all of that gear on these balloons, is that correct?

A: No, not on all of them. That mention of a sonobuoy microphone, in the early... While the improved low frequency microphones were being designed and built, we flew on balloons, believe it or not, sonobouy used to detect submarines. We were flying sonobuoy microphones on the balloons.

Q: But the material that's been identified as Watson Lab gear shows up as very generic in all of these reports and things. That was all part of Mogul also, is that correct?

A: That's correct. I think what happened is because the Watson Laboratory radar wasn't very successful, I think we made a number of flights like this. I think I sent a sketch like that to you. We made a number of flights like that which was an unorthodox use of radar targets, and it's my opinion that the thing that caused the debris that was picked up was probably from a cluster of meteorological balloons carrying a cluster of targets.

When something like the idea of a cluster balloon was not only to carry the weight, but was also to keep the target in the air for a long time. If one balloon burst, we still would have enough buoyancy for awhile to keep the thing airborne. When it would come to the ground this would drag along the ground and get shredded, but this would still be carried downwind until another balloon would burst, whereupon this one would start getting shredded. So I think the explanation of why things were over such a large area was, indeed, because it was a cluster, it was multiple targets and cluster balloons.

Q: Of course the issue of the large area has been different in different reports. Different people have stated the 200 yards, Cavitt in his description, described it in terms of his living room which was not that large.

A: Even a single target, if it came down, wouldn't have filled a single living room, but a multiple target, begins dragged sideways and then blown transversally by any later winds, could have filled a reasonable area.

Q: And left pieces of debris everywhere. Depending on...

A: What the wind did.

The description that Brazel gives here that everything would weigh about five pounds when it was all together, is more than you would have gotten from a single balloon.

Q: Those were measured in terms of 300 to 500 grams or something like that?

A: Three hundred and fifty only. At that time we didn't have any bigger balloons than 350 grams, so the balloons would have been 350 grams.

Q: About one pound.

A: Correct. And the targets are nominally maybe a quarter of a pound.

Q: Those targets are only four to five ounces?

A: Here was the specification spelled out for it. Approximate weight, 100 grams. These, as I say, are somewhat heavier than the ones we had.

Q: You indicated that the balsa wood was coated with some sort of glue such as Elmer's glue.

A: That's my memory. It wasn't completely coated. Some of it was and some of it wasn't.

Q: Some of the balsa wood is fairly dense, as far as being durable, and one of the descriptions concerning this "wood-like" material was that you couldn't dent it with your fingernail. So if you have a fairly dense balsa wood coated with a glue, it may be quite possible that a person would not be able to put their fingernail in it.

A: That's correct. It's my memory that the reflective material was more aluminum foil than here. These are second or third iteration targets, as evidenced by this picture, wherever that picture is down in here of the 1948 flight. It certainly looks more aluminum-foil like.

Q: What year were you discharged from active duty?

A: '46.

Q: Before you left active duty, while you were still working with Duffy and Spilhaus, did they invite you to join the staff at New York University, or to continue your studies there?

A: I came back from overseas and was assigned to Colonel Duffy's, he had a little flight detachment assigned to him with a B-29 and a B-25 and some other aircraft. I ended up being the executive officer of a flight detachment at Newark Airport. I got back from overseas in February of '46, I think. After getting out of the replacement depot, I got assigned back to Colonel Duffy and was assigned at Newark. I went on terminal leave something like July of '46 and went back to Georgia Tech and finished two quarters. I had two quarters to finish at Georgia Tech. While I was at Georgia Tech I began working with a microwave, an anonymous propagation research group that turned out, oddly enough, was under Colonel Duffy's direction. I didn't know it. It had nothing to do with my getting deployed there, but I had a student assistanceship working on that.

I made some report, and my name came back in front of Colonel Duffy in September, I think, of '46, and I got asked to come up to his office. I think he was still at Bradley Beach, Sharp River Hills Hotel there near Belmar, New Jersey. When I was there, who should come in but Spilhaus. They told me they had a problem involving balloons and asked if I would be interested in working with them, and they offered me a graduate assistanceship at NYU, and I wanted to go to graduate school in physics, so I was delighted to have that opportunity. That was either September or October of '46.

Q: So Spilhaus, since he was on the staff there, he invited you to come to New York University.

A: Yes, he did.

Q: So you went to New York University when?

A: Right after Christmas. January 1, 1947. The program had already started. I presume you have all the details. I have a copy of (inaudible) letter to General Spaatz. I presume you have all of that.

Q: I believe we do, but I'd still like to review it and make sure it's the same letter.

A: In any event, there was a big push. I guess after Operation Crossroads the first nuclear test in the Pacific was in July of '46, and Crary, because of the long range detection concept, Crary was sent to Ascension Island which is the antipode for, as close as they could get to the antipode for Bikini, and failed to detect any signal from Operation Crossroads, from the nuclear explosion.

Q: You mentioned detection. What drove the aspect of detection? Was it because of our test?

A: Yes, our test was being used as a signal source. The question was in order to detect any Soviet test, could we detect our own tests. So Crary was essentially sent to Ascension to see if he could detect the nuclear explosion.

Q: He was unsuccessful?

A: He was unsuccessful.

Q: What method did he employ?

A: Low frequency microphones on the ground. Are you familiar with the Krakatou measurements?

Q: No.

A: In 1883, Krakatou, near Java, made an enormous explosion and the pressure wave from that went around the world seven times, and was picked up and... There was a report, a big analysis by Lord Railey and others...

Q: A volcanic eruption?

A: Volcanic eruption. Here are the isocomes of the pressure waves from Krakatou as it went out. From the time it took the signal to go out and come back, he went to the antipode which is around Colombia or Venezuela, and came back as a big spherical wave. It went back and forth around the earth. The British investigators were able to show that there was a duct up around the tropopause, and the speed of sound, as I remember, was something like 310 meters per second instead of the regular 334 that we had at sea level. From that they could deduce the temperature of the medium in which the sound was propagating and it was something like minus 25.

Q: How was this detected as a pressure wave in that time frame?

A: Barograph.

Q: What year?

A: 1883. This is what prompted Ewing.

Q: I'm familiar with barometer-type measurements being used to measure that pressure wave and the fact that it traversed the earth, you said seven times.

A: Maurice Ewing had been an oceanographer at Woods Hole and had found a similar acoustic duct in the ocean. You may be familiar with what's called Sofar. In 1945 he wrote a letter to Spaatz suggesting this might be useful in detection of Soviet activity.

Q: The 1945 letter was kind of the initiative as a means of detection.

A: That's correct. That caused the Army Air Force to begin this research.

Q: How did you come in possession of it?

A: Todd. Todd does everything.

Q: Did he say where he got these documents?

A: Freedom of Information, I think.

Q: It looks like National Archives. I believe I have this letter.

So Ewing was at Woods Hole...

A: And was going to head up the geophysics department at Columbia. These are subsequent documents of people in the Air Force considering the desirability of it.

After Crossroads there seemed to be an enormous push to try to put microphones into the sound channel. During WWII, the Signal Corps had laid on them the requirement to develop a constant level balloon. It had not been very successful. I knew a bunch of people in the balloon branch.

The reason I got into balloons is that while I was working on this manual there was a great problem in the winter of '43 with the supply of gum rubber cut off, meteorological sounding balloons weren't flying very well. In the summer time, the balloons would go through the depth of the troposphere, but in the winter time, the balloons began bursting down at levels of 15,000 feet or so because the neoprene wouldn't stretch at low temperatures. Somewhere Spilhaus came up with the idea, talked to somebody in the Weather Bureau, that maybe you ought to heat the balloons. He told a couple of us second lieutenants, that I wonder if that would work. We got a blow torch and a mop bucket and we had a radiosonde, and he was in charge of the Air Force push on radiosonde technology. I was his leg man on that. We put a blow torch on a mop bucket and heated the water to boiling and flew the balloon. Much to our surprise, the balloon went to about 60,000 feet.

Q: So it stretched without rupturing.

A: It turns out that neoprene crystallizes and you can make it back into an amorphus state with high elasticity. Elasticity changes as a function of the degree of crystallinity. By heating, we removed that.

In any event, there was a group in Spilhaus's detachment known as the balloon [boilers]. The Signal Corps, it turned out, was very unhappy with this idea. They wanted no interest in it at all, and their manual doesn't use it. But that was my introduction, that's how I got attached to ballooning, as a result of doing this simple thing for Spilhaus.

It's of interest, in the Holloman report there's a big talk about boiling balloons. That's certainly a heritage of the association from our early balloon boiling days. When you look at the instructions on the modern balloon, you see that it is really a physical effect that can be controlled.

Q: You went on board at New York University, and you immediately set out, as documented in the reports, acquiring the various materials, [putting out bids], things of this nature. At that point you were working at New York University under the direction...

A: Spilhaus was the nominal principal investigator and director of the project, but he just turned us loose.

Q: So you were the project engineer?

A: I was the project engineer, and Schneider was the project administrator. We employed a lot of students, a lot of people that we could, and were a mixture of trying to develop a constant level balloon and providing service flights for Peoples. Peoples was entirely our contact.

Q: He would come to New York University?

A: He would go down to Red Bank. He'd call and say he wanted certain things, can you do it, so we made this flight out at Lehigh and then we made the Helgoland flight down at Red Bank, and he wasn't really happy. There were all sorts of constraints flying balloons in the New York City area even then.

Q: All the problems with air traffic and getting FAA, or their equivalent at that time, approval, etc.

A: So up in the stratosphere above my level, a decision was made that we go to Alamagordo, and there would be a big flight. We had balloons promised, but even ahead of that time people wanted to test microphones. He had Crary already, about from December of '46, I think Crary went to Alamagordo and ran a field station and...

Q: That field station was for ballooning in general?

A: For Mogul. It was more than that. Crary was operating sound-ranging microphones on the ground there. He was having bombs dropped off the New Jersey coast and trying to pick up the acoustic signals in New Mexico.

Q: He was having the bombs dropped in New Jersey, off the coast, and trying to detect them in New Mexico?

A: That's correct.

Q: What technique? Balloon borne?

A: No. We were the balloonists. This was all ground-based stuff. There was also an operation in Bermuda. Then later you'll find...

Q: Crary also initiated that?

A: He was in charge of it. He was running it. They went and got a whole bunch of 500 pound bombs out of the Earl Ammunition Depot in New Jersey. Later you'll find that they did a bunch down in the Canal zone. Then eventually they went to Alaska.

Q: This was prior to '47?

A: The New Jersey, and I think the Bermuda operation, you'll find a hint in this diary I gave you, you'll find a hint about Bermuda and so on in there. He was talking about trying to measure the sky waves coming in.

If you're interested, we can go extract, there's a paper in the Journal of Meteorology in something like '47.

Q: I believe I have that. Is that the same one?

A: No, this is by Crary.

Q: Crary did quite a few publications for Red Bank and then for Cambridge Labs.

A: Correct. But you'll find one, I think it's either '74 or '49. If you want we can go over to our library and make you a xerox of it.

Q: I'm familiar with that one.

A: It's very circumspect as far as classified matter.

Q: So Peoples and Crary had Columbia University affiliation?

A: Well, Watson. They were derived from Columbia. Both of them were derived... I think Peoples got his PhD under Ewing at Columbia, and Crary didn't get his doctorate until later.

Q: You said Crary's ground station was Alamagordo, but he was actually doing explosions in Alaska, off Bermuda, Panama, the Jersey coast.

A: In the late '46, early '47 era, he was in Alamagordo, in and around Alamagordo. He was very concerned about explosions off the Jersey coast and I think off Bermuda. The Panama Canal operation I think was not associated with Alamagordo at that time.

Here's a nice paper that came through courtesy of Todd. In '48 there was a big operation in the Pacific for Operation Sandstone, and we were heavily involved in that. Here's the Fitzwilliam... Schneider and J.R. Smith... My chief associate technically was a fellow named Dick Smith, James Richard Smith, who unfortunately, died two years ago. Smith and Schneider and some other of my associates went out on Sandstone to Kwajelin, Guam, and then Oahu.

Q: I've seen that in publication. I have to acquire it.

A: You can xerox it.

Q: Moving chronologically, Professor Ewing had affiliation with Woods Hole, and he was a meteorologist by trade?

A: No, oceanographer. He was a physicist, a geo-physicist.

Q: What was he doing at Columbia?

A: I think he ended up head of the Department of Geo-Physics. I don't know the details.

Q: For the AMC contract he was developing...

A: He, as we, were contractors.

Q: He was developing the acoustical...

A: That's correct.

Q: That acoustical gear, this is a later flight but it's a fairly good depiction. It shows payload here, and payload is mentioned in a lot of the reports without any further elaboration, what the payload was. That was primarily the low frequency microphones...

A: That was their euphemism for...

Q: So as not to be able to talk about what was then a classified payload.

A: Here are the sort of instruments. A chamber with a leak in it, and then a method of sensing the pressure inside the chamber. That affected the frequency of an oscillator that came to ground. That's the sort of thing that was developed at Columbia.

Q: Dr. Spilhaus also mentioned about trying to detect particulate matter.

A: That was another operation. A Tracer lab, have you come across Charlie Ziegler at Brandeis?

Q: No.

A: He worked for a Tracer lab and is just bringing out a book on the early detection system.

Q: That was Project Center. MX-968.

A: There was another one that followed on this to measure krypton. It was called Grab Bag in our lexicon.

Q: Did you ever hear of the project Bequeath?

A: No. Being a civilian and outside, I was more knowledgeable, essentially, of the intent and what was required rather than the project names.

Q: What type of clearance did you hold?

A: At various times I had Top Secret and Q and I don't remember exactly when I got various clearances. I also had a clearance with the CIA.

Q: So at this time in New York University you were cleared but you had no need to know.

A: I knew exactly what we were doing. I knew about Helgoland. I knew, just being an atmospheric physicist, I knew about the sound duct channel and I knew what we were doing, but I just didn't know any of the operational details and I wasn't concerned with them.

Q: From a security standpoint, did anyone ever discuss with you, other than the letter that I showed you stating that this is now unclassified, did anyone ever tell you never to discuss any of this with anyone?

A: I can't say they did.

Q: It was just a matter of enforcing the need to know what classified project...

A: I guess I was aware this was highly classified, and having been in the military was aware this wasn't something to be discussed lightly. But no, I can't say that...

Q: The reason I ask the question is there are some statements made in the various publications and books -- the popular press, about people being threatened not to talk about things they had seen or that sort of thing. I just wanted to see if there had been anything stated to you never to discuss any of the activities either related to this project or any other project.

A: There's a gray area here. I was certainly aware that what we were doing in Alamagordo was highly classified and was well aware, and I guess had been perhaps encouraged to have a suitable cover story to explain what we were doing.

Q: So you were encouraged by whom to have a cover story?

A: Probably by James Peoples, who was our scientific monitoring... As you may be aware, there is a former colonel, later General DuBose, who makes a statement that something was a cover story. When I read this, I was not at all surprised. I interpreted that as saying someone was covering up on Mogul. That was my interpretation when I read what was attributable to General DuBose. So from his point of view, there were certainly no threats, but we were aware we weren't supposed to be talking.

Q: So was it Dr. Peoples then who actually actively said use meteorology as a cover story, or...

A: I don't remember the details, to be truthful...

Q: But it was kind of a natural thing to think of in terms of meteorology?

A: We were careful around NYU with the various technicians we hired. We kept our knowledge of what we were doing to ourselves. It's certainly my memory that we were aware that this was classified, but we weren't threatened. We were just instructed that this sort of information was not to be passed out, even though the technical aspects we understood. So the answer is yes, we very well understood this was classified; and second, there was no physical threat or anything like that. We were instructed not to talk about it, and until Todd told me that Mogul had been declassified I was very reluctant to say anything about it.

Q: Anywhere in the early days were you ever aware of involvement by General LeMay?

A: Not at all.

Q: Not at your level. How about the [AFOAT-1] study group?

A: I became involved with them later on Project Grab Bag and others, and I knew a bunch of people in [AFOAT-1] -- Doyle Northrop... I knew that, but later ballooning got even more heavily involved in various classified things.

Q: Where were your duty locations involved with [AFOAT-1]?

A: Probably at General Mills.

Q: Not ever in Washington?

A: Oh, yeah. I visited people in Washington.

Q: Just for the record, Major Marcel later worked at [AFOAT-1]. Do you recognize him at all?

A: Not at all. The people I was involved with were civilian scientists. If we looked at a list of people at Northrop, Doyle Northrop sort of sticks in my mind, and there are other names I've seen related to that. Yeah, I knew that guy, but I never knew Marcel.

Q: So you went, moving into Mogul, you did go on the June and July field trips.

A: I ran them.

Q: How many did you go on? All of them?

A: I didn't go to the one in the Pacific. If you look at the planning on the Project Fitzwilliam, my name was listed as the person as being there. Then suddenly, I'm not. What happened, my people got taken away from me and I had to recruit brand new people to help me fly balloons into Alamagordo during the April and May 1948 operations. So I had new personnel, and we went up and down the Rio Grande Valley trying to launch balloons so they would pass over the ground stations at Alamagordo.

Q: During that early period, before you had your full complement of various types of balloons, did you ever use any of the Japanese balloons? We were given the impression there were at least a few of the Japanese balloons made available.

A: I got very interested in the Japanese balloons and communicate, and I have pieces of the Japanese balloon downstairs if you're interested in seeing a piece of it. And I've got translations. I met the chief of the Central Meteorological Office, a Dr. Wadati, and he put me in contact, so I have extensive files on the Japanese balloons.

Q: But were any of those used as precursors to Mogul or...

A: None whatsoever. That was part of a promotion that... When I went to General Mills, Winzen who had been the great entrepreneur, had gotten fired. He'd gotten caught in a prevarication about whether or not the Navy was going to provide money. He was replaced by a fellow named Frank Jewitt. Jewitt recruited me out of graduate school. We really promoted balloons. That's part of the balloon promotion.

Q: None of the Japanese balloons were actually used as far as a precursor to Mogul or anything like that.

A: That is absolutely correct.

Q: But you had them available for study, but you didn't launch them.

A: No, they didn't have any.

Q: In the New York University report it says that you were provided two Japanese balloons.

A: That's interesting, because I have no memory of them whatsoever. Spilhaus may have. But I have no memory that I ever saw them. In the spirit of being given proper scientific credit, in the paper that you have, the Journal of Meteorology Paper, we, heavily written by Spilhaus, credited the Japanese with doing, with their trans-Pacific flights. So what we were doing certainly was based, came after what they had done, and we didn't want to take credit away from them. But I'm told that on my own, completely free from this, I talked with Wadati and others on a Japanese balloon. I've never seen a Japanese balloon that I know of, I've never seen the payload, but I do have fragments of the Mulberry Favor.

Frankly, we did not depend on the Japanese balloons. The Japanese just preceded us. But we didn't pattern what we were trying to do on what the Japanese did. After all, they had opaque balloons, and my belief from the beginning is balloons ought to be transparent so they don't absorb sunlight so at sunset you don't have the cooling and the ballasting. So we owe nothing to the Japanese other than the fact they were ahead of us.

Q: You went on these field trips. When you left, getting back to the cover story, you were the project engineer. Did people come to you and say you need to put something together in case one of these things falls in somebody's hands?

You didn't.

Did you brief your people, your personnel, when they were there, that they if should go into town for food or something if someone says "Why are you there?"...

A: We were certainly secretive and not talkative, but at the same time...

Q: In other words, was there a developed cover story where everyone got together, discussed what you were going to say or not say concerning the various activities that were going on at Alamagordo and other locations?

A: That's a good question. I have no memory of such a thing. I'm just aware that we were under very strong stricture not to encourage speculation on what we were doing.

Q: So is that pretty much maybe a condition of hiring? I notice you used a lot of former military people. Did you just tell them at the outset, "This is a classified project for AMC?" Or were they not read on to the project at all?

A: By and large, people thought we were flying balloons for the Air Force.

Q: As far as they were concerned they were just launching meteorological balloons?

A: That's correct.

Q: They didn't particularly quiz you about the microphone you hung in there or...

A: No.

Q: The balloons that you did launch for Project Mogul and some of the other test balloons, without the actual instrument packages, did they have reward tags, "Return to New York University," or "Return to Roswell Army Air Field," or to Alamagordo Army Air Field or anything like that?

A: The ones that we wanted to get back, which were the test constant level balloons and the ones that had microphones on them, by and large, they did have NYU reward tags on them.

Q: Dr. Peoples, whoever was directing you, was there ever any concern voiced that this is a top secret object we're sending into the atmosphere and we're not sure where it's going to come to earth. Did they ever express any problem with that, that wherever it came down, it came down?

A: I think the argument was that when it came down, it would be mixed in with our other gear, and it was just part of a flight that was to be recovered by NYU. He thought nobody would interpret what those sorts of instruments would be.

Q: So the tags were kind of generic, like a meteorological tag, say. "This consists of meteorological instruments..."

A: "This is a research balloon flown by New York University..."

Q: Were you doing other research? When you went to New Mexico was there another agenda other than the top secret project?

A: None whatsoever. Our whole life revolved around the NYU constant level balloon project. We were developing constant level balloons, and the service flights for Peoples just sort of got hidden in that.

Q: The service flights were which ones?

A: The ones carrying the microphones.

Q: So specifically that term was used for the microphone flights from...

A: That's right. You'll notice when you look at this, that the flights out in the Pacific don't even get mentioned. There's just no report on the flights in the Pacific, and the flights in '48 that we made for Sandstone, there are some flight numbers recorded, but there are no details at all provided.

Q: That was Grab Bag?

A: No, Grab Bag was to grab stratospheric air to measure the krypton 85...

Q: Essentially particulate detection and gaseous...

A: That was gaseous. The particulate was, I think we were less involved in grabbing particulates. There have been thousands of flights made, and certain people did carry cascade impactors and other things, but that was a minor part of what we did, whereas Grab Bag was a very measure effort.

Q: That was in '48?

A: That was more '50 odd.

Q: Was that Fitzwilliam?

A: No, Fitzwilliam was entirely acoustic detection. Again, very long range detection. Fitzwilliam was spring of '48. There were various code names, and thanks to our friend Todd, I've learned about the code name got termed Black Heart and a whole bunch of odd names...

Q: Black Heart, Rock Fish. He may be wrong on that part. He may be right, but...

A: I heard Mogul got converted into Rock Fish. But I heard the detection part of Fitzwilliam ended up being called Black Heart.

Q: He may be in error on that.

A: As I say, I'd been much more concerned with the technical aspects than the military operations.

Q: This is one of the technical reports and it's talking about the various flights, and this is the report that lists all of the numbered flights and it talks about, it says, "Excluded are the flights made to test," it's technical report number one, "Excluded are those two tests' special gear in launches which were not successful."

A: Right.

Q: So the special gear that's referred to here is the microphone gear?

A: Yes, sir.

Q: There's another passage that talks about the intelligence gear. Was that considered also...

A: Did we make such a faux pas as that?

Q: It's in there.

Q: I have the classification letter from July of '46. You might want to review this. Maybe your friend has shown that to you.

A: No, I've never seen this.

Trakowski argued that even the name Mogul was classified, and he said it had the same classification as the Manhattan Project had, which surprises me, because in various reports that Todd has sent me, such as the monthly progress reports from the people at later Holloman Air Force Base, Mogul appears in things that are no higher classification than confidential, but Trakowski insists that Mogul was super classified.

(END OF SIDE)

Q: This is a copy of the letter you wrote to Colonel Weaver. One of the things that you talk about in this letter was that the radar test flights were not reported, which is exactly what we were discussing a moment ago in your kitchen. Would you go over again what you just described as far as this particular test flight that occurred? What we just went through in there.

A: As I said initially, the essence in trying to develop constant level balloons, we needed to know what the altitude was. At the same time, we were under a lot of pressure to carry the test microphones for the Watson Laboratory and Columbia people. We got into an operation at Alamagordo in early June of 1947, in which we were required to make flights in which the tracking of the flights would be provided by the Watson Laboratory Radar that was already in place at Alamagordo for tracking the V-2s and other rockets the Ordnance Corps people were flying over at White Sands. So we came down to fly balloons in early June, in which the tracking of the flights was to be done by radar, tracking corner reflector targets, which I think we brought with us. I don't have any evidence of this.

Q: So you made your plan in New York to fly... Your primary research was the acoustical detect...

A: That's correct.

Q: Secondary was refining the technique of constant level balloons.

A: And that was on hold until we got the delivery of the polyethylene balloon that was scheduled for the end of June. So the first of June we came, really, just for the test flight of microphones, doing service flights for Watson Laboratories.

Q: To fly the balloons in association with...

A: To fly meteorological balloons, tracked by a Watson Lab radar on the ML-307B targets that I think we brought with us.

Q: And you launched these balloons in conjunction with V-2 firings?

A: Those went independently. Albert Crary was monitoring the V-2 firings.

Q: That was with the ground microphones?

A: You're right, I beg your pardon. As you'll find in the diary, that we launched Flight 8, these cluster balloons, we launched those at 3:00 o'clock in the morning for a V-2 firing. You're quite right. I'd forgotten that. We launched those in the morning, then the rocket got scrubbed while Flight 8 was in the air, and we were out of plastic balloons that day in early July -- this is jumping ahead to early July -- and we inflated meteorological balloons for the delayed firing of the V-2 rocket on the afternoon of July 3rd, you'll see. Then there was an accident over at White Sands and the V-2 got scrubbed a second time. What was Flight 9, we launched Flight 9, as you will see in here, as a dummy flight, and it probably had radar targets on it.

Let me just read this. This is Crary's summary for the week of 30 June-5 July 1947. "Balloon tests 7, 8, 9, and 10 off this week. Test 7 slated for July 1 postponed to July 2nd because equipment not ready. A hundred tanks with helium obtained from Amarillo Monday evening. Trakowski went over in a C-54 and picked them up. Also radiosonde receivers set up by NYU but sonobuoy not operable. Test 7 at dawn, July 2nd, with Pi Ball. One hour, first falling with the autolights. Winds were very light, and balloons up between base and mountains most of the time. Included a cluster of met balloons, followed by C-54 several hours, and finally landed in mountains near road, south cloudcroft. Before gear could be recovered, most of it had been stolen. Station operating in north hangar, Cloudcroft and Roswell. Shots made repeatedly at Site 4 and picked up goods from north hangar and from Cloudcroft for awhile. Nothing from Roswell.

"On Thursday morning, July 3rd, a cluster of GM plastic balloons sent up for V-2 recording, but V-2 not fired. No shots fired. Balloons up for some time."

Q: What is a shot?

A: Explosive on the ground.

Q: You were doing explosives on the ground in New Mexico too?

A: Crary.

Q: So Crary would give you the signal, he'd say at 0400 I'm going to launch a balloon, and at 0500 I'm going to...

A: No, he wouldn't launch a balloon. I'd launch a balloon. What Peoples would do is say I want a flight up tomorrow morning. So the NYU group would get ready to make a flight, and then Crary would go out with his crew and fire explosives up and down the Tulerosa Basin while our balloons were in the air.

Q: So you had multiple explosions on the ground, the V-2...

A: And explosions on the East Coast.

Q: On the East Coast, Caribbean, and you had those timed so you knew when those were going to take place and you were simply waiting for...

A: They had them timed and we balloon types just fit into the schedule. But the master, the timing, bringing all this together, we knew nothing about. We were just scheduled to fly balloons.

Q: But you did want to launch early morning for the light winds.

A: We did want to launch early in the morning for light wind. We had freedom to tell them what we could do and what we couldn't do. We actually on this, in addition to everything else, we actually flew blocks of TNT on free balloons and fired them while we had other balloons in the air.

Q: Did those have radar targets on them also?

A: Probably.

Q: Were those detonated by...

A: By a pressure switch.

Q: Were those tracked? Was there some sort of log that would tell you where those particular balloons were? You wouldn't want to just release TNT to float anywhere, would you?

A: They wouldn't float. The balloons would just go up until they burst. And we were on the edge of the restricted area. So the answer is yes, we did.

I'll have to get back to this. The radar tracking turned out to be abysmally poor. I don't know why, but they were abysmally poor. That's why I got off onto this part of it. And when you asked me the V-2 question...

Let me finish this, and then we'll get back to what you asked.

"Thursday morning, cluster of GM balloons sent out, V-2 not fired, no shots fired. Balloons up for some time, no recording. Pi Ball showed no West winds. Balloons picked up by radar, WS." I presume that means White Sands. You'll find this hard... and hunted by somebody's name I couldn't get. It looks like Maryalls' "C-54, located on Tulerosa Range by air. Out PM with several NYU men by weapons carrier, but we never located it. Rocket postponed until 7:30 p.m. Thursday night," which was the third. "But on last minute before balloon went up, V-2 was called off on of accident at White Sands. Sent up cluster balloons with dummy load. Balloon Flight 10 on dawn, July 5th, had gone out with C-54, again with Moses and Dufeld to hunt for Flight 8 but not sure was found then."

Then I added a note here, "Flight 8 was never recovered."

"C-54 went to El Paso July 4th and picked up single smith plastic balloon and GM cluster plastic balloons."

So the answer is yes. We did try to coordinate the balloon launchings for the V-2 firings, and Crary would also take that as a time of opportunity to go out on the desert and fire TNT. He had vast stocks of explosives available to him.

Q: Was that primarily on the White Sands range, or did he go out into other areas, say Northwest of Roswell? Did he contract with any of the ranchers to use these locales, other than the actual missile range itself?

A: I think all the explosions he made were coordinated with the White Sands Proving Ground people. Alamagordo Airfield, later Holloman, was just on the fringe of the proving ground at that time. Crary sent his men to all sorts of places -- over to Roswell, to Artesia, to Hagerman, up and down the Pecos River area. He had a place you'll read about, Fabians, Texas, which turns out to be just down the Rio Grande from El Paso, maybe 50 miles. Then he had Don Edmondson went to Silver City frequently. Then he had some place he called Donna, Las Cruces is in Donna Anna County, but I don't know where his Donna site was. But I think he had microphones scattered all around in central New Mexico and West Texas. But the explosions were all created either on the White Sands Proving Ground, or there were V-2 rockets, or they were things coming from...

I won't take the time now, but he talks about cruises, which apparently are, maybe they were cruisers firing off the Jersey coast.

We got off into this, we were talking about tracking, and we went down to, in early June, to make service flights which were to be tracked by radar, and the radar was unsuccessful. It's my memory that we made a number of flights just to test out the radar. These would not have had a reward tag on them. These were throw away flights. Once a target like this comes down from high altitude or drag, you don't want it back. It's my memory we didn't want to have anything traced back to us, if we weren't going to go out and pick it up.

Q: So you just kind of let the material lie wherever it fell?

A: We shot a balloon into the air and didn't want to do any more. There are some pictures of our going out to recover things. On one of the early flights we went out east of Roswell, and I remember beyond the Bottomless Lakes, going out in oil well country, picking up one of our flights that had come down. We aggressively tried to recover our own flights.

Q: So were you directed to that location by aircraft?

A: By the aircraft.

Q: Did they give you a lat and long, landmark?

A: We talked to them by radio. The transmitters on these microphones were so low powered that, believe it or not, they had B-17s just orbiting under our balloons with receivers aboard the aircraft, and we, of course, would talk to the aircraft, and they'd tell us when things would come down. So it was a coordinated operation.

Q: So you had explosions or V-2 going through. So the aircraft had recording devices. You had the acoustical pickup on the balloon and the aircraft had the recording device that would record the sounds.

A: That's correct. Would record the signal from the balloon.

Q: In what media was it recorded on?

A: Brush recorders. [Strip charge] recorders feeding out at high speed. You'll see in here, you'll see the sort of records.

Q: The graphic representation.

A: The recorders looked like that.

Q: So that was recorded on the aircraft and then...

A: That's correct. As you'll see, they said they had receivers at Roswell, at Alamagordo, and they had them on the airplane.

Q: But most of the detection was via the aircraft because of the low power receivers.

A: Most of the reception, the detection, was really... The balloon received the acoustics, and sent it down by radio to the aircraft. It often didn't work. That was the reason why for Operation Sandstone in April and May of '48, we went up and down the Rio Grande Valley... Here are some of the pictures. There's a ground cloth for the balloon to be laid out. There's a balloon being inflated, just getting ready. So we tried to get up wind.

That's a device from White Sands that was picked up around Carazoso and was reported in to us, and we thought it was one of ours. So I took a weapons carrier and drove up there. We were aggressively trying to recover our equipment and that just happened to be something that was on the ground. The technician that had been in that group, remember the [Marginal] tape, Herbert Crow. That's a picture he took when we were aggressively trying to recover a load. That turned out not to be ours.

Q: What is it, and who did it belong to?

A: It probably was flown on a rocket or by Marcus O'Day who was the chief scientist at Watson Laboratory. Dr. O'Day. You'll see, when you read the Duffy thing, where Duffy thinks maybe there were things that were flown by Dr. O'Day. Anyway, that just happens to be a picture in the collection of NYU photographs.

Q: So there were a lot of other people flying balloons or launching...

A: Not balloons. We were the only balloon flyers. That came down by parachute. But there were a lot of rockets being flown in the early days there, and a lot of high altitude aircraft. Duffy says there were dropsondes.

Q: So it could be that some of the material found may not have been associated with a balloon. It is possible it could have been some other type of material. But the description that

Brazel gives the impression that it is the smoky rubber of a balloon that's been in the sunlight.

A: That's circumstantial. That fits exactly with what would have been done, and orthodox use of radar targets would not have produced what he found. But you're quite right, there's debris that was reported to us that...

Q: ...some sort of cylindrical instrument, though, that's obviously an instrument package of some sort.

A: It had a plexiglass, it looked like maybe it had a UV sensor. There was some optical equipment under the plexiglass dome that was shattered...

Q: You're familiar with the popular literature about the various crash sites. There's one crash site, two crash sites, three crash sites and all that craziness?

A: Yes.

Q: What I'm thinking is we may have two incidents here, where they collected your debris from your radar targets, and then there may have been another something else not related to a balloon.

A: There could have been other things from White Sands. This was on the edge of the proving ground. There's a story behind this, and that is that a rancher, whose land had been taken from him to form the proving ground, had cattle that were still on what had been his land. He had found this while he was looking for his cattle, I can show you on the map if you're interested. Anyway, he called in to Alamagordo about this. So I went up to see if it was one of our missing balloons. While we were there, a range security guard came on the rancher and really castigated him for breaking the law, coming back onto the range. So this was really on the range. It would be hard for me to understand how the sort of operations, which I knew, could have fallen as far away as these other sites you talk about. This was really on the northeast corner of the range, just west of the town of Carazoso.

Q: So that's not too far from here.

A: Here's the northeast corner. [Looking on map] Right on this road, right about there is where that load there was found. Here is where the Brazel finding was, just north of this bend of the road here, and there's Roswell.

Q: You're talking in terms of sites around Corona and in that vicinity. So it's quite possible that there had been other types of debris from the proving ground or...

A: As I say, I find it hard to think that something... While we may have been flying TNT on balloons and being very carefree about it, I really doubt that a thing of any military significance would have fallen this far away from the proving ground. It could have, but...

Q: Other than your balloons.

A: Oh yeah, those first flights we didn't even coordinate with CAA. Peoples was so eager to go get those measurements, that these were going to be flown from a restricted area and he didn't worry about it. We later, before the Civil Air Board in El Paso, but that was two or three months later.

Q: When you went on the field trips, what was the chain of command at that point when you arrived? Who did you report to?

A: We were somewhat self contained, but we got housing provided by, I guess Crary was our contact, if you will. Some way or another, barracks were made available for us to live in at Alamagordo.

Q: Would anyone at Roswell Army Air Field have known about your activities, what your purpose was?

A: Not at all. In fact, we went over and tried to get into the weather station at Roswell and because of the atomic bomb security of the 509th, as I remember, we couldn't even get on the base. We drove up in a weapons carrier to the Roswell Army Air Field, and tried to get on the base because we wanted to go to the weather station, wanted to see if we could put a radiosonde receiver there. As I remember we got turned away.

Q: But you ultimately did put a radioson receiver there.

A: In a motel. We just worked out of motels in Roswell.

Q: I thought I saw you had a radioson receiver on Roswell Army Air Field.

A: Again, forgive my memory, but I do remember being turned away. But if you can find it, I'd be glad to have my memory refreshed.

Q: I saw that you had a copy of the 509th Bomb Group history. In the 509 the Bomb Group history from September I saw a meeting where Dr. Peoples met with LTC Joe Briley, 830th the Bomb Squadron Commander, 509th, Air Group Roswell. Do you know why Dr. Peoples would meet with the squadron commander of a B-29 outfit?

A: Only if he wanted to get in to put a receiver on the base there. That would be my guess. We had a big operation. We went back to Alamagordo in September. We had our first 20 foot diameter General Mills balloons. We had a very successful set of balloon launches in Alamagordo in September of '47. My only guess is trying to have a down-wind receiving station.

Q: There are some other names mentioned that I can't recall.

Q: What about then Colonel Blanchard and General Ramey? Do you think they may have had any knowledge of what your ultimate purpose was?

A: I think not. I want to say something about Colonel J.D. Ryan. He was Chief of Staff of the Air Force later, but "Dr. Peoples, Murray Hackman, and First Lieutenant Thompson from Air Material Command, were out at the field to inspect Air Material Command installations and to confer with LTC Briley."

Well, well. Hackman was one of our radiosonde operators. There's Colonel John D. Ryan right there. That's interesting.

On the morning of this famous press release, July 8th, in The Roswell Daily Dispatch, there is a statement about a flying disc being identified, and Colonel J.D. Ryan who is on the staff of 8th Air Force said that the Air Force was now using radar targets to measure winds aloft in some stations.

I find that of interest because apparently in reading some of the various things that happened in General Ramey's office, apparently someone that afternoon did think this was a radar target that had been brought in. But the Roswell morning paper clearly showed that there was a knowledgeable person in Fort Worth.

Q: Is that in the article, the 8 July article, that Ryan made the statement?

A: Yes. Maybe not the article you're talking about.

Q: Is this the one that William Haut...

A: No, this is that morning, not that afternoon. (Pause to look for clipping) There's Newt Goldenberg, you mentioned him earlier in one of our conversations. That's one of our altitude controls.

Here's the morning paper, "Report flying disc found." Down here is about Colonel J.D. Ryan, and he mentioned the existence of radar wind measuring equipment in the Air Force. If you want a copy of that...

Q: Then there's, subsequently, no mention of the radar targets until General Ramey discusses it on the 9th, talking about the material being a balloon.

A: On the afternoon of the 8th. It may have been published on the 9th, but...

Q: You're right. Evening of the 8th. Examination by the Army revealed last night, a high altitude weather balloon. General Ramey, Commander, 8th Air Forces, cleared up the mystery.

A: In these pictures here, don't show these flaps. This, I think, is my step ladder that I used to reach high targets, when we have these big balloon trains going way up in the air. Here again, is an unorthodox use of radar targets. We did that, and as far as I know, other people didn't.

Q: Did you ever use radar targets with the polyethylene balloons?

A: Yes, sir. In fact somewhere I have a picture where we flew a missile, we launched a missile for O&R Special Devices Center in 1949. I have a picture showing the targets up and down the balloon train there.

Q: Do you remember trying to pin down some of these flights that could possibly cause this misunderstanding? You talk about putting a target with the neoprene balloons, but at that time you also launched them with the polyethylene?

A: This picture I showed you right here. This is a polyethylene balloon.

Q: So you used a visual by the aircraft to watch the balloon? It would circle underneath.

A: The aircraft circling underneath were really to pick up the microphone signals. That was part of the Watson Lab operation. Our operation, we depended on radiosons and where we could get radar tracking for tracking air balloons. But the aircraft operation here was entirely to support Project Mogul. We didn't consider ourselves Mogul because I didn't even know the name.

Q: The summary of flights...

A: That's one of the flights with the mixed interpretations because of the radiosondes.

Q: In one column it says "tracking percent." Then sometimes it will say by aircraft.

A: That's true.

Q: So "aircraft observation", was that a visual observation or an electronic?

A: That's really saying did we have aircraft on it or not, and what percentage. Here the B-17 was on it for 40 percent of the time. Indeed, that was the aircraft tracking for the Mogul operation.

Q: That was for the electronic data gathering.

A: That's correct.

Q: Not observing the balloon to tell you where it went down.

A: That's right. Well, we did have the aircraft stay as long as we could. As long as we could end up with that very expensive aircraft chasing an air balloon, we were happy. On the flight that came down east of Roswell on one of these, Flight 5 or so on came down east of Roswell, the aircraft spotted it on the ground for us and told us where to go to look for it.

Q: About 17 miles east of Roswell.

A: Then we had another one, Flight 11...

Q: That's the one that appears to come down northwest of Roswell.

A: Correct.

Q: It appears to have almost come down exactly where they're talking about.

A: That's right.

Q: That's the one where you provided a depiction to Colonel Weaver.

Q: No, that's another one.

Q: That's an earlier one, that's right.

A: Where is that old NYU report? (Pause)

Here it is right here. More or less due west of Walker, Roswell Army Air Field.

Q: Then this graphic conflicts with this graphic, which shows Number 11 coming down... Is that circle the Roswell reporting station?

A: That's about right.

Q: Is this circle a weather reporting station which would be Roswell?

A: You're right.

Q: This has it coming down northwest.

A: What's the origin of this?

Q: It's in the back of one of the reports.

A: It looks to me like it may have been out of this report.

Q: Not every report had this graphic depiction like this which was number eight.

(Pause to look through documents)

A: With those numbers it wouldn't have been in that first report because these flights were much later.

Q: Technical Report No. 1.

A: Right. And Flight 58 and 55 aren't going to be in that early report. They occurred after that report was written.

(Pause)

A: I would say what was in that first report is more accurate than this. This, I think, occurred after I left NYU. It's a general summary. Flight 11 was a very important flight. They got very important data on it -- Crary and Peoples.

Q: Spilhaus based his article from Journal of Meteorology on it.

A: Right, and he wrote a paper in the bulletin. The fact that the balloon trajectory has this hook in it when it went over the mountain ridge...

Q: That's obviously the [ano-cyclonic] winds aloft.

A: Exactly. So he and Bernard Harwitz were very excited about the fact that the balloon at nominal constant level, had a change in direction when the air was forced over the mountain barrier, and they published a special paper on that. So everybody was happy with this flight.

As soon as that flight was made, that was the 7th, and we went home on the 8th.

Q: That would be the reason why there would be no one there in the area who could explain this debris that was brought in. There were no experts there who dealt with this particular type of material or radar reflectors.

A: There was really no contact, at that time, as far as I know, between Peoples and Roswell, and there's no way Roswell, other than my memory of getting turned away by the MPs at the gate, there's no way that the people at Roswell would have known what was going on over at Alamagordo. When we sent people to Roswell, Hackman worked out of a motel to receive.

So the more puzzling thing in line with what you say comes from Crary's diary. Here's what Crary's diary says: "Alamagordo. Balloon Flight 11A, off at 5:07. Big plastic balloon with small auxiliary plastics," etc. "Watson Lab and gear." "Followed" (inaudible) "receiver until about 11. Picked up on radiosonde receiver at Roswell then followed. Then came down. At 10,000 feet, cap should have punctured plastic. Then it came down near Highway 70, between Roswell and Tulerosa.

"Second balloon, met balloons with radiosonde up about 6:30. Third balloon with two and a half pound stick of TNT and cap set by pressure element set to fire at 35,000 feet, up at 6:20."

Q: What day is that again?

A: July 7th.

"Surface bombing at Site 4 from 5:45 to 8:45 at 15 minute intervals. (Inaudible) followed main receiver only three-quarters of an hour, but followed radiosonde about three hours. Thirty-five thousand food implosion? off about 6:55. Vivian got instructions for completing work on Flights 1 to 30 and packed all records and photo. Sent off TWX regarding Bermuda flight and wrote up memo on it. Worked with Eileen on April 1st rocket plotting HD5 HT SST, whatever [that is]."

July 8th. "C-54 off about 10:30 with 23 people, all NYU, Watson Lab including Vivian, Eileen," and somebody else. I can't tell. "Lieutenant Thompson, Edmondson, Reynolds and myself left. Wrote a report on East Coast flights for Peoples."

Here's 9 July, the time this occurred at Alamagordo. "Worked today on balloon flight. Studied Watson Lab records of them briefly and wrote memorandum to Peoples about results. Left in car this PM later. Flat tire between Roswell and Tulerosa, and stayed there."

July 10th. "Changed tire and went into Roswell. Bought new tire. Off to El Rino, Oklahoma today. Stopped in cafe in Hereford, Texas and met Danny Hard from UGC. Went up to office and saw Bob Cowden, somebody in charge, and supervisor."

That's the end of it. So there's no hint that Crary was involved in any coverup such as this clearly is. This is a coverup right here because they talk about our operations, they talk about our balloons we thought went to Colorado,and they all claim it to be part of Pritchard's radar operation.

Q: But he wasn't launching balloons.

A: He wasn't launching balloons.

Q: So where did they get the equipment to take this picture? Did you leave equipment behind?

A: This is right outside of the hangar.

Q: Those are your people?

A: It's our equipment and my stepladder.

Q: Did you leave equipment there?

A: Yes. Everything

Q: Because you expected to return.

A: We were just going back...

Q: It looked pretty tricky. How did they know how to do that?

A: I just don't know anything about the hierarchy above us. I do know that I worked carefully with a guy named Larry Dyvad, a pilot, who later became a private pilot, running a fixed base operation in Alamagordo, and got killed 20 years ago. But I know I worked with Larry Dyvad whose name you'll see here. I don't remember Pritchard at all, but Dyvad was my contact with the radar. I know they didn't have balloons or anything else, yet they talk about boiling balloons there.

Q: So when you returned in September, did you see that somebody had tampered with your equipment and used up some of your balloons?

A: If it did, it didn't ring a bell.

Q: And no one mentioned it to you. No one said hey, look, we had to do something while you were gone.

A: I think we were just some ignorant, little innocent graduate student contractors on a military base, and things were going on that we didn't know anything about.

Q: So no one approached you to say they had used some of your equipment?

A: Not at all.

Q: This photo that's depicted here n the July 10th Alamagordo News, this could have been taken during one of your actual launches versus...

A: I think not, because they say, the whole article is this was a demonstration. I would have thought, since Crary was a senior person and he and Peoples, Peoples was our contact with the base. But other than Dyvad, we had no real contact with anyone I remember. I do remember being very disappointed with the radar.

Q: If this were a demonstration sometime on the 9th or 10th of July, prior to this being published, they talk in terms here of these radar reflectors. These particular radar reflectors, as having labels on them. The radar reflectors you were using, did they have any type of labels talking about being property of U.S. Army, or Watson Laboratories?

A: None that I know of. We were strongly encouraged not to mix in the Air Force with what we did. Everything we did had an NYU label. I may be able to dig back in my file somewhere...

Q: So they may have had an NYU label on it. Even the service ones.

A: On service, but on radar test flights, there's no way we would have put a label on.

Q: Those were just shakedown flights. You were just saying hey, what's going to work best to get the data, so let's use some of the equipment we have and see what works, so you'd have someone on the radar and say yeah, this configuration works, this one doesn't. That's what you were doing. Then later on you refined your technique...

A: What we would do is we would put up things and they'd come back and say it didn't work. So we'd scratch our heads and do something else. But we were running that end of the balloon end of the operation. Nobody else was flying balloons around us. There may have been a radiosonde operation out over White Sands, but there was not one, as far as I know, at either Roswell or Alamagordo. If there had, I would have used them because we were using standard AMQ-1...

Q: But you did coordinate with Big Spring, Texas.

A: Did we?

Q: It's in the report, saying you guys, when you came back to New Jersey, you were sending thank you letters to various organizations that helped you while you were in the field. Big Springs, Texas; some other places that you had coordinated with.

A: Thank you...

Q: The New York University reports are very voluminous. There are three big bound volumes. I have the originals with your signature.

A: You're making my point, that there probably wasn't any other nearby radiosonde station for us to receive things. I'd forgotten all about Big Springs, but I'm sure we made every effort we could to get radiosonde reception.

Q: Can you think of, just in general, any other explanation for what became the so-called Roswell incident, other than what we've discussed here as far as potentially your balloon project, which at that time was a very secretive project. Is there any other explanation you can think of?

