AD NUMBER: AD0075997
LIMITATION CHANGES
TO: Approved for public release; distribution is unlimited.
FROM: Distribution authorized to U.S. Government agencies and their contractors; Administrative or operational use; 15 Jun 1952. Other requests shall be referred to Office of Naval Research, Arlington, VA 22203.
AUTHORITY
ST-A ONR LTR, 15 AUG 1968

UNCLASSIFIED

AD 75997

Armed Services Technical Information Agency

ARLINGTON HALL STATION
ARLINGTON 12 VIRGINIA

FOR
MICRO-CARD
CONTROL ONLY

OF

CLASSIFICATION CHANGED TO UNCLASSIFIED

BY AUTHORITY OF ASTIA RECLASS. BULLETIN 23

Date 1-Feb.-59

Signed Richard L. Reedy
OFFICE SECURITY ADVISOR

PROGRESS REPORT ON
HIGH ALTITUDE PLASTIC BALLOONS
CONTRACT NONR-710 (01)
DECEMBER 13, 1951 to JUNE 15, 1952
VOLUME IV
CONFIDENTIAL SECURITY INFORMATION
Copy No. 5 [illegible]

CONFIDENTIAL

CONFIDENTIAL

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

CONDUCTED UNDER
CONTRACT NONR-710(01), NR 320 159
FOR PERIOD DECEMBER 13, 1951 to JUNE 15, 1952
WITH THE
OFFICE OF NAVAL RESEARCH

AND SPONSORED JOINTLY
BY THE ARMY, NAVY AND AIR FORCE

This document contains information affecting the National Defense of the United States. Its transmission or the disclosure of its contents in any manner to an unauthorized person is prohibited and may result in severe criminal penalties under applicable Federal laws.

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

Copy No. 4 81

CONFIDENTIAL

PROGRESS REPORT ON CONTRACT #710(01)

From Iniation of Contract to June 15, 1952

VOLUME IV

CONFIDENTIAL SECURITY INFORMATION

Table of Contents

SECTION VIII

METEOROLOGY

The work of the meteorological group has so far been largely of an exploratory nature. Four principal studies have been initiated: (1) plastic balloon failure in the "jet stream", (2) comparison of the character of the flow in the stratosphere with the flow in the troposphere, (3) a case study of the vorticity change as measured by the constant altitude balloon, (4) the computation of balloon height and temperature.

In addition, this group prepares the balloon trajectory charts and analysis of wind data from the balloon flights, and provides a number of minor services, generally in interpreting meteorological data. Forecasts are made for flight planning purposes and computations of the infrared flux has been made for selected rays.

1. Plastic Balloon Failure in the Jet Stream

It had been observed in earlier General Mills flight data that there is a relatively high incidence of plastic balloon failure in the vicinity of the tropopause. Since this is the coldest region through which the balloon ascends, the brittleness of the balloon fabric at these low temperatures has been suggested as an important cause of failure. Pilot reports of turbulence associated with high winds at the tropopause led Dr. R. A. Craig to advance the opinion that turbulence may be a further contributing factor.

All available data on previous plastic balloon flights are, therefore, being examined with reference to the following meteorological elements: wind velocity, vertical wind shear, and atmospheric stability. This analysis is made as the meteorological data become available, and, at present, is only completed for irregular intervals in the periods 1948-1949 and 1951-1952. The meteorological data have been studied for a total of 38 flights made by General Mills and also by the Moby Dick project. Only five balloon failures at the tropopause were noted in this group. Four cases of failure occurred under conditions of higher than average wind velocity (70-100 kt) and relatively large values of the vertical wind shear. One failure could be considered a borderline case with a wind velocity of 50 kt. In this group of 38, however, there were also four cases of successful flights through wind streams of equally high wind velocities and vertical wind shear. No obvious relationship was observed between atmospheric stability or temperature and balloon failure. In one of the cases of balloon failure it was observed that the horizontal wind shear was abnormally large, a value of 2×10^{-4} sec^{-1} obtained from measured winds.[1] The further possibility exists, therefore, that the horizontal wind shear may be important in isolating the dangerous meteorological situations.

The erratic nature of this failure is also born out by recent Minnesota flights. Since the balloons in this group are not of identical manufacture, it seems quite likely that differences in balloon construction and materials may be the decisive factor as to whether the "jet stream" will cause balloon failure. The limited number of failures available for study prevents final conclusions on this point.

2. Comparison of the Character of the Flow in the Stratosphere with the Flow in the Troposphere

As a means of interpreting the information obtained on the stratospheric flow, various characteristics of the flow in the stratosphere are being compared with the characteristics of the flow in the troposphere. The trajectories of the early Moby Dick flights in the wind season 1951-1952, were used in a preliminary study in an effort to determine to what elevations one could successfully extrapolate the methods of conventional synoptic analysis. Spe-

---

[1]Palmen and Nagler point out that 10^{-4} sec^{-1} is a large value of the horizontal shear, Journ. Met., 1948, vol. 5, p. 64.

cifically, 100 mb charts were constructed for the flights which floated near 55,000 ft. and 50 mb charts for the flights at approximately 70,000 ft. From these limited cases it appeared that the broad features of the flow in the 100 mb chart were quite similar to those at 200 mb and the flow described by the balloon's trajectory corresponded, within the limits of accuracy of the trajectory, to the flow indicated by the 100 mb chart. The construction of the 50 mb charts was not successful. The upper air data is quite limited at these elevations and from the available data it appears that considerable changes in flow pattern are possible in the layer 100 to 50 mb.

The velocity fluctuations or accelerations are a quantitative and descriptive characteristic of the flow. The mean velocity over varying time intervals is being computed from the trajectories at constant altitude. Similar computations have been made for the General Mills 300 mb flights so as to provide the tropospheric comparison. The compilation of data and the analysis have not been completed but certain features are evident. Velocity changes over adjacent 5 minute periods are of about equal magnitude in the troposphere and in the stratosphere at 80,000 ft. Velocity changes over adjacent periods of 1 to 2 hours are also very nearly equal in the stratosphere and in the troposphere. In some stratospheric flights, notably Minnesota flight 12, the fluctuations over 20 to 40 minute periods are about an order of magnitude greater than have been observed in the troposphere.[2]

The complicated pattern made by the trajectory of Flight 12 (see the latter part of this section), suggests the above result merely by inspection. The winds at floating level were quite light and since no tropospheric data

[2]The magnitude of the velocity fluctuations in the troposphere were found to be consistent with the observations of Durst, 1948: The fine structure of wind in the free air, QJRMS, vol. 74. Also Durst and Gilbert, 1950: Constant-height balloons--Calculations of geostrophic departures and ensuing discussion, QJRMS, vol. 76, 75-88.

under similar conditions were available, some doubt must remain that this condition is unique in the stratosphere. One further remark in this connection may be in order; both the cusp in the trajectory of Flight 12 and the sudden shift in direction of the trajectory of Flight 8 occur with anticyclonic motion of the trajectory. If the wind is anywhere approaching geostrophic balance it means that the air decelerated as it was directed toward low pressure. One must conclude therefore that in this case, either the Coriolis acceleration is relatively unimportant, which would be true in the flow about very small pressure systems, or that the pressure field is moving rapidly with respect to the wind velocity. Since the complicated trajectory patterns, illustrated by Flight 12, are generally associated with light winds, it may be that these are typical observations in the layer of very light winds which is found between the lower westerly and upper easterly currents throughout the summer half of the year.

3. A Case Study of the Vorticity Change

The measurement of atmospheric accelerations by the constant altitude balloon may make possible a more complete description of the atmospheric flow processes. For example, the relationship of the accelerations to be divergence may be expressed by the vorticity equation. The usefulness of the measurement of the accelerations in this connection, is being examined by means of a case study of the vorticity change for a twenty-four hour period corresponding to General Mills Flight 578. The three dimensional field of motion has been analyzed in the layer 400 mb to 200 mb; the vertical velocity has been computed by the adiabatic method outlined by Panofsky (1946). From these values, cross sections of the horizontal divergence were prepared following Fleagle, (1948). This information and the measurements of the balloon trajectory will then be used in the computation of the vorticity change and independent values of the divergence will be computed from the vorticity equation.

The vorticity equation has been derived in vector form following the suggestion of Hsu (1951), the equation obtained is

$$\frac{d}{dt}(\zeta + f) + (\zeta + f)\nabla \cdot \vec{V} - (\nabla \times \vec{V} + 2\vec{\Omega}) \cdot \nabla_2 w = \vec{k} \cdot \nabla_2 p \times \nabla_2 \alpha ,$$

where the symbols have their conventional meteorological significance:

$(\zeta + f)$ is the vertical component of the absolute vorticity;

$\vec{V}$ the velocity vector;

$\vec{\Omega}$ the angular rotation of the earth;

w the vertical component of the velocity;

$\vec{k}$ the unit vector in the zenith direction;

p and α are pressure and specific volume of the air, respectively;

∇_2 and ∇ are the horizontal and three dimensional del operators.

The advantage of this derivation is the limited number of assumptions required; the principal assumptions retained here are:

1. That the frictional forces may be neglected;
2. That the gravitational acceleration does not vary in the tangent plane;
3. That the earth is spherical.

The evaluation of vorticity change will be made in two ways; by measurement of the vorticity difference at the beginning and end of the trajectory and by measuring individual terms when expressed in natural coordinates, as suggested by Hsu (1951). It is hoped thereby to determine which features of the accelerations are important in producing the divergence and to provide a better estimate of the accuracy and type of measurement required for a complete computation.

4. Computation of Height and Temperature in the Stratosphere

The balloon elevation is being computed from the photographs taken from the balloon by comparing distances on the film with map distances. The basic limitation to the accuracy of this procedure is the measurement of true or map distance. With a map scale of 1:50,000 the error of an appropriate distance seems to be at best 0.2% and possibly nearer 0.5% on the average. Somewhat greater accuracy may be possible by using the map only to identify clearly marked section boundaries and assuming the distance between to be exactly one mile.

The balloon elevation computed from the pictures of Flight 8 is compared with the pressure altitude computed from the standard atmosphere in Figure 1. The interval between photographs was found to vary slightly over the period of the flight and the time scale used here was interpolated by comparing the theodolite and photo trajectories. The time altitude curve in Figure 1 is relatively smooth so that it seems likely that large changes in ascent rate can be detected by this method. The oscillation of the values of elevation computed from the photographs about the values determined by the pressure reports, however, suggests that camera sway is not negligible.

The mean temperature of any layer may also be computed from the elevation and the pressure observations by means of the hydrostatic equation. The temperature distribution resulting from this computation for Flight 8, is shown in Figure 2 where the temperature reported by St. Cloud, the nearest radiosonde observation station, is given for comparison. It is probably a safe assumption that the St. Cloud temperature at 200 mb is correct to within a few degrees since both the height computation and temperature are consistent with the nearby radiosonde reports.

The results of the temperature computation were found to be particularly dependent upon a good time coordination of the various observations. A sample calculation of the effect of the probable error in timing showed that a variation in 10 degrees could be expected from this error alone. In view of the difficulties of instrumentation and measurement encountered in a satisfactory height and temperature determination by this method, it seems desirable to have a further elevation check (for example by double theodolite) during the balloon ascent.

REFERENCES

Durst, C. S., 1948: The fine structure of the wind in the free air, QJRMS, vol. 74.

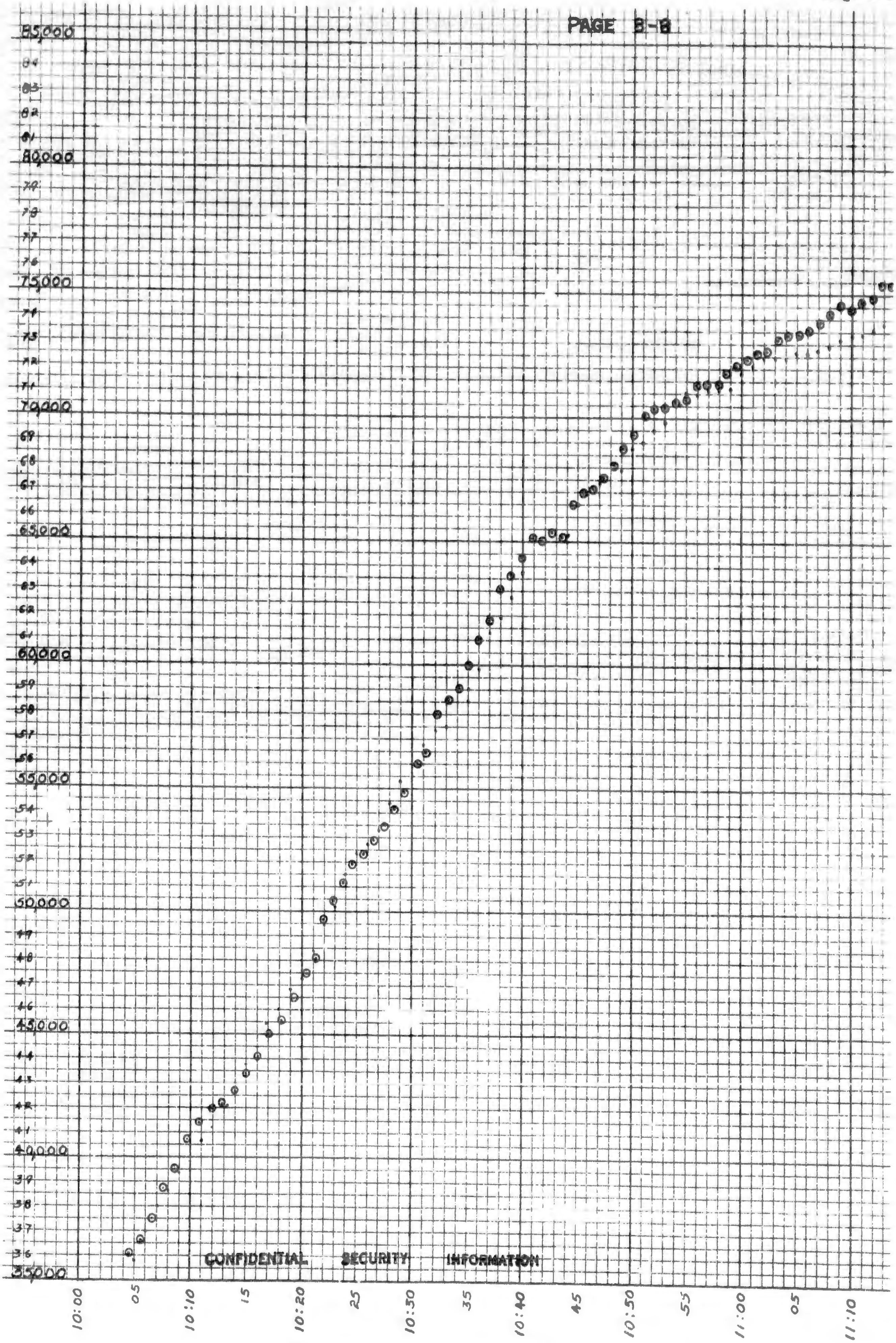
------------, and G. H. Gilbert, 1950: Constant-height balloons--Calculations of geostrophic departures and discussion ensuing, QJRMS, vol. 76, 75-88.

Fleagle, R. G., 1948: Quantitative factors influencing pressure change, Journal of Meteorology, vol. 5, 281-292.

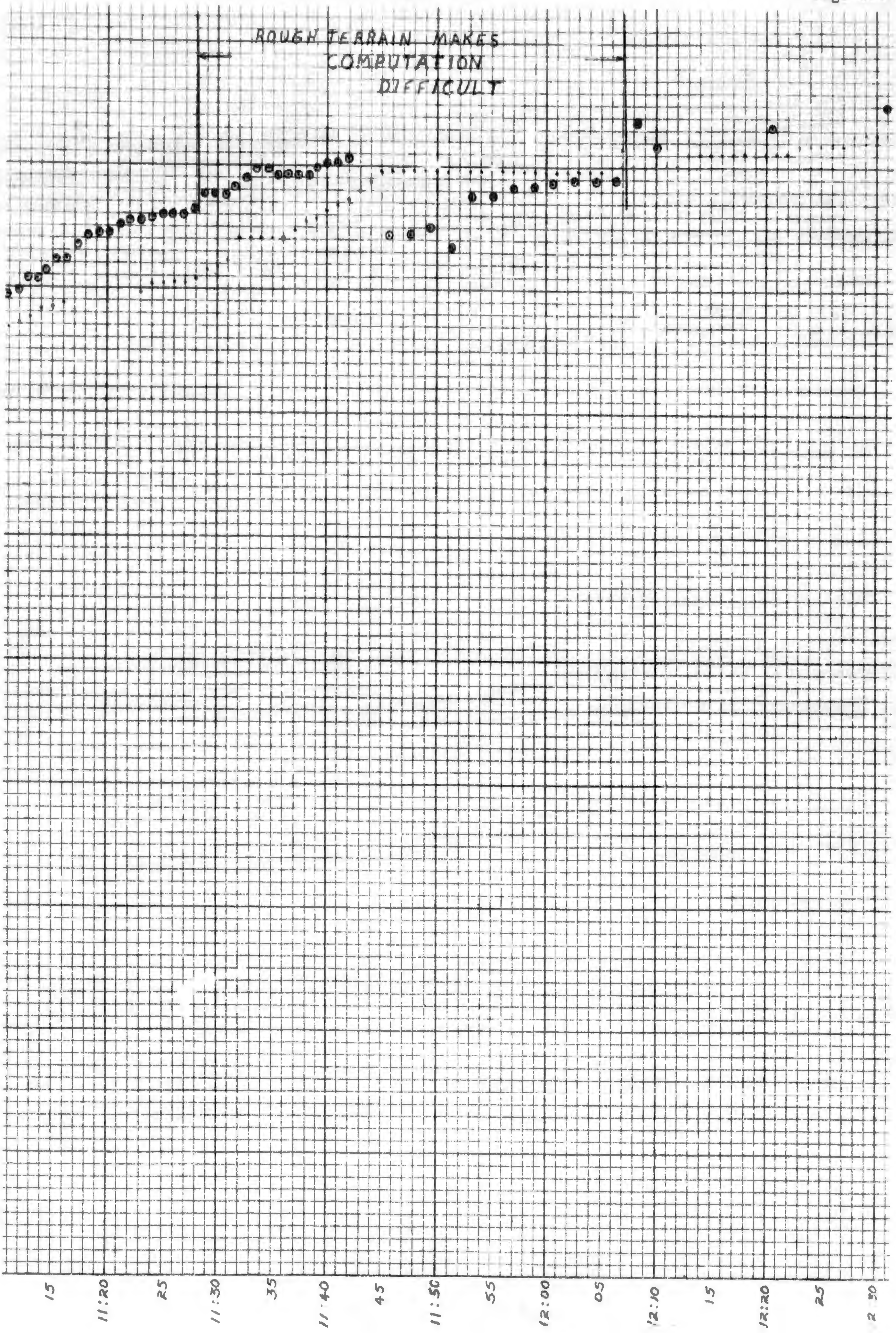
Hsu, E. H., 1951: A general equation of horizontal mass divergence in the atmosphere, Journal of Meteorology, vol. 8, 395-397.

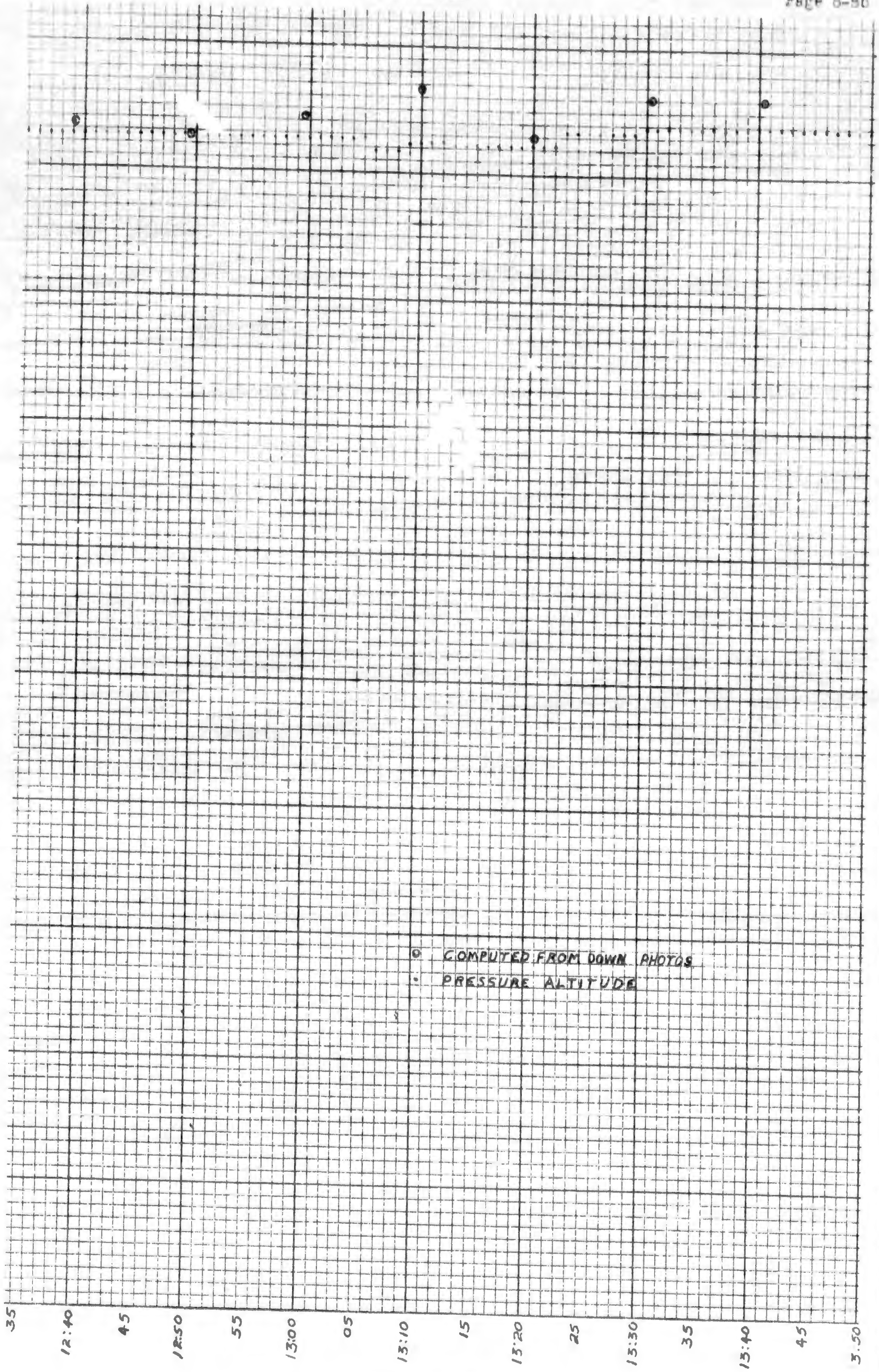
Palmen, E., and K. M. Nagler, 1948: An analysis of the wind and temperature distribution in the free atmosphere over North America in a case of approximately westerly flow, Journal of Meteorology, vol. 5, 64.

