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# General Mills, Inc.

## Mechanical Division

**ENGINEERING RESEARCH & DEVELOPMENT DEPARTMENT**

2003 EAST HENNEPIN AVENUE
MINNEAPOLIS 13, MINN.

8268 MD

GENERAL MILLS, INC.
Mechanical Division
Engineering Research & Development Department
Minneapolis, Minn.

# DATA ON
# THE USE OF CONSTANT LEVEL BALLOONS
# TO MEASURE THE HORIZONTAL MOTION
# IN THE ATMOSPHERE

from C ... Moore

Report No. 1164
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Prepared by: C. B. Moore
J. R. Smith
A. Gaalswyk

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DATA ON THE USE OF CONSTANT LEVEL BALLOONS

TO MEASURE THE HORIZONTAL MOTION IN THE ATMOSPHERE.

## SUMMARY

In the course of Navy-sponsored investigations of cosmic rays and other atmospheric phenomena, the authors at General Mills, Inc. have made many constant level balloon flights on the standard meteorological surface of 300 mb (nominally 30,000 feet). The tracks of these flights are of general meteorological interest, as they are believed to delineate the actual trajectory of an equivalent mass of air travelling on a constant pressure surface. Some of the original flight data are presented for the information of other investigators of air motions, to illustrate the application of constant level balloons to meteorological problems, particularly atmospheric diffusion and the variability of the wind. Suggestions are made of the significance of the data presented, and further experiments are proposed which might result in a better understanding of the mechanisms of air motion. Possible applications of constant level balloons in routine observations to obtain representative measurements of wind velocity are set forth.

## INTRODUCTION

The determination of air trajectories is an essential quantity needed in modern meteorology. No forecaster can expect great success without a knowledge of the area of origin of tomorrow's weather, as the weather of tomorrow is in a large part determined by the atmospheric conditions of today, at points upwind. Presently, meteorologists attempt to determine air flow by the application of hydrodynamics to upper air data observed simultaneously over a large region. Using the instantaneous observations of wind and pressure fields, efforts are made to determine the air flow by the integration of all these data with time. However, the integrated trajectories thus obtained do not provide a satisfactory picture of the motion of the air.

The fundamental reasons for this appear to be the non-representativeness of the present upper air observations and the difficulty of obtaining a sufficiently accurate model of the atmosphere which is simple enough to be worked with.

The wind observations determined by use of ascending sounding balloons in the weather services appear to be not sufficiently representative of the true air motion at any one level for at least three reasons:

1. Eddy motions, superimposed on the field of translation, introducing dispersions and variability into the instantaneous observations. This effect when coupled with the short sampling time of rawin observations, results in wind measurement distributed about the representative air translation value.

2. Inherent limits of accuracy of the older wind measuring systems, such as pibals and rawins, obtained from the SCR658. However, a study by Rapp ( ) shows that the winds measured by newer military systems have a greater precision than is afforded by the wind variability over time and space.

3. Non-synopticity of winds. This arises from operational considerations whereby the wind observations may depart from simultaneity at various stations by an hour or more (Gabriel & Belucci).

The combined effect of the limiting factors listed has caused one observer to conclude that a wind report of 30 knots from 270° must be considered as possibly indicating a true wind somewhere between 21 and 40 knots blowing from between 240 to 300° (Machta). With such lack of precision, meteorologists frequently disregard the reported wind when analyzing upper level charts and computing trajectories.

Lacking trustworthiness and direct wind observations, the "geostrophic" wind derived from pressure observations is widely used in dynamic meteorology. This "wind" in its simple form is derived from the horizontal pressure gradient by means of the following relation and assumption:

$$\text{Geostrophic velocity} = \frac{\text{pressure gradient}}{\text{air density x coriolis force}}$$

The coriolis force ( $\lambda$ ) is a function of the earth's rotation ( $\omega$ )

and the latitude ( $\phi$ ) of the air parcel. ( $\lambda = 2\omega \sin \phi$ )

$$\text{hence V geostrophic} = \frac{\partial p}{\partial n}\left(\frac{1}{\rho\lambda}\right)$$

The assumptions used in this relation are:

a. The vertical velocity of the air parcel is negligible.

b. No frictional stresses exist.

c. The isobars are straight, parallel and the wind blows parallel to them at constant velocity, i.e. the accelerations are zero.

Obviously these assumptions cannot be met in operational meteorology. Therefore, a wind so estimated will be defective according to the deviations from the assumption.

In addition, in the measurement of the pressure gradient itself lies possible sources of error due to the necessarily inexpensive construction of the radiosonde instruments as well as the systematic and operational errors in measuring atmospheric pressure and temperature. The errors permitted in a radiosonde measurement of pressure may exceed 4 mb. These errors in pressure measurements on the 300 mb surface at two different stations may cause a wind error of 8 mb at 300 mb $\sim$ 600 feet 2 sta 300 miles apart cross isobar with $\Delta h$ for 300 mb level = 600 ft. Geo wind = 75 knots $\Delta h = 0 \Rightarrow$ geo wind = 0 $\therefore$ 100% wind error.

In view of this, it appears that a trajectory which is obtained by a forecaster using non-representative data smoothed subjectively and integrated, using non-valid assumptions <u>cannot</u> be expected to define the air flow accurately.

Needed, therefore, is some way of <u>naturally</u> integrating these transient effects into a simpler overall picture of atmospheric motion. Trajectories obtained from constant level balloons have been suggested as one fundamental approach.

## STUDIES WITH CONSTANT LEVEL BALLOONS

In an effort to study geostrophic departures, Durst made use of "constant level" rubber balloons in 1943 and 1944. The experiments were of great interest despite the fact that the balloons did not remain aloft very long and were not well stabilized on a constant pressure level (variations of 25 mb over one-half hour intervals are reported).

More recently, the development of instrumented constant level plastic balloons has been reported by Spilhaus ( ). Significant trajectory data have now been obtained from these balloons both by New York University and General Mills investigations. Three sets of experiments involving air trajectories are described here.

In the first of these, actual balloon trajectories are compared with the "hindcast" trajectories computed from conventional upper air data. In the second and third studies, the separation of multiple constant level flights made simultaneously and sequentially is described to suggest the order of magnitude of eddy motion encountered by the balloons in flight.

## TRAJECTORIES COMPARED WITH FORECASTS

A large number of constant level balloon flights were made by the authors during the summer of 1951. The balloons were normally spheres, 25 feet in diameter, instrumented to float on the 300 mb pressure surface. Launchings were made from Hill Air Force Base, Ogden, Utah, and balloons were tracked by aircraft over constant level trajectories averaging about 1000 miles. Attempts were made to forecast the impact point of the balloons at the end of their flight. The forecasts of trajectories and impacts were made before the balloons were launched to insure complete honesty in the predictions. Such flights were carried out repeatedly using multiple forecasters and standardized procedures to minimize subjectivity. Although it was found that better forecasts could be made under certain selected weather situations and that some proficiency improved the forecasts, the accuracy which could be obtained under the best conditions was limited. Average errors in the prediction of the impact point of about 23% of the total range were experienced under all weather situations for which balloons were flown. Under conditions selected by the forecaster as optimum, this error could not be reduced below 18% of the distance travelled.

It was recognized that operational degradation would reduce the effectiveness of the forecasts whenever the time of launching, rate of rise, floating altitude or flight duration were different from those assumed by the forecaster. In addition, errors in the basic forecast of the pressure and wind fields to be encountered during flight would affect the accuracy of the trajectory forecast. A third cause for failure to make a good trajectory forecast would be the possible falseness of the assumption that the horizontal motion of the balloon is controlled by the air with which it is surrounded.

In an attempt to separate these variables, a study was made of 20 flights selected for good mechanical behavior, i.e. adherence to the 300 mb level and extension of an average length of 1000 miles. An independent forecaster, Dr. Homer Mantis of the University of Minnesota, compared the trajectories of these flights, using "hindcast" trajectories made from the in-flight winds and pressure fields as reported by the U. S. Weather Bureau stations during the flight period. Consideration was given to the exact launching time, ascent vector, floating altitude, and flight duration. For these 20 flights of an average 1000 miles length, the average error in the end point was 20% of the total flight length. This surprisingly large "hindcast" error amounts to about 80% of the original forecast error and strongly suggests that either (1) the balloon held on a constant pressure surface does not move with the horizontal wind at that surface, or (2) the field of motion as it is presently described is far more inadequate than previously believed.

EFFECTS OF EDDY DIFFUSION

If the balloons do not move with the wind at their level, is it because no representative wind exists? It has been postulated that air motion is such a complex of eddies that conceivably a large number of trajectories might be obtained in a single given situation. To test this assumption, simultaneous multiple constant level balloon flights were made. They have been studied by Mantis and Gaalswyk and the pertinent conclusions are quoted below.

"The effects of eddy motion appear in the equations of motion as eddy stresses, and therefore depend on the definition of the average large scale flow. In a sense, conventional synoptic analysis represents a large scale flow which is averaged over the space between the reporting stations. The trajectory of a single balloon, therefore, should consist of a component due to the large scale motion and a component due to the eddy motions. A random distribution of eddy motions would have the effect of diverting a single balloon from the large scale flow or causing the diffusion of a cluster of balloons. The magnitude of this effect is not known; estimates vary by as much as several orders of magnitude. In past experiments on the diffusion of balloon clusters or other tracers, it appears that the effect of eddy motions is frequently obscured by the effect of the vertical shear on the motion of tracing elements at slightly different altitudes.

"The results of a limited number of simultaneous multiple constant level balloons made by General Mills therefore offer unique opportunities for the examination of the diffusion effects. On three occasions, it is possible to isolate the effects of eddy diffusion by multiple flights in which a minimum difference in balloon altitude was maintained during the flights. In the flights 557-558, 566-567-568, and 561-562, the maintenance of altitude was within ± 150 ft. (± 2 mb) of the desired control altitude for each balloon. The only exception occurred on flight 566 which was off by 300 feet for a short time. The results of these flights are given in the following table:

| Flights compared | Distance of flight under comparison Miles | Duration of flt. under comparison Hrs. | Distance balloons were apart Mi. | Balloon separation as % of distance % | Across-track variation of trajectory |
|---|---|---|---|---|---|
| 557-558 | 750 | 14.5 | 11 | 1.3 | |
| 561-562 | 1000 | 18.0 | 14 | 1.8 | |
| 566-567 | 1200 | 20.2 | 1 | .08 | 1 |
| 566-567 | 1200 | 20.2 | 5 | .4 | 1 |
| 567-568 | 1200 | 20.2 | 5 | .4 | 1 |

"The consistence of these results seems to definitely establish the order of magnitude of the effect of eddy diffusion. This effect is certainly negligible as a factor in the accuracy of trajectory construction."

A few other multiple flights have been made where the balloons have been separated in time or altitude. Flights 564-565 travelled 1640 miles in 27.2 hours, one at an average altitude of 32,000, the other at 29,500. At the termination of the flight, the balloons were 18 miles apart with a cross track separation of the trajectories of only 7 miles.

Flights 576-577 were launched 51 minutes apart. Flight 576 floated at an average altitude of 30,500; flight 577 floated at about 31,000 ft. At the end of 31 hours, the balloons had travelled about 1200 miles and were 44 miles apart with a 17 mile separation between their trajectories (apparently due to change of the pressure field).

Similar experiments were made to show the effect of separating trajectories in time. In each case, a regular progression of the trajectories was observed and a general adherence to the synoptic track as reported by standard observations was noted, although the balloon trajectories could not be predicted persistently nor made to conform rigorously to the computed in-flight trajectories.

From this study, one may conclude that a representative trajectory of some sort can be obtained by constant level balloons. If this is truly the large-scale air motion which is represented, the instantaneous field of motion in the upper air is being misrepresented by 20% with present observation techniques.

PILLOW BALLOONS

In other efforts to trace air parcels inexpensively, small constant volume balloons were devised at General Mills. These balloons, because of their square shape arising from their construction, have been labelled 'pillow balloons'. Many mass flights of these balloons have been made in which 50 or more balloons were launched simultaneously. It appears that these balloons do not maintain a long constant level flight, except under special operating conditions. The recoveries of these balloons show that they fall out along a line which frequently has been no wider than ten miles for a mean range of 600 miles. The data on these flights are also given in the attached exhibits.

Two such inexpensive, uninstrumented balloons launched from Minneapolis, have been returned from Ireland, illustrating the trajectory tracing potential possible for inexpensive constant volume balloons.

CONCLUSION

From the controlled altitude flights, and the pillow balloon data given in the exhibits, it appears that a meaningful and representative measurement of horizontal wind velocities might be made using a constant level balloon principle. From the repeatability of the wind measurements made from trajectory balloons, it appears that the small scale variability of the wind may give non-representative values for short term wind observations. The use of a small, inexpensive, constant-level balloon on standard surfaces to complement wind measurements by sounding balloons should integrate out the variability of effects and permit better delineation of the flow of the air.

To use these constant level balloons meaningfully, it will be necessary to determine the minimum constant level flight duration feasible which will smooth out the effects of superimposed eddy motion and to permit the direct observation of a wind good enough for determinations of atmospheric accelerations as well as the representative air velocity. This problem has been considered by Durst, Machta and Mantis and some definitive experiments are being planned. It appears, however, that 30 minute observations of the displacement of a constant level balloon will yield a much more representative wind measurement than the present two-minute, sounding balloon observations.

Direct observation of balloon trajectories should be a valuable forecast tool, particularly for tropical meteorology. By this method, fields of divergence or convergence might be directly observed and studied rather than inferred by the existing weather and measurement of the pressure gradients in those latitudes.

The tracking of constant level balloons to obtain air trajectories at great ranges from otherwise inaccessible areas may be another use and extension of this technique for meteorological problems. Such a use is being contemplated by the Naval Research Laboratory in the transosonde project to obtain wind and trajectory data from over the Central Pacific.

Consideration should also be given to the direct observation of trajectories as a routine weather observation tool complementing existing techniques.

## DEFINITIVE EXPERIMENTS WHICH ARE NEEDED

1. Repeated, simultaneous observations of the variability of the wind, made by launching small meteorological constant level balloons at intervals, comparing the wind attained for each two minute period with an average from a 30 minute displacement. These data should in turn be compared with:

   a. synoptic rawin soundings,

   b. the constant level wind measured by similar units located across wind at distances of 1, 10, and perhaps 100 miles,

   c. the wind measured by the same stations on any constant level balloons 30 and 60 minutes later.

2. Nationwide wind observations on a standard surface by one hour flights of small constant level balloons from the U. S. Weather Bureau rawin stations synoptic with the standard rawin soundings.

3. Establishment of a tracking net for larger constant level balloons in the tropics and the making of simultaneous flights to observe directly the atmospheric convergence and divergence particularly around hurricane time.

## REFERENCES


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Gabriel, J. E. and Bellucci, R. "Time Variation of Winds Aloft" Journal of Meteorology, Vol. 5 #6, Dec. 1951, PP 422-423.

Perkins, D. T. "The Response of Balloons to the Wind", Bulletin, American Meteorological Society, Vol. 33 #4, April 1952.

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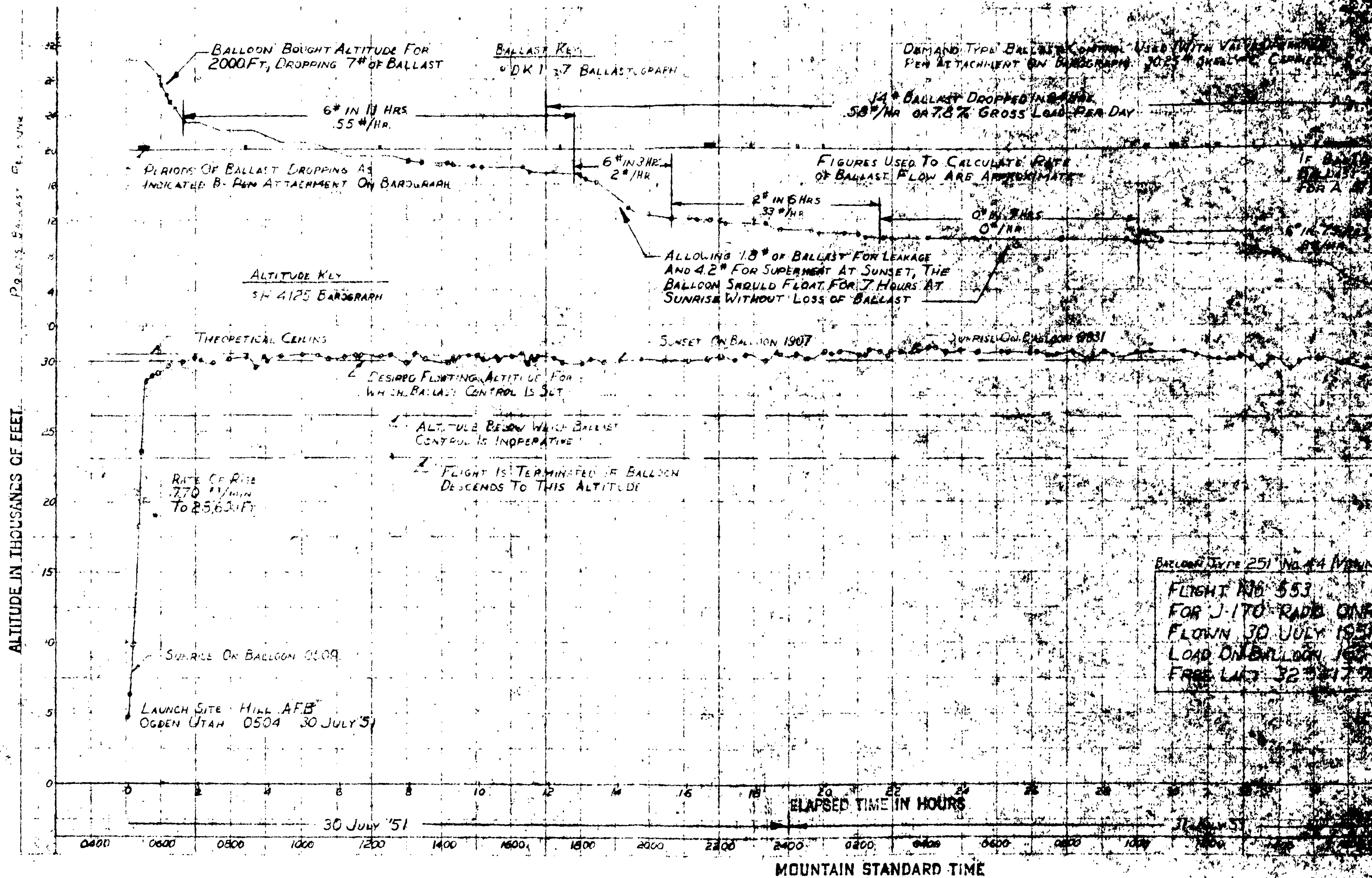
Spilhaus, A. F., "Proposed Weather Services Utilization of Constant Level Balloons to Measure Trajectory Segments" Private Communication.

Four twenty-five foot diameter balloons being inflated for a simultaneous launching. These balloons carrying a 160 pound payload, will float on the 300 millibar surface where they will be used to study atmospheric divergence.