A: No, and the particulars of this case are sufficiently nearly unique, that I think no one else had anything that could have fit into providing these results. No, we were doing something that was unorthodox, using targets that, as far as I know, had not been flown before in New Mexico. There's no way that the rancher could have ever seen one. And there's no way that either Major Marcel nor General Ramey or General Ramey's people could have come up with providing a radar to substitute for the real debris. I think there's a very high likelihood that the unusual things we were doing provided this debris.

However, all the other stuff that's in, and a lot of the material, I can't explain bodies or material that can't be [folded] by a sledge hammer.

Q: Let's dwell on the bodies just for a second here. It turns out that during this time frame, 1947, 1948, 1949, there were numerous aircraft accidents, a lot of fatal aircraft accidents, in this general vicinity. Did you all ever come across any of those?

A: No, sir.

(END OF SIDE)

Q: There was an accident that took place right out of Roswell, a B-29, two B-29 accidents that resulted in fatal crashes. We were wondering if maybe over time people were beginning to think in terms of those fatal accidents, which essentially scattered body parts, small parts, over areas, where people were getting confused with what occurred in those aircraft accidents with the sensationalism of this UFO story.

A: As I said in my letter, all of us went back to NYU on the 8th of July and we heard about that afternoon, and we just thought it was one of our balloons. All of us that were in that group have held onto that view for a long time. I do have Crow's letter here. He apparently joined us for that Operation Sandstone pickup crew in '48, but he knew that we knew that we thought the Roswell incident, so-called, was caused by one of our balloons.

Q: Did anyone ever mention it to you once you returned? Did any of the Red Bank folks mention it to you, or even in passing, or told you that maybe you'd better tighten up your procedures or anything of that nature, or a memo?

A: I have no memory. I do think that Peoples had the idea that it was one of our balloons, and it wasn't a matter of tightening up our procedures, it was just one of our balloons we couldn't recover. As you'll see looking at Crary's diary, there was no frantic effort to recover the earlier flights, even though they had microphones on them. I read to you one about some equipment had been stolen by the time we got there. As you can see in the diary, there's no record that there was any major problem.

Q: So even though the equipment was taken, there was no shroud of secrecy, the MPs didn't come out and close down the area or anything of this sort.

A: No, not at all.

Q: It was just expected in the normal course of research . Expendable equipment.

A: Expendable equipment.

Q: And you had no fear that it was going to be taken by enemy agents or...

A: No, the biggest fear was the thought of loose talking, and we just didn't talk about the purpose of this. We certainly did talk a lot about our balloons, and there was just no security or no concern. We were flying constant level balloons.

Q: For pressure and temperature...

A: For meteorological trajectories. A lot of interest in trajectories.

One thing I should mention is that after I had visited from William Moore around '80 or '81, I wrote Ro Peoples and at that time Jim Peoples was in the Geology Department at the University of Kansas. I wrote him and got a letter back from Ro Peoples saying that he had died. So I wrote her back and said there was considerable interest still in this Roswell incident, and did he ever get called out... I do know that on occasion he got involved in classified things and left us. I asked her did he ever talk to her about anything regarding this debris that had been recovered. Her letter, which I perhaps can find somewhere, was the fact that no, he thought that flying saucers were a bunch of hooey, and he had a very low opinion of people who believed in flying saucers. I did get a letter back from Ro to the response that he had not been, as far as she knew, he had not been involved in any classified identification of something. That had occurred to me that things could have gone on that I had no need to know. I tried to extract that.

Q: So you had no recollection or strong recollection of him, when you got back to New Jersey, discussing it. It caused a lot of fuss.

A: I'm really surprised at this newspaper story because implicit in this is the idea that someone provided a good cover for us, and yet Crary's diary doesn't show that he was involved in it, and I wasn't aware that my contact, Dyvad, was privy enough to our operations to have carried this out. So this is a bit of a mystery to me.

Q: What would you speculate, how would someone, just circumstances, coincidences, or intentional?

A: It's very clear that it was intentional, and there was a better security operation going on than I appreciated at the time. That would be my assessment.

Q: So you believe that someone was privy to your activities...

A: Trakowski was there. I had forgotten, but he reminded me that he had gone on the C-54 to pick up the helium at Amarillo. I asked Trakowski had he been involved in manufacturing a cover story. He kept saying how important Mogul was, how highly classified it was, and how he was really wheeling and dealing. He apparently went down to Fort Bliss, to the commanding general there -- I guess he was a captain at the time -- and had no trouble talking the general into releasing something like maybe several hundred 500 pound bombs for this. At the same time, Trakowski has no memory of a coverup.

Q: He didn't have participation.

A: Whether he was on that C-54 that had 23 people on it or not, I don't know. Crary's list of the people left, there was only one military type, a Lieutenant Thompson, in what you have here.

Q: Who did you report to?

A: Peoples.

Q: Then getting back to talking about quarters and things like that, did you have to go introduce yourself to the commanding officer at the base, or...

A: That's the surprising thing. As far as I know we just never interfaced with the military.

Q: Where were you actually operating from?

A: We operated out of the north area of Alamagordo Army Air Field. This hangar right here, which was a big wooden hangar, on the south side of the ramp in the north area.

Q: That was arranged by Peoples?

A: Crary was already resident there when we had arrived.

Q: That's right. He arrived first to establish the ground stations first.

A: Correct. As you'll see in this, he was already firing explosive for the GR-6, the various sound-ranging microphones.

Q: Did he have a cover story for those ground explosions and the microphones?

A: I don't know. There were very few enlisted men on the airfield. As Trakowski said, it was about to be closed. There was a motor pool, because in the stuff Todd has dug up, there were a bunch of weapons carriers being requisitioned. We certainly had some brand new, good ground transportation that was just turned over to us. We civilians were driving weapons carriers to carry helium around, and to go into town to get meals, etc.

Q: So you operated from Alamagordo Army Air Field. You did not operate out of White Sands.

A: That is correct.

Q: There is a difference.

A: A very strong schism between the ordnance people across the valley 50-odd miles at the proving ground, and the skeleton group at Alamagordo Army Air Field.

Q: So there weren't many people at Alamagordo.

A: Correct. The main people I have a memory of were the people operating what sticks in my mind as either C-5 or an M-5 radar. I knew the Signal Corps designation, the SCR-584s and 270-s, etc., but this was some new radar that had a bigger dish on it and was on the north side of the ramp. It would have been... This is looking toward the south. You can see here, those are some old abandoned, those were barracks used to handle air crew during training of World War II. They were all closed and dusty and we didn't use them. We were in barracks down somewhere on the main base. But we were just in an enlisted men's barracks down on the main base and there was a mess hall that we ate lunch in, ate our meals. We were up at odd hours, as you can see, these 3:00 o'clock launchings.

Q: Who did Alamagordo report to? You indicated it was Fort Bliss?

A: No. There was a commanding officer, and I'm not sure which command he was in, but the people in the north area were all, if you will, tenants. We didn't use that word, but we were all associated, one way or another with Watson Labs.

Q: So Trakowski then, his reporting chain was...

A: His reporting chain was Watson Lab to Colonel Duffy.

Q: There was no real interface, Trakowski had no real interface with the Alamagordo people or anyone else around 8th Air Force.

A: There were some fancy orders that gave him a position to talk to the commanding officer and get what he wanted, to arrange what he wanted on the basis of orders out of Headquarters Army Air Force.

Q: While you were operating, doing your procedure, did it take a security monitor type person or security officer to come by and just say I wanted to see how you were...

A: No interface at all.

Q: You don't remember any strangers poking around or....

A: No, just absolutely nothing. We were just a little bunch of civilians there on an almost deserted base, doing what we wanted.

Q: Going back to the orders that you mentioned, were these some sort of special orders different from what we would typically see as military orders?

A: You'll have to talk to Trakowski on it, but my opinion is that he had orders that came from a fairly high level that introduced him and let him do what he wanted to. As the research changed, he didn't have to go back and get new orders. He was in the position of doing what Crary and Peoples wanted.

Q: Like Jim and I have blanket orders that say we're authorized to go anywhere, essentially, in the world; but was there anything specific in those orders that said provide all assistance requested...

A: I suspect so. I too, have had such general orders -- do as someone may deem necessary. In fact I have a copy of my

1944 orders that say such things here. But you'll have to talk to Trakowski. My feeling is that he and Peoples provided the interface to the base and we just weren't bothered. We never saw anybody in security. There was certainly nobody keeping us secure. If anything, we were keeping ourselves secure.

Q: These are the pictures taken in General Ramey's office, 8th Air Force Headquarters by a news photographer of the Fort Worth Star Telegram. It's four pictures that show various people with some equipment, and I'd just like to know what you believe that equipment to be.

A: Joe Fletcher has written your friend Todd, and said there's no question that's a target. The only question is that there are people who allege this is a target that's been substituted for the real debris, and there are also stories where Marchelle said the picture in which he appears are the real stuff, etc. That looks very much like our radar targets. And you'll notice that this does look more aluminum foilish than what I have here. It's my memory that there was good, bright, aluminum metal foil, not painted stuff on the targets we were using. That looks like more than one target to me in the various pictures. That looks like the stuff we were flying.

Q: I think they talked in terms of being a rawin target in this book.

A: It's just radio wind. There are two kinds of radio winds -- the 400 megacycle transmitters tracked by the SCR-658, the old bed springs; and then the radar wind. Ray Win is the right way to say it.

Q: So the rawin would be a radar target that most of the officers and the weather people there would have been associated with, they would have some knowledge of?

A: Not really. As I say, these came out right at the end of the war. The warrant officer, I have a letter that he wrote Todd, I don't know if you've seen it...

(Pause)

Q: We've got this thing narrowed down to just a few flights. There couldn't have been... Due to your time frame, when you were there, the rancher went on the record of saying he picked it up the 14th or the 15th.

A: The 14th.

Q: So it would have to be in the June field trip, early in June. You had several service flights but you also had, you called them experimental flights. The experimental flights with the testing...

A: The ones in early June were all service flights. In other words, all flights we were making for Peoples, and we had some radar test flights.

Q: So to go with the June 14th date, what type of flight do you think would have...

A: All the balloons launched in that period would have been meteorological balloons, 350 gram meteorological balloons, some of them with radar targets just to test the radar out and some of them, I'd forgotten all about it, but Crary's diary says we had sonobuoy microphones on some of them. So that black box that Cavitt had really began to get my attention.

Q: That would not be a radiosonde.

A: That would not be a radiosonde.

Q: What would a radiosonde look like?

A: It would be a white, usually a cardboard or a plastic box, and the fact that we were involved in radar is because we weren't allowed to have our radiosonde equipment. We weren't all set up for that.

Q: You said you didn't bring it with you.

A: We didn't bring the receiver. I have to correct myself, we did attach radiosondes to them, to the flights carrying microphones because there's a statement in this summary here of radiosonde reception. Radiosonde recording. So I take that back. Yes, we had radiosonde. But we did fly this one mentioned here, on June 4th, out to Tulerosa range, no balloon flight, again, on account of clouds. By that he means none of their flights. Then "Flew regular sonobuoy mike on a cluster of balloons and had good (inaudible) receiver on ground but poor on plane."

Q: I notice early on you were going ahead with the Navy stocked sonobuoy while Professor Ewing was trying to perfect his technique of the low range frequency microphone.

A: Oh, the low frequency microphone, right. That's correct.

Q: He was experimenting with both AM and FM, is that your recollection?

A: In the laboratory, devices for measuring low frequency acoustic waves were well known, but what he was attempting to do was to modify these and devise something to be a throw-away microphone and radio transmitter, so this was to build an instrument for a certain purpose. He actually had a fellow named

Joe Johnston, the electrical engineer at Columbia, whose name will come up as the person who did these.

Q: But you think in these early service flights you did have sonobouys?

A: Initially we had sonobouy, according to Crary. We initially were flying radar targets on the balloons only. Then by about Flight 5, we'd had sufficient lack of results that we began putting radiosondes on.

(Pause)

Q: The end report we're going to write is going to be based on official records, and essentially, transcripts such as this. So there will be a lot of things, Cavitt's tape, the transcript will not be part of that. This statement will be.

A: If you remember, there's a note in there from Dave Atlas to Colonel Duffy, a copy of a letter. Dave mentioned somewhere or another that Colonel Duffy took him down in the basement and Colonel Duffy had trunkfulls of documents that were unclassified. I wonder if it would be possible for you to contact Mrs. Duffy...

Q: I was wondering about what she might have.

A: She may have a great deal. Maybe in the Duffy file I have the address and phone number. I think it's Barrington, Rhode Island.

(Looking for name and phone number)

A: Here's a letter Todd got having to do with chasing down modern targets, the people who now make targets, who know nothing about this earlier affair.

Q: We talked with the Signal Corps up at Fort Monmouth and that's where we got the copy of the engineering drawing, which is a copy for you. They said these targets are no longer made. They have a national stock number and they can be made, but they would have to go out and write a new contract for them.

A: This is the C Model. It doesn't show the reinforcements.

Q: The young lady I talked with at Fort Monmouth indicated this drawing pre-dated that time frame. June of '44.

A: I'll be darned.

Q: I found that unusual when she said that was June of '44, and I didn't pick up on the designation being printed on the side. I thought the B Model was a 1947 vintage and assumed, wrongly so, that the C Model would have come later.

A: This, then, is really... So they didn't change the numbers. It does show the little swivel there, in '44. Well, as always, my memory can be improved.

Tibbetts, the radar lieutenant working for Fletcher, said that when they got these in '44 there was a lot of trouble with breakage in the air and they had to go back for reinforcement.

Q: That's where maybe the tape came in?

A: He said that's where the tape came in. Because it certainly doesn't show this. There's just no question in my memory, bad as it may be, that there was a tape there. That impelled me to drag out Herbert Crow's letter. While I'm finding that, here is a communication between Todd and a Warrant Officer Newton, who identified things in General Ramey's office.

(Pause)

Q: It says a material like mylar. Do you have any knowledge of when that term came into use? mylar is a polyethylene, it's a metalized polyethylene.

A: It's not really a polyethylene, it's a polyturpoline...

Q: I'm not a chemist.

A: It's really quite a different thing. We certainly got involved with mylar balloons in General Mills around 1950 or 1951.

Q: Nothing that early, though.

A: I think not. It was really quite a new plastic. This is mylar. As you can see from the appearance, it's really quite different than polyethylene. It's non-extensible, where this really stretches. This scatters light and this doesn't. We have flown mylar balloons and mylar balloons vacuum coated with aluminum, but I think we didn't fly any in this era. It would be my guess that someone is sort of confusing this with later things. There were a lot of mylar balloons carried on rockets, and it was called Jim's sphere. Someone named Jim came up with the idea of increasing the turbulence around a following sphere by putting a little protuberance, little combs out on it. That was Jim's sphere. A lot of them were flown to measure winds in the low ionosphere, flown on rockets, from White Sands. They could well have fallen, but to my memory, it would have been anachronistic, out of times.

Here's a letter to me from Herbert Crow who was one of my technicians in the 1948 operation. These pictures you saw, including that debris, are pictures that he sent to me with that letter and a subsequent letter. These are pictures taken by Crow.

Q: When did Alamagordo become Holloman?

A: Probably about September of '47.

Q: It says HAFB on the back of the truck.

A: Those pictures were taken during the Sandstone operation in April of '48.

Q: I take it the side arm was for protection against rattle snakes?

A: Good question.

Q: Some of the popular writers have alleged that certain persons were turned away by armed guards, etc.

A: Not in our area.

Q: I mean as far as the so-called...

A: Oh, out at the ranch.

(END)

21

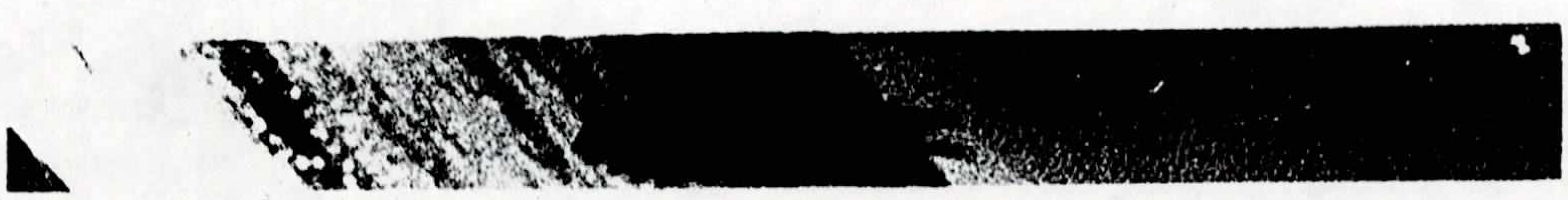
Appendix 21

Progress Summary Report
on USAF Guided Missile
Test Activities
August 1, 1948

49-539

VOL. 1 1 AUG. '48 NO. 10

COPY # 50



49-529

HOLLOMAN AIR FORCE BASE
Alamogordo, New Mexico

P R O G R E S S S U M M A R Y R E P O R T

on

U. S. A. F

GUIDED MISSILE TEST ACTIVITIES

Compiled by:

D. M. BROWN,
Major, USAF,
Director of Technical
Information Division

Reviewed by:

THOMAS R. WADDLETON,
Lt. Colonel, U S A F
Deputy for Operations
and Projects

Approved by:

PAUL F. HELMICK,
Colonel, U S A F
Commanding

[redacted]

Vol. I 1 August 1948 No. 10

Copy # 50

radar station was not troubled by this phenomenon due to its antenna directivity and elevation orientation of 60 degrees. It is believed that the intermediate loss of signal by the radar station is normal because of elevation pattern lobing produced by ground-reflection interference which is initiated by secondary antenna lobe transmission. Since this condition exists in the transmitting pattern, it affects both the radar station and its remote receiving station. Current effort is concentrated on improvement of photography and antenna orientation in preparation for additional tests.

b. Tracking Projects:

(1) Radar Tracking Set AN/MPS-6 - A letter was received from Watson Laboratories authorizing changes and modifications of the range circuits necessary for conditions as encountered at this location. The fore part of July was spent in achieving these betterments, and in the installation and orientation of an M-2 optical tracker to be used in conjunction with the MPS-6 and as a tracking aid.

Experimental tracking of three balloons furnished and flown by the Atmospheric Group was performed for the dual purpose of checking the signal return of the radar with various reflecting targets, and for precise position data of the balloon equipment for use by the Atmospheric Group. On 19 July, a 130 foot balloon carrying no radar reflector was tracked. Radar contact was made at a range of about 3K yards with signal return being above saturation on the scopes of the MPS-6. Tracking was automatic in Azimuth and Elevation and aided in range. Signal return remained above saturation until a range of 7K yards was read, at which point grass appeared on the scopes and signal to noise averaged about 4 to 1 out to a range of 23K yards where too frequent radar losses necessitated that automatic tracking be abandoned. This balloon was then tracked manually to a maximum range of 27K yards.

On 20 July 1948, a weather balloon carrying one kite type reflector was flown and tracked. Contact was made at a range of 3K yards, and signal return was above saturation at all times until a range of 10K was exceeded and grass showed only occasionally out to 24,360 yards. This balloon was obscured by clouds at a range of 33K yards, but tracking was continuous in automatic Azimuth and Elevation throughout its flight, and the maximum range read was 34K yards.

On 21 July, a 130 foot balloon, identical with the one flown on 19 July except for three kite reflectors being carried, was flown and tracked. Radar contact was made at a range of 1,510 yards. Grass first appeared on scopes at a range of 24.5K yards, and signal was above saturation to 30K yards. Tracking was continuous and automatic throughout the flight, and a maximum range of 121K yards was reached.

Permission to use the MPS-6 in tracking further V-2 missiles having been received, plans were formulated for operation in conjunction with the missile scheduled to be fired Thursday, 22 July and postponed until Monday, 26 July at 1100. Plans contemplated that the crew on the M-2 Optical Tracker would track visually at all times during the flight with their elevation and azimuth readings repeated on the antenna. The MPS-6 antenna was initially positioned in azimuth on the calculated bearing to the launcher and raised slightly above the horizon in elevation, with the correct range gated on the scopes and with a velocity of about 300 MPH set in the aided range motor and the motor initially stopped. It was further planned that when target echo would bloom on the scopes, the echo should be trued up in Azimuth, Elevation, and Range; and antenna control would be thrown to automatic with range followed manually until speed of the missile approximated the 300 MPH as set on the motors, at which time the video motor would be activated and range tracking thrown to "Aided." It was planned to throw antenna control to the M-2 Tracker only if target failed to show or if extended "loss" subsequently occurred.

During the half-hour period prior to the take-off, several random aircraft were noted in the vicinity of the launcher; and at X-5 minutes, one low flying aircraft was observed on the scopes at a range beyond the launcher directly in line with it and flying in towards the launcher.

Timing signals and the zero signal were received, and at about X plus 2 seconds the target "bloomed" on the J Scopes at the calculated range to the launcher (62,800 yards). This pip went almost instantly to far beyond saturation, and all grass disappeared from the scopes. The Azimuth and Elevation, and Range controls were centered on the target, and antenna control was thrown to automatic. Range started to slowly increase as did elevation with azimuth being stationary. The echo remained beyond saturation for about two seconds after automatic control was thrown in, at which time grass appeared on the scopes and the signal fell rapidly to zero and the antenna whirled off target at about X plus 6 seconds. Upon returning antenna to position manually, a strong target appeared at a range of about 2K yards outside the range gate, and believing this to be the rocket, this pip was trued up and antenna locked in "Automatic" and this target was tracked for a period of about 10 seconds or until it was noted that range was decreasing and elevation was stationary at the horizon while the M-2 Elevation repeater showed the optical tracker to be looking at approximately 50 degrees. Realizing that the target being followed was the aircraft noticed before take-off, antenna control was transferred to the optical tracker and left in its control until the M-2 crew lost the missile. During this time, no target was visible at any time and no further radar contact was made with the missile. However, slightly before the missile impact was heard, a cluster of small echoes were found at a

22

Appendix 22

Interview
Col Jeffrey Butler and
1st Lt James McAndrew with
Col Albert Trakowski, USAF(ret)
June 29, 1994

Colonel Albert Trakowski
29 June 1994

Q: We have connected independently from several other researchers the fact that Mogul is probably responsible for the so-called Roswell incident... The Air Force position on that is that it was a misidentified balloon. The balloon was not a weather balloon, but was then a classified project, Project Mogul, which has since been declassified.

What we have not found is any documented evidence that there was a planned cover story related to Project Mogul. Jim has culled through literally millions of pages in various archives and repositories trying to find some sort of documented evidence where somebody at some level has stated that a cover story of weather research or weather-related activities would be used for Project Mogul, the real purpose of which was nuclear detection...

(Pause)

A: ...All of that is to say that I know these people, and I know of what their involvement was, so I can at least give credibility and corroboration to what it was they did and where they fit in the picture.

There have been several writers who have been interested in this story and they have been in touch with me. I have given them a lot of words, and in some cases documents that I had in my personal files. They were at first a Charles Todd, from Ardmore, Pennsylvania, who was writing a story, and I never quite could determine whether he was on the side of the believers in UFOs or was writing to refute the believers. That I really was unsure of. One thing, he did appear to be sincere in getting the facts that surrounded the matter.

Another was a Charles Ziegler, a professor of physics at Brandeis University who was writing a monograph or perhaps a book on the history of nuclear weapons detection. It figured, of course, that Project Mogul would come into view. So he had done a great deal of documentary searching and had found some documents that I did not have. For example, the original letter form Maurice Ewing to Carl Spaatz, then Chief of Staff of the Air Force. And some of the original letters of General Spaatz directing the establishment of Project Mogul. All of this apparently Charles Ziegler apparently found, and I did not have them at all.

Another fellow recently came into view, a Carl Pflock from Albuquerque, New Mexico. He appeared to want to substantiate the existence of the UFO incident as a UFO. I have a tape here, a one-sided tape, my half of the conversation only, with him. You're welcome to listen to that.

Charlie Moore has been in it since the beginning. Charlie was not a general project scientist or engineer on Project Mogul. His efforts were confined to the development of the constant level balloons which were the instrument carriers for the devices that we hoped would pick up the sound waves operating in the sound channel in the stratosphere. The constant level balloon was the lifting mechanism, and Charlie was the principal in the development of that.

All of these things I have recorded on this tape to Mr. Pflock and also on the tapes that I made for Ruth Liebowitz, the historian at the Air Force Cambridge Research Center.

Maybe the best thing to do before plowing over all this old ground would be to consider some specific questions you may have. In the course of that, the history may come out.

Q: Were there any documents, or were there any directions either from yourself or from someone else up the chain to develop a cover story for Mogul?

A: Not to my knowledge, no. I have never seen such a document nor have I ever heard of any effort to develop a cover story for Mogul. The security of Mogul was a great concern of mine from the very beginning, because it was like trying to hide an elephant in an open farmyard -- almost ludicrous.

Q: Both Dr. Spilhaus and Professor Moore had indicated that they did use weather research as essentially cover stories when asked questions about what they were doing.

A: Correct. That we did. I'm aware of that. But it was not a policy. It was, if anything, a lash-up idea on the spur of the moment. And indeed, it was obvious. I may have been involved in using such a story myself, but to the best of my recollection there was no official stimulation or documentation of doing that. If you find such a document I, indeed, would be surprised.

Q: In the course of the research projects you worked on, in that time frame, the post-war period, would they give you a cover story on any particular project, even other than this one? Would they say this is what you do, to say this? Or would they kind of leave it to you, that it was a classified project and you just didn't discuss it and you just avoided questions?

A: The latter. I have no recollection of a cover story being used on any project that I was involved in, or that a prefabricated cover story existed. No. I never encountered any such thing. We simply treated the security classification straight and did all we could to adhere to it.

Q: So you, as the project officer, you knew that Mogul was a Top Secret...

A: Did I know it? There was no way to avoid it. I was the project officer, succeeding Colonel Duffy, and all that history is in the tapes that I made for Ruth Liebowitz. I came into being as the project officer on Project Mogul about November of 1946. I had considerable background in nuclear weapons detection using devices that I had developed in the Signal Corps. I was an Air Force officer assigned to the Signal Corps as part of Colonel Duffy's office. Much to the chagrin of the Signal Corps hierarchy, I was appointed a laboratory chief in the Signal Corps for purposes of developing instrumentation that the Air Force required, and I did that. In connection with that instrumentation I conceived of an application of that instrumentation for use in detection of nuclear weapons. We conducted field experiments which at best were controversial, and at worst showed no positive result.

So my studies took me into the nuclear weapon problem. I had a background in physics, in nuclear physics and high energy physics and modern physics, so I had some understanding of what was going on. I then took over the development of the original weather radar prototypes that the Air Force required in 1946. I did that in 1946. From that position, I was transferred to Colonel Duffy's new position as project officer for Project Mogul in the Watson Air Force, Watson Laboratories. I took up that task, I believe, around November. Those dates I think are specific in the tapes I made for Ruth Liebowitz. November of 1946. Colonel Duffy was reassigned to Wright Field and I was the project officer. I was Top Secret control officer in addition to other duties. It being the only Top Secret project at Watson Laboratories at the time, probably ever. I remained project officer of Project Mogul through or move of the laboratory from Watson Laboratories at Eatontown, New Jersey, to Cambridge, Massachusetts, and combined my laboratory, which was then known as the Geophysical Research Directorate, with that of John Marchetti's Electronics Research Directorate, and the two components made up the Air Force Cambridge Research Center.

I continued in my position of the Director of the geophysics component until May of 1949 when I was relieved of the duty at my own request and returned to school at MIT.

Q: Up until '49 were you still on Project Mogul?

A: Yes, indeed. And Project MX-968.

Q: You were on-site in New Mexico when Charlie Moore was doing most of his work. Some of the early launches out of Alamagordo?

A: Yes. Jim Peoples and I went down to Alamagordo in earl July 1947 to assist and observe the prototype launches being done by Charlie Moore and his crew from New York University.

Q: You said you went in July of '47, so you were there only in July. Was that early in July?

A: Yes, it was early in July. Again, I think those dates are in this tape of my conversation with Mr. Pflock. It was early in July. The Roswell incident occurred after I returned back to Watson Laboratories. I wasn't involved in it at all. Really the only thing that I knew about it, after it happened, was that Colonel Duffy called me on the telephone from Wright Field and gave me a story about a fellow that had come in from New Mexico, woke him up in the middle of the night or some such thing with a handful of debris, and wanted him, Colonel Duffy, to identify it.

Q: Did he identify who the person was?

A: No, I don't remember the person at all. I don't remember who came from New Mexico, no.

Q: Someone came from New Mexico with this debris?

A: Yes, I believe that's correct.

Q: They came to his quarters?

A: Yes, at Wright Field, yes. He had quarters on the base at Wright Field.

Q: His family there?

A: Yes.

Q: Did he identify the type of debris?

A: He just said it sure looks like some of the stuff you've been launching at Alamagordo and he described it, and I said yes, I think it is. Certainly Colonel Duffy knew enough about radar targets, radio sondes, balloon-borne weather devices. He was intimately familiar with all that apparatus.

Q: What was his position at Wright Field?

A: He was on the staff of General Tom Reeves who was Director of the Electronic Subdivision of the Air Materiel Command, and under whose purview the Watson Laboratories was run.

Q: Why did they bring this debris to Colonel Duffy? Why didn't they bring it to someone else?

A: Probably questions about who knows about this project, put to people at Alamagordo. I'm not sure. I can't answer that with any firm knowledge at all.

Q: So you had no idea there was an "incident" until Colonel Duffy called you, and you were back in Massachusetts at this time?

A: At that time we were at Eatontown, New Jersey. But what you said is correct. I had no knowledge of the so-called "incident" until Colonel Duffy called me.

Q: Do you recall what day you actually departed Alamagordo?

A: No. No, I don't. I have a full file of my TDY orders upstairs. Right off-hand I can't tell you, but I was back in Watson Laboratories for several days before Colonel Duffy called me.

Q: Do you recall there being a Major Pritchard on-site?

A: I remember the name, yes.

Q: Did he work for you at Watson Laboratories?

A: No. He didn't work for me. I don't recall him working for me. I only had one major working for me, and I was a captain. He was a dull fellow... Right off-hand I can't remember.

Q: You were the Chief of the Applied Propagation Subdivision.

A: Yes.

Q: I've seen the organizational chart, the way those things go...

A: I was.

Q: You were at the top, and then down below, as a technical adviser, below your name on the chart is Major Pritchard.

A: Is that so? I don't remember. I simply don't remember. But if the chart says that, I'll go along with the chart.

Q: Major W. D. Pritchard. On July 10th in the Alamagordo newspaper, there's an article where it shows, it doesn't say when this was taken, but it says a Major Pritchard and his balloon group are demonstrating to reporters what these balloons and the various radar reflectors look like. Now Charlie Moore took a look at that and he said, "I don't recall there being any other balloon group in New Mexico or in that area at the same time we were there."

A: I think Charlie's right. I don't recall any either.

Q: So we were trying to figure out whether Major Pritchard was maybe a counter-intelligence type person or maybe he was there reviewing the security procedures, or maybe he was there for the promulgating, the cover story of weather balloon and weather research, so that Mogul would not come out in the open. Because the article in the paper talks about the use of reflectors for tracking purposes, the radar reflectors for tracking purposes, but never comes out talking about Mogul and the instrumentation that you all were using for nuclear detection or the tests that were being conducted.

A: Could Major Pritchard have been attached to or some way connected with the base weather station at Alamagordo?

Q: Well, sir, we don't know, but he is identified in that newspaper article as being a public information officer. When we traced that name back to your organization, we thought he may have been essentially undercover himself. We don't know that it's the same person, even though it's the same name.

A: I'm afraid that I can't offer any positive knowledge here.

Q: Were you associated with any counter-intelligence people in Watson Labs or...

A: Not to my knowledge. If some were around, they were spoofing me because I didn't know it.

Q: Were there any other types of intelligence persons on your staff or the staff of Watson Laboratories?

A: Not to my knowledge.

Q: So the only people you had were actually civilian researchers...

A: And a few military officers, yes.

Q: Signal Corps and Army Air Force?

A: All the officers that I had on my staff were all Air Force. No Signal Corps at all.

Q: A couple more names that came off that news article where they're displaying the balloon launch. It's Major W. D. Pritchard, Major C. W. Manglin, Lieutenant Siegal, and a Captain L. H. Divack.

A: None of those names are in my memory, firm in my memory at all.

Q: You were aware of the previous Colonel Duffy's predecessor, Major Crane...

A: I never met Richard Crane. I knew him only by the path of debris that he left behind. I never met him.

Q: When you took over, was there any worry about security on the project? That it was possibly a problem, there was a problem or there could be a potential problem that may warrant scrutiny by Air Force intelligence or security people?

A: We were aware of the delicacy of security on the project, and the reason was obvious. You could not conduct field operations of the size that we had without somebody asking questions. Anybody with a pair of 8x50 binoculars on the side of the mountain could look down and see what was going on and that, of course, would prompt questions, and we were aware of that, and didn't really know what to do about it except to go on doing our job and taking care of things as they occurred. But we were aware of the sensitivity and of the weakness of security in the Project Mogul. Not from the people in it, disclosure by the people, but simply the obvious activity that could be observed.

You can't fill a balloon that's give or take 60 feet high, without somebody seeing it.

Q: When you were at Alamagordo and some of the various balloons were being launched, what was the largest array that you saw out there?

A: You mean payload?

Q: No, the entire assembly. The balloons, payloads, reflectors...

A: I didn't observe any of the reflectors, and if I did, they were so common place that it wouldn't have stuck in my memory. The neoprene balloons bearing reflectors were just common occurrences. I wouldn't have lodged any of those observations in memory because they were just too common.

Q: Charlie Moore had indicated that some of the balloons they tried during the early experiments were relatively new types of reflectors that probably had never been used in New Mexico before, the M307B model. And that Ed Istvan had gone to several, essentially toy manufacturers, to try to get some of these reflectors made.

A: That's correct. I don't know that Ed Istvan... Ed Istvan got out of line. He may have told you this, and I don't mean to tell tales about Ed, but Ed was a very... Indeed, every man on Colonel Duffy's staff was very energetic. It was the Signal Corps' responsibility to procure those targets. Not ours and Colonel Duffy's office. However, to accelerate the activity of the Signal Corps and spur them on to action, our Air Force officers in Colonel Duffy's office, were literally on the backs of the Signal Corps people who did the job, and oftentimes did things that they shouldn't have done and were out of channel, so to speak. It was on such an occasion that Ed Istvan acted to line up contractors for these targets. He got into a considerable amount of, shall we say, controversy with the Signal Corps because he was out of line.

Q: Do you recall any of the contractors he may have worked with?

A: No, I don't remember them by name. They were not within my purview at the time. As I have told others, including Mr. Pflock, we had an outstanding expeditor on our staff, on Colonel Duffy's staff, by the name of John E. Peterson. Jack Peterson was a major at the time. He was a pre-war graduate of Harvard Business School, and he knew business operations inside and out. Again, he was an extremely energetic fellow. He was very, very valuable and successful at breaking loose stuck contracts and stuck production and things that weren't moving as fast as they should. During the war that was very important.

Jack monitored the procurement of these radar targets, and I believe Ed Istvan either worked for or alongside of Jack Peterson, and I remember when they finally... Now this was all not under my purview, but I worked in the same building with them, and I knew Jack very well, he was a very good friend and we talked and joked with each other a lot. I remember so clearly when the contractor for these targets was selected and Jack thought it was the biggest joke in the world that they had to go to a toy manufacturer to make these radar targets. Then it was even a bigger joke when it turned out that because of wartime scarcities of materials, the tape that they used to assemble these targets, the reflecting material on the balsa frames was some kind of a pinkish purple tape with hearts and flowers designs on it. This was, again, a big flap.

Q: Did you ever see any of those?

A: Yeah, I saw some of them. Not in connection with my work, but they were around the office. The prototypes were around the office and the first production runs were there.

Q: So you would say it's a limited number of a few runs maybe.

A: I have no idea how many hundreds were made, or even thousands. But like everything else that goes into production, they have a limited production to begin with until they work out the bugs, and then they go full blower in the high production.

Q: Do you remember a rough span of times that you remember seeing these? When you saw the first one and when you saw the last one?

A: It was probably 1944 or 1945. It was probably late in 1944 when the first ones were produced.

Q: Where did you see those? What part of the country?

A: Right there at Signal Corps. We were all working at that time, and John Peterson had his offices in a location called the Toms River Signal Laboratory, which was actually located on the jurisdictional lines between Siegart and Spring Lake, New Jersey. It was an old night club that the Signal Corps had rented for the purposes of doing remote experimentation.

Q: The Siegart Inn?

A: Exactly. That's where John had his office, and I was there for a time doing work on developing the operational procedures of the SCR-658, the radio direction of wind, meteorological data. Rawin sonde I did most all the work on developing how to use that instrument, and it was done there at the Siegart Inn.

Q: Do you recall any other physical attributes about the radar reflectors, the balsa wood? Charlie Moore had indicated that the material had been coated in something like Elmer's glue which made it much more durable. Do you recall anything like that?

A: No, I don't. I didn't concern myself with that except as an observation to the side. The radar targets were geometrically elementary. They were three intersecting planes -- X, Y, and Z. The geometry of them was such, as you well know, that any incident wave would be reflected exactly, precisely, in the direction from which it came. So they were simple. I don't recall any of the details of how they were made or what materials were used or the coatings or anything. At the time it wasn't within my range of job.

Q: Did Colonel Duffy inform you officially? When he said he called you, was this like an official...

A: No. It was just an informative call. There wasn't any official transmission of knowledge nor expected action to result from it.

Q: Did Colonel Duffy consider this to be some sort of security violation?

A: No. Not to my knowledge, no. It's part of doing business.

Q: So he wasn't particularly upset, and he didn't require a formal explanation.

A: No.

Q: So that's the first you were aware, when he called you. None of your technicians had mentioned it to you?

A: No. Not to my knowledge.

Q: Did you have any interaction with the people at 8th Air Force such as General Ramey or anyone else who may have been at Roswell Army Air Field?

A: No. I don't recall any interaction with them, no.

Q: What about Dr. Crary or Dr. Peoples? Do you know if they had interaction with those folks?

A: I don't recall any, no.

Q: At some point in Project Mogul did you utilize equipment based at Roswell Army Air Field?

A: No, we had our own aircraft based at Fort Dix, New Jersey.

Q: Did you ever have a rawinson receiver at Roswell?

A: Not to my memory. No. We may have, but the specifics on that, I don't recall.

Q: Can you think of any reason why Dr. Peoples would meet with one of the bomb squadron commanders at Roswell in September of 1947?

A: Probably to arrange air drops of bombs as signal sources for testing the Mogul sound receivers. We had a fellow that was assigned to the electronics test squadron at Fort Dix by the name of Duff, Eugene Duff, who was an ordnance expert and he may have been involved in arranging bomb drops which would have been exploded in air as a sound signal source for the purpose of testing the Mogul receivers.

Q: Did you also procure aircraft from Middletown, Pennsylvania?

A: Yes. I believe our electronic squadron was moved from Fort Dix to Middletown. To Olmstead Air Force Base. When that was, I can't exactly pinpoint, but it was probably some time in 1947. Gene Duff, our ordnance man, was a part of that group. I don't know whether Gene Duff still lives or not, but he is a name that you might look into. Eugene Duff.

Q: Has anyone asked you to explain what happened at Roswell? In your opinion, what happened?

A: Until these recent inquiries, I don't recall anyone asking me to explain. I don't recall it ever coming up for me to answer in connection with the Mogul tests. I don't recall that. You know, things happen every day, and you treat crises from moment to moment as though they were so much cord wood. They aren't all worthy of memory. But I don't recall it.

Q: Other than our conversation here today, has anyone ever discussed with you not talking about Mogul? It's essentially declassified, it is no longer a classified project, but has anyone in the government -- the Air Force, the Army, Department of Energy or anyone else, ever said don't discuss this?

A: Absolutely not. No such thing.

Q: What we're trying to do is make sure we are open to the General Accounting Office and to the American public in general when we publish our reports. So all the people that we've discussed this with, we want to make absolutely sure that someone has not come to them and said you're going to get in the cover story, because we want this to be as open as possible and get this thing resolved once and for all. There are going to be those, as you stated, the true believers, who may not accept what we have to say, but we just want to try to get everything out in the open.

A: It's about 45 years since all of this happened. Even at the time, as I mentioned a moment ago, one gets very busy in a project of this sort and you treat rather large events as they come, and you give them action and then you go on to the next one. All of them don't stay in memory.

Q: We understand that you've been contacted by various people such as Mr. Pflock and Mr. Todd and we do appreciate you spending some time with us in this endeavor. We think it's very valuable for those people who were actually on the scene to provide their accounts of what actually occurred. It is valuable to us and we do appreciate that.

A: I wish I could be of more help on this thing. Apparently, things like this die very hard. (Laughter)

Q: Did you ever hear of any intelligence people getting involved in this thing? Colonel Duffy mentioned that some of the people at AMC maybe wanted...

A: No, I don't. Certainly no intelligence people... Certainly I was not involved with any intelligence people in this matter. If I was, I don't recall it. Colonel Duffy and the group at Wright Field protected me greatly, and I know that. They never said that, but I know they did because they left me free to do the project. And anything that would interfere with getting that project done as quickly as could be done, they would try to steer it away from me. I know they did that. Again, they never said that, but the action was obvious.

(Pause)

A: ...I was assigned for about two months to AFOC-1. Then Colonel Benjamin Holtzman, later General Holtzman, pulled me out of AFOC-1 and sent me to Baltimore because the Air Research and Development Command had just been organized, and I arrived on the scene while they were still trying to find chairs and desks. we worked in the old Sun Newspaper building in downtown Baltimore.

Q: They had intelligence personnel there, didn't they

A: They may have. I'm not aware of that. Then after I left the headquarters of ARBC in Baltimore, I spent four years at the Air Force Research and Development Command Office in Brussels, Belgium. Following that, I spent over three years on the Air Staff in the Pentagon.

Q: What year did you retire?

A: On my birthday in 1963. I then went into industry, and I worked for EG&G, a high technology company based near Boston, and I became a Vice President of one of their subsidiaries. I became the project manager and developer of the National Space Science Data Center at Goddard, in Greenbelt. I built that and set it up.

Then when the EPA, the Environmental Protection Agency, was formed in December of 1970, I was invited to join the newly formed EPA, and I did. I accepted the position. I went into the EPA as a Deputy Assistant Administrator in the Office of Research and Development. Then in 1973 and 1974 I was made Assistant Administrator for Research and Development in the EPA, the position from which I retired in 1982.

Q: Then did you have interaction with Spilhaus in your civil service career?

A: No. Oh, I met with him. Spilly was a consultant, and he even in his advancing age he was still an enormous source of ideas. If you brought him into a meeting as a consultant, surely somewhere along the line he would offer an idea that was useful. So he found a lot of contact throughout many organizations, particularly in those related to geophysics. Meteorology, geology; I know the worked with the U.S. Geological Survey, a very, very fine organization, and with NOAA. Those are two that I know he continued relationships with. But I had very little contact with him.

Spilly was a very intimidating character. I lived with him for awhile.

Q: Were you involved in his exploits in North Africa, out there in the desert with him?

A: No. Nor in China.

Q: He had quite some stories about some of his past exploits.

A: No matter where he went, he gathered stories.

(END)

23

Appendix 23

Review of USAF Geophysical Test
Activities by Brigadier General
D.N. Yates and Staff of the
Air Weather Service
February 10, 1949

[redacted]

[redacted]

47

copy?

Review of Air Materiel Command Geophysical Activities by
Brigadier General D. N. Yates, and Staff, of the Air Weather Service

Cambridge Field Station
Air Materiel Command
Cambridge 39, Massachusetts

23

PROGRAM

10 Feb. 1949

I. Introduction

II Tour of Geophysical Research Laboratories

a. Review of Facilities

b. Project Presentations

III Discussion

DOWNGRADED AT 12 YEAR INTERVALS; NOT AUTOMATICALLY DECLASSIFIED. DOD DIR. 5200.10

~~EXCLUDED FROM GENERAL DECLASSIFICATION SCHEDULE~~

[redacted]

38

[redacted]

2-1081

J. TERRESTRIAL SCIENCES LABORATORY

Chief: Dr. James A. Peoples, Jr.

1. Project title: Acoustic Sounding of the Atmosphere

Project scientists: Dr. J. A. Peoples, Jr., Dr. Norman Haskell

Summary of In-Laboratory work:

When large explosions have occurred, it has been observed that the sound was heard locally, say up to 25 miles, and also at distances of 100 to 200 miles, but that nothing was heard at intermediate distances. This phenomenon can only be explained by assuming that the sound is refracted into the atmosphere over the intermediate observers and then is bent back down to the more distant areas. For this to occur the velocity of propagation must first decrease with altitude and then increase again to a value at least as large as ground velocity. This is due to a decrease of temperature up to the tropopause followed by an increase in temperature above that level. Winds also have an appreciable affect which can be determined from asymmetrical propagation.

Up to about 1946 most data on this phenomenon had been obtained by taking polls after accidental explosions had occurred. Zones of audibility were mapped out and general conclusions then drawn. Very little systematic work was done in which accurate travel times and other factors were obtained. Beginning in 1946 at these laboratories, a systematic study of these propagation anomalies were started. Sound ranging detectors were set up in arrays, so that the direction and time of arrival of compressional waves could be determined. Explosions were set off on or near the g ground at ranges varying from 25 to 200 miles. Data has been taken which has resulted in the indirect determination of the temperature (sound velocity) structure of the atmosphere up to the stratospheric level. East-west propagation was first studied off the New Jersey coast. These tests show there is little or no regular diurnal variation, and that some annual variation in the temperature structure exists. High level winds are shown to be generally easterly. Additional tests have been made in New Mexico to determine the diurnal and annual variations of the temperature structure at that latitude. Some accurate observations of wind velocity are indicated by observations taken along a north-south line as well as an east-west line. Winter observations have been taken in the vicinity of Fairbanks, Alaska for information on at very high latitudes. Observations have been taken near the Panama Canal Zone for additional information in the tropics.

The sounds produced by rockets launched at Alamogordo have been recorded with acoustic detector arrays located on the ground near the rocket trajectory. From data gathered in this manner, some indications of upper air temperature and winds have been obtained and much more accurate determinations could be made if the rocket trajectori were more accurately known.

[redacted]

Additional details of the atmospheric temperature and wind structure can be obtained by placing microphones near the tropopause where the velocity of sounc is at a minimum. To our knowledge, no one has ever tried such an experiment, and in order to do this new equipment had to be developed, since wind produces strong noise in any microphone it was obvious that the detectors could not be used on an aircraft, It was further believed that the noise level of an instrument placed on a constant level balloon would be far below that generally observed on ground equipment. Both a satisfactory constant level balloon and a light weight microphone and telemetering system has been developed in this laboratory.

Basic acoustic propagation information is now being accumulated from equipments launched at Eglin Field Florida. The sound for these experiments is obtained from high altitude (20,000 to 25,000 feet) bomb bursts. Sufficient data have not yet been obtained to justify complete analysis, but it can be stated that observed results generally agree with predictions based upon theory.

Observations of the travel times of waves from an explosive source has yielded a considerable amount of data on the temperature and wind structure of the atmosphere up to altitude of about 50 km (160,000 feet). The interpretation of the data has so far been based on geometrical wave theory, and leads to a variation of propagation velocity with altitude which is in reasonable agreement with other lines of evidence. There are, howecer, several observed facts which cannot be explained on the basis of the elementary geometrical ray theory, and require a more complete analysis in terms of wave theory. They are: --(1) the "zones of silence", that follow according to geometrical ray theory from the initial decrease of velocity with altitude, which do not have sharply defined boundaries; (2) the same apparent angle of arrival is often observed over a considerable range of distance from the source, whereas on the ray theory a given angle of arrival was associated with one particular distance only; (3) at large distances, the total duration of the signals rec is very much greater than can be explained by ray theory, and the character of the signal received is that of a long train of waves of varying amplitude and frequency rat a limited number of well defined transient pulses.