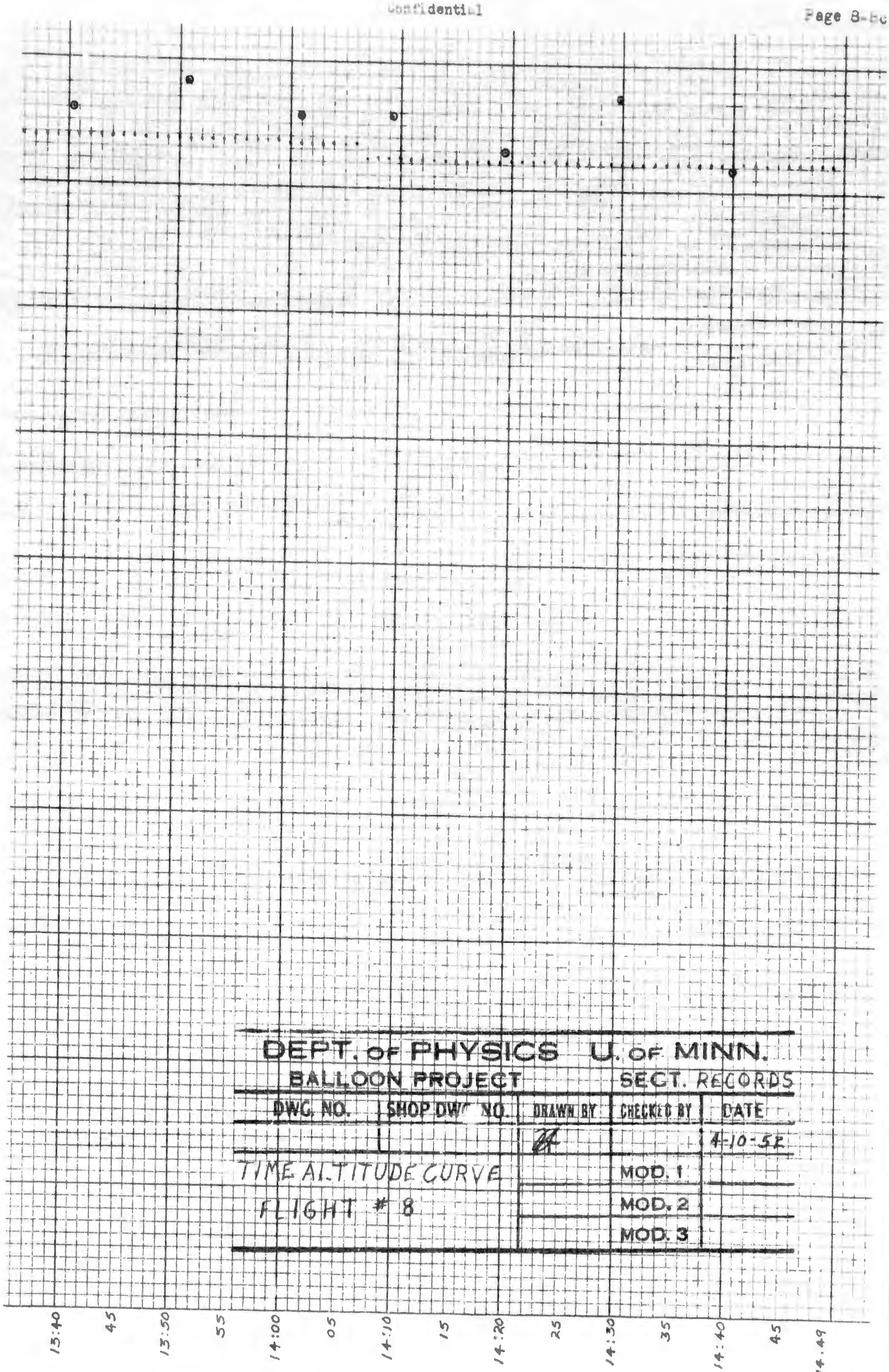
Panofsky, H. A., 1946: Methods of computing vertical motion in the atmosphere, Journal of Meteorology, 3:271-275.



CONFIDENTIAL SECURITY INFORMATION


ROUGH TERRAIN MAKES
COMPUTATION
DIFFICULT
15
11:20
25
11:30
35
11:40
45
11:50
55
12:00
05
12:10
15
12:20
25
12:30


COMPUTED FROM DOWN PHOTOS
PRESSURE ALTITUDE
35
12:40
45
12:50
55
13:00
05
13:10
15
13:20
25
13:30
35
13:40
45
13:50


DEPT. OF PHYSICS U. OF MINN.
BALLOON PROJECT
SECT. RECORDS
DWG. NO.
SHOP DWG NO.
DRAWN BY
CHECKED BY
DATE
4-10-52
TIME ALTITUDE CURVE
FLIGHT # 8
MOD. 1
MOD. 2
MOD. 3
13:40
45
13:50
55
14:00
05
14:10
15
14:20
25
14:30
35
14:40
45
14.49

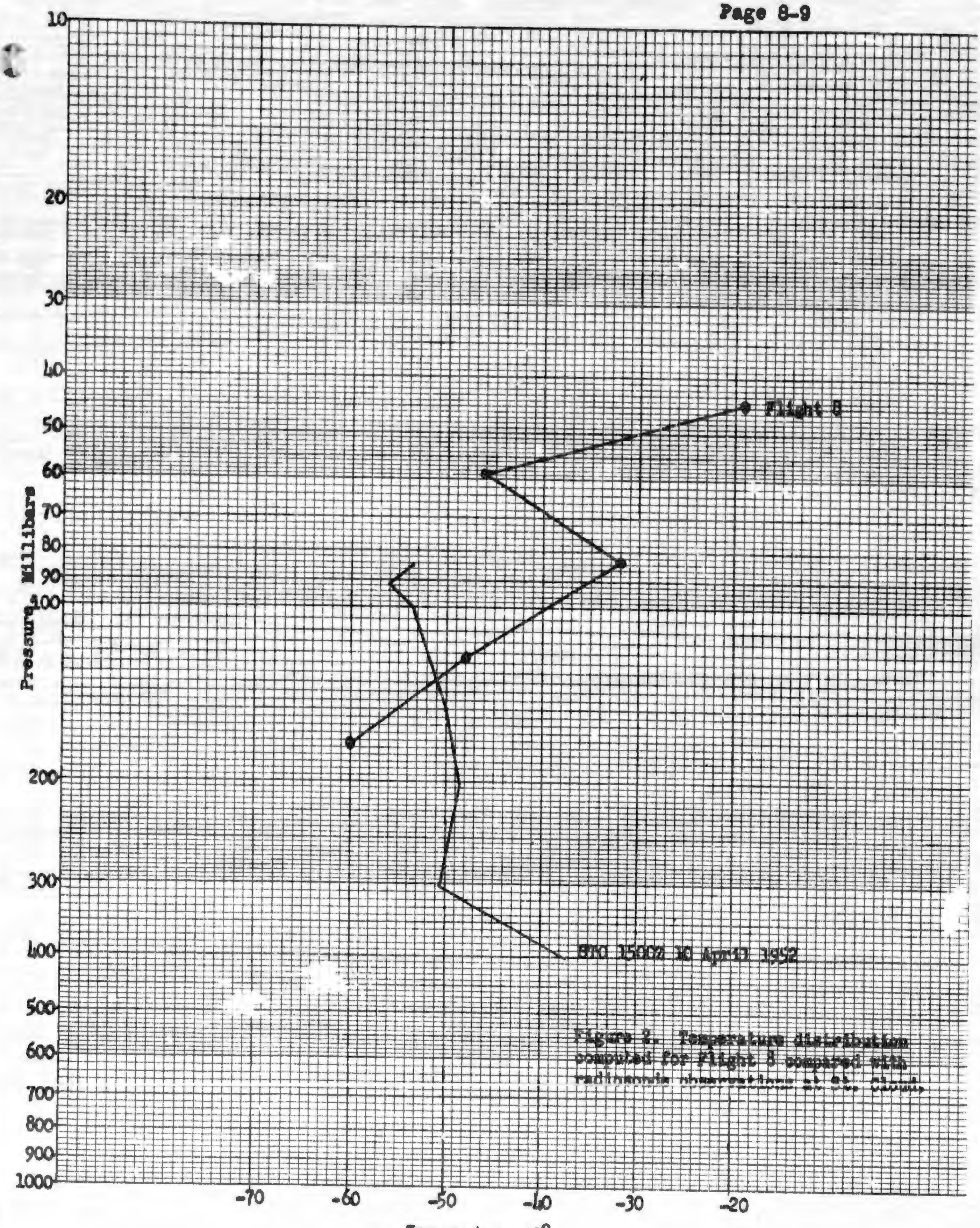
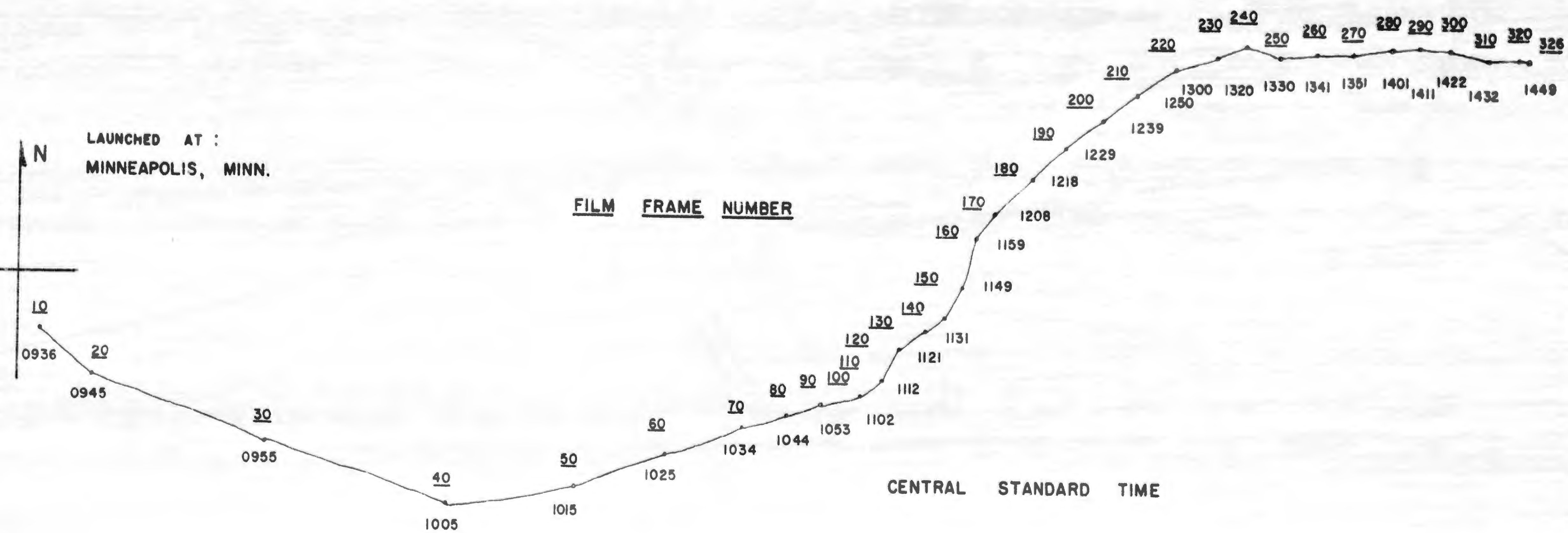


Figure 2. Temperature distribution computed for Flight 8 compared with radiosonde observations at St. Cloud.



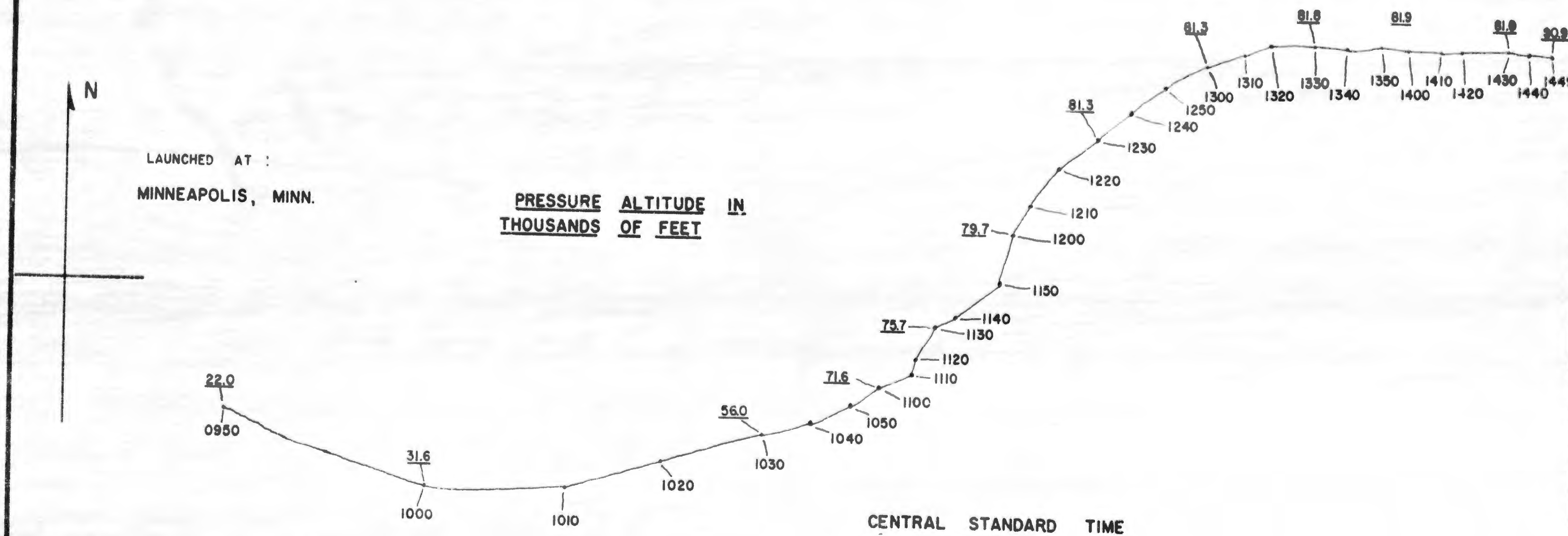
FLIGHT NO. 8

Launched 0926 CST

10 APRIL, 1952

TRAJECTORY FROM DOWN PICTURE

SCALE 1:5 x 10^5



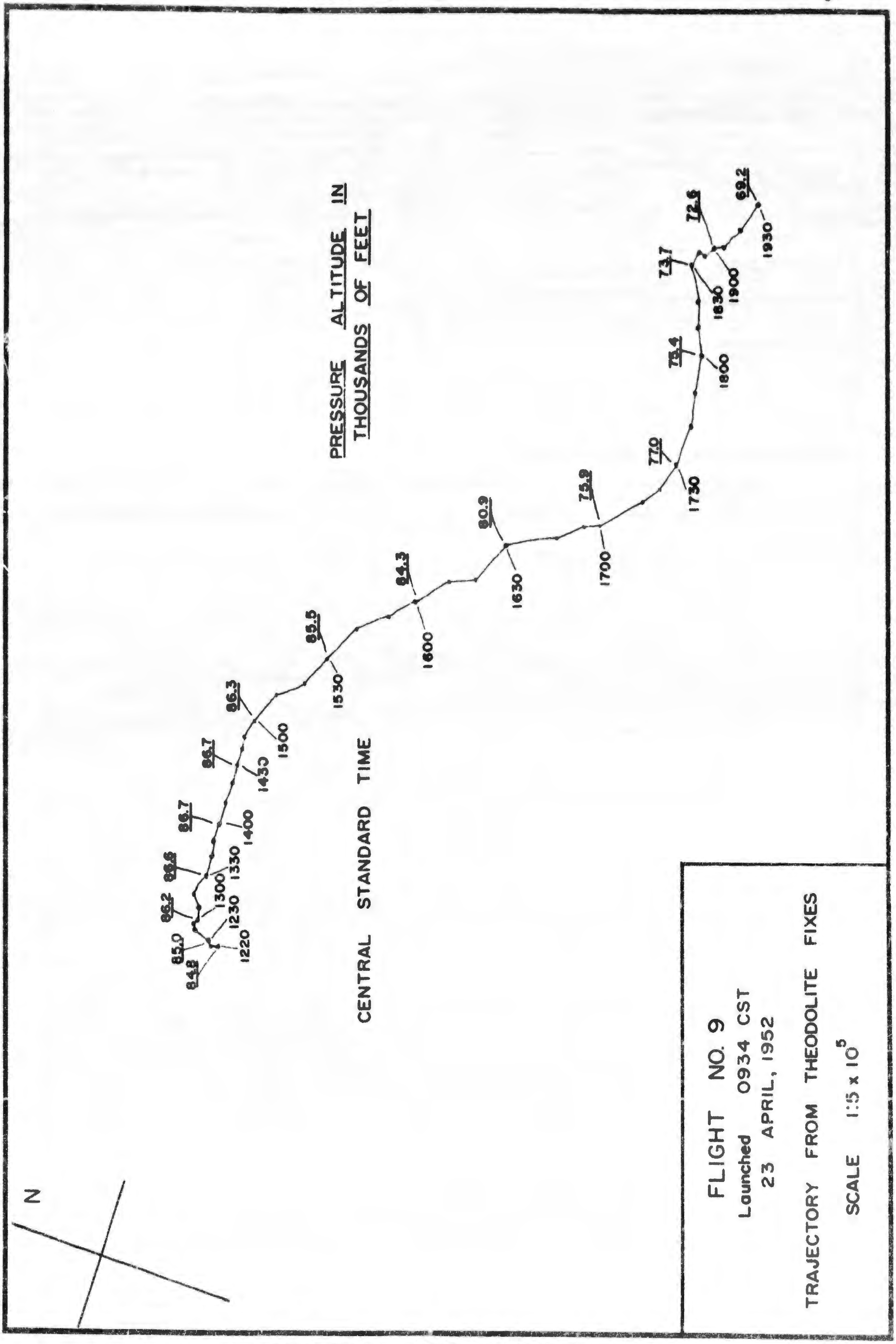
FLIGHT NO. 8

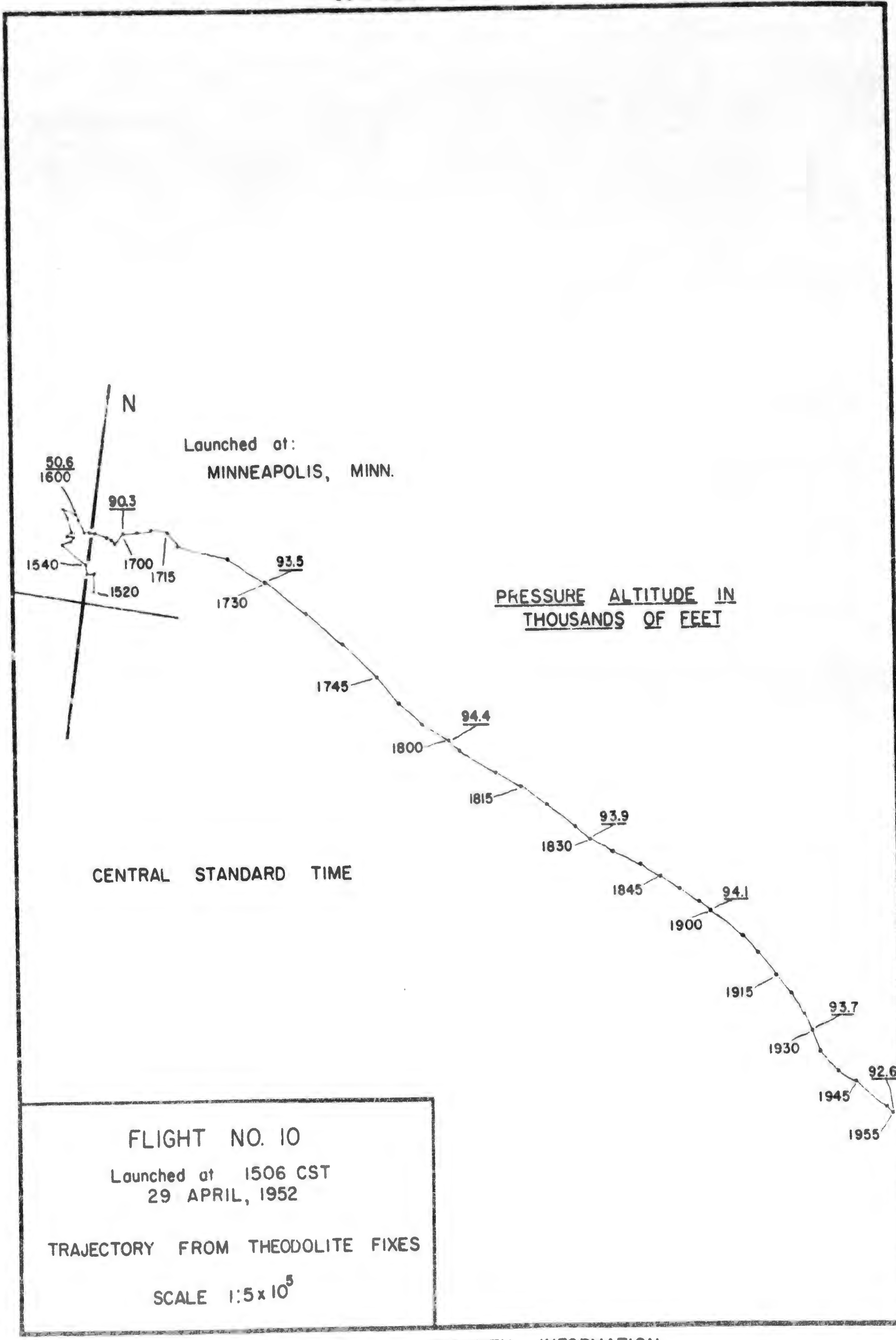
Launched 0926 CST

10 APRIL, 1952

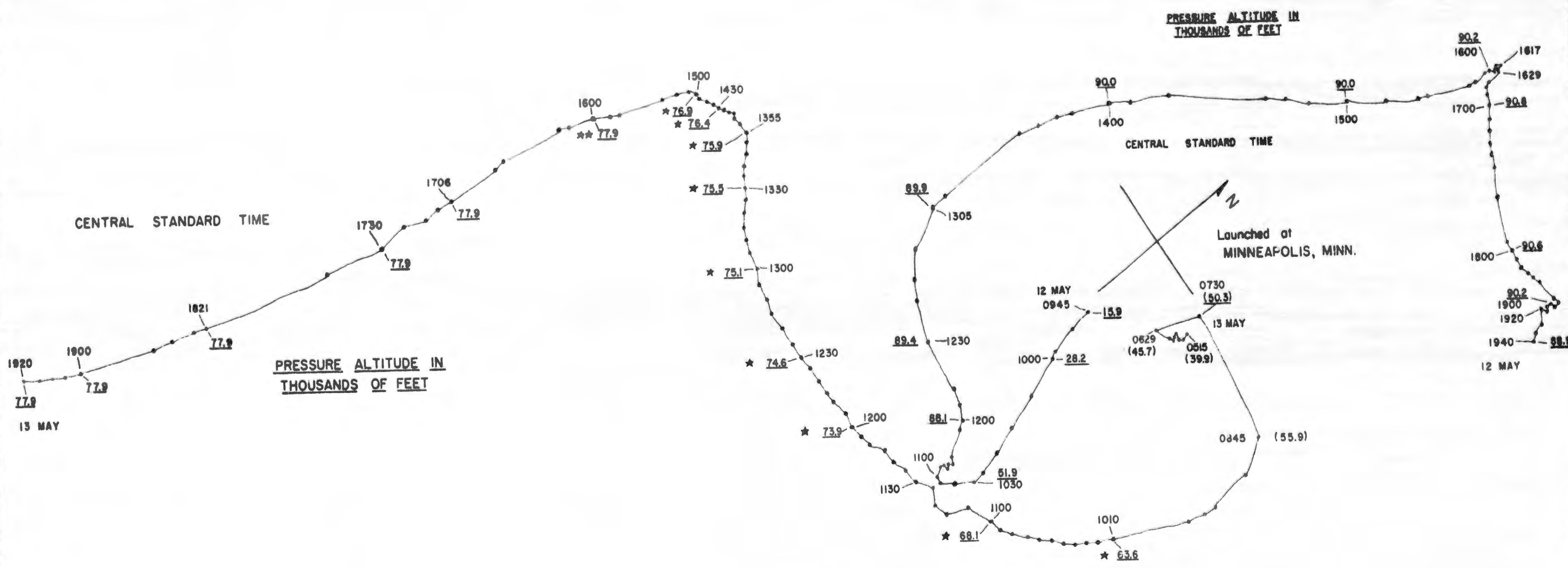
TRAJECTORY FROM THEODOLITE FIXES

Scale : 1 : 5 x 10^5


PRESSURE ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
N
84.8
85.0
86.2
86.6
86.7
86.7
86.3
85.5
84.3
80.9
75.9
77.0
73.4
73.7
72.6
69.2
1220
1230
1300
1330
1400
1430
1500
1530
1600
1630
1700
1730
1800
1830
1900
1930
FLIGHT NO. 9
Launched 0934 CST
23 APRIL, 1952
TRAJECTORY FROM THEODOLITE FIXES
SCALE 1:5 x 10^5


N
Launched at:
MINNEAPOLIS, MINN.
50.6
1600
90.3
1540
1700
1715
1520
93.5
1730
PRESSURE ALTITUDE IN THOUSANDS OF FEET
1745
94.4
1800
1815
93.9
1830
CENTRAL STANDARD TIME
1845
94.1
1900
1915
93.7
1930
92.6
1945
1955
FLIGHT NO. 10
Launched at 1506 CST
29 APRIL, 1952
TRAJECTORY FROM THEODOLITE FIXES
SCALE 1:5 x 10^5