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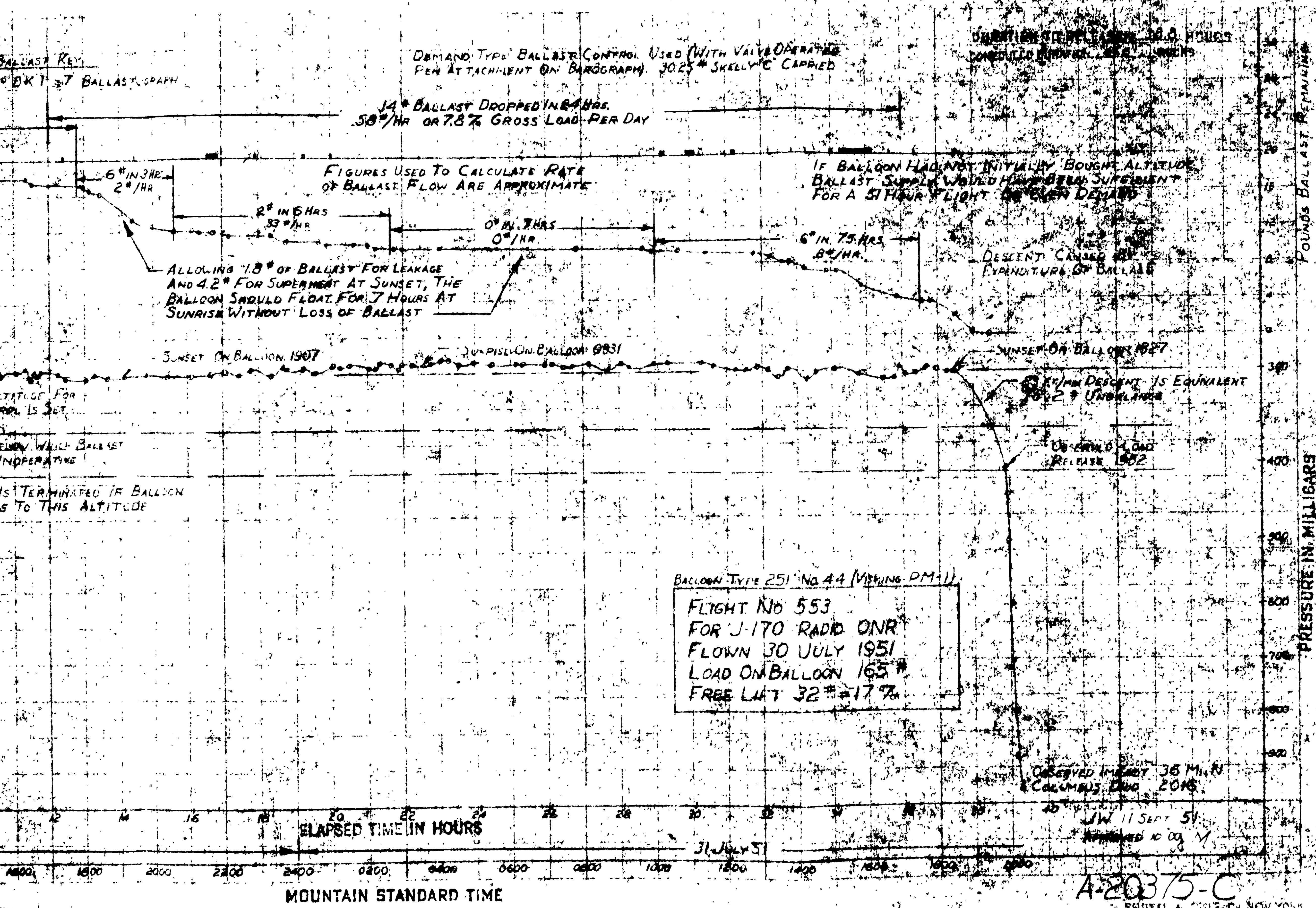


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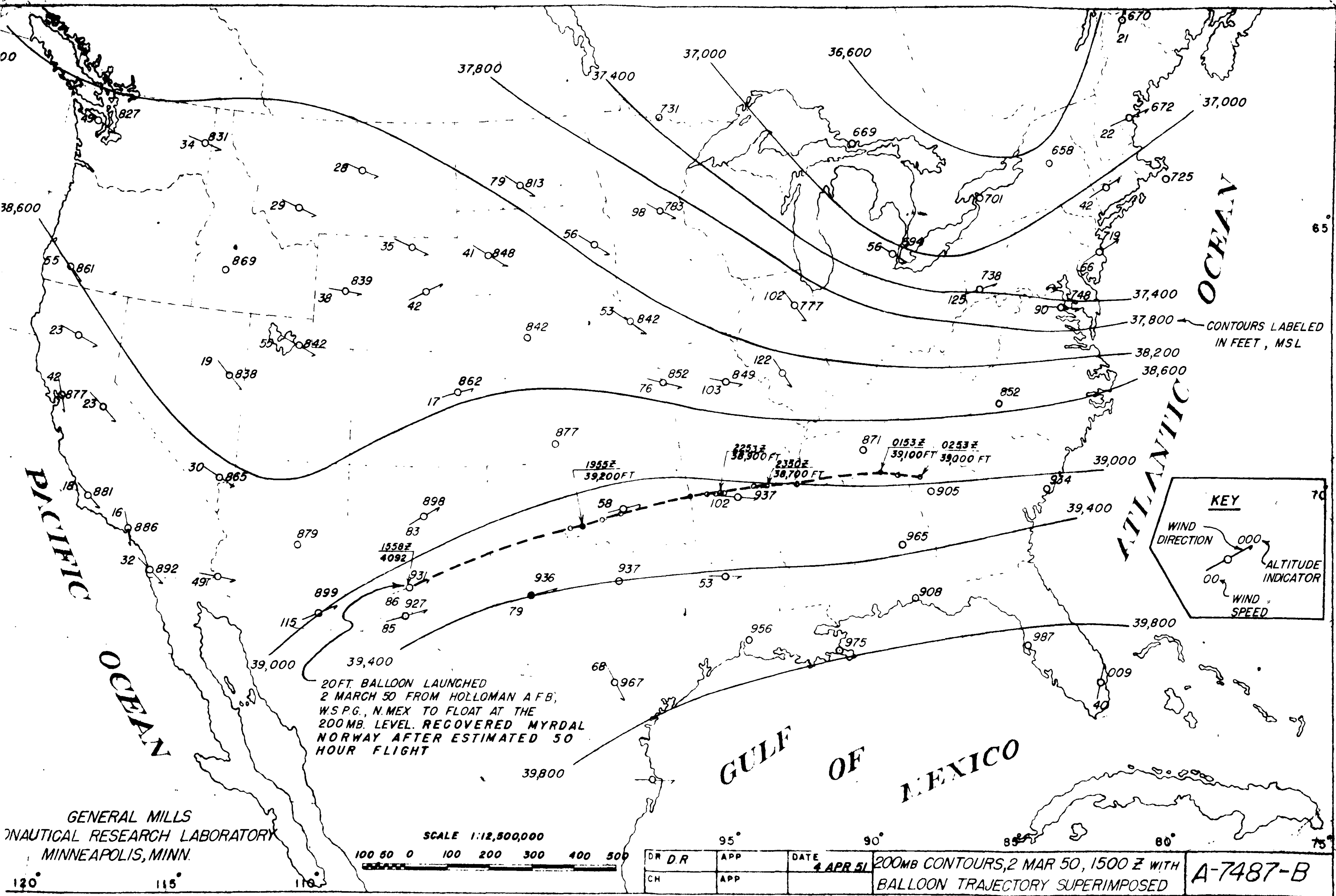
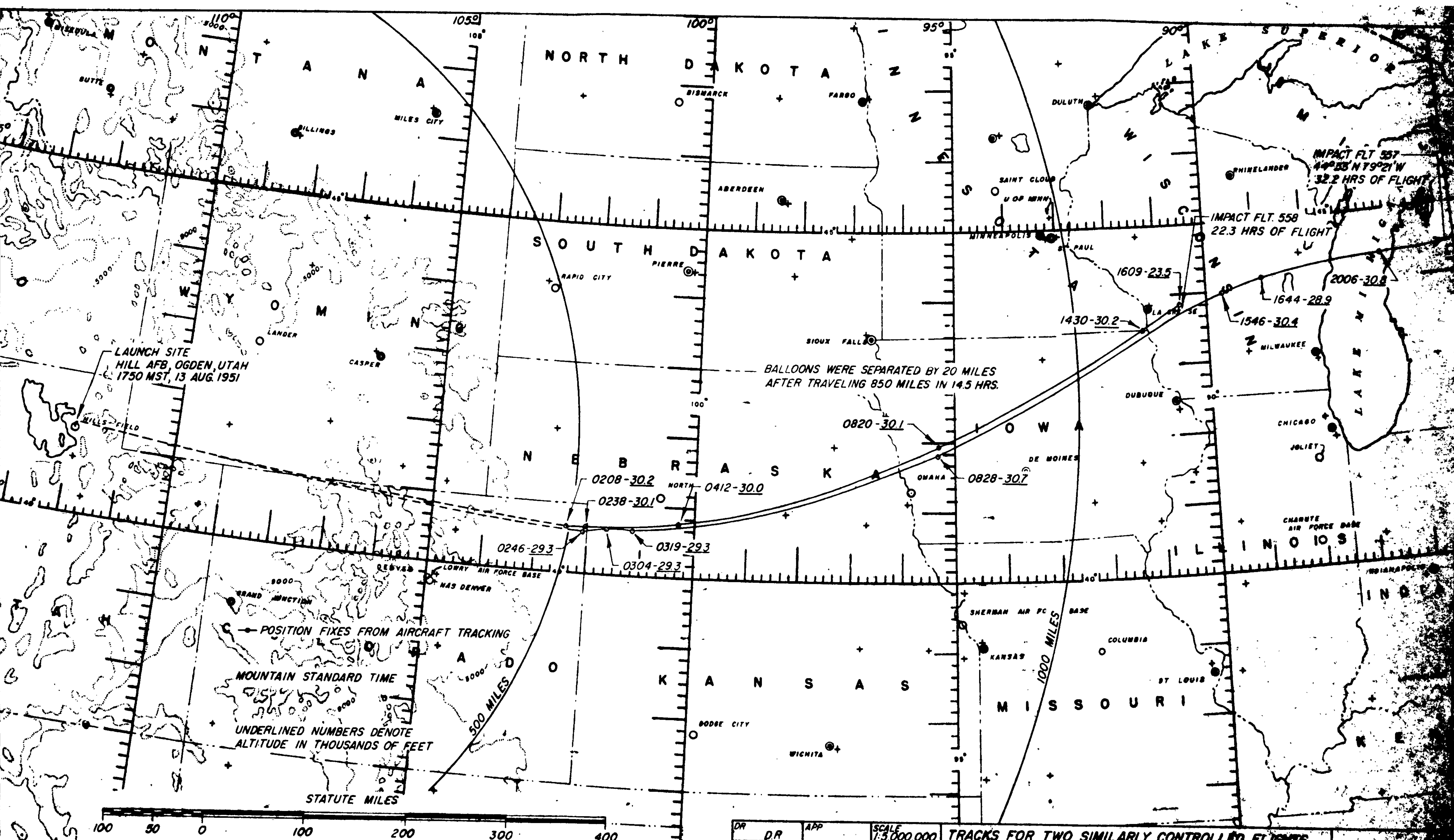

CONTOURS LABELED IN FEET, MSL
KEY
WIND DIRECTION
ALTITUDE INDICATOR
WIND SPEED
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
20 FT. BALLOON LAUNCHED 2 MARCH 50 FROM HOLLOMAN A.F.B., W.S.P.G., N.MEX TO FLOAT AT THE 200 MB. LEVEL. RECOVERED MYRDAL NORWAY AFTER ESTIMATED 50 HOUR FLIGHT
1558Z 4092
1955Z 39,200 FT
2251Z 38,900 FT
2350Z 38,700 FT
0153Z 39,100 FT
0253Z 39,000 FT
37,000
36,600
37,400
37,800
38,200
38,600
39,000
39,400
39,800
SCALE 1:12,500,000
100 50 0 100 200 300 400 500
GENERAL MILLS
AERONAUTICAL RESEARCH LABORATORY
MINNEAPOLIS, MINN.
DR D.R
CH
APP
APP
DATE 4 APR 51
200 MB CONTOURS, 2 MAR 50, 1500 Z WITH BALLOON TRAJECTORY SUPERIMPOSED
A-7487-B

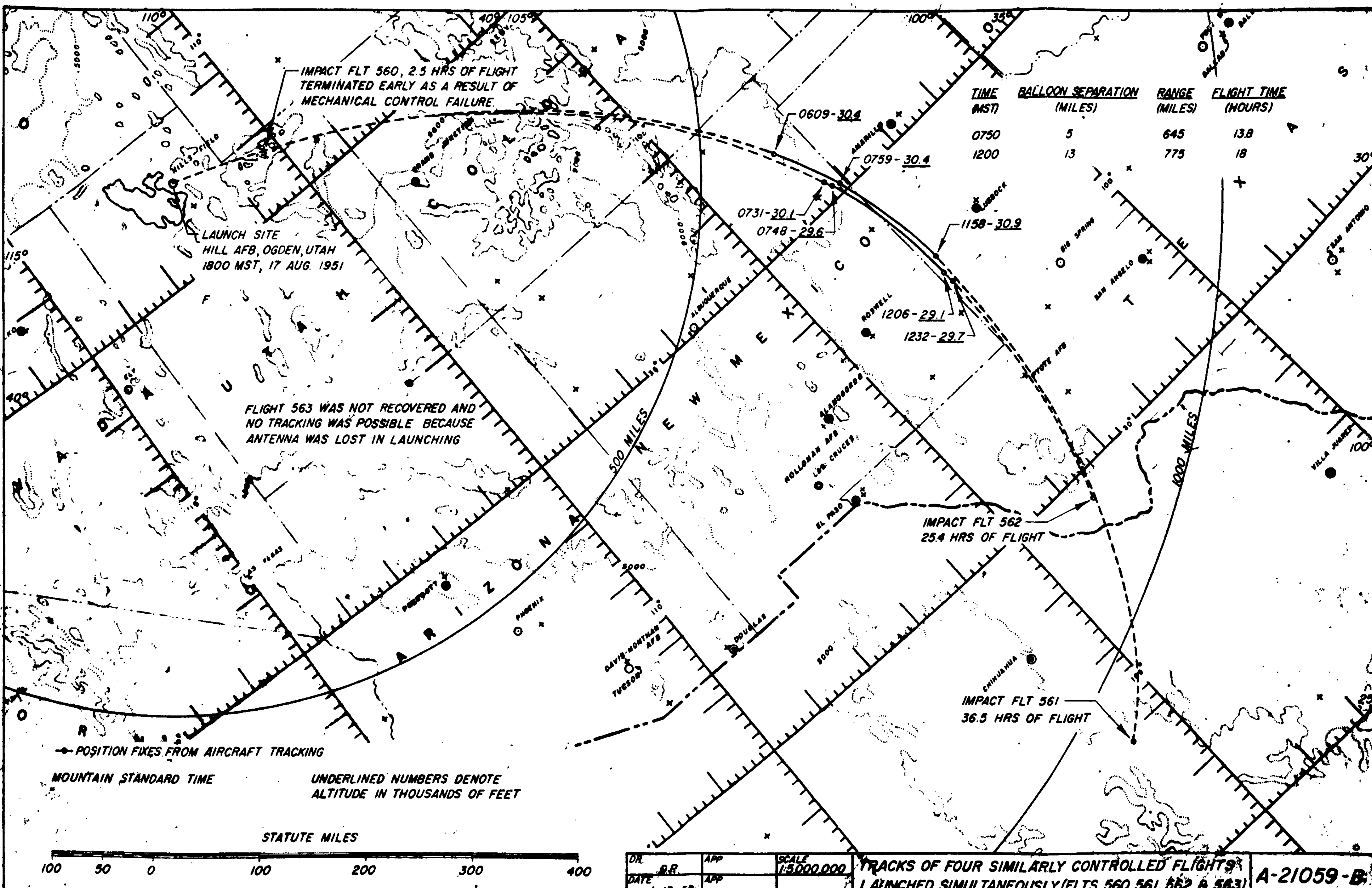
DATA ON CONTROLLED
ALTITUDE FLIGHTS




| DR | DR | APP | SCALE 1:5,000,000 | TRACKS FOR TWO SIMILARLY CONTROLLED FLIGHTS LAUNCHED SIMULTANEOUSLY (FLTS. 557 & 558) | A-21088-C |
|---|---|---|---|---|---|
| DATE | 1-12-53 | APP | | | |

GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA

JAN 21 1953

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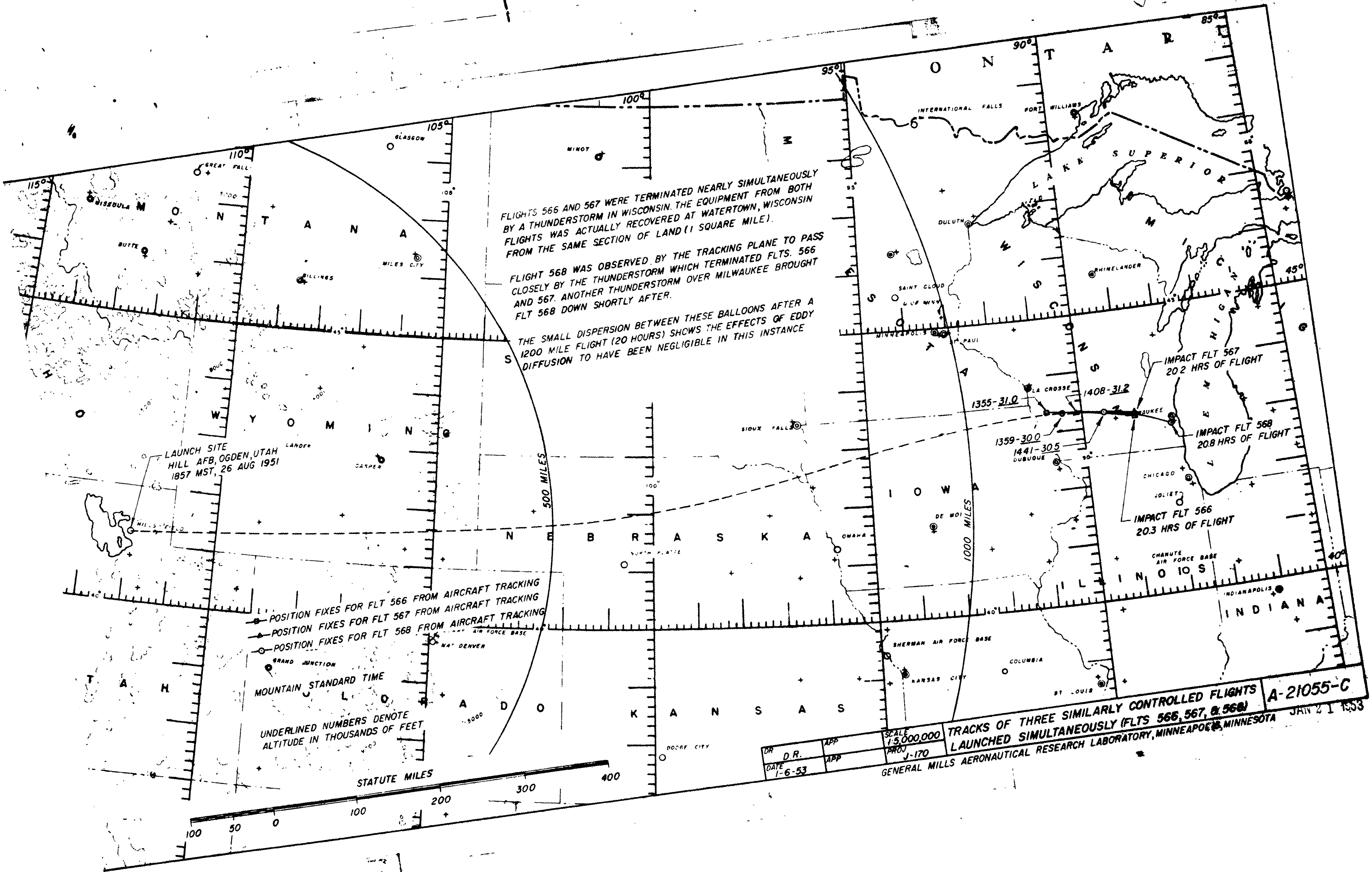
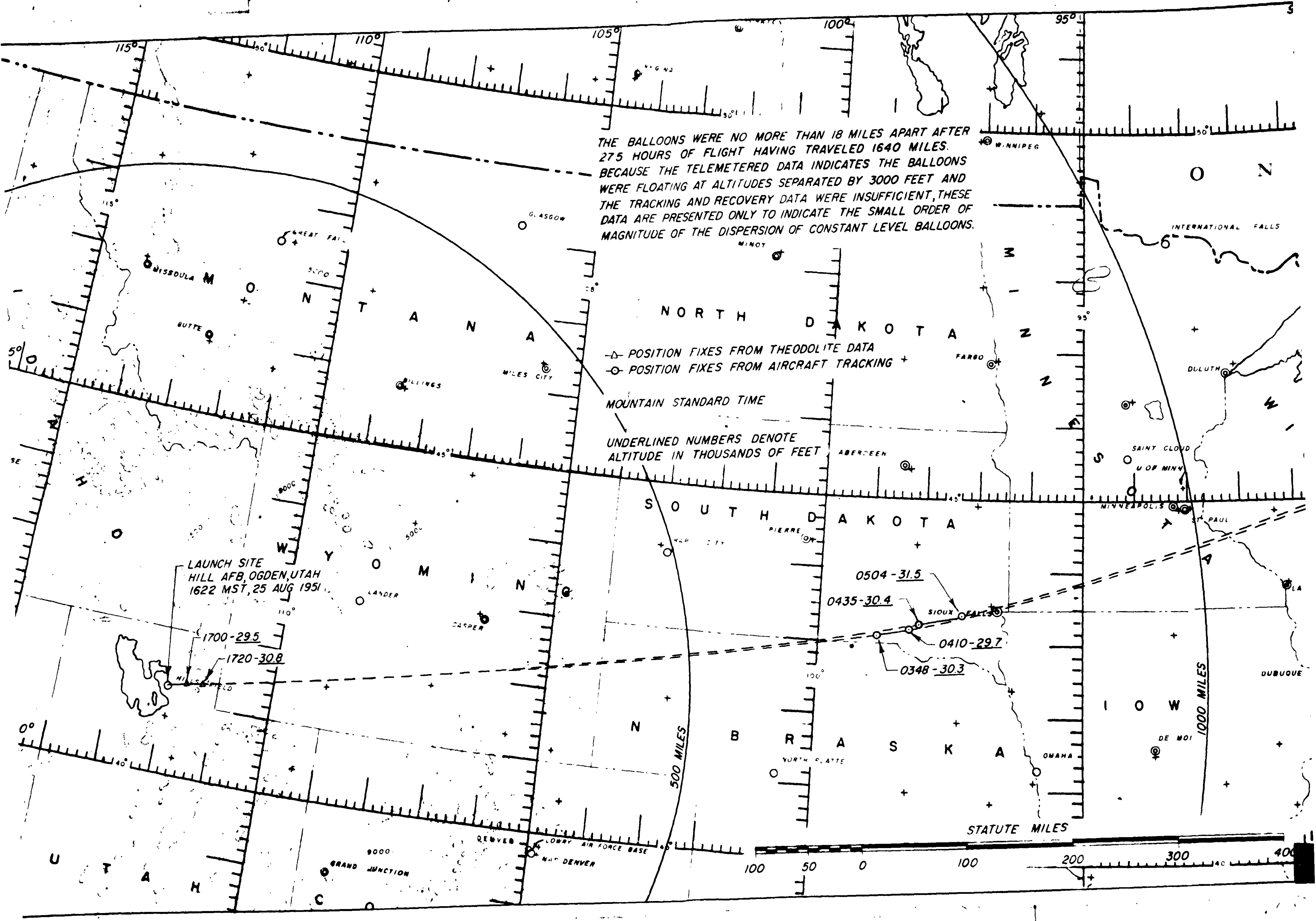