Preliminary studies indicate that all of these facts may be explained qualatatively by more complete wave theoretical analysis of the diffraction of wave energy into the regions that are zones of silence in the elementary ray theory, and furt work, aimed at quantative treatment is in progress. Until an analysis of this kind has been carried through, one can not feel too much confidence in attempts that have been made to use long distance sonic and microbaremetric wave propagation data to deduce atmospheric temperatures at levels above the second inversion.

In addition to the theoretical approach to this problem, consideration is being given to the use of surface waves on shallow water as a model of wave propagation in the atmosphere. The velocity of surface waves whose wave length is greater than the depth of the water is a function of the depth, so that the variation of veloci with altitude in the atmosphere can be simulated on a thin sheet of water by suitable contouring of the bottom. Surface tension and visosity set at a lower limit of about 4 cm. to the wave lengths that can be used in such a model. With a water table about four feet wide simulating the atmosphere up to 50 km. a four centimeter wave length would represent a wave length in the atmosphere of about 1 mile, or a period of about fi seconds.

 [redacted]

Complementary Contracts:

a. Columbia University
No. W28-099-ac-82

b. University of California at Los Angeles
No. W28-099-ac-228

c. Woods Hole Oceanographic Institution
No. W28-099-ac-227
All contracts on: "Consultation and Assistance in Research on Atmospheric Acoustical Wave Propagation."

2. Project title: Development of Constant Level Balloons

Project scientist: Dr. James A. Peoples, Jr.

Summary of In-Laboratory Work:

The development of a constant level balloon was at first motivated by the needs of the acoustic upper air sounding program. As it has developed, this balloon is now a principal atmospheric probing tool in its own right. In order to develop this balloon several special devices have been invented. An Olland cycle pressure indicator, accurate to better than one millibar, has been developed. A device has been constructed which will deflate and bring down balloons in flight either by timing or by pressure activated mechanisms. A balanced flow control valve has been made which gives a constant flow of ballast material proportional to pressure change. Other accessories include a telemetering device to indicate the rate of ballast flow, minimum ballast flow, minimum pressure switches, barographs, and balloon tracking radio transmitters which can be picked up by an aircraft radio compass at a range of 100 miles or more. A sensitive intergrating vertical anemometer is now being developed which will aid in the interpretation of atmospheric oscillations.

A thorough investigation of balloon materials and fabrication methods has been conducted, and balloons have been designed suitable for use with the balisting mechanisms developed. Launching and operational techniques have been developed which permit the launching of balloons in winds up to 20 per hour. Good control of ascent rate and ceiling altitude has been obtained. Constant level flights of several hours duration are now routine and flights lasting up to 5 hours with pressure variations not greater than one or two milabars have been obtained. Simplified control which operate satisfactorily during the day or night are not adquate when sunset occurs during a flight. A system for maintaining constant level thru sunset has been devised and tested in a bell jar, but in actual flight tests have not yet been made. Temperature measurements have been made both inside and outside of balloons to show the affects of super-heat. Temperature measurements have also been made in instrument and battery cases during flight. Measurements to show the actual characteristics of control devices have been made on balloons in flight and simulated in the laboratory. This

[redacted]

includes rate of ballast expenditure, diffusion, leakage, and stability of control.

By-product information of importance to meteorology or balloon flying techniques includes the following: Observation, measurement and theoretical analysis of high altitude atmospheric oscillations has been accomplished. These oscillations are several milibars in amplitude (as indicated on balloon baragraph traces) and the period of oscillation varies between 4 and 10 minutes. Air mass trajectories have been measured over ranges up to about 400 miles and have been indicated by the recovery of gear up to 2,000 miles from the launching point. Additional field tests on air mass trajectories are now being made.

Complementary Contracts:

a. New York University
No. W28-099-ac-241
"Development of Constant Level Balloon"

b. Melpar, Inc.
No. W28-099-ac-429
"Development of Balloon Telemetering System"

24

Appendix 24

New York University Constant Level Balloons Section 2, Operations

RESEARCH DIVISION
COLLEGE OF ENGINEERING
NEW YORK UNIVERSITY

Technical Report No. 93.02

CONSTANT LEVEL BALLOONS

SECTION 2

OPERATIONS

Prepared for
AIR MATERIEL COMMAND
Watson Laboratories
Red Bank, N. J.
Project No. 93
Contract No. W28-099-ac-241

Technical Report No. 93.02

CONSTANT LEVEL BALLOONS
Section 2

OPERATIONS

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.

Prepared by: Charles B. Moore, Project Engineer
and
James R. Smith, Project Meteorologist

Approved by: William D. Murray for
Professor E. N. Kemler
Acting Director of the Research Division

College of Engineering
New York University
31 January 1949
New York 53, New York

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

A. Purpose of Manual

This manual is designed to serve as a guide in the preparation, launching, and tracking operations of constant-level balloons. In the body of this manual, most of the discussion applies specifically to the 20-foot diameter balloon developed by General Mills, Inc. In Section IX, a brief description is given of the other sizes of balloons used for constant-level flight. The manual is based upon the experiences and investigations of the Constant Level Balloon Project, Research Division of the College of Engineering, New York University. The charts and tables which were developed to use for this work are included in Appendix II of the manual.

B. Principles of Altitude Control

For constant-level work, non-extensible balloons are used for three reasons:

(1) With a given weight of equipment, it is possible to determine before the release of the balloon, the maximum altitude which will be attained.

(2) Without special control equipment, it is possible to maintain a nearly constant altitude for periods from one to six hours, depending upon atmospheric conditions and floating level. Generally, it is not possible to extend such flights through a sunset.

(3) By adding altitude control equipment, it is possible to maintain the balloon at various nearly constant, predetermined levels for periods of much more than six hours regardless of the time of day.

II. GENERAL MILLS 20-FOOT BALLOONS

A. Description

General Mills, Inc. of Minneapolis, Minnesota, has developed a series of non-extensible, plastic balloons. These balloons are tear-drop in shape, made from extruded polyethylene sheet, 0.001" thick. Cells are currently produced with a diameter of 7, 20, 30 and 70 feet. The volume of the 20-foot cell is about 4300 cubic feet and its uninflated length is 38 feet. It is made up of 20 gores, heat sealed together in a butt weld. Along the seams thus formed, a special acetate-fiber scotch type tape (Minnesota Mining and Mfg. Co.,) is laid to reinforce the weld and to carry and distribute the load. These tapes converge to an appendix ring at the balloon bottom, to which the load harness is attached. By using this stressed tape design, much larger loads may be carried than the thin polyethylene alone could hold. To exclude air entering through the bottom, which is left open, an external skirt or appendix is added.

Figure 1 shows a 20-foot balloon ready to be released, with an external appendix in position. As the balloon rises, the lifting gas inside will expand until the balloon is full, whereupon the excess gas which was needed to make the balloon rise will be valved out. The full balloon will then float at a level where the buoyancy just balances the load. It will remain there until buoyancy is lost by diffusion of the lifting gas, or by cooling, as at sunset.

Neglecting minor effects, the amount of gas which is needed to just balance the load at the maximum or floating elevation would also just balance the load at any lower level, including the surface, although the balloon would be less than completely full at such a lower level.

B. Load Limits

For a given lifting gas, the altitude to which a balloon will rise is determined principally by the load it bears. With a 20-foot General Mills balloon, using helium, a payload of 40 pounds will reach approximately 46,000 feet and an 18-pound load will go to about 58,000 feet. Although the manufacturers recommend keeping the payload between 18 and 40 pounds, no trouble has been found in launching loads of as much as 70 pounds (37,000 feet) or as small as 4 pounds (67,000 feet).

C. Appendices

For highest altitudes and smallest sunset effects on a balloon, it is necessary to keep air from diluting the helium. To accomplish this, a check valve is required in order that helium may be valved when the balloon is full, yet air not be permitted to enter at any time. An appendix, consisting of a tube of balloon material, whose length is about 2 to 2½ times its diameter is used for this purpose, and is supplied as part of the General Mills balloon.

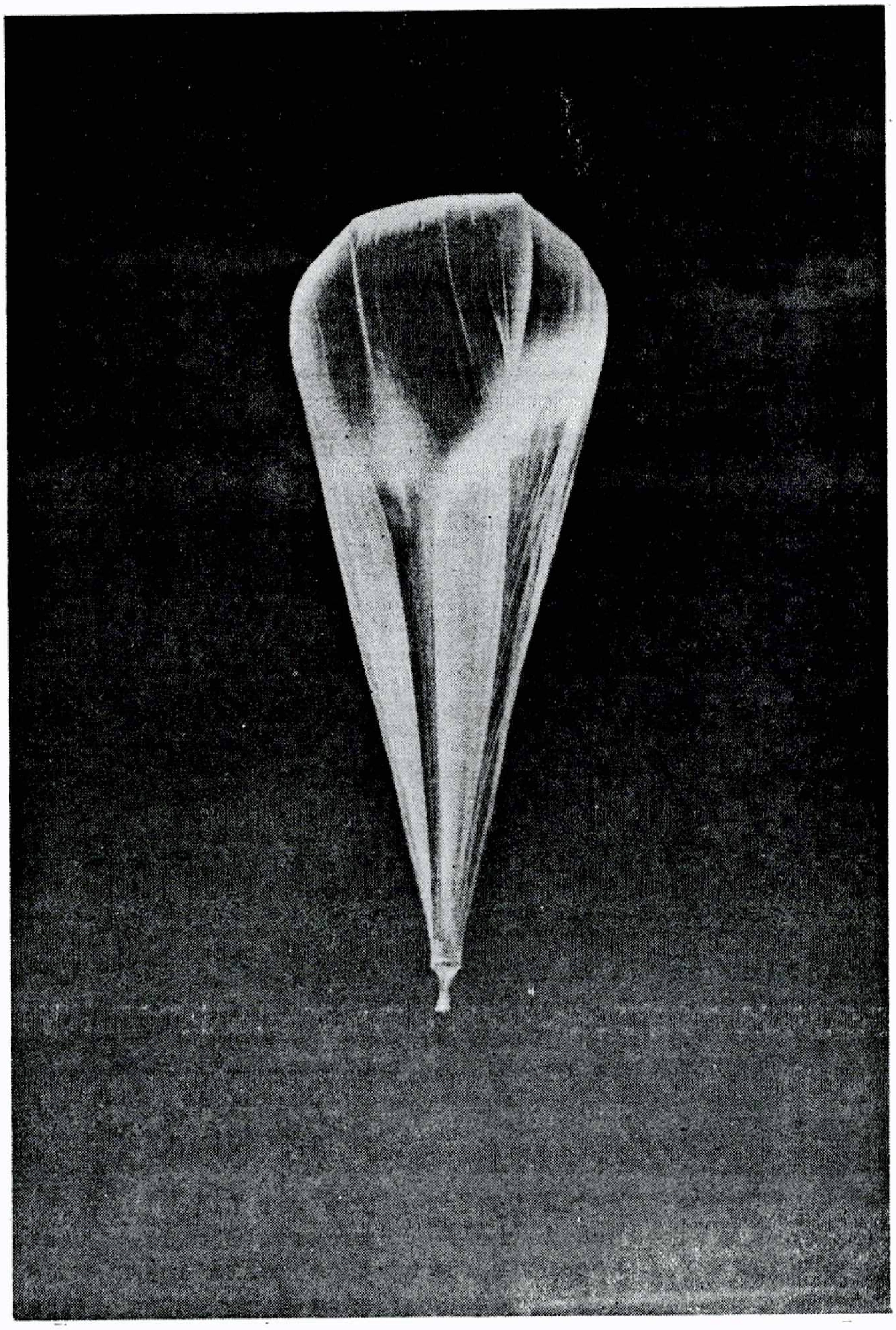


Figure 1
General Mills 20 foot balloon in flight with 2 foot appendix, stiffened with cardboard battens.

Stiffeners are added so that the appendix will not foul in the rigging. With a fouled appendix the helium cannot be valved, and the balloon after becoming full at its ceiling will burst. These stiffeners are taped to the outside of the appendix just before inflation.

The various appendix types which have been used are given in the following table:

Appendix Data

Appendix Type	Stiffeners	Effect on Altitude Attained	Effect on Descent
None	None	Ceiling is 10,000 to 20,000 feet lower than computed.	Balloon remains full at all times after ceiling is reached by taking on air. Greatly complicates control.
Standard	3 corrugated cardboard battens, $2\frac{1}{2}$" by 15"	Computed ceilings attained.	Balloon remains full at all times after ceiling is reached by taking on air. Greatly complicates control.
Standard	4 aluminum battens 15 x $\frac{1}{2}$ x .030" 24 ST	Computed ceiling attained if balloon does not burst due to restriction on appendix.	Air excluded during any descent fairly well.
Flattened Tube	Metal spring bow to hold appendix flat, like pressed trousers	Not yet flight tested. Similitude tests indicate computed ceiling would be reached with no bursts due to appendix at 1000 ft/min rate of rise.	Not yet flight tested. Similitude tests indicate almost complete exclusion of air.

Figures 2, 3, and 4 show the various appendices described in the above table.

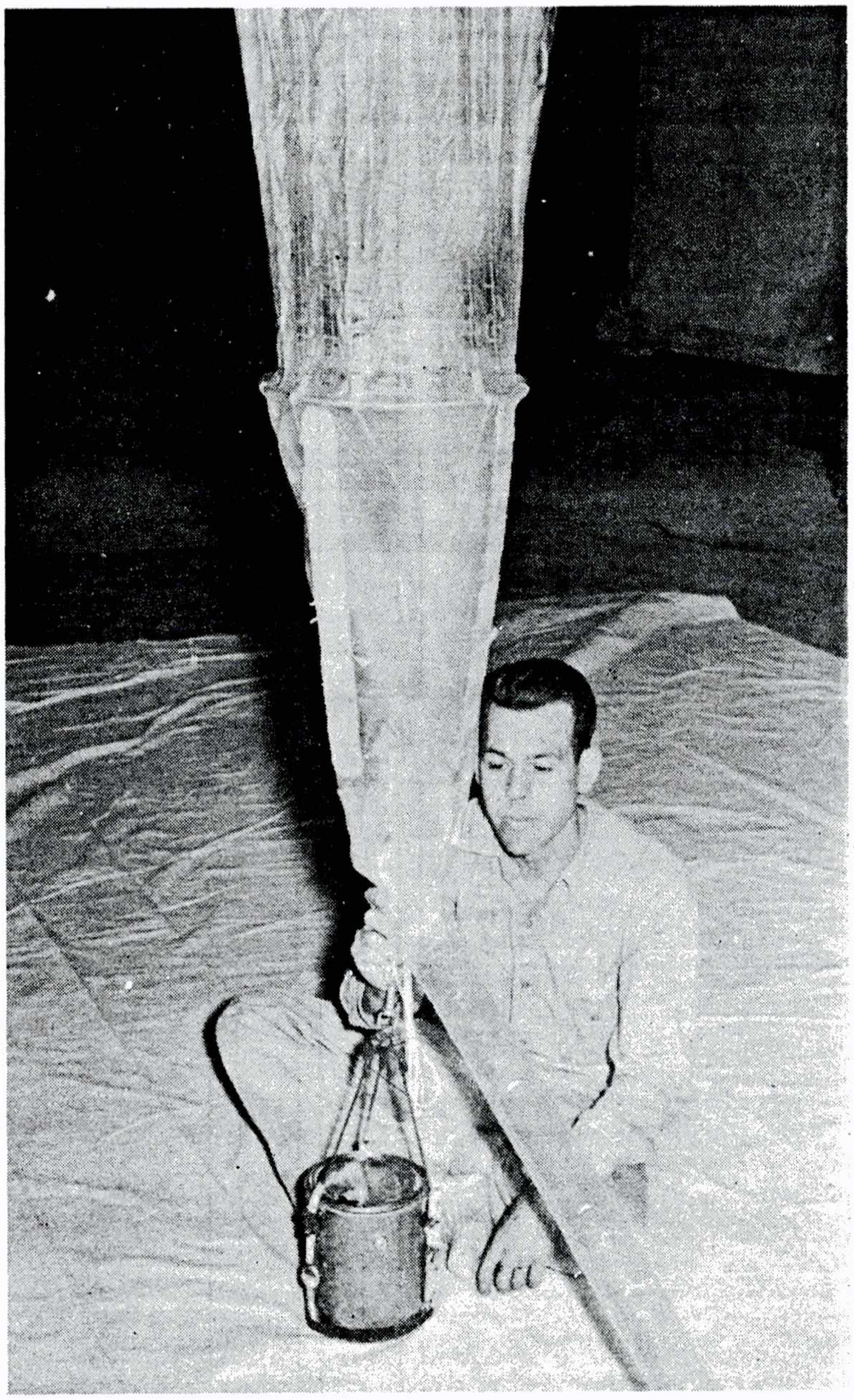
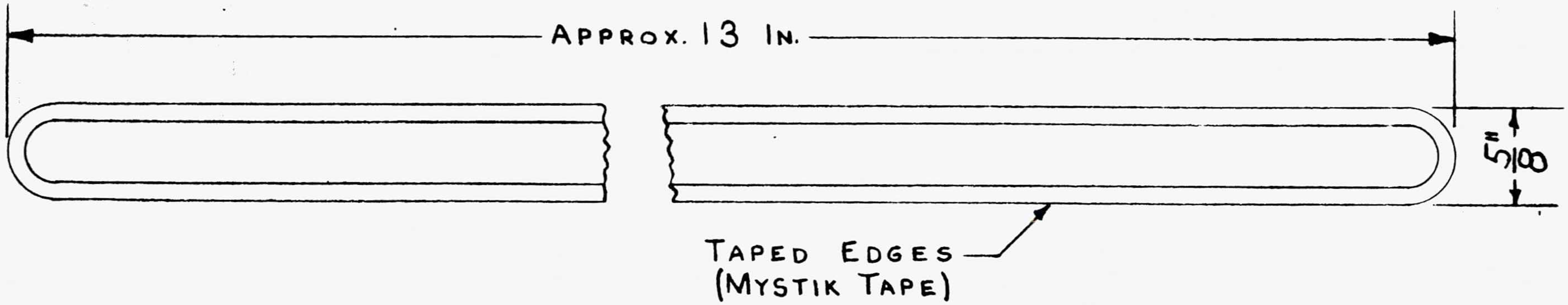
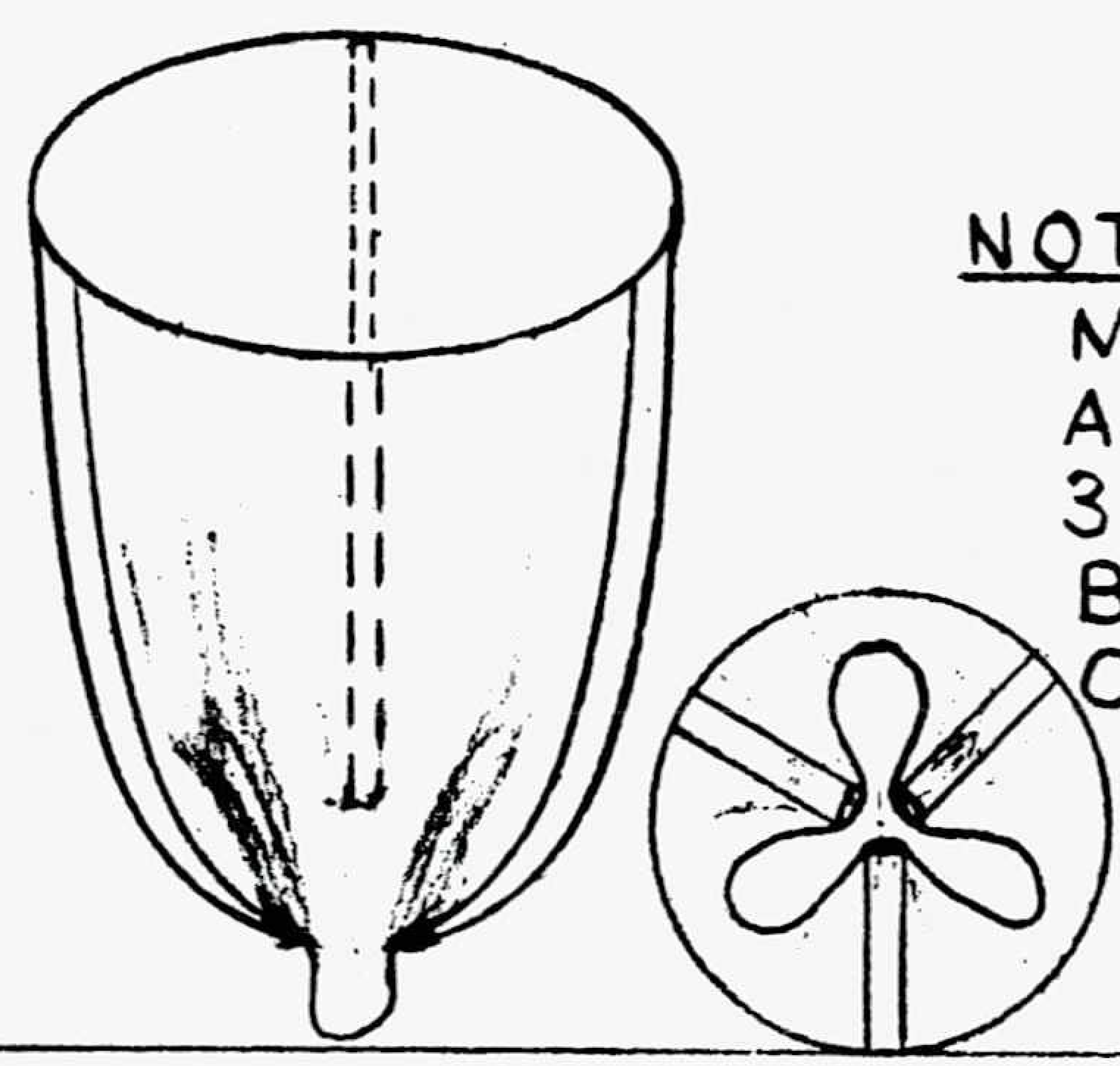


Figure 2
Two foot appendix, stiffened with card-board battens, shown on a General Mills balloon. The swollen inflation tube indicates that the balloon is being filled.





NOTE:

Mat'l: 17ST or 24ST. Al. Sheet-.032 Thk.
All Edges To Be Covered With Tape
3 Battens, 120° Apart
Bent In Field To Form Light
Closure Of Appendix

Fig. 3

Battens For G.M 20 Ft. Balloon	
DWN. BY LHM	ED48-95A
DATE 10-14-48	

Figure 4
Two foot appendix, showing
metal spring bow in position.

Since the back pressure forcing the helium out of a full balloon when it is rising is 4 times as great at 1000 feet per minute as at 500 feet per minute, the rate of rise is critical when an appendix is used. It has been found necessary to limit the rate of rise to 700 feet per minute to prevent bursting at ceiling when using General Mills 20-foot balloons with standard appendix. It is believed, from laboratory tests, that use of the spring bow stiffeners on the new appendix will permit rates of rise up to 1000 feet per minute. Flutter in the balloon fabric while rising is apt to cause failure due to ripping at speeds of more than 1000 feet per minute. A 20-foot General Mills balloon will burst with an internal pressure of 0.014 psi., which is about 1 mb., equivalent to a 200-foot rise at ceiling with a closed appendix.

III. EQUIPMENT TRAIN

A. Lines and Rigging

Following rigging failures early in the testing program, careful study was given to the lines and rigging methods used to attach flight instruments to the balloon. For safety in launching, a factor of 10 to 1 is used on all loads. Thus, if a 40-pound load is to be lifted, it is not safe to use less than a 400-pound tested line. The line strength should be determined independently if possible, since the actual breaking point of lines runs between 50 and 70% of the manufacturer's rated strength.

Braided or woven nylon is recommended for all rigging. A stranded or laid line is subject to untwisting in flight, twirling the suspended instruments and reducing line strength. The nylon material is weather resistant to a high degree and tends to stretch under shock rather than to snap. For some purposes it may be desirable to use a line of constant length, in which case the nylon may be prestretched. Only a few of the common knots are useful in tying nylon. Bowlines and square knots have been found to slip and are hard to untie. The carrick bend, shown in Figure 5, is recommended. In addition to this, a safety knot is made in the loose end, and the entire tie secured by a final taping. For convenience in assembly, the individual pieces of line and equipment are rigged with harness snaps at each end. This permits unit replacements or removal at the last minute with a minimum of delay. For extremely light-weight rigging, wooden toggles and loops in the nylon may be used instead of the heavier metal snaps.

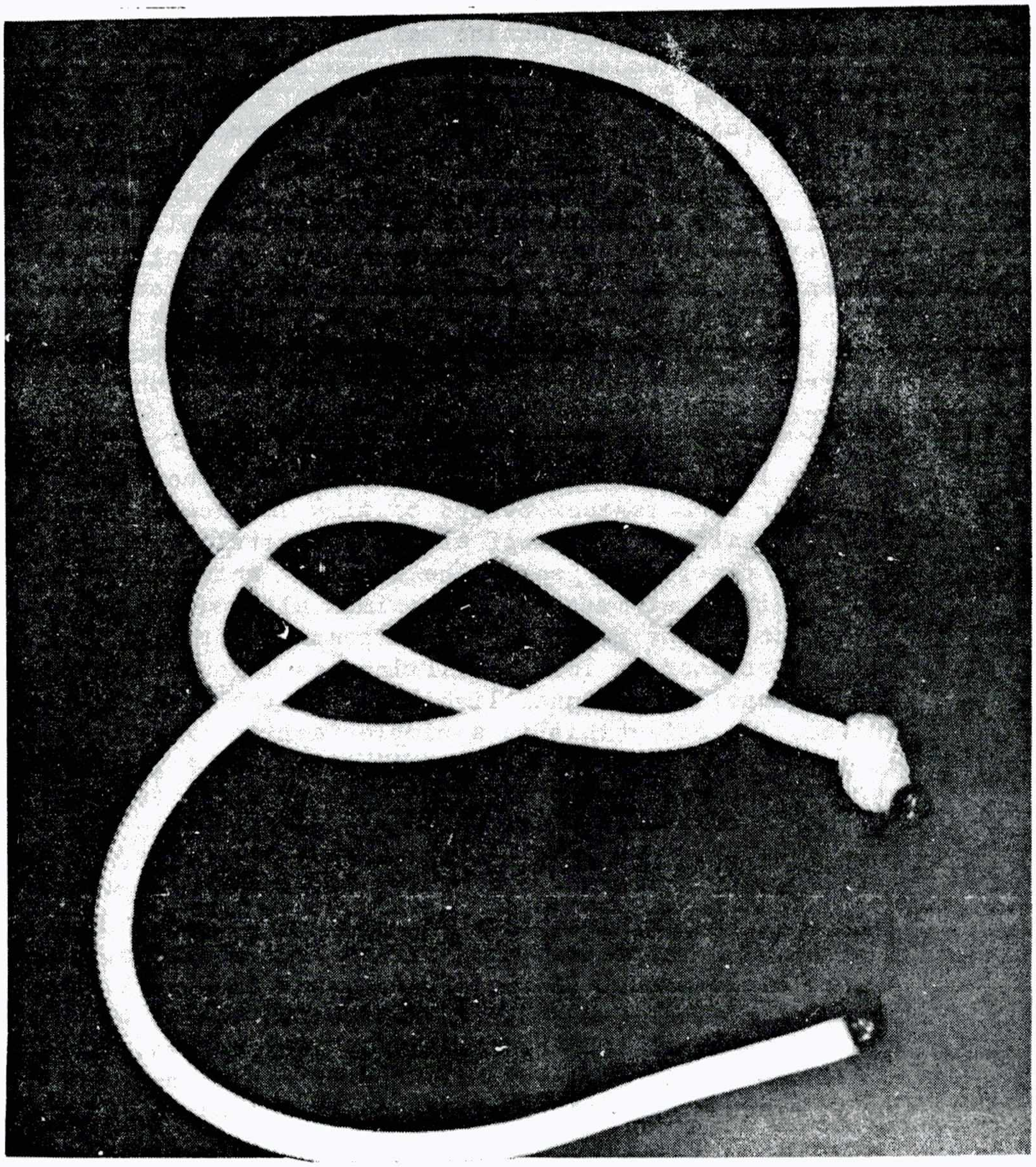


Figure 5

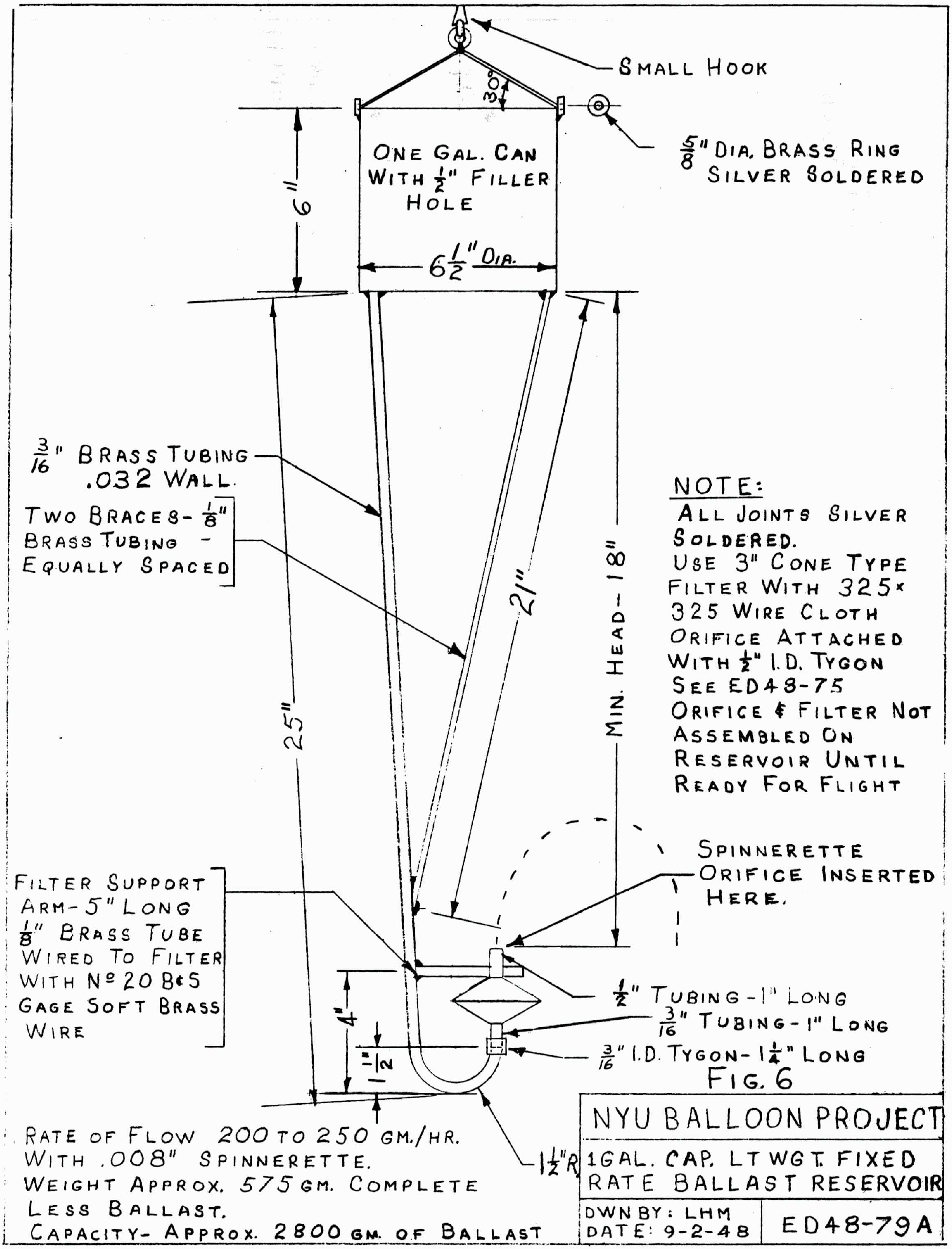
Carrick Bend

B. Altitude Control Equipment

Flights of 20-foot General Mills balloons, using no control equipment, have been sent to altitudes of about 50,000 feet. After reaching maximum altitude, the balloons all exhibit a tendency to float then descend at an increasing rate for periods of from 2 to 6 hours. In stable layers of air such as the stratosphere the descent of a balloon is retarded by the helium, on compression, getting warmer than the surrounding air. This results in much longer duration flights requiring no external control though, strictly speaking, the altitude is not constant. This concept is in good general agreement with the observed data; balloons have remained in a semi-floating state much longer (up to 30 hours) when in the stratospheric inversion than when in less stable lower atmospheric layers.

When it is desired to maintain a balloon at constant level for a guaranteed period of time in excess of two hours, a ballast system of altitude control should be added to the flight gear. The level at which the balloon is to float must be the maximum altitude to which it can carry the payload. To compensate for loss in buoyancy occasioned by loss of lifting gas through diffusion and leakage, a continual lightening of the load is required. To effect this in a simple fashion, liquid ballast is permittted to flow through an orifice at a predetermined rate which exceeds the expected loss of lift. (See Section IV, D) The reservoir and ballast assembly which has been developed for this use is shown in Figure 6. A detail sketch of the orifice in its mounting is shown as Figure 7, and Figure 8 shows a suitable filter which must be used to protect the orifice from clogging. The liquid ballast must (1) not freeze, but flow well at cold temperature (-80°C); (2) not absorb water, which would freeze; and (3) be relatively inexpensive. A recommended liquid is Aeromobil Compass Fluid, made by Socony-Vacuum Co. (Air Force Spec. AN-C-116).

There are three possible objections to the use of this simple control system. First, a continued lessening of the total weight on the balloon--with no change in volume--must result in a constantly rising ceiling. For a 20-foot balloon at 45,000 feet, this change is approximately 1000 feet with each kilogram of ballast dropped (see Section IV, E). Second, only a prefixed ballast flow is permitted, and excessive loss of lift, as might come when the gas is colled at sunset (when the balloon loses superheat),


SMALL HOOK
30°
5/8" DIA. BRASS RING SILVER SOLDERED
ONE GAL. CAN WITH 1/2" FILLER HOLE
6"
6 1/2" DIA.
3/16" BRASS TUBING .032 WALL.
TWO BRACES - 1/8" BRASS TUBING - EQUALLY SPACED
21"
25"
MIN. HEAD - 18"
NOTE:
ALL JOINTS SILVER SOLDERED.
USE 3" CONE TYPE FILTER WITH 325 × 325 WIRE CLOTH
ORIFICE ATTACHED WITH 1/2" I.D. TYGON
SEE ED48-75
ORIFICE & FILTER NOT ASSEMBLED ON RESERVOIR UNTIL READY FOR FLIGHT
SPINNERETTE ORIFICE INSERTED HERE.
FILTER SUPPORT ARM - 5" LONG 1/8" BRASS TUBE WIRED TO FILTER WITH Nº 20 B&S GAGE SOFT BRASS WIRE
1/2" TUBING - 1" LONG
3/16" TUBING - 1" LONG
3/16" I.D. TYGON - 1 1/4" LONG
4"
1 1/2"
1 1/2" R
FIG. 6
RATE OF FLOW 200 TO 250 GM./HR. WITH .008" SPINNERETTE.
WEIGHT APPROX. 575 GM. COMPLETE LESS BALLAST.
CAPACITY - APPROX. 2800 GM. OF BALLAST
NYU BALLOON PROJECT
1 GAL. CAP. LT WGT. FIXED RATE BALLAST RESERVOIR
DWN BY: LHM
DATE: 9-2-48
ED48-79A

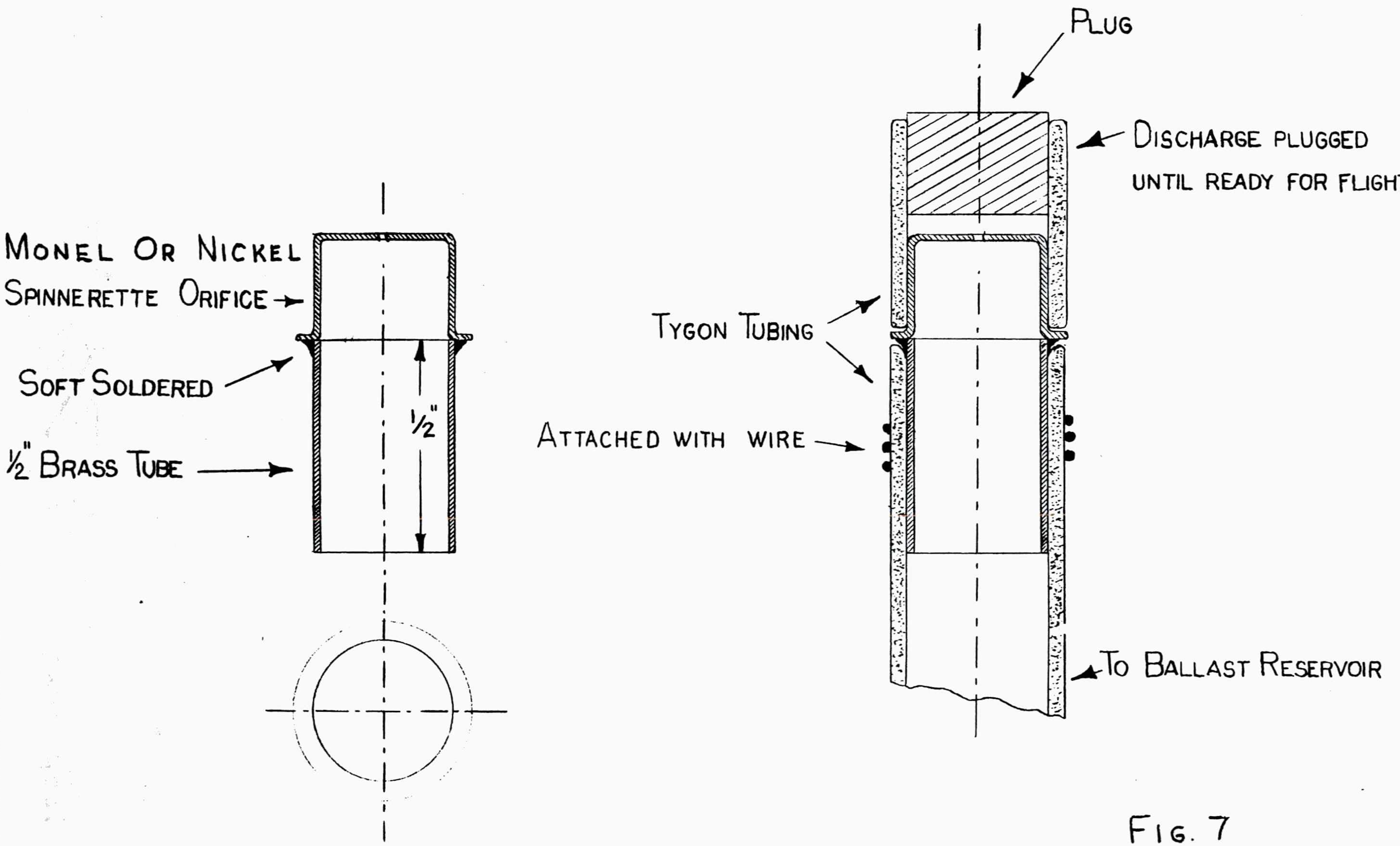


Fig. 7

Note

Spinnerette Orifice Mfd. By J. Bishop Co., Malvern, Pa.

NYU BALLOON PROJECT	
Orifice Assembly	
DATE 8-25-48	ED48-75A

JN

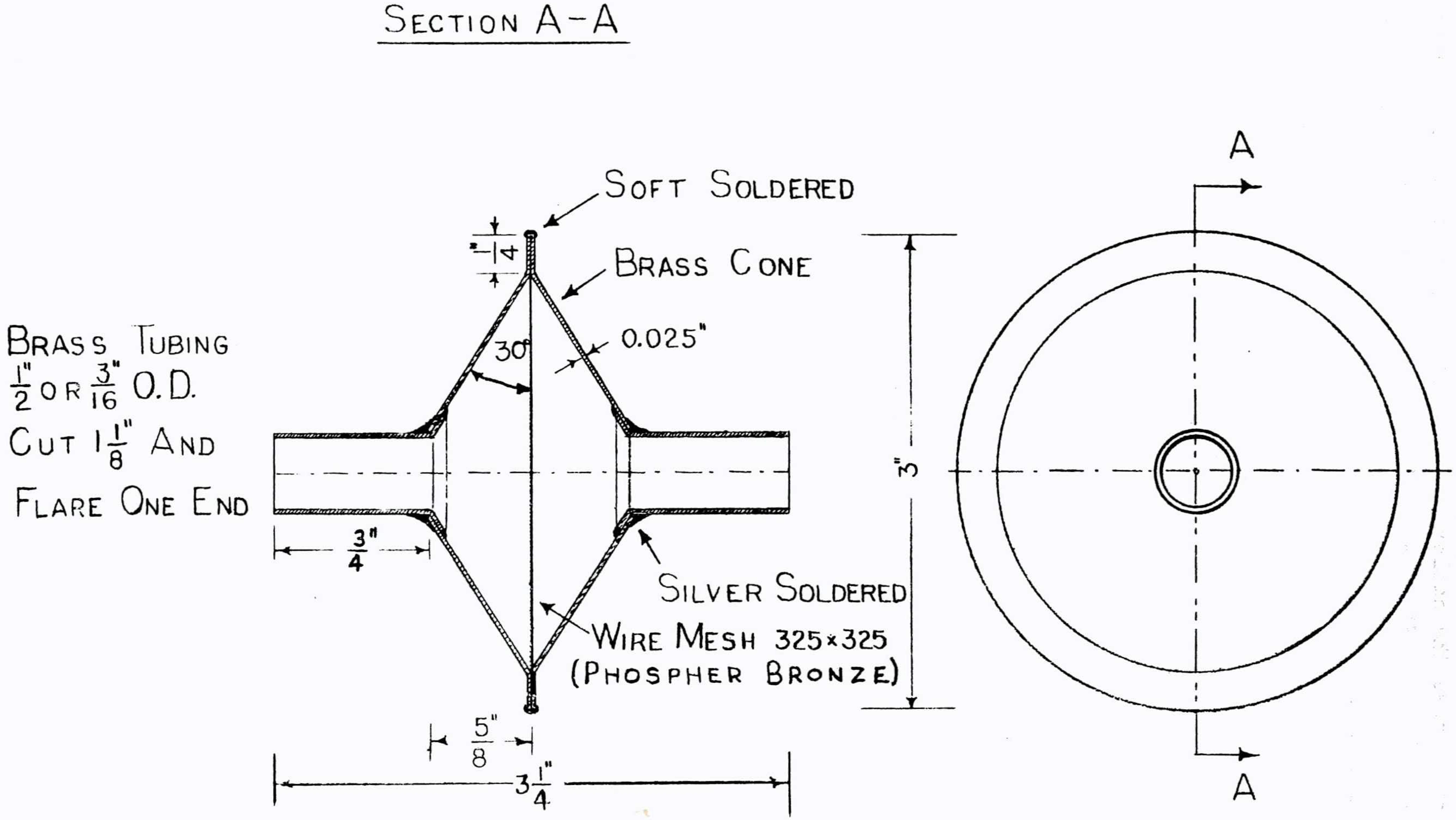


FIG. 8

SCALE 1:1

NOTE
WIRE MESH FROM NEWARK WIRE CLOTH CO., TWILLED WEAVE CODE PYA, OR EQUIVALENT.

NYU BALLOON PROJECT	
TYPE "C" FILTER	
Date: 5-18-48	ED 48-54A

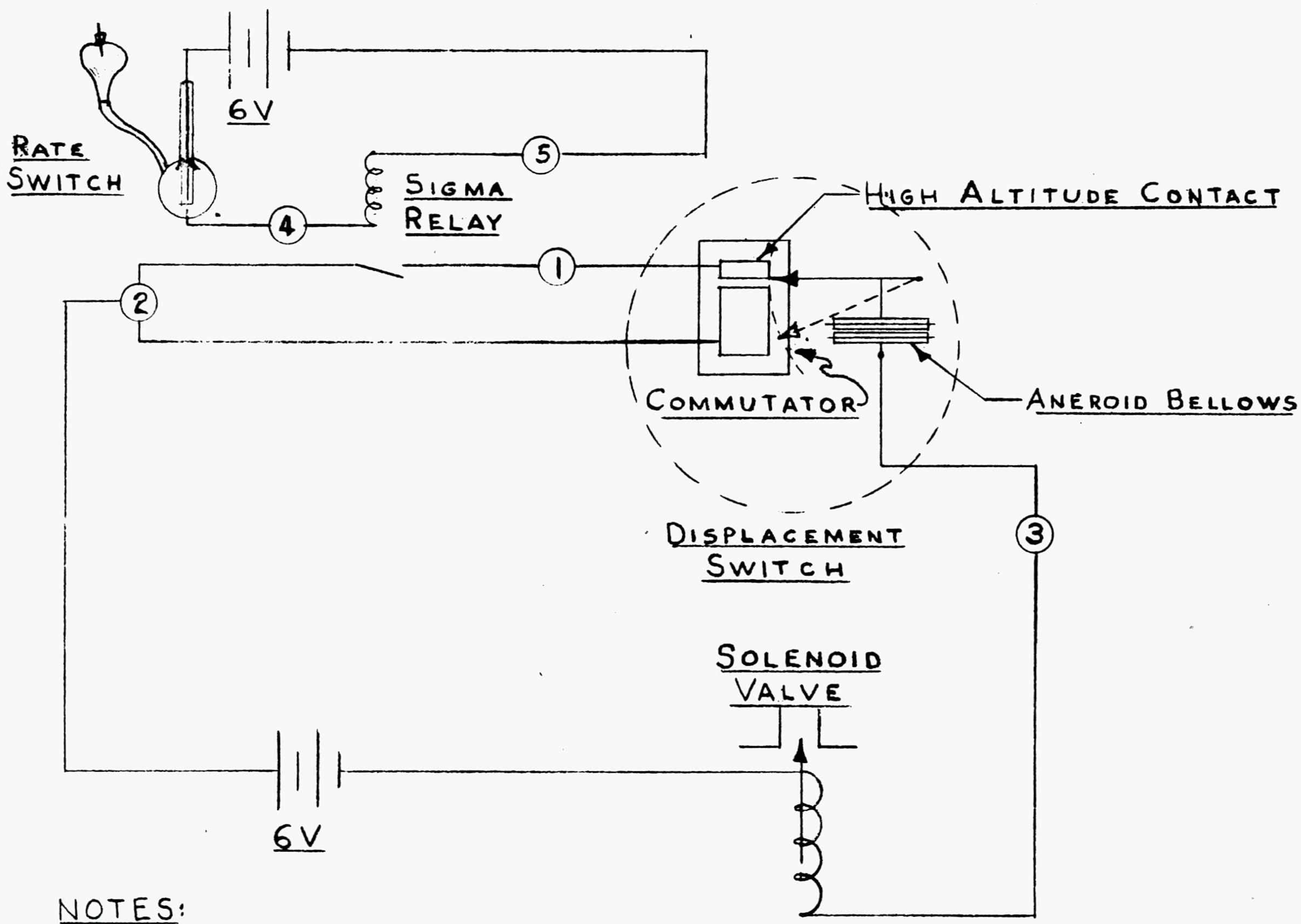
JN

will cause the balloon to descend. Third, as a consequence of the previous limitation, the maximum floating period of a balloon with this control system is 24 hours, achieved when launching is at sunset.

When any or all of the above objections prohibit the use of this simple control system, more complex ballast dropping devices may be used. Figure 9 shows in schematic form the servo or demand type control which has been used to maintain balloons at a constant pressure level, with high ballast efficiency and without harmful sunset effects. Figure 10 is the ballast reservoir assembly which is used with this type control. A more detailed discussion of this servo-control is given in Techncial Report Number 2 of the Balloon Project, New York University.