CONFIDENTIAL



FLIGHT NO. 12

Launched 0929 CST

12 & 13 MAY, 1952

CODE

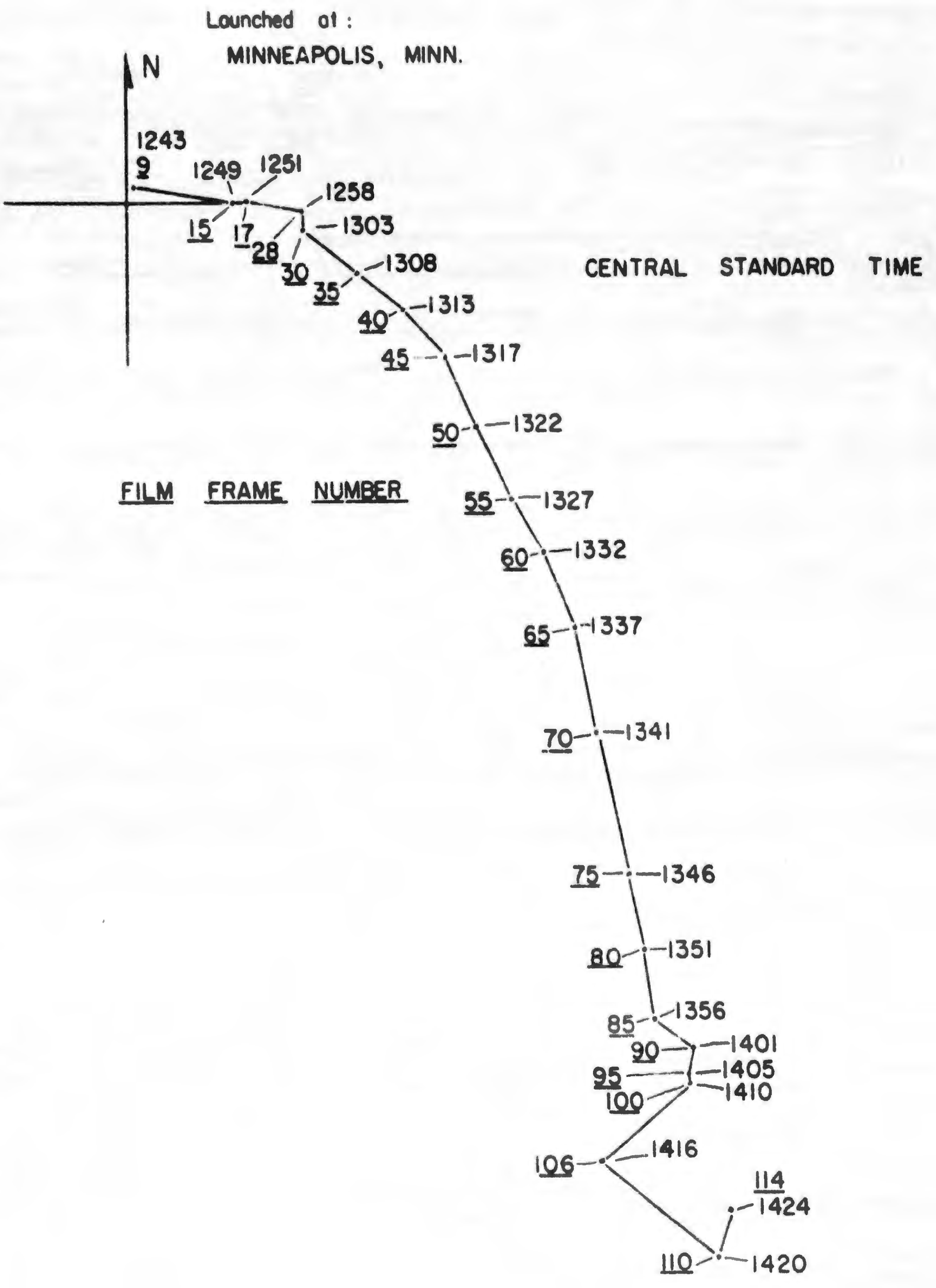
( ) ELEVATION FROM SUBTENDED ANGLE

★ ELEVATION FROM DOUBLE THEODOLITE

★★ NO OBSERVATIONS AFTER 1600

SCALE 1:5 x 10^5

CONFIDENTIAL SECURITY INFORMATION



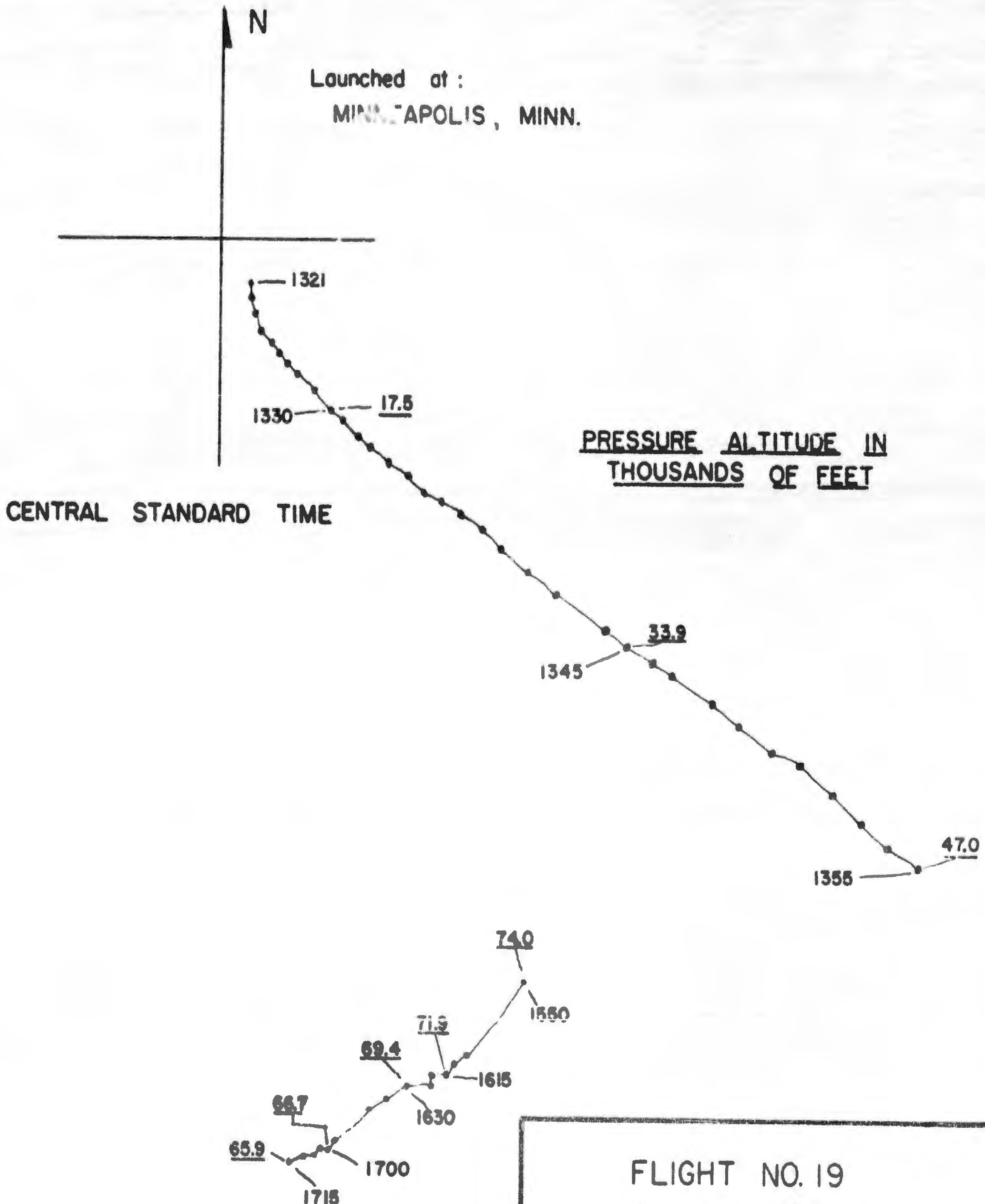
FLIGHT NO. 17

Launched 1234 CST

5 JUNE, 1952

TRAJECTORY FROM DOWN PICTURES

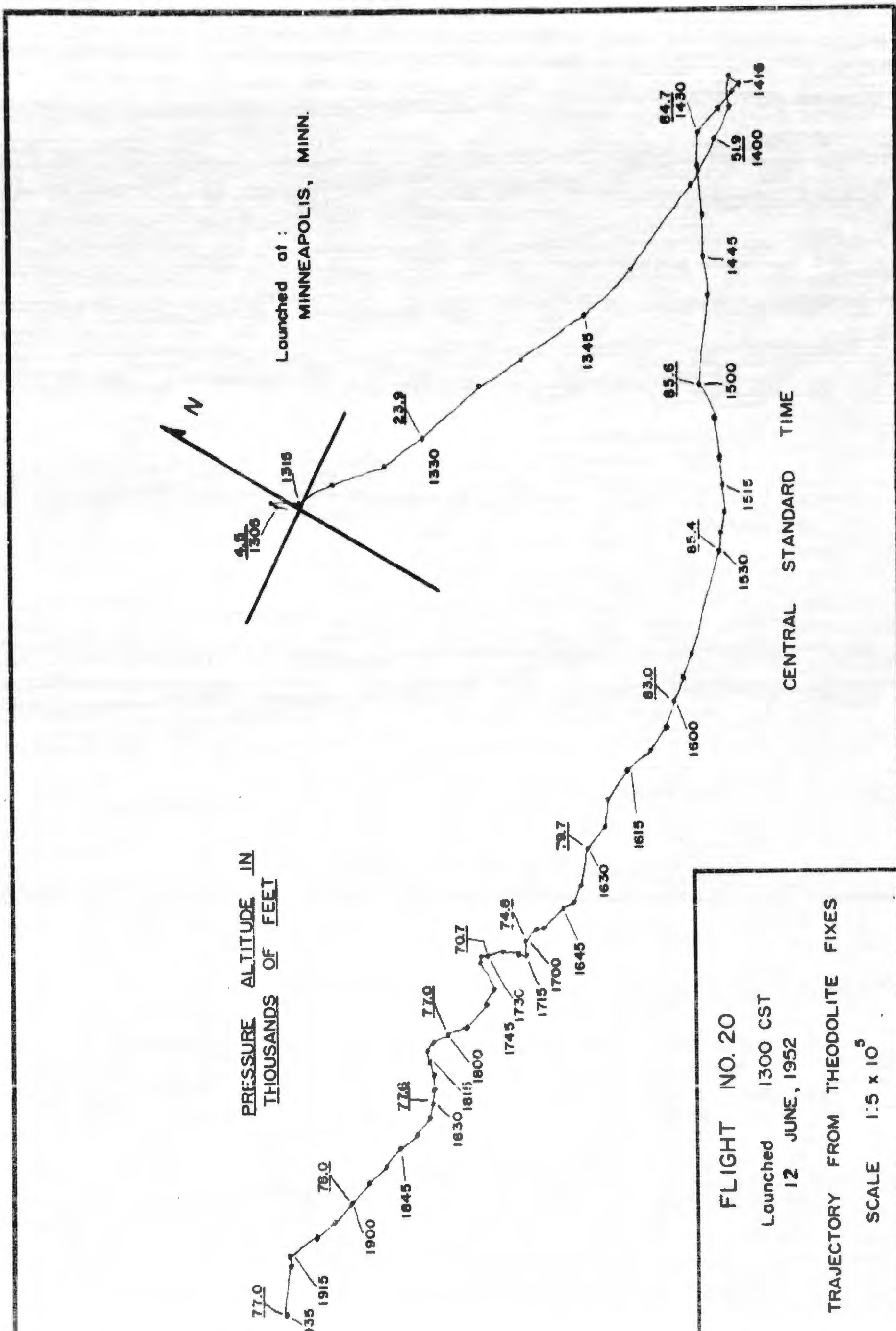
SCALE 1:5 x 10^5

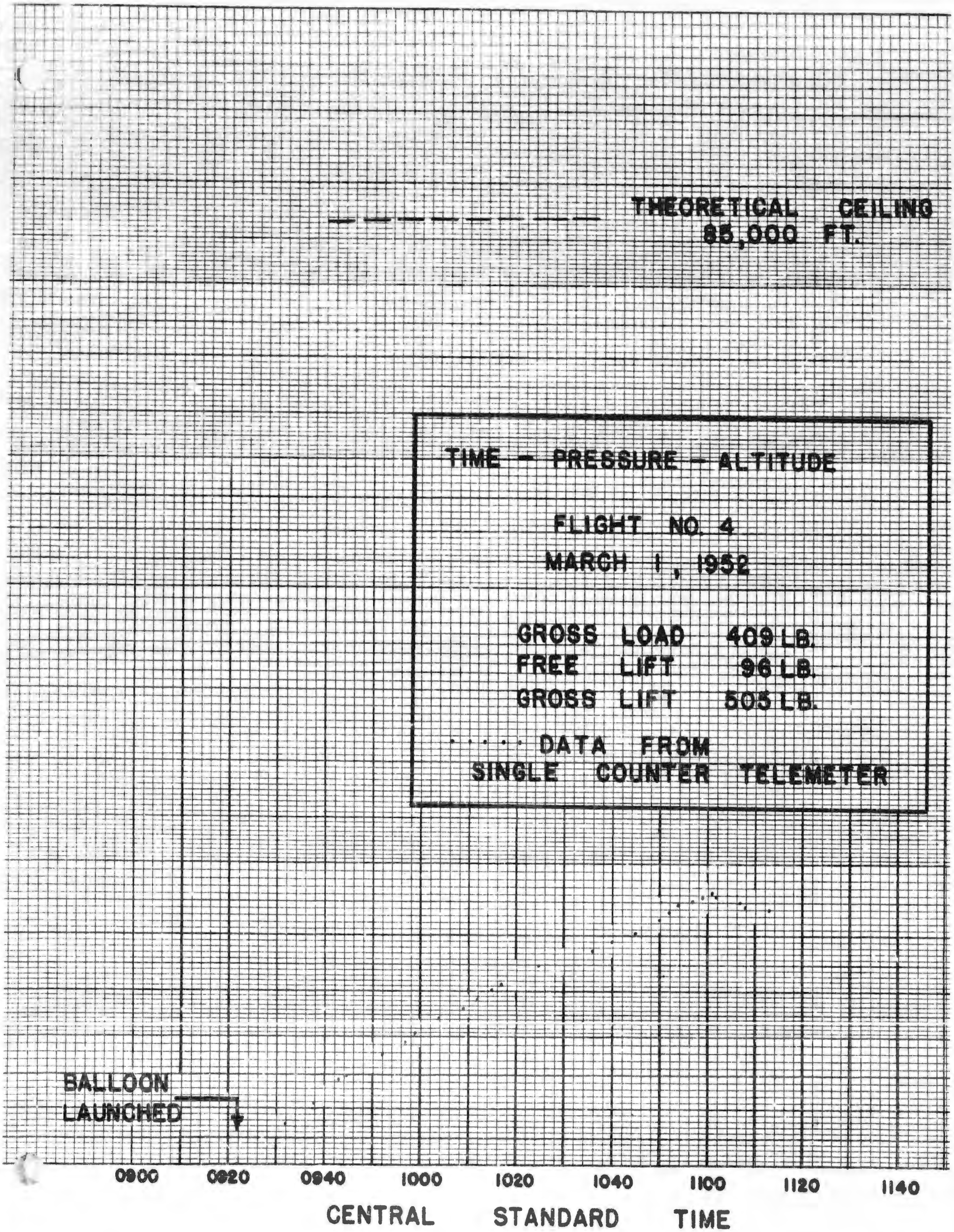


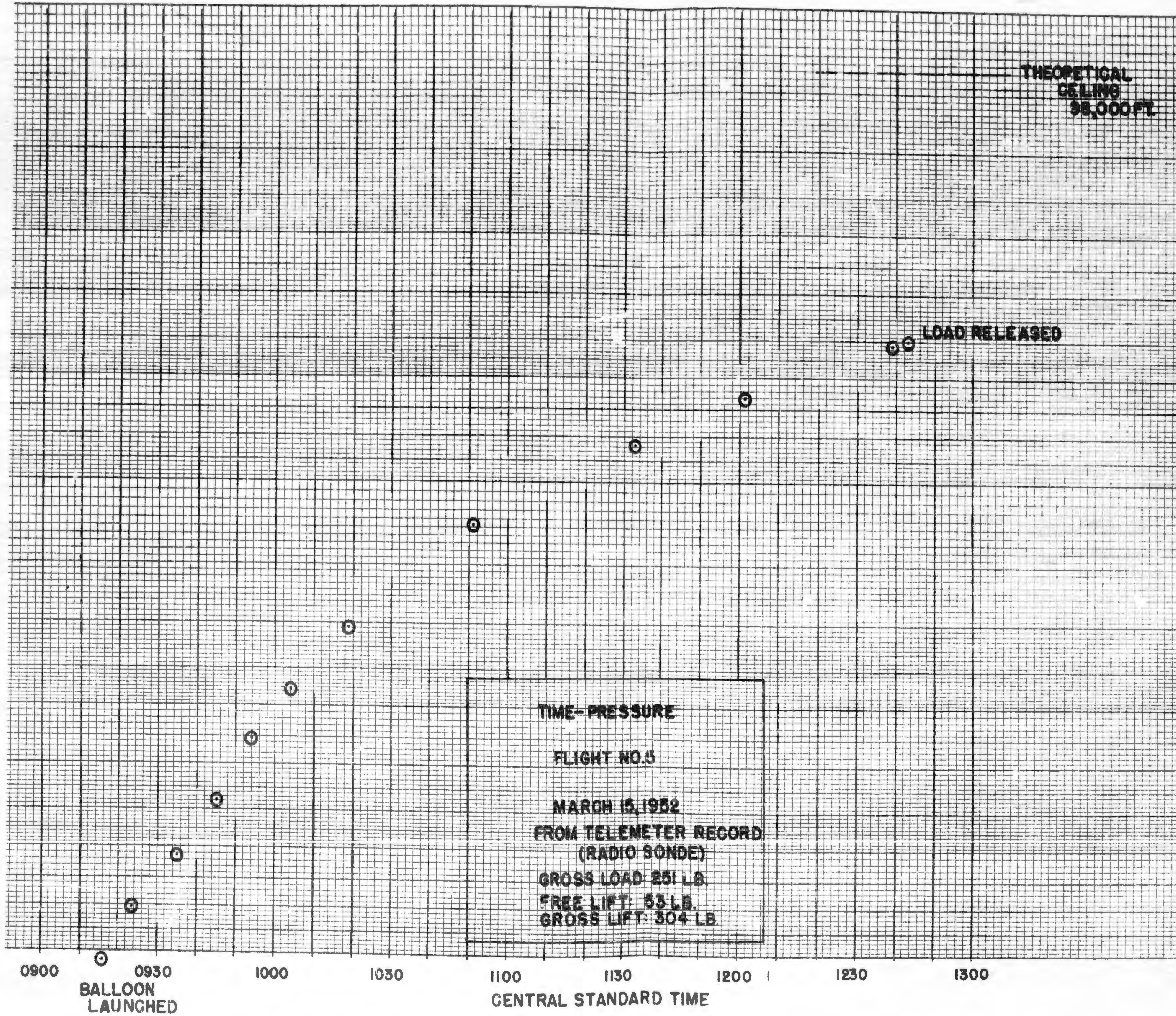
FLIGHT NO. 19
Launched 1313 CST
10 JUNE , 1952

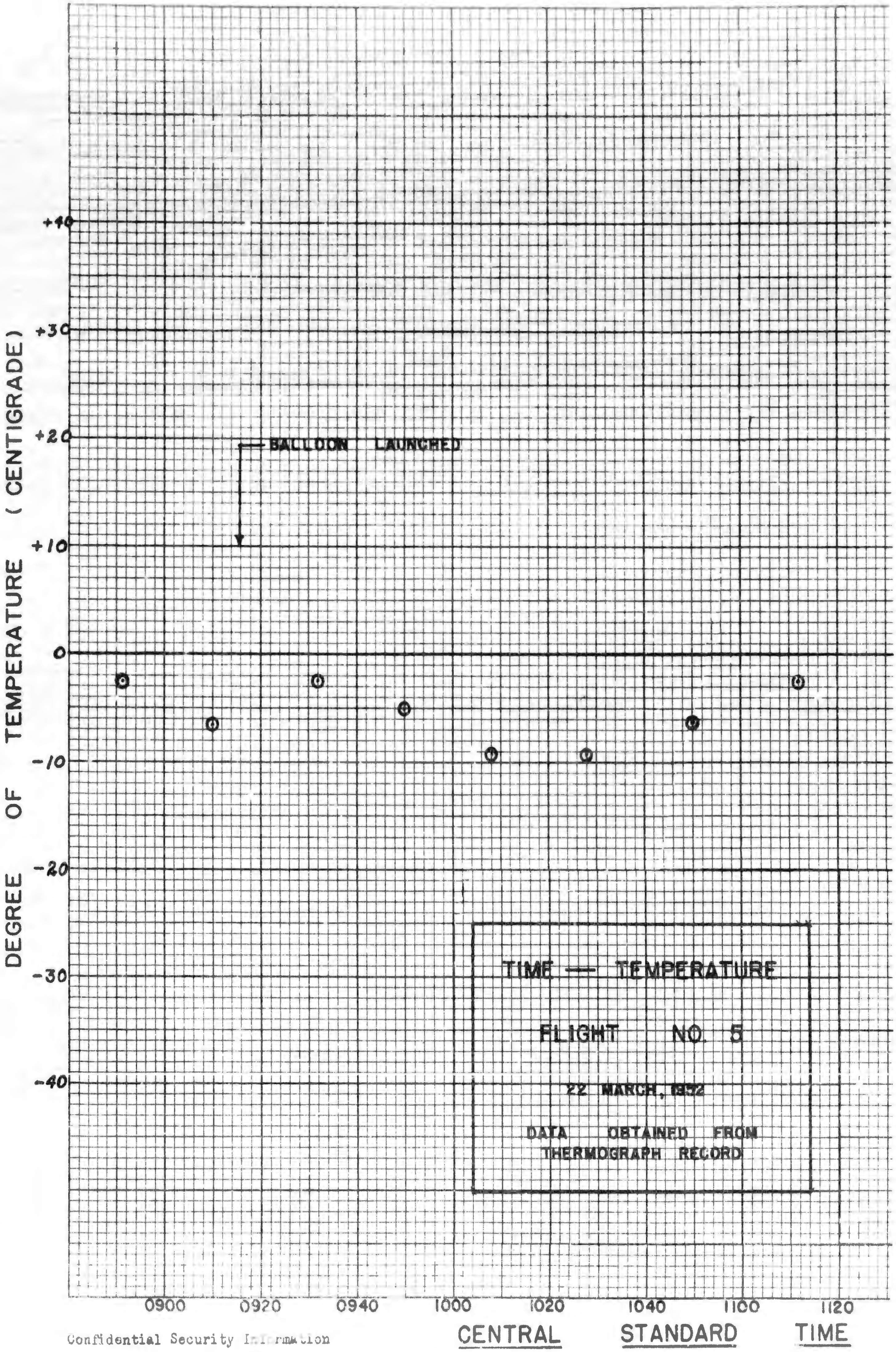
TRAJECTORY FROM THEODOLITE FIXES

SCALE $1:5 \times 10^5$

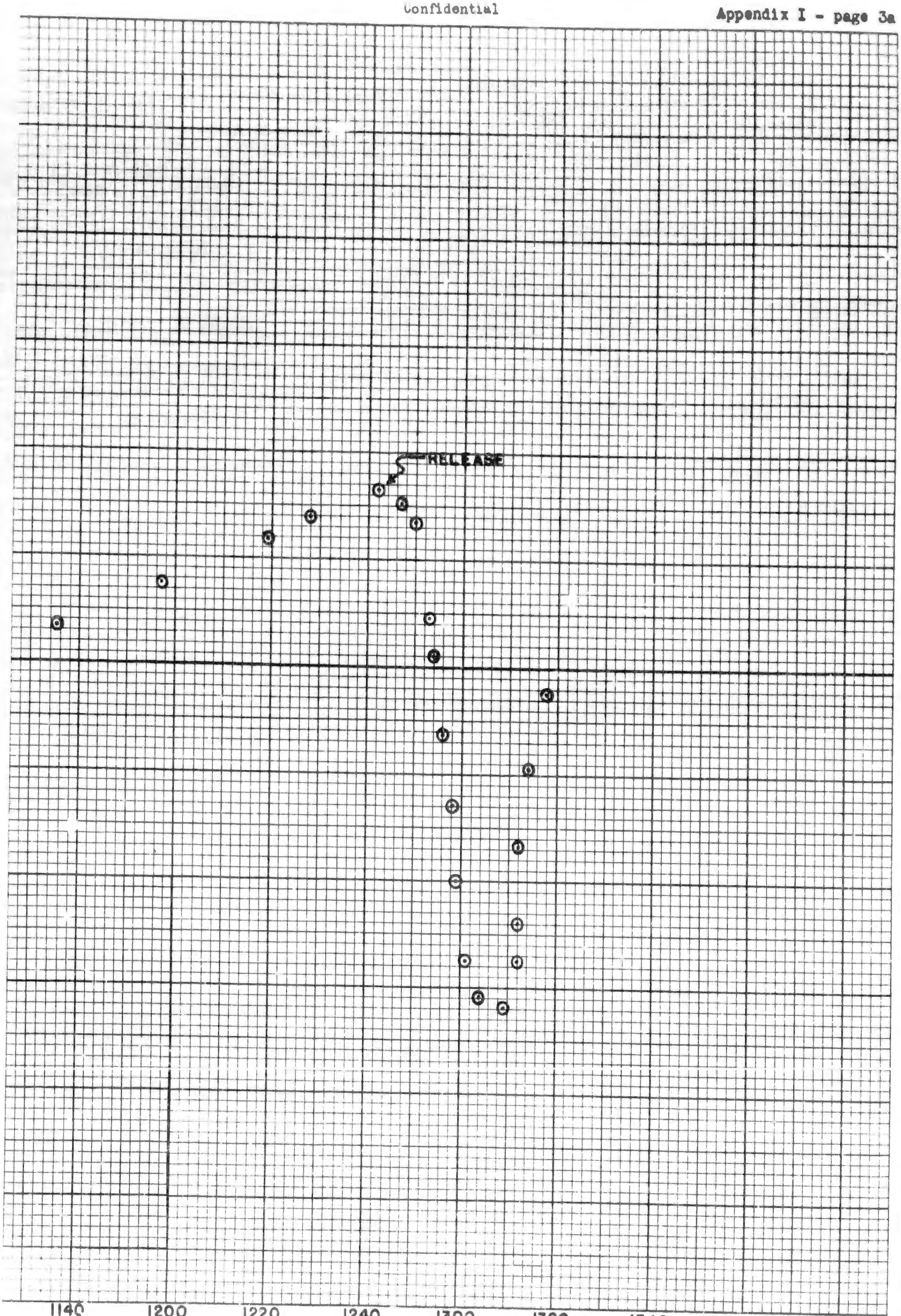

Launched at :
MINNEAPOLIS, MINN.
N
PRESSURE ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
FLIGHT NO. 20
Launched 1300 CST
12 JUNE, 1952
TRAJECTORY FROM THEODOLITE FIXES
SCALE 1:5 x 10^5
4.5
1308
1316
23.9
1330
1345
51.9
1400
1415
64.7
1430
1445
85.6
1500
1515
85.4
1530
83.0
1600
1615
79.7
1630
1645
74.8
1700
1715
70.7
1730
1745
77.0
1800
1815
77.6
1830
1845
78.0
1900
1915
77.0
1935