FLIGHTS 566 AND 567 WERE TERMINATED NEARLY SIMULTANEOUSLY BY A THUNDERSTORM IN WISCONSIN. THE EQUIPMENT FROM BOTH FLIGHTS WAS ACTUALLY RECOVERED AT WATERTOWN, WISCONSIN FROM THE SAME SECTION OF LAND (1 SQUARE MILE).
FLIGHT 568 WAS OBSERVED BY THE TRACKING PLANE TO PASS CLOSELY BY THE THUNDERSTORM WHICH TERMINATED FLTS. 566 AND 567. ANOTHER THUNDERSTORM OVER MILWAUKEE BROUGHT FLT 568 DOWN SHORTLY AFTER.
THE SMALL DISPERSION BETWEEN THESE BALLOONS AFTER A 1200 MILE FLIGHT (20 HOURS) SHOWS THE EFFECTS OF EDDY DIFFUSION TO HAVE BEEN NEGLIGIBLE IN THIS INSTANCE
LAUNCH SITE
HILL AFB, OGDEN, UTAH
1857 MST, 26 AUG 1951
IMPACT FLT 567
20.2 HRS OF FLIGHT
IMPACT FLT 568
20.8 HRS OF FLIGHT
IMPACT FLT 566
20.3 HRS OF FLIGHT
1355-31.0
1408-31.2
1359-30.0
1441-30.5
500 MILES
1000 MILES
POSITION FIXES FOR FLT 566 FROM AIRCRAFT TRACKING
POSITION FIXES FOR FLT 567 FROM AIRCRAFT TRACKING
POSITION FIXES FOR FLT 568 FROM AIRCRAFT TRACKING
MOUNTAIN STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
STATUTE MILES
100 50 0 100 200 300 400
MONTANA
WYOMING
NEBRASKA
KANSAS
IOWA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
ONTARIO
LAKE SUPERIOR
LAKE MICHIGAN
MINNESOTA
COLORADO
UTAH
IDAHO
115°
110°
105°
100°
95°
90°
85°
45°
40°
MISSOULA
BUTTE
GREAT FALLS
GLASGOW
BILLINGS
MILES CITY
MINOT
LANDER
CASPER
SIOUX FALLS
NORTH PLATTE
OMAHA
DES MOINES
DUBUQUE
LA CROSSE
SAINT CLOUD
MINNEAPOLIS
ST. PAUL
DULUTH
INTERNATIONAL FALLS
FORT WILLIAMS
RHINELANDER
CHICAGO
JOLIET
CHANUTE AIR FORCE BASE
INDIANAPOLIS
ST. LOUIS
COLUMBIA
KANSAS CITY
SHERMAN AIR FORCE BASE
DODGE CITY
DENVER
GRAND JUNCTION
DR D.R.
DATE 1-6-53
APP
APP
SCALE 1:5,000,000
PROJ J-170
TRACKS OF THREE SIMILARLY CONTROLLED FLIGHTS LAUNCHED SIMULTANEOUSLY (FLTS 566, 567, & 568)
GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA
A-21055-C
JAN 21 1953


THE BALLOONS WERE NO MORE THAN 18 MILES APART AFTER 275 HOURS OF FLIGHT HAVING TRAVELED 1640 MILES. BECAUSE THE TELEMETERED DATA INDICATES THE BALLOONS WERE FLOATING AT ALTITUDES SEPARATED BY 3000 FEET AND THE TRACKING AND RECOVERY DATA WERE INSUFFICIENT, THESE DATA ARE PRESENTED ONLY TO INDICATE THE SMALL ORDER OF MAGNITUDE OF THE DISPERSION OF CONSTANT LEVEL BALLOONS.
POSITION FIXES FROM THEODOLITE DATA
POSITION FIXES FROM AIRCRAFT TRACKING
MOUNTAIN STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
LAUNCH SITE
HILL AFB, OGDEN, UTAH
1622 MST, 25 AUG 1951
1700-29.5
1720-30.8
0348-30.3
0410-29.7
0435-30.4
0504-31.5
500 MILES
1000 MILES
STATUTE MILES
100
50
0
100
200
300
400
115°
110°
105°
100°
95°
MONTANA
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
MINNESOTA
IOWA
UTAH
ONT
MISSOULA
BUTTE
GREAT FALLS
GLASGOW
MILES CITY
BILLINGS
MINOT
FARGO
ABERDEEN
PIERRE
LANDER
CASPER
DENVER
LOWRY AIR FORCE BASE
GRAND JUNCTION
NORTH PLATTE
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MINNEAPOLIS
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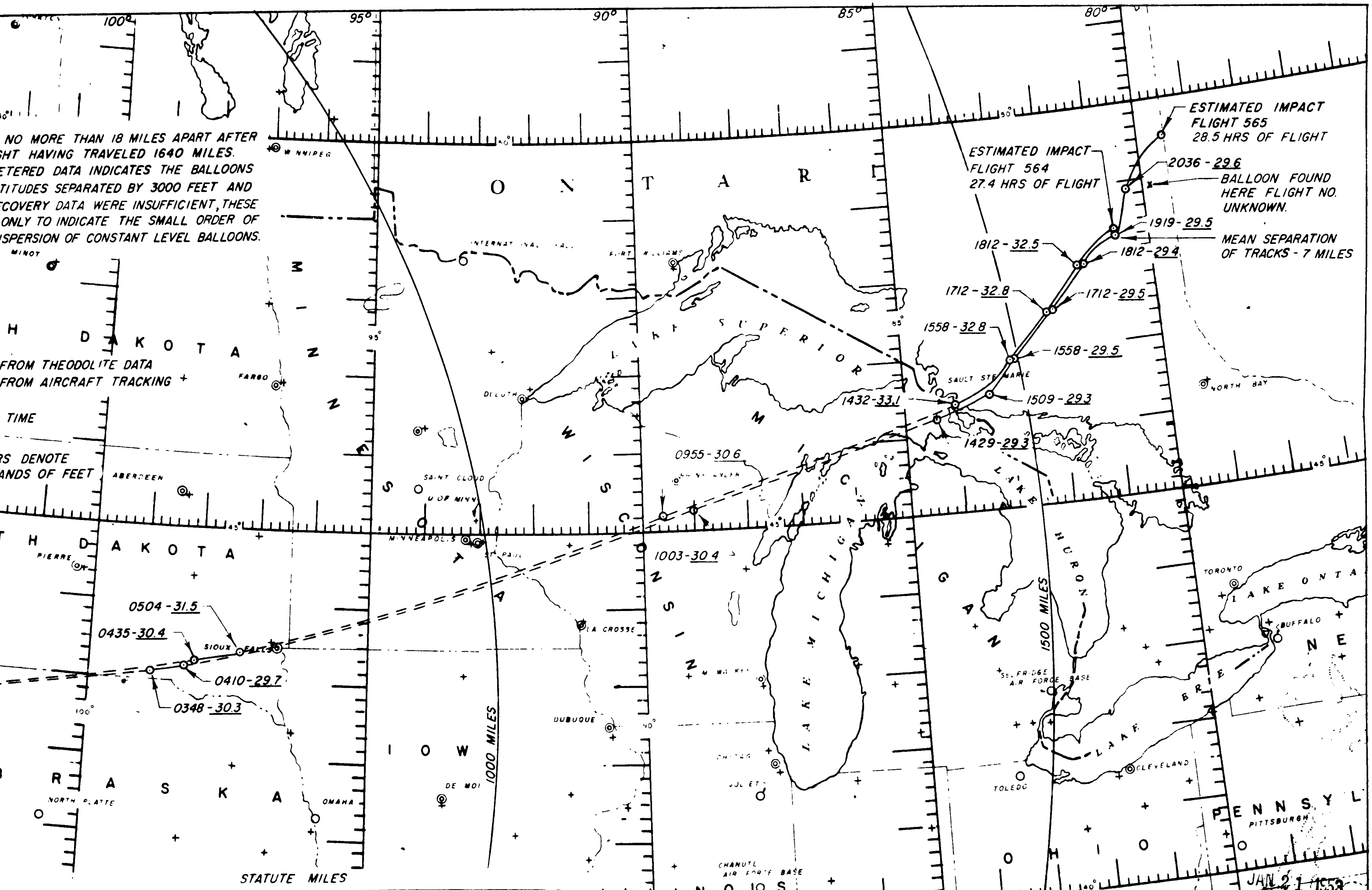


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|---|---|---|---|
| DR | APP | SCALE 1:5,000,000 | TRACKS OF TWO SIMILARLY CONTROLLED FLIGHTS LAUNCHED SIMULTANEOUSLY (FLT. NOS. 564 & 565) |
| DATE 12-31-52 | APP | PROJ J-170 | A-21053-D |

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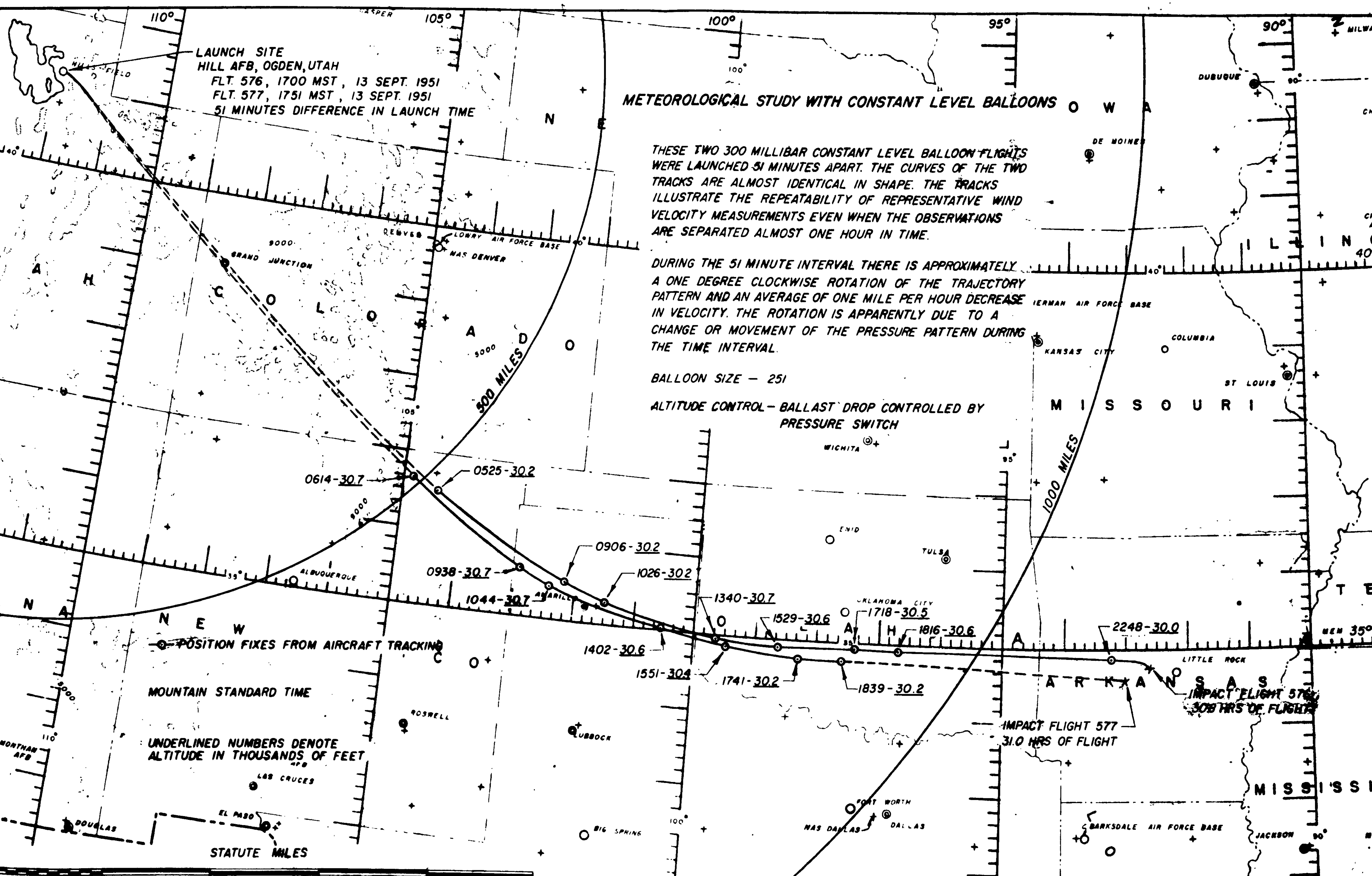
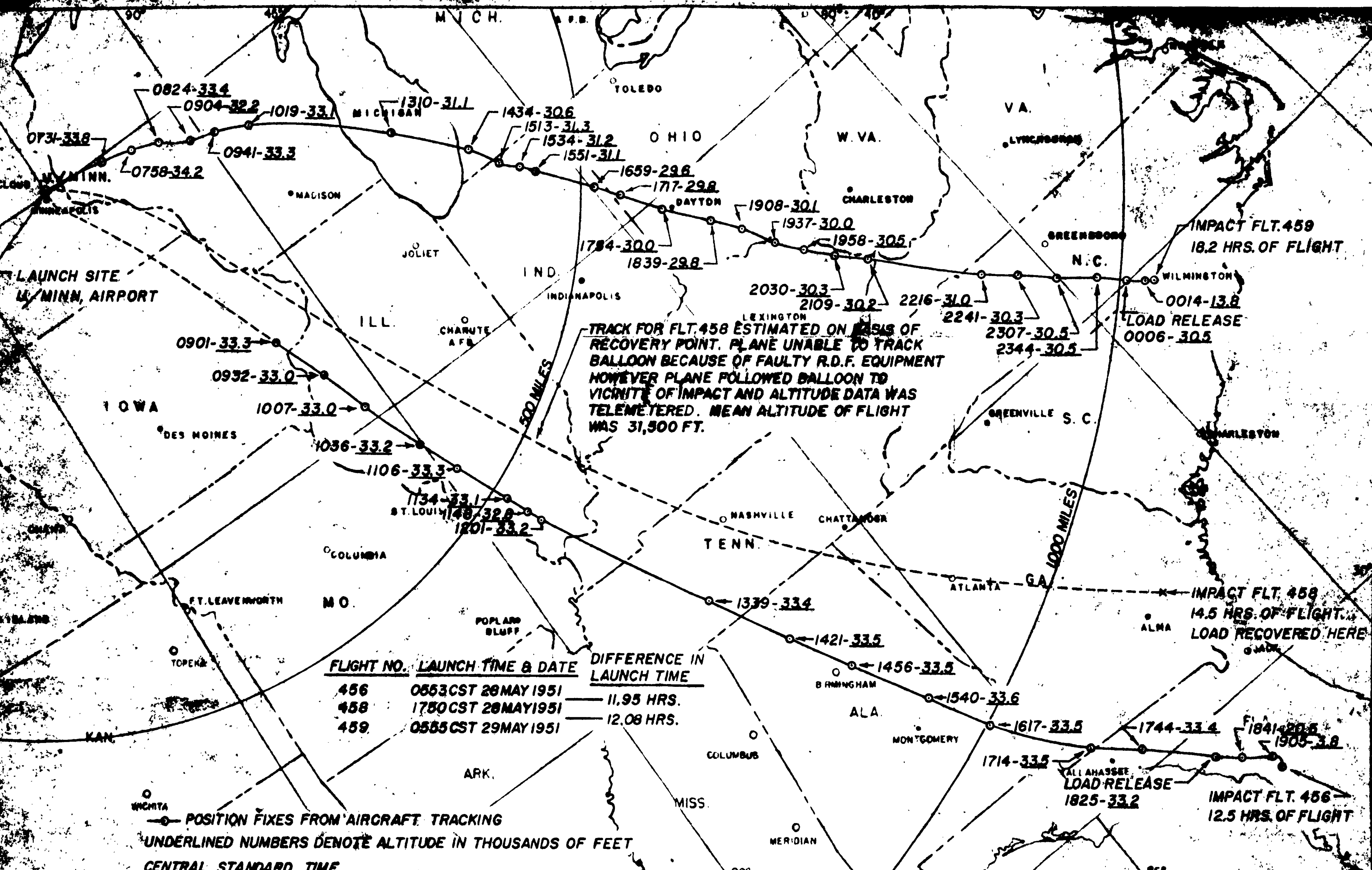



| DR. D.R. | APP | SCALE 1:5,000,000 | TRACKS OF FLIGHTS 576 AND 577 WHICH HAD 51 MINUTES BETWEEN LAUNCHINGS | A-21054-B |
|---|---|---|---|---|
| DATE 1-5-53 | APP | PROJ. J-202 | | |

GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA

JAN 21 1953




| FLIGHT NO. | LAUNCH TIME & DATE | DIFFERENCE IN LAUNCH TIME |
|---|---|---|
| 456 | 0553 CST 28 MAY 1951 | |
| 458 | 1750 CST 28 MAY 1951 | 11.95 HRS. |
| 459 | 0555 CST 29 MAY 1951 | 12.08 HRS. |

—o— POSITION FIXES FROM AIRCRAFT TRACKING

UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET

CENTRAL STANDARD TIME

STATUTE MILES

0 100 200 300 400

DR. J.N. | APP | SCALE 1/5,000,000 | DATE 12-29-52 | APP | PROJ.

GROUND TRACKS OF 3 SUCCESSIVE 300 MB. CONSTANT LEVEL FLIGHTS LAUNCHED DURING A 24 HR. PERIOD.