C. Flight Termination Gear

When a balloon loses buoyancy by the loss of lifting gas, it sinks slowly to earth. To prevent the balloon from remaining in airplane traffic lanes for a long period of time, a flight termination device is added to the equipment train. This device, shown in Figure 11, consists of a pressure-actuated switch and rigging to tear a large hole in the balloon when it descends to some predetermined height. A pressure pen is held above its commutator by a short shelf (see Figure 12). After passing an altitude corresponding to the end of the shelf, the pen falls onto the commutator. Upon subsequent descent to 20,000 feet, it closes an electrical circuit. When this circuit is closed, a squib is detonated in an aluminum "cannon" (see Figures 13 and 14) driving a pellet through the main load line. As the line is severed, the weight of the load is suddenly taken by a rip line which extends nearly taut (about 2 feet slack) up the side of the balloon to a point about 10 feet below the balloon crown. At this point, two small holes about 18" apart have been made, and the rip line is passed from the outside into the balloon through the top hole, then down the inside and out the bottom hole. Both holes are securely taped with acetate fiber tape. About 6 inches of slack line is left inside the balloon. When the main line is cut, a large hole is made in the fabric by this rip line as it pulls out of the balloon. After the instruments have fallen about 10 feet and the rip is made, they are caught up by a snub line and the load is again taken to the load ring. The ruptured balloon then acts as a parachute for the load, descending at about 1000 to 1500 feet per minute.



NOTES:

Batt. Pack in Transmitter Box
Sigma Sensitive Type 5F Relay- Coil Resistance-16000 Ohms
Displacement Switch-ED48-107
Rate Switch-ED48-115
Solenoid Valve-ED48-110
Use 4FH-6 V Lithium Chloride Batteries (Burgess)
For Details of Displacement Sw. See ED48-126

Fig. 9

NYU BALLOON PROJECT

Ballast Control Circuit

LHM
11-12-48

ED48-114 B

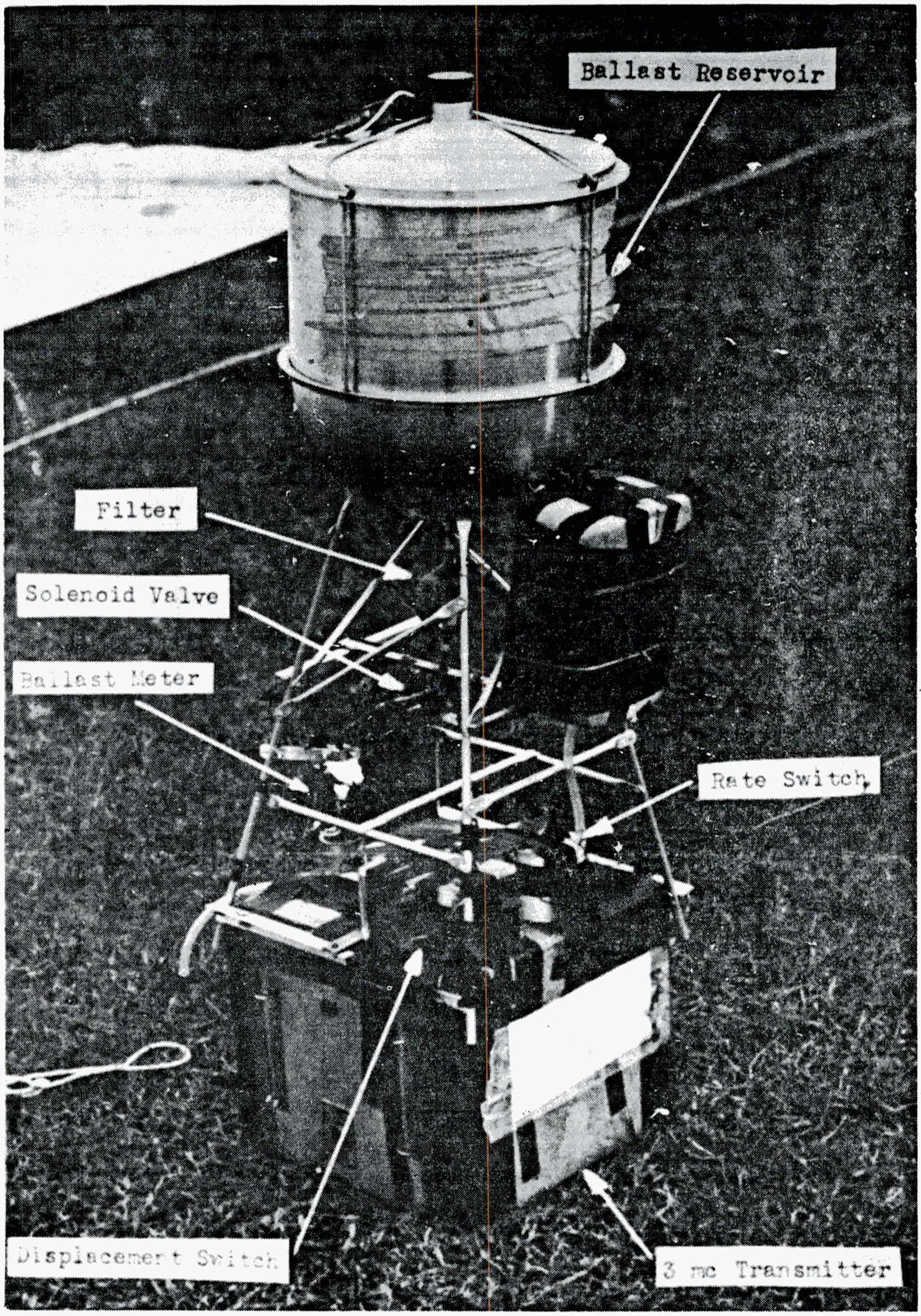


Figure 10
Ballast reservoir assembly
showing component parts

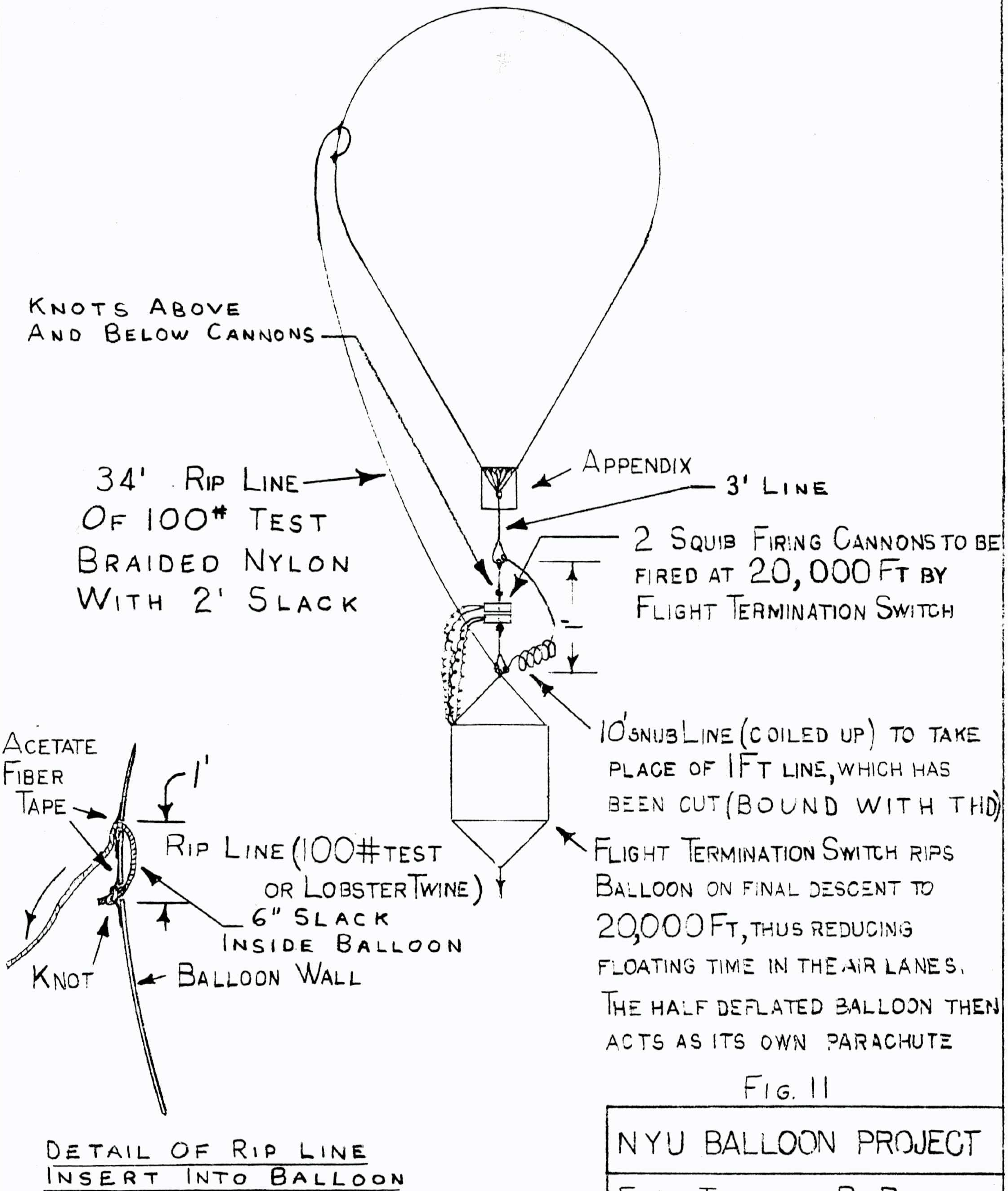
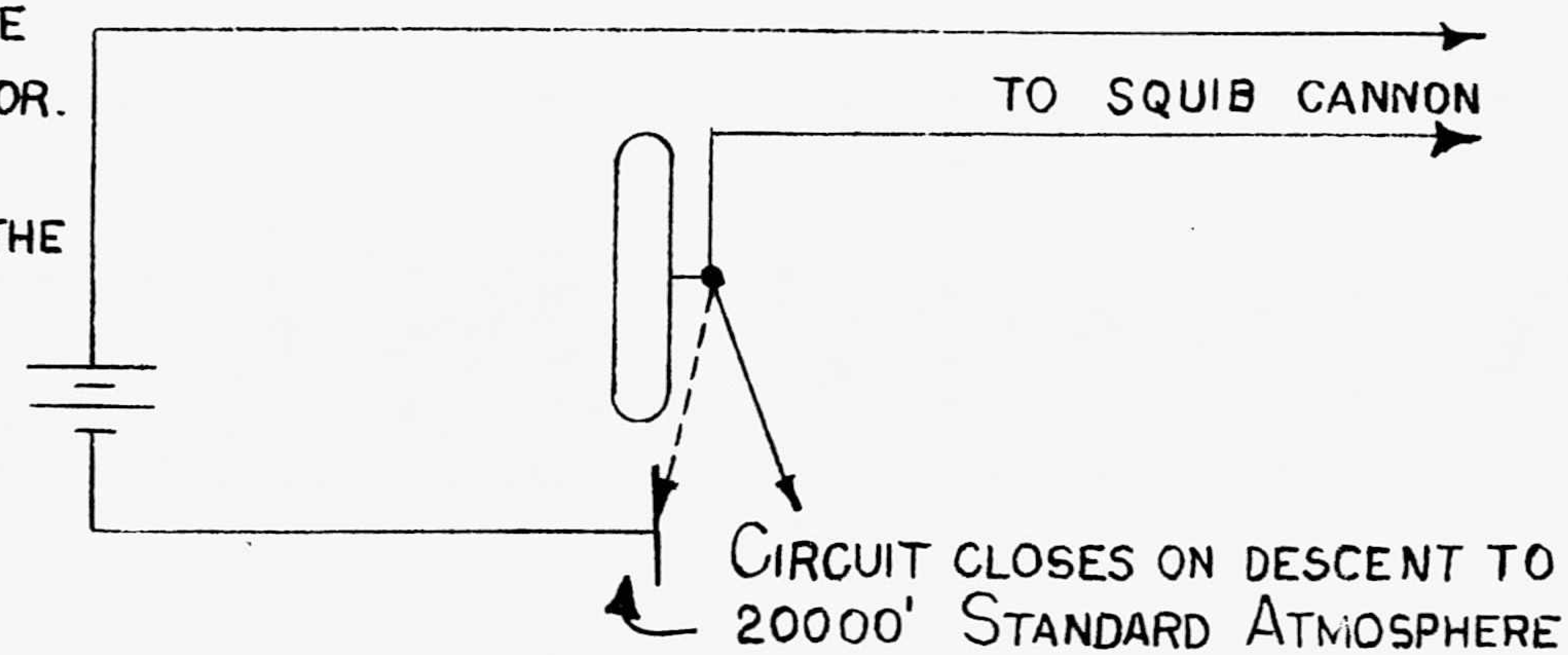
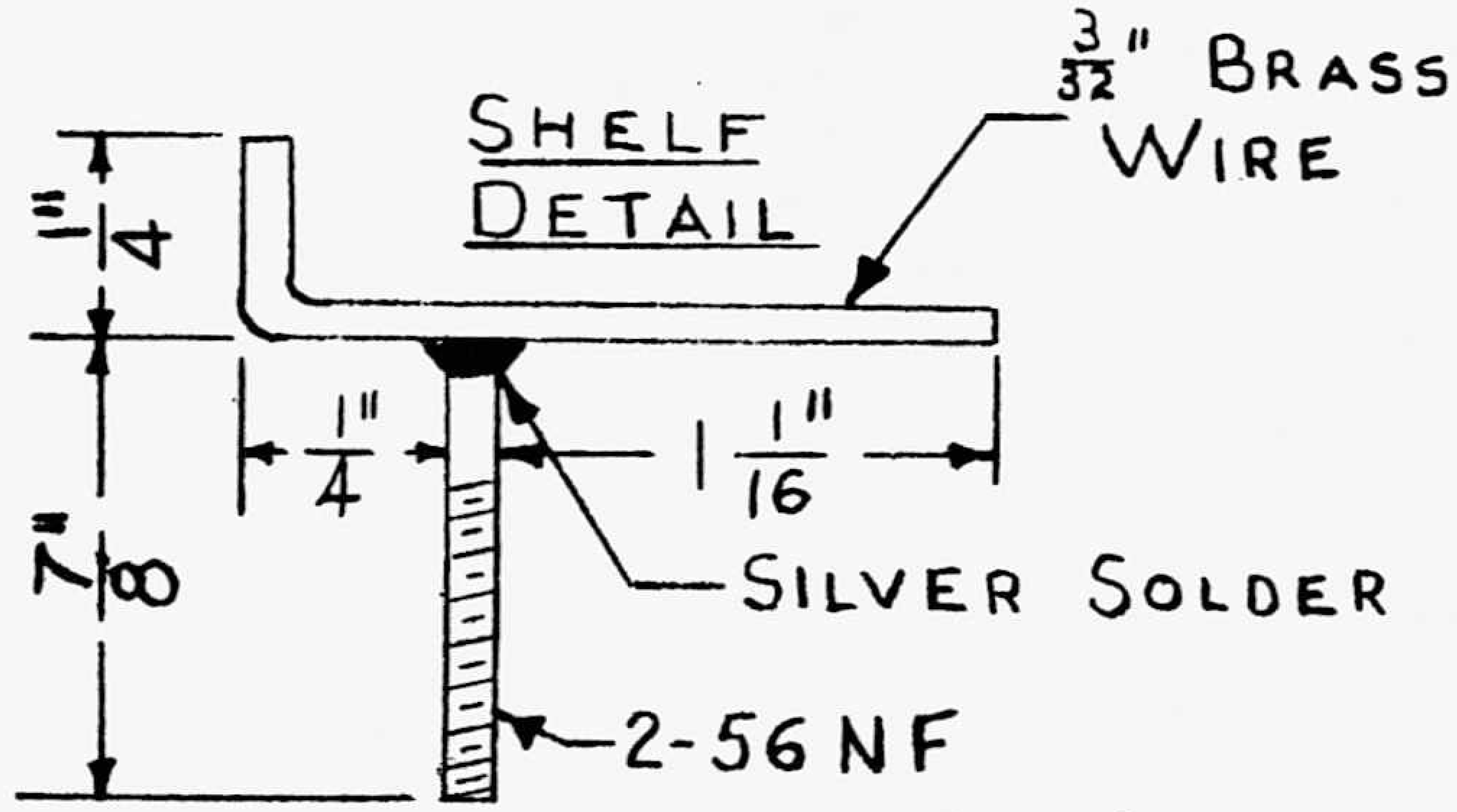


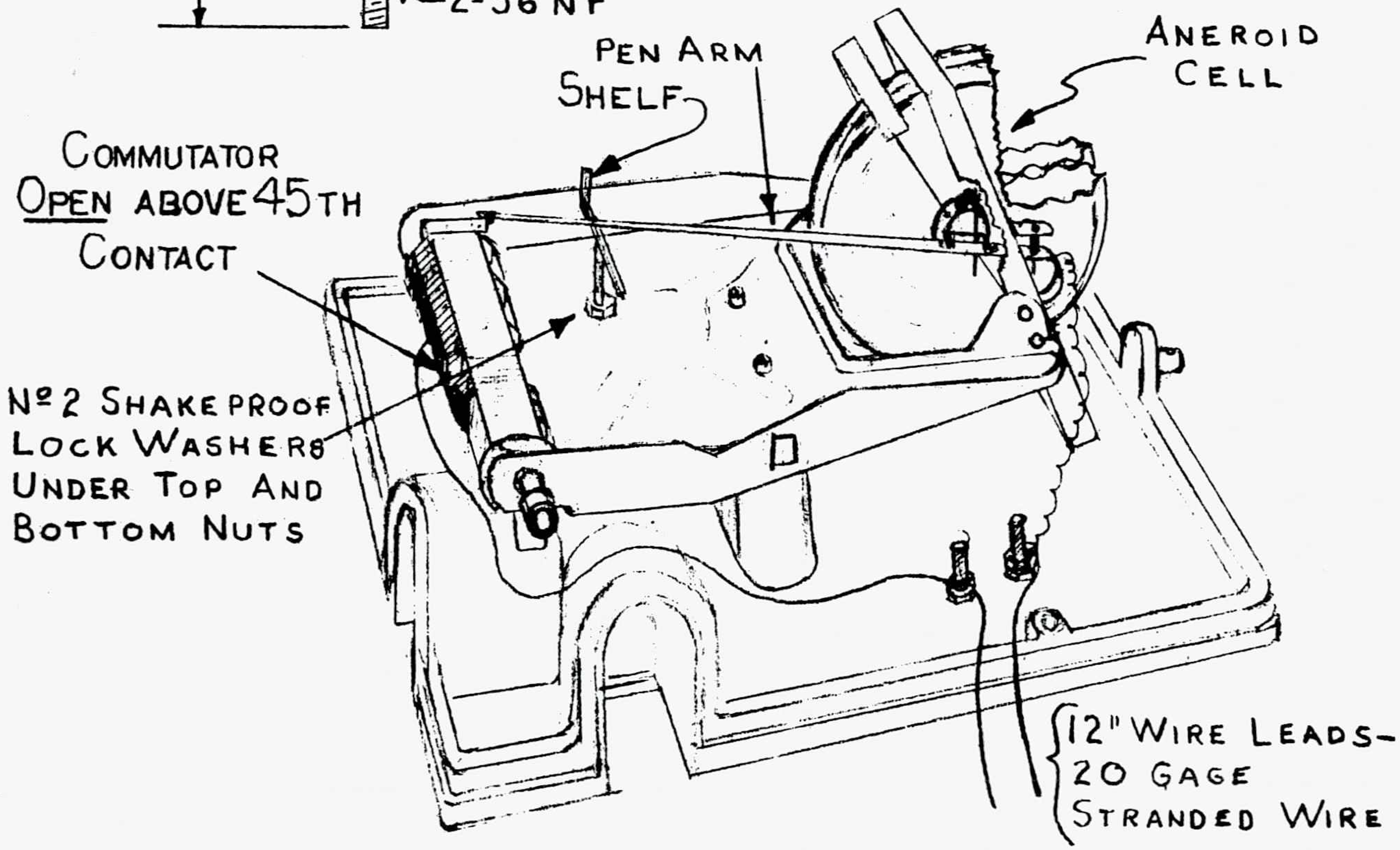
FIG. 11

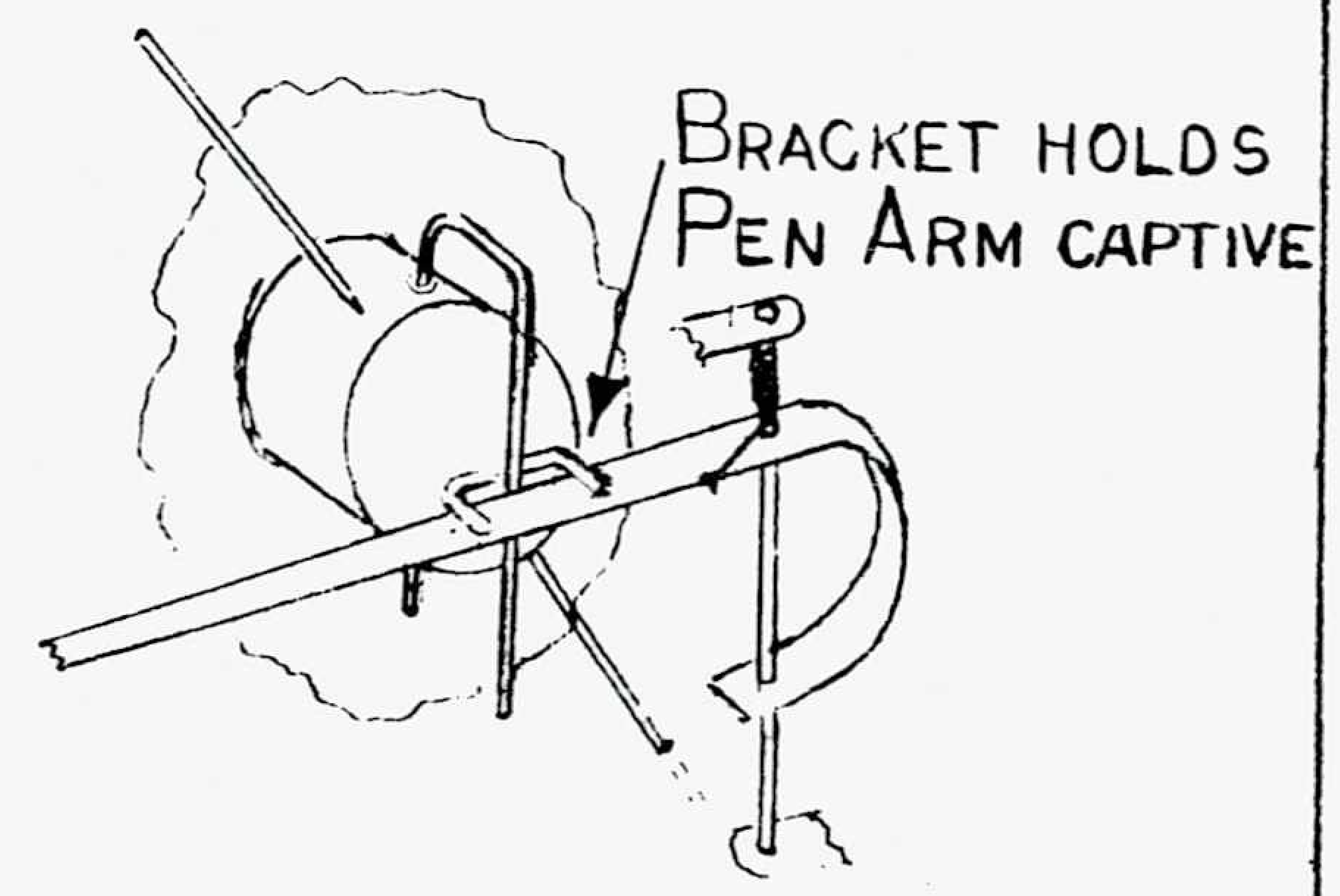
NYU BALLOON PROJECT	
FLIGHT TERMINATION RIP RIGGING	
DATE 7-19-48	ED 48-68A

Pen Arm is on Shelf until Balloon rises above 25,000 Ft. where it falls on to the Commutator. When the Balloon descends the Pen Arm rides down on Commutator under the Shelf, closing the Circuit at 20,000 Ft.









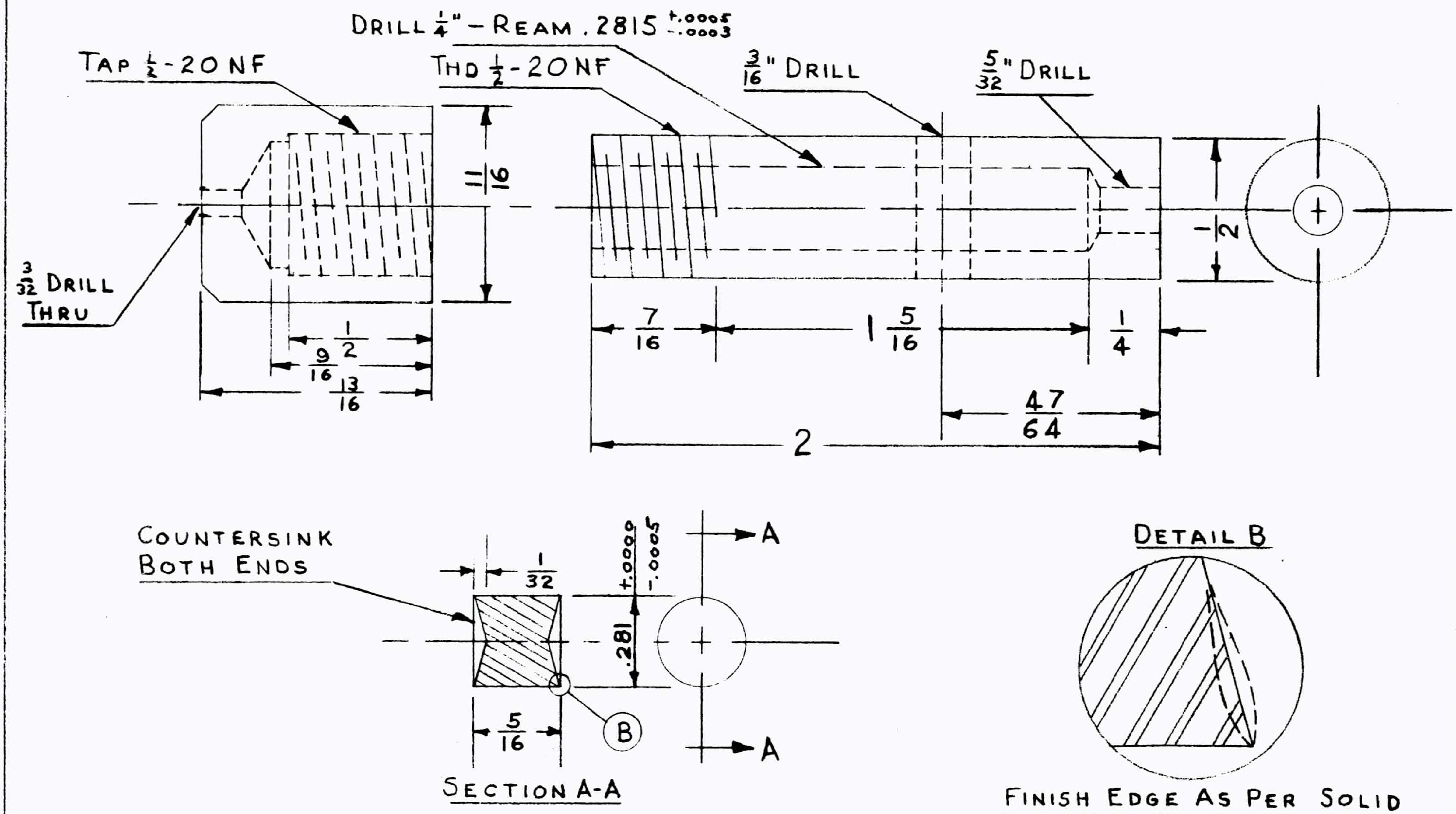
Linkage Detail

Fig. 12

NYU BALLOON PROJECT	
Flight Termination Switch	
DATE 7-27-48	ED48-70A

Note: Mfd by Kollsman

JN



Harden Drill Rod Bullet

Finish Edge As Per Solid Line, Not As Broken Lines

Fig. 13

NOTES:

For Use With:–
1. Du Pont S-64 Squib (3' Wires)
2. 500# Test Parachute Shroud Line

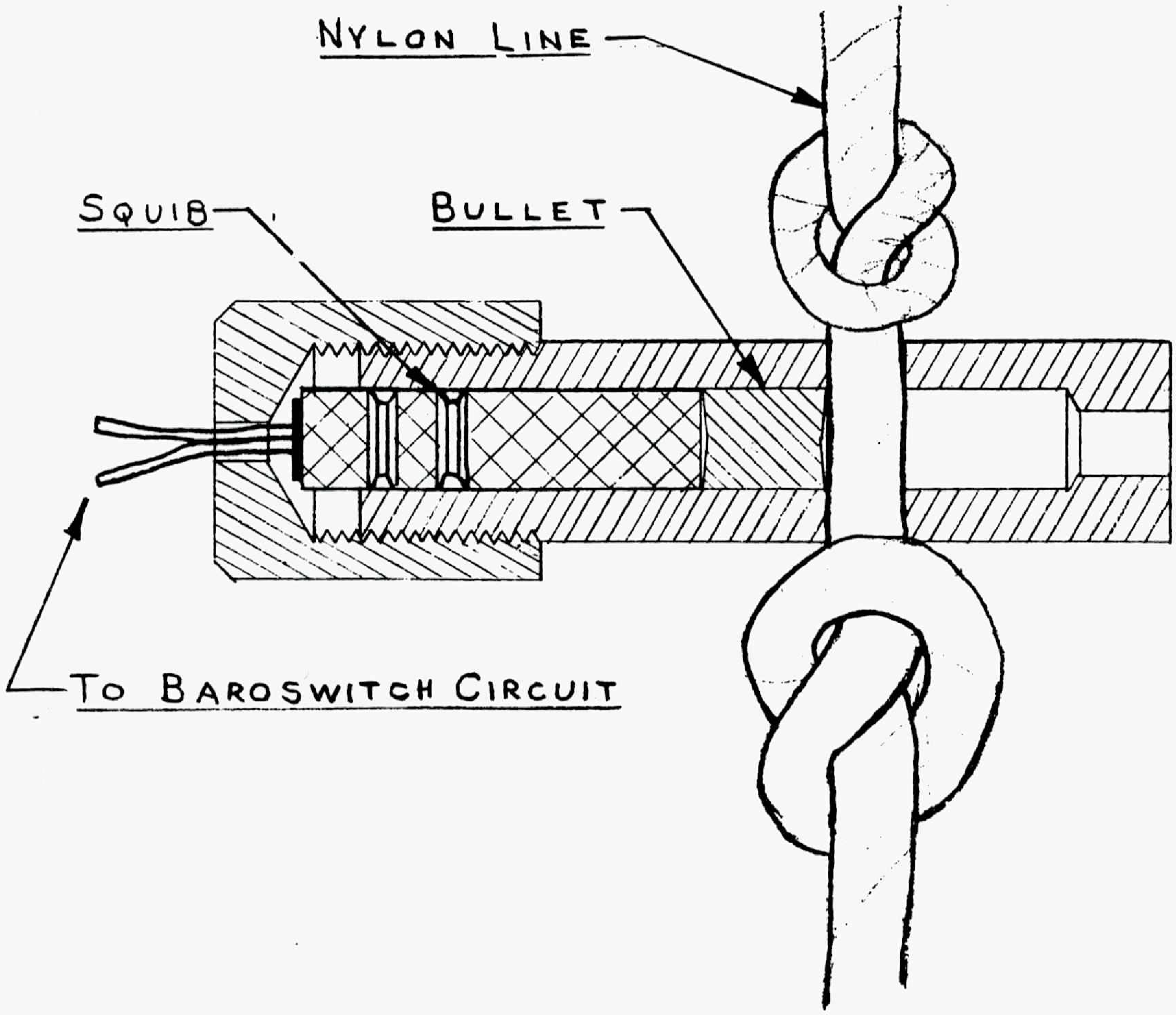
Part	Material
Cannon	24 or 61ST Al
Cap	24 or 61ST Al
Bullet	Drill Rod Or Cast Lead

N.Y.U. BALLOON PROJECT

Line Cutter Cannon

LHM 11-15-48

ED48-117A



NOTES
FOR CANNON DETAILS SEE ED 48-117A
USE KNOTS ABOVE AND
BELOW CANNON
SQUIB - DUPONT S-64

FIG. 14

N.Y.U. BALLOON PROJECT	
ASSEMBLY OF LINE CUTTER CANNON	
DWN. BY: LHM DATE: 2-1-49	ED49-5A

D. Accessory Flight Equipment

On most flights, three pieces of equipment are added to the train for special purposes. These are: (1) a banner, (2) a drag parachute, and (3) safety weights.

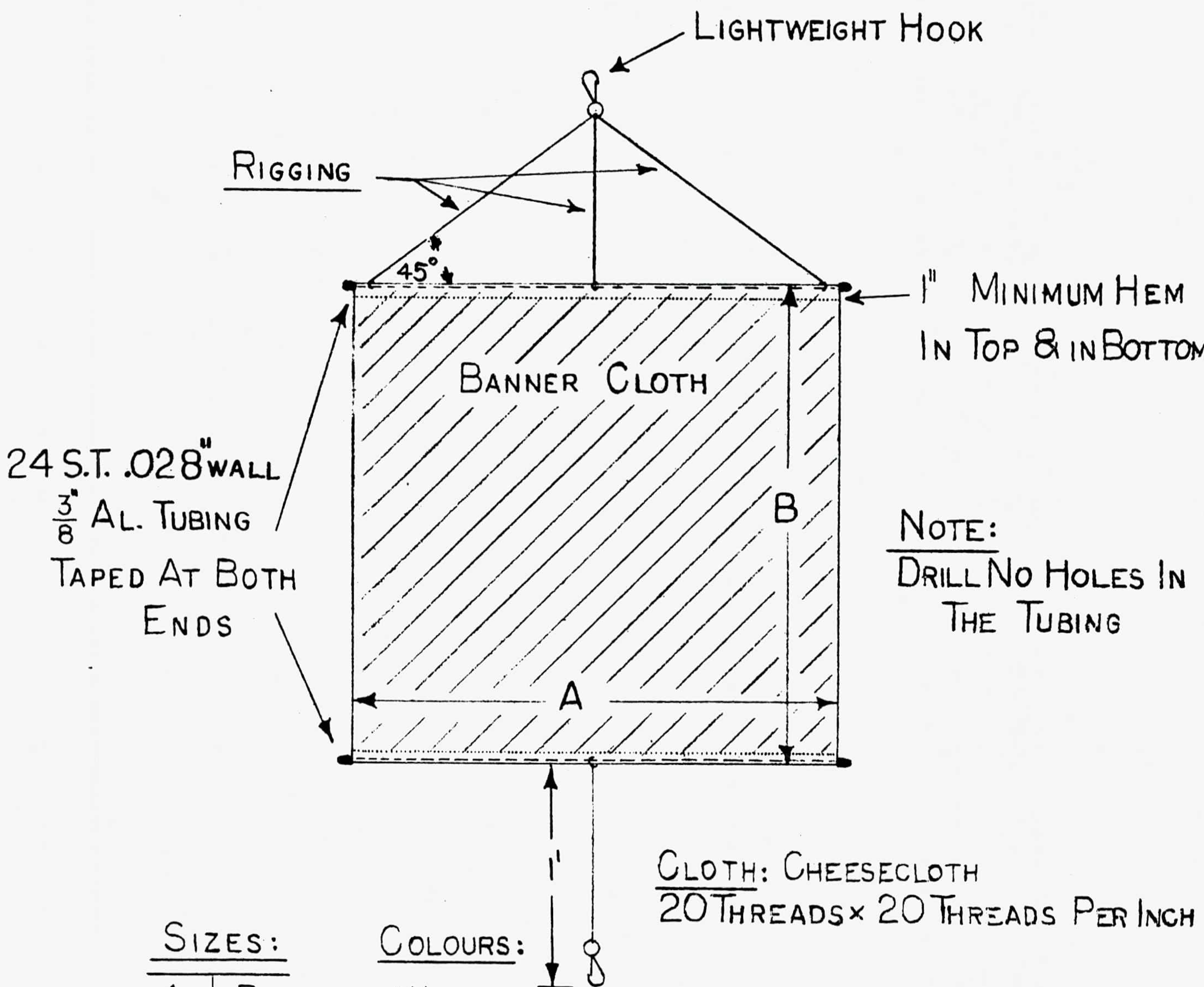
The banner is a red or yellow cheesecloth rectangle, 3 x 6 or 6 x 12 feet, with aluminum spreaders at top and bottom. Shown in Figure 15, the banner is tied taut to the load line, and serves to reduce sidewise swaying as the balloon rises. Due to the bright color, it is useful in locating the balloon after being grounded and acts as a warning to air craft during descent and ascent. If thodolite stadia determinations are being made, the banner can be used as one of the check points on the train.

The drag parachute is inserted into the train above the banner in inverted position and serves to retard the ascending balloon somewhat, thus reducing the probability of bursting due to excessive rates of rise.

To correct a too slow rate of rise, (which may result from under inflation due to gage errors, freezing of valves, or excessive adiabatic cooling of the gas during inflation) two small bags of sand or shot are added to the bottom of the restraining line. If it appears that the balloon is not rising with the desired velocity as it picks up the equipment, one or both of these safety weights are cut free. The weight of each bag is equal to the desired free lift, so that if the computed free lift is not available, this lift may be supplied. Prior to the adoption of this practice, it was necessary to sacrifice equipment or the balloon in such cases.

E. Tracking and Recording Instruments

Depending upon the nature of the flight, the weather conditions, and the equipment available, gear may be added to the flight train to aid in horizontal position determination and altitude measurement. The discussion of suitable equipment for such work is given in Section VII. In general, the equipment added may be either radio transmitters or gear of other assorted types. Each unit is rigged separately, with hooks at each end of the line segment. Prior to the inflation of the balloon a thorough check of all such equipment, especially radio gear, is made. It is necessary to have spare equipment tested, calibrated, and assembled for last minute replacement if failure is detected at this time.



SIZES:

A	B
3'	3'
6'	6'
6'	12'
3'	6'

COLOURS:

WHITE
YELLOW
RED

FIG. 15

NYU BALLOON PROJECT	
BANNER	
Date: 5-19-48	ED 48-56

JN

Position of recording and radio instruments in the flight train is in some cases dictated by the size and shape of antennae or other special part. In general this type of gear is not placed below the altitude control equipment because of possible damage which might result from ballast being dropped upon them. Typical trains are shown in Figures 16, 17, and 18.

F. Flight Tools and Equipment

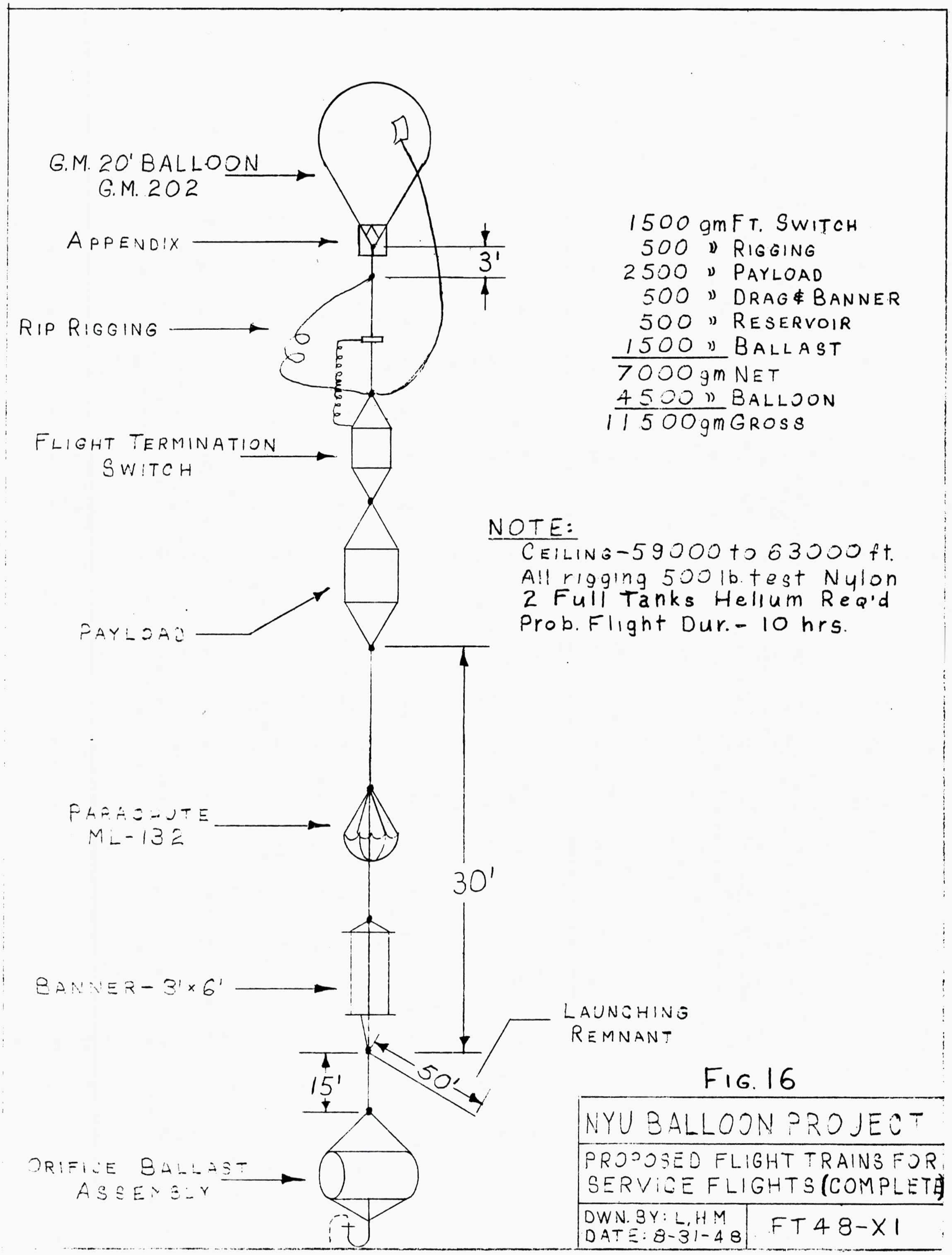
A list of tools and equipment and facilities which should be provided for any launching site is given in Appendix II.

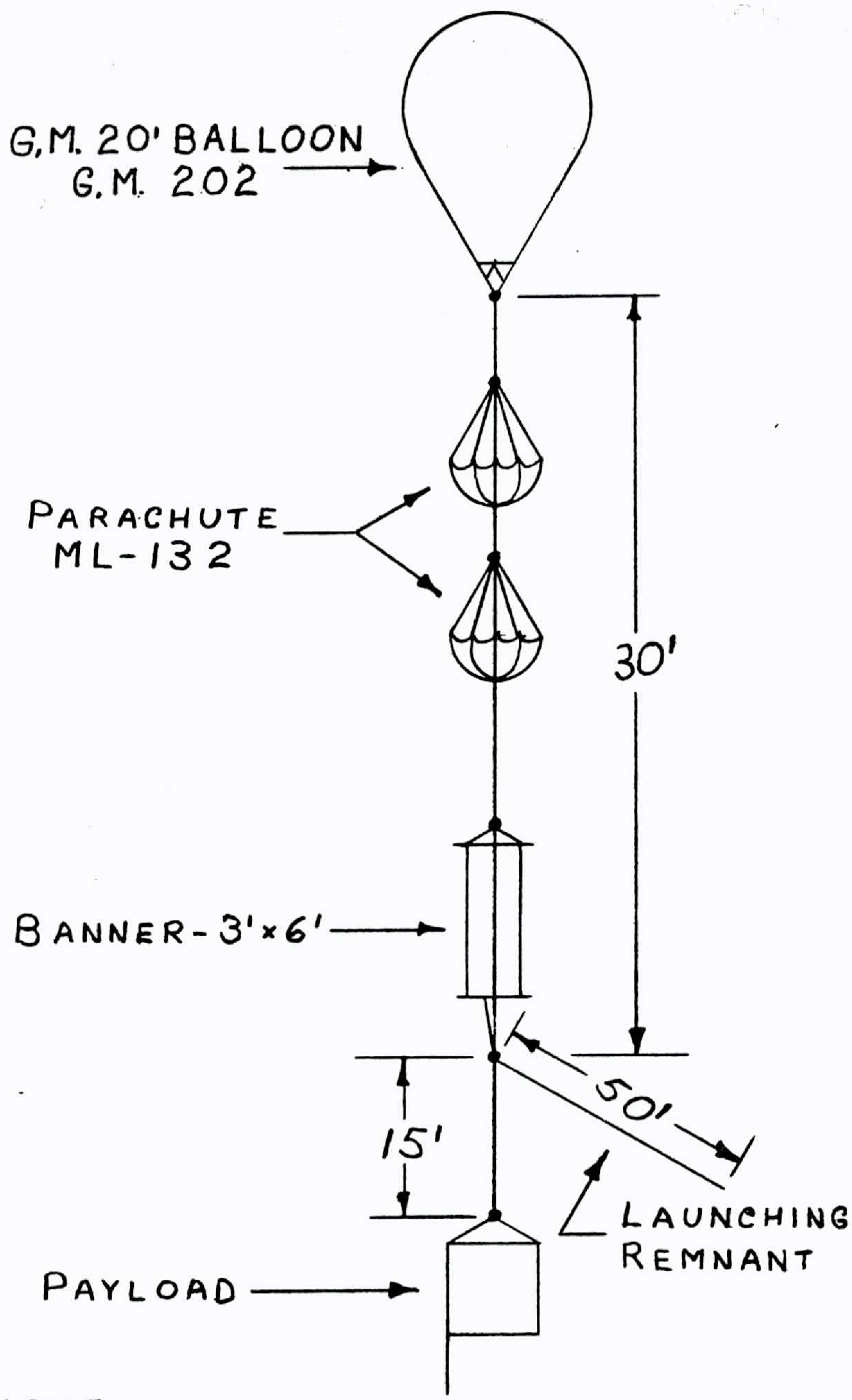
IV. PRE-FLIGHT COMPUTATIONS

A. Lifting Gas and Rate of Rise

When the equipment for a flight is in readiness and the inflation procedure is to be begun, the total weight to be lifted must be determined. A weight sheet (shown in Appendix I) is filled in, with the final weight of each piece of gear with its rigging. In this work the weights of the equipment are measured in grams and kilograms for ease of computation. The gross load reported should be accurate to the nearest 200 grams. The amount of lifting gas to be used must be carefully figured to prevent incorrect inflation which might result either in the balloon failing to rise, or perhaps rising too fast and rupturing at its ceiling. After the total weight to be lifted is found, a percentage of this total is added to provide for lifting the load at some specified rate. With a given excess of buoyancy, a balloon will lift its load at an almost constant predictable speed. (The rate of rise will increase by about 25% at higher altitudes, due to the changes in balloon shape and decrease of air density.) Graph 1 of Appendix II shows the relationship between the free lift and the rate of rise, with free lift expressed as a percentage of the total or gross load (which includes the weight of the balloon itself). For example, if a gross load of 10.0 kilograms is to be lifted at a desired ascent rate of 600 feet per minute, 9.2% of the gross load should be added, giving a gross lift of 10.0 + .920 = 10.920 kilograms. (The rate of rise should not exceed 700 feet per minute if a standard appendix is used.)

It should be noted that this graph, derived from equations for spherical balloons, applies also to the tear-drop cells of General Mills, Inc., without regard for the balloon diamter.


G.M. 20' BALLOON
G.M. 202
APPENDIX
3'
RIP RIGGING
FLIGHT TERMINATION SWITCH
PAYLOAD
PARACHUTE ML-132
30'
BANNER – 3'×6'
LAUNCHING REMNANT
50'
15'
ORIFICE BALLAST ASSEMBLY
1500 gm FT. SWITCH
500 » RIGGING
2500 » PAYLOAD
500 » DRAG & BANNER
500 » RESERVOIR
1500 » BALLAST
7000 gm NET
4500 » BALLOON
11500 gm GROSS
NOTE:
Ceiling – 59000 to 63000 ft.
All rigging 500 lb. test Nylon
2 Full Tanks Helium Req'd
Prob. Flight Dur. – 10 hrs.
FIG. 16
NYU BALLOON PROJECT
PROPOSED FLIGHT TRAINS FOR SERVICE FLIGHTS (COMPLETE)
DWN. BY: L.H.M
DATE: 8-31-48
FT48-X1



500	gm	DRAG CHUTES
300	"	BANNER
2000	"	PAYLOAD
4500	"	BALLOON
7300	"	GROSS LOAD

<u>NOTE</u>:

Use low rates of rise (500 ft per min) to prevent balloon failure during ascent.
All rigging 500 lb. test Nylon.
<u>Max. Ceiling</u> with this load:
67000 to 70000 ft.
<u>Probable Ceiling</u>: 45000 ft. since no appendix is used.
<u>Prob. Flight Duration</u>– 3 hrs.
1 1/4 FULL TANKS HELIUM REQ'D.