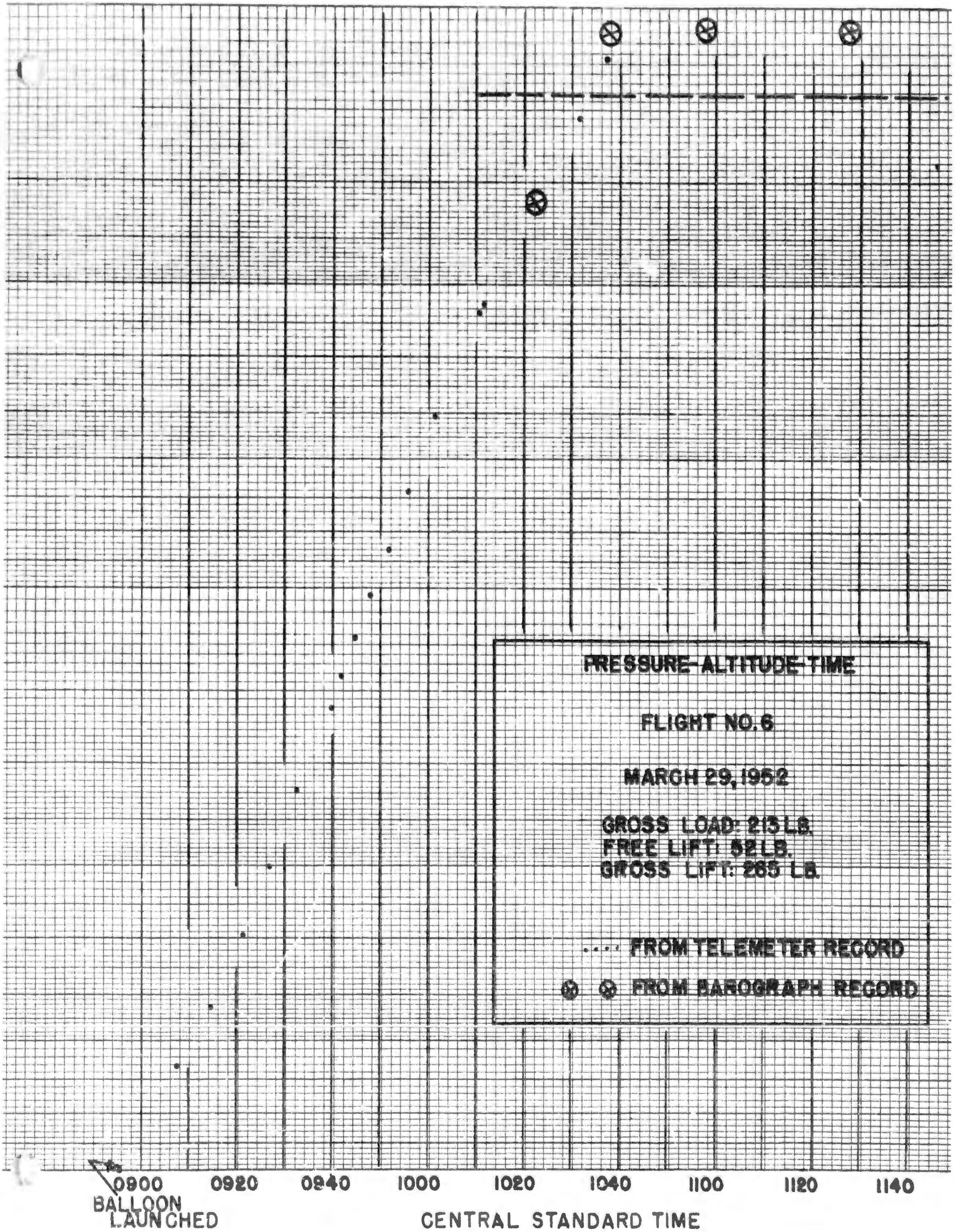

THEORETICAL CEILING
85,000 FT.
TIME - PRESSURE - ALTITUDE
FLIGHT NO. 4
MARCH 1, 1952
GROSS LOAD 409 LB.
FREE LIFT 96 LB.
GROSS LIFT 505 LB.
DATA FROM
SINGLE COUNTER TELEMETER
BALLOON
LAUNCHED
0900
0920
0940
1000
1020
1040
1100
1120
1140
CENTRAL STANDARD TIME

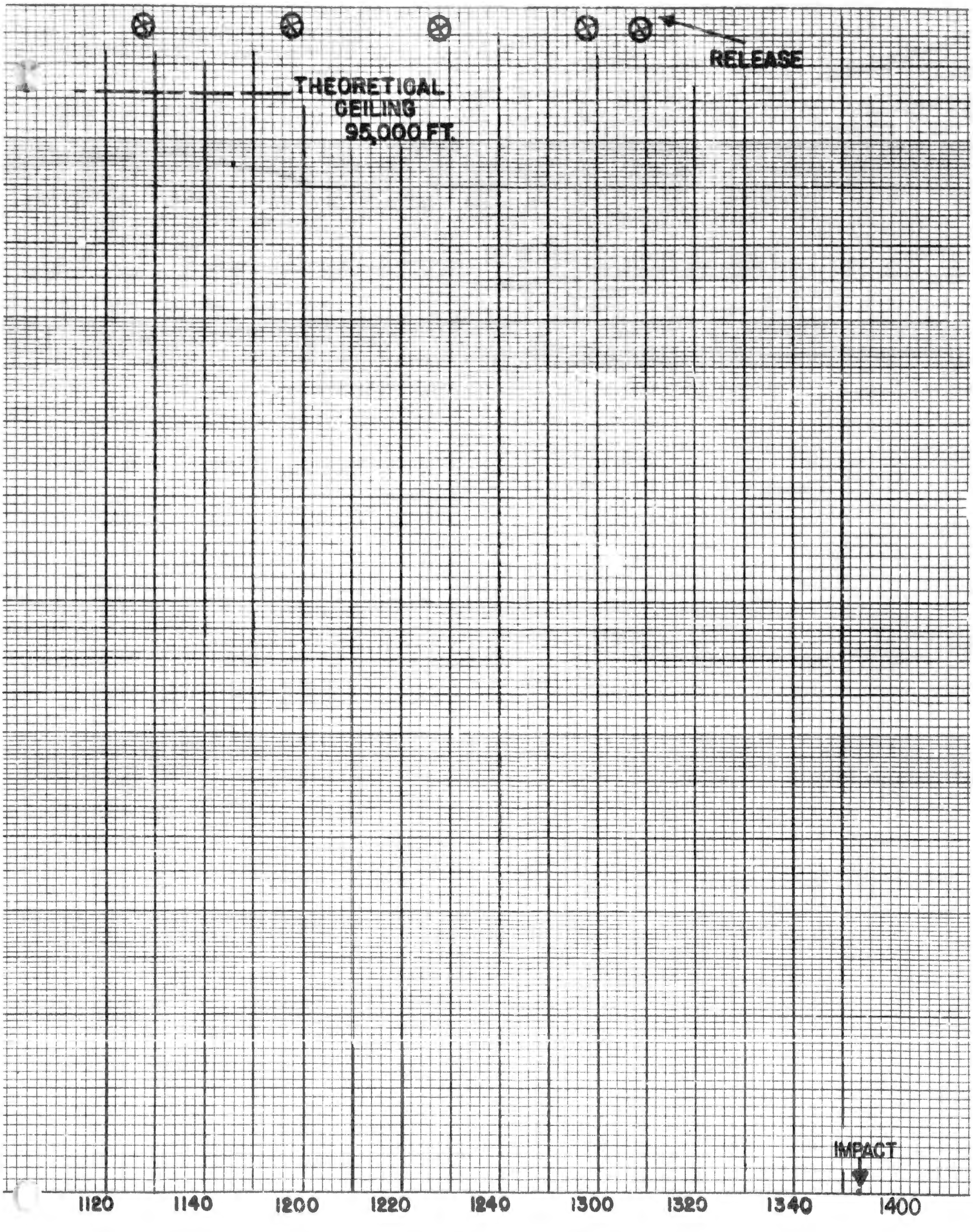

THEORETICAL CEILING 98,000 FT.
LOAD RELEASED
TIME-PRESSURE
FLIGHT NO.5
MARCH 15, 1952
FROM TELEMETER RECORD
(RADIO SONDE)
GROSS LOAD: 251 LB.
FREE LIFT: 53 LB.
GROSS LIFT: 304 LB.
0900
0930
1000
1030
1100
1130
1200
1230
1300
BALLOON LAUNCHED
CENTRAL STANDARD TIME

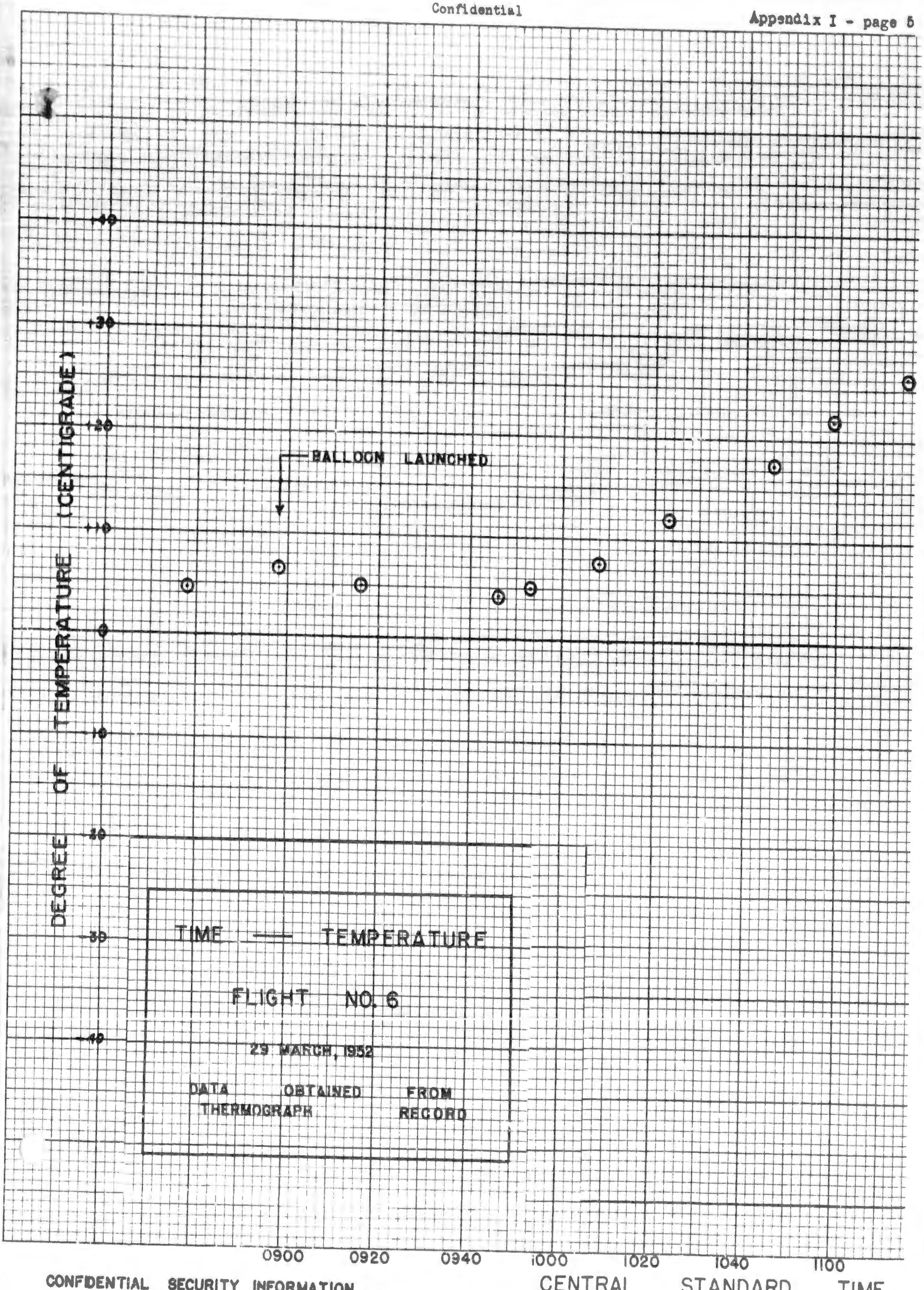


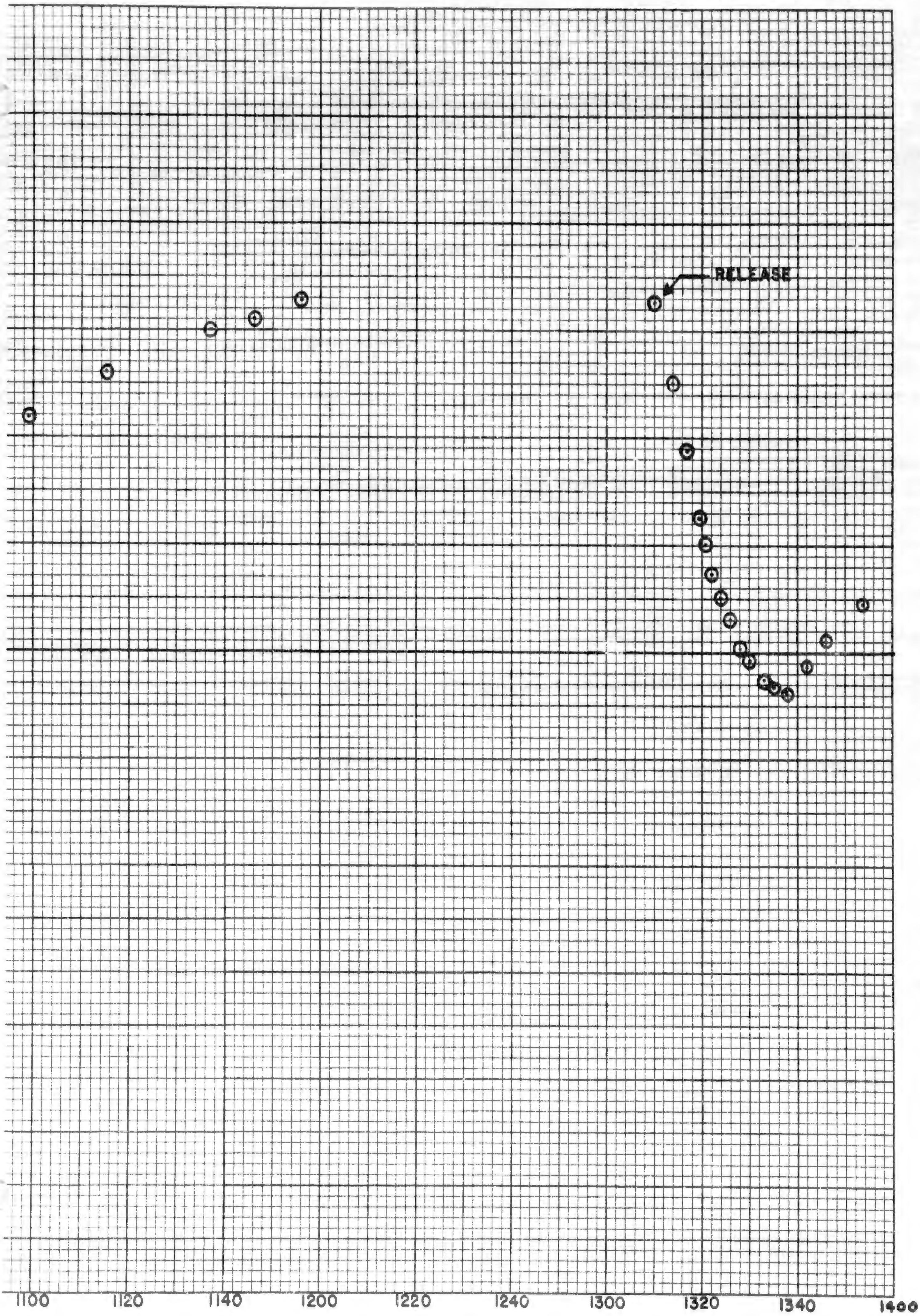
DEGREE OF TEMPERATURE (CENTIGRADE)
+40
+30
+20
+10
0
-10
-20
-30
-40
BALLOON LAUNCHED
TIME — TEMPERATURE
FLIGHT NO. 5
22 MARCH, 1952
DATA OBTAINED FROM THERMOGRAPH RECORD
0900
0920
0940
1000
1020
1040
1100
1120
CENTRAL STANDARD TIME

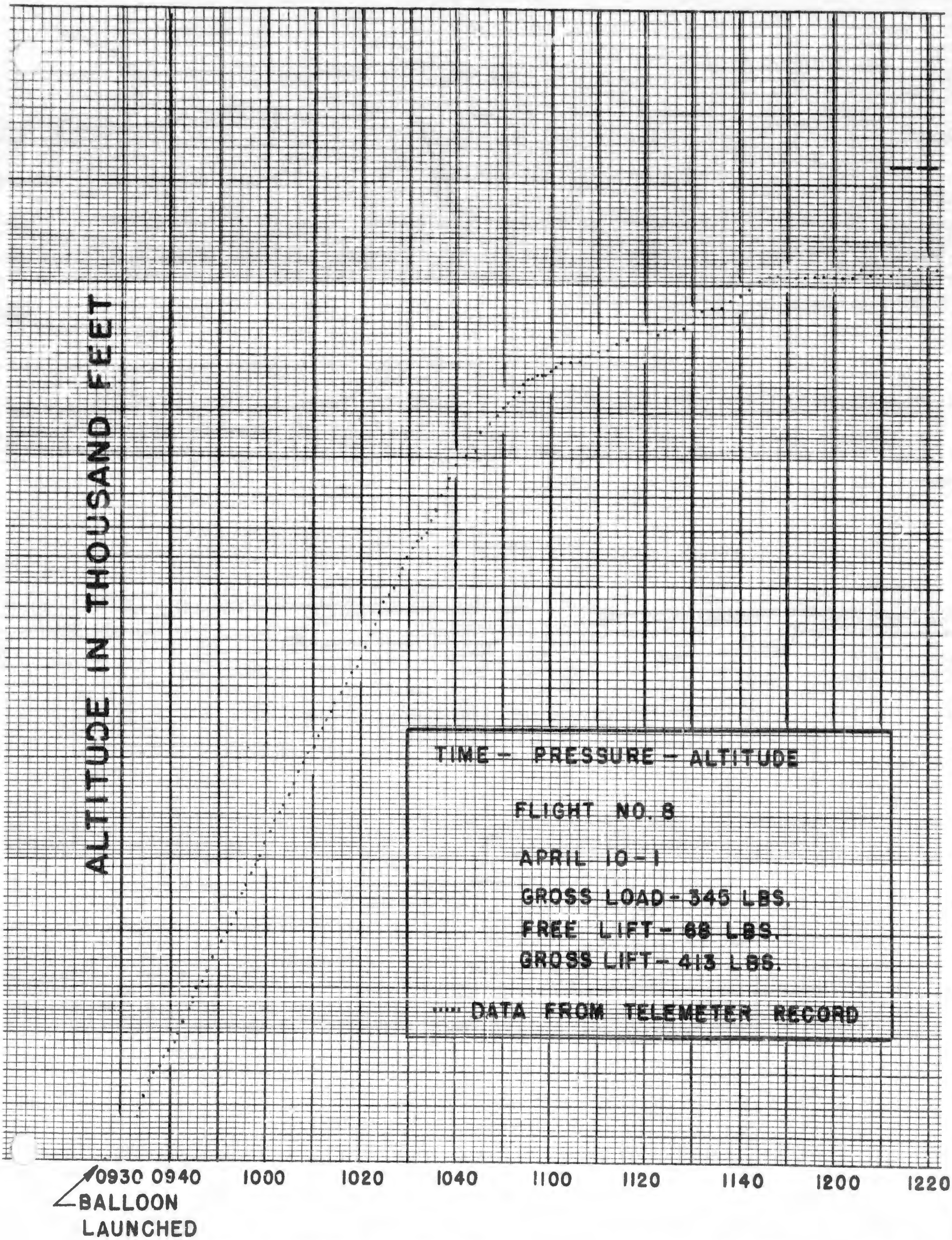

RELEASE
1140
1200
1220
1240
1300
1320
1340
1400

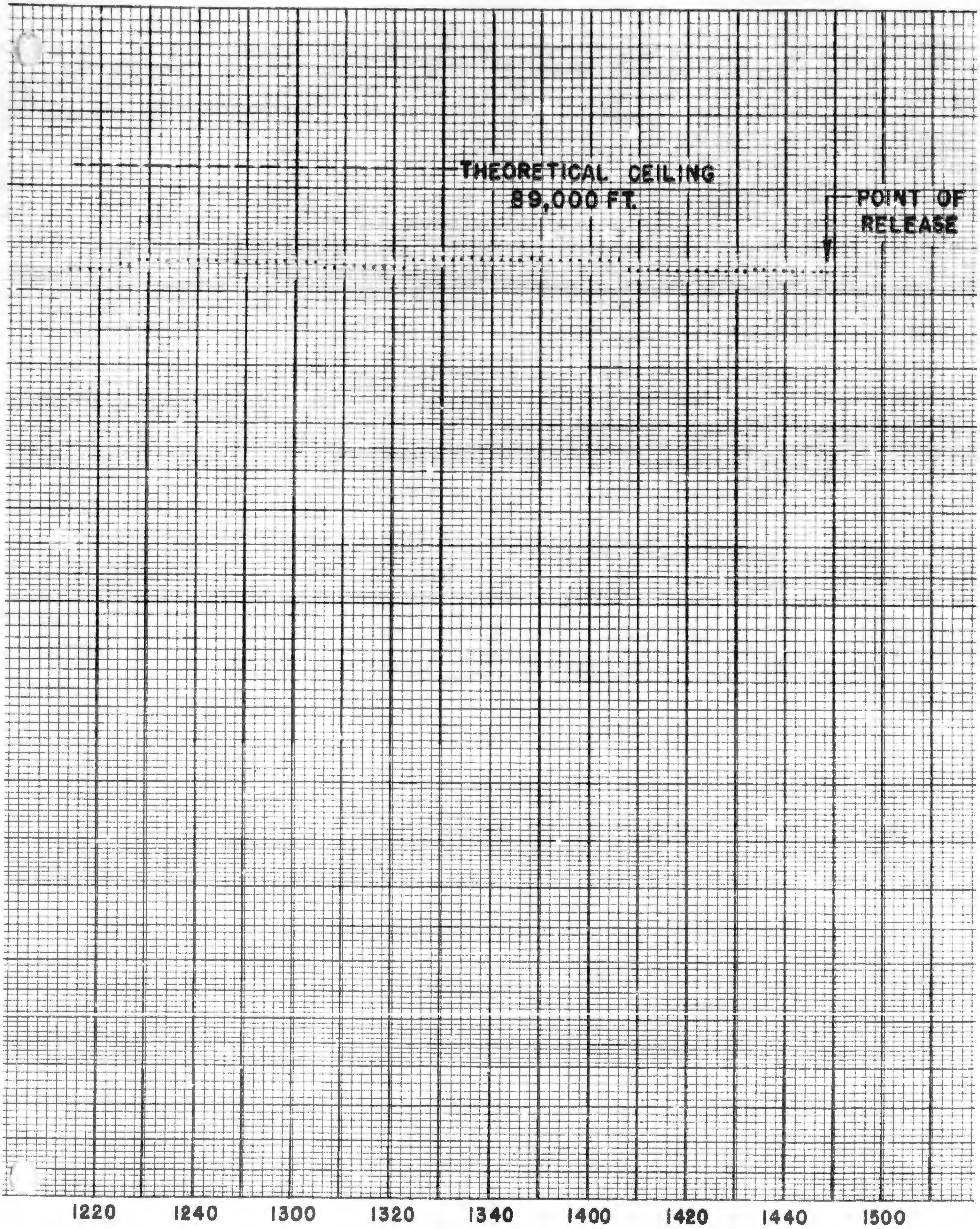

PRESSURE-ALTITUDE-TIME
FLIGHT NO. 6
MARCH 29, 1952
GROSS LOAD: 213 LB.
FREE LIFT: 52 LB.
GROSS LIFT: 265 LB.
.... FROM TELEMETER RECORD
⊗ ⊗ FROM BAROGRAPH RECORD
0900
0920
0940
1000
1020
1040
1100
1120
1140
BALLOON LAUNCHED
CENTRAL STANDARD TIME