A21052B

GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINNESOTA

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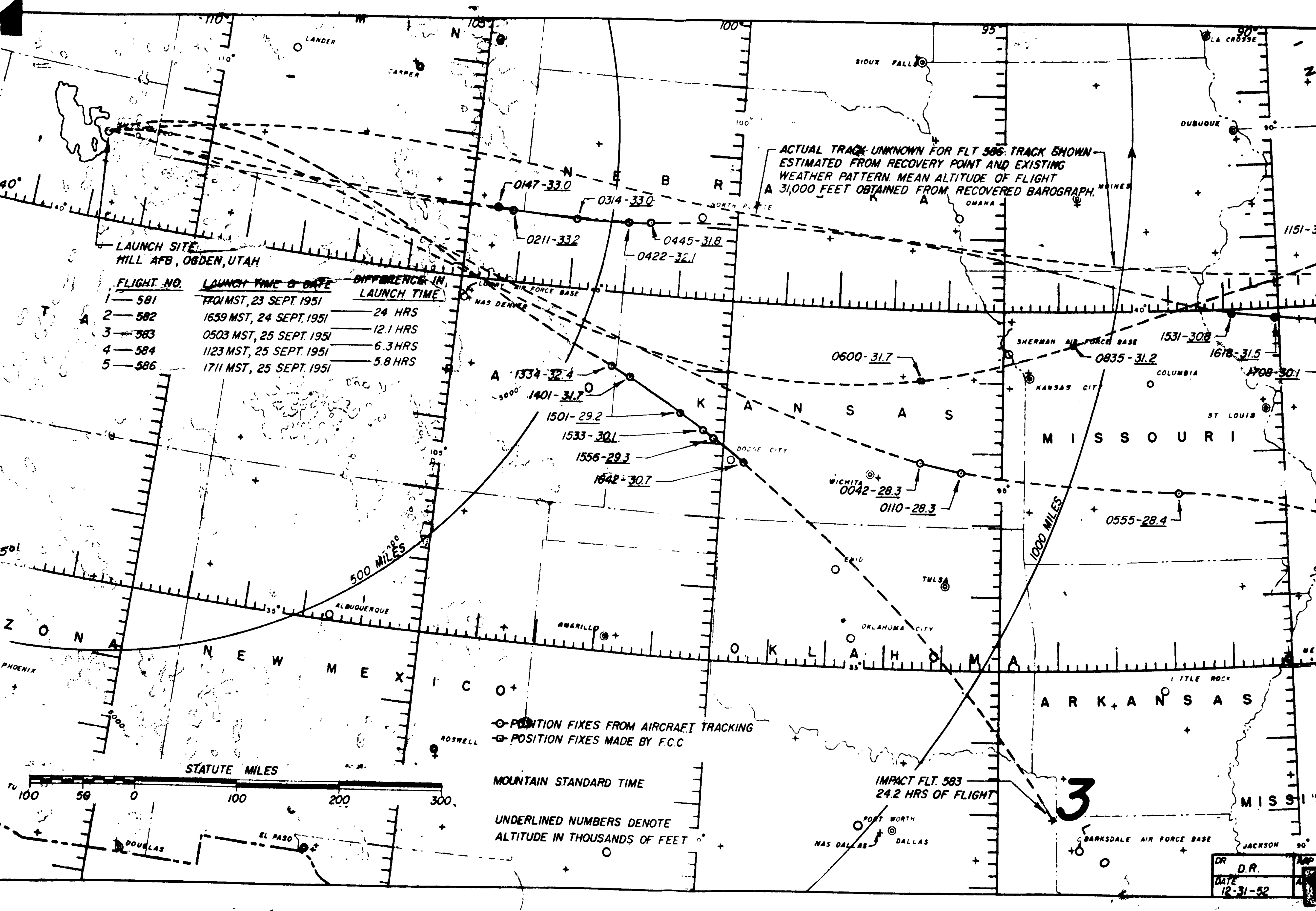
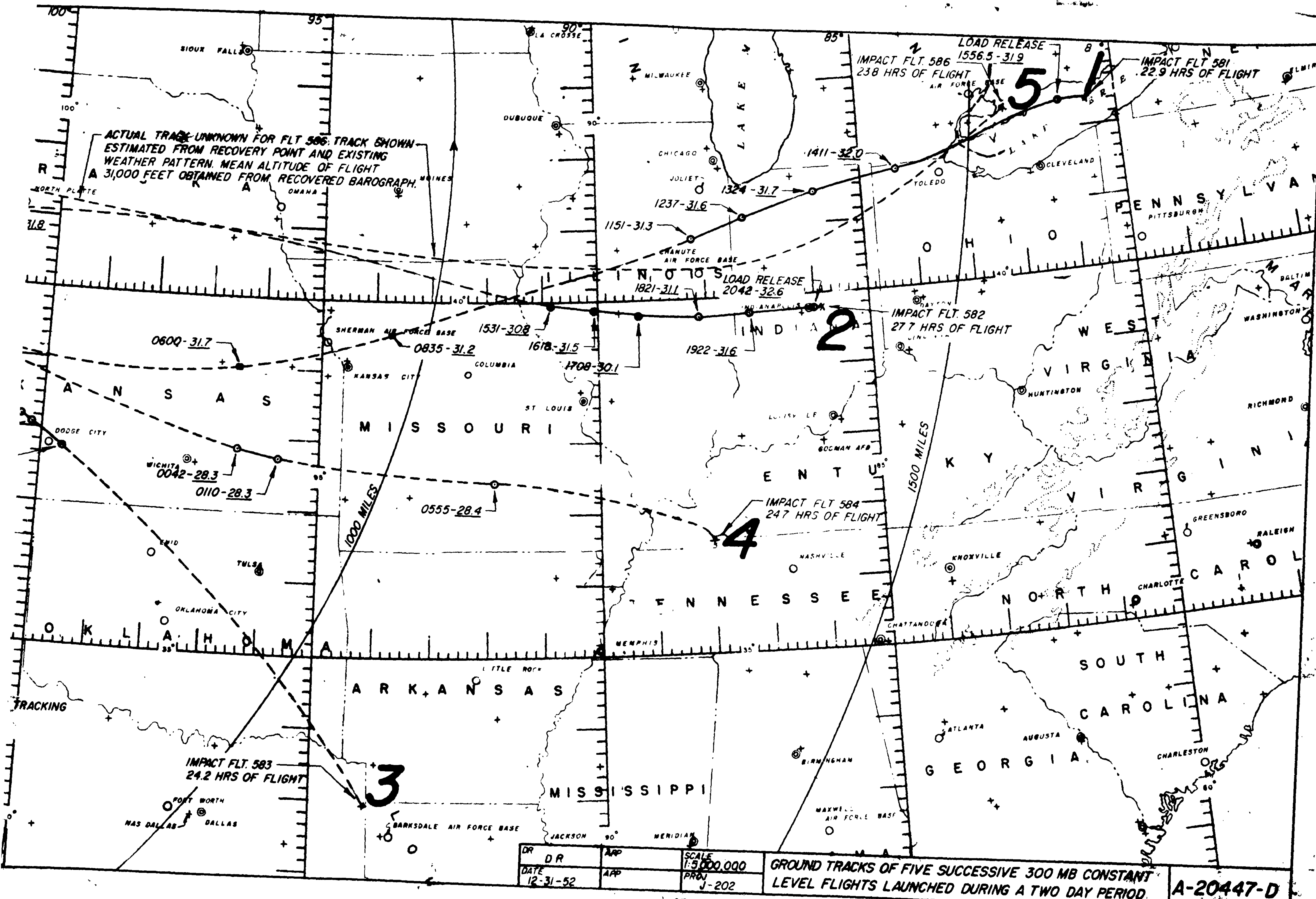
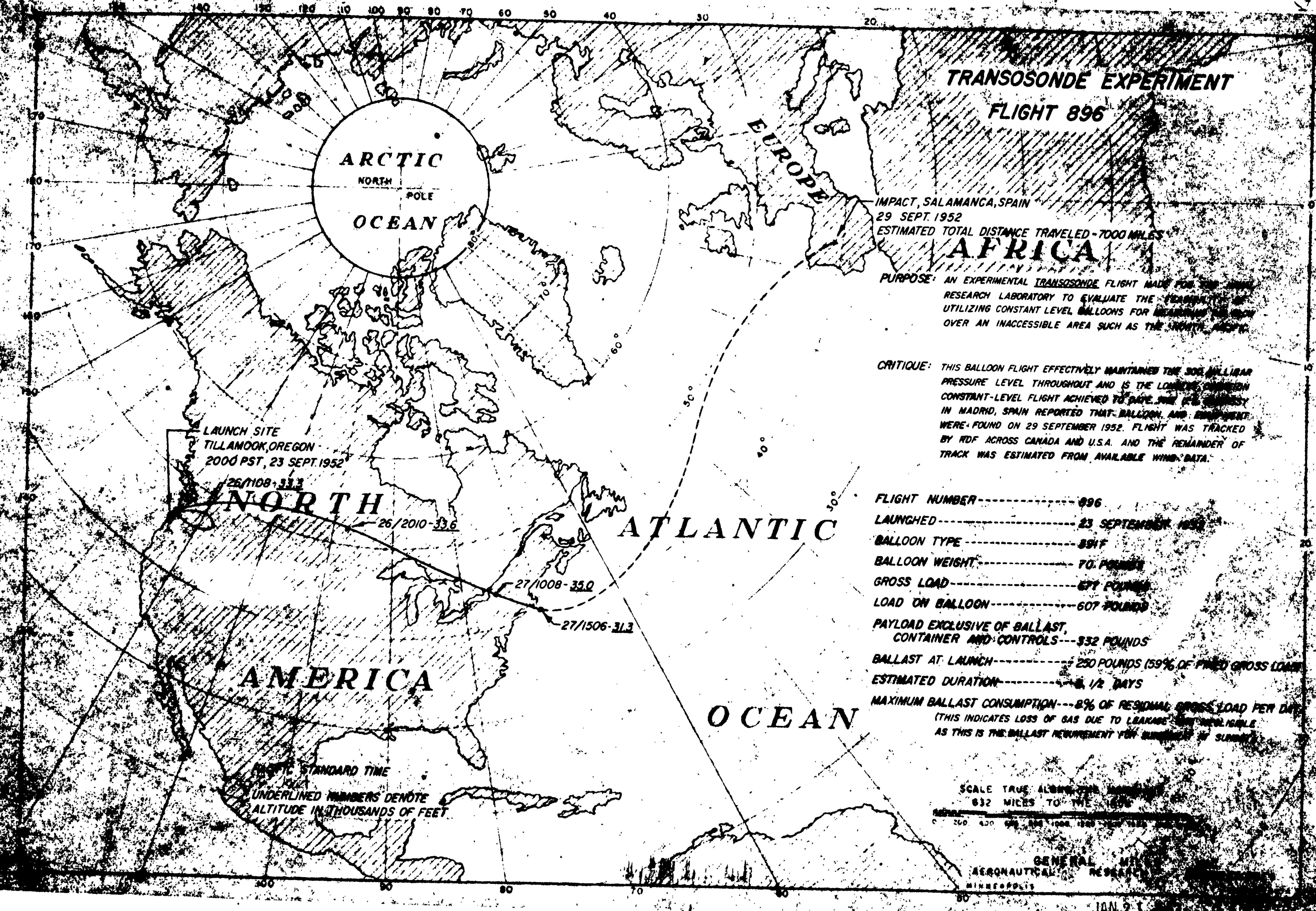

ACTUAL TRACK UNKNOWN FOR FLT 586. TRACK SHOWN ESTIMATED FROM RECOVERY POINT AND EXISTING WEATHER PATTERN. MEAN ALTITUDE OF FLIGHT 31,000 FEET OBTAINED FROM RECOVERED BAROGRAPH.
LAUNCH SITE HILL AFB, OGDEN, UTAH
FLIGHT NO. | LAUNCH TIME & DATE | DIFFERENCE IN LAUNCH TIME
1 — 581 | 1701 MST, 23 SEPT. 1951 | 24 HRS
2 — 582 | 1659 MST, 24 SEPT. 1951 | 12.1 HRS
3 — 583 | 0503 MST, 25 SEPT. 1951 | 6.3 HRS
4 — 584 | 1123 MST, 25 SEPT. 1951 | 5.8 HRS
5 — 586 | 1711 MST, 25 SEPT. 1951
0147-33.0
0211-33.2
0314-33.0
0422-32.1
0445-31.8
1334-32.4
1401-31.7
1501-29.2
1533-30.1
1556-29.3
1642-30.7
0600-31.7
0835-31.2
1531-30.8
1618-31.5
1708-30.1
0042-28.3
0110-28.3
0555-28.4
500 MILES
1000 MILES
IMPACT FLT. 583 24.2 HRS OF FLIGHT
3
POSITION FIXES FROM AIRCRAFT TRACKING
POSITION FIXES MADE BY F.C.C
MOUNTAIN STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
STATUTE MILES
100 50 0 100 200 300
NEBRASKA
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
NEW MEXICO
ZONA
LANDER
CASPER
SIOUX FALLS
DUBUQUE
LA CROSSE
OMAHA
NORTH PLATTE
LOWRY AIR FORCE BASE
NAS DENVER
SHERMAN AIR FORCE BASE
KANSAS CITY
COLUMBIA
ST LOUIS
DODGE CITY
WICHITA
ENID
TULSA
OKLAHOMA CITY
AMARILLO
ALBUQUERQUE
ROSWELL
PHOENIX
DOUGLAS
EL PASO
FORT WORTH
DALLAS
NAS DALLAS
LITTLE ROCK
BARKSDALE AIR FORCE BASE
JACKSON
110° 105° 100° 95° 90° 40° 35°
DR D.R.
DATE 12-31-52