FIG. 17

NYU BALLOON PROJECT

PROPOSED FLIGHT TRAINS FOR SERVICE FLIGHTS (SIMPLE GEAR)

DWN. BY: L.H.M.
DATE: 8-30-48

FT48-X2

Approx. Weights: (Gms)	
Balloon	4200
Barograph	1500
Flight Term. Sw. With Batt.	1000
All Line	400
Antenna	860
Ballast Assy. + Transmitter	17000
Ballast	5000
Banner and Drag Chute	450
Total	30410

Safety Wts. - Equal To Free Lift

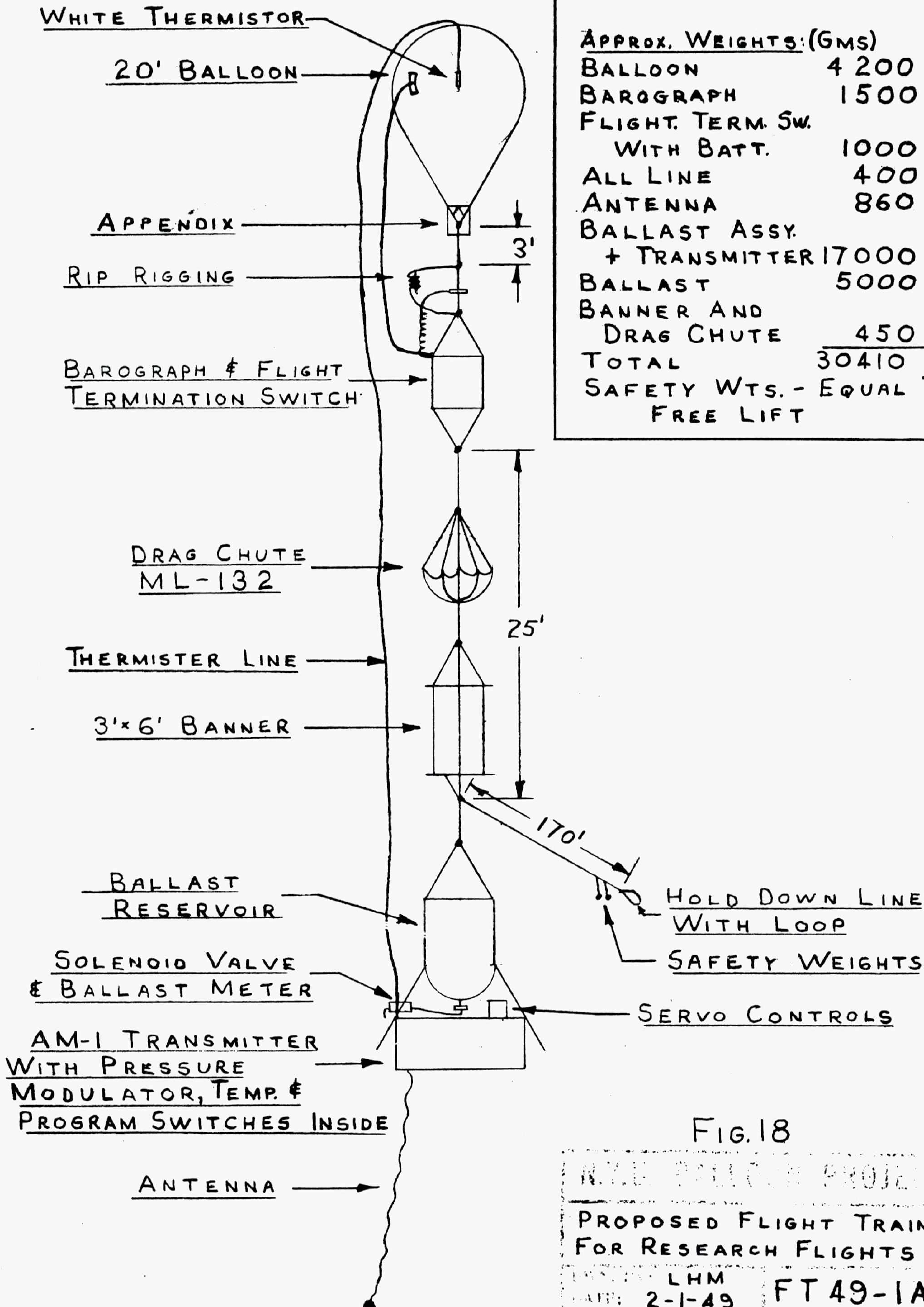


Fig. 18

N.Y.U. BALLOON PROJECT

Proposed Flight Trains For Research Flights

DRAWN BY: LHM
DATE: 2-1-49
FT 49-1A

When the total quantity of gas needed has been computed, the lift requirement may be expressed in terms of the pressure of a number of cylinders of gas. It is not possible to assume that each tank of gas will give the same amount of lift, nor is it possible to use a gage which has not been experimentally calibrated to relate lift to pressure. For calibration of a gage it is sufficient to valve gas from an observed equilibrium temperature and pressure in a cylinder into a rubber balloon and then measure the total lifting capacity of the gas from the tank. Check points should be made with tanks under varying amounts of pressure. Figure 19 shows a sample gage calibration worked up for varying temperatures assuming the simple gas law

$$\text{Lift}_2 = \frac{P_2}{P_1} \times \frac{T_1}{T_2} \text{Lift}_1$$

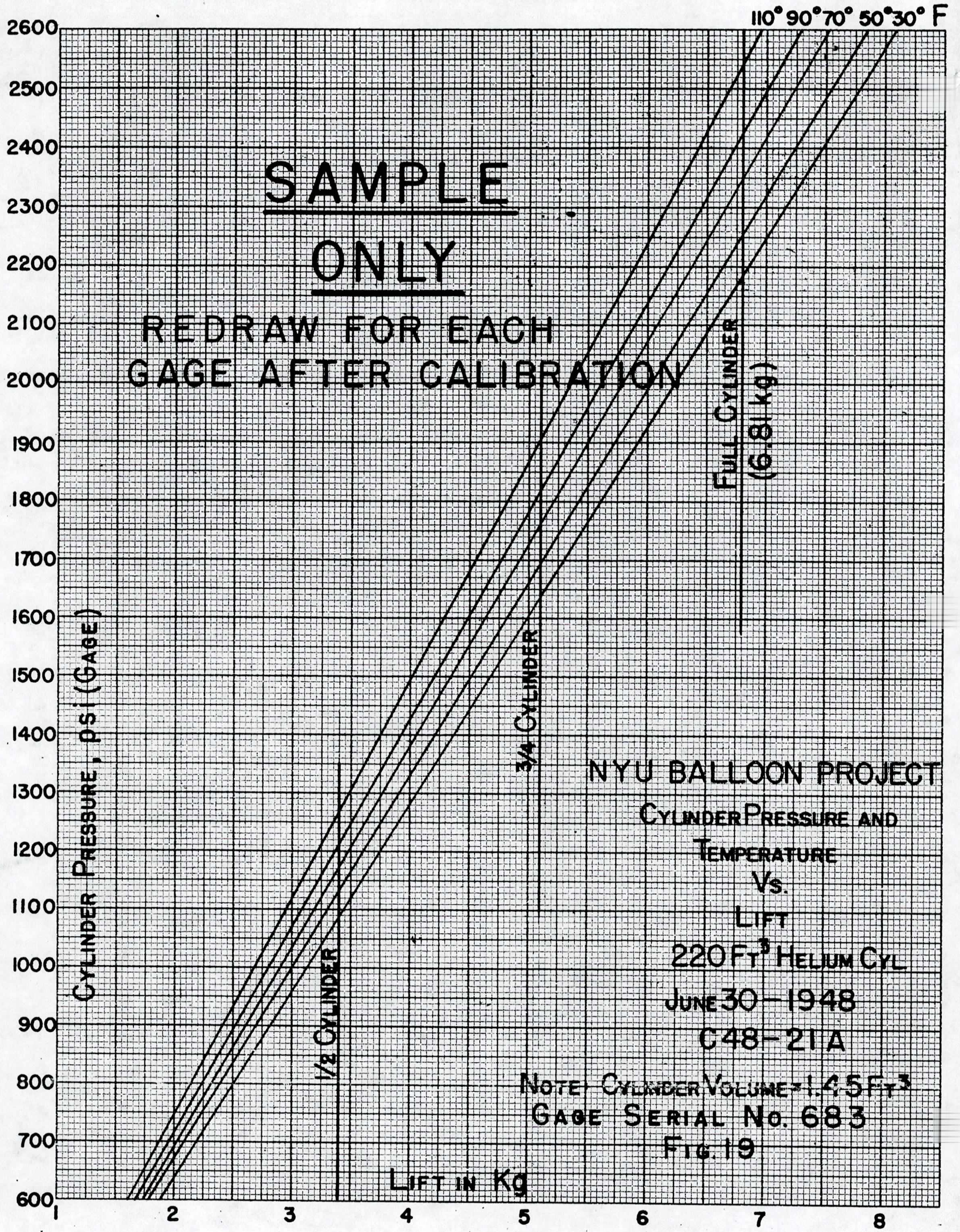
This law applies to within ±1%. Note: Do not use Graph 6 without checking calibration of gage to be used. Ordinarily a whole number of full tanks of gas will not exactly supply the desired lift, which should be figured with not more than one-tenth full tank tolerance in excess (permit no under inflation). It is thus necessary to prepare partially full tanks and by combining full and partially full cylinders get the required total. It is necessary to allow the cylinders to attain equilibrium temperature after valving them before taking final pressure readings.

B. Length of Balloon Bubble

The volume of gas required for a given balloon may be expressed as the length of an uninflated bubble at the crown of the balloon. Graph 2 of Appendix II gives the relationship between bubble length and resultant inflated volume, using gross lift as an expression of volume. It will be noted that when the elevation of the launching site is markedly different from sea level, a shift in this curve is needed to accomodate varying densities of the atmosphere. The inflation of this bubble, which is pinched off by launching equipment or shot bags, will serve as a good check of the final amount of gas in the balloon, thus warning if the balloon is underinflated.

C. Expected Altitude

To predict the altitude to which a balloon will rise it is necessary to know the volume of the balloon, the total


110° 90° 70° 50° 30° F
SAMPLE ONLY
REDRAW FOR EACH GAGE AFTER CALIBRATION
FULL CYLINDER (6.81 kg)
3/4 CYLINDER
1/2 CYLINDER
CYLINDER PRESSURE, psi (GAGE)
LIFT IN Kg
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
1
2
3
4
5
6
7
8
NYU BALLOON PROJECT
CYLINDER PRESSURE AND TEMPERATURE
VS.
LIFT
220 FT³ HELIUM CYL
JUNE 30 - 1948
C48-21A
NOTE: CYLINDER VOLUME = 1.45 FT³
GAGE SERIAL NO. 683
FIG. 19

weight of equipment and balloon, the distribution of density in the atmosphere and the buoyancy of the lifting gas. Assuming that the lifting gas is helium, Graph 3 in Appendix II summarizes the relationship between gross load and floating level for balloons of several diameters. To use this graph to find the floating level of a balloon of given size and load, enter with the required buoyancy (equal to the gross load). Go vertically to the diagonal line corresponding to the balloon size and then horizontally to the extreme left-hand edge and read the altitude. The volume of the balloon is related to density by the use of the molar volume in this chart. Assuming observed pressure and temperature distributions over selected stations and the N. A. C. A. standard atmosphere, the molar volume is given as well as the altitudes. Table 1 of Appendix II gives the N. A. C. A. Standard Atmosphere relating pressure with altitude, and Table 2 gives the variation of temperature with altitude. For local conditions more exact measurements may be made using the temperature and pressure distribution indicated by a sounding rather than the standard. To do this, it is necessary to compute the molar volume from this relationship

$$\text{molar volume}_z = 359 \text{ ft.}^3 \times \frac{T_z}{273^\circ C} \times \frac{1013.3 \text{ mb}}{P_z}$$

Example: Find the molar volume at 30,000 feet MSL where the reported temperature is -30°C, and the reported pressure is 300 mb.

$$\text{molar volume}_{30,000} = 359 \text{ ft.}^3 \times \frac{(273-30)^\circ C}{273^\circ C} \times \frac{1013 \text{ mb.}}{300 \text{ mb.}} = 1080 \text{ ft.}^3$$

This is the volume of a pound mol of any gas at those conditions.

By plotting several points of this curve of molar volume versus altitude, it is possible to locate very exactly the altitude which corresponds to the molar volume to which the balloon will go (found from Graph 3 or as follows). This density or molar volume to which a balloon will rise is given by the following formula:

$$\text{Molar volume} = \frac{\text{Balloon volume}}{\text{Gross load}} \quad \text{Gas Lift/mol}$$

Gas lift/mol = 11.1 kg/mol (using Helium)

D. Ballast Requirements

For a 20-foot General Mills balloon, a flow of ballast of at least 200 grams per hour is needed to keep the balloon aloft. Flow of the compass fluid used varies (through a sharp-edged orifice) with the head, or vertical distance between the free surface of the liquid and the orifice. It is not affected by the temperature or pressure, so long as the reservoir is properly vented.

Flow also varies with the size and shape of the orifice. Using round spinnerette orifices, the flow of various heads has been computed and is shown in Table 3, Appendix II. From a knowledge of the minimum head to be expected (depending on the construction of the ballast reservoir and its connection to the orifice), the desired rate of flow can be obtained by proper selection of orifice size. While 200 grams per hour has been used successfully for the usual floating altitudes of the General Mills 20-foot cells, this figure should be considered as an absolute minimum. A short period check of the flow rate through each ballast assembly prior to flight is recommended.

E. Altitude Sensitivity

The altitude gained by a balloon when its load is reduced by one kilogram is called its altitude sensitivity. This amount is affected by the density of the atmosphere at the floating level; for 20-foot balloons between 40,000 and 53,000 feet, it is roughly 1000 feet per kilogram of weight lost. This weight is normally lost by ballast dropping. The altitude sensitivity and the ballast drop control the rate of rise of the ceiling. Graph 4, Appendix II gives more exact values for this figure at various altitudes.

F. Forms and Records

For the purpose of making standard pre-flight computations, a series of computation sheets have been drawn up. These are shown in Appendix I. Reward tags attached to components of the flight train have encouraged the finders to protect the equipment and report its location for recovery. The tags, questionnaires, and the warning notices which are used on appropriate gear where squibs or acid are used are shown in Figures 20 and 21.

V. BALLOON INFLATION

A. Preparation of Balloon

From the moment the protective packing of the balloon is removed, great care must be exercised to prevent tears

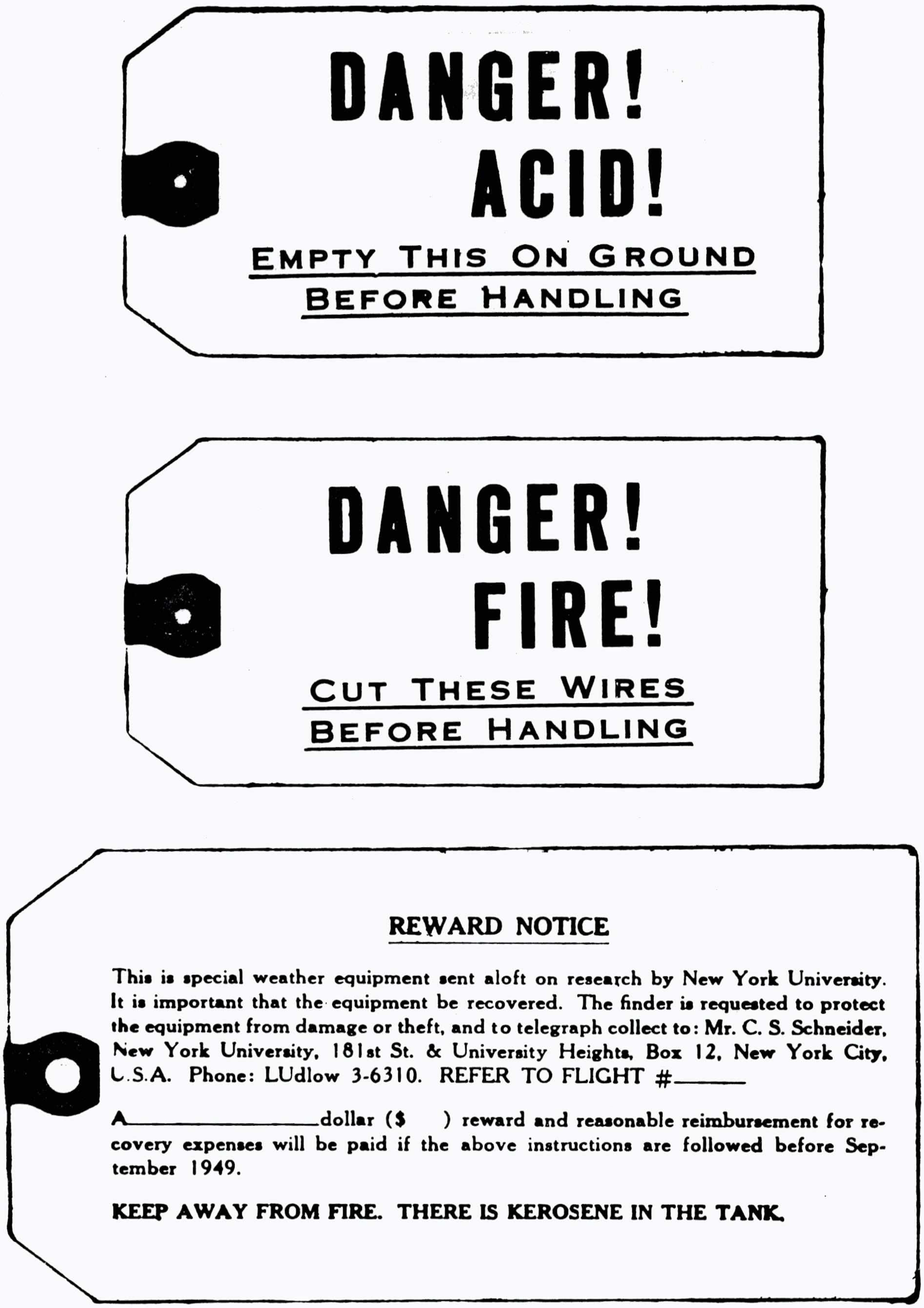


Figure 20
Sample warning and reward tags

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, at what time?

4. Did it float down slowly or fall rapidly?

5. How much kerosene was there in the tank?

Remuneracion

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

Con este motivo, se dara una remuneracion de __________ dolares norteamericanos y una suma proportional para devolver todos los apartos en buen estado. Para recibir instrucciones de embarque, comuniquense con la persona siguiente por telegrafo, gastos pagados por el recipiente, refirriendo 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, New York

Figure 21
Sample Spanish reward notice and English questionnaire.

and pin holes from being made in the fabric. For example, the film is so easily injured that it is not safe to lay a folded-up balloon on a bare table-top or other hard surface on which sand or splinters might be found. For this reason a clean ground cloth of canvas should always be used for the lay-out of the balloon. Once the balloon has been laid out on the ground cloth, it is made ready for inflation and the rip line of the flight-termination gear is inserted into the cell (see Section III, C).

B. Use of Shot Bags and Releasing Device

While the balloon is being inflated it is necessary to hold it in position. Under conditions of calm wind, this may be accomplished by simple fastening heavy weights to the loading ring and allowing the entire balloon envelope to rise freely above its anchor.

Since only 10 to 20% of the balloon is full at the surface when the inflation is complete, it is possible to restrict the volume filled and so cut down the area exposed to the wind on days which are not calm. The volume required can be expressed as the length of the bubble collected at the head or top of the balloon. Having determined the desired length (see Section IV, B), the remainder of the balloon may be held down on the ground cloth by weighted bags wrapped in protective sheets of polyethylene (see Figures 22 and 23). Elliptical shot bags, weighing 100 pounds, are used to hold the base of the bubble to be inflated. Twenty-pound sand bags are used to keep the appendix closed to prevent filling of the balloon with air and to restrict the uninflated folds of the balloon. A more elaborate system of holding the gas in the upper section of the bubble makes use of the General Mills releasing device shown in Figures 24 and 25. Mounted on wheels, this mechanism is rolled into position with the head of the balloon lying across the platform. The protective roller arms lock into position holding the bubble until launching. This device is used with large loads when shot bags might roll or slide off the balloon. As the arms open outward as well as upward when the locking pins are removed, it is necessary to position the platform with the arms opening away from the bubble.

C. Inflation Techniques

When the balloon is manufactured, a polyethylene inflation tube about 4" in diameter is inserted. This tube extends from a few feet outside the appendix to near the top of

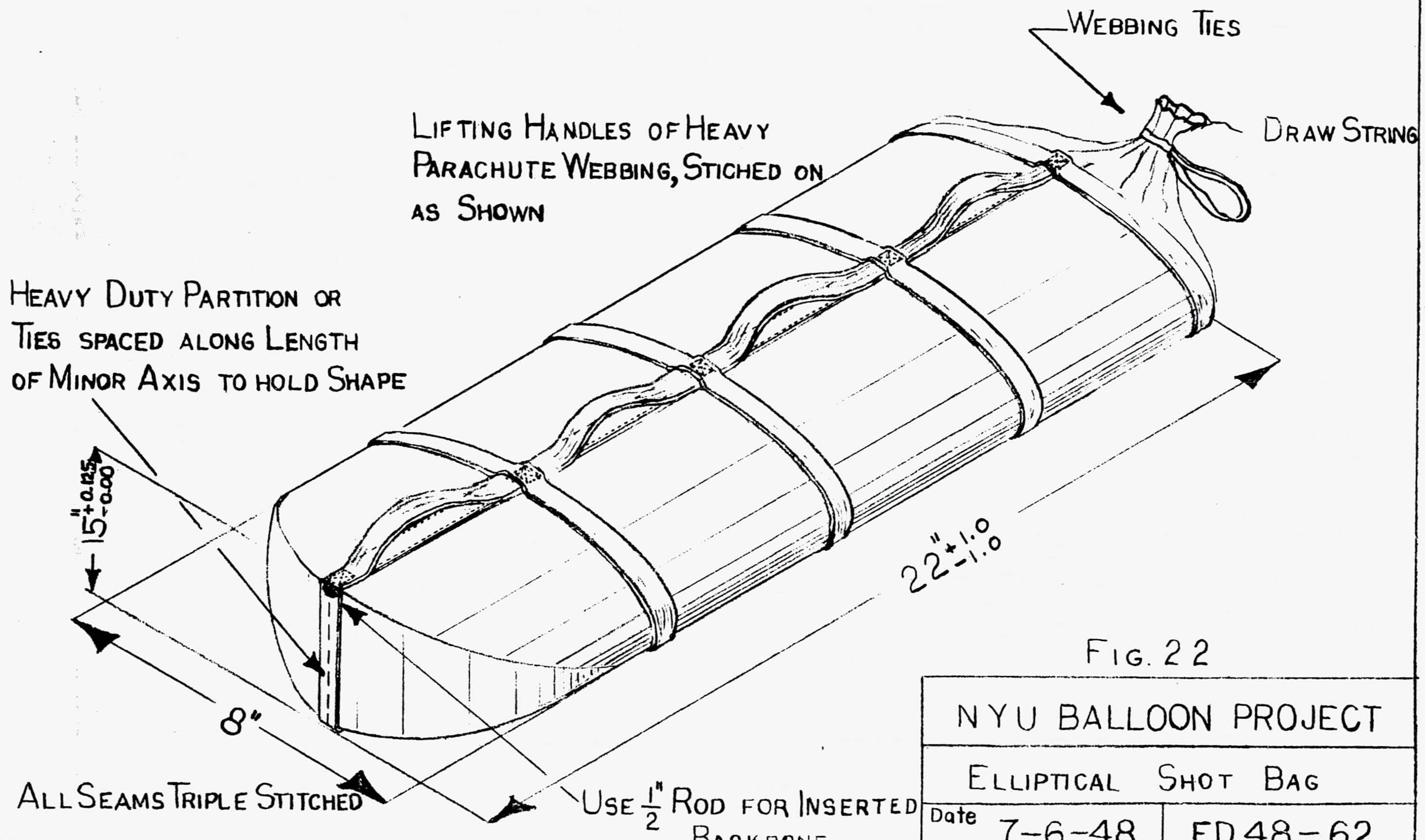
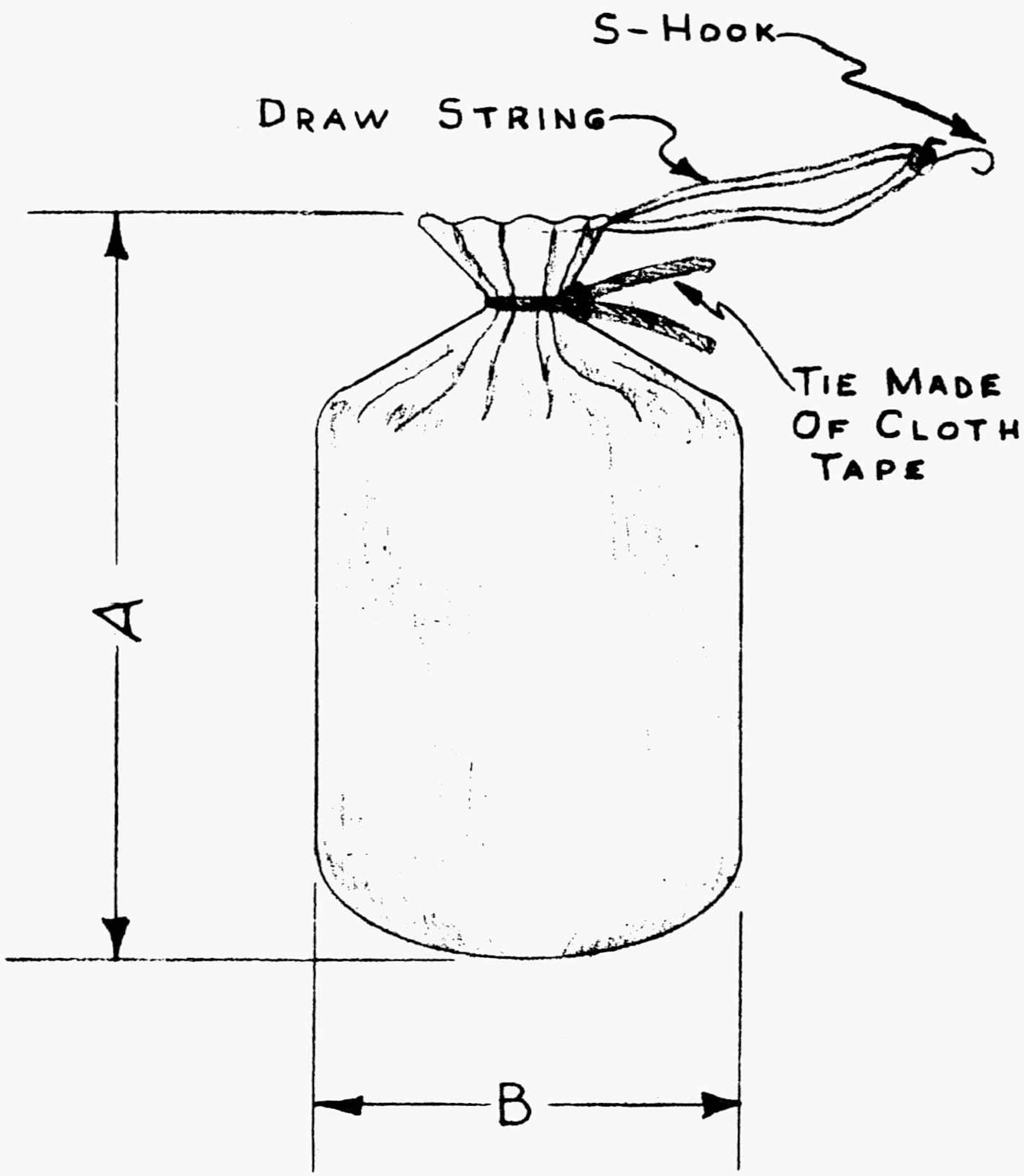


FIG. 22

NYU BALLOON PROJECT	
ELLIPTICAL SHOT BAG	
Date 7-6-48	ED 48-62



BAG SPECIFICATIONS			
TYPE	A	B	BOTTOM
40# SAND	12"	10"	DOUBLE
40# SHOT	7"	6"	DOUBLE
SAFETY WT.	5"	3"	SINGLE

MATERIAL- HEAVY CANVAS DUCK

FIG. 23

N.Y.U BALLOON PROJECT	
SAND AND SHOT BAG SPECIFICATIONS	
DRAWN BY: LHM DATE: 11-23-48	ED48-122A

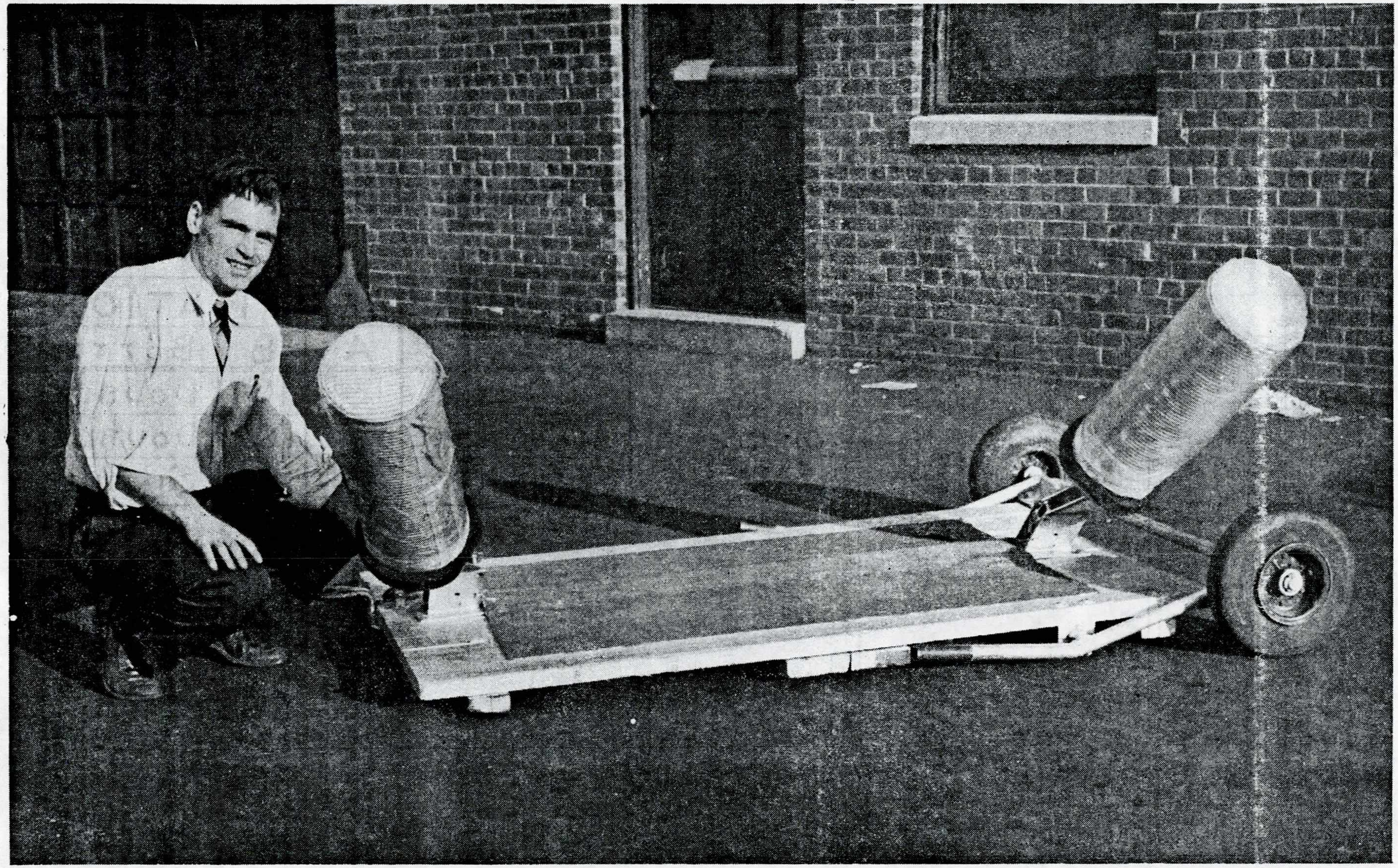


Figure 24
General Mills launching platform for large balloons.

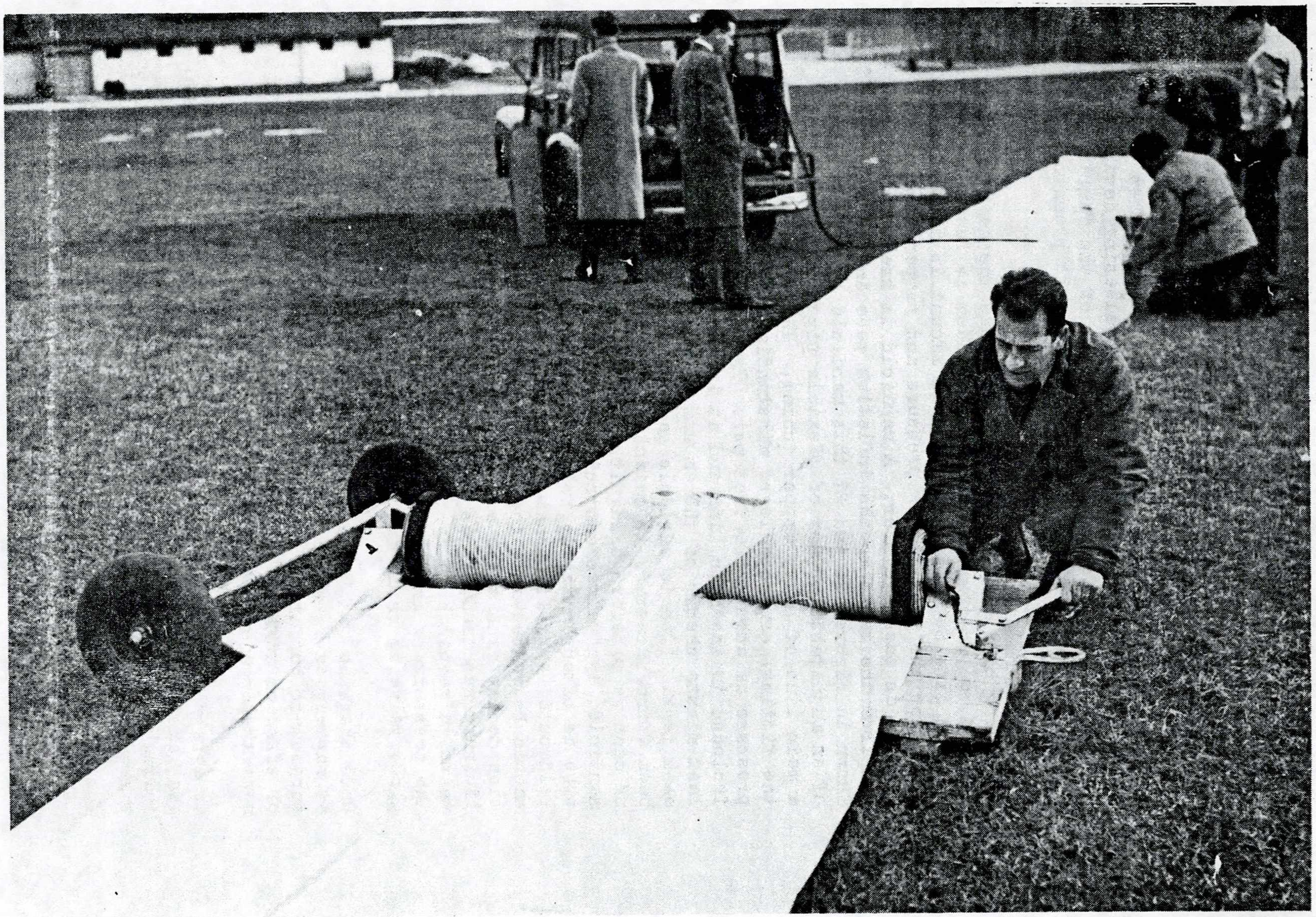


Figure 25

Launching platform with balloon fixed in place for inflation.

the balloon and permits gas to be introduced into the top of the cell first. As the balloon is laid out and shotbags are positioned, this tube must be kept clear. At the point where the bubble is pinched off the folds of the balloon are carefully divided; the inflation tube is made as free as possible with only one layer of polyethylene above and one below it. The tube is then pulled up above and between the arms of the releasing device or the heavy shot bags, and the remainder of the fabric is pinned down so that no shifting will permit premature release.

Depending upon the load to be lifted and the rate of rise desired, a pre-computed amount of helium is fed into the balloon (see Section IV, A). This amount is determined by noting the equilibrium pressure and temperature of the gas in each cylinder. A manifold is used to feed the gas from the tanks to the inflation tube in the balloon. Shown in Figures 26 and 27 this manifold system consists of an adjustable number of flexible pigtails leading into a main line of heavy copper tubing. This main line and the fittings are capable of withstanding the full tank pressure of about 2500 feet psi. Two pressure gages are included in the main line and it is thus possible to make last-minute checks of the amount of gas (pressure) in each tank. (Due to variable gage-calibrations, it has been found necessary to establish the lift-pressure ratio of each gage before using it.) In the main line of the manifold, two valves control the gas flow. The inflation tube is often initially twisted when the balloon is first laid out. A small amount of gas at very low pressure should be valved into the tube to strengthen it. In addition to the fine valve control required for this preliminary gas feed, it is also nedessary for a manifold valve to permit high gas flow from the tanks even when the pressure is greatly reduced. For this, the coarse globe valve is used.

Once the tube has been checked, inflation should proceed as rapidly as possible. The balloon is outdoors and so subject to buffeting by the wind. The limiting factor of speed of inflation is the vibration of the fabric near the open end of the inflation tube.

As a result of the extreme cooling of the rapidly expanding gas, the manifold and the tank valve generally become coated with frost. Too rapid cooling may actually cause the valve to freeze shut.

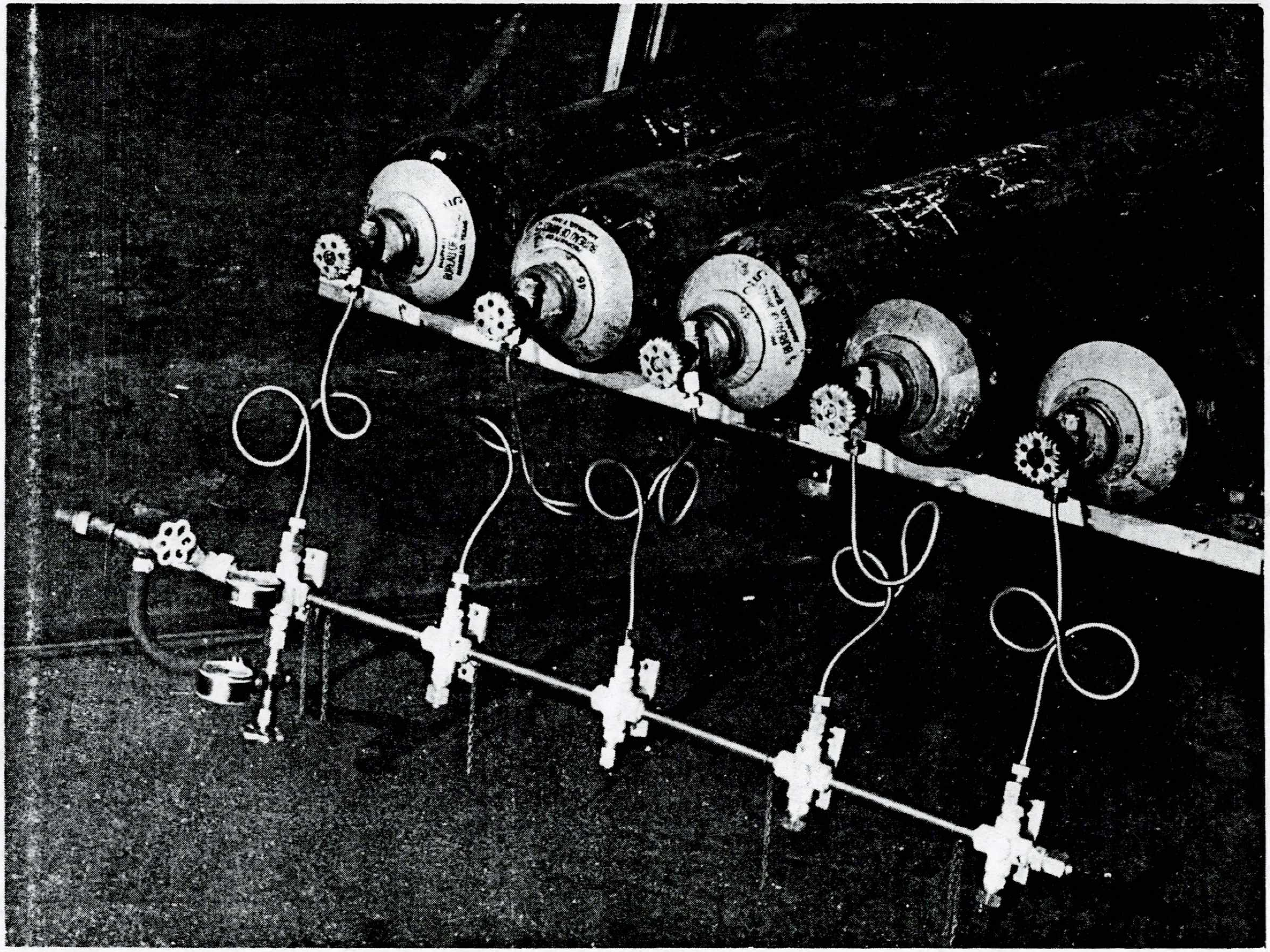
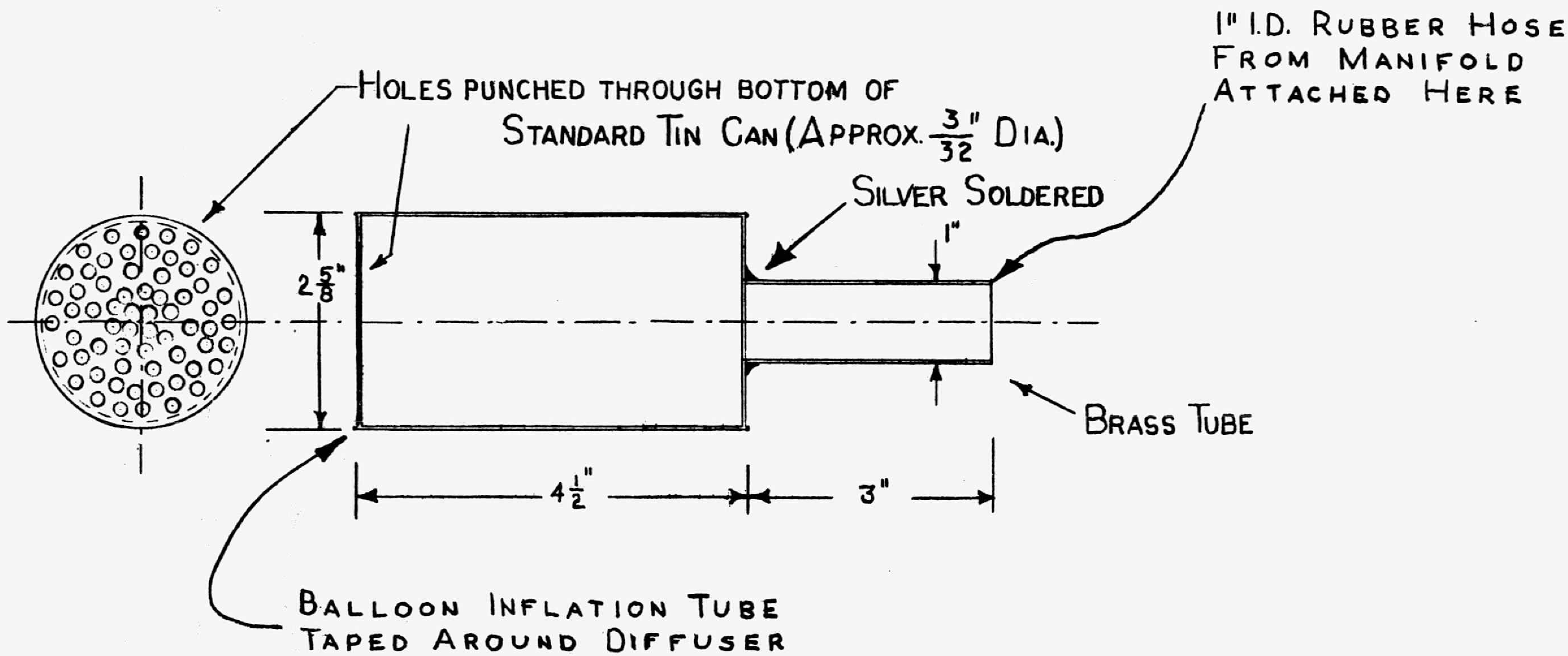


Figure 26
Five Tank Helium Manifold



SCALE 1:2

FIG. 27

NYU BALLOON PROJECT	
TYPE 2 DIFFUSER	
DATE 8-25-48	ED48-76A

JN

The effect of this cooling is evidenced in the lifting power of the gas. When a rapidly filled balloon is launched immediately after inflation, it has less lift than desired and may even be "heavy" rather than buoyant. 20°C cooling will make balloon 1% heavier. This may be 25% of free lift. In the inflation of the 70-foot balloons where more gas is used, and the cooling effect is more often harmful, a heating unit is added to the inflation equipment. The gas passes from the manifold through a coil which is centrally warmed by a blow torch and on into the inflation tube. The gas should arrive in balloon no more than 20°C cooler than the air.

VI. BALLOON LAUNCHING

When the balloon inflation is complete, the inflation tube is removed from the balloon as gently as possible. There is apt to be constriction at the point where the bubble is formed by the launching arms or the shot bags. If the tube does stick at this point, great care must be given to freeing without ripping the balloon.

Should the balloon be torn in this or any other manner, it may be possible to patch the fabric and salvage the flight. The acetate-fiber scotch tape, used to attach the batten is used for patching. Transverse tapes are laid across the tear and the entire region is covered with a matting of tape.

When the inflation tube is freed and the restrained bubble is ready for launching, the lower portion of it is laid out down wind, as is all of the gear on the load line. The inflation is generally done in the lee of the hangar or "Y"-shaped wind screen (see Figures 28 and 29) with the bubble as close to the wall as possible. It is imperative that the wind direction be noted prior to launching and that the equipment be directly downwind from the head of the bubble. It is strongly recommended that a standard meteorological rubber balloon be inflated and tethered on a 150-foot line near the point of release to serve as a wind indicator. This balloon is much more effective than a standard wind vane.