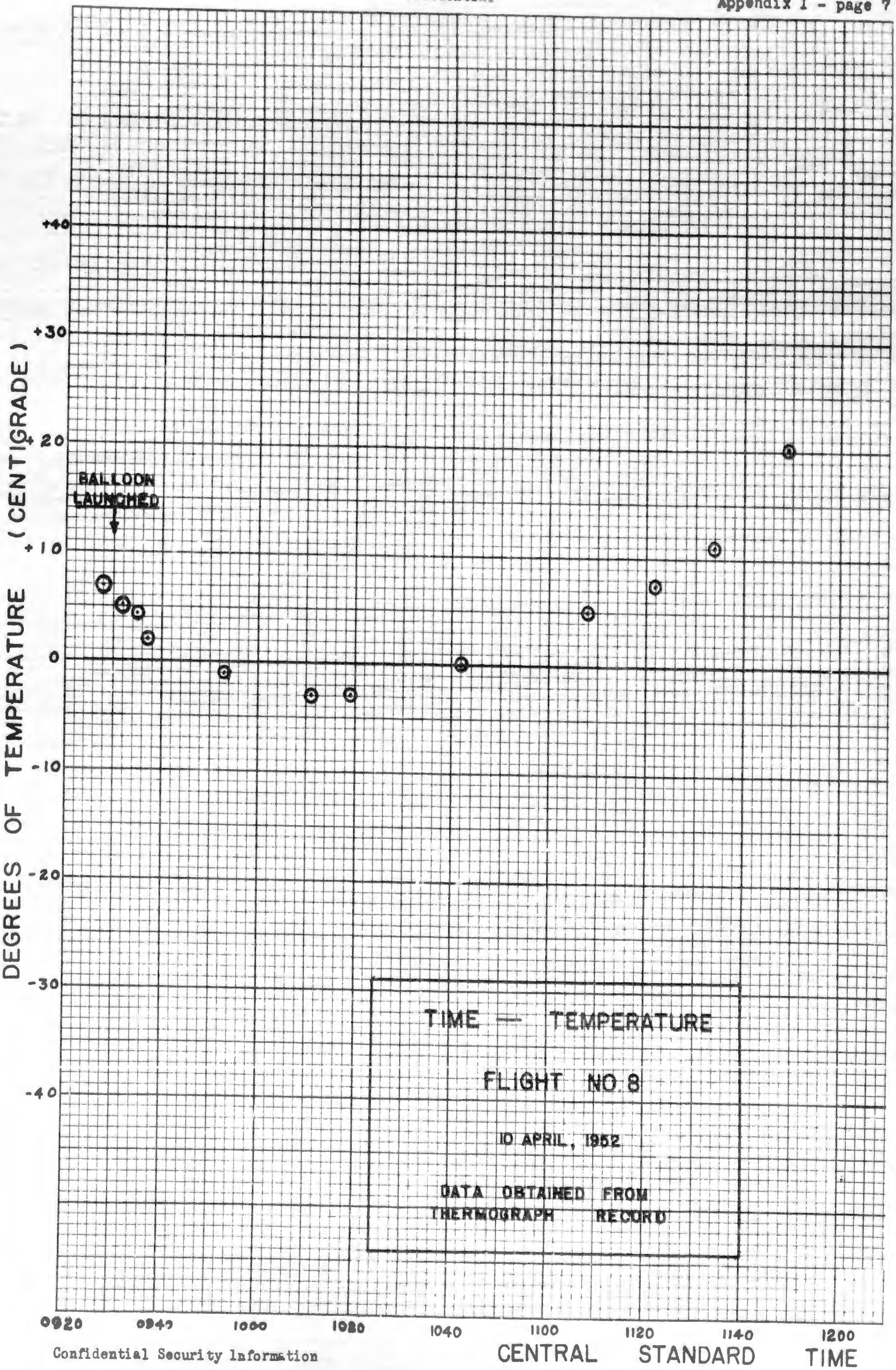

RELEASE
THEORETICAL CEILING 95,000 FT.
IMPACT
1120
1140
1200
1220
1240
1300
1320
1340
1400

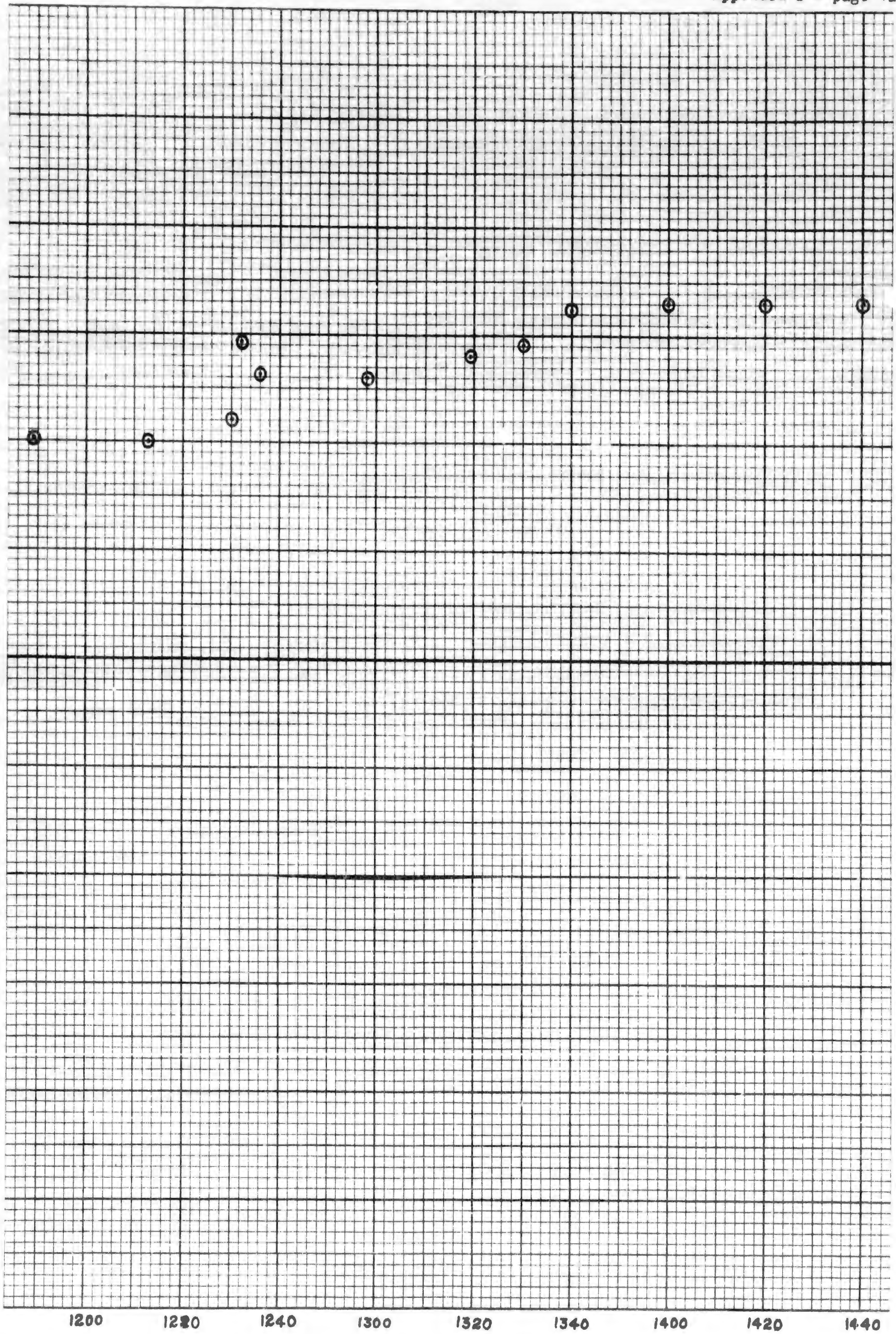

+40
+30
+20
+10
0
-10
-20
-30
-40
DEGREE OF TEMPERATURE (CENTIGRADE)
BALLOON LAUNCHED
TIME — TEMPERATURE
FLIGHT NO. 6
29 MARCH, 1952
DATA OBTAINED FROM THERMOGRAPH RECORD
0900
0920
0940
1000
1020
1040
1100
CENTRAL STANDARD TIME

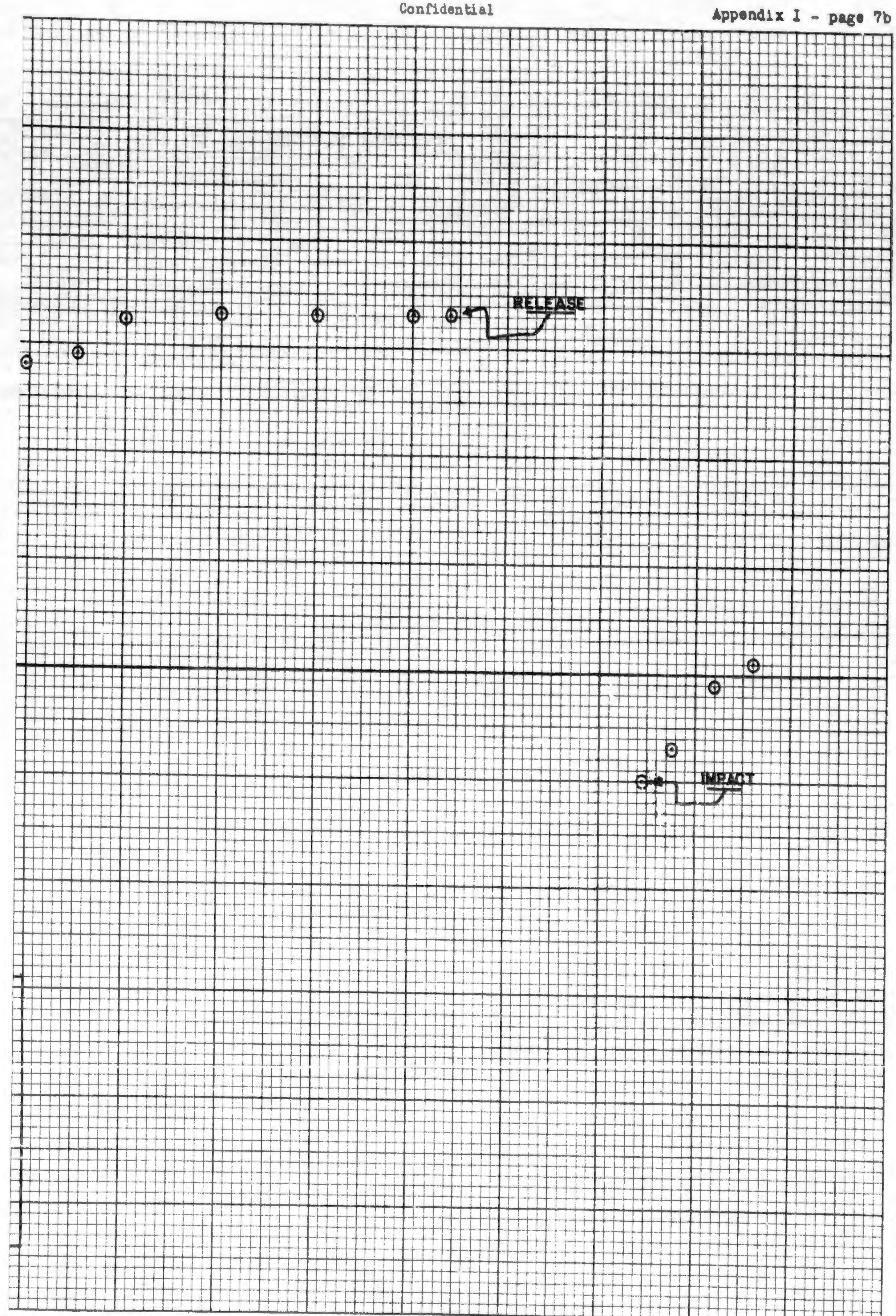

RELEASE
1100
1120
1140
1160
1200
1220
1240
1300
1320
1340
1400

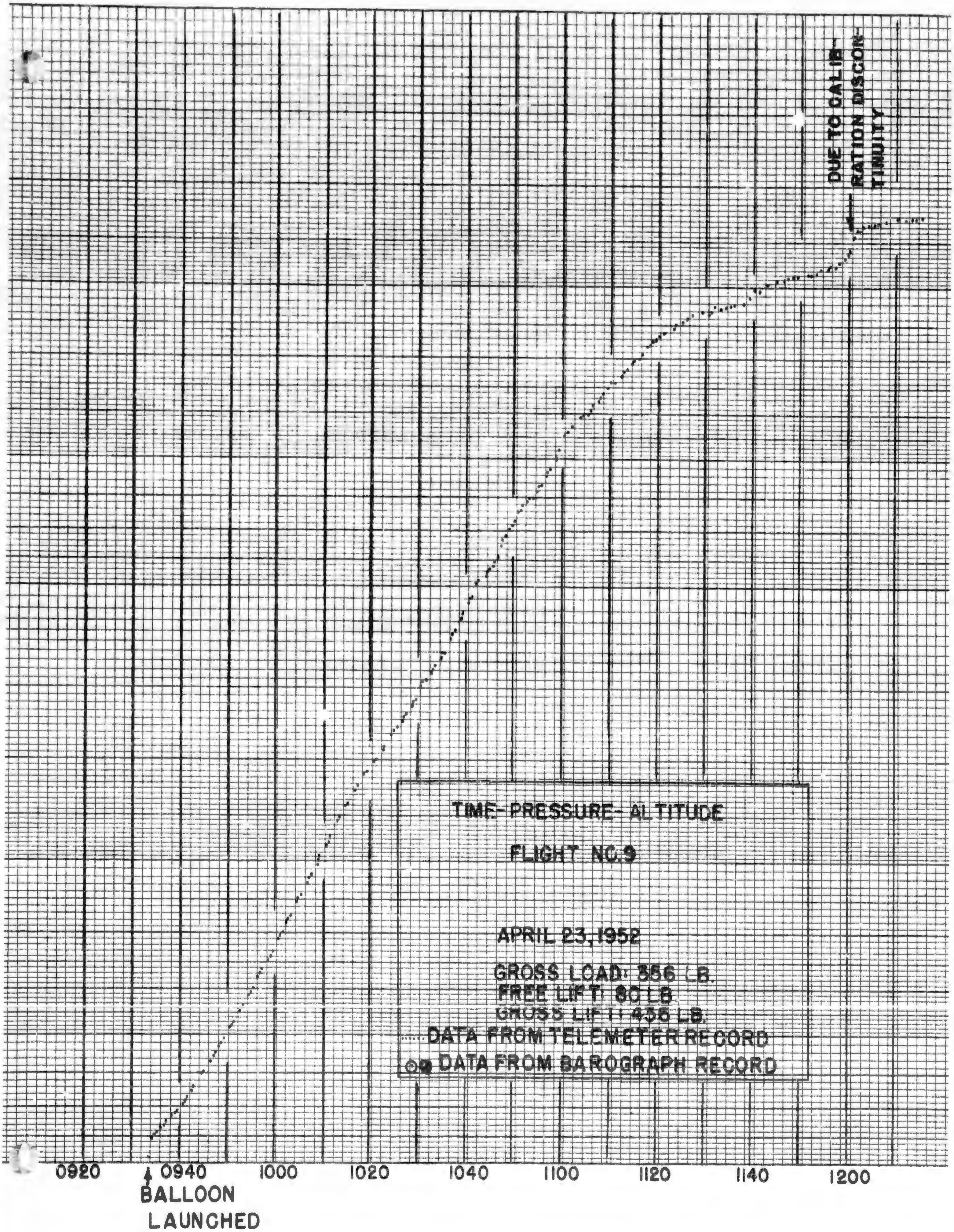

ALTITUDE IN THOUSAND FEET
TIME - PRESSURE - ALTITUDE
FLIGHT NO. 8
APRIL 10-1
GROSS LOAD - 345 LBS.
FREE LIFT - 68 LBS.
GROSS LIFT - 413 LBS.
····· DATA FROM TELEMETER RECORD
0930 0940 1000 1020 1040 1100 1120 1140 1200 1220
BALLOON LAUNCHED
CENTRAL STANDARD TIME

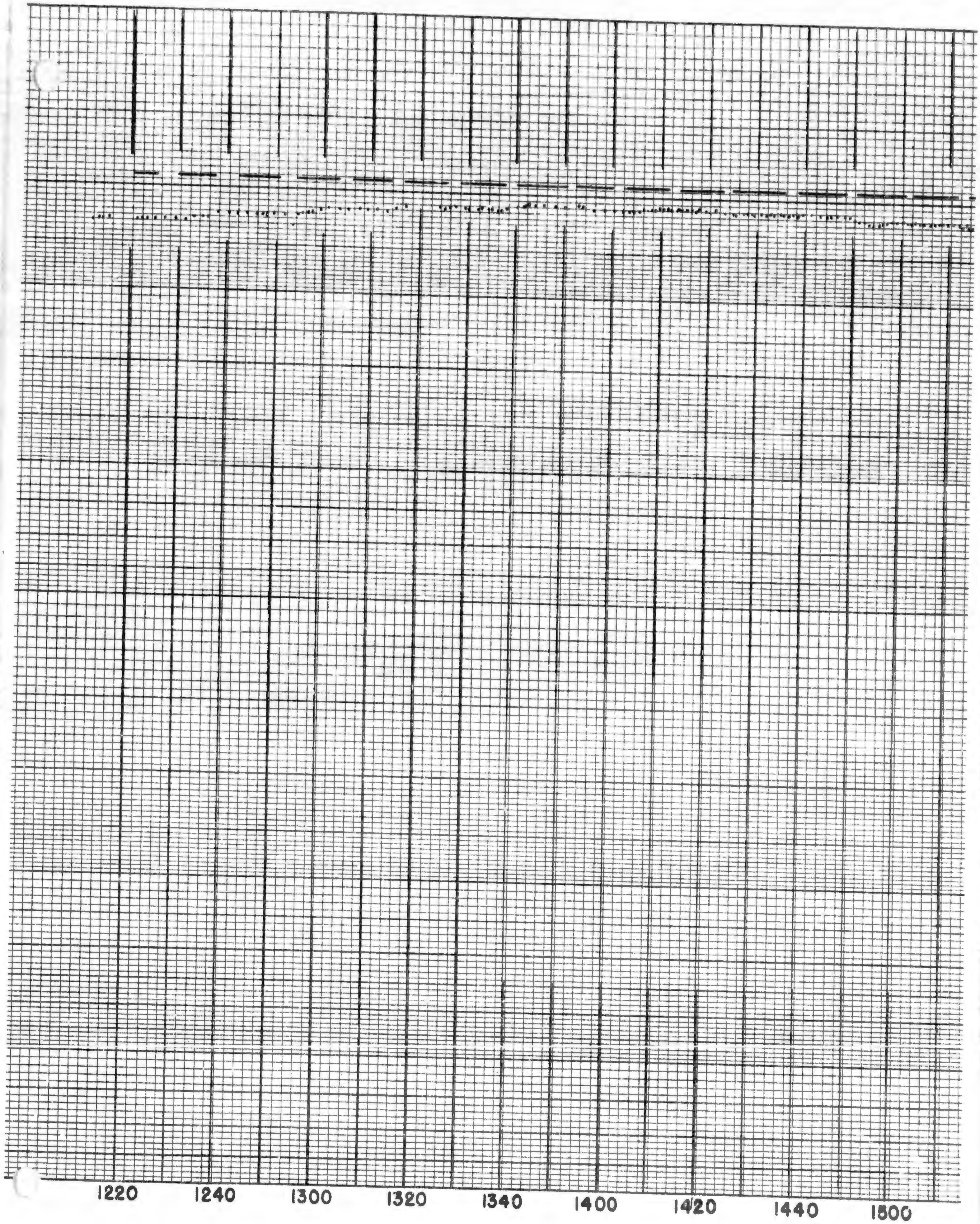

THEORETICAL CEILING
89,000 FT.
POINT OF
RELEASE
1220
1240
1300
1320
1340
1400
1420
1440
1500

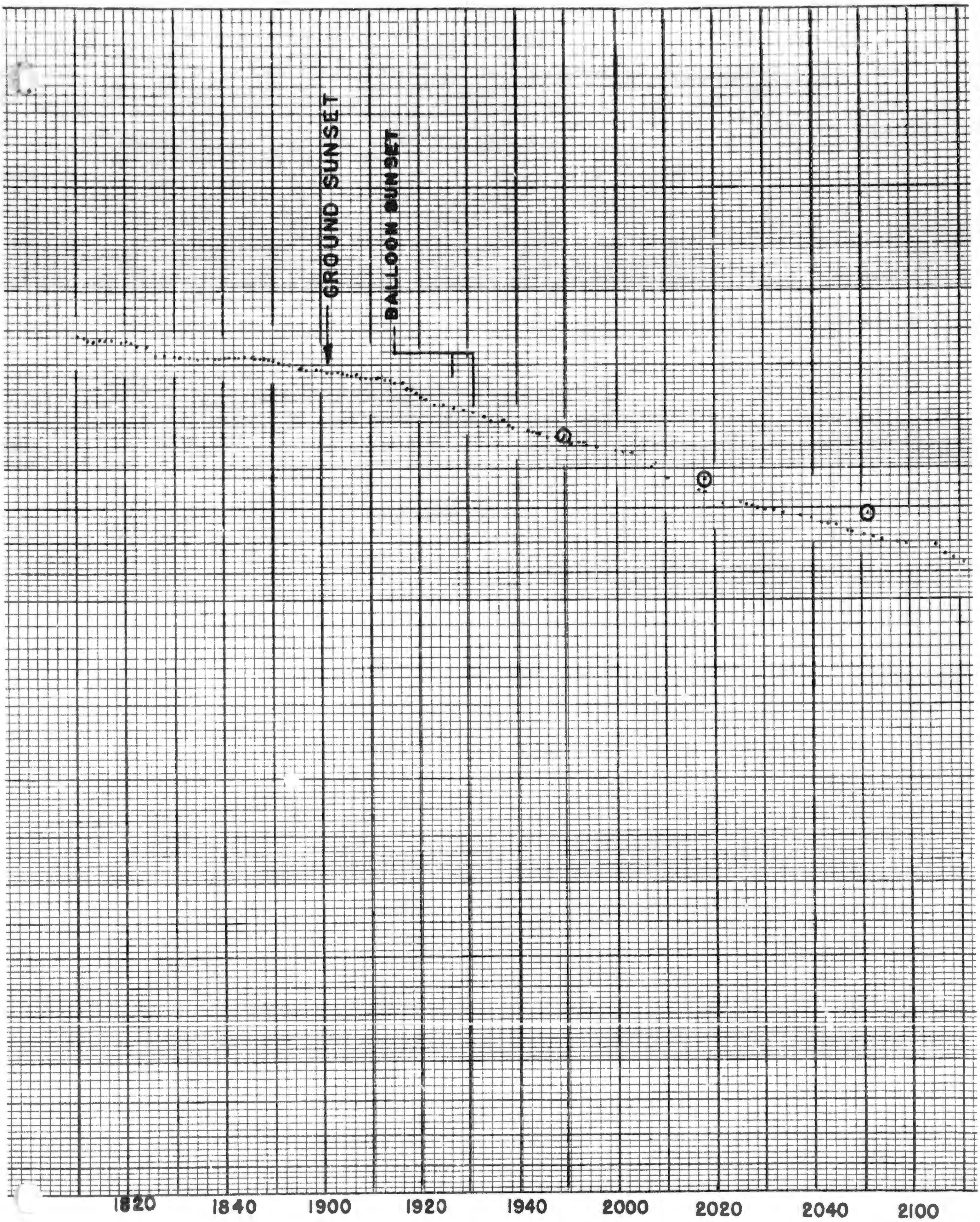

+40
+30
+20
+10
0
-10
-20
-30
-40
DEGREES OF TEMPERATURE (CENTIGRADE)
BALLOON LAUNCHED
TIME — TEMPERATURE
FLIGHT NO. 8
10 APRIL, 1952
DATA OBTAINED FROM THERMOGRAPH RECORD
0920
0940
1000
1020
1040
1100
1120
1140
1200
CENTRAL STANDARD TIME