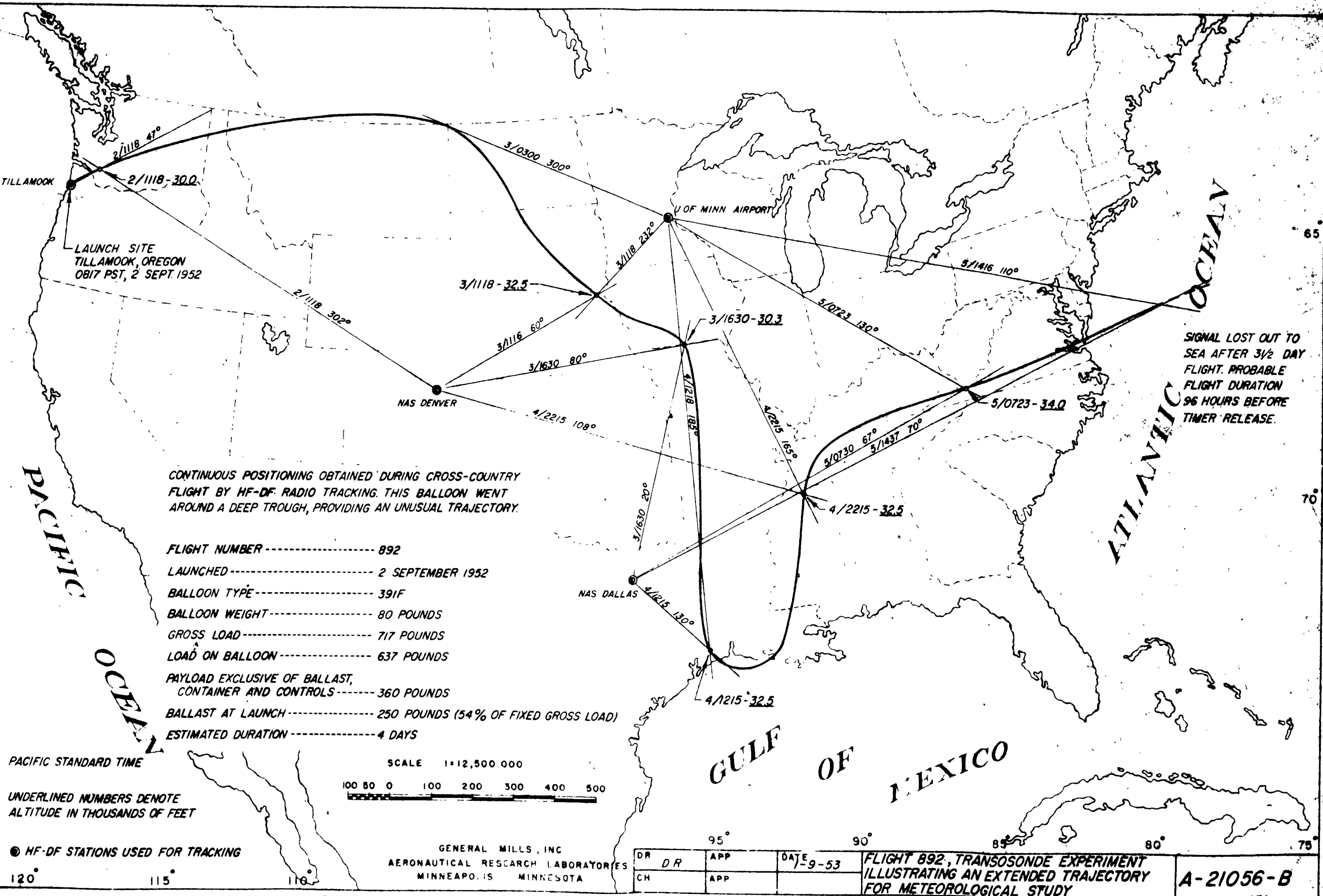



GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA

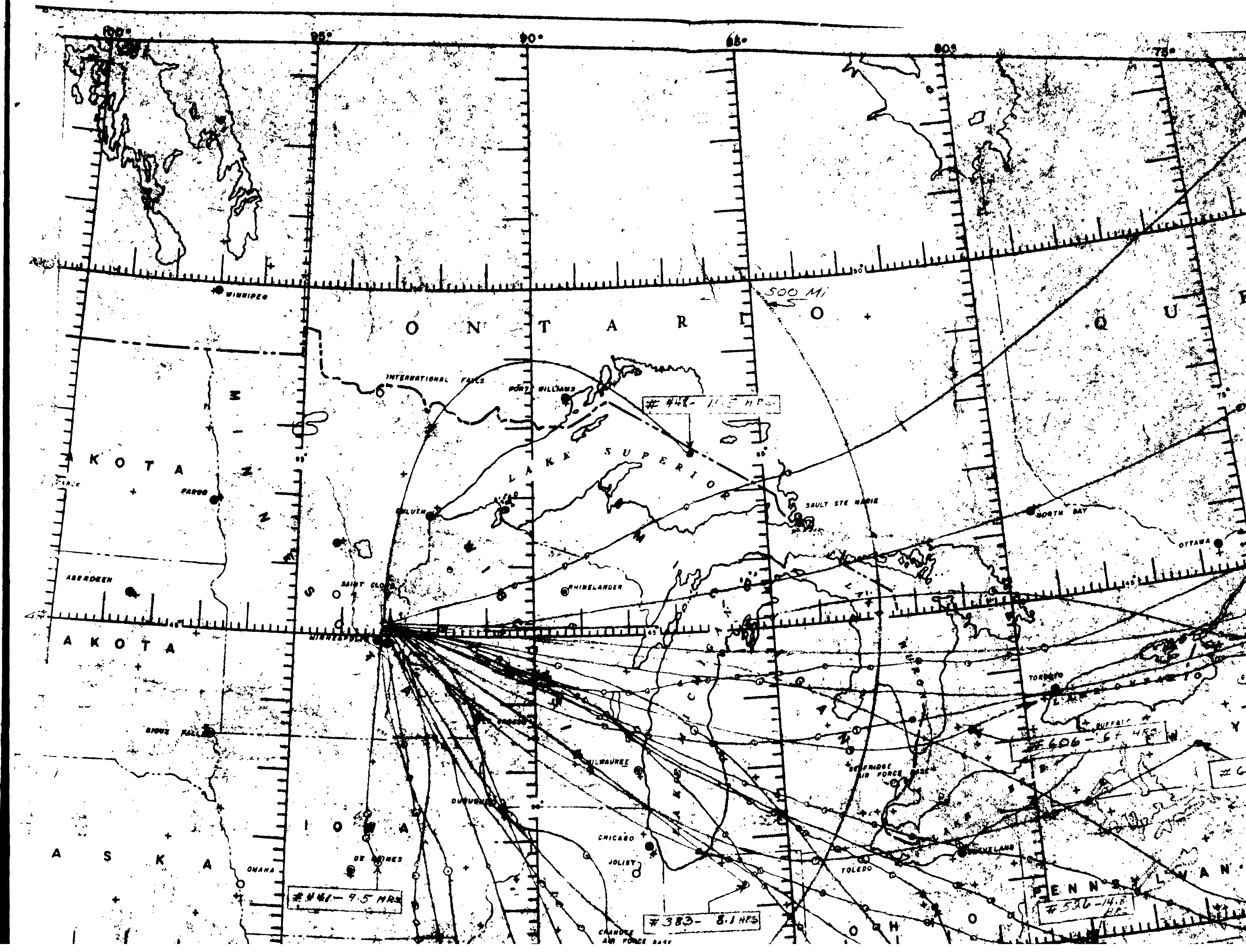
JAN 21 1953



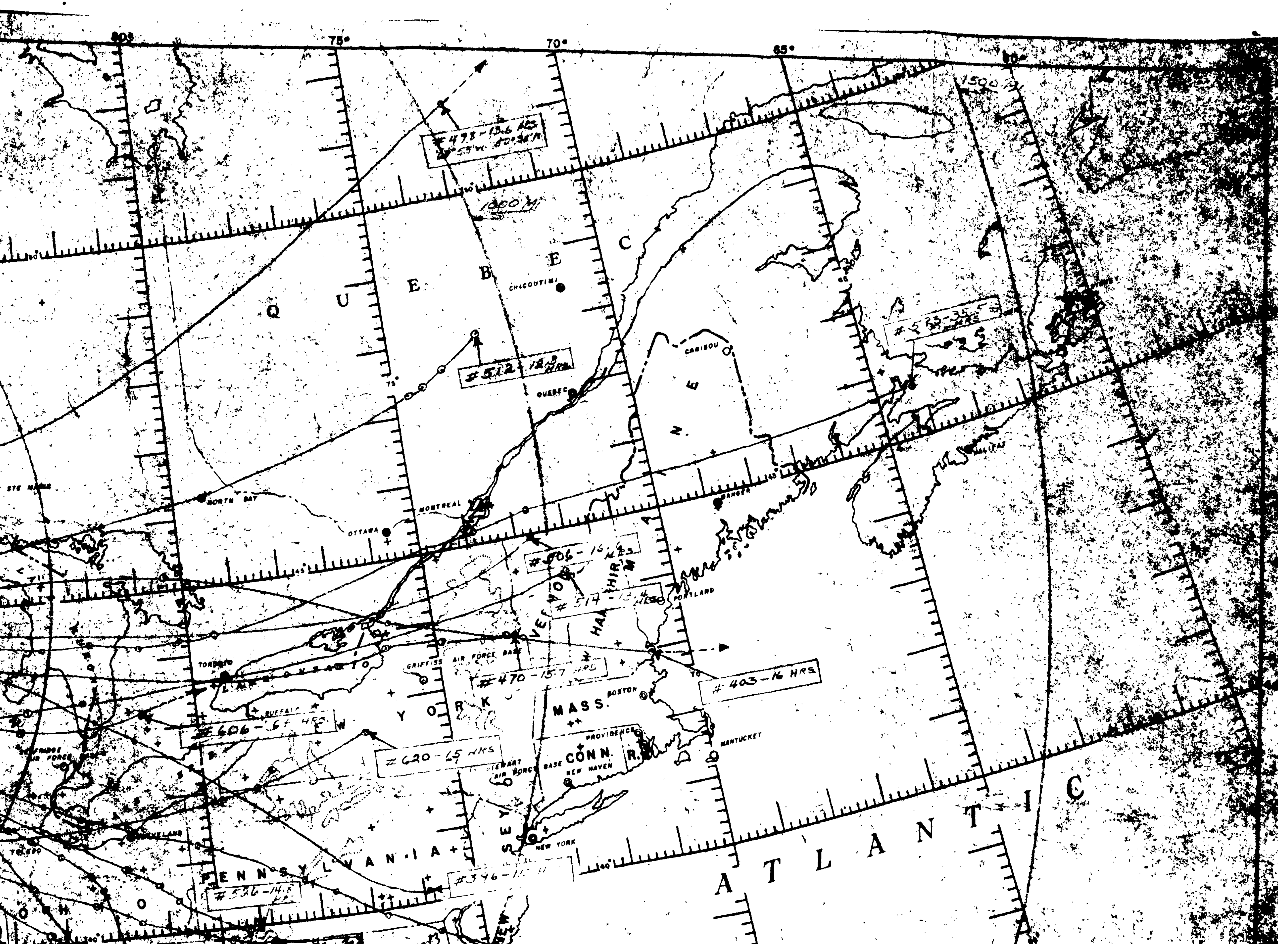
TRANSOSONDE EXPERIMENT
FLIGHT 896
ARCTIC
NORTH POLE
OCEAN
EUROPE
AFRICA
NORTH
AMERICA
ATLANTIC
OCEAN
IMPACT, SALAMANCA, SPAIN
29 SEPT. 1952
ESTIMATED TOTAL DISTANCE TRAVELED - 7000 MILES
PURPOSE: AN EXPERIMENTAL TRANSOSONDE FLIGHT
RESEARCH LABORATORY TO EVALUATE THE
UTILIZING CONSTANT LEVEL BALLOONS FOR
OVER AN INACCESSIBLE AREA SUCH AS THE
CRITIQUE: THIS BALLOON FLIGHT EFFECTIVELY MAINTAINED THE
PRESSURE LEVEL THROUGHOUT AND IS THE
CONSTANT-LEVEL FLIGHT ACHIEVED TO DATE.
IN MADRID, SPAIN REPORTED THAT BALLOON AND
WERE FOUND ON 29 SEPTEMBER 1952. FLIGHT WAS TRACKED
BY RDF ACROSS CANADA AND U.S.A. AND THE REMAINDER OF
TRACK WAS ESTIMATED FROM AVAILABLE WIND DATA.
FLIGHT NUMBER---------------896
LAUNCHED---------------23 SEPTEMBER
BALLOON TYPE---------------
BALLOON WEIGHT---------------70
GROSS LOAD---------------
LOAD ON BALLOON---------------607
PAYLOAD EXCLUSIVE OF BALLAST, CONTAINER AND CONTROLS---332 POUNDS
BALLAST AT LAUNCH---------------250 POUNDS (59% OF
ESTIMATED DURATION---------------1/2 DAYS
MAXIMUM BALLAST CONSUMPTION---8% OF
(THIS INDICATES LOSS OF GAS DUE TO
AS THIS IS THE BALLAST
LAUNCH SITE
TILLAMOOK, OREGON
2000 PST, 23 SEPT. 1952
26/1108-33.3
26/2010-33.6
27/1008-35.0
27/1506-31.3
STANDARD TIME
UNDERLINED NUMBERS DENOTE
ALTITUDE IN THOUSANDS OF FEET
SCALE TRUE
632 MILES TO THE
GENERAL
AERONAUTICAL
MINNEAPOLIS
JAN 21

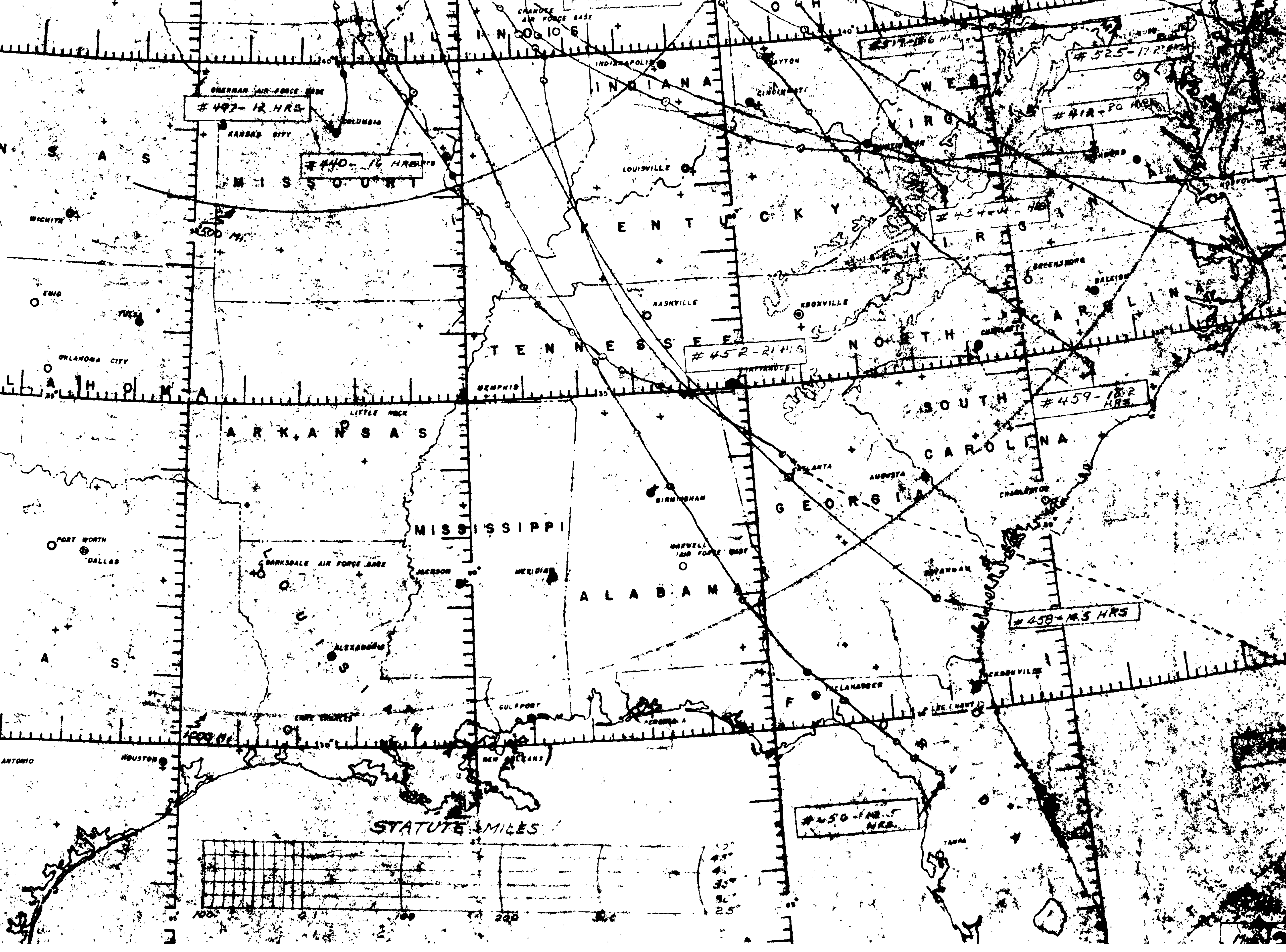


TILLAMOOK
2/1118 47°
2/1118-30.0
LAUNCH SITE
TILLAMOOK, OREGON
0817 PST, 2 SEPT. 1952
3/0300 300°
U OF MINN AIRPORT
3/1118 232°
3/1118-32.5
2/1118 302°
3/1116 60°
3/1630-30.3
3/1630 80°
NAS DENVER
4/2215 108°
4/1218 185°
4/2215 165°
5/0723 130°
9/1416 110°
5/0723-34.0
5/0730 67°
5/1437 70°
4/2215-32.5
3/1630 20°
NAS DALLAS
4/1215 130°
4/1215-32.5
SIGNAL LOST OUT TO SEA AFTER 3½ DAY FLIGHT. PROBABLE FLIGHT DURATION 96 HOURS BEFORE TIMER RELEASE.
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
CONTINUOUS POSITIONING OBTAINED DURING CROSS-COUNTRY FLIGHT BY HF-DF RADIO TRACKING. THIS BALLOON WENT AROUND A DEEP TROUGH, PROVIDING AN UNUSUAL TRAJECTORY.
FLIGHT NUMBER ------------------- 892
LAUNCHED ------------------------ 2 SEPTEMBER 1952
BALLOON TYPE -------------------- 391F
BALLOON WEIGHT ------------------ 80 POUNDS
GROSS LOAD ---------------------- 717 POUNDS
LOAD ON BALLOON ----------------- 637 POUNDS
PAYLOAD EXCLUSIVE OF BALLAST, CONTAINER AND CONTROLS ------- 360 POUNDS
BALLAST AT LAUNCH --------------- 250 POUNDS (54% OF FIXED GROSS LOAD)
ESTIMATED DURATION -------------- 4 DAYS
PACIFIC STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
HF-DF STATIONS USED FOR TRACKING
SCALE 1:12,500,000
100 50 0 100 200 300 400 500
GENERAL MILLS, INC
AERONAUTICAL RESEARCH LABORATORIES
MINNEAPOLIS MINNESOTA
DR DR
APP
CH
APP
DATE 1-9-53
FLIGHT 892, TRANSOSONDE EXPERIMENT ILLUSTRATING AN EXTENDED TRAJECTORY FOR METEOROLOGICAL STUDY
A-21056-B
JAN 21 1953
120° 115° 110° 95° 90° 85° 80° 75°
40 35 30 25 20 65 70

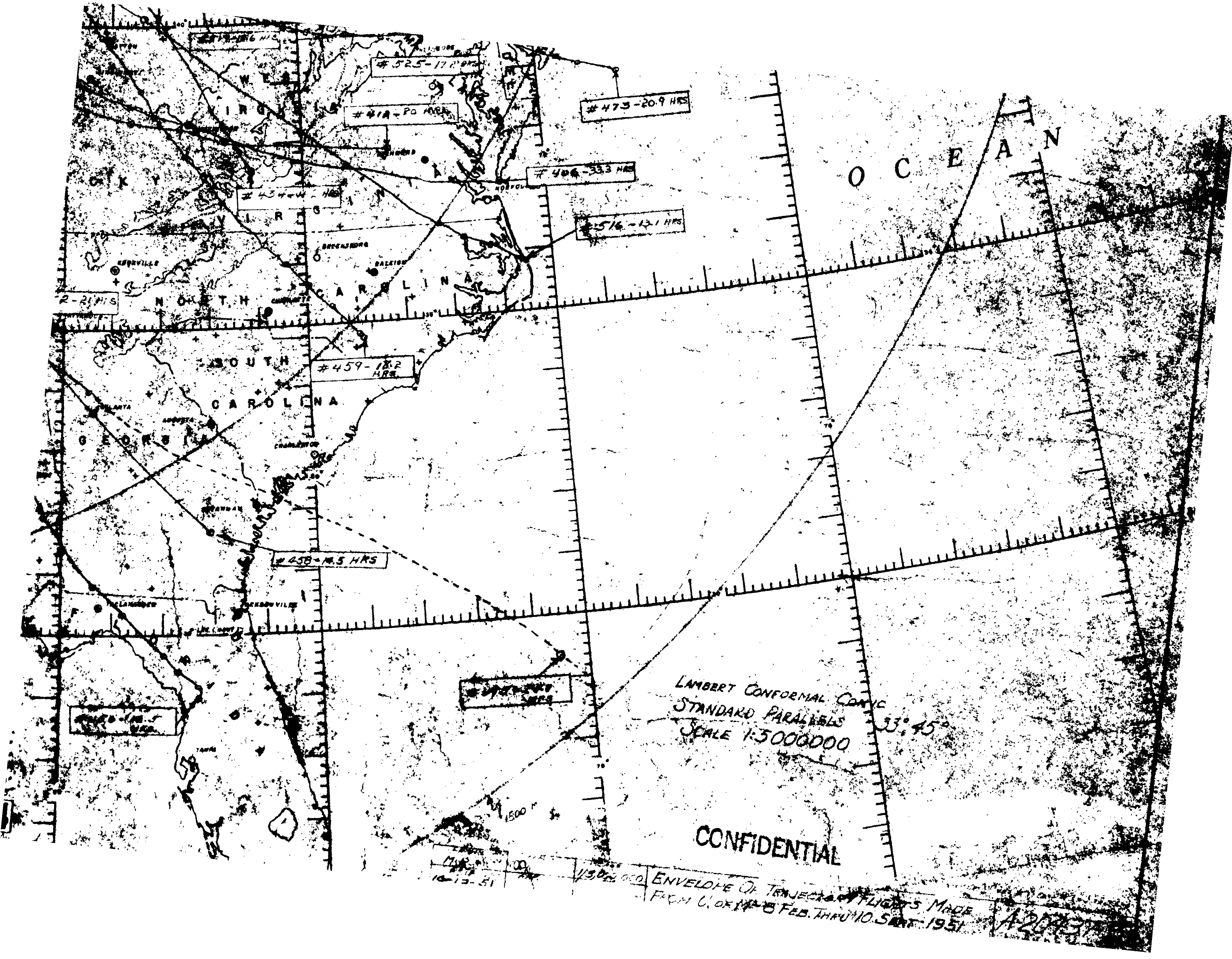


100°
95°
90°
85°
80°
75°
ONTARIO
QUE
MINN
DAKOTA
AKOTA
IOWA
ASKA
WIS
MICHIGAN
OHIO
PENNSYLVAN
LAKE SUPERIOR
LAKE HURON
LAKE MICHIGAN
WINNIPEG
INTERNATIONAL FALLS
PORT WILLIAMS
DULUTH
FARGO
ABERDEEN
SAINT CLOUD
MINNEAPOLIS
RHINELANDER
SAULT STE MARIE
NORTH BAY
OTTAWA
TORONTO
BUFFALO
SIOUX FALLS
OMAHA
DES MOINES
DUBUQUE
MILWAUKEE
CHICAGO
JOLIET
CHANUTE AIR FORCE BASE
SELFRIDGE AIR FORCE BASE
TOLEDO
CLEVELAND
500 MI
#448- 11.5 HRS
#441- 9.5 HRS
#383- 8.1 HRS
#406- 6+ HRS
#536-14.8 HR

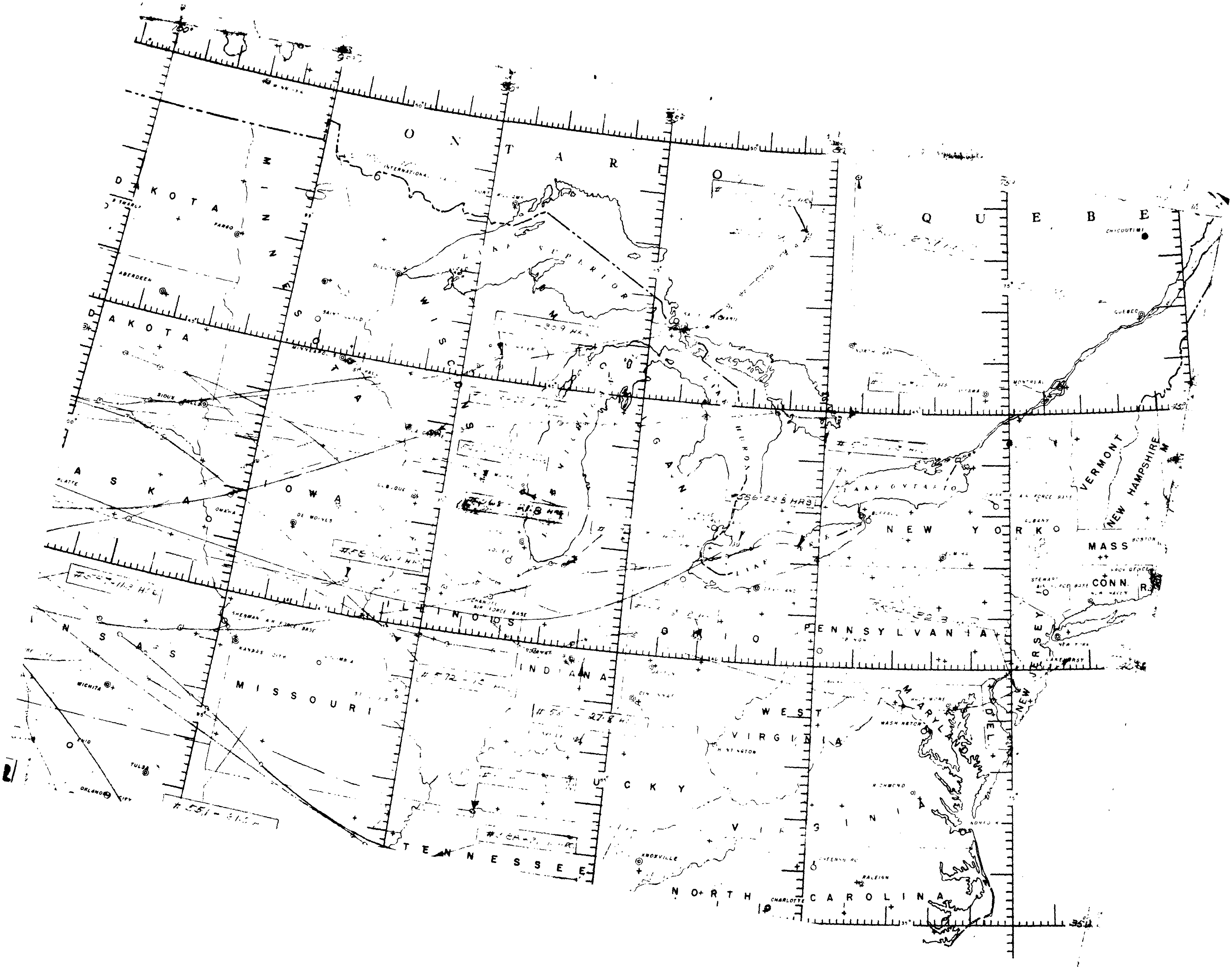

80°
75°
70°
65°
60°
1500 MI
1000 MI
QUEBEC
CHICOUTIMI
QUEBEC
MONTREAL
OTTAWA
NORTH BAY
STE MARIE
CARIBOU
BANGOR
PORTLAND
HALIFAX
BOSTON
PROVIDENCE
NEW HAVEN
NEW YORK
NANTUCKET
TORONTO
BUFFALO
GRIFFISS AIR FORCE BASE
STEWART AIR FORCE BASE
TOLEDO
MASS.
CONN.
R.I.
YORK
PENNSYLVANIA
ATLANTIC
#512 - 12.3 HRS
#406 - 16.4 HRS
#514 - 13.4 HRS
#470 - 15.7 HRS
#403 - 16 HRS
#406 - 6+ HRS
#620 - 15 HRS
#536 - 14.8 HR
#346