All pieces of equipment and all on-lookers must be removed from the immediate vicinity to prevent accidental entanglement of the load line when the balloon begins to rise. Each piece of delicate gear to be carried aloft should be cradled by one man. As a signal given by the flight director (after checking to see everyone is ready and that the balloon will go in the desired direction), the bubble is released (see Figure 30). If "launching arms" are used, this is not

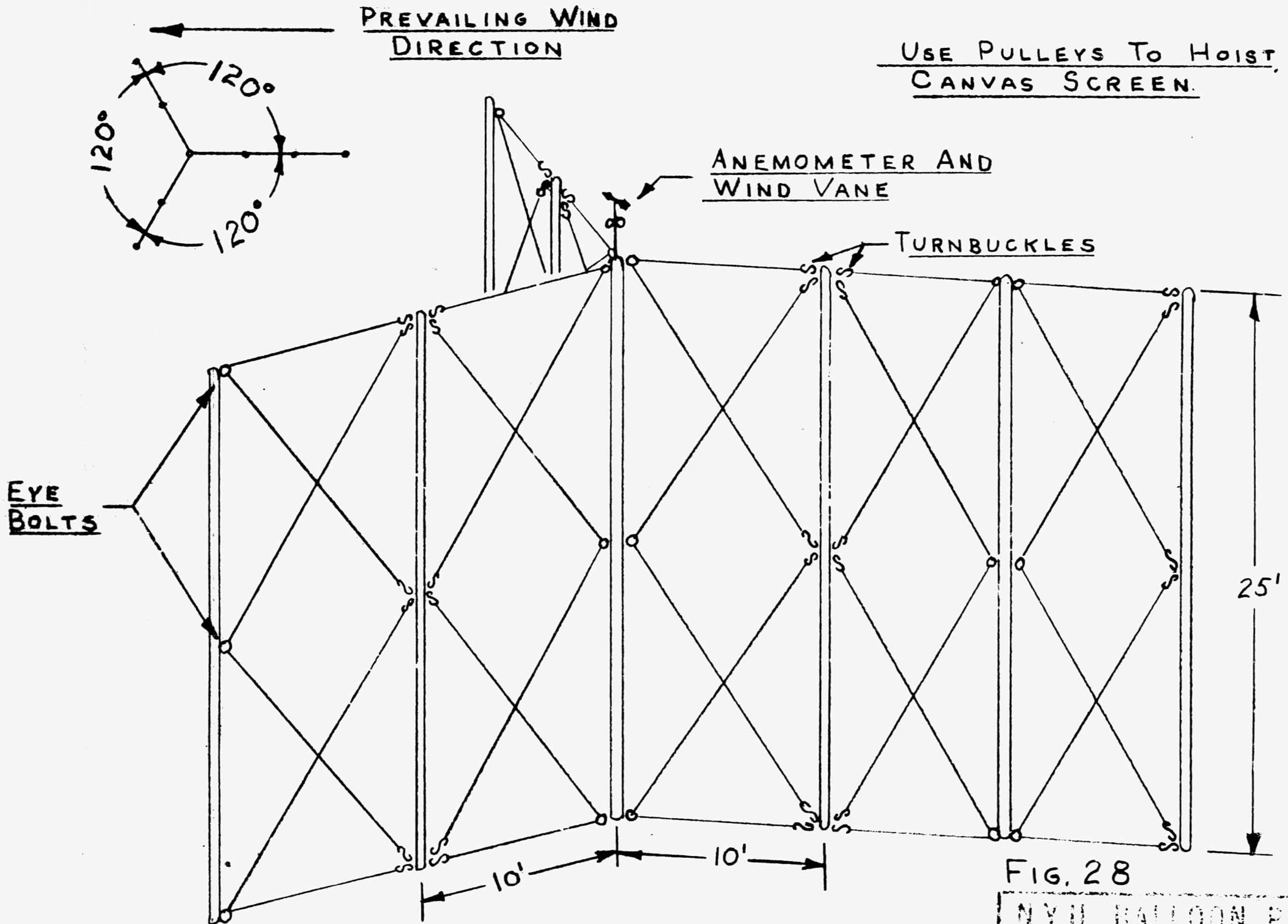


Fig. 28

Telephone Poles Cross Braced With Steel Cable To Support Canvas Wind Screen. Canvas Removed After Use. Permanent Wind Screen May Be Erected Using Wooden Sides.

N.Y.U. BALLOON PROJECT	
Y-SHAPED WIND SCREEN	
DWN. BY: LHM DATE 1-25-49	ED49-3A

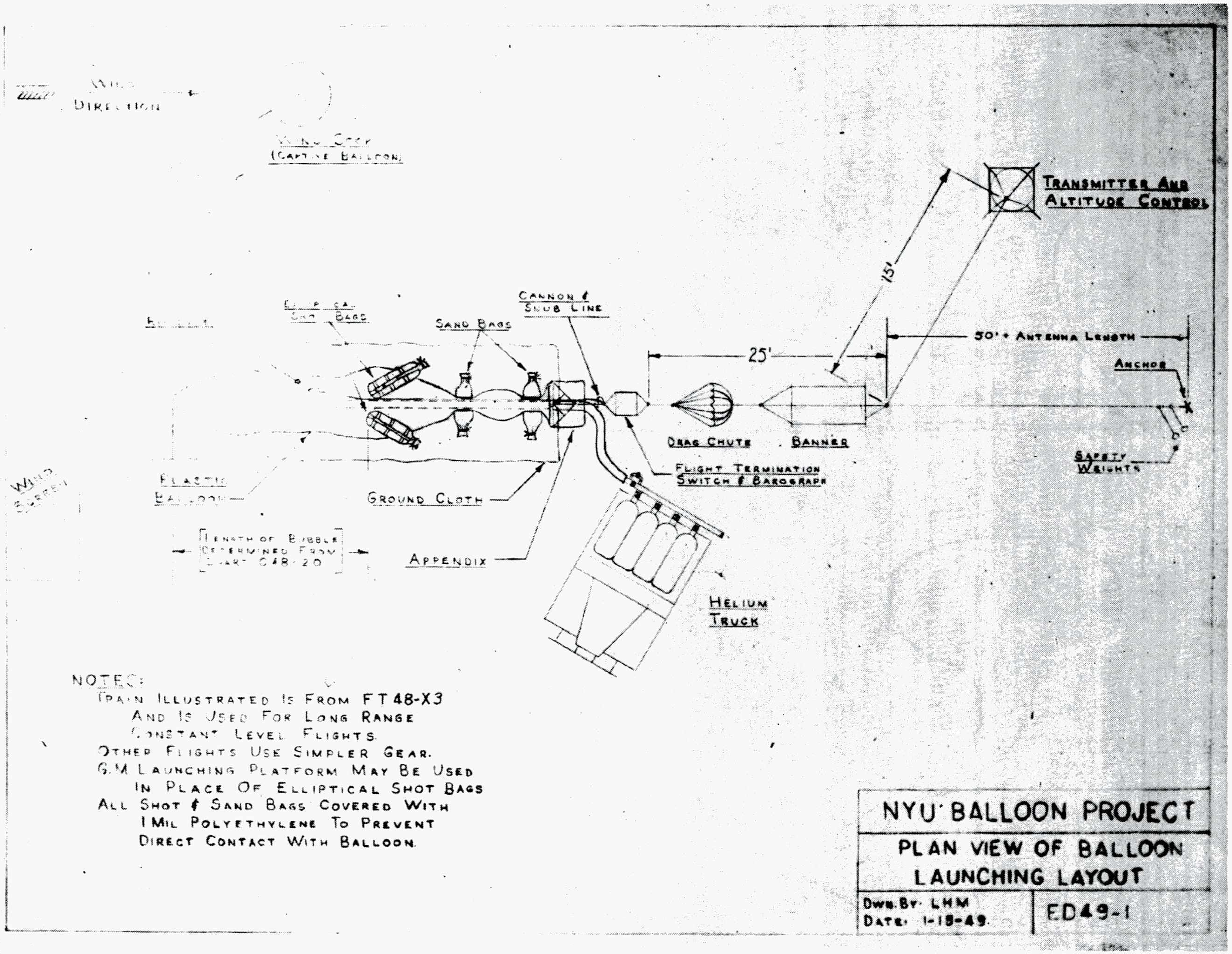

TRANSMITTER AND ALTITUDE CONTROL
15'
CANNON & SNUB LINE
SAND BAGS
25'
50'+ ANTENNA LENGTH
ANCHOR
DRAG CHUTE
BANNER
FLIGHT TERMINATION SWITCH & BAROGRAPH
SAFETY WEIGHTS
GROUND CLOTH
APPENDIX
HELIUM TRUCK
NOTES:
TRAIN ILLUSTRATED IS FROM FT 48-X3
AND IS USED FOR LONG RANGE
CONSTANT LEVEL FLIGHTS.
OTHER FLIGHTS USE SIMPLER GEAR.
G.M LAUNCHING PLATFORM MAY BE USED
IN PLACE OF ELLIPTICAL SHOT BAGS
ALL SHOT & SAND BAGS COVERED WITH
1 MIL POLYETHYLENE TO PREVENT
DIRECT CONTACT WITH BALLOON.
NYU BALLOON PROJECT
PLAN VIEW OF BALLOON
LAUNCHING LAYOUT
DWN. BY LHM
DATE 1-18-49
ED49-1

Figure 29

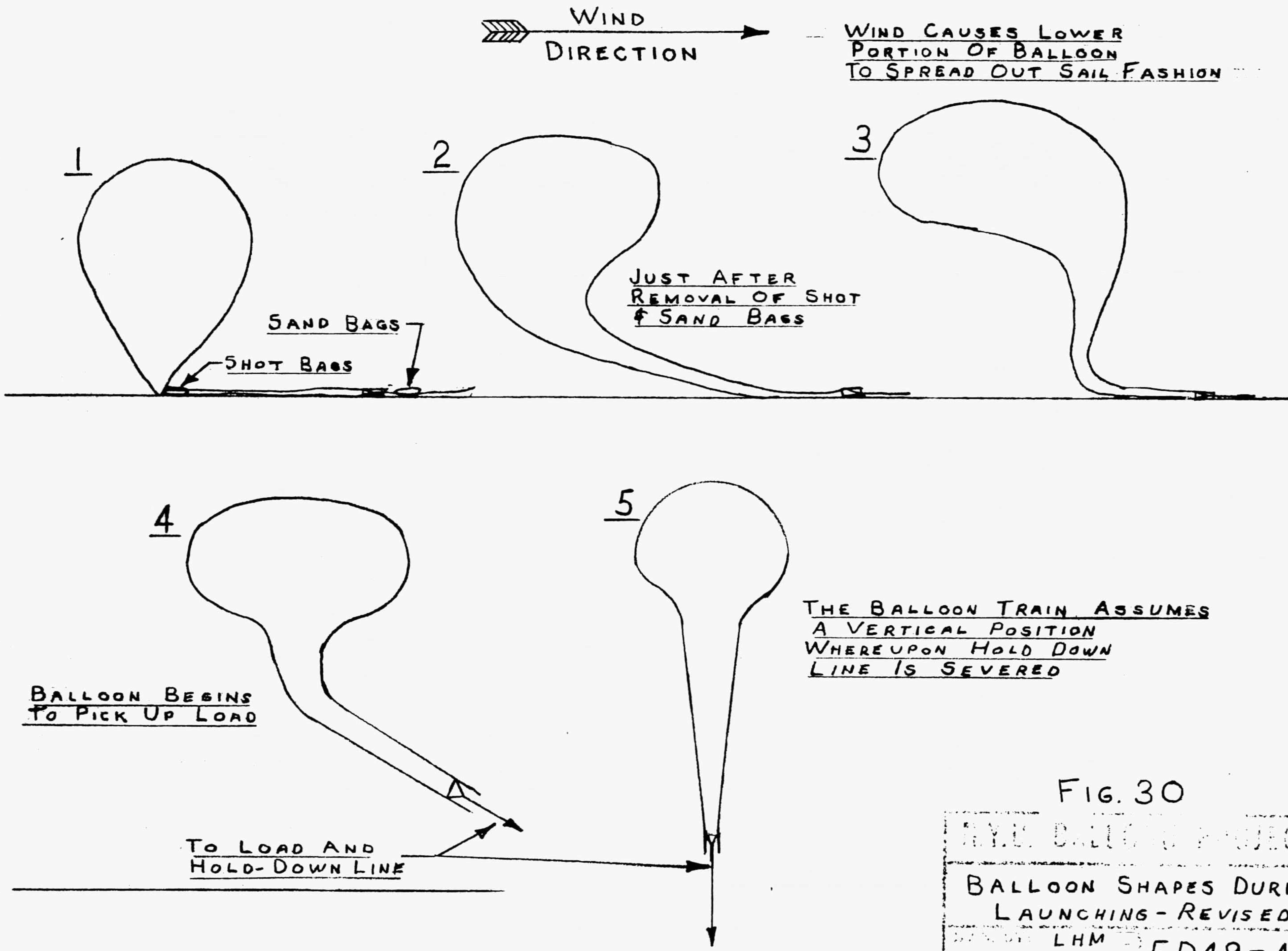


FIG. 30

N.Y.U. BALLOON PROJECT

BALLOON SHAPES DURING LAUNCHING - REVISED

LHM 1-28-49 | ED49-4

difficult, but if the two elliptical shot bags are employed, they must be lifted simultaneously upward and outward away from the balloon. As the cell rises, each piece of gear must be cradled by its bearer allowing it to be lifted vertically when the balloon passes overhead. In many instances where the wind direction is not constant at the surface or changes as the balloon goes upward, and exact downwind positioning of launching personnel will be difficult. It is often necessary for these men to run to one side or forward or backward to get directly beneath the balloon. In cases of extreme wind speed, it has been found necessary to load the lower pieces of equipment on to a truck bed before release of balloon and launch it by driving underneath the balloon.

It is possible to estimate the space required to launch a train of given length if the wind speed is known. By using the computed figure for rate of rise, the length of time required to lift the entire train is found. The distance the bubble will travel during this time is proportionate to the wind speed. For example, if a train 250 feet long is launched with the rate of rise at 500 feet per minute, a bubble will move downwind at 660 feet if the wind is 15 miles per hour (22 feet per second), and the man at the end of the equipment train must cover 410 feet in 30 seconds carrying the gear with him.

The use of a restraining line attached to the load line above any heavy gear or delicate gear is recommended. A loop in this restraining line is attached to a winch mounted on a track a few hundred feet downwind of the lowest piece of gear, or is held by a well-gloved man. The safety weights are attached near the end of this line. The balloon tends to pull the gear in beneath itself in calm or light winds, and may pull sidewise if the train alignment is not perfectly downwind; the restraining line withstands this pull. Thus tethered, the balloon is forced to come overhead of the equipment bearers, and they are able to launch with less difficulty and danger of equipment damage. If the apparent ascent rate is too slow, the restraining line is cut between the safety weights and the other pieces of equipment. If the rate of rise appears to be high enough, the restraining line is severed below the safety weights and they rise, completing the launching.

VII. TRACKING AND ALTITUDE DETERMINATION

Following release, it is often necessary to know the position of the balloon and its height as long as possible. Several methods of position and height determination have been found useful. Advantages and limitations of each system are given.

A. Positioning Equipment

(1) SCR-658

The radio direction finding set SCR-658 has been found to be the most useful unit to track a balloon-borne transmitter, within its limited range. If the set is in good condition and the transmitter signal is good, it is possible to receive from a transmitter which is 150 miles away at an altitude of 50,000 feet. At this distance, the elevation angle is usually not high enough to be reliable, since below angles of 13°, ground reflection of signals makes them nearly meaningless. The azimuth angle and the elevation angle, when above 15°, are accurate to about 0.5°. It is thus necessary to use two such sets on about a 100-mile base line to give a position fix. If the elevation of the balloon is determined independently, and the elevation angle is above 13°, it is possible to locate the balloon-borne transmitter with one SCR-658.

The installation and maintenance of SCR-658 requires the services of a specially trained man, while the operation procedure may be made by relatively unskilled personnel, with limited training. For details of the use of the SCR-658, see War Department publication TM11-1158A.

(2) Theodolite

The meteorological theodolite is useful on daytime flights when skies are clear for ranges up to 100 miles. If radio data are available to give height, the additional information obtained from this instrument--elevation and azimuth angle--will completely fix the balloon's position in three dimensions. When pressure data are known, two theodolites with a base line several miles in length will also uniquely locate the balloon. A third method, less accurate but still useful, is the method of stadia measurements. By carefully measuring, prior to release, the distance between two distinctive portions of the train and then noting the angular distance subtended during flight by these instruments, the altitude and hence all coordinates of the balloon may be determined.

Regular and frequent checks must be made of the scale adjustments of the instruments and of the base plate levels when the instrument is located out of doors. For details of the use and care of theodolites, see either the War Department publication TM-11-423 or the U. S. Weather Bureau Circular "O".

(3) Aircraft Radio Compass

It has been found feasible to determine the position of the balloon by following the signal from a balloon-borne transmitter, using an aircraft radio compass as receiving unit. In this way it is possible to fly along a path toward the balloon, usually at a much lower altitude, and, by noting the plane's position where the compass reading is reversed, the position of the transmitter is found. The main disadvantage of using this system is that aircraft is needed, but there is no other method which will so readily position the balloon over great distances and periods of time. With this system, the limit of transmission time is a function of the weight of transmitter batteries which can be carried rather than distance. It is possible to power a transmitter to supply 2 watts, for about 15 hours, using 15 pounds (7 kilograms) of batteries. Longer periods of transmission may be achieved by intermittent operation of the transmitters or use of heavier batteries.

(4) Radar

If ground radar is available, accurate positioning over a limited range can be made. It is helpful but not strictly required to add radar targets (corner reflectors) to the flight train for such tracking. Using radar, the elevation angle, azimuth angle and slant distance out are obtained, giving a complete fix on the balloon with one set. The maximum distance to which appropriate sets can reach is about 65 miles; such sets are the SCR-584, the SPM-1 and the MPS-6. With good orientation and leveling such sets have an accuracy of 1.0° and about 500 feet of slant range. Because of the limited range, radar sets are not generally useful. Attempts to use radar mounted atop aircraft for aerial observation have been abandoned in favor of the radio compass.

B. Altitude Determination

In early attempts to utilize standard radiosonde pressure modulators they were found to be unsatisfactory. The Diamond-Hinman system of counting signal changes is not useful when the changes occur at a nearly constant altitude due to the width of the steps and the ambiguity of direction of vertical motion. Two pressure measuring systems have been found satisfactory for use in constant-level work and are discussed below. For a discussion of the radio transmitters which have been used (the standard T-69 and the NYU AM-1), see Technical Report No. 2, Balloon Project, New York University Research Division.

(1) Olland Cycle Pressure Measuring Instrument

This instrument, shown in Figure 31, is used in balloon flights as the primary pressure measuring unit, as it will continuously measure pressure without ambiguity. It modulates the transmitted radio signal at intervals whose timing is determined by the pressure of the air at the balloon's position.

As presently designed, the modulator contains a standard Signal Corps ML-310E radiosonde aneroid unit, a rotating cyclinder of insulating material with a metal helix wound around the cylinder, and a 6-volt electric motor which rotates the cylinder.

There are two contacting pens which ride on the cylinder and conduct electrical current when they touch the helix. One pen is fixed in position and makes a contact at the same time in each revolution of the helix. This contact is used as a reference point for measuring the speed of rotation of the cylinder. The time that the second one, which is linked directly to the aneroid cell, makes contact with the spiral, is dependent on the cylinder speeed and on the pen position which is determined by the pressure. By an evaluation chart, the atmospheric pressure can be determined as a function of the relative position of the pressure contact as compared to the reference thus eliminating all rotation effects but short term motor speed fluctuations.

Preparation of the modulator for flight consists of the following steps:

(a) Test the motor operation. When a 6-volt battery is inserted in the motor circuit with the proper polarity, the motor should run smoothly at one revolution per 60 to 80 seconds. Noisy operation is probably a sign of dirty or corroded

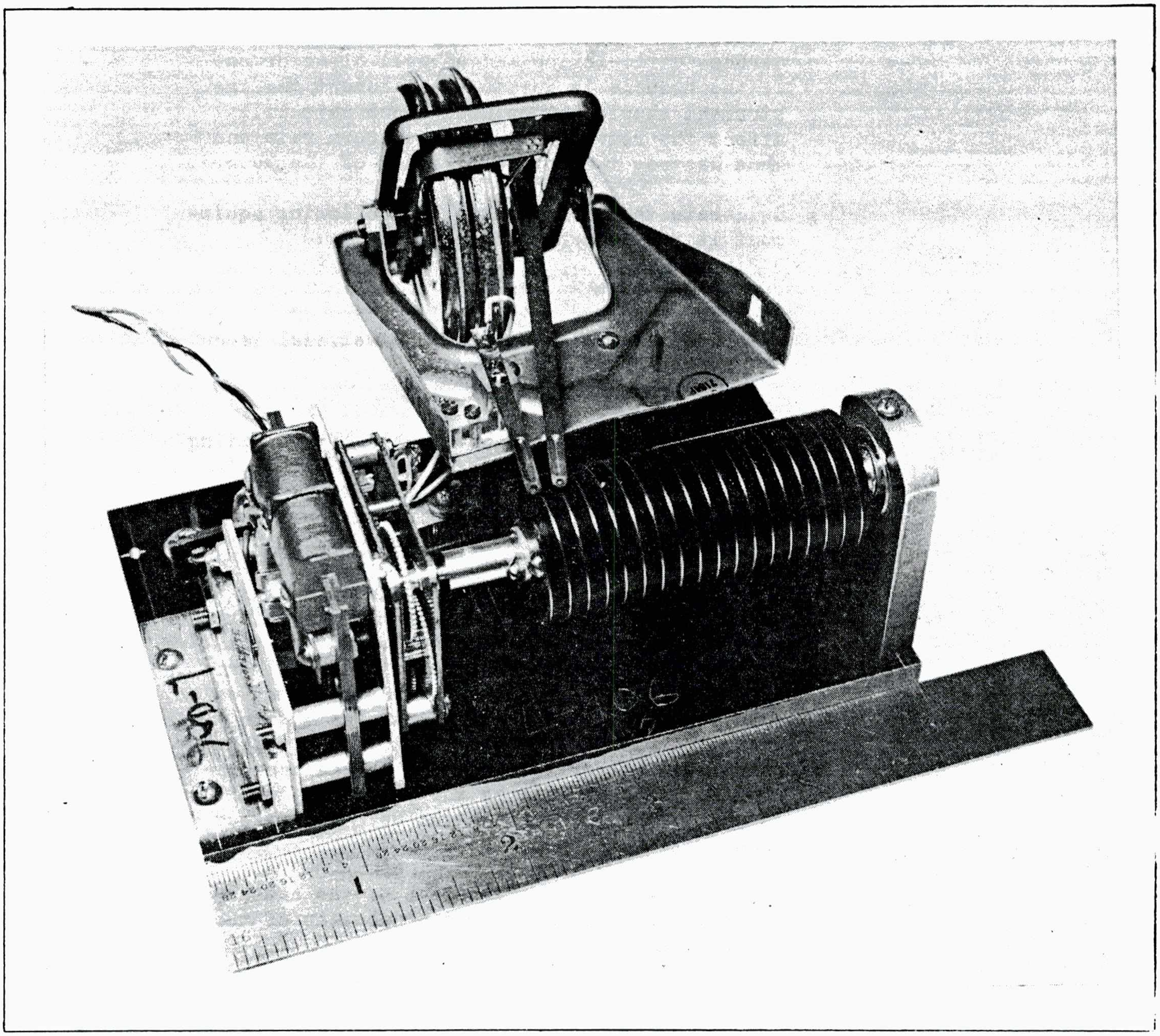


Figure 31
Olland Cycle Pressure Modulator

gears or poor alignment of the rotating cylinder. The motor gears may be cleaned with carbon tetrachloride and a small clean brush. If the trouble is due to misalignment, the instrument should not be used since this will affect the rotation at a non-uniform rate and thus destroy the entire accuracy of the record.

(b) Calibrate the instrument. The following equipment is required for the calibration:

Vacuum pump
Bell jar
Base plate with at lest 4 electrical leads
Manometer
Tape recorder

The vacuum pump should be capable of evacuating the bell jar to a pressure lower than that to be reached by the balloon in flight. A pressure of ten millibars, corresponding to about 100,000 feet elevation is usually a good minimum.

Four wires are necessary to conduct the six volts to the motor and to transmit the reference and pressure signals. The wires must pass out of the bell jar through an air-tight seal in the base plate. The base plate also needs a tube leading to the manometer and a tube to the vacuum pump. It is advisable to use two separate tubes rather than placing the manometer lead in the same line as the pump lead in order to obtain the pressure in the bell jar rather than that in the pumping line.

In operation the negative line of the battery leads is used as the ground connection of the output signal.

A tape recorder such as the Brush Development Co. model BL-902 oscillograph and amplifier BL-905, is needed to record the signal both during calibration and during the balloon flight. The Brush recorder is used at present and the discussion of the operation will be made in terms of the characteristics of this instrument. When using the slow speed of the recorder, which feeds the paper at the rate of 30 centimeters per minute, the distance between successive reference marks will be 30 to 40 centimeters depending upon the speed of rotation of the modulator motor. The pressure signal appears at any point along the record between or overlapping the references depending upon the pressure. A sample record of this sort is shown in Figure 32.

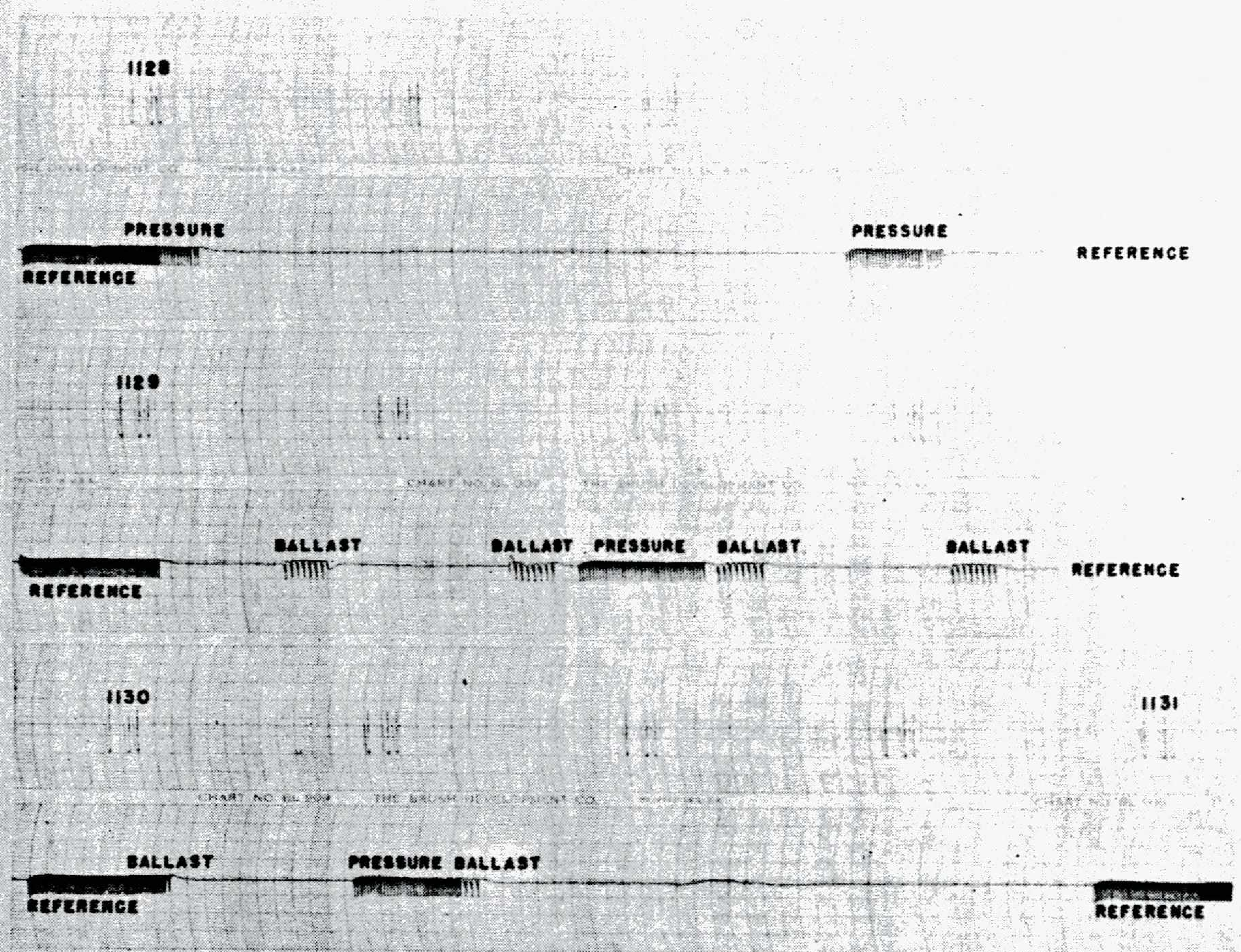
The Olland cycle acts as a switching unit for the test oscillator (see Figure 33) whose signal is fed into the Brush amplifier and finally to the recorder. By adjusting the resistors in the test circuit, the frequency of oscillation may be adjusted. Since within the usual range, the frequency of oscillation is approximately additive when the two signals overlap, the suggested frequencies are about 4 cycles per second for pressure and 8 cycles per second for reference. When overlapping signals are being recorded the frequency will be about 12 cycles per second which is easily recognizable on the record.

The calibration of the modulator unit should be in steps of 25 to 30 millibars in order to have at least three points within each turn of the helix.

Evaluation of the record is accomplished with the aid of a nomogram divided into 100 equal parts. The record is laid on the nomogram with the leading edge of the first reference on the zero line and the leading edge of the second reference on the 100th line. The position of the leading edge of the pressure signal is then read to the nearest third of a division on the nomogram. If one complete turn of the spiral represents 75 millibars, it is thus possible to read the pressure to an accuracy of one-three-hundreth of 75 or about one-quarter millibar.

In evaluating the record the tape should be kept parallel to the horizontal lines on the nomogram or perpendicular to the zero line in order to avoid errors in interpretation.

The total motion of the pen arm of the modulator is normally 12 to 14 turns of the spiral. Therefore, there will be the same number of points at which the pressure and reference signals overlap. The calibration curve (Figure 34) is drawn to show pressure from zero to surface pressure (about



Sample Record Of Olland Cycle Pressure Modulator Signal As Recorded On Brush Oscillograph

Reference – 9 cps
Pressure – 5 cps
Ballast – 2.5 cps

Time Signal Every 15 Seconds On Channel 2.

C49-6
Feb. 25, 1949 – LHM

Figure 32

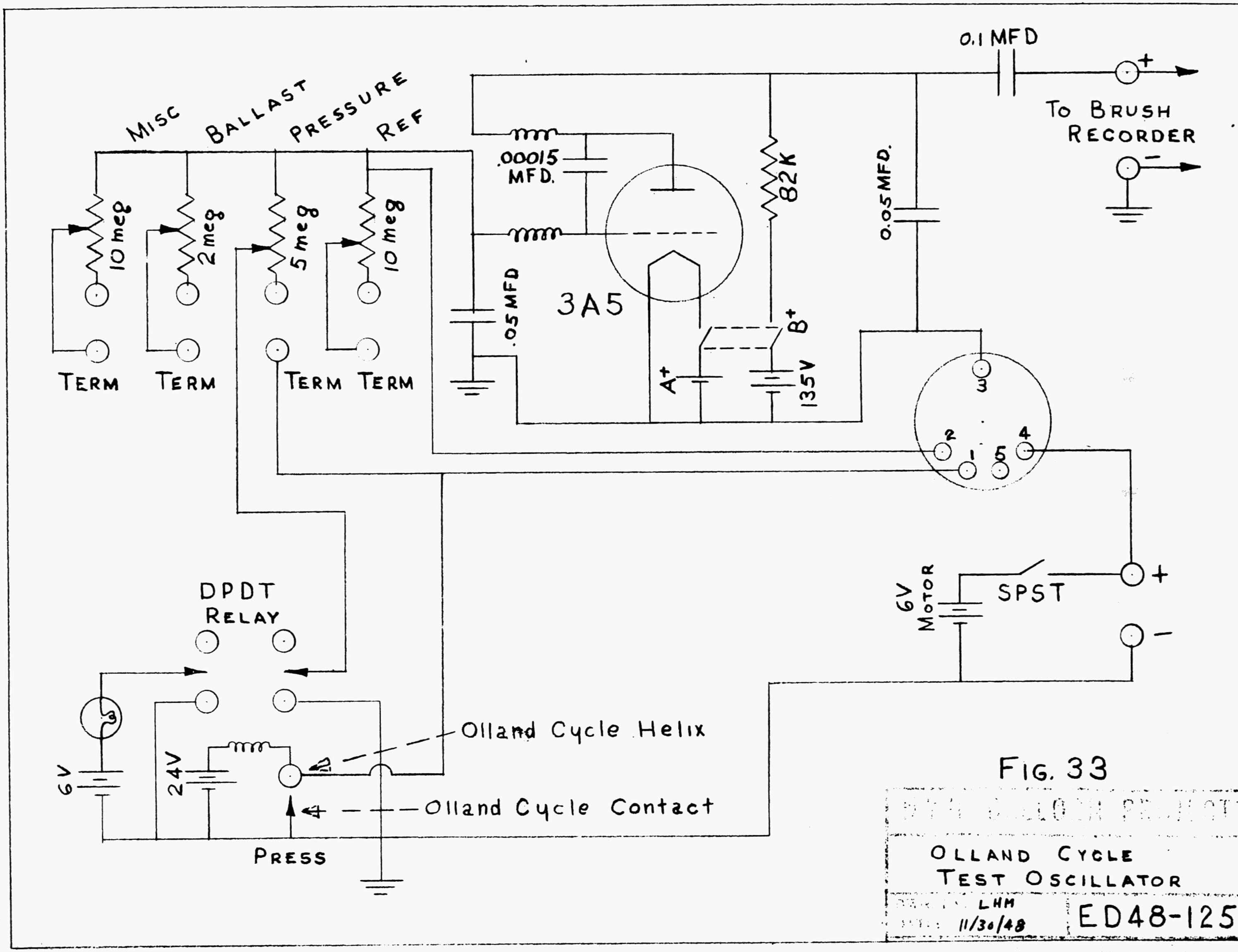


FIG. 33

OLLAND CYCLE TEST OSCILLATOR

LHM

11/30/48

ED48-125

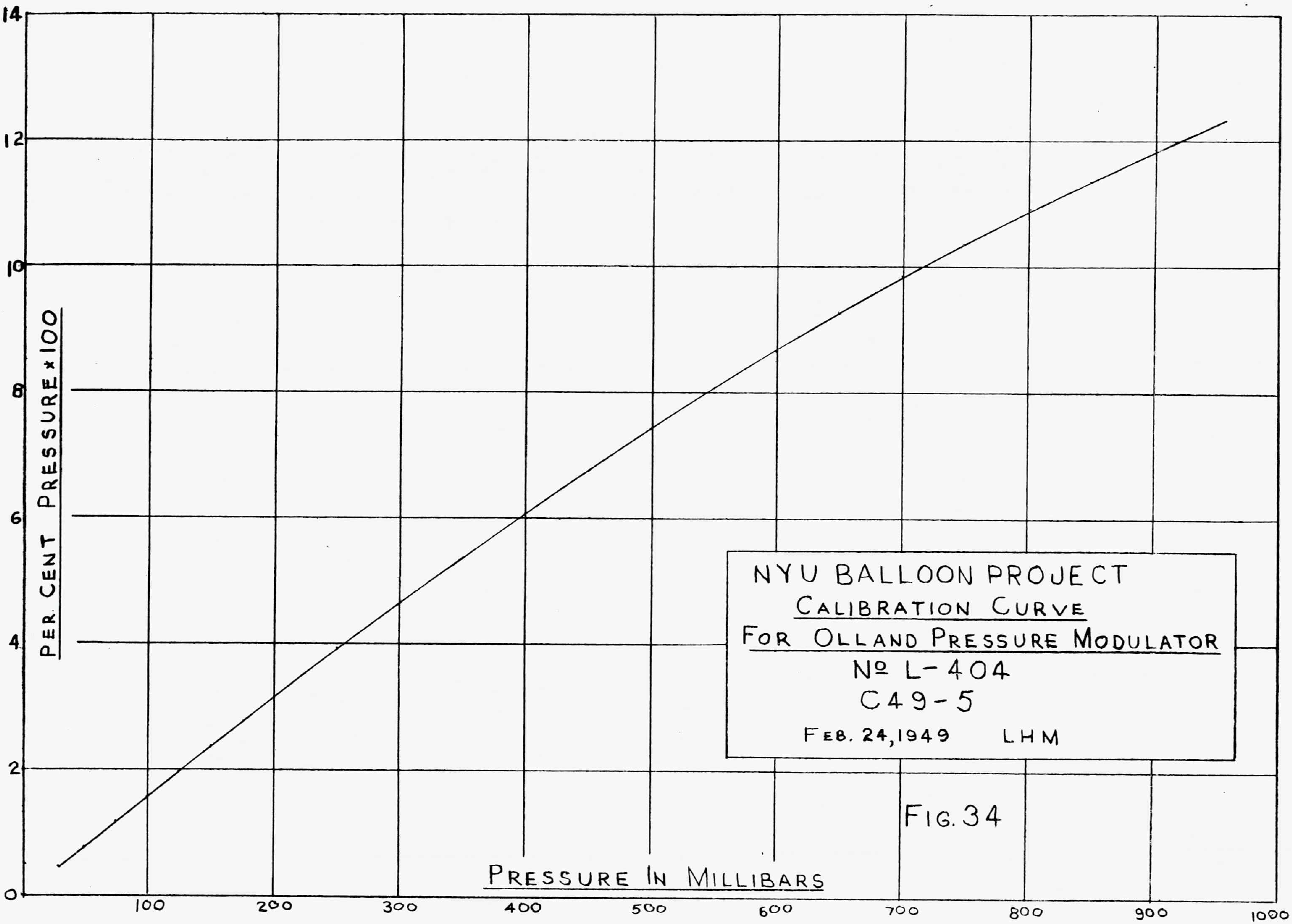

NYU BALLOON PROJECT
CALIBRATION CURVE
FOR OLLAND PRESSURE MODULATOR
№ L-404
C49-5
FEB. 24, 1949 LHM
PER CENT PRESSURE × 100
PRESSURE IN MILLIBARS
0
2
4
6
8
10
12
14
100
200
300
400
500
600
700
800
900
1000

FIG. 34

1020 millibars) against percentage of the turns as read on the nomogram. The lowest pressure reading is numbered as read and succeeding pressures are plotted in a continuous ascending series. When the pressure reading reached the first overlap on the reference, it is called 100 percent; the second overlap is 200 percent and so on until the last overlap which may be 1200 or 1300 percent.

(c) Pack the modulator and insert it inside the transmitter box. The modulator should be protected from extreme cold since the motor operation becomes erratic when the temperature reached 30° to 40°C below zero. A box or paper cover over the modulator will keep particles of insulation and dirt from the moving parts.

(d) When the entire assembly has been made and inflation of the balloon is about to begin, the transmitter and motor should be turned on and reception of the signal tested. If any serious trouble appears, the modulator should be replaced by another calibrated modulator since any work on the instrument will probably change the calibration.

During the flight, radio static and noise will appear on the Brush record as pips which may resemble the transmitted signals and with increasing distance or weakening transmitter the noise will finally completely obscure the pressure record. Careful tuning of the receiver will prolong the record as long as possible. When tuning the receiver, the sensitivity control of the Brush amplifier should be turned to the least sensitive position since any sudden change in the tuning may throw the pen off its supports and damage its glass tip.

When the flight reception is completed the record is evaluated exactly as in the evaluation of the calibration record--using the same nomogram. However, since the instrument is subjected to different atmospheric conditions, the motor speed may vary suddenly, giving false values for the pressure. These values may be detected by carefully observing the rate of rotation of the motor, which is measurable by the distance between the reference marks. If there is a sudden change in motor speed of five percent or more from the preceding rotation, the pressure value should be rejected. A slow, continuous change in speed from minute to minute may be neglected since it is probably a uniform change throughout the rotation period. The motor speed will decrease during the flight, as a result of the low temperatures and the drop in battery voltage. This of itself does not decrease the value of the record, as long as the speed does not change suddenly.

(e) Olland-Cycle Pressure Element Specifications

(1) Pressure range: 1050 to 5 mb.

(2) Desired accuracy: Surface to 300 mb ±5 mb.
300 mb to 50 mb ±2 mb.
50 mb to 5 mb less than ±2 mb, ±1 mb if possible.

Highest accuracy and readability desired on low pressure end. Temperature compensation, as required to meet pressure accuracy requirements for temperature, range +30° to -70°C or equivalent for medium and high altitude flights. Mean operating temperature required more than 0°C.

(3) Helix:

Cylinder--made of insulating material with low temperature coefficient.
Diameter 3/4 inch to 1 inch, length $2\frac{1}{4}$ inch.

Spiral--made of nickel or other metal which does not corrode in the atmosphere, .010 inch or less in diameter.
Eight turns per inch on cylinder.

Check-points--Six points located between turns of spiral, starting with 9th turn, 60 degrees apart.
Made of the same material as the spiral.
In the electrical circuit of the pressure signal.
Suggested shape 1/16 inch diameter, round pin, flush with surface of helix.

General--Helix mounted in a rigid frame to prevent lengthwise movement or springing out through bending of a frame.
Joined to motor drive by a pin through both drive shaft and helix shaft.
When rotating at about 1 rpm duration of signals not over 3 to 4 seconds.
Surface of helix to be polished with rouge or crocus cloth.
Loading edge of the metal spiral will be true and smooth to within .0005 inch.

(4) Motor:

6 to 7.5 volts
1 rpm gear train
20 to 40 milliamperes drain
Constant speed--change of speed during any single revolution not more than 0.3%
Speed change at low temperature not more than ±20%

(5) Mounting of Unit:

Mounting in such manner that temperature changes and stresses will not change the relative positions of the aneroid and the helix. This may be done by mounting all elements on a ¾" metal plate or by mounting all parts in a frame supported on a single pedestal.

Mount unit in an easily opened, stiff single thickness cardboard or plastic box to protect it from other units in flight trains.

External terminal strip with four terminals connected to ground, motor, reference, and pressure.

Total weight not over 500 grams.

Overall dimension not over 5 x 5 x 4 inches.

To be mounted in transmitter, where insulation will prevent cooling below 0°C within 6 hours at air temperature of -40° to -50°C.

(2) Codesonde

The modified radiosonde built by Brailsford and Co., Rye, New York, called the codesonde, has been found valuable when knowledge of small variations in the height of the balloon is not required. Using this system, a radio transmitter is modulated by a Morse code signal which is a function of pressure (and temperature if desired). This system is useful for tracking a balloon with aircraft since no recording equipment is necessary for data interperlation.

Each combination of dots or dashes may be identified by ear, and with a calibration chart, the pressure which corresponds to the balloon's height may be thus determined by anyone who can read Morse code with a suitable radio receiver. The advantages of using this system for a balloon which is to be followed by aircraft include the fact that it is necessary to receive only one complete code group to completely identify the pressure level of the balloon. It is thus possible to interrupt the period of reception without permanently losing the altitude record. It is expected that a balloon transmitter which can be followed with an aircraft radio compass will be used in conjunction with this pressure modulator, giving three-dimensional position data.

(3) Barograph

Many balloon flights pass out of the range of even a network of receiving stations. When it is not possible, because of weather or other considerations, to follow the balloon with aircraft, a clock-driven meteorograph may be added to the flight train to record data, such as pressure and temperature. It is necessary to recover the balloon equipment to evaluate this sort of record. With inland release points, it has been possible to recover about 75% of all flights.

The model U-48 Lange barograph, shown in Figure 35, is designed to give a record of atmospheric pressure and the temperature of the barograph case. In order to obtain a maximum spread of the pressure record in the range at which the data is most useful, the linkages are arranged so that recording begins at about 500 millibars or around 19,000 feet, and may be continued as high as the balloon rises. The

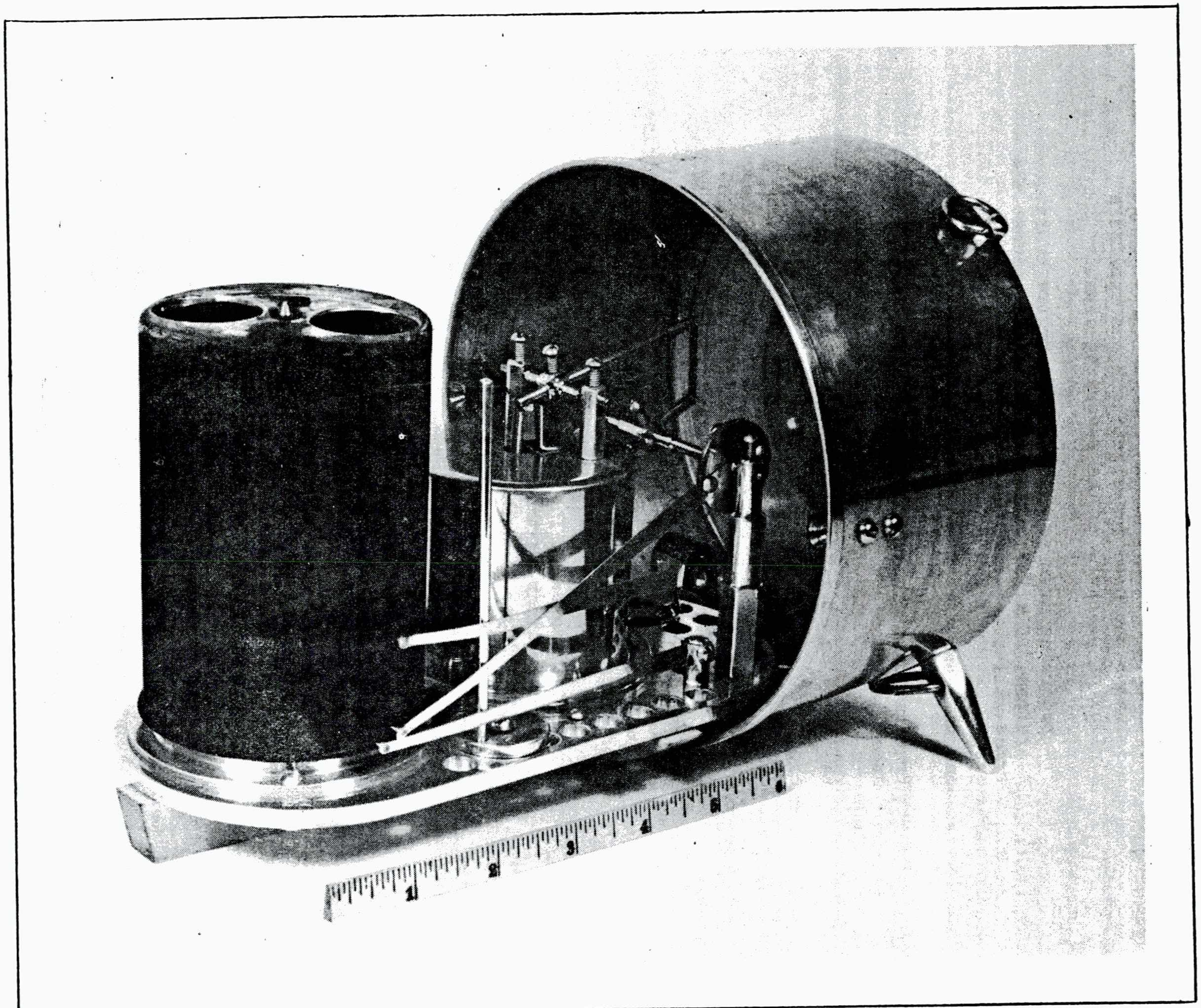


Figure 35
Lange Barograph Thermograph With
Smoked Foil on Recording Drum

temperature recording is confined to the lower 2 inches of the drum so as to interfere as little as possible with the pressure record when the balloon floats above 30,000 feet.

Recording is accomplished by three pens which scratch carbon from a smoked aluminum foil. This method eliminates the need for liquid ink and applies a minimum of pressure to the recording drum.

The recording drum rotates once in twelve hours. Therefore, if a flight lasts over twelve hours, the trace will overlap. Such a record is shown in Figure 36. The clock runs for 36 to 40 hours on one winding.