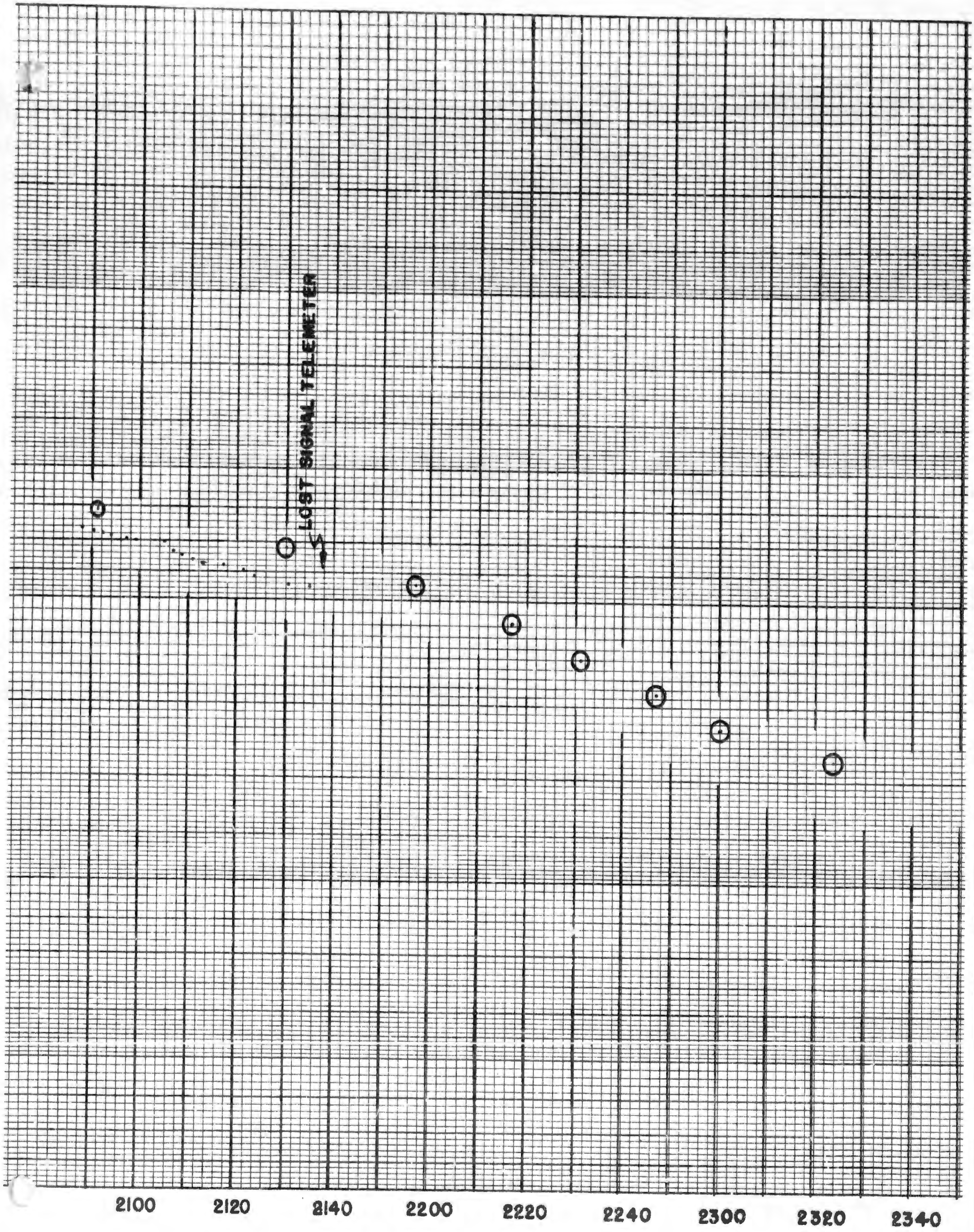

1200
1220
1240
1300
1320
1340
1400
1420
1440

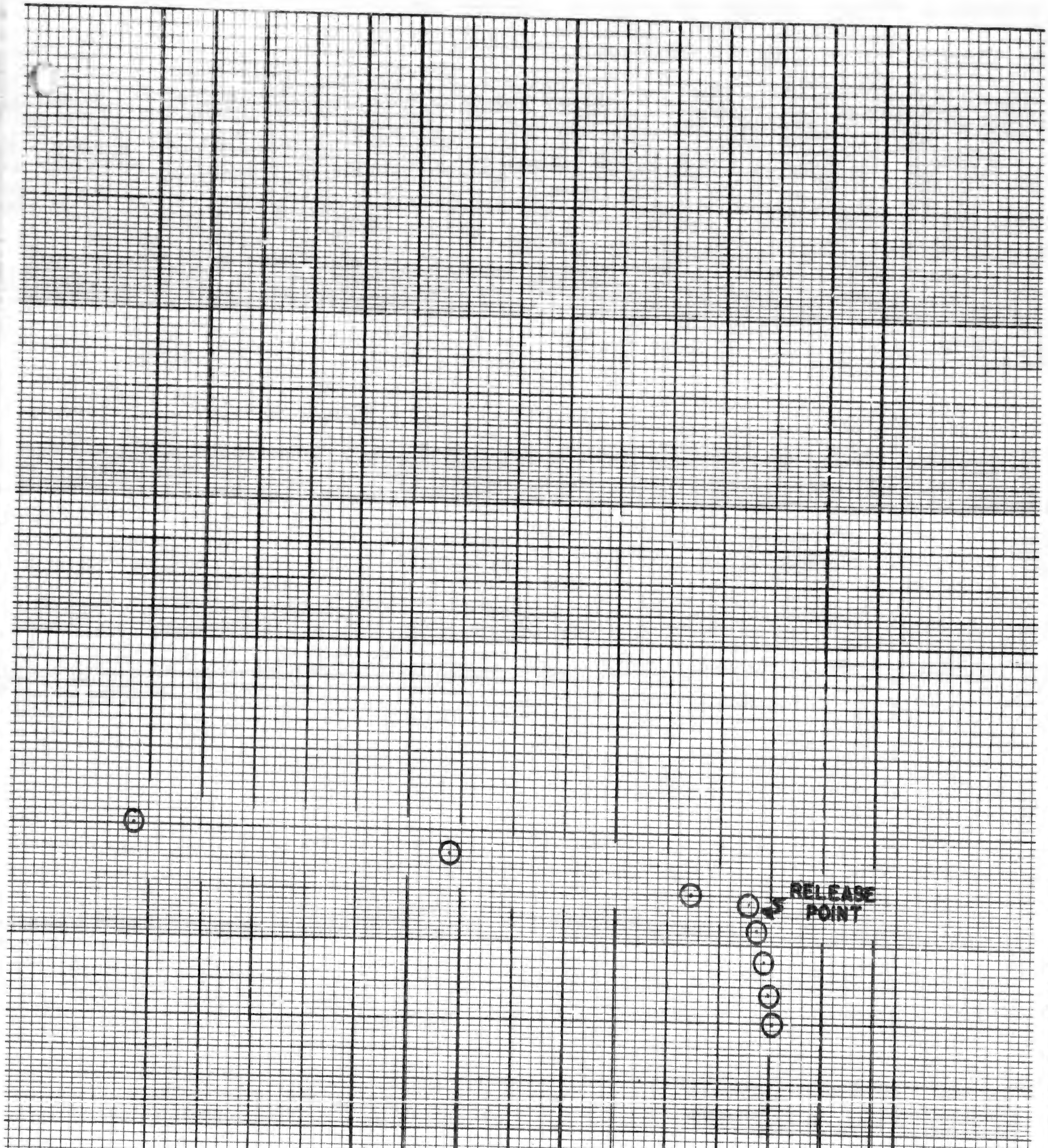

RELEASE
IMPACT
1320
1340
1400
1420
1440
1500
1520
1540
1600

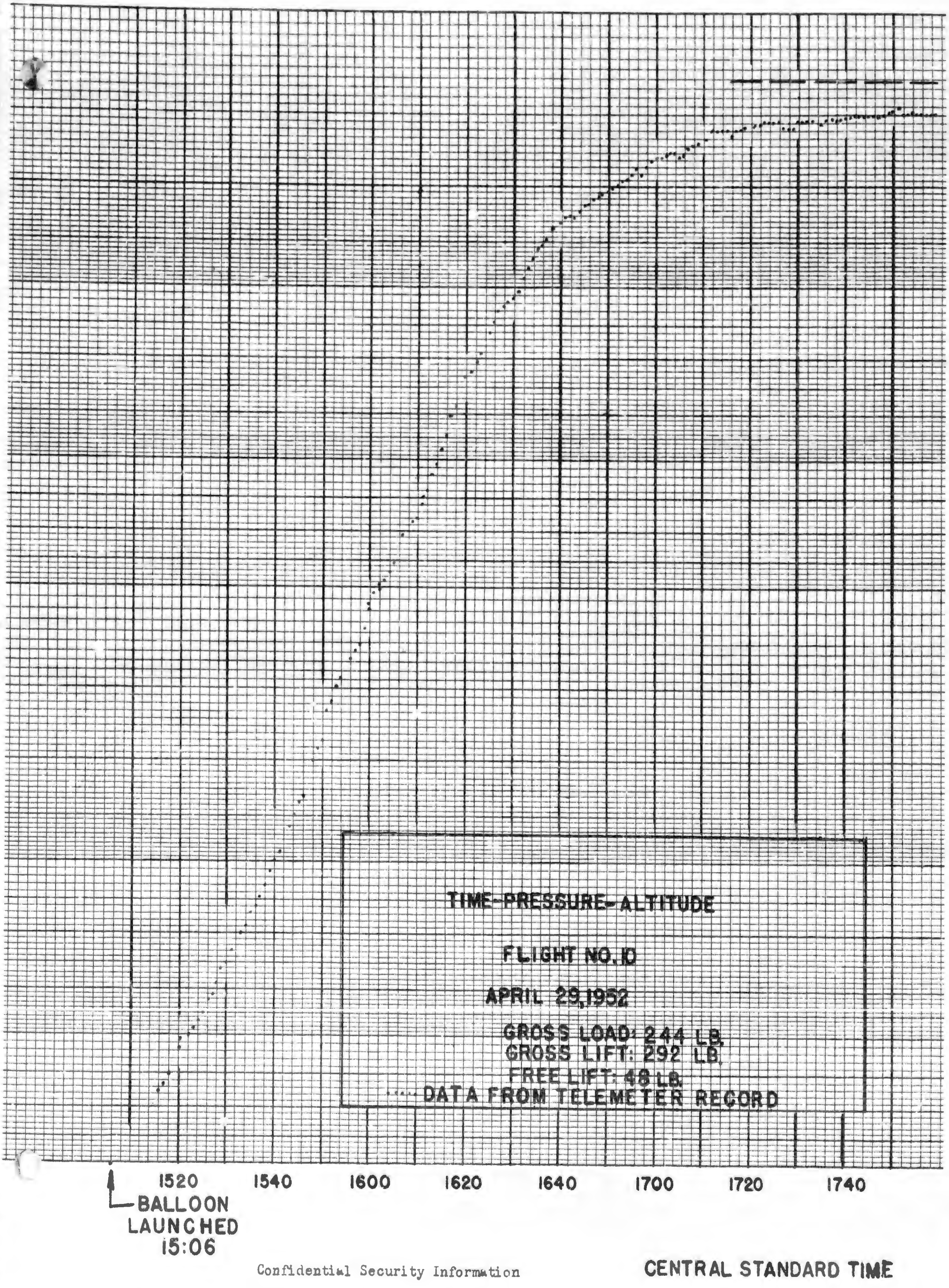

DUE TO CALIB-
RATION DISCON-
TINUITY
TIME-PRESSURE-ALTITUDE
FLIGHT NO.9
APRIL 23, 1952
GROSS LOAD: 356 LB.
FREE LIFT: 80 LB.
GROSS LIFT: 436 LB.
DATA FROM TELEMETER RECORD
DATA FROM BAROGRAPH RECORD
0920
0940
1000
1020
1040
1100
1120
1140
1200
BALLOON
LAUNCHED
CENTRAL STANDARD TIME