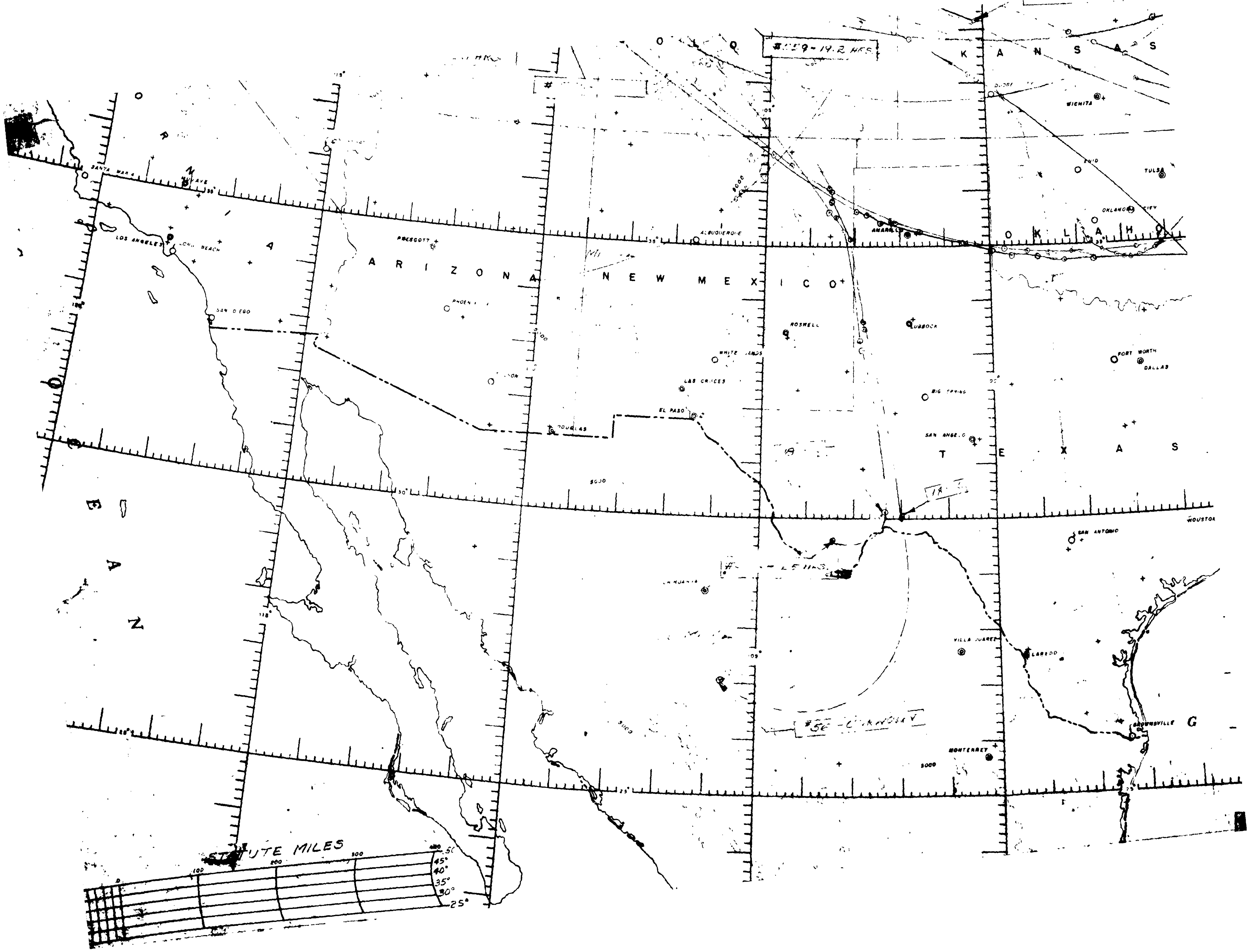


NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
TENNESSEE
KENTUCKY
ARKANSAS
MISSOURI
INDIANA
STATUTE MILES
#497-12 HRS
#440-16 HRS
#452-21 HRS
#459-18.2 HRS
#458-14.5 HRS
SHERMAN AIR FORCE BASE
CHANUTE AIR FORCE BASE
BARKSDALE AIR FORCE BASE
MAXWELL AIR FORCE BASE
KANSAS CITY
COLUMBIA
WICHITA
ENID
TULSA
OKLAHOMA CITY
FORT WORTH
DALLAS
HOUSTON
ANTONIO
LOUISVILLE
INDIANAPOLIS
CINCINNATI
DAYTON
NASHVILLE
KNOXVILLE
MEMPHIS
LITTLE ROCK
JACKSON
MERIDIAN
BIRMINGHAM
ATLANTA
AUGUSTA
CHARLESTON
SAVANNAH
GREENSBORO
RALEIGH
ALEXANDRIA
GULFPORT
NEW ORLEANS
TALLAHASSEE
JACKSONVILLE
TAMPA

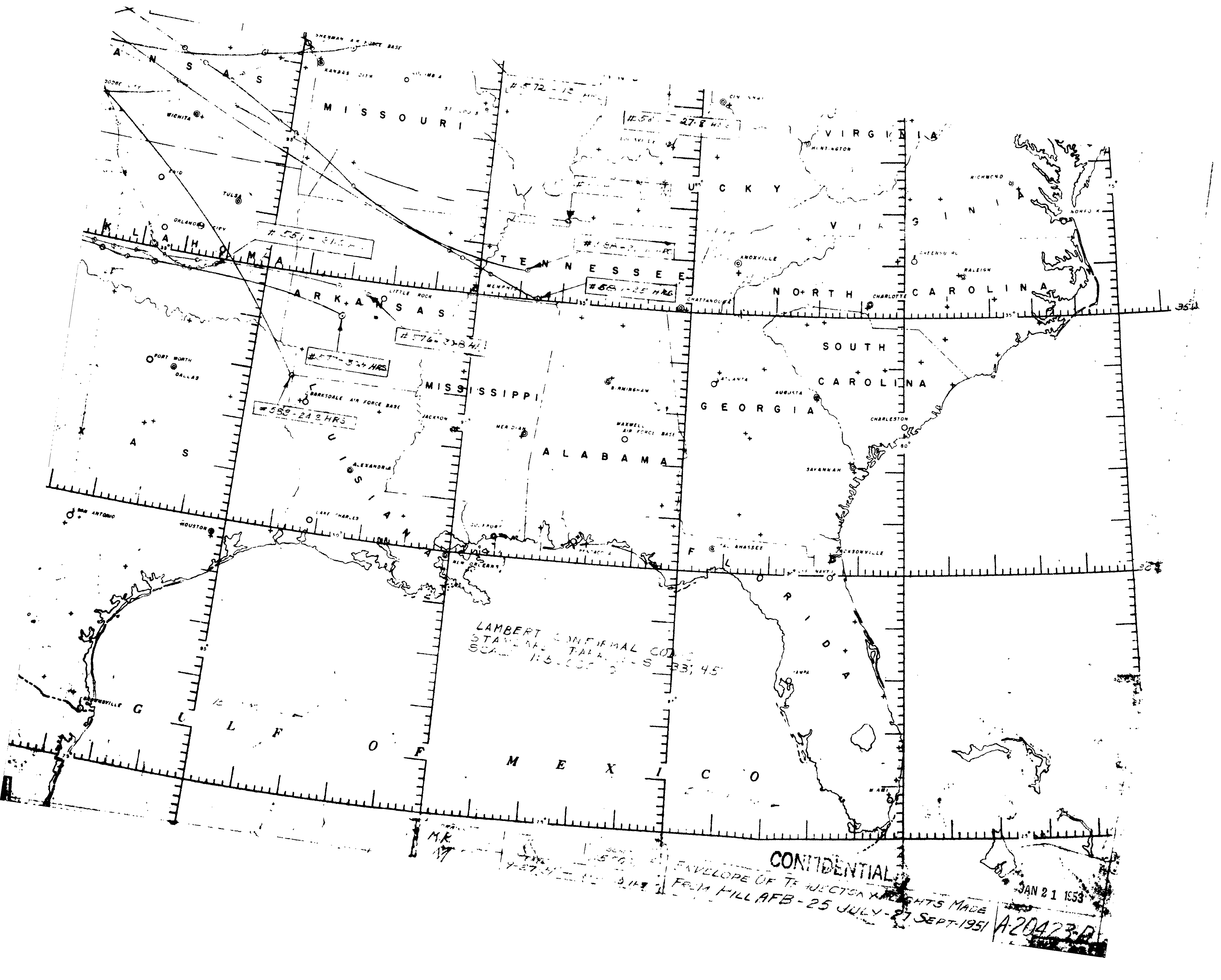


OCEAN
# 525 - 17.? HRS
# 418 - 20 HRS
# 473 - 20.9 HRS
# 406 - 33.3 HRS
# 516 - 13.1 HRS
# 459 - 18.2 HRS
# 458 - 14.5 HRS
WEST VIRGINIA
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
NORFOLK
GREENSBORO
RALEIGH
CHARLESTON
SAVANNAH
JACKSONVILLE
TAMPA
LAMBERT CONFORMAL CONIC
STANDARD PARALLELS 33° 45°
SCALE 1:5000000
CONFIDENTIAL
ENVELOPE OF TRAJECTORY FLIGHTS MADE
FROM U. OF M. 8 FEB. THRU 10 SEPT. 1951
10-12-51
1:5000000
A2093


ONTARIO
QUEBEC
CHICOUTIMI
QUEBEC
MONTREAL
LAKE SUPERIOR
LAKE ONTARIO
LAKE ERIE
HURON
DULUTH
FARGO
ABERDEEN
SIOUX
OMAHA
DE MOINES
KANSAS CITY
WICHITA
TULSA
OKLAHOMA CITY
DAKOTA
DAKOTA
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
NEBRASKA
KANSAS
MISSOURI
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMPSHIRE
MASS
CONN.
R.I.
NEW JERSEY
DEL.
MARYLAND
WEST VIRGINIA
VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
KNOXVILLE
RALEIGH
RICHMOND
CHARLOTTE
ALBANY
BOSTON
NEW HAVEN
NEW YORK
HUNTINGTON
SHERMAN AIR FORCE BASE
CHANUTE AIR FORCE BASE
#556-23.3 HRS



K A N S A S
O K L A H
N E W M E X I C O
A R I Z O N A
T E X A S
WICHITA
TULSA
ENID
OKLAHOMA CITY
AMARILLO
ALBUQUERQUE
PRESCOTT
LOS ANGELES
LONG BEACH
SAN DIEGO
ROSWELL
LUBBOCK
FORT WORTH
DALLAS
WHITE SANDS
LAS CRUCES
EL PASO
DOUGLAS
BIG SPRING
SAN ANGELO
HOUSTON
SAN ANTONIO
LAREDO
VILLA JUAREZ
BROWNSVILLE
MONTERREY
#119-14.2 HRS.
#56-CANOPY
STATUTE MILES


MISSOURI
TENNESSEE
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
ARKANSAS
FLORIDA
GULF OF MEXICO
KANSAS CITY
WICHITA
TULSA
OKLAHOMA CITY
LITTLE ROCK
MEMPHIS
KNOXVILLE
CHATTANOOGA
CHARLOTTE
RALEIGH
RICHMOND
HUNTINGTON
ATLANTA
AUGUSTA
CHARLESTON
SAVANNAH
JACKSONVILLE
TALLAHASSEE
TAMPA
MIAMI
BIRMINGHAM
MAXWELL AIR FORCE BASE
MERIDIAN
JACKSON
ALEXANDRIA
LAKE CHARLES
NEW ORLEANS
HOUSTON
SAN ANTONIO
FORT WORTH
DALLAS
BARKSDALE AIR FORCE BASE
SHERMAN AIR FORCE BASE
BROWNSVILLE
#572 - 12
#551 - 31.2
#576 - 33.8 H
#577 - 32.4 HRS
#559 - 24.2 HRS
#561 - 25 HRS
#58 - 27.8 HRS
LAMBERT CONFORMAL CONIC
CONFIDENTIAL
ENVELOPE OF TRAJECTORY FLIGHTS MADE
FROM HILL AFB - 25 JULY - 27 SEPT - 1951
JAN 21 1953
A-20423-D

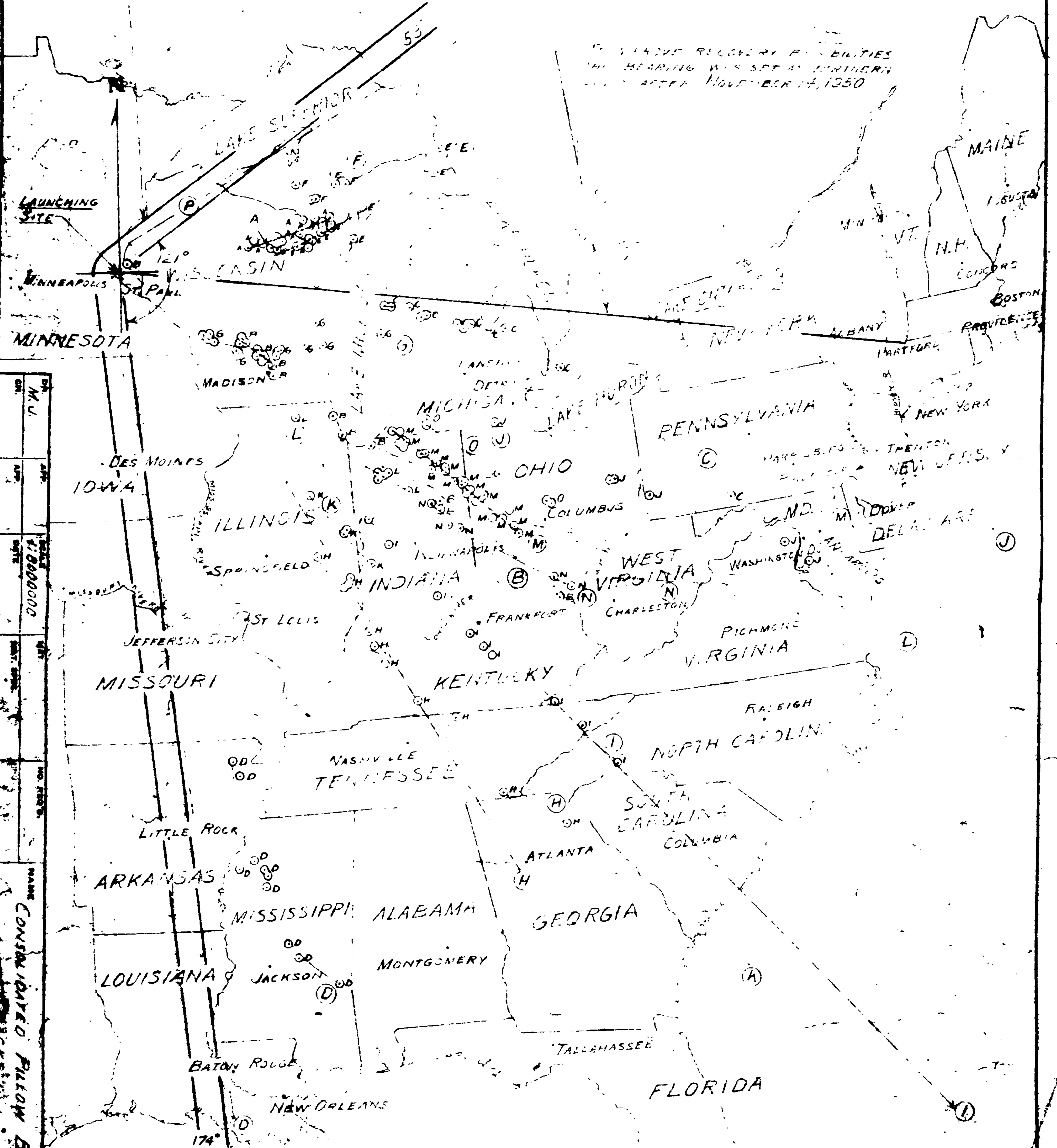
PILLOW BALLOON DATA

NOTE:

① FORECAST FLIGHT TRACKS ARE SHOWN WITH DASHED LINES. THE ENDS OF THESE INDICATE THE ESTIMATED MINIMUM AND MAXIMUM BALLOON TRAVEL OF A CLUSTER OF PILLOWS.

② SOLID LINES INDICATE ACTUAL MEAN TRAJECTORIES THROUGH IMPACT POINTS

PROBABLE WINTER ENVELOPE OF PILLOW BALLOON TRAJECTORIES POSSIBLE FROM MINNEAPOLIS (USING 2 P.20 FLIGHTS AT ABOUT 35,000 FT.)




* TIME IS IN HOURS

| CODE | DATE | NO. FLOWN | NO. RECOV'D | *EST. MEAN DUR. | CODE | DATE | NO. FLOWN | NO. RECOV'D | *EST. MEAN DUR. |
|---|---|---|---|---|---|---|---|---|---|
| A | 10-25-50 | 20 | 12 | 3.8 | J | 11-30-50 | 20 | 6 | 9.9 |
| B | 10-27-50 | 20 | 17 | 4.2 | K | 12-12-50 | 20 | 4 | 6.3 |
| C | 10-30-50 | 20 | 13 | 6.2 | L | 12-13-50 | 20 | 6 | 5.8 |
| D | 11-24-50 | 20 | 10 | 11.5 | M | 12-15-50 | 100 | 28 | 7.1 |
| E | 11-2-50 | 20 | 15 | 3.8 | N | 12-20-50 | 20 | 5 | 8.2 |
| F | 11-7-50 | 20 | 8 | 3.7 | O | 12-15-49 | 5 | 5 | 7.6 |
| G | 11-10-50 | 20 | 14 | 3.1 | P | 11-14-50 | 20 | 0 | ... |
| H | 11-20-50 | 20 | 11 | 8.8 | | | | | |
| I | 11-28-50 | 20 | 9 | 9.6 | | | | | |

NAME CONSOLIDATED PILLOW BALLOON TRACKS

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY

SCALE 1:8000000 DR. M.J.

JAN 7 1953

# RECOVERY CHART
## CLUSTER FLIGHT 30 OCTOBER 1950
## GM P-20 BALLOONS

#296

| | | |
|---|---|---|
| BALLOON GROSS WEIGHT | - | 207 gms. |
| FREE LIFT | - | 27 gms. |
| THEOR. FLOATING ALTITUDE | - | 32,000 FEET |
| PAYLOAD | - | 28 gms. |
| VOLUME | - | 20 cu. ft. |

LAUNCHED - 1558

| BALLOON NUMBER | DATE FOUND | TIME FOUND | DISTANCE & DIRECTION FROM NEAREST TOWN | LANDING SEEN? | GAS IN BALLOON? | |
|---|---|---|---|---|---|---|
| 3040 | 10-31-50 | 0930 | EAST PROV. TOWNSHIP NEAR MATTIE, PENNSYLVANIA | YES | NO | |
| 3041 | | | | | | |
| 3042 | 10-31-50 | 0945 | 20 MILES SO., 10 MILES EAST SARNIA, ONTARIO | NO | YES | ✓ |
| 3043 | | | | | | |
| 3044 | 11-5-50 | 1200 | 1 MILE WEST FOUNTAIN, MICHIGAN | NO | [illegible] | ✓ |
| 3045 | | | | | | |
| 3046 | | | | | | |
| 3047 | | | | | | |
| 3048 | 12-10-50 | 1000 | 19 MILES WEST MIDLAND, MICHIGAN | NO | NO | |
| 3049 | 10-31-50 | 1600 | 10 MILES SOUTH, 2 MILES EAST MANISTEE, MICHIGAN | NO | YES | ✓ |
| 3050 | 10-31-50 | 1700 | 7½ MILES NORTH EAST ST. LOUIS, MICHIGAN | NO | NO | ✓ |
| 3051 | | | | | | |
| 3052 | 10-31-50 | 0800 | 4 MILES WEST, 2 MILES NO. SAGINAW, MICHIGAN | NO | YES | ✓ |
| 3053 | 11-19-50 | 1030 | 7 MILES SO. 1½ MILES EAST EVART, MICHIGAN | NO | YES | |
| 3054 | | | | | | |
| 3055 | 11-17-50 | 1200 | 1 MILE SOUTH HERSHEY, MICHIGAN | NO | NO | |
| 3056 | 10-31-50 | 0615 | 8 MILES WEST CARO, MICHIGAN | NO | YES | ✓ |
| 3057 | 11-4-50 | 1200 | SEC 23 LEE TOWNSHIP 9 MI. N., 1¼ MI. S MIDLAND, MICHIGAN | NO | NO | ✓ |
| 3058 | 11-19-50 | 1400 | 1 MILE NORTH NOXEYVILLE, MICHIGAN | NO | NO | |
| 3059 | 12-4-50 | 1500 | No. CARTER RD. 8 MILES MIDLAND MICHIGAN | NO | YES | |

IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

A-6276-A

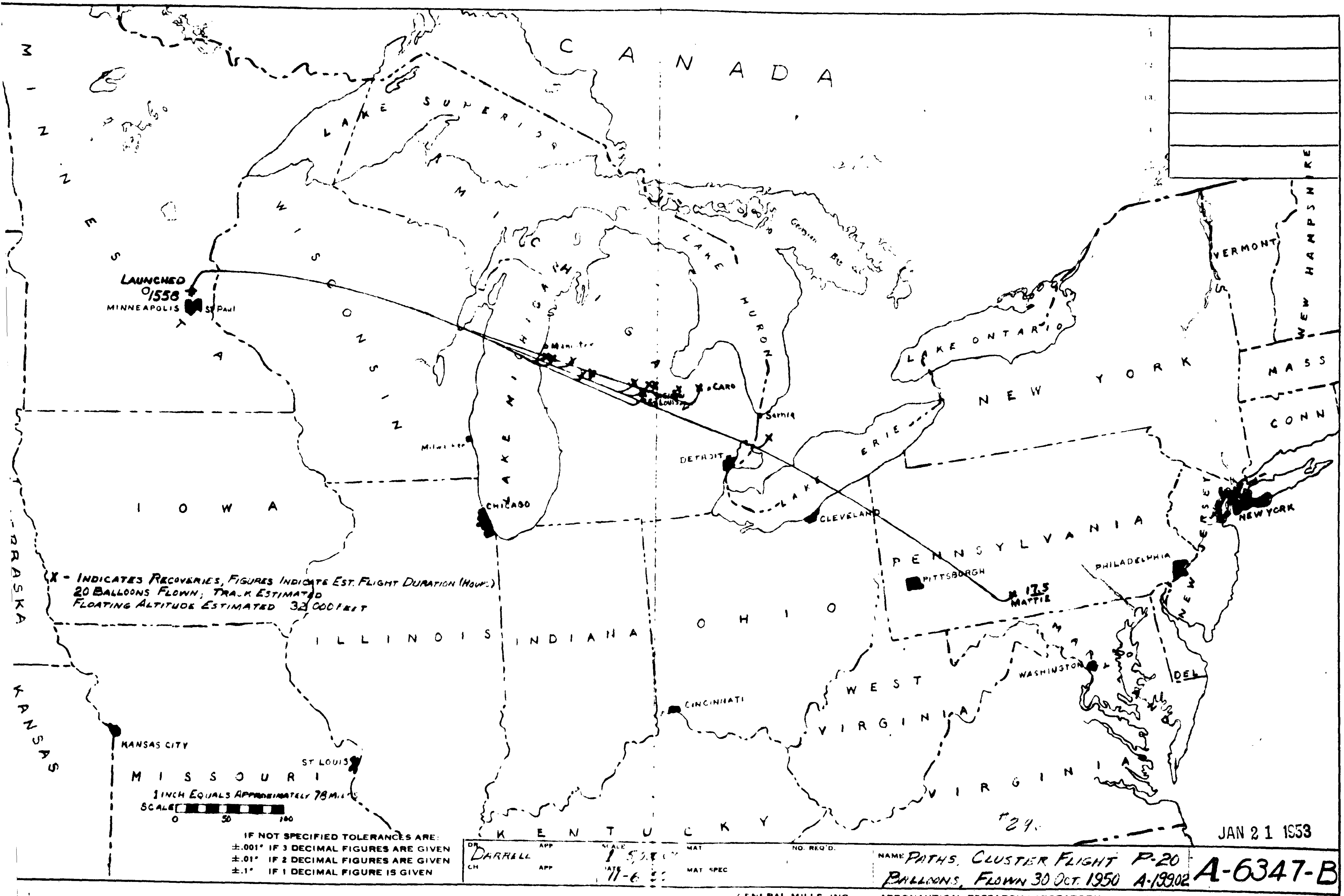
GENERAL MILLS, INC.
AERONAUTICAL RESEARCH LABORATORY
MINNEAPOLIS, MINN.