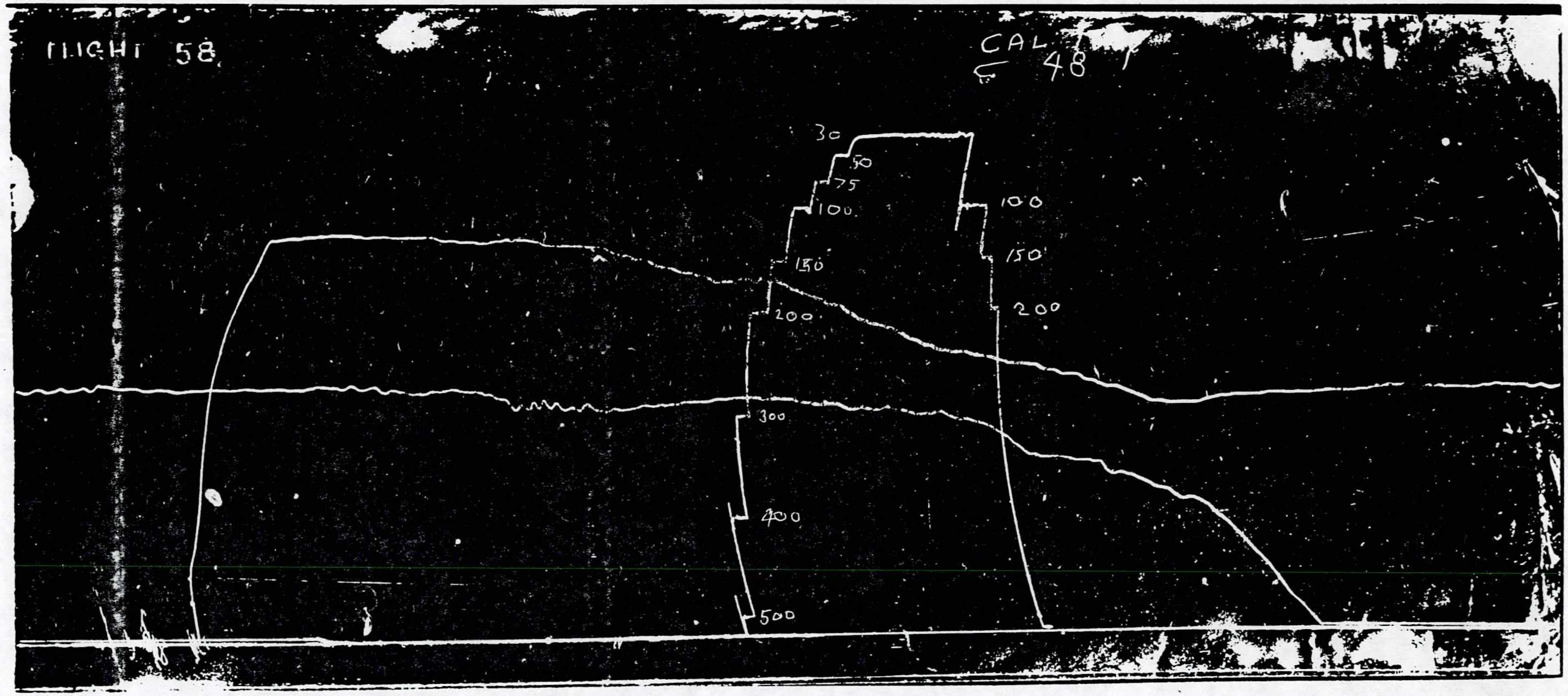
Preparation of the barograph for use on a balloon ascension requires the following:

(a) Place an aluminum foil about 10 inches long by 3 3/4", .002" thick on the drum. Care should be taken to have the overlapping edge of the foil face in the direction of rotation of the drum so that the stylus slides off the edge instead of catching and tearing the foil. A few drops of rubber cement along each edge of the foil are sufficient to fasten the foil to the drum and will not interfere with removal of the foil after recovery of the barograph.

(b) Wind the clock. The clock should not be wound tightly since at the low temperatures encountered in the upper atmosphere the clock spring may snap. However, if the clock is wound an hour or so before release, it will be sufficiently relaxed by the time the low temperatures are reached.

(c) Check pressure of the marking pens. Too much pressure of the pens on the drum will introduce an error due to the frictional lag. When the drum is removed from the clock mechanism, and the pen lifter released, the stylus points should touch the clock housing lightly.

(d) Smoke the drum. A very thin, fine-grained carbon film should be deposited on the aluminum foil. The best result will be obtained by use of a bright yellow gas flame, although a kerosene flame gives a satisfactory coating. Solid or liquid



NYU BALLOON PROJECT

Barograph Record

FLIGHT 58

Released at Alamogordo, N.M. May 10-1948 2033 M.S.T., Recovered at Val D'or, Quebec, Canada

(Orifice Ballast-Leak 300gm/hour)

Duration $24\frac{1}{2}$ hours

Figure 36

fuels usually give a coating which is too coarse grained and heavy. In smoking the drum a long rod is used as a rotating axis. The drum is rotated rapidly in the flame so as to prevent overheating and oxidizing of the foil. The carbon should not be so thick as to obscure the metallic appearance of the aluminum foil.

(e) Calibrate the barograph for pressure. The instrument is placed in a bell jar and the air evacuated. The pressure is kept constant at a number of pressures so that as the drum turns a step, record is made on the smoked foil. Pressure recording starts at about 500 millibars so the first level in the calibration should be at that value. At each level the pressure should be kept constant for three to five minutes in order to obtain a measurable line. Great care and considerable practise are required to control the valves of the vacuum system so that the pressure does not change noticeably during each step.

The pressure steps at which the barograph is calibrated may be either at regular pressure intervals or at the pressure values corresponding to regular height intervals according to the standard atmosphere figures. The recommended steps are listed below. If the balloon is not expected to go to the higher altitudes, the calibration may be stopped at correspondingly higher pressures.

Pressures	Standard Atmosphere Heights
500 mb	466 mb corresponding to 20,000 ft.
400 mb	300 mb " " 30,000 ft.
300 mb	188.5 mb " " 40,000 ft.
200 mb	117 mb " " 50,000 ft.
150 mb	72.8 mb " " 60,000 ft.
100 mb	45.3 mb " " 70,000 ft.
50 mb	28.2 mb " " 80,000 ft.
10 mb	17.5 mb " " 90,000 ft.
	10.9 mb " " 100,000 ft.

The temperature calibration may be made by recording two widely spaced temperatures, such as room temperature and the temperature of dry ice (-78°C). This calibration will be approximately a straight line and, therefore, two points are sufficient to plot the curve.

Immediately before the balloon release, when the clock is wound and the pens lowered against the drum, the pressure and temperature pens should be tapped lightly so as to make short marks and the time noted.

When the barograph is recovered the smoked foil should be treated to preserve the record. A solution of clear shellac diluted with about ten times its volume of alcohol may be used. The drum is immersed in the shellac and allowed to dry thoroughly before further handling.

(f) Evaluation of the record. In evaluating, the record heights of significant points are measured vertically from the reference line. The pressure calibration steps are measured first and plotted on graph paper, vertical distance versus pressure or altitude. Each significant point on the flight trace is then measured and the corresponding altitude determined from the calibration curve.

The same procedure is followed in evaluating the temperature record, measuring from the reference line.

The curvature of the record due to the motion of the pens must be corrected for. Since the temperature record covers a short vertical range, the time correction may be neglected. Corrections for curvature of the pressure record may be read directly from Figure 37, which gives the correction in inches as a function of the distance of the point in question from the center of the record.

The final time correction is made to correlate the temperature and pressure records. This may be done by measuring the horizontal distance between the temperature and pressure marks as made before release and correcting this amount for vertical position. The rotation of the drum is once in 12 hours and, therefore, the time-distance relation may be computed by noting the total length of record obtained in one revolution.

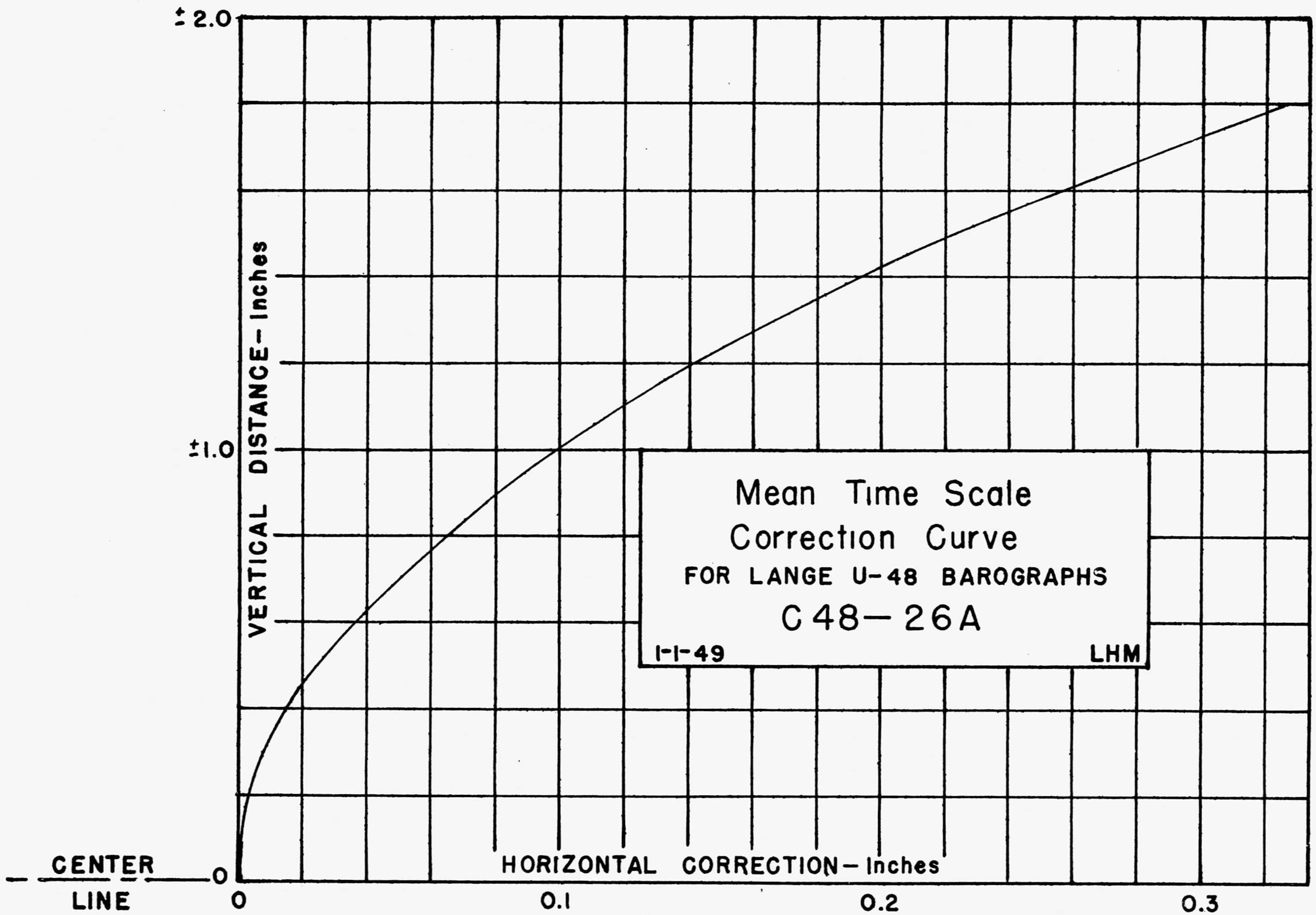

±2.0
±1.0
0
VERTICAL DISTANCE - Inches
HORIZONTAL CORRECTION - Inches
CENTER LINE
0
0.1
0.2
0.3
Mean Time Scale
Correction Curve
FOR LANGE U-48 BAROGRAPHS
C48-26A
1-1-49
LHM

FIG. 37

VIII. ANALYSIS

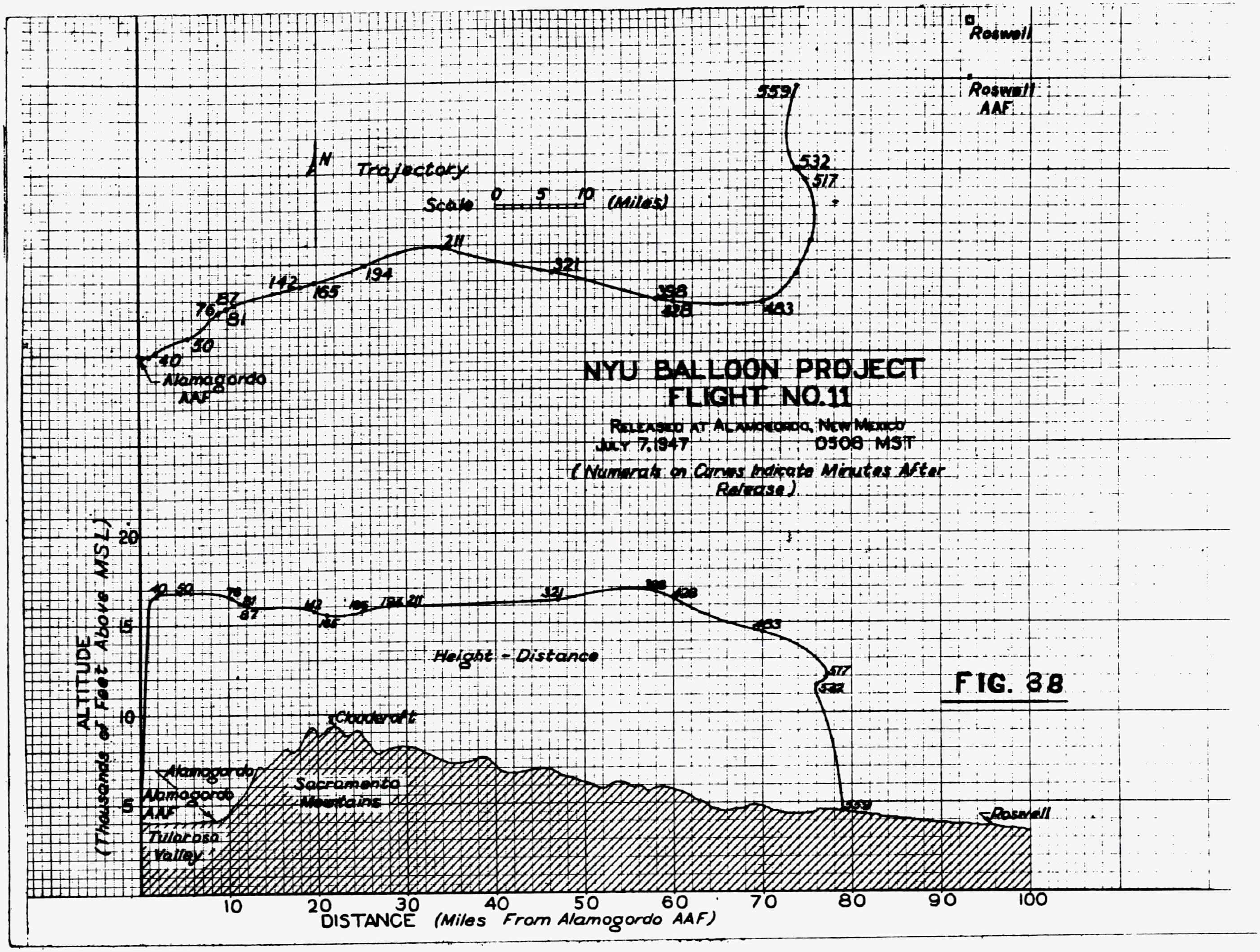
During and following the flight it is customary to analyze the behavior of the balloon. Two curves are usually drawn when data is available for their preparation. The first of these is a time-height curve which gives the altitude of the balloon at all times with respect to sea level. On this curve also it is customary to plot the temperature data and ballast flow data when such has been recorded. In some cases it has been found useful to plot a profile of the terrain over which the balloon is passing. The second diagram usually prepared is the trajectory of the balloon, and again it may be prepared with respect to the terrain over which the balloon was passing. That is to say, it is plotted on an aircraft map of the area, with positions and heights plotted every ten minutes. Figures 38 and 39 show sample plots.

IX. GENERAL MILLS 7-, 30-, AND 70-FOOT BALLOONS

The altitudes reached and loads which may be carried by the General Mills balloons other than the 20-foot cell are shown in Table 4, Appendix II. Graph 3, Appendix II may be used for interpolation of the tabulated values to give the relationship between floating altitude and gross load, and Graph 4 shows the altitude sensitivity at various heights. It has been assumed that helium is the lifting gas. Graph 1, Appendix II is useable for all of these balloons to determine the amount of free lift which is needed to give a desired rate of rise.

To launch a 7-foot balloon, it is not necessary to utilize the elaborate technique of the larger balloons. A can of sand is made to weigh the same amount as the required gross lift (equipment weight plus free lift), and attached to the load ring. Inflation from a single tank may be made inside any building with relatively large doors and when the balloon just lifts the inflation weights it may be attached to the equipment line, carried outdoors and released. In light winds the equipment may be released with a hand-over-hand paying out of the line. If there is too much wind for this method, the equipment is laid out downwind and the balloon released so as to pass over the pieces of gear and pick them up while rising.

A 7-foot balloon being inflated is seen in Figure 40. The appendix which is shown is made of a flattened 2-foot length of inflation tube, from a 20-foot balloon, without stiffeners. Such a balloon has been sustained with a fixed ballast leak



Roswell
Roswell AAF
559
532
517
N
Trajectory
Scale 0 5 10 (Miles)
211
321
194
142
165
398
428
483
76
87
81
30
40
Alamogordo AAF
NYU BALLOON PROJECT
FLIGHT NO.11
RELEASED AT ALAMOGORDO, NEW MEXICO
JULY 7, 1947 0508 MST
(Numerals on Curves Indicate Minutes After Release)
Height - Distance
FIG. 38
Cloudcroft
Alamogordo
Alamogordo AAF
Tularosa Valley
Sacramento Mountains
Roswell
ALTITUDE (Thousands of Feet Above MSL)
DISTANCE (Miles From Alamogordo AAF)
5
10
15
20
10
20
30
40
50
60
70
80
90
100

Figure 38

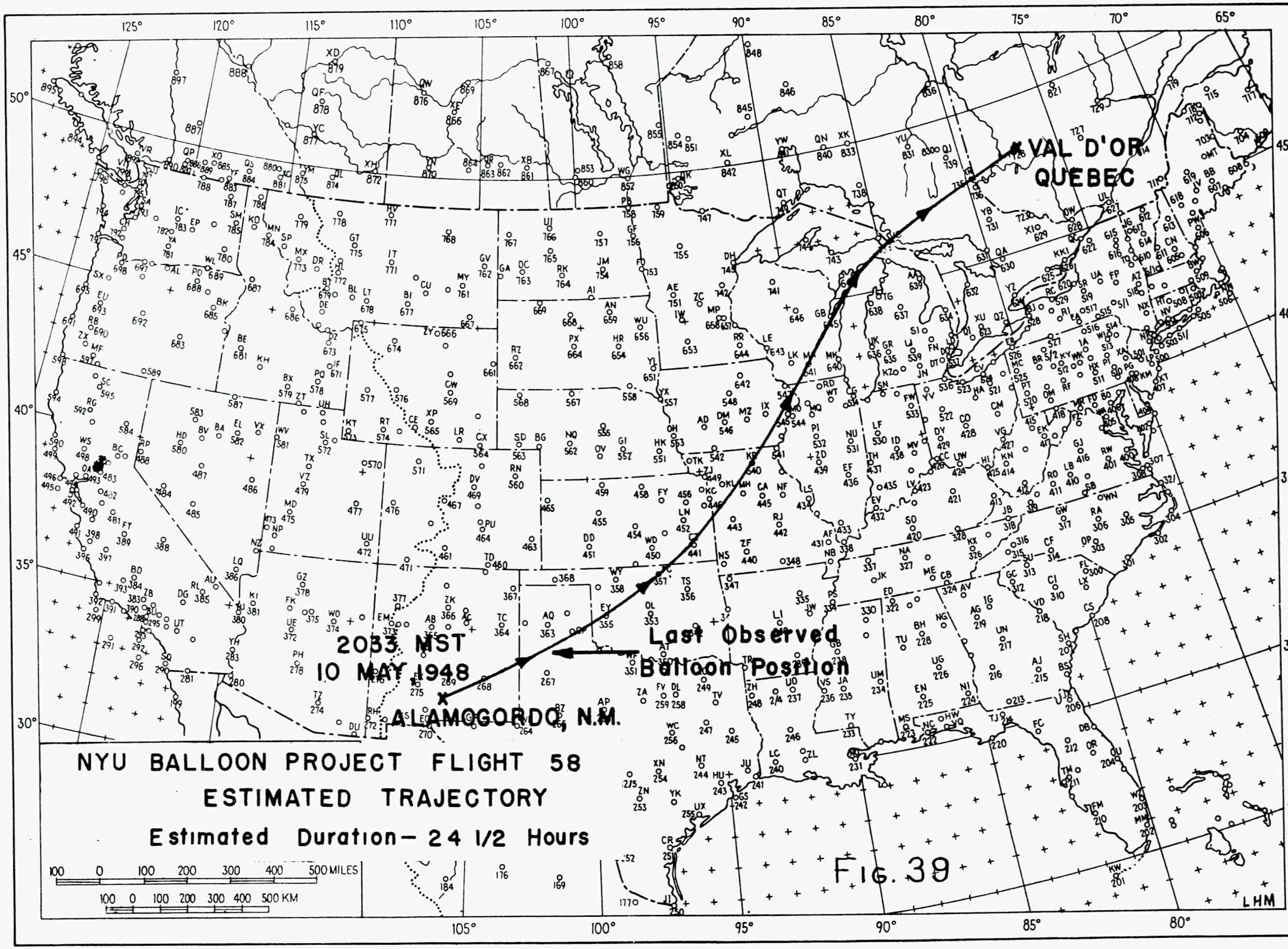

VAL D'OR
QUEBEC
Last Observed
Balloon Position
2033 MST
10 MAY 1948
ALAMOGORDO, N.M.
NYU BALLOON PROJECT FLIGHT 58
ESTIMATED TRAJECTORY
Estimated Duration— 24 1/2 Hours
100 0 100 200 300 400 500 MILES
100 0 100 200 300 400 500 KM
LHM

FIG. 39

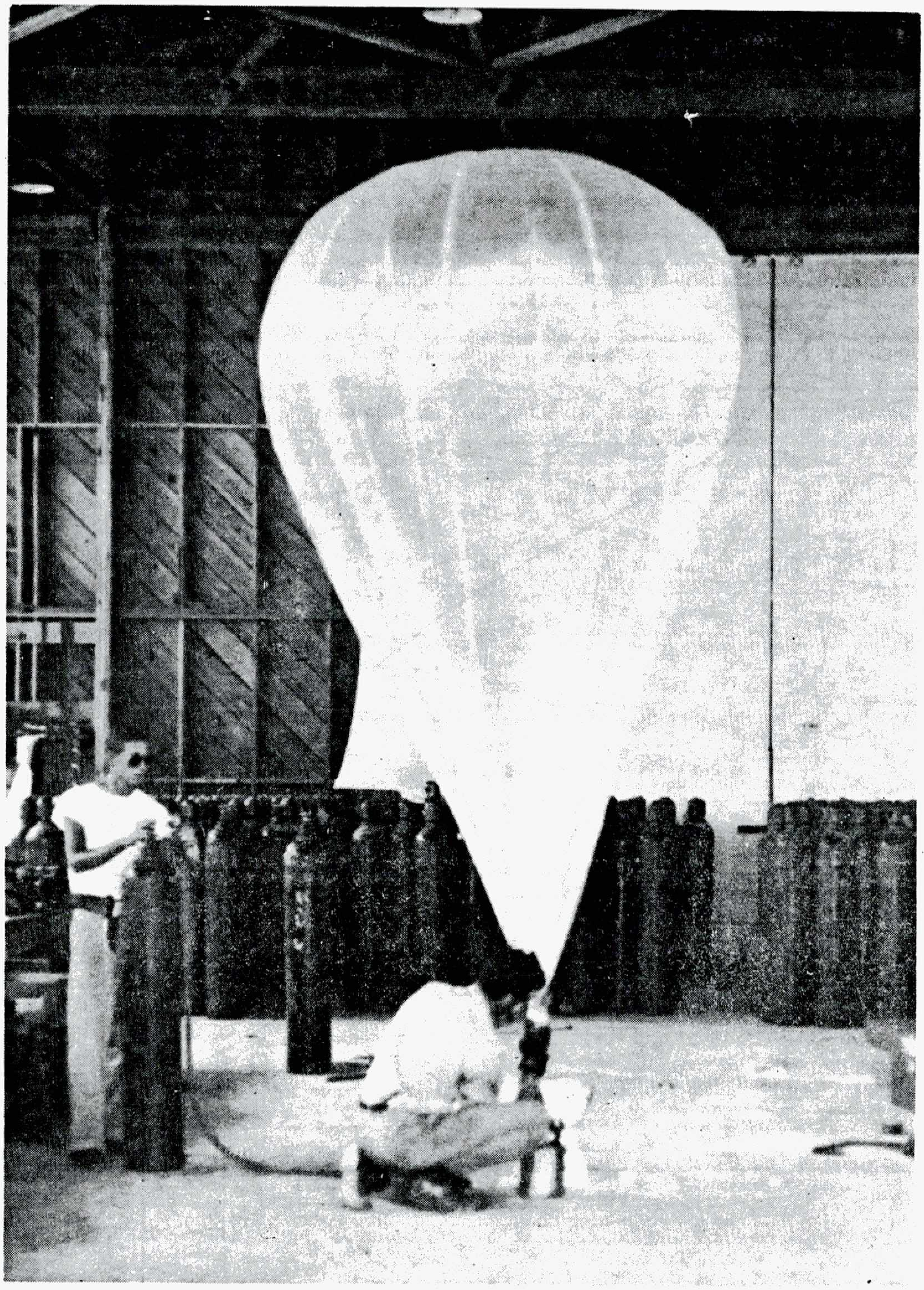


Figure 40
General Mills 7 foot
balloon being inflated.

of 170 grams per hour. A balloon of this type with no altitude control stayed aloft for more than two hours and after reaching ceiling, the altitude did not vary by more than 1500 feet while the balloon was within range of the observing station.

The preparation and launching techniques discussed for the 20-foot balloon apply also to the 30-foot cell. No further discussion is required for the 30-foot balloon.

The 70-foot balloon seen in Figures 41 and 42 is launched in the same manner as the 20-foot cell. A much larger amount of gas is required and since it is valved rapidly into the balloon, it has been found necessary to pass the gas through a heating coil to prevent it from reaching the balloon so adiabatically cooled as to be incapable of lifting the load. This heater is shown in Figure 43. Due to the large lift and area exposed to the wind at launching, the large cell may be dangerous if personnel attempt to hold the gear or act as anchors. If possible, all gear should be laid out downwind to be picked up from the ground by the balloon. The anchor should be a winch mounted on a truck which can move around the balloon so as to be downwind at launching.

Since the altitudes where the 70-foot balloons normally float are high in the stratosphere, the natural stability of the balloon in the temperature inversion keeps these cells up for a long period of time without ballast or other controls. One such flight fell slowly during a period of 75 hours and was still above 65,000 feet when the barograph record ended.

Figure 41
Inflation of 70 foot diameter
General Mills balloon.

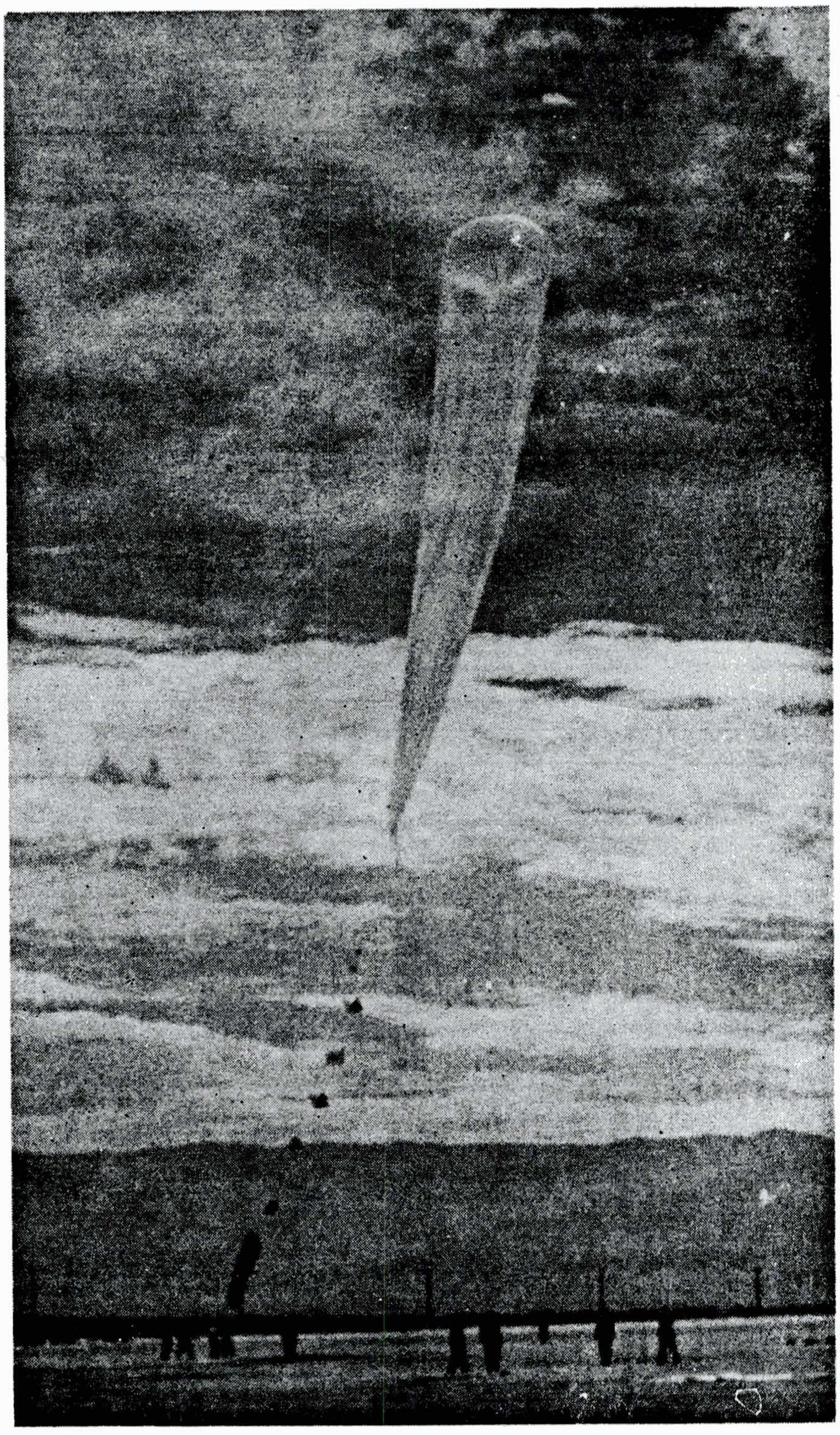


Figure 42
General Mills 70 foot balloon
being launched in a 5 knot wind.

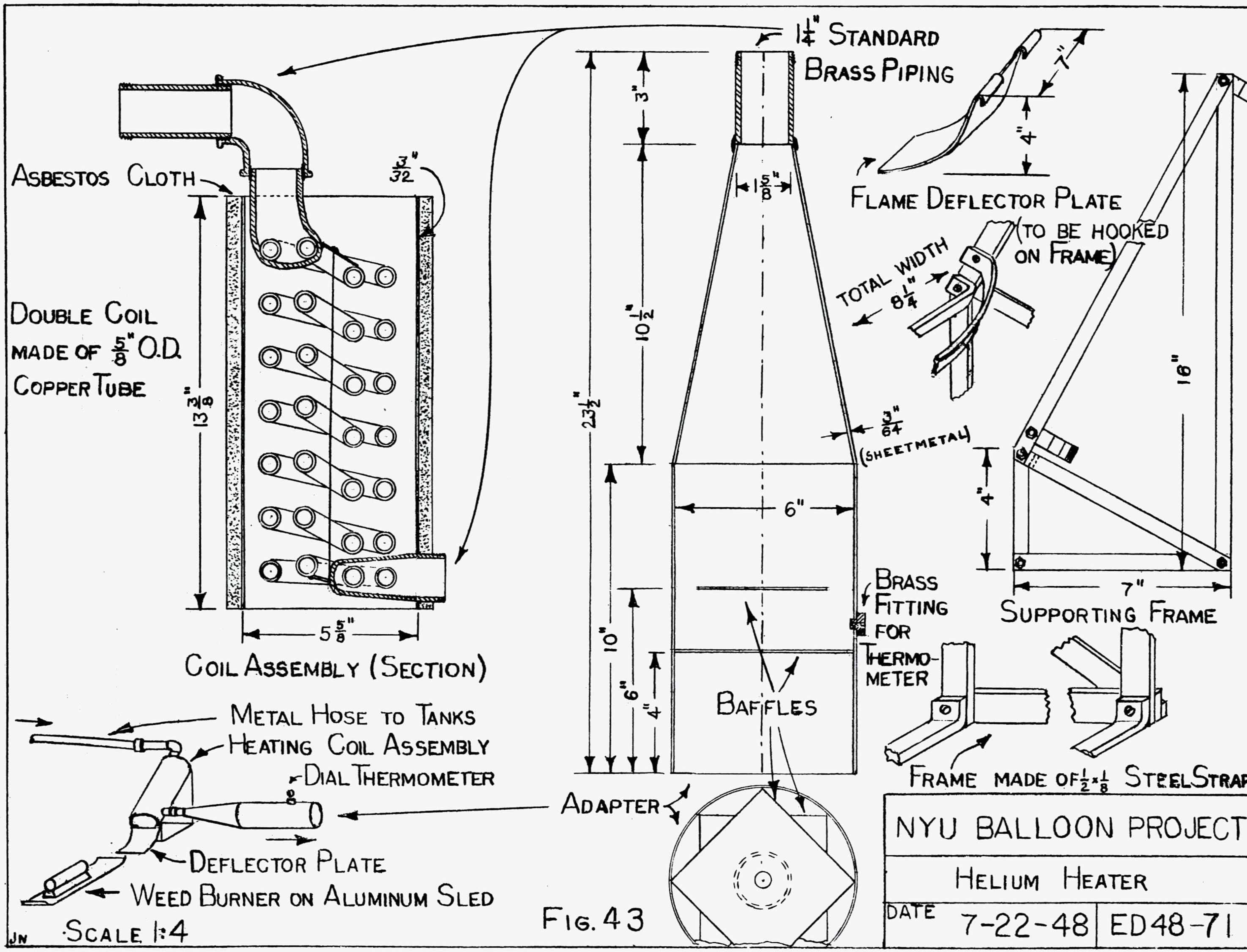

1¼" Standard Brass Piping
Asbestos Cloth
3/32"
Double Coil made of 5/8" O.D. Copper Tube
13 3/8"
5 5/8"
Coil Assembly (Section)
3"
1 5/8"
10½"
23½"
3/64"
(Sheetmetal)
6"
10"
6"
4"
Brass Fitting for Thermometer
Baffles
Adapter
Flame Deflector Plate (to be hooked on Frame)
7"
4"
Total Width 8¼"
16"
4"
7"
Supporting Frame
Frame made of ½×⅛ Steel Strap
Metal Hose to Tanks
Heating Coil Assembly
Dial Thermometer
Deflector Plate
Weed Burner on Aluminum Sled
JN
Scale 1:4
NYU Balloon Project
Helium Heater
Date 7-22-48
ED48-71

Fig. 43

GLOSSARY

Altitude Sensitivity: The altitude gained by a balloon when its load is reduced by one kilogram.

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).

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.

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

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.

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).

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

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.

Appendix I

Table Number | Page Number

Table 1

BASIC EQUIPMENT FOR FIELD TRIPS
LAUNCHING OF 20' BALLOONS
WITH SIMPLE CONTROL GEAR

GROUND EQUIPMENT:	NYU Balloon Project Drawing No. or Figure No. in Operations Manual
1 ea. Set instructions (Operations Manual)	
2 ea. Elliptical shot bags (each filled with 100 # of shot)	ED-48-62
2 ea. 40 # Sand bags	ED-48-122A
4 ea. 40 # Sand bags	
1 ea. 40' x 6' Ground Cloth	
4 ea. Sheets polyethylene, .001" to .004", 4' x 4'	
1 ea. 5 Tank manifold with pressure gages and valve	Figure 26
1 ea. Rubber hose, 1" I.D., 10' long	
1 ea. Gas diffuser	ED-48-76A
2 ea. Rubber tubing $\frac{1}{2}$" bore, 1/8" wall, 8' long	
2 ea. Hose clamps, aeroseal, $1\frac{1}{4}$" I.D.	
3 ea. Hose ends for helium tanks	ED-48-80
1 ea. Box white chalk	
1 ea. Solution balance Fisher #2-100	
1 ea. Inflation nozzle, ML-196	
3 ea. Weems plotters	
1 ea. Set aircraft maps of area	
1 ea. Tool kit complete with 2 sheath knives, 50' cloth measuring tape, brass wire, 1" Mystic tape, volt ohmmeter, pliers, screwdrivers, inflation tools, flashlights, crescent wrenches,	

NYU Balloon Project Drawing No. or Figure No. in Operations Manual

Item	NYU Balloon Project Drawing No. or Figure No. in Operations Manual
(Tool kit, cont'd.) soldering iron, compass, 2 open-end wrenches 1-1/8" x 1-1/4" openings, 14" pipe wrench, spanner for helium tank valves	
2 ea. Theodolite ML-247 with tripod ML-78	
2 ea. Recorder, Brush oscillograph or other	
2 ea. Standby power units	
2 ea. SCR-658 Radio direction finder or 2 ea. Hammerlund Super-Pro receiver 2 ea. Kytoon with spare bladders for antenna support 2 ea. Captive balloon, Dewey & Almy N4	
4 ea. Chronometers	
4 ea. Clip boards	
2 ea. Complete set of communication equipment Telephone account	
Wind screen, 30' x 20', Y-shaped, equipped with flood lights and anemometer	ED-49-3

FLIGHT GEAR:

Item	NYU Balloon Project Drawing No. or Figure No. in Operations Manual
2 to 5 Tanks helium	
1 ea. General Mills 20' balloon (or other balloon to be used) plus spare	
24 ea. Rolls acetate fiber scotch tape	
3 ea. Appendix stiffeners (if appendix is to be used)	ED-48-95A
1 ea. 200' 500 # Test nylon line	
1 ea. 100' 75 # Test linen twine	
2 ea. 350 Gram balloon ML-131A (for wind sock)	
5 to 10 Toggles or hooks	

	NYU Balloon Project Drawing No. or Figure No. in Operations Manual
2 ea. Parachutes ML-132	
1 ea. Banner, 3' x 6'	ED-48-56
4 ea. Data sheets	
4 ea. Weight sheets	
4 ea. Reward tags (English, Spanish or other language)	Figure 21
2 ea. "Danger Fire" tags	Figure 20
2 ea. Other Danger tags as required	

<u>If Flight Termination gear is to be used:</u>

1 ea. Flight termination switch	ED-48-70A
1 ea. Set rip rigging	ED-48-68A
2 ea. Cannons	ED-49-5
2 ea. Squibs Du Pont S-64 (treated for high altitude)	

<u>If fixed rate ballast release is to be used:</u>

1 ea. Orifice spinnerette, to give ballast flow of 250 gm/hr (.008" D.)	ED-48-75A
1 Gallon ballast, compass fluid AN-C-116	
1 ea. Ballast reservoir (1 gallon capacity)	ED-48-79A
1 ea. Filter 3" diameter, 325 x 325, phosphor bronze mesh	ED-48-54A
4 feet Tubing (Tygon) $\frac{1}{2}$" bore	
6 inches Tubing (Tygon) 3/16" bore	
Metal beakers or rimless 1 qt. tin cans	
Metal funnel	

Table 2

WEIGHT SHEET

Flight No. ________________ Date ________________

Time ________________

Balloon Manufacturer ________________ Weight ________________

Number ________________

Appendix or valve ________________ ________________

Shrouds . . . . ________________

Total Balloon Weight . . . . ________________

Launching Remnant . . . . ________________

Line Length . . . . ________________

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 ________________ ________________

Drag chute ________________ ________________

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 . . . __________ grams

Free Lift - from Rise chart __________ grams

Free Lift $= \frac{V}{412} \; {}^{2}G^{2/3}$ ____________ grams

Equipment Weight ______________ grams

Desired Balloon Inflation = Free Lift + Equipment Total _________ grams

Allowance for Leakage @ __________ gm/hr., _____ hrs. waiting ________ grams

Actual balloon lift . . . . ________ "

AActual gross lift (Balloon lift & balloon wt.) . . . . . ________ "

Number Helium tanks required at ____ kg lift/full tank . . . ________ tanks

Length balloon above shot bag . . . . ________ feet

---

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 # ____________

Balloon Surface Diffusion {measured / estimated} gm/hr. o/o Inflation __________ o/o

Full balloon surface diffusion - balloon surface diffusion (o/o Inflation) 2/3 __________ gm/hr.

Estimated full Balloon ceilin diffusion - F. B. Surface Diffusion $\times \frac{\text{Ceiling Pr.}}{\text{Surface Pr.}}$ ________ gr/hr.

Description of Ballast Unit: (components, serial nos. Dimensions)

Amount of Ballast ____________________ gm.

Initial flow, maximum head ______________ gm./min.

Maximum flow, maximum head ______________ gm./min.

Estimated Ballast duration $\frac{\text{Amount of ballast}}{\text{Full balloon ceiling diffusion}}$ __________ hrs.

Size Orifice used _________ in. Waiting time before release _______ min.

Size Limiting Orifice used ___________ in.

Size filter used _______________ in.

Initial Head to valve or orifice __________ in.

Final " " " " " __________ in.

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:

Description of Pressure Unit

Description of Special Equipment

Reception at Station #2

Reception at Station #3

Critique

Appendix II

PRESSURE AND TEMPERATURE

IN THE N.A.C.A. STANDARD ATMOSPHERE

December 1948

Prepared by

Irwin Brill
Research Assistant

Balloon Project
Research Division
New York University

Under Contract W28-099-ac-241 with
Watson Laboratories, A.M.C., U.S. Air Forces

Source

Pressure from surface (0 feet) to 65,000 feet: taken from National Advisory Committee for Aeronautics Report #538, and corrected as noted below.

Pressure from 65,000 feet to 163,538 feet: taken from National Advisory Committee for Aeronautics Report #1200.

Temperatures at 1000-foot intervals, taken from National Advisory Committee for Aeronautics Reports #538 and 1200.

Geopotential Assumptions for pressure corrections:

0 feet to 30,000 feet based upon assumed constant geopotential.

30,000 feet to 65,000 feet corrected for geopotential, by approximate correction factors. (Taken from extrapolated curve of difference in feet, from 65,000 to 100,000 feet, between N.A.C.A. table #538 (uncorrected) and N.A.C.A. Technical Note #1200 (corrected).

135,000 feet to 163,538 feet, corrected for geopotential by National Advisory Committee for Aeronautics, Note #1200.

Accuracy

Surface to 30,000 feet ± 15 feet, assuming constant geopotential.