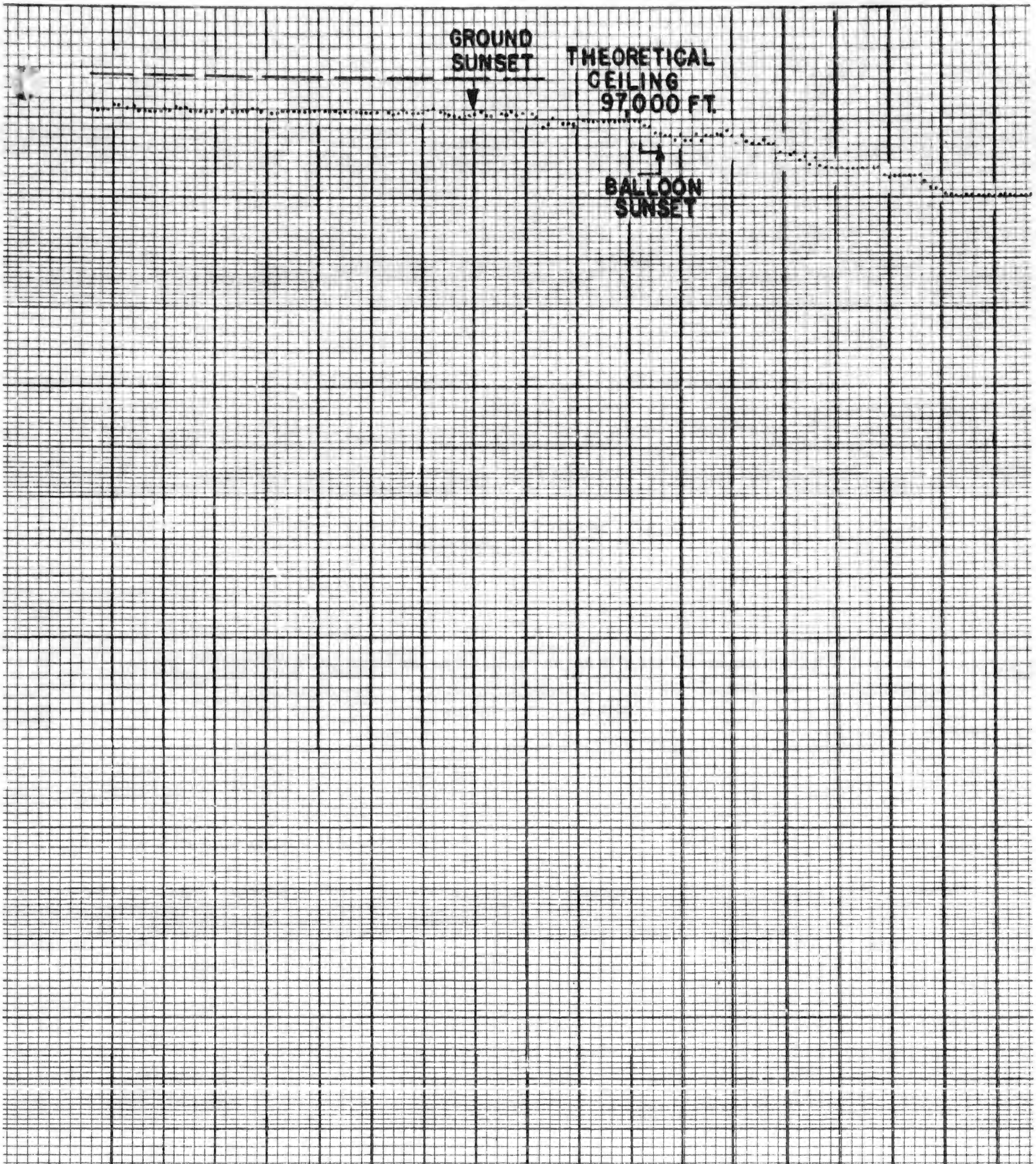

1220
1240
1300
1320
1340
1400
1420
1440
1500

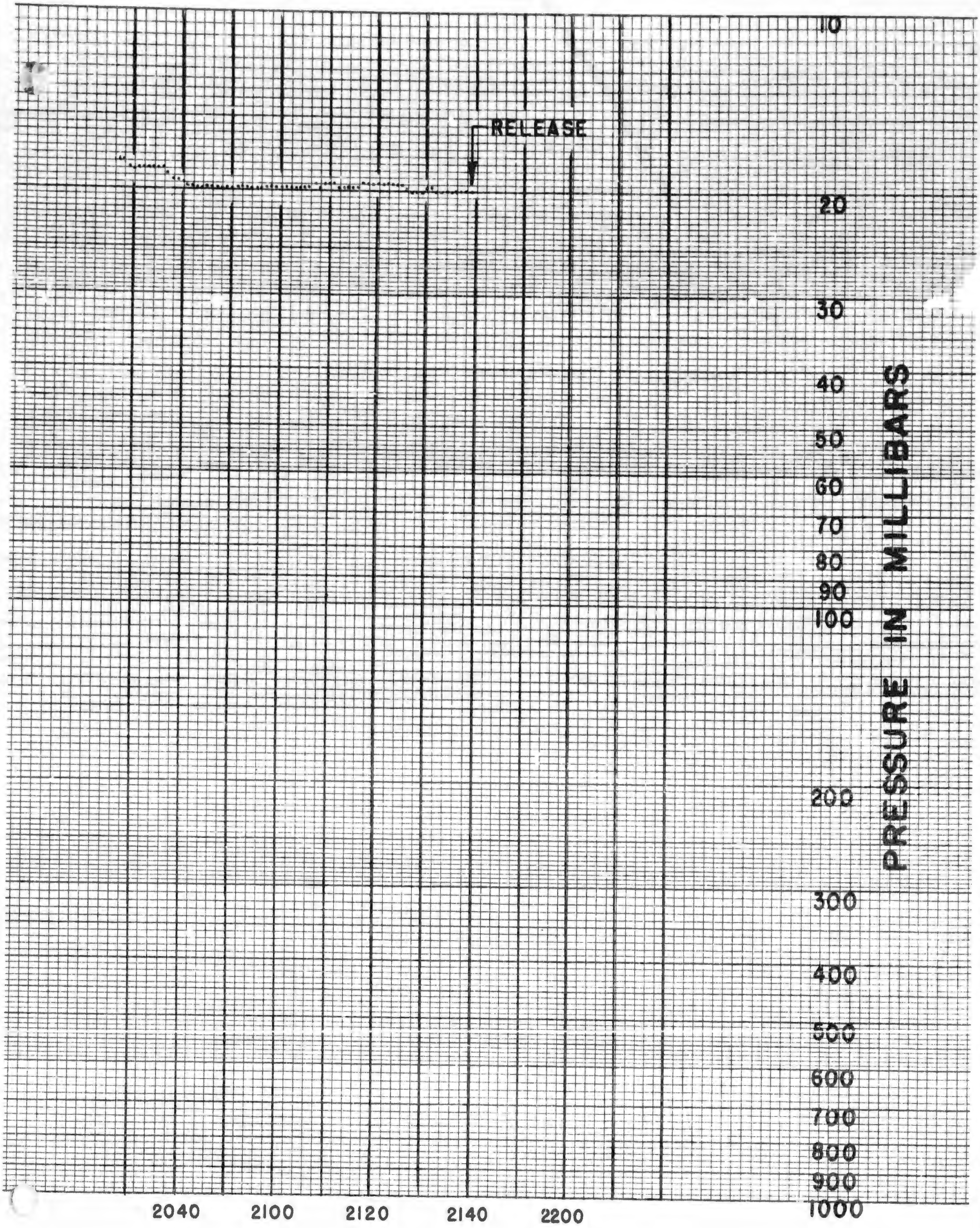

GROUND SUNSET
BALLOON SUNSET
1820
1840
1900
1920
1940
2000
2020
2040
2100

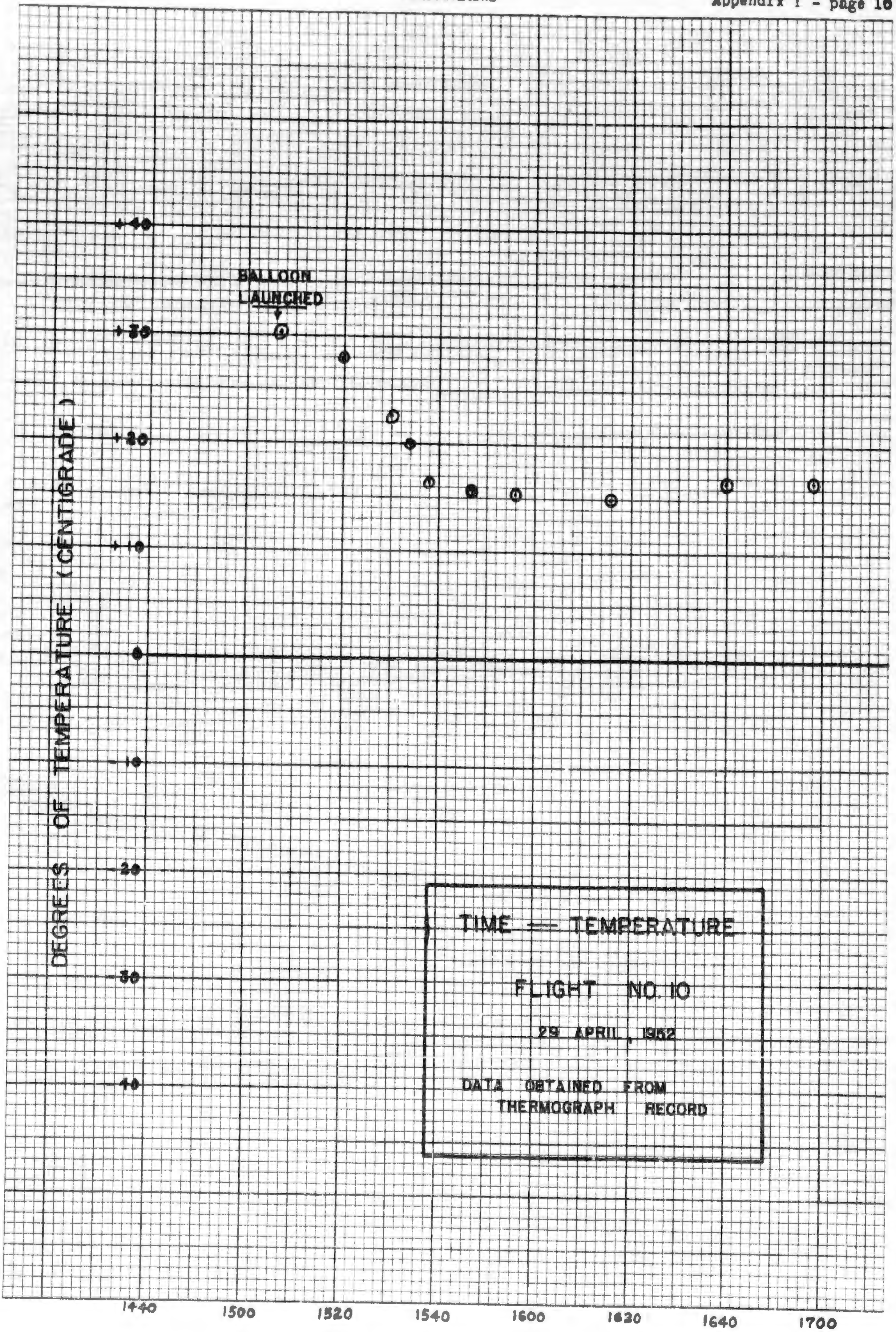

LOST SIGNAL TELEMETER
2100
2120
2140
2200
2220
2240
2300
2320
2340

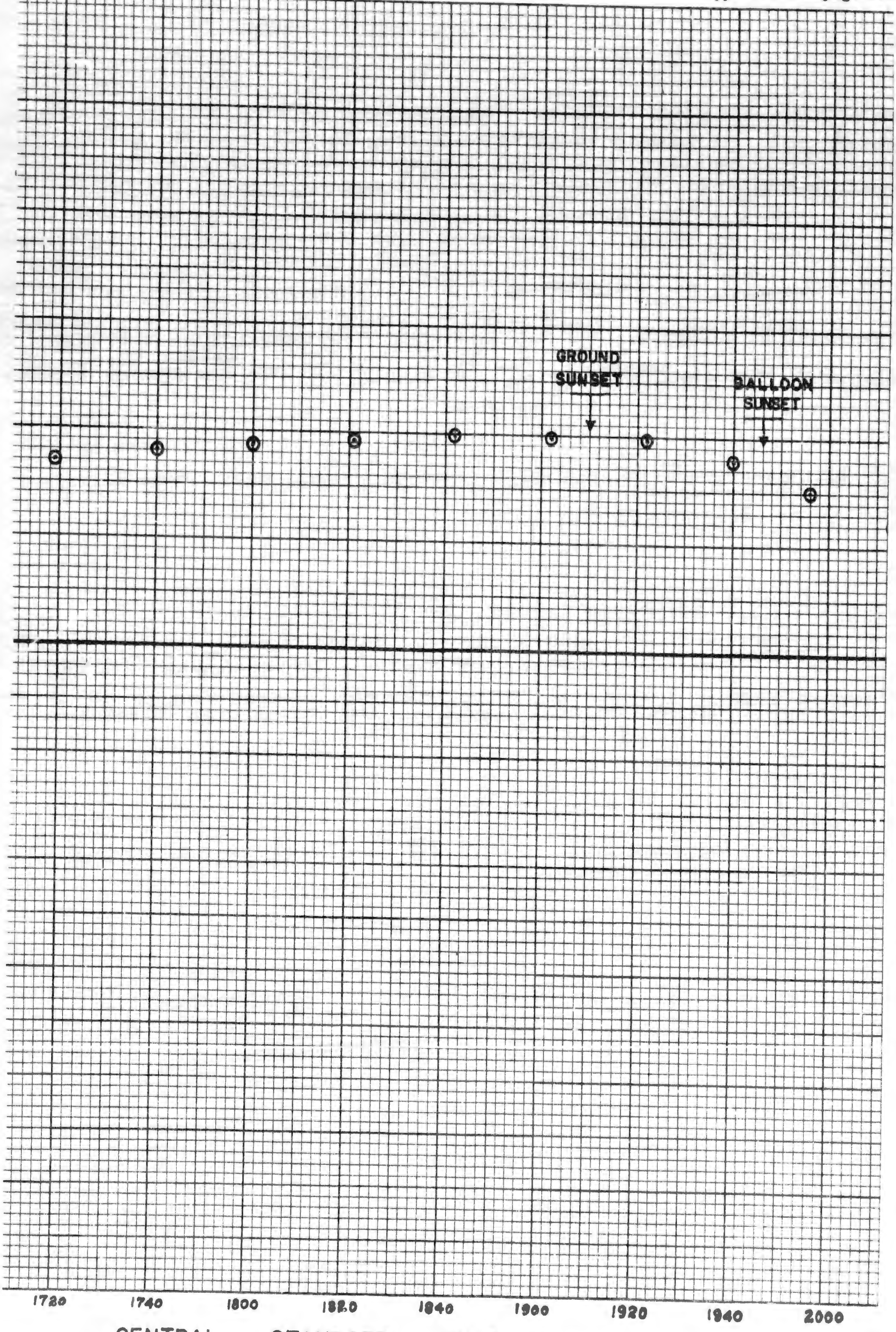

RELEASE POINT
2400
0020
0040
0100
0120
0140
0200
0220
LOAD DOWN

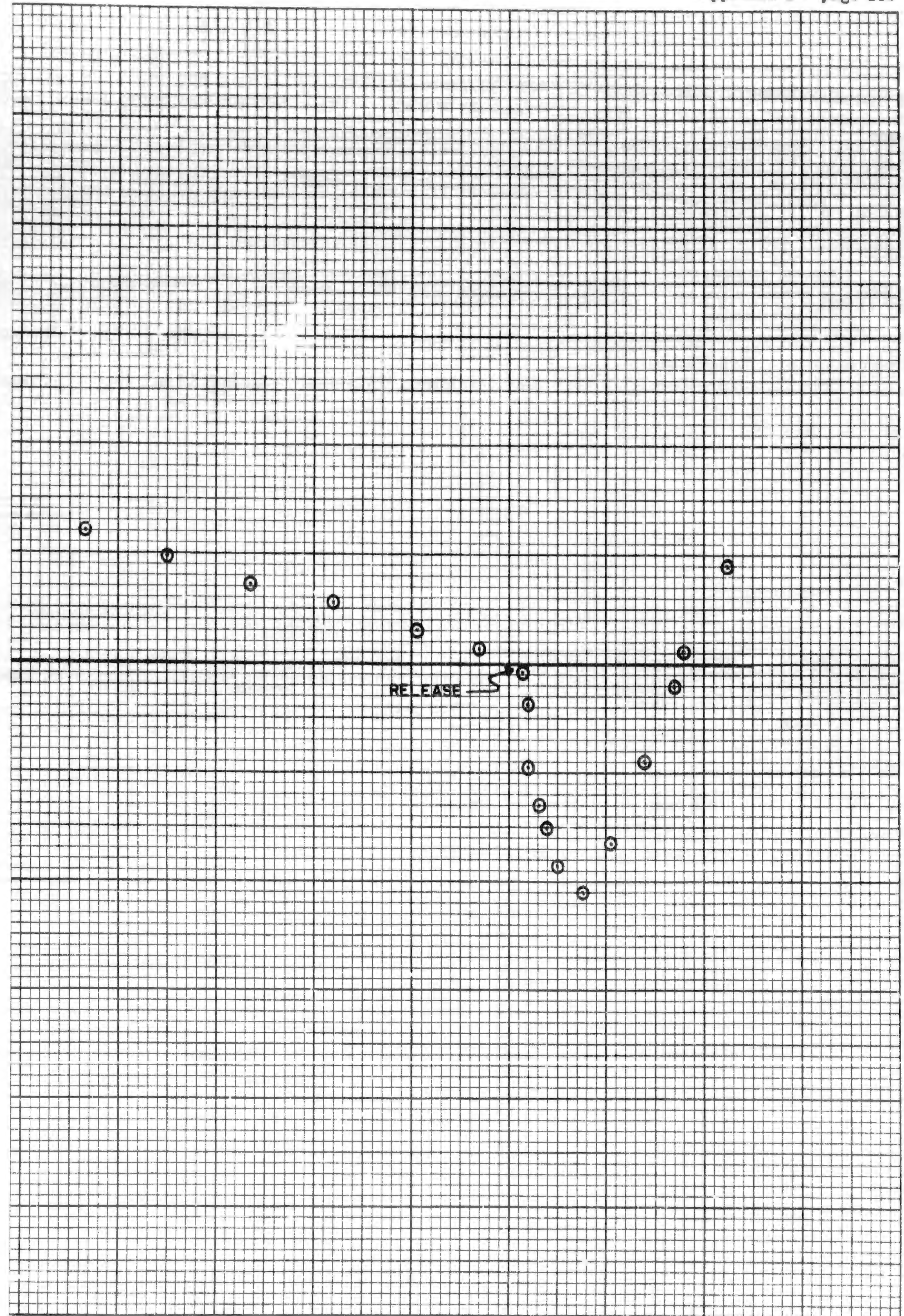

TIME-PRESSURE-ALTITUDE
FLIGHT NO. 10
APRIL 29, 1952
GROSS LOAD: 244 LB.
GROSS LIFT: 292 LB.
FREE LIFT: 48 LB.
..... DATA FROM TELEMETER RECORD
1520
1540
1600
1620
1640
1700
1720
1740
BALLOON LAUNCHED 15:06
CENTRAL STANDARD TIME

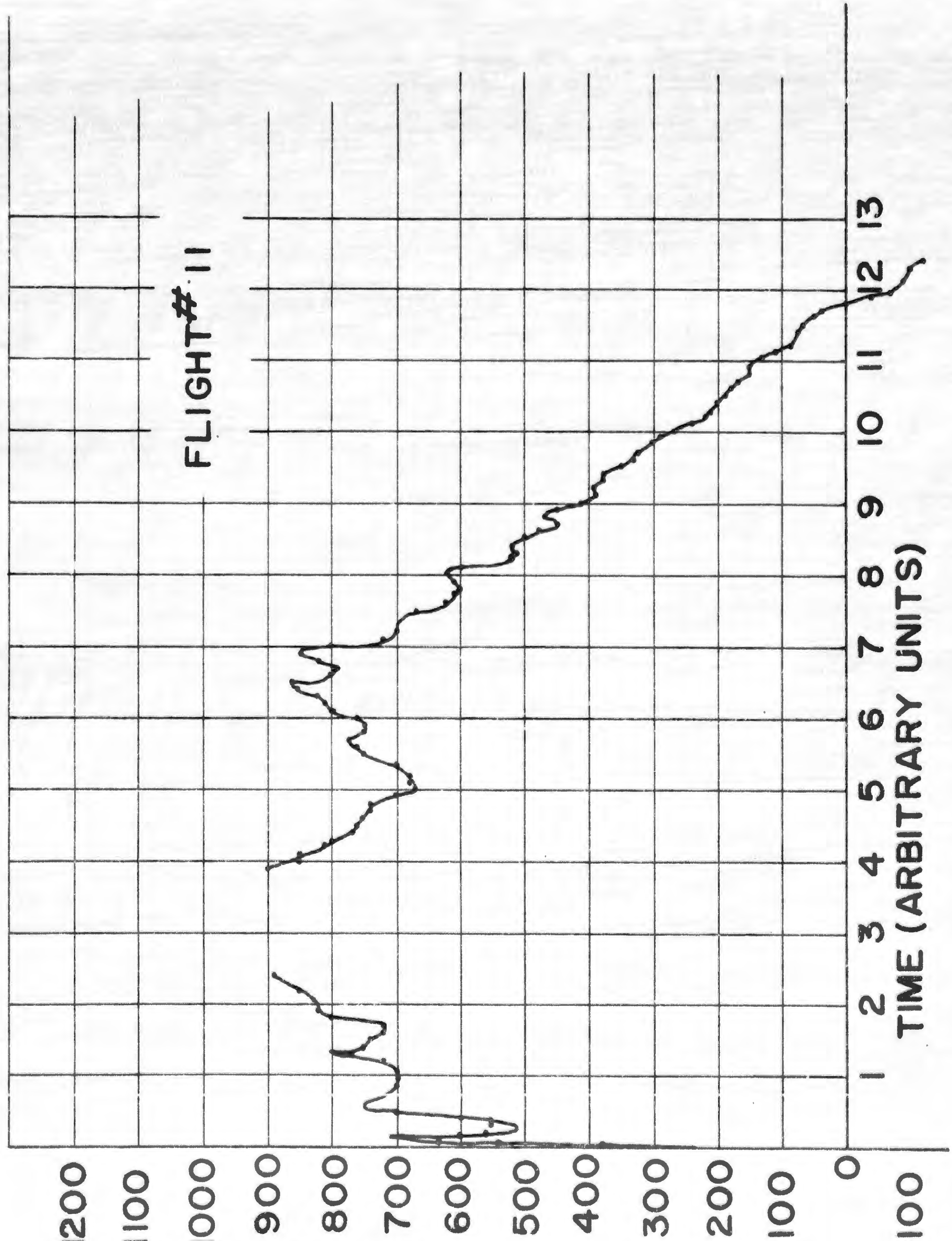

GROUND SUNSET
THEORETICAL CEILING 97,000 FT.
BALLOON SUNSET
1800
1820
1840
1900
1920
1940
20 0
2020
2040

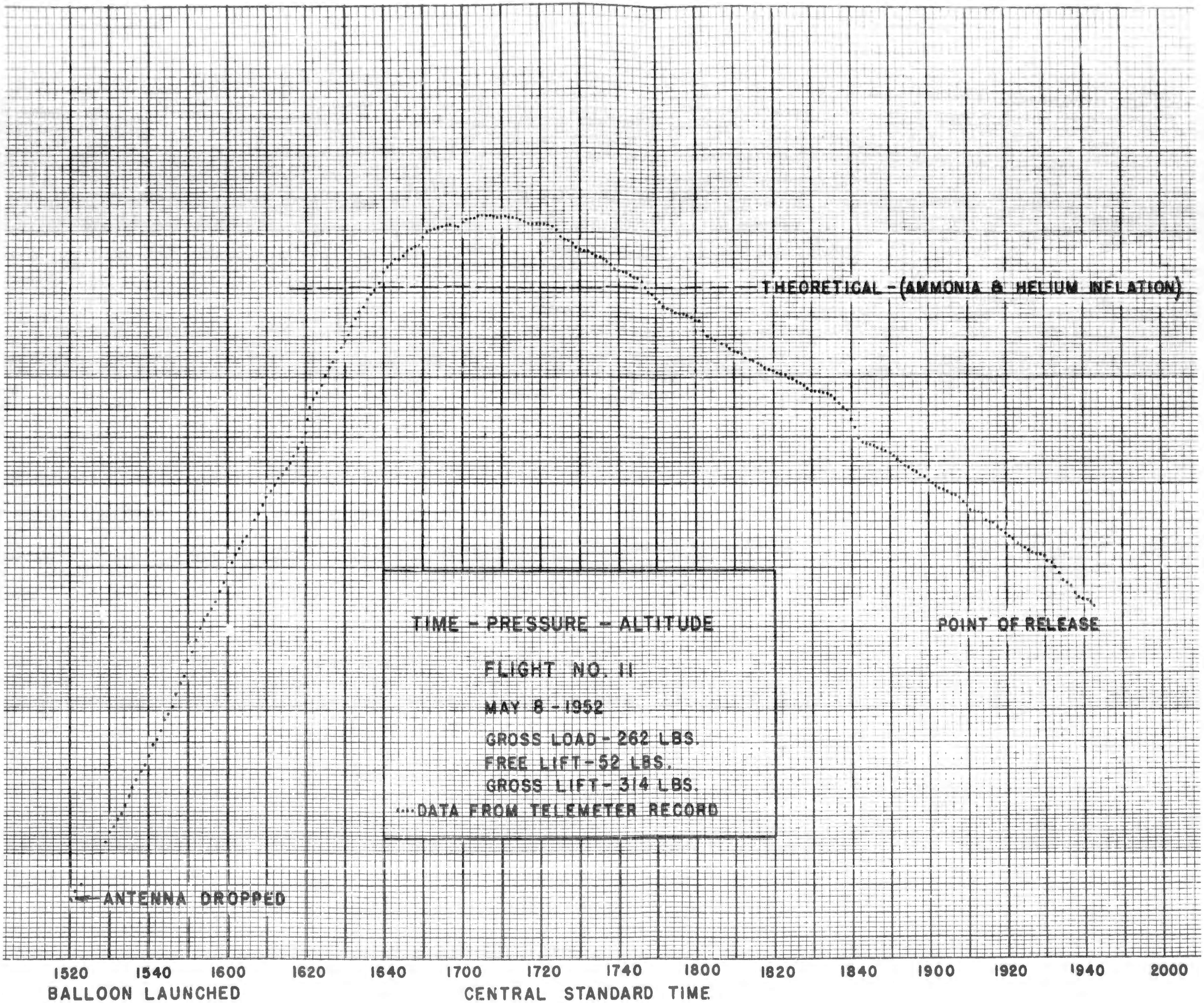

RELEASE
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
PRESSURE IN MILLIBARS
2040
2100
2120
2140
2200

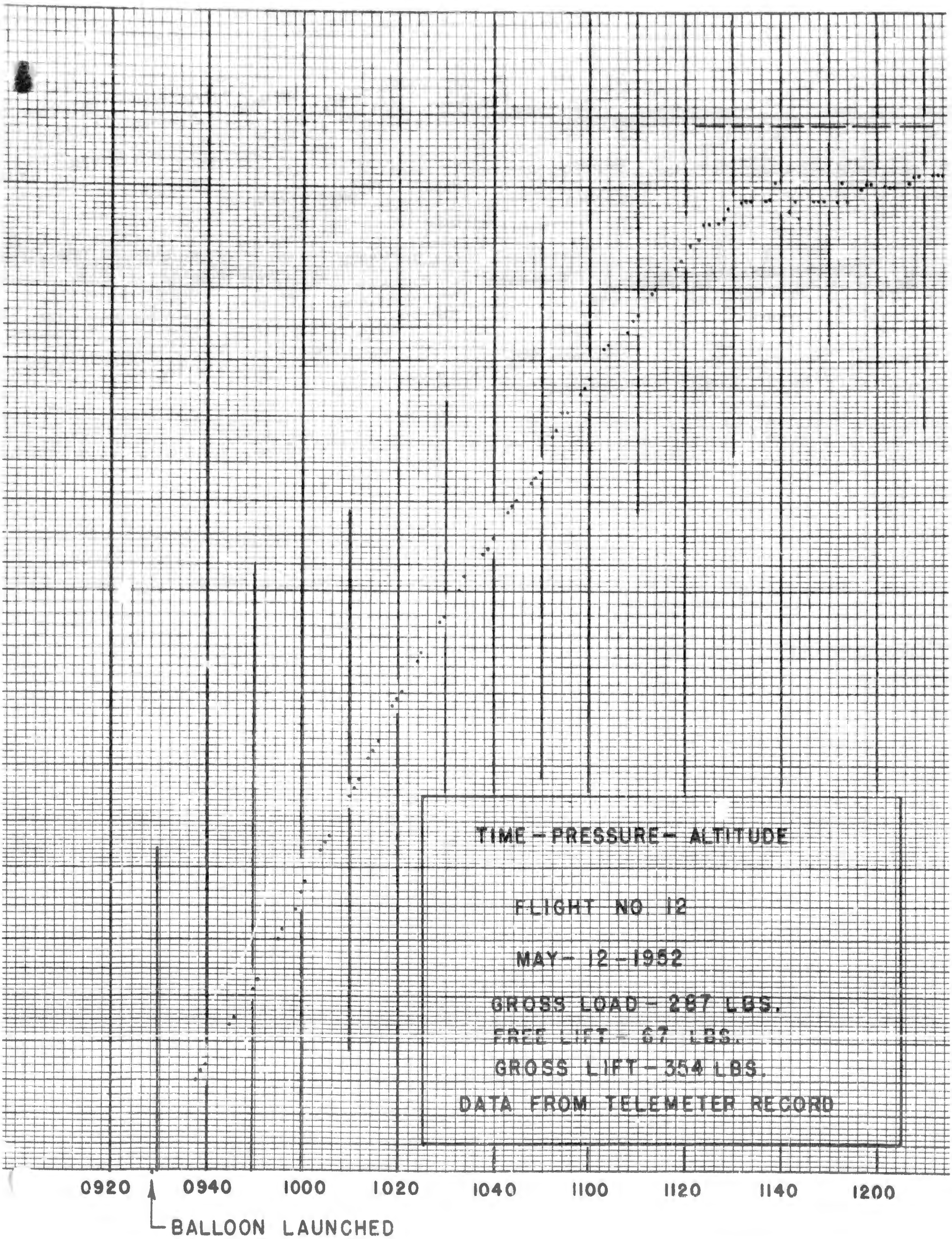

BALLOON
LAUNCHED
DEGREES OF TEMPERATURE (CENTIGRADE)
+40
+30
+20
+10
0
-10
-20
-30
-40
1440
1500
1520
1540
1600
1620
1640
1700
TIME — TEMPERATURE
FLIGHT NO. 10
29 APRIL, 1952
DATA OBTAINED FROM
THERMOGRAPH RECORD


GROUND
SUNSET
BALLOON
SUNSET
1720
1740
1800
1820
1840
1900
1920
1940
2000
CENTRAL STANDARD TIME


RELEASE
2000
2020
2040
2100
2120
2140
2200
2220

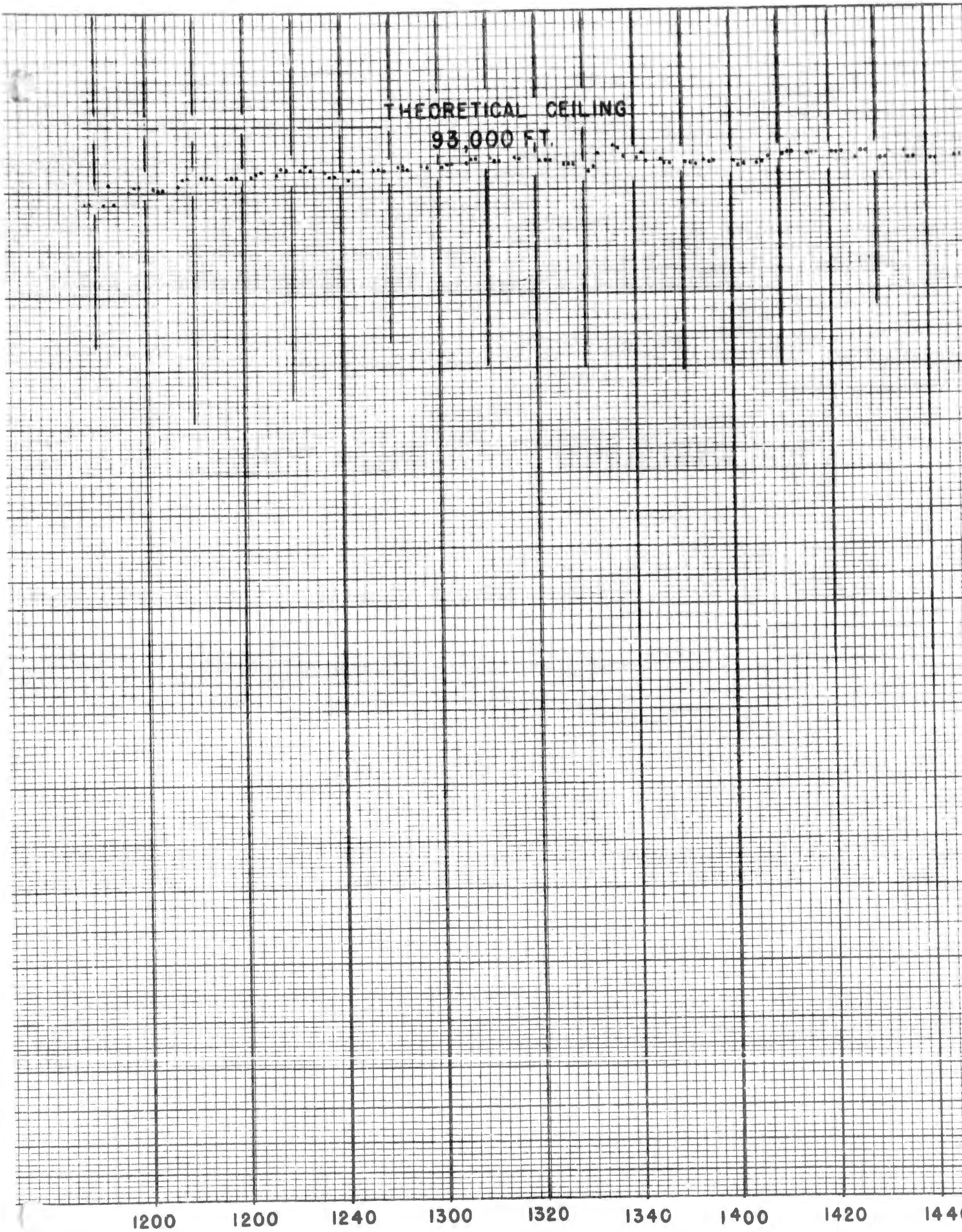

FLIGHT # 11
TIME (ARBITRARY UNITS)
1 2 3 4 5 6 7 8 9 10 11 12 13
RATE OF RISE (FEET/MINUTE)
1200 1100 1000 900 800 700 600 500 400 300 200 100 0 −100