NAME: RECOVERY CHART CLUSTER FLIGHT 10-30-50

DATE: 10-30-50

DR.: DARRELL

21 1953


CANADA
LAKE SUPERIOR
MICHIGAN
WISCONSIN
MINNESOTA
IOWA
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
NEW YORK
VERMONT
NEW HAMPSHIRE
MASS
CONN
NEW JERSEY
PENNSYLVANIA
OHIO
INDIANA
ILLINOIS
MISSOURI
KANSAS
NEBRASKA
KENTUCKY
WEST VIRGINIA
VIRGINIA
DEL
LAUNCHED
1558
MINNEAPOLIS
St Paul
Sarnia
Caro
DETROIT
CHICAGO
CLEVELAND
PITTSBURGH
17.5
MATTIE
PHILADELPHIA
NEW YORK
WASHINGTON
CINCINNATI
KANSAS CITY
ST LOUIS
X - INDICATES RECOVERIES, FIGURES INDICATE EST. FLIGHT DURATION (HOURS)
20 BALLOONS FLOWN; TRACK ESTIMATED
FLOATING ALTITUDE ESTIMATED 32,000 FEET
1 INCH EQUALS APPROXIMATELY 78 MILES
SCALE 0 50 100
#29
JAN 21 1953
IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN
DR DARRELL
APP
CH
APP
SCALE
DATE 11-6
MAT
MAT SPEC
NO. REQ'D.
NAME PATHS, CLUSTER FLIGHT P-20
BALLOONS, FLOWN 30 OCT. 1950 A-19902
A-6347-B
GENERAL MILLS, INC.
AERONAUTICAL RESEARCH LABORATORY
MINNEAPOLIS

# RECOVERY CHART

## CLUSTER FLIGHT 27 OCTOBER 1950
## GM P-20 BALLOONS

#295

BALLOON WEIGHT (NOMINAL) - 192 gms.
FREE LIFT - 27 gms.
THEOR. FLOATING ALTITUDE - 32,000 Ft.
PAYLOAD - 28 gms.
VOLUME - 20 cu. ft.

LAUNCHED - 1529

| BALLOON NUMBER | DATE FOUND | TIME FOUND | DISTANCE & DIRECTION FROM NEAREST TOWN | LANDING SEEN? | GAS IN BALLOON? |
|---|---|---|---|---|---|
| 3020 | 10-28-50 | 1000 | 1 MILE NORTH OF UPLAND, INDIANA | NO | YES |
| 3021 | 10-28-50 | 0600 | 5 MILES WEST ASHLAND, KENTUCKY | NO | NO |
| 3022 | 10-28-50 | 0830 | 12 MILES SOUTHEAST MADISON, WISCONSIN | NO | YES |
| 3023 | 10-28-50 | 0600 | 1 MILE EAST LODI, WISCONSIN | NO | YES |
| 3024 | 10-28-50 | 1145 | 7 MILES NE MADISON 3 MILES SW SUN PRAIRIE WIS. | NO | YES |
| 3025 | 10-28-50 | 0630 | 2½ MILES SOUTH UPLAND, INDIANA | NO | YES |
| 3026 | 10-28-50 | 0600 | HIGHWAY DM, ¼ MILE NORTH DANE, WISCONSIN | NO | YES |
| 3027 | 10-28-50 | 1015 | 5½ MILES SOUTH MAUSTON, WISCONSIN | JUST LANDED | YES |
| 3028 | 10-28-50 | 0645 | 73RD & COLES ST. CHICAGO, ILLINOIS | NO | YES |
| 3029 | | | | | |
| 3030 | 10-28-50 | 1030 | 201 SHERIDAN ROAD KENILWORTH, ILLINOIS ¼ MILE NO. WILMETTE HARBOR | NO | YES |
| 3031 | 10-27-50 | 1700 | 3/4 MILE NORTH 1½ MILE WEST HUGO, MINNESOTA | NO | YES |
| 3032 | 10-28-50 | 0700 | 5 MILES NORTHEAST CHESTERTON, INDIANA | NO | YES |
| 3033 | 10-28-50 | 0700 | 4 MILES SOUTH HGWY. O MAUSTON, WISCONSIN | NO | NO |
| 3034 | 10-29-50 | 0850 | 4 MILES NORTHEAST MERRIMAC, WISCONSIN | NO | YES |
| 3035 | 11-18-50 | 1200 | 4½ MILES WEST WISCONSIN DELLS | NO | NO |
| 3036 | | | | | |
| 3037 | 10-29-50 | 0600 | 2 MILES WEST BARABOO, WISCONSIN | NO | NO |
| 3038 | | | | | |
| 3039 | 11-1-50 | 0930 | 7½ MILES NORTH LAVALLE, WISCONSIN | NO | YES |

IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

A-6275-A

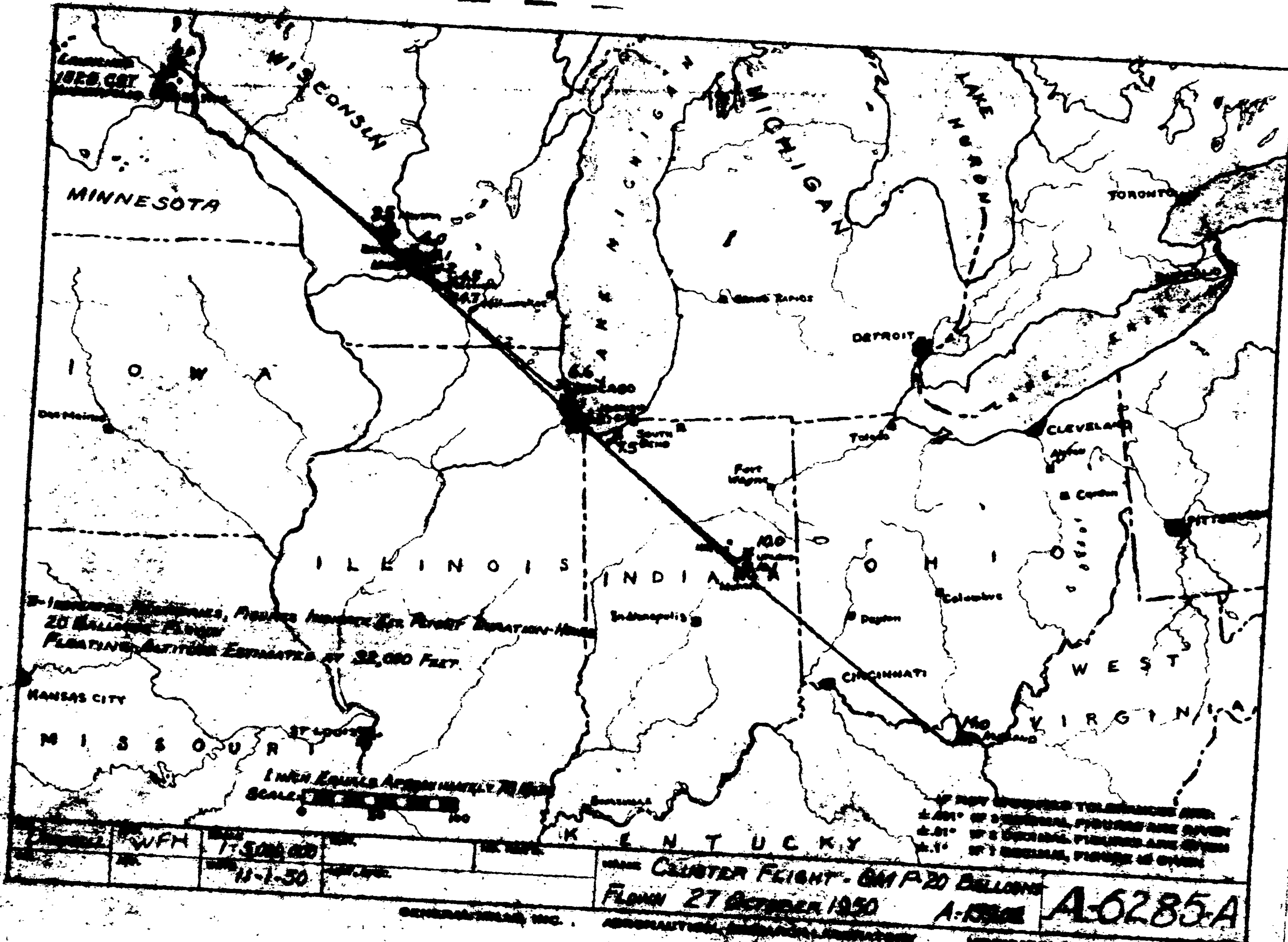
JAN 21 1953

NAME: RECOVERY CHART CLUSTER FLIGHT 10-27-50 A-6275

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

DATE 10-30-50

DR. DARRELL




#2-95

JAN 21 1953

# RECOVERY CHART
## CLUSTER FLIGHT 20 NOVEMBER 1950
## GM P-20 BALLOONS

#347

BALLOON GROSS WEIGHT -
FREE LIFT - 50 gms.
THEOR. FLOATING ALTITUDE - 32,000 Ft.
PAYLOAD - 28 gms.
VOLUME - 20 Cu. Ft.

LAUNCHED - 1435

1 1/2 MIL

| BALLOON NUMBER | DATE FOUND | TIME FOUND | DISTANCE & DIRECTION FROM NEAREST TOWN | LANDING SEEN? | GAS IN BALLOON? | |
|---|---|---|---|---|---|---|
| 3161 | 4-15-51 | 1030 | 2 MILES S E ATWOOD, ILL | No | No | |
| 3162 | 11-30-50 | 0800 | 1 MILE FROM OHIO RIVER 17 MILES EAST EVANSVILLE, IND. | No | No | |
| 3163 | 11-21-50 | 1000 | 17 MILES SOUTH OWENSBORO, KENTUCKY | No | YES | |
| 3164 | 11-21-50 | 0700 | 10 MILES SOUTH MARTINSVILLE, ILLINOIS | No | YES | |
| 3165 | 12-21-50 | 1430 | 5 MILES SOUTH CLEVELAND, TENN. | No | No | |
| 3166 | 3-12-51 | 1630 | BRUSH CREEK, TENN. 12 MILES FROM CARTHAGE | No | No | |
| 3167 | | | | | | |
| 3168 | 11-21-50 | EST 0630 | 2 1/2 MILES NORTH PENDERGRASS, GEORGIA | No | YES | 919 MILES |
| 3169 | | | | | | |
| 3170 | 12-25-50 | 1315 | 15 MILES NORTHEAST EVANSVILLE, INDIANA | No | No | |
| 3171 | | | | | | |
| 3172 | 11-21-50 | 0800 | 12 MILES WEST GAINSBORO, TENNESSEE | No | YES | |
| 3173 | | | | | | |
| 3174 | 11-21-50 | 1400 | 9 MILES SOUTH BOWLING GREEN, KENTUCKY 300 yds. WEST of [illegible] | No | YES | |
| 3175 | | | | | | |
| 3176 | 12-5-50 | 1020 | 1 1/4 MILES EAST WILLOW HILL, ILLINOIS | No | No | |
| 3177 | 11-20-45 | 2345 | 3 MILES WEST OBLONG, ILLINOIS | No | YES | |
| 3178 | 12-3-50 | — | 7 MI WEST TUSCOLA, ILLINOIS 22 MI. NNW MATTOON | No | No | |
| ~~3179~~ | 3-29-51 | 0900 | 5 1/2 SOUTH, 1/2 EAST OBLONG, ILLINOIS | No | No | NUMBER ILLEGIBLE |
| ~~3180~~ | 3-19-51 | 1330 | 5 MILES SOUTHEAST BRIDGEPORT, ILLINOIS | No | No | NUMBER ILLEGIBLE |

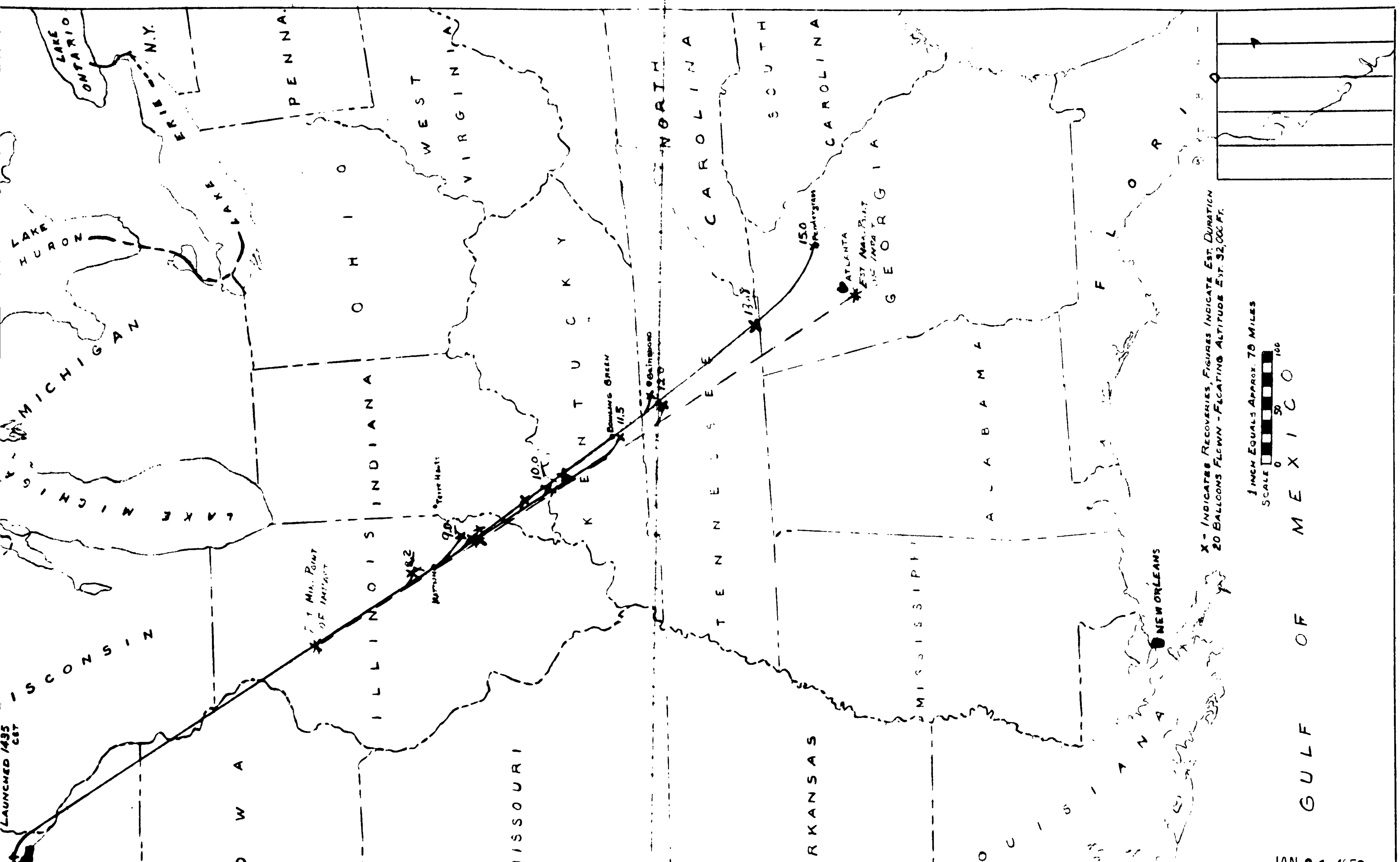
IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

NAME RECOVERY CHART CLUSTER FLIGHT 11-20-50 | NO. REQ'D. | MAT. | MAT. SPEC. | SCALE | DATE 11-20-50 | APP. | APP. | DR. DARRELL | CH.

A-19802 A-6439-A

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

JAN 21 1953




JAN 21 1953

IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

| | | | | |
|---|---|---|---|---|
| DR. DARRELL | APP | SCALE | MAT | NO REQ'D. |
| CH. | APP | DATE 11-28-50 | MAT SPEC | |

NAME CLUSTER FLIGHT - P-20 BALLOONS
FLOWN 20 NOVEMBER 1950
A-199.02
A-6440-B

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

# RECOVERY CHART
## CLUSTER FLIGHT 15 DECEMBER 1950
## GM P-20 BALLOONS

#326

BALLOON GROSS WEIGHT - 128 grams
FREE LIFT - 60 grams
THEOR. FLOATING ALTITUDE - 42,000 FT.
PAYLOAD - 2.3 grams
VOLUME - 20 CU. Ft.

LAUNCHED - 1302

1½ MIL

| BALLOON NUMBER | DATE FOUND | TIME FOUND | DISTANCE & DIRECTION FROM NEAREST TOWN | LANDING SEEN? | GAS IN BALLOON? | EST. FLIGHT DURATION (HRS) |
|---|---|---|---|---|---|---|
| 3301 | 4-21-51 | 1030 | 7 MI S.W. ROCKFORD, OHIO | No | No | |
| 3302 | | | | | | |
| 3303 | 12-16-50 | 1430 | 9 MILES WEST FORT WAYNE, INDIANA | No | YES | |
| 3304 | | | | | | |
| 3305 | [illegible]-51 | 1430 | 3 SE SIDNEY, OHIO | No | No | |
| 3306 | [illegible]-2-51 | [illegible] | SIDNEY OHIO | — | — | |
| 3307 | | | | | | |
| 3308 | 4-15-51 | | 6.5 MI W.N.W. BUCHANAN, MICH | No | No | |
| 3309 | | | | | | |
| 3310 | 12-16-50 | 1030 | CHICKASAW OHIO | No | No | |
| 3311 | 12-16-50 | 0945 | 7 MILES SOUTH LONDON, OHIO ROUTE 56 | No | YES | |
| 3312 | 12-16-50 | 0700 | 2½ MI NORTH 2½ MI. EAST OSSIAN, INDIANA | No | YES | |
| 3313 | | | | | | |
| 3314 | | | | | | |
| 3315 | | | | | | |
| 3316 | 12-16-50 | 1125 | 1 MILE NORTH, 1½ MI. WEST KETTERSVILLE OHIO | No | YES | |
| 3317 | | | | | | |
| 3318 | 12-16-50 | 1125 | 1 MILE NORTH 1 MI. WEST KETTERSVILLE OHIO | No | YES | |
| 3319 | | | | | | |
| 3320 | 12-23-50 | 1505 | 1 MILE NORTH CHATTANOOGA, OHIO | No | No | |

A-6732A
JAN 21 1953
RECOVERY CHART CLUSTER FLIGHT 12-15-50
A-1302
12-20-50
DARRELL
GENERAL MILLS, INC.
AERONAUTICAL RESEARCH LABORATORY
MINNEAPOLIS, MINN.

| BALLOON NUMBER | DATE FOUND | TIME FOUND | DISTANCE & DIRECTION FROM NEAREST TOWN | LANDING SEEN? | GAS IN BALLOON? | EST. FLIGHT DURATION (HRS) |
|---|---|---|---|---|---|---|
| 3321 | 12-28-5[illegible] | 1430 | 3 MILES SOUTH SOUTH BEND, IND. | NO | YES | |
| 3322 | [illegible] | [illegible] | 6 [illegible] SE [illegible] | No | No | |
| 3323 | | | | | | |
| 3324 | | | | | | |
| 3325 | | | | | | |
| 3326 | 12-16-50 | 1445 | 2 MILES SOUTHEAST SAINT PARIS, OHIO | No | No | |
| 3327 | 1-5-51 | 1330 | 9 MILES SOUTH EAST COLUMBIA CITY, IND. | No | No | |
| 3328 | 12-17-50 | 1430 | DEWART LAKE 5 MI. SOUTH SYRACUSE, IND. | No | No | |
| 3329 | 12-21-50 | 1000 | 8 MILES NORTHWEST COLUMBIA CITY, IND. | No | No | |
| 3330 | 12-16-50 | 0730 | 12 MILES SOUTHEAST SIDNEY, OHIO | No | No | |
| 3331 | 12-25-50 | 1215 | 4 MILES WEST WAKARUSA, IND. | No | No | |
| 3332 | | | | | | |
| 3333 | 1-20-51 | | 7 MI S.W. FORT WAYNE IND. | No | No | |
| 3334 | 12-17-50 | | 1/2 MI NW CELINA, OHIO | No | No | |
| 3335 | | | | | | |
| 3336 | 12-29-50 | 1500 | 1 1/2 MI. SAWYER, MICH. 1/2 MI. LAKE MICH. SHORE | No | No | |
| 3337 | | | | | | |
| 3338 | 12-16-50 | 0800 | 6 MILES SOUTHEAST SOUTH BEND, IND. | No | No | |
| 3339 | | | | | | |
| 3340 | | | | | | |
| 3341 | 2-24-51 | 1300 | 5 MI. SE AST NORTH WEBSTER, IND. | No | No | |
| 3342 | 5-1-51 | | 6 S W [illegible] | No | No | |
| 3343 | | | | | | |
| 3344 | | | | | | |
| 3345 | 12-16-50 | 1315 | 3 MILES NORTHEAST ROCKFORD, OHIO | No | YES | |
| 3346 | | | | | | |

NAME RECOVERY CHART CLUSTER FLIGHT 12-15-50 A-19802 A-6733-A

NO REQ'D. MAT. MAT. SPEC.