30,000 feet to 65,000 feet	± 30 feet
65,000 feet to 100,000 feet	± 50 feet
100,000 feet to 120,000 feet	± 100 feet
120,000 feet to 135,000 feet	± 150 feet
135,000 feet to 163,538 feet	± 250 feet

Table 1

PRESSURE (MB) VERSUS HEIGHT (FEET)

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
1015	-47	27	969	1228	28	922	2593	29	875	4002	31
1014	-20	27	968	1256	28	921	2622	29	874	4033	31
1013.25	0	27	967	1284	28	920	2651	29	873	4064	31
1013	7	27	966	1312	28	919	2680	29	872	4095	31
1012	34	27	965	1340	28	918	2709	29	871	4126	31
1011	61	27	964	1368	28	917	2738	29	870	4157	31
1010	88	27	963	1396	28	916	2767	29	869	4188	31
1009	115	27	962	1424	28	915	2796	29	868	4219	31
1008	142	27	961	1452	28	914	2825	29	867	4250	31
1007	169	27	960	1481	29	913	2854	29	866	4281	31
1006	198	27	959	1510	29	912	2883	29	865	4312	31
1005	223	27	958	1539	29	911	2912	29	864	4343	31
1004	250	27	957	1568	29	910	2942	30	863	4374	31
1003	277	27	956	1597	29	909	2972	30	862	4405	31
1002	304	27	955	1626	29	908	3002	30	861	4436	31
1001	332	28	954	1655	29	907	3032	30	860	4467	31
1000	360	28	953	1684	29	906	3062	30	859	4498	31
999	388	28	952	1713	29	905	3092	30	858	4529	31
998	416	28	951	1742	29	904	3122	30	857	4560	31
997	444	28	950	1761	29	903	3152	30	856	4591	31
996	472	28	949	1790	29	902	3182	30	855	4622	31
995	500	28	948	1829	29	901	3212	30	854	4653	31
994	528	28	947	1858	29	900	3242	30	853	4684	31
993	556	28	946	1887	29	899	3272	30	852	4715	31
992	584	28	945	1916	29	898	3302	30	851	4746	31
991	612	28	944	1945	29	897	3332	30	850	4777	31
990	640	28	943	1974	29	896	3362	30	849	4808	31
989	668	28	942	2003	29	895	3392	30	848	4840	32
988	696	28	941	2032	29	894	3422	30	847	4872	32
987	724	28	940	2061	29	893	3452	30	846	4904	32
986	752	28	939	2090	29	892	3482	30	845	4936	32
985	780	28	938	2129	29	891	3512	30	844	4968	32
984	808	28	937	2158	29	890	3542	30	843	5000	32
983	836	28	936	2187	29	889	3572	30	842	5032	32
982	864	28	935	2216	29	888	3602	30	841	5064	32
981	892	28	934	2245	29	887	3632	30	840	5096	32
980	920	28	933	2274	29	886	3662	30	839	5128	32
979	948	28	932	2303	29	885	3692	30	838	5160	32
978	976	28	931	2332	29	884	3723	31	837	5192	32
977	1004	28	930	2361	29	883	3754	31	836	5224	32
976	1032	28	929	2390	29	882	3785	31	835	5256	32
975	1060	28	928	2419	29	881	3816	31	834	5288	32
974	1088	28	927	2448	29	880	3847	31	833	5320	32
973	1116	28	926	2477	29	879	3878	31	832	5352	32
972	1144	28	925	2506	29	878	3909	31	831	5384	32
971	1172	28	924	2535	29	877	3940	31	830	5416	32
970	1200	28	923	2564	29	876	3971	31	829	5448	32

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
828	5480	32	781	7026	34	734	8648	35	687	10358	37
827	5512	32	780	7060	34	733	8683	35	686	10395	37
826	5544	32	779	7094	34	732	8718	35	685	10433	38
825	5576	32	778	7128	34	731	8754	36	684	10471	38
824	5608	32	777	7162	34	730	8790	36	683	10509	38
823	5640	32	776	7196	34	729	8826	36	682	10547	38
822	5672	32	775	7230	34	728	8862	36	681	10585	38
821	5704	32	774	7264	34	727	8898	36	680	10623	38
820	5736	32	773	7298	34	726	8934	36	679	10661	38
819	5768	32	772	7332	34	725	8970	36	678	10699	38
818	5800	32	771	7366	34	724	9006	36	677	10737	38
817	5833	33	770	7400	34	723	9042	36	676	10775	38
816	5866	33	769	7434	34	722	9078	36	675	10813	38
815	5909	33	768	7468	34	721	9114	36	674	10851	38
814	5932	33	767	7502	34	720	9150	36	673	10889	38
813	5965	33	766	7536	34	719	9186	36	672	10927	38
812	5998	33	765	7570	34	718	9222	36	671	10965	38
811	6031	33	764	7604	34	717	9258	36	670	11003	38
810	6064	33	763	7638	34	716	9294	36	669	11041	38
809	6097	33	762	7672	34	715	9330	36	668	11079	38
808	6130	33	761	7706	34	714	9366	36	667	11117	38
807	6163	33	760	7740	34	713	9402	36	666	11155	38
806	6196	33	759	7774	34	712	9438	36	665	11193	38
805	6229	33	758	7808	34	711	9474	36	664	11231	38
804	6262	33	757	7843	35	710	9510	36	663	11270	39
803	6295	33	756	7878	35	709	9546	36	662	11309	39
802	6328	33	755	7913	35	708	9582	36	661	11348	39
801	6361	33	754	7948	35	707	9618	36	660	11387	39
800	6394	33	753	7983	35	706	9655	37	659	11426	39
799	6427	33	752	8018	35	705	9692	37	658	11465	39
798	6460	33	751	8053	35	704	9729	37	657	11504	39
797	6493	33	750	8088	35	703	9766	37	656	11543	39
796	6526	33	749	8123	35	702	9803	37	655	11582	39
795	6559	33	748	8158	35	701	9840	37	654	11621	39
794	6592	33	747	8193	35	700	9877	37	653	11660	39
793	6625	33	746	8228	35	699	9914	37	652	11699	39
792	6658	33	745	8263	35	698	9951	37	651	11738	39
791	6691	33	744	8298	35	697	9988	37	650	11777	39
790	6724	33	743	8333	35	696	10025	37	649	11816	39
789	6757	33	742	8368	35	695	10062	37	648	11855	39
788	6790	33	741	8403	35	694	10099	37	647	11894	39
787	6823	33	740	8438	35	693	10136	37	646	11933	39
786	6856	33	739	8473	35	692	10173	37	645	11972	39
785	6890	33	738	8508	35	691	10210	37	644	12011	39
784	6924	34	737	8543	35	690	10247	37	643	12051	40
783	6958	34	736	8578	35	689	10284	37	642	12091	40
782	6992	34	735	8613	35	688	10321	37	641	12131	40

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
640	12171	40	592	14130	42	543	16270	45	494	18574	49
639	12211	40	591	14172	42	542	16315	4[illegible]	493	18623	49
638	12251	40	590	14214	42	541	16360	45	492	18672	49
637	12291	40	589	14256	42	540	16405	45	491	18721	49
636	12331	40	588	14298	42	539	16451	46	490	18770	49
635	12371	40	587	14341	43	538	16497	46	489	18819	49
634	12411	40	586	14384	43	537	16543	46	488	18868	49
633	12451	40	585	14427	43	536	16589	4[illegible]	487	18917	49
632	12491	40	584	14470	43	535	16635	[illegible]6	486	18966	49
631	12531	40	583	14513	43	534	16681	46	485	19015	49
630	12571	40	582	14556	43	533	16727	46	484	19065	50
629	12611	40	581	14599	43	532	16773	46	483	19115	50
628	12651	40	589	14642	43	531	16819	46	482	19165	50
627	12691	40	579	14685	43	530	16865	46	481	19215	50
626	12731	40	578	14728	43	529	16911	46	480	19265	50
625	12771	40	577	14771	43	528	16957	46	479	19315	50
624	12811	40	576	14814	43	527	17003	46	478	19365	50
623	12851	40	575	14857	43	526	17049	46	477	19415	50
622	12891	40	574	14900	43	525	17095	46	476	19465	50
621	12931	40	573	14943	43	524	17141	46	475	19515	50
620	12971	40	572	14986	43	523	17188	47	474	19565	50
619	13012	40	571	15029	43	522	17235	47	473	19616	51
618	13053	41	570	15072	43	521	17282	47	472	19667	51
617	13094	41	569	15115	43	520	17329	47	471	19718	51
616	13135	41	568	15158	43	519	17376	47	470	19769	51
615	13176	41	567	15202	44	518	17423	47	469	19820	51
614	13217	41	566	15246	44	517	17470	47	468	19871	51
613	13258	41	565	15290	44	516	17517	47	467	19922	51
612	13299	41	564	15334	44	515	17564	47	466	19973	51
611	13340	41	563	15378	44	514	17611	47	465	20024	51
610	13381	41	562	15422	44	513	17658	47	464	20075	51
609	13422	41	561	15466	44	512	17705	47	463	20127	52
608	13463	41	560	15510	44	511	17752	47	462	20179	52
607	13504	41	559	15554	44	510	17800	48	461	20231	52
606	13545	41	558	15598	44	509	17848	48	460	20283	52
605	13586	41	557	15642	44	508	17896	48	459	20335	52
604	13627	41	556	15686	44	507	17944	48	458	20387	52
603	13668	41	555	15730	45	506	17992	48	457	20439	52
602	13710	42	554	15775	45	505	18040	48	456	20491	52
601	13752	42	553	15820	45	504	18088	48	455	20543	52
600	13794	42	552	15865	45	503	18136	48	454	20595	52
599	13836	42	551	15910	45	502	18184	48	453	20647	52
598	13878	42	550	15955	45	501	18232	48	452	20699	52
597	13920	42	549	16000	45	500	18280	48	451	20751	52
596	13962	42	548	16045	45	499	18329	49	450	20803	52
595	14004	42	547	16090	45	498	18378	49	449	20856	53
594	14046	42	546	16135	45	497	18427	49	448	20909	53
593	14088	42	545	16180	45	496	18476	49	447	20962	53
			544	16225	45	495	18525	49	446	21015	53

MB	ALT.	DIF.	MB	ALT.	DIF.	MB.	ALT.	DIF.	MB	ALT.	DIF.
445	20543	53	397	23741	58	349	26684	64	301	29989	74
444	21122	54	396	23799	58	348	26748	64	300	30061	74
443	21176	54	395	23857	58	347	26812	64	299	30139	76
442	21230	54	394	23915	58	346	26878	66	298	30217	76
441	21284	54	393	23973	58	345	26944	66	297	30295	76
440	21338	54	392	24031	58	344	27010	66	296	30373	76
439	21392	54	391	24090	60	343	27076	66	295	30451	76
438	21446	54	390	24150	60	342	27142	66	294	30529	78
437	21500	54	389	24210	60	341	27208	66	293	30607	78
436	21554	54	388	24270	60	340	27274	66	292	30685	78
435	21608	54	387	24330	60	339	27340	66	291	30763	78
434	21662	54	386	24390	60	338	27406	66	290	30841	78
433	21716	54	385	24450	60	337	27472	66	289	30919	78
432	21770	54	384	24510	60	336	27538	66	288	30977	78
431	21824	54	383	24570	60	335	27604	66	287	31075	78
430	21878	54	382	24630	60	334	27670	66	286	31153	78
429	21932	54	381	24690	60	333	27738	68	285	31231	78
428	21986	54	380	24750	60	332	27806	68	284	31309	78
427	22040	54	379	24810	60	331	27874	68	283	31387	78
426	22095	55	378	24870	60	330	27942	68	282	31465	78
425	22151	56	377	24930	60	329	28010	68	281	31544	80
424	22207	56	376	24990	60	328	28078	68	280	31624	80
423	22263	56	375	25050	60	327	28146	68	279	31704	80
422	22319	56	374	25112	62	326	28214	68	278	31784	80
421	22375	56	373	25174	62	325	28282	68	277	31864	80
420	22431	56	372	25236	62	324	28350	68	276	31944	80
419	22487	56	371	25298	62	323	28418	68	275	32024	80
418	22543	56	370	25360	62	322	28487	69	274	32104	80
417	22599	56	369	25422	62	321	28557	70	273	32184	80
416	22655	56	368	25484	62	320	28627	70	272	32264	80
415	22711	56	367	25546	62	319	28697	70	271	32344	80
414	22767	56	366	25608	62	318	28767	70	270	32424	80
413	22823	56	365	25670	62	317	28837	70	269	32504	80
412	22879	56	364	25732	62	316	28909	72	268	32584	80
411	22935	56	363	25794	62	315	28981	72	267	32264	80
410	22991	56	362	25856	62	314	29053	72	266	32744	80
409	23047	56	361	25918	62	313	29125	72	265	32824	80
408	23103	56	360	25980	62	312	29197	72	264	32904	80
407	23161	58	359	26044	64	311	29269	72	263	32984	80
406	23219	58	358	26108	64	310	29341	72	262	32064	80
405	23277	58	357	26172	64	309	29413	72	261	33144	80
404	23335	58	356	26236	64	308	29485	72	260	33226	82
403	23393	58	355	26300	64	307	29557	74	259	33308	82
402	23451	58	354	26364	64	306	29629	74	258	33390	82
401	23509	58	353	26428	64	305	29701	74	257	33472	82
400	23567	58	352	26492	64	304	29773	74	256	33554	82
399	23625	58	351	26556	64	303	29845	74	255	33638	84
398	23683	58	350	26620	64	302	29917	74	254	33722	84

MB	ALT.	DIF.
253	33806	84
252	33890	84
251	33974	84
250	34060	86
249	34146	86
248	34232	86
247	34318	86
246	34404	86
245	34490	86
244	34576	86
243	34662	86
242	34749	88
241	34837	88
240	34925	88
239	35013	88
238	35101	88
237	35189	88
236	35277	88
235	35367	90
234	35457	90
233	35547	90
232	35637	90
231	35727	90
230	35819	90
229	35911	92
228	36003	92
227	36095	92
226	36187	92
225	36281	94
224	36375	94
223	36469	94
222	36563	94
221	36658	96
220	36754	96
219	36850	96
218	36946	96
217	37042	96
216	37138	98
215	37236	98
214	37334	98
213	37432	98
212	37530	98
211	37630	100
210	37730	100
209	37830	100
208	37930	100
207	38032	100
206	38134	102
205	38236	102

MB	ALT.	DIF.
204	38338	102
203	38440	102
202	38544	104
201	38648	104
200	38752	104
199	38858	106
198	38964	106
197	39070	106
196	39178	108
195	39286	108
194	39394	108
193	39502	108
192	39612	110
191	39721	110
190	39832	112
189	39944	112
188	40056	112
187	40168	112
186	40280	112
185	40392	112
184	40506	116
183	40622	116
182	40738	116
181	40854	116
180	40970	116
179	41086	116
178	41202	118
177	41321	120
176	41441	120
175	41561	120
174	41681	120
173	41801	120
172	41921	120
171	42044	124
170	42168	124
169	42292	124
168	42416	124
167	42541	128
166	42669	128
165	42797	128
164	42925	128
163	43053	128
162	43181	128
161	43311	132
160	43443	132
159	43575	132
158	43707	132
157	43839	132
156	43974	134

MB	ALT.	DIF.
155	44110	136
154	44246	136
153	44382	136
152	44520	138
151	44660	140
150	44800	140
149	44940	140
148	45081	142
147	45225	144
146	45369	144
145	45513	144
144	45657	144
143	45804	146
142	45952	148
141	46100	148
140	46248	148
139	46400	150
138	46552	152
137	46704	152
136	46856	152
135	47012	156
134	47168	156
133	47324	156
132	47484	160
131	47644	160
130	47804	160
129	47968	164
128	48132	164
127	48296	164
126	48464	168
125	48632	168
124	48800	168
123	48969	172
122	49141	172
121	49313	172
120	49488	176
119	49664	176
118	49840	176
117	50018	180
116	50198	180
115	50381	184
114	50565	184
113	50752	188
112	50940	188
111	51129	190
110	51321	192
109	51513	192
108	51707	196
107	51903	196

MB	ALT.	DIF.
106	52099	196
105	52299	200
104	52499	200
103	52701	204
102	52905	204
100	53316	208
△ MB= .50		
99.50	53421	105
99.00	53526	105
98.50	53631	105
98.00	53741	110
97.50	53851	110
97.00	53961	110
96.50	54071	110
96.00	54181	110
95.50	54291	110
95.00	54401	110
94.50	54511	110
94.00	54621	110
93.50	54733	115
93.00	54848	115
92.50	54963	115
92.00	55078	115
91.50	55433	115
90.00	55548	115
89.50	55653	115
89.00	55770	120
88.50	55890	120
88.00	56010	120
87.50	56130	120
87.00	56250	120
86.50	56370	120
86.00	56491	120
85.50	56616	125
85.00	56741	125
84.50	56866	125
84.00	56991	125
83.50	57116	125
83.00	57241	125
82.50	57366	125
82.00	57495	130
81.50	57625	130
81.00	57755	130
80.50	57885	130
80.00	58015	130
79.50	58145	130
79.00	58279	135
78.50	58414	135
78.00	58549	135

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF
77.50	58684	135	52.50	66884	200	27.50	80502	380	20.60	86606	102
77.00	58819	135	52.00	67086	205	27.00	80892	390	20.50	86708	102
76.50	58959	140	51.50	67291	205	26.50	81284	400	20.40	86812	104
76.00	59099	140	51.00	67499	210	26.00	81684	410	20.30	86916	104
75.50	59239	140	50.50	67709	210	25.50	82090	420	20.20	87020	104
75.00	59379	140	50.00	67922	215	△P = .1mb			20.10	87124	104
74.50	59519	140	49.50	68137	215	25.00	82510	84	20.00	87228	104
74.00	59659	140	49.00	68352	215	24.90	82596	86	19.90	87334	106
73.50	59799	140	48.50	68567	215	24.80	82682	86	19.80	87440	106
73.00	59943	145	48.00	68782	215	24.70	82768	86	19.70	87546	106
72.50	60088	145	47.50	68997	220	24.60	82854	86	19.60	87654	108
72.00	60233	145	47.00	69207	220	24.50	82940	86	19.50	87762	108
71.50	60378	145	46.50	69432	225	24.40	83026	86	19.40	87870	108
71.00	60527	150	46.00	69669	230	24.30	83112	86	19.30	87978	108
70.50	60677	150	45.50	69899	230	24.20	83200	88	19.20	28088	110
70.00	60827	150	45.00	70132	235	24.10	83288	88	19.10	88198	110
69.50	60977	150	44.50	70367	240	24.00	83376	88	19.00	88308	110
69.00	61131	155	44.00	70607	240	23.90	83464	88	18.90	88418	110
68.50	61286	155	43.50	70848	245	23.80	83552	88	18.80	88532	114
68.00	61441	155	43.00	71093	245	23.70	83640	88	18.70	88646	114
67.50	61596	155	42.50	71338	250	23.60	83730	90	18.60	88760	114
67.00	61751	155	42.00	71585	250	23.50	83820	90	18.50	88874	114
66.50	61908	160	41.50	71835	255	23.40	83910	90	18.40	88988	114
66.00	62068	160	41.00	72087	255	23.30	84000	90	18.30	89102	114
65.50	62228	160	40.50	72346	260	23.20	84092	92	18.20	89216	114
65.00	62388	160	40.00	72608	265	23.10	84184	92	18.10	89330	114
64.50	62551	165	39.50	72873	270	23.00	84276	92	18.00	89448	118
64.00	62716	165	39.00	73141	270	22.90	84368	92	17.90	89566	118
63.50	62881	165	38.50	73411	275	22.80	84462	94	17.80	89684	118
63.00	63047	170	38.00	73685	275	22.70	84556	94	17.70	89802	118
62.50	63217	170	37.50	73966	280	22.60	84650	94	17.60	89920	118
62.00	63387	170	37.00	74243	285	22.50	84744	94	17.50	90039	118
61.50	63557	170	36.50	74531	290	22.40	84838	94	17.40	90160	122
61.00	63727	170	36.00	74823	295	22.30	84932	94	17.30	90282	122
60.50	63899	175	35.50	75120	300	22.20	84028	96	17.20	90404	122
60.00	64074	175	35.00	75420	305	22.10	84124	96	17.10	90526	122
59.50	64249	175	34.50	75725	310	22.00	85220	96	17.00	90648	122
59.00	64429	180	34.00	76032	310	21.90	85316	96	16.90	90774	126
58.50	64609	180	33.50	76344	315	21.80	85412	96	16.80	90900	126
58.00	64789	180	33.00	76660	320	21.70	85508	96	16.70	91026	126
57.50	64970	185	32.50	76980	325	21.60	85606	98	16.60	91152	126
57.00	65155	185	32.00	77304	330	21.50	85704	98	16.50	91278	126
56.50	65340	185	31.50	77634	335	21.40	85802	98	16.40	91408	130
56.00	65525	190	31.00	77972	340	21.30	85900	98	16.30	91538	130
55.50	65715	190	30.50	78314	350	21.20	86000	100	16.20	91668	130
55.00	65905	190	30.00	78664	360	21.10	86100	100	16.10	91798	130
54.50	66095	195	29.50	79022	360	21.00	86200	100	16.00	91928	130
54.00	66290	195	29.00	79382	365	20.90	86300	100	15.90	92064	136
53.50	66485	200	28.50	79748	370	20.80	86402	102	15.80	92200	136
53.00	66684	200	28.00	80122	380	20.70	86504	102	15.70	92336	136

MB	ALT.	DIF.
15.60	92472	136
15.50	92608	136
15.40	92744	136
15.30	92886	142
15.20	93028	142
15.10	93170	142
15.00	93312	142
14.90	93454	142
14.80	93596	142
14.70	93738	142
14.60	93880	142
14.50	94022	142
14.40	94164	142
14.30	94306	142
14.20	94454	148
14.10	94602	148
14.00	94750	148
13.90	94898	148
13.80	95046	148
13.70	95200	154
13.60	95360	160
13.50	95520	160
13.40	95680	160
13.30	95840	160
13.20	96000	160
13.10	96160	160
13.00	96320	160
12.90	96480	160
12.80	96648	168
12.70	96816	168
12.60	96984	168
12.50	97152	168
12.40	97320	168
12.30	97498	178
12.20	97676	178
12.10	97854	178
12.00	98032	178
11.90	98210	178
11.80	98388	178
11.70	98566	178
11.60	98744	178
11.50	98922	178
11.40	99100	178
11.30	99288	188
11.20	99476	188
11.10	99664	188
11.00	99852	188
10.90	100040	188
10.80	100238	198
10.70	100436	198
10.60	100634	198
10.50	100832	198
10.40	101030	198
10.30	101240	210
10.20	101450	210
10.10	101660	210
10.00	101870	210
9.90	102080	210
9.80	102304	224
9.70	102528	224
9.60	102752	224
9.50	102976	224
9.40	103200	224
9.30	103424	224
9.20	103648	224
9.10	103872	224
9.00	104096	224
8.90	104342	246
8.80	104588	246
8.70	104834	246
8.60	105080	246
8.50	105326	246
8.40	105572	246
8.30	105818	246
8.20	106064	246
8.10	106339	275
8.00	106614	275
7.90	106889	275
7.80	107164	275
7.70	107439	275
7.60	107714	275
7.50	107989	275
7.40	108296	307
7.30	108603	307
7.20	108910	307
7.10	109217	307
7.00	109524	307
6.90	109831	307
6.80	110138	307
6.70	110482	344
6.60	110828	346
6.50	111174	346
6.40	111520	346
6.30	111866	346
6.20	112246	380
6.10	112626	380
6.00	113006	380
5.90	113386	380
5.80	113766	380
5.70	114146	380
5.60	114578	432
5.50	115010	432
5.40	115442	432
5.30	115874	432
5.20	116338	464
5.10	116802	464
5.00	117266	464
4.90	117730	464
4.80	118194	464
4.70	118724	530
4.60	119254	530
4.50	119784	530
4.40	120352	568
4.30	120920	568
4.20	121488	568
4.10	122056	568
4.00	122696	640
3.90	123336	640
3.80	123976	640
3.70	124672	696
3.60	125368	696
3.50	126064	696
3.40	126858	794
3.30	127652	794
3.20	128464	812
3.10	129276	812
3.00	130088	812
2.90	131032	944
2.80	131976	944
2.70	132984	1008
2.60	133992	1008
2.50	135074	1082
2.40	136156	1082
2.30	137438	1282
2.20	138720	1282
2.10	140002	1282
2.00	141462	1460
1.90	142922	1460
1.80	144382	1460
1.70	146182	1800
1.60	148062	1880
1.50	150040	1978
1.40	152176	2136
1.30	154384	2208
1.20	156792	2408
1.10	160040	3248
1.00	163538	3498

Table 2

TEMPERATURE IN N.A.C.A. STANDARD ATMOSPHERE

Altitude	Temp.(°C)	Altitude	Temp.(°C)	Altitude	Temp.(°C)
0	15			96,000	-55
1,000	13	48,000	-55	97,000	-55
2,000	11	49,000	-55	98,000	-55
3,000	9.1	50,000	-55	99,000	-55
4,000	7.1	51,000	-55	100,000	-55
5,000	5.1	52,000	-55	102,000	-55
6,000	3.1	53,000	-55	104,000	-55
7,000	1.1	54,000	-55	104,987	-55
8,000	- 0.8	55,000	-55	106,000	-52.9
9,000	- 2.8	56,000	-55	108,000	-48.5
10,000	- 4.8	57,000	-55	110,000	-43.9
11,000	- 6.8	58,000	-55	112,000	-39.5
12,000	- 8.8	59,000	-55	114,000	-35.0
13,000	-10.8	60,000	-55	116,000	-30.6
14,000	-12.7	61,000	-55	118,000	-26.1
15,000	-14.7	62,000	-55	120,000	-21.6
16,000	-16.7	63,000	-55	122,000	-17.1
17,000	-18.7	64,000	-55	124,000	-12.7
18,000	-20.7	65,000	-55	126,000	- 8.2
19,000	-22.6	66,000	-55	128,000	- 3.7
20,000	-24.6	67,000	-55	130,000	+ .72
21,000	-26.6	68,000	-55	132,000	+ 5.2
22,000	-28.6	69,000	-55	134,000	+ 9.7
23,000	-30.6	70,000	-55	136,000	+14.2
24,000	-32.5	71,000	-55	138,000	+18.6
25,000	-34.5	72,000	-55	140,000	+23.1
26,000	-36.5	73,000	-55	142,000	+27.6
27,000	-38.5	74,000	-55	144,000	+32.1
28,000	-40.5	75,000	-55	146,000	+36.5
29,000	-42.5	76,000	-55	148,000	+41.0
30,000	-44.4	77,000	-55	150,000	+45.5
31,000	-46.4	78,000	-55	152,000	+50.0
32,000	-48.4	79,000	-55	154,000	+54.4
33,000	-50.4	80,000	-55	156,000	+58.9
34,000	-52.4	81,000	-55	158,000	+63.4
35,000	-54.3	82,000	-55	160,000	+67.8
35,332	-55	83,000	-55	162,000	+72.3
36,000	-55	84,000	-55	164,000	+76.8
37,000	-55	85,000	-55		
38,000	-55	86,000	-55		
39,000	-55	87,000	-55		
40,000	-55	88,000	-55		
41,000	-55	89,000	-55		
42,000	-55	90,000	-55		
43,000	-55	91,000	-55		
44,000	-55	92,000	-55		
45,000	-55	93,000	-55		
46,000	-55	94,000	-55		
47,000	-55	95,000	-55		

Table 3

Table of flows in gm/hr. from "Spinnerette Orifices"

dia. (in inches)	Q (actual) in gm/hr.			
	at 24 Hd.	at 22" Hd.	at 20" Hd.	at 18" Hd.
.003	35	33.5	32	30.5
.004	62.8	60	57	54.5
.005	97.5	93.5	88.8	84.5
.006	141	134	128	122
.007	192	184	175	166
.008	251	241	229	217
.009	317	303	289	274
.010	392	375	358	340
.011	474	453	433	410
.012	564	540	515	488

$$Q \text{ (actual) gm/hr.} = C_d \,(\text{dia.}")^2 \,(\text{hd.}")^{\frac{1}{2}} \times 1.003 \times 10^6$$

(C_d varies from .78 to .82)

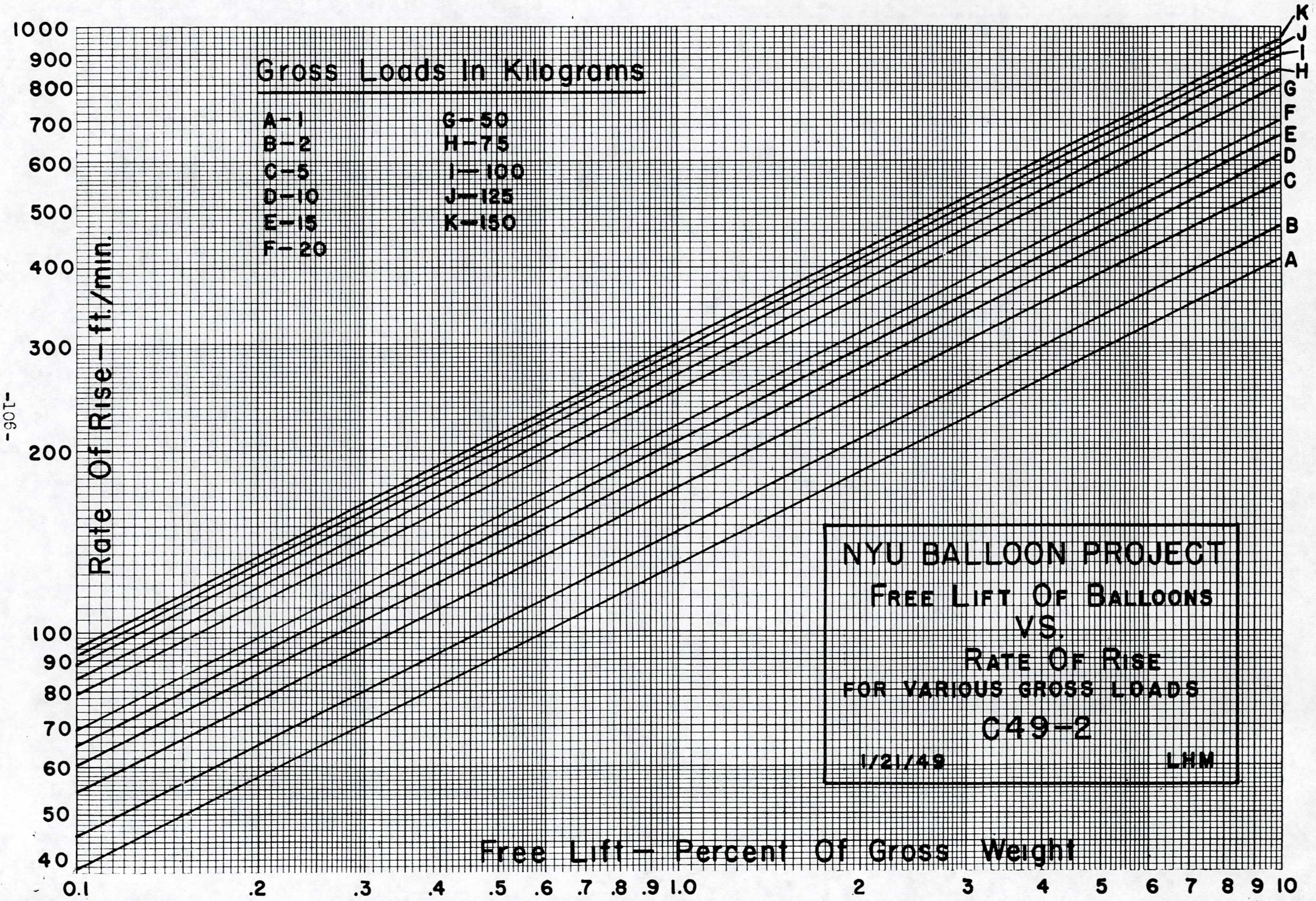
C_d (mean) = .80 (used above)

$$\frac{Q_1}{Q_2} = \left(\frac{\text{hd.}_1}{\text{hd.}_2}\right)^{\frac{1}{2}}$$

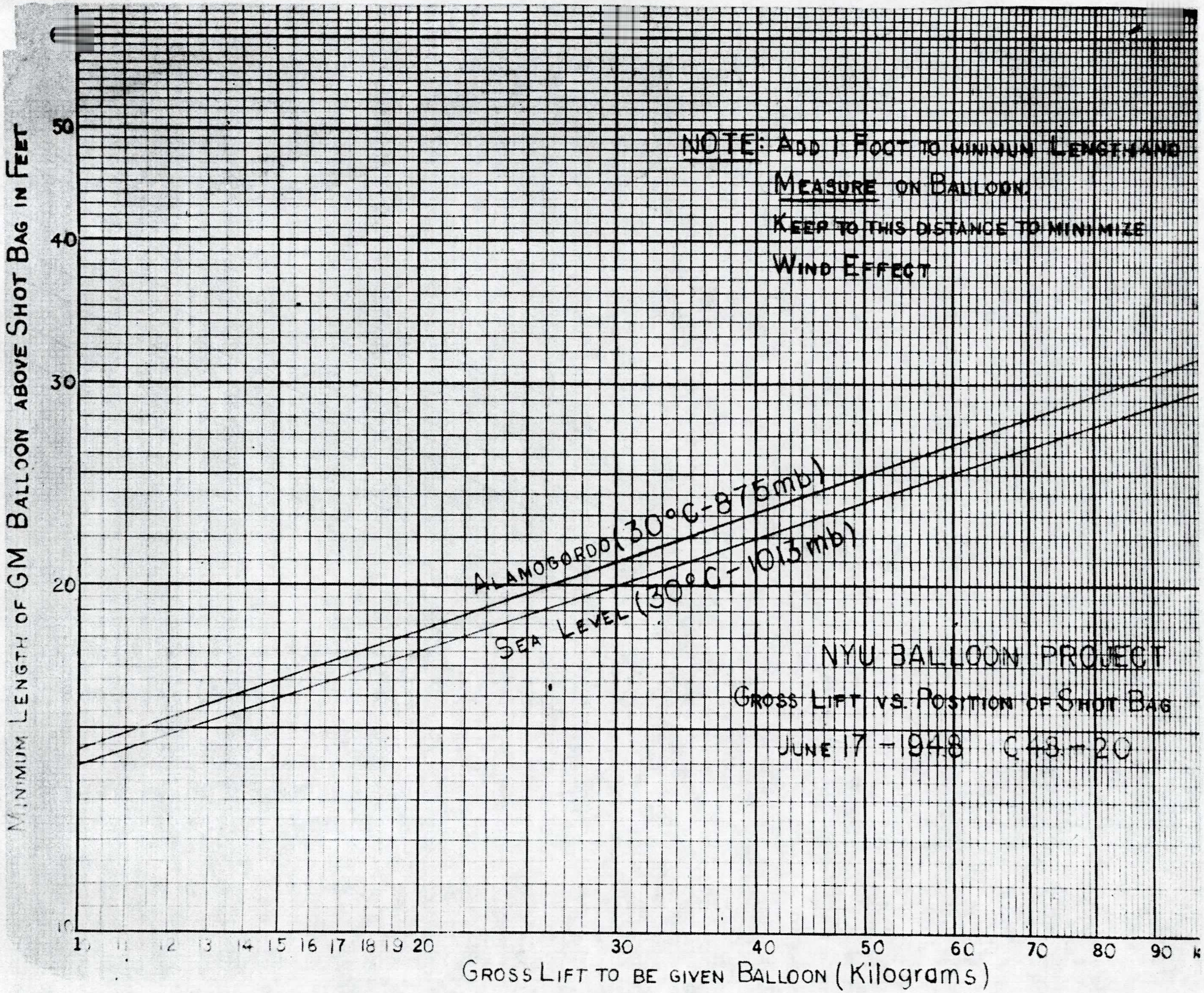
Table 4

BALLOON DATA

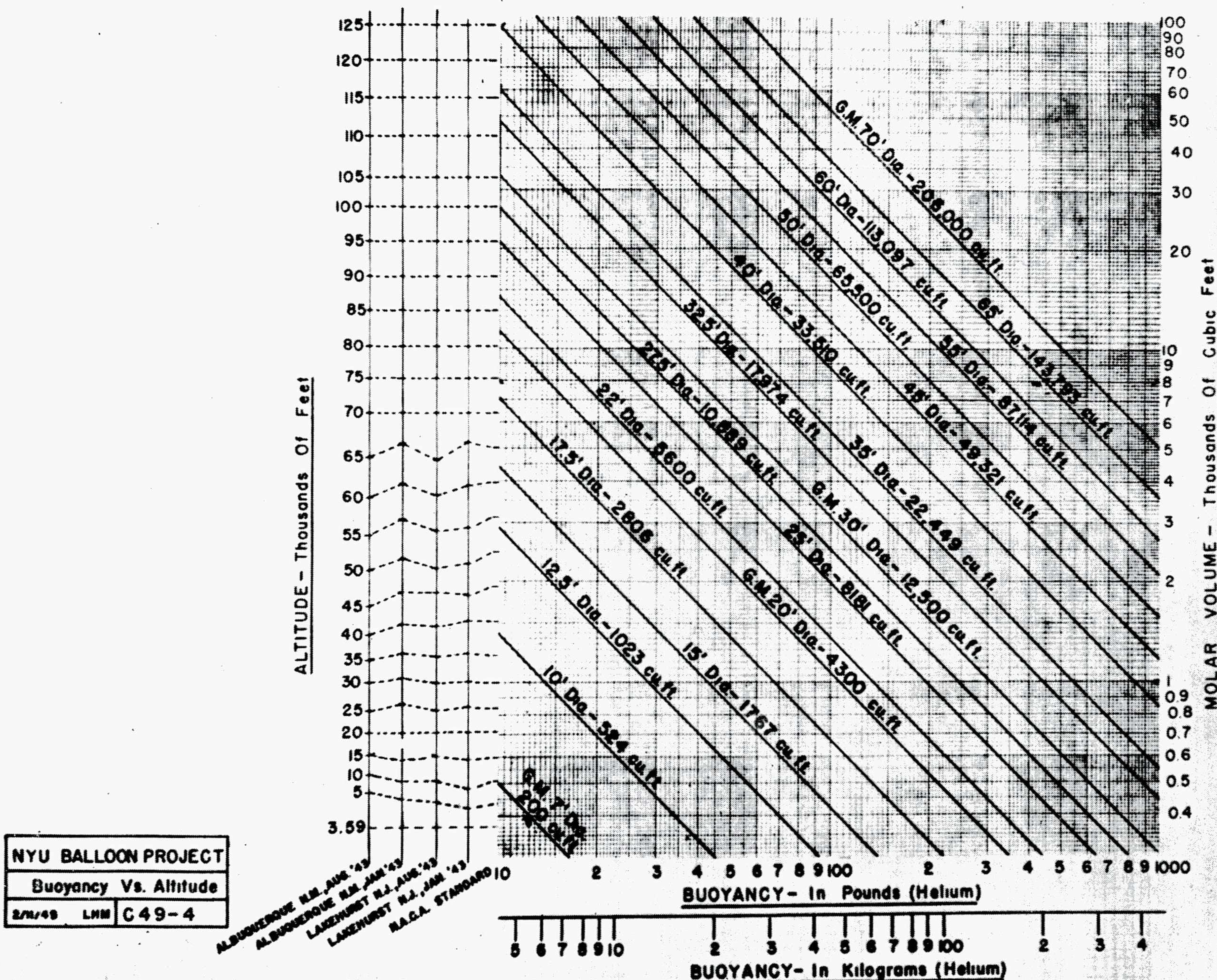
General Mills Nominal Diameter ft.	Actual Volume cu.ft.	Balloon Weight kg.	Estimated Gross Load Limit kg.	Altitude Range ft.
7	200	0.6	1.5 to 5	38,000 to 0
20	4300	3.8 to 5.0	7 to 36	68,000 to 37,000
30	12,700	8.9	12 to 60	82,000 to 50,000
70	200,000	41 to 54	50 to 175	110,000 to 84,000



Gross Loads In Kilograms
A-1
B-2
C-5
D-10
E-15
F-20
G-50
H-75
I-100
J-125
K-150
Rate Of Rise - ft./min.
Free Lift - Percent Of Gross Weight
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
0.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
2
3
4
5
6
7
8
9
10
K
J
I
H
G
F
E
D
C
B
A
NYU BALLOON PROJECT
FREE LIFT OF BALLOONS
VS.
RATE OF RISE
FOR VARIOUS GROSS LOADS
C49-2
1/21/49
LHM

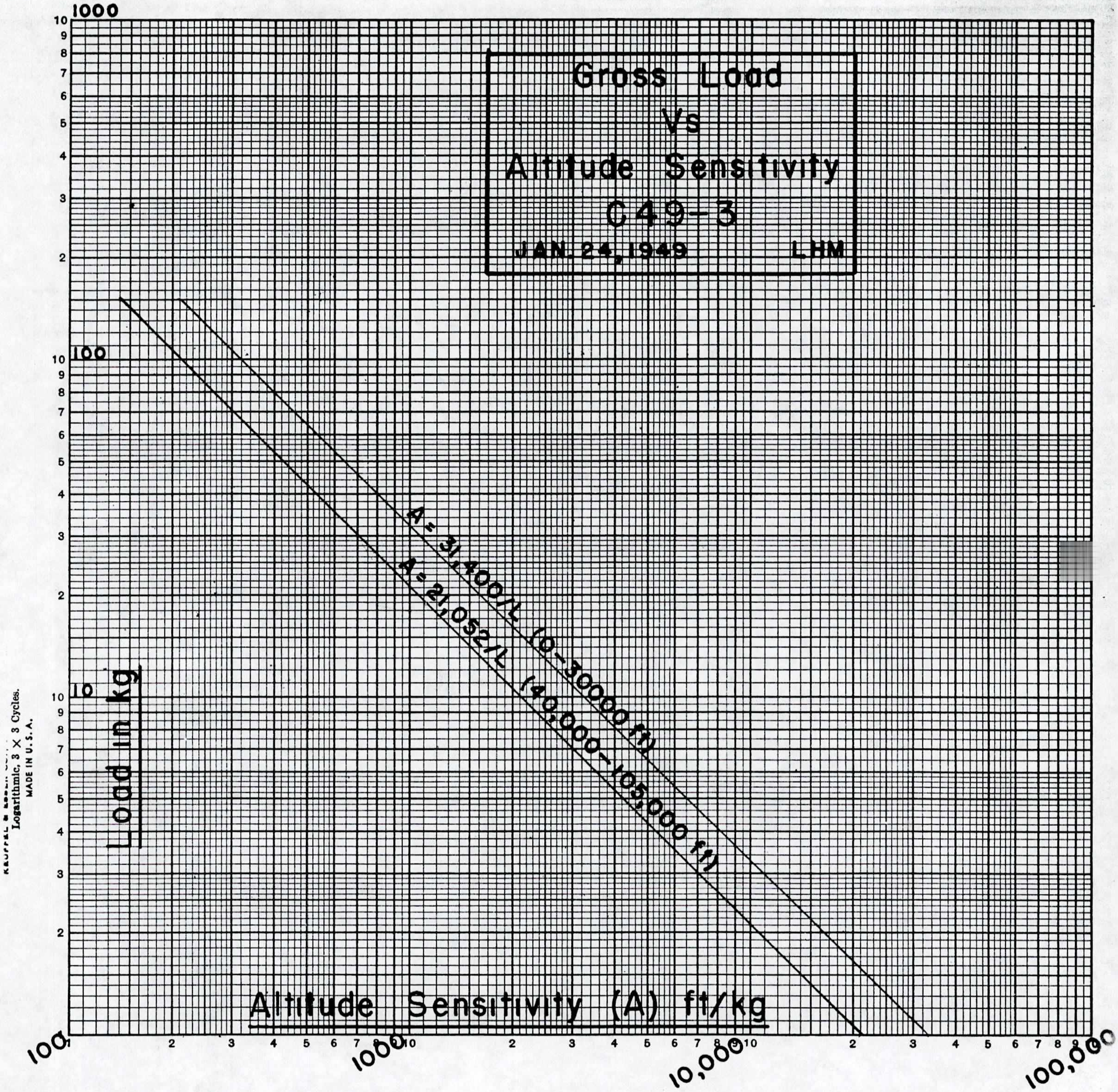

NOTE: Add 1 Foot to minimum Length and Measure on Balloon.
Keep to this distance to minimize Wind Effect
Alamogordo (30°C - 875 mb)
Sea Level (30°C - 1013 mb)
NYU BALLOON PROJECT
Gross Lift vs. Position of Shot Bag
June 17 - 1948 C48-20
Minimum Length of GM Balloon above Shot Bag in Feet
Gross Lift to be given Balloon (Kilograms)
10
20
30
40
50
10 11 12 13 14 15 16 17 18 19 20 30 40 50 60 70 80 90

Graph 2



NYU BALLOON PROJECT
Buoyancy Vs. Altitude
2/11/49 LHM C49-4
ALTITUDE - Thousands Of Feet
MOLAR VOLUME - Thousands Of Cubic Feet
BUOYANCY - In Pounds (Helium)
BUOYANCY - In Kilograms (Helium)
ALBUQUERQUE N.M. AUG. '43
ALBUQUERQUE N.M. JAN. '43
LAKEHURST N.J. AUG. '43
LAKEHURST N.J. JAN. '43
N.A.C.A. STANDARD
G.M. 70' Dia. - 206,000 cu.ft.
65' Dia. - 143,793 cu.ft.
60' Dia. - 113,097 cu.ft.
55' Dia. - 87,114 cu.ft.
50' Dia. - 65,500 cu.ft.
45' Dia. - 49,321 cu.ft.
40' Dia. - 33,510 cu.ft.
35' Dia. - 22,449 cu.ft.
32.5' Dia. - 17,974 cu.ft.
G.M. 30' Dia. - 12,500 cu.ft.
27.5' Dia. - 10,889 cu.ft.
25' Dia. - 8181 cu.ft.
22' Dia. - 5600 cu.ft.
G.M. 20' Dia. - 4300 cu.ft.
17.5' Dia. - 2806 cu.ft.
15' Dia. - 1767 cu.ft.
12.5' Dia. - 1023 cu.ft.
10' Dia. - 524 cu.ft.
G.M. 7' Dia. 200 cu.ft.

Graph 3



Gross Load
Vs
Altitude Sensitivity
C49-3
JAN. 24, 1949
LHM
A = 31,400/L (0-30000 ft)
A = 21,052/L (40,000-105,000 ft)
Load in kg
Altitude Sensitivity (A) ft/kg
1000
100
10
1
100
1000
10,000
100,000
KEUFFEL & ESSER CO.
Logarithmic, 3 X 3 Cycles.
MADE IN U.S.A.

Graph 4

Note: On flights made in February, 1949, spring bow appendix closers were used successfully with rates of rise exceeding 1000 feet per minute. Of those described on page 10, this type of appendix stiffener is now recommended.

25

Appendix 25

Combined History of the
509th Bomb Group and
Roswell Army Airfield
1 September through
30 September 1947

UNCLASSIFIED

SECURITY INFORMATION

RESTRICTED

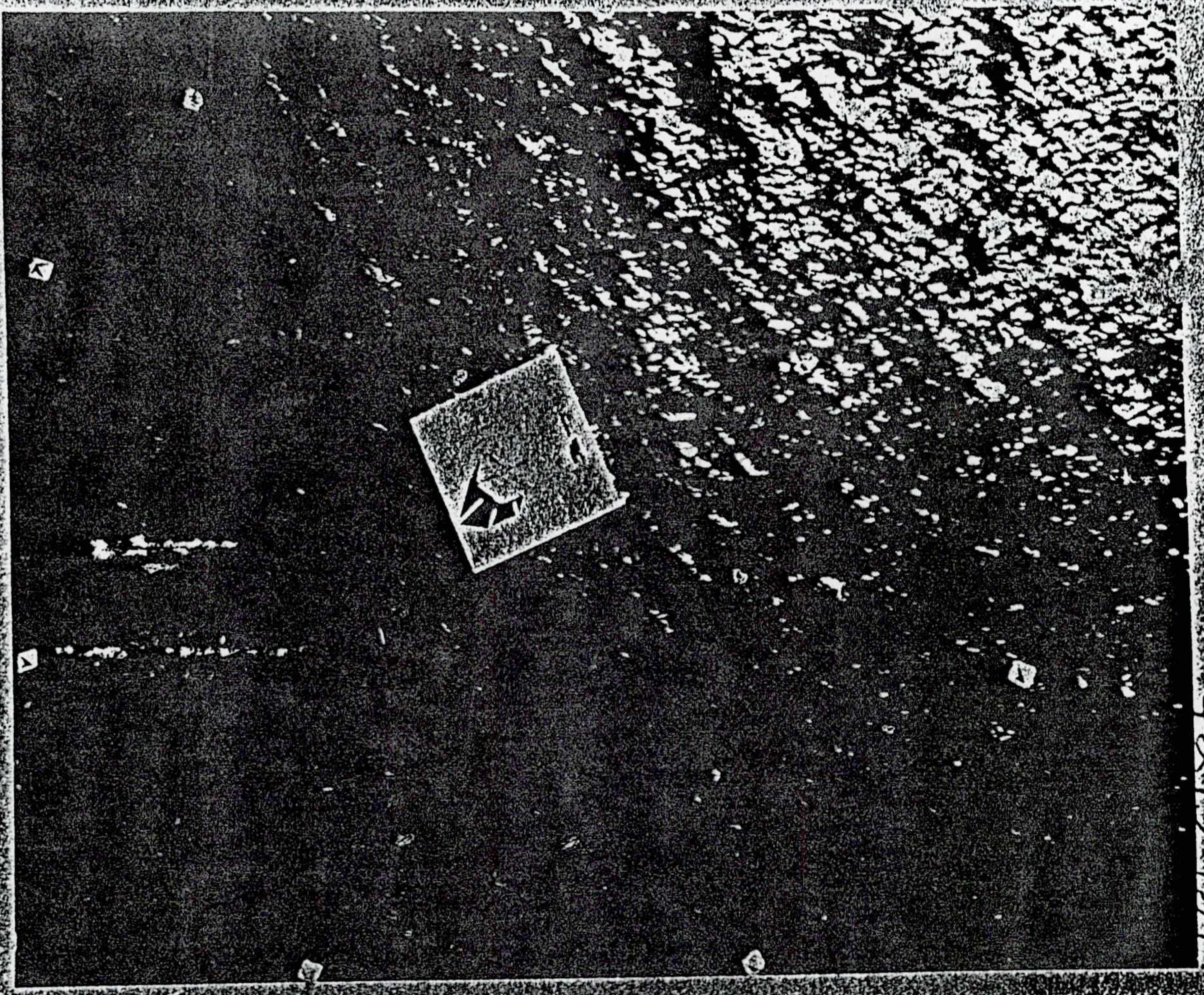
COMBINED HISTORY

509TH BOMB GROUP

AND

ROSWELL ARMY AIR FIELD

1 SEPTEMBER 1947 THROUGH 30 SEPTEMBER 1947



CHAPTER XIII

VISITORS and EXECUTIVE CALENDAR

3 September 1947 - Colonel Blanchard and Lt. Haut went to Artesia where Colonel Blanchard was guest speaker at the Artesia Woman's Club luncheon.

3 September 1947 - Colonel Pelham D. Glasford, Eighth Air Force Air Inspector's Office and Lt. Colonel John A. Roberts, Assistant Chief of Staff, arrived for general familiarization with various activities on the field as pertains to their respective jobs.

3 September 1947 - Col. John D. Ryan, A-3; Lt. Colonel Calvin W. Fite, Jr., Lt. Colonel Carl V. Ekstrand, Lt. Colonel Ray C. Milton, Major Leroy S. English, Captain Floyd R. Creasman, Captain James W. Brady, all from Headquarters Eighth Air Force, arrived here for a conference and inspecting and coordination with various sections on the base. Lt. Colonels Harman and Ord arrived from Alburquerque for the conference.

4 September 1947 - The above-named group departed for Forth Worth and Tucson.

5 September 1947 - Mr. Lawrence A. Deason, Sr., liason representative from San Antonio, called on Colonel Blanchard.

10 September 1947 - Mr. Peoples, Mr. Hackman and First Lieutenant Thompson from Air Material Command arrived on the field to inspect Air Material Command installations and to confer with Lt. Colonel Briley.

11 September 1947 - Captain J. P. Morgan, from Headquarters Eighth Air Force, was here to confer with the Engineering Officer, Captain Peterson, in regard to the de-icer boot on C-54 aircraft.

12 September 1947 - Inspection teams from this Base inspected various Base activities, organizations, and installations.

15 September 1947 - Troops from Roswell Army Airfield marched in a parade in the City of Roswell at 1030 for the benefit of the Chavez County Memorial Youth Center.

15 September 1947 - A meeting of S-1, S-2, S-3, S-4, DCO, Executive, Air Inspector, Adjutant and Commanding Officers of the 393rd, 830th, and 715th Bomb Squadrons was held in the Control Room to discuss the reorganization.

26

27

28

29