SCALE DATE 12-20-50

DR. DARRELL CH. APP. APP.

GENERAL MILLS, INC AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

JAN 21 1953

| Balloon Number | Date Found | Time Found | Distance & Direction From Nearest Town | Landing Seen? | Gas in Balloon? | Est. Flight Duration (Hrs) |
|---|---|---|---|---|---|---|
| 3347 | | | | | | |
| 3348 | | | | | | |
| 3349 | | | | | | |
| 3350 | 12-18-50 | 1530 | 3 Mi. West ¼ Mi. South WILLSHIRE, OHIO | No | No | |
| 3351 | | | | | | |
| 3352 | 3-12-51 | 0900 | 3 MILES NORTHWEST ST. PARIS, OHIO | No | No | |
| 3353 | 12-16-50 | 1745 | 22 MILES SOUTHEAST FORT WAYNE, IND. [illegible] | No | No | |
| 3354 | | | | | | |
| 3355 | | | | | | |
| 3356 | | | | | | |
| 3357 | [illegible] | [illegible] | [illegible] | [illegible] | No | |
| 3358 | 12-25-50 | 1330 | NYC RR. 1½ MILES BUCHANAN MICH. | No | YES | |
| 3359 | 12-18-50 | 1000 | 8 MILES NORTHWEST DECATUR, INDIANA | No | No | |
| 3360 | 3-10-51 | 1000 | 10 MILES SOUTHEAST COLUMBIA CITY, INDIANA | No | No | |
| 3361 | [illegible] | 1508 | [illegible] WEST [illegible] | No | YES | |
| 3362 | 12-16-50 | 1330 | 9 MILES SOUTHEAST MISHAWAKA, INDIANA | No | YES | |
| 3363 | | | | | | |
| 3364 | | | | | | |
| 3365 | 12-16-50 | 1100 | 13 MILES EAST SPRINGFIELD BRIGHTON, OHIO | No | YES | |
| 3366 | 1-5-51 | 1100 | WOODS 7 MILES EAST COLUMBIA CITY, IND. | No | No | |
| 3367 | 3-6-51 | — | 4 MILES NORTH W. ROCKFORD, OHIO | | | |
| 3368 | | | | | | |
| 3369 | | | | | | |
| 3370 | | | | | | |
| 3371 | | | | | | |
| 3372 | | | | | | |

A-6734-A

NAME RECOVERY CHART CLUSTER FLIGHT 12-15-50 A-199.02

NO. REQ'D. MAT. MAT. SPEC. SCALE DATE 12-20-50 DR. DARRELL CH. APP. APP.

GENERAL MILLS, INC AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

JAN 21 1953

| Balloon Number | Date Found | Time Found | Distance & Direction From Nearest Town | [illegible] Seen? | [illegible] | Est. Flight Duration Hrs |
|---|---|---|---|---|---|---|
| 3373 | | | | | | |
| 3374 | | | | | | |
| 3375 | | | | | | |
| 3376 | | | | | | |
| 3377 | 6-1-51 | 1730 | 4 MI FROM ROCKFORD, OHIO | No | No | |
| 3378 | 12-16-50 | 1530 | 3½ MILES NORTHEAST LEESBURG, INDIANA | No | No | |
| 3379 | | | | | | |
| 3380 | 12-16-50 | 1700 | 3½ MILES EAST NEW BREMAN, OHIO | No | No | |
| 3381 | | | | | | |
| 3382 | | | | | | |
| 3383 | | | | | | |
| 3384 | 3-17-51 | 1000 | 4 MILES NORTH COLUMBIA CITY, IND. | No | No | |
| 3385 | 4-25-51 | 1000 | COLUMBIA CITY, IND | No | No | |
| 3386 | | | | | | |
| 3387 | 4-18-51 | | 3 MI. S W BUCHANAN, MICH | No | No | |
| 3388 | | | | | | |
| 3389 | | | | | | |
| 3390 | | | | | | |
| 3391 | 2-25-51 | 1300 | 4 MILES SOUTH SOUTH BEND, IND. | No | No | |
| 3392 | 12-17-50 | 1145 | 9 MILES SOUTHEAST COLUMBIA CITY, INDIANA | No | NO TORN | |
| 3393 | 12-23-50 | 1430 | WOODS, 9 MILES NORTHWEST URBANA, OHIO | No | No | |
| 3394 | 4-24-51 | 0900 | 2½ mi S, 3 mi W ROCKFORD, OHIO | No | No | |
| 3395 | 6-6-51 | 1500 | 6 MI S FT WAYNE, IND | No | No | |
| 3396 | 4-13-51 | 1500 | 13 MI SO FORT WAYNE, IND | No | No | |
| 3397 | | | | | | |
| 3398 | 12-16-50 | 1230 | 4 MILES EAST DECATUR IND. ON HGWY 224 1 MI. NO. ON HGWY 101 | No | YES | |

A-6735-A

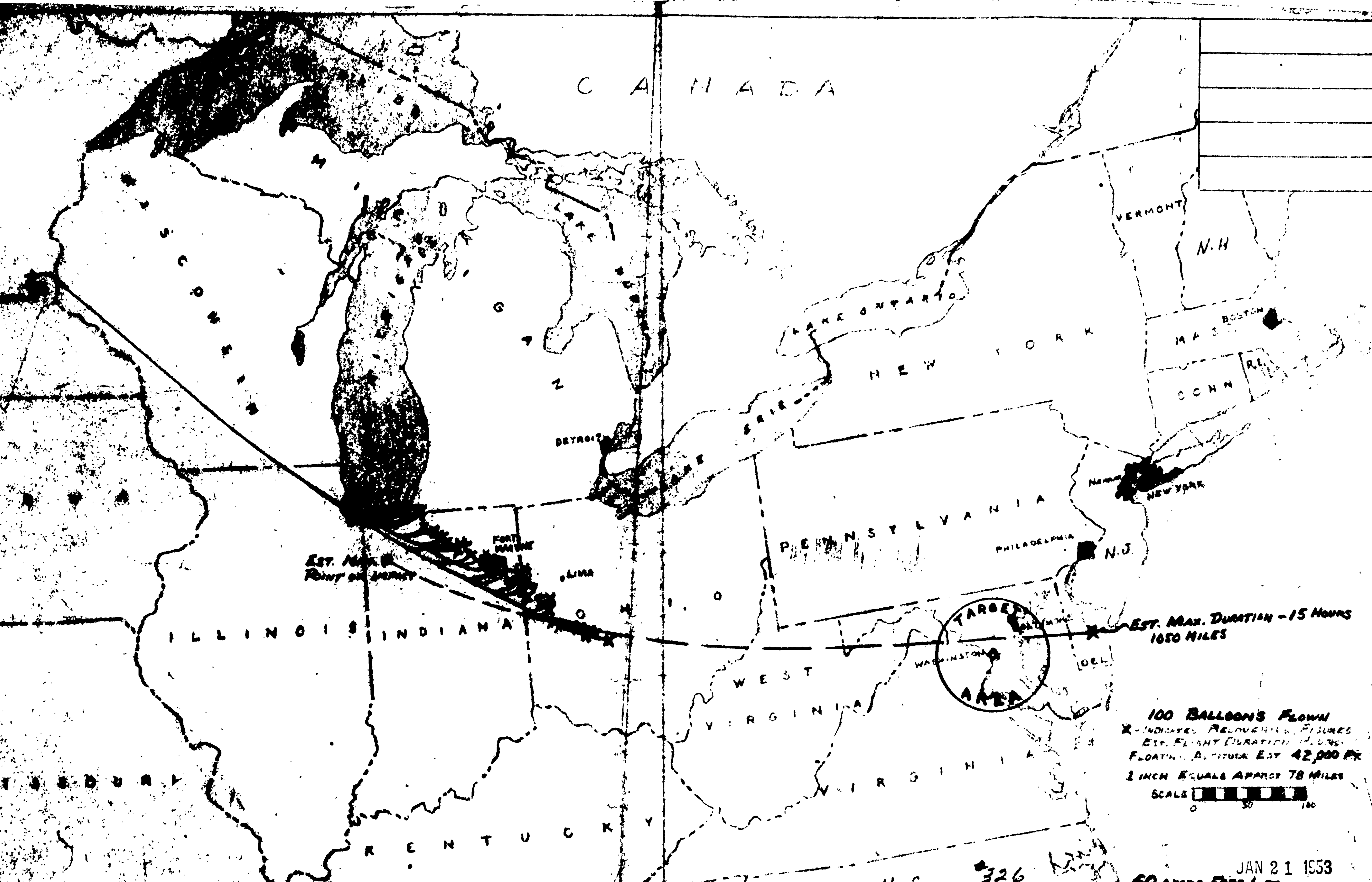
NAME RECOVERY CHART CLUSTER FLIGHT 12-15-50 AMH

NO. REQ'D. MAT. MAT. SPEC. SCALE DATE 12-20-50 APP. APP. DR. DARRELL CH.

AERONAUTICAL RESEARCH LABORATORY
GENERAL MILLS, INC.
MINNEAPOLIS, MINN.

JAN 21 1953

#326




X - Indicates Recoveries, Figures Est. Flight Duration Hours
Floating Altitude Est 42,000 Ft.
1 Inch Equals Approx 78 Miles

#326

JAN 21 1953

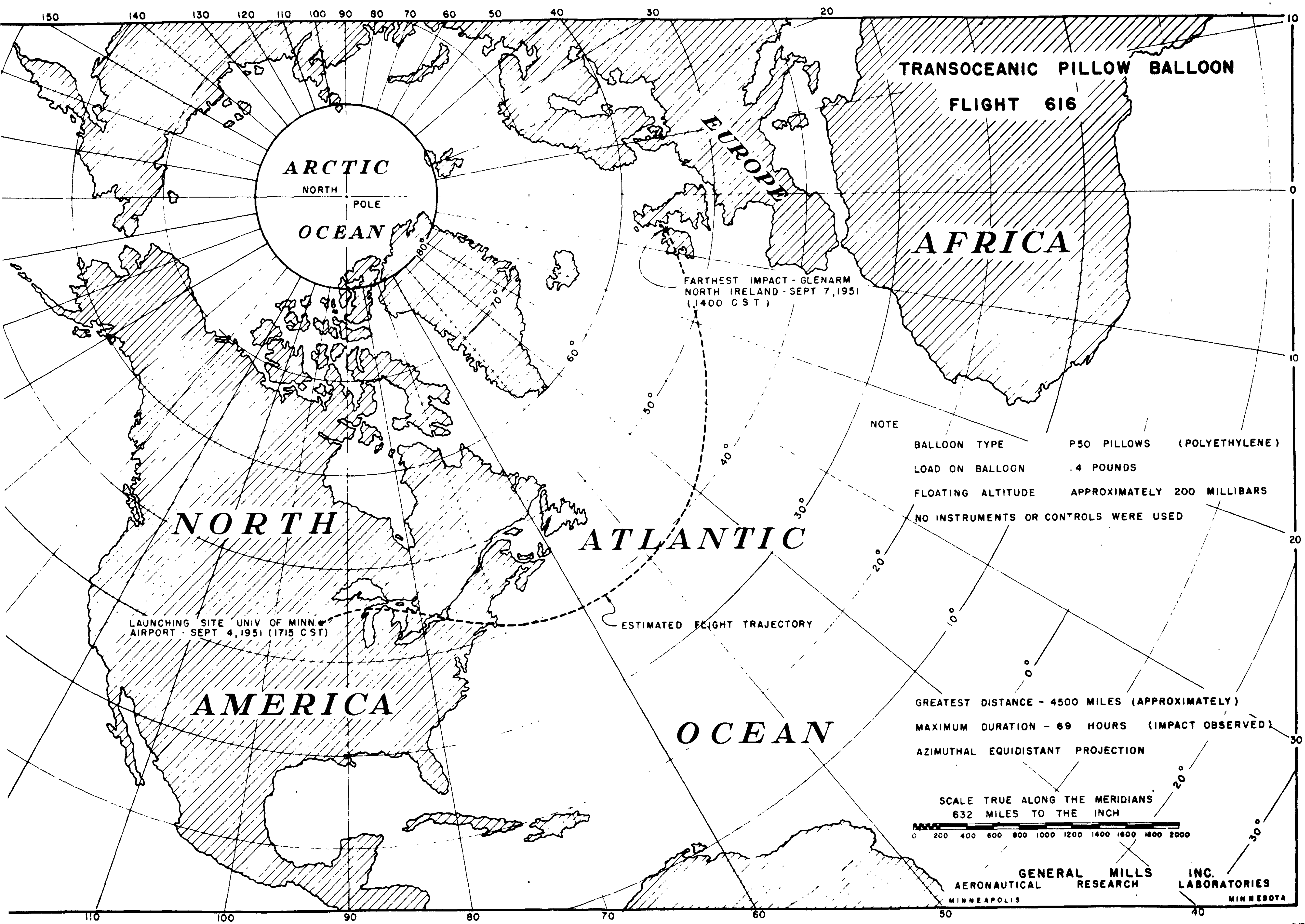
60 grams Free Lift

IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

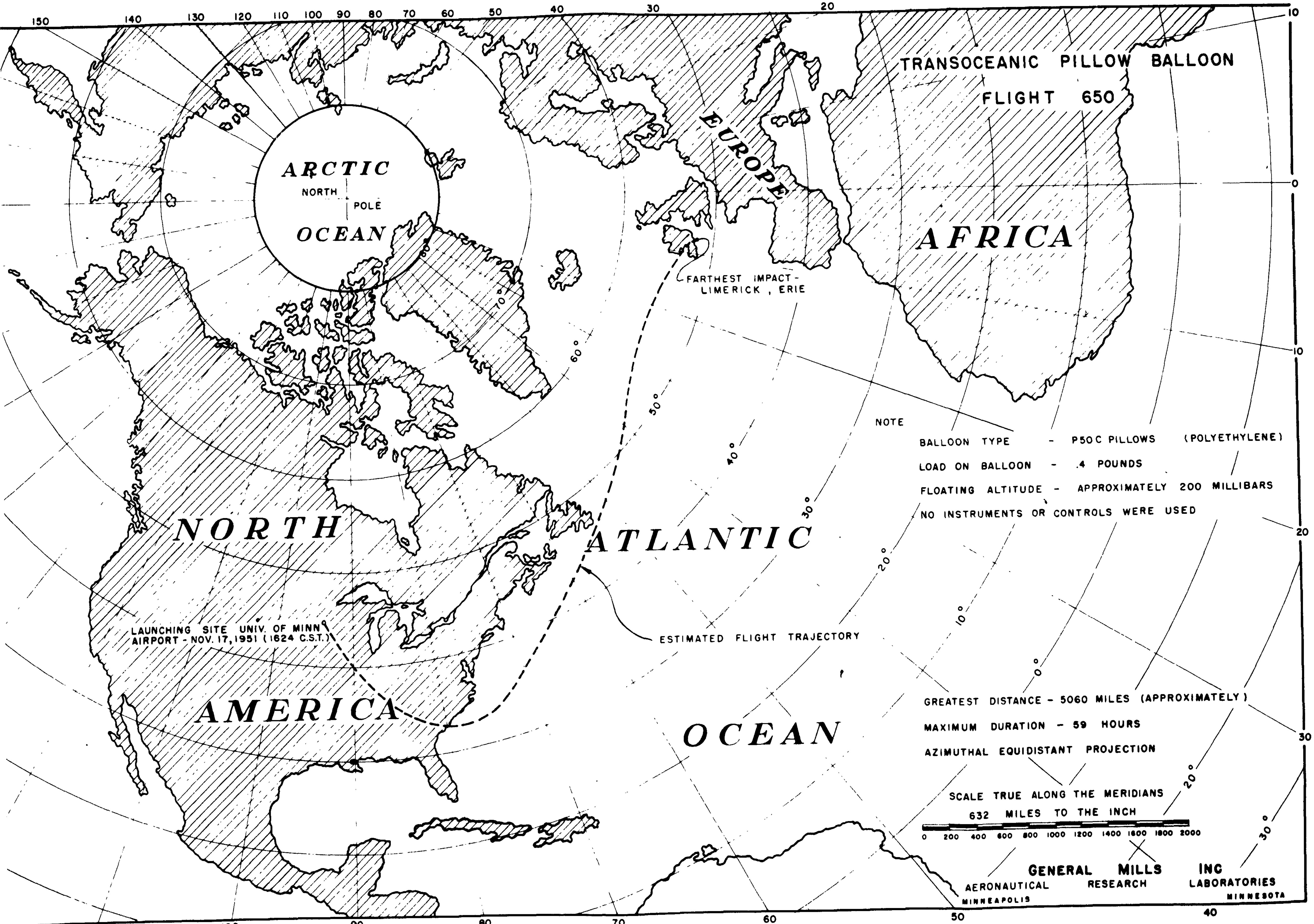
| DR. | APP. | DATE | MAT. | NO. REQ'D | NAME |
|---|---|---|---|---|---|
| DARRELL | | | | | CLUSTER FLIGHT P20 BALLOONS |
| CH. | APP. | 12-19-50 | MAT. SPEC. | | FLOWN 15 DECEMBER 1950 A-19902 |

A-6731-B

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.



TRANSOCEANIC PILLOW BALLOON
FLIGHT 616
ARCTIC
NORTH POLE
OCEAN
EUROPE
AFRICA
NORTH ATLANTIC OCEAN
NORTH AMERICA
FARTHEST IMPACT - GLENARM NORTH IRELAND - SEPT 7, 1951 (1400 C S T)
LAUNCHING SITE UNIV OF MINN AIRPORT - SEPT 4, 1951 (1715 C S T)
ESTIMATED FLIGHT TRAJECTORY
NOTE
BALLOON TYPE P50 PILLOWS (POLYETHYLENE)
LOAD ON BALLOON .4 POUNDS
FLOATING ALTITUDE APPROXIMATELY 200 MILLIBARS
NO INSTRUMENTS OR CONTROLS WERE USED
GREATEST DISTANCE - 4500 MILES (APPROXIMATELY)
MAXIMUM DURATION - 69 HOURS (IMPACT OBSERVED)
AZIMUTHAL EQUIDISTANT PROJECTION
SCALE TRUE ALONG THE MERIDIANS
632 MILES TO THE INCH
0 200 400 600 800 1000 1200 1400 1600 1800 2000
GENERAL MILLS INC.
AERONAUTICAL RESEARCH LABORATORIES
MINNEAPOLIS MINNESOTA


TRANSOCEANIC PILLOW BALLOON
FLIGHT 650
ARCTIC
NORTH POLE
OCEAN
EUROPE
AFRICA
FARTHEST IMPACT - LIMERICK , ERIE
NORTH
ATLANTIC
AMERICA
OCEAN
LAUNCHING SITE UNIV. OF MINN AIRPORT - NOV. 17, 1951 (1624 C.S.T.)
ESTIMATED FLIGHT TRAJECTORY
NOTE
BALLOON TYPE - P50C PILLOWS (POLYETHYLENE)
LOAD ON BALLOON - .4 POUNDS
FLOATING ALTITUDE - APPROXIMATELY 200 MILLIBARS
NO INSTRUMENTS OR CONTROLS WERE USED
GREATEST DISTANCE - 5060 MILES (APPROXIMATELY)
MAXIMUM DURATION - 59 HOURS
AZIMUTHAL EQUIDISTANT PROJECTION
SCALE TRUE ALONG THE MERIDIANS
632 MILES TO THE INCH
0 200 400 600 800 1000 1200 1400 1600 1800 2000
GENERAL MILLS INC
AERONAUTICAL RESEARCH LABORATORIES
MINNEAPOLIS MINNESOTA