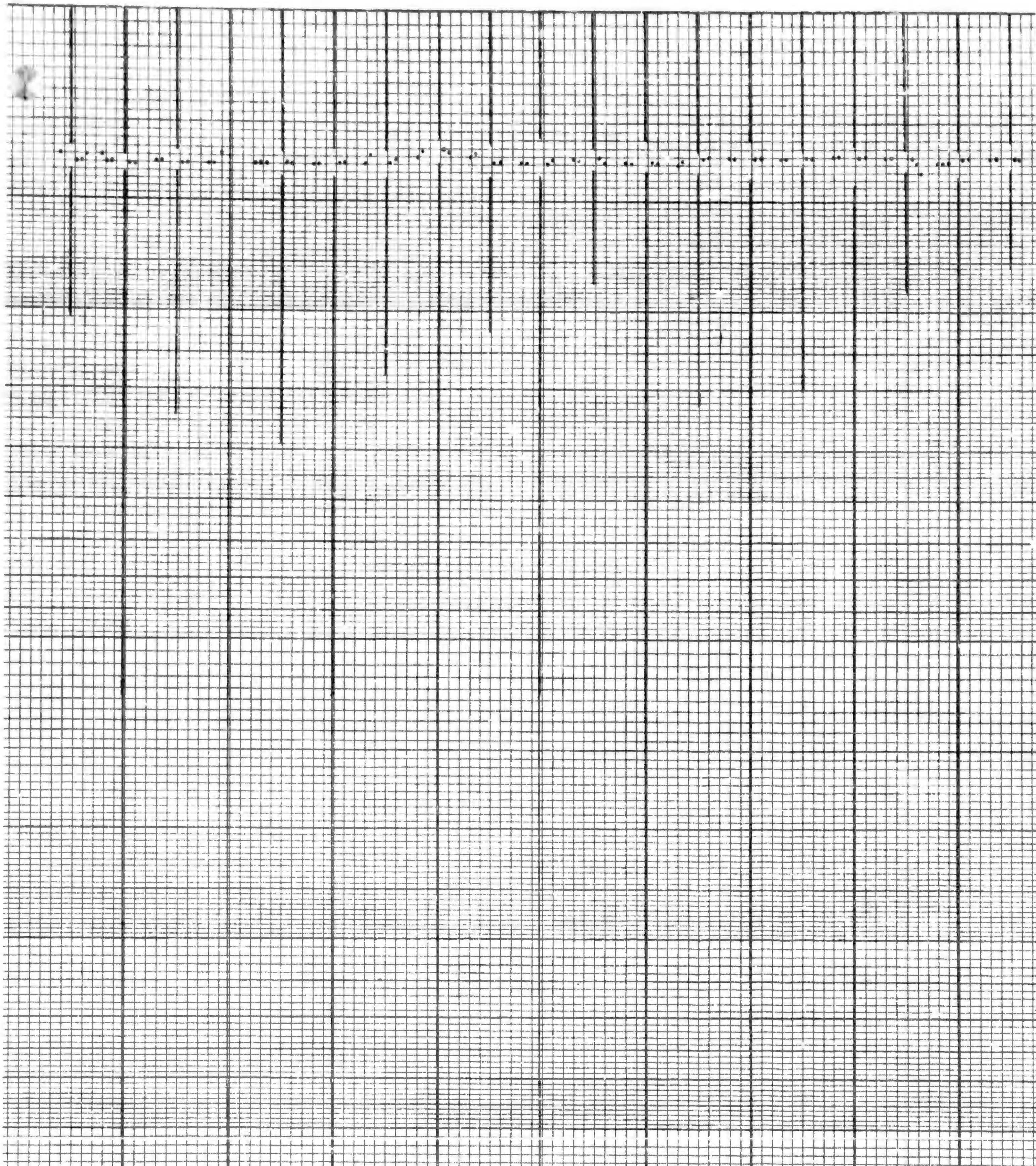

THEORETICAL - (AMMONIA & HELIUM INFLATION)
TIME - PRESSURE - ALTITUDE
FLIGHT NO. 11
MAY 8 - 1952
GROSS LOAD - 262 LBS.
FREE LIFT - 52 LBS.
GROSS LIFT - 314 LBS.
....DATA FROM TELEMETER RECORD
POINT OF RELEASE
ANTENNA DROPPED
1520
1540
1600
1620
1640
1700
1720
1740
1800
1820
1840
1900
1920
1940
2000
BALLOON LAUNCHED
CENTRAL STANDARD TIME

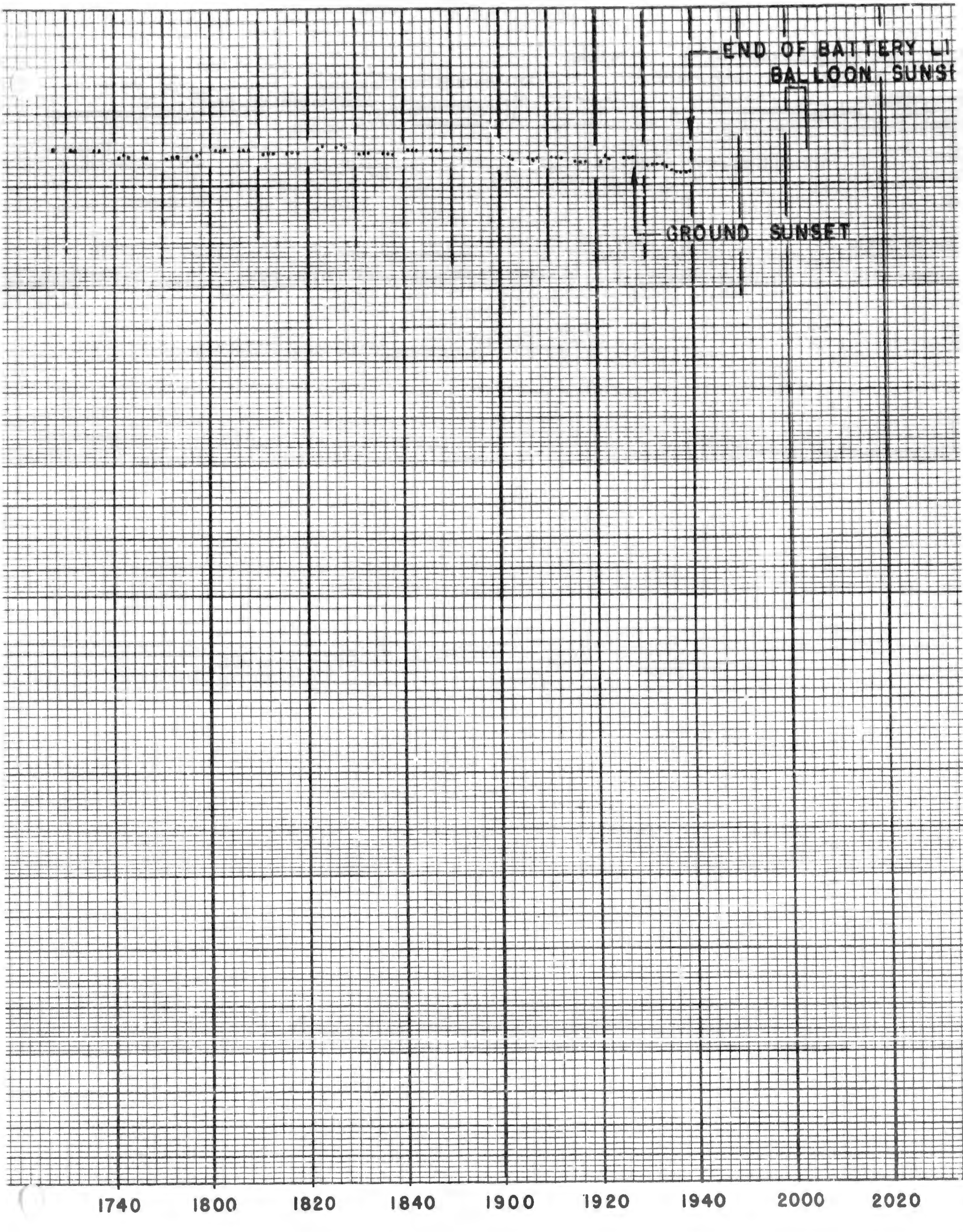


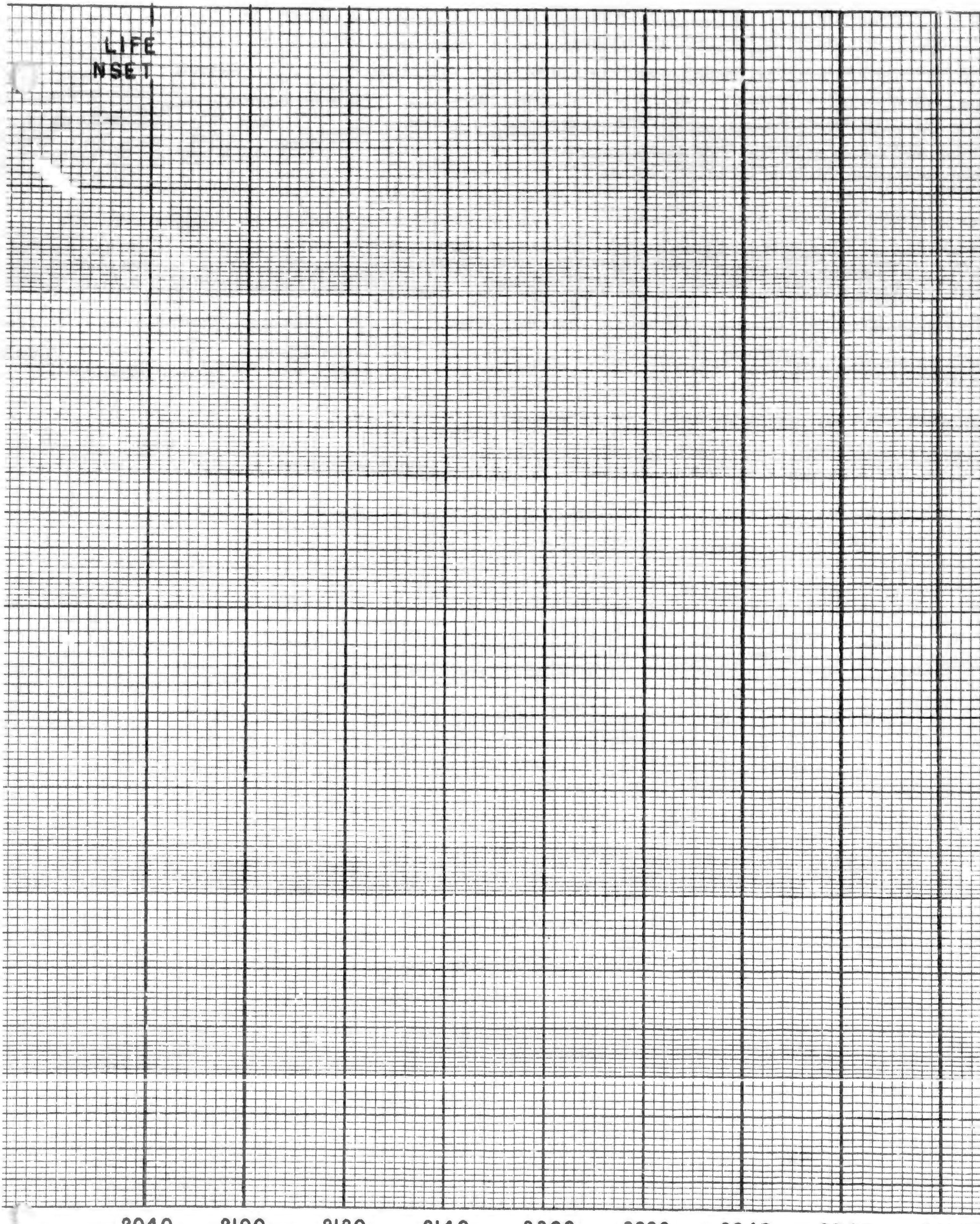
CONFIDENTIAL SECURITY INFORMATION

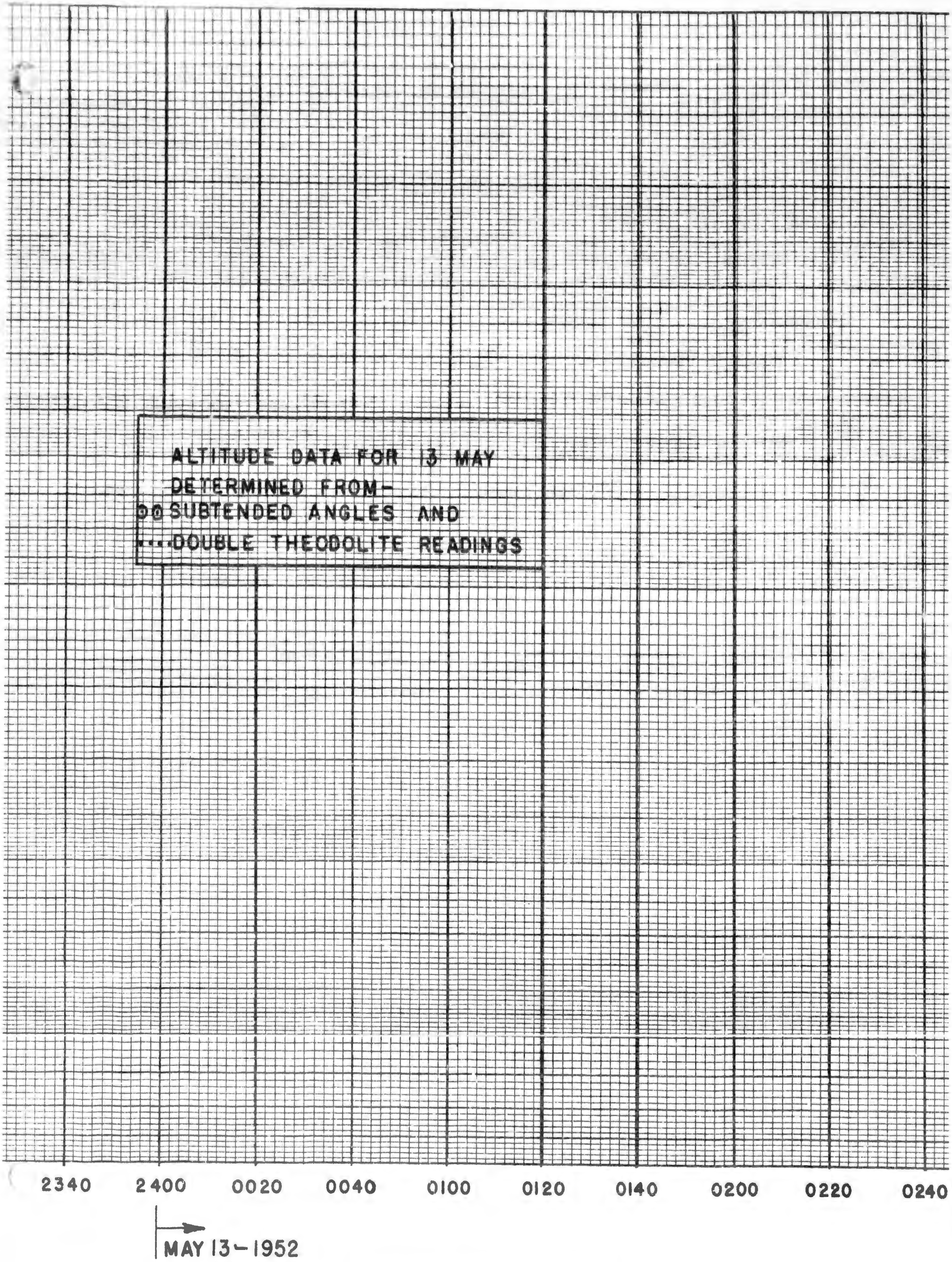
CENTRAL STANDARD TIME

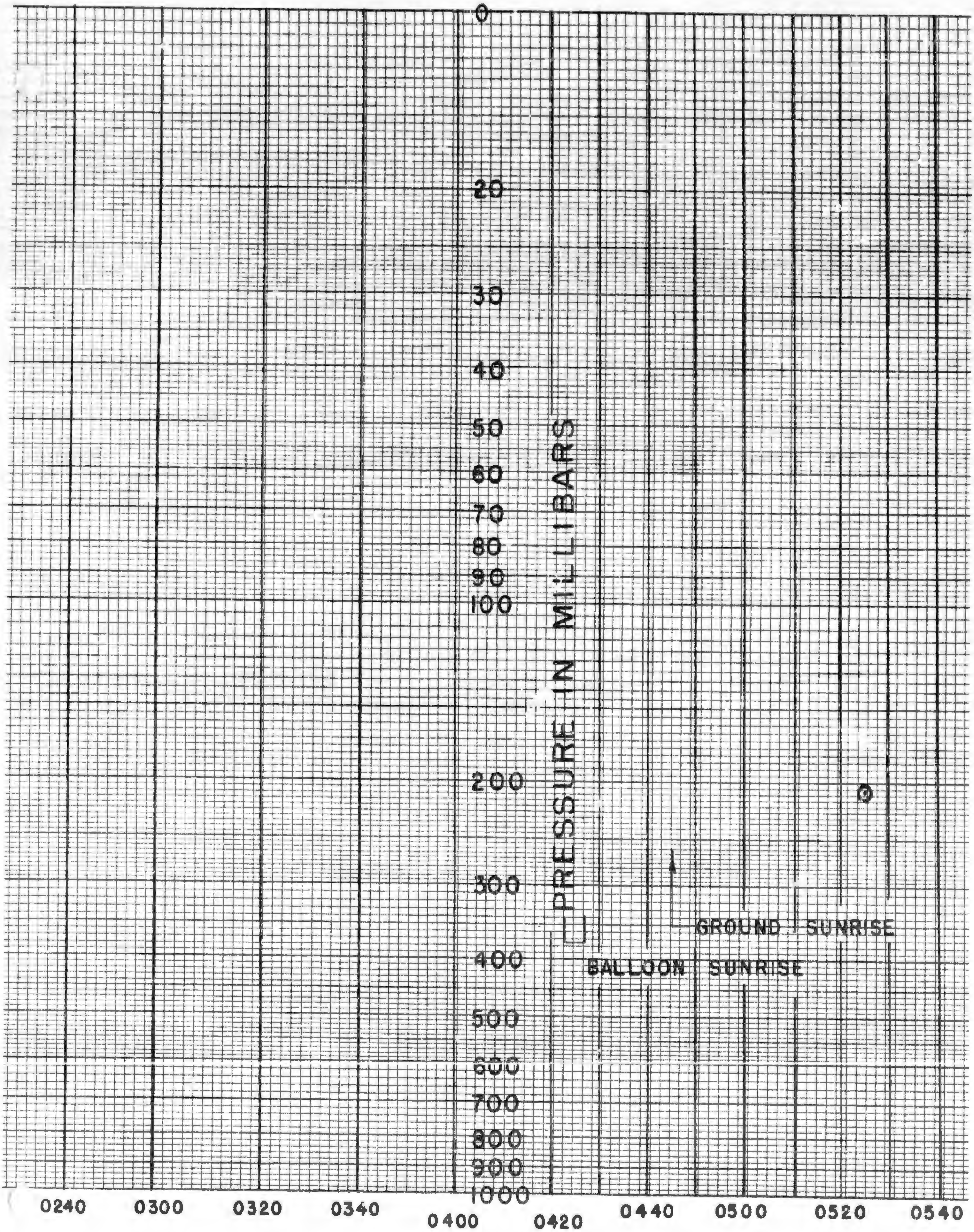

THEORETICAL CEILING
93,000 FT.
1200
1200
1240
1300
1320
1340
1400
1420
144

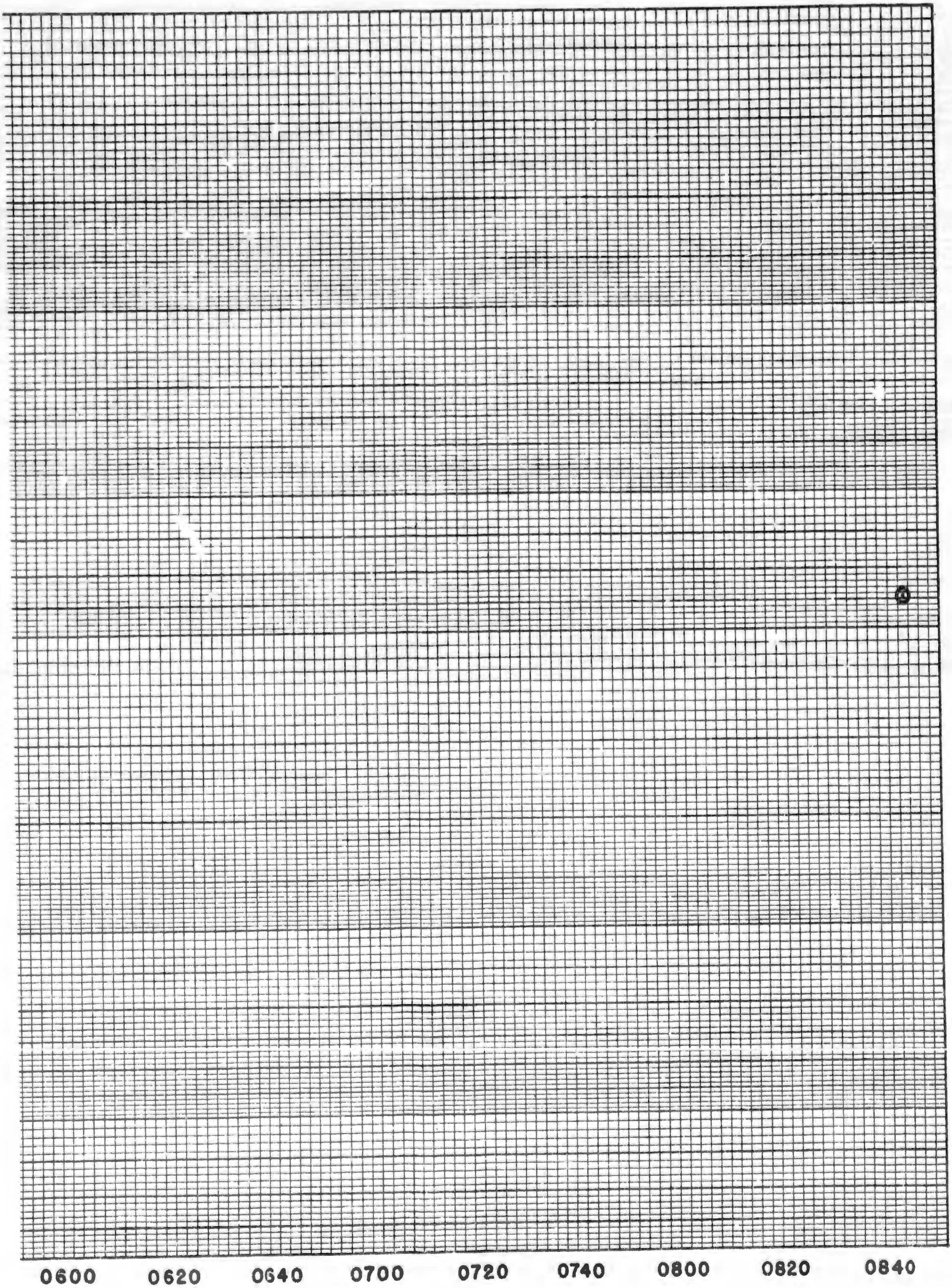

1440
1500
1520
1540
1600
1620
1640
1700
1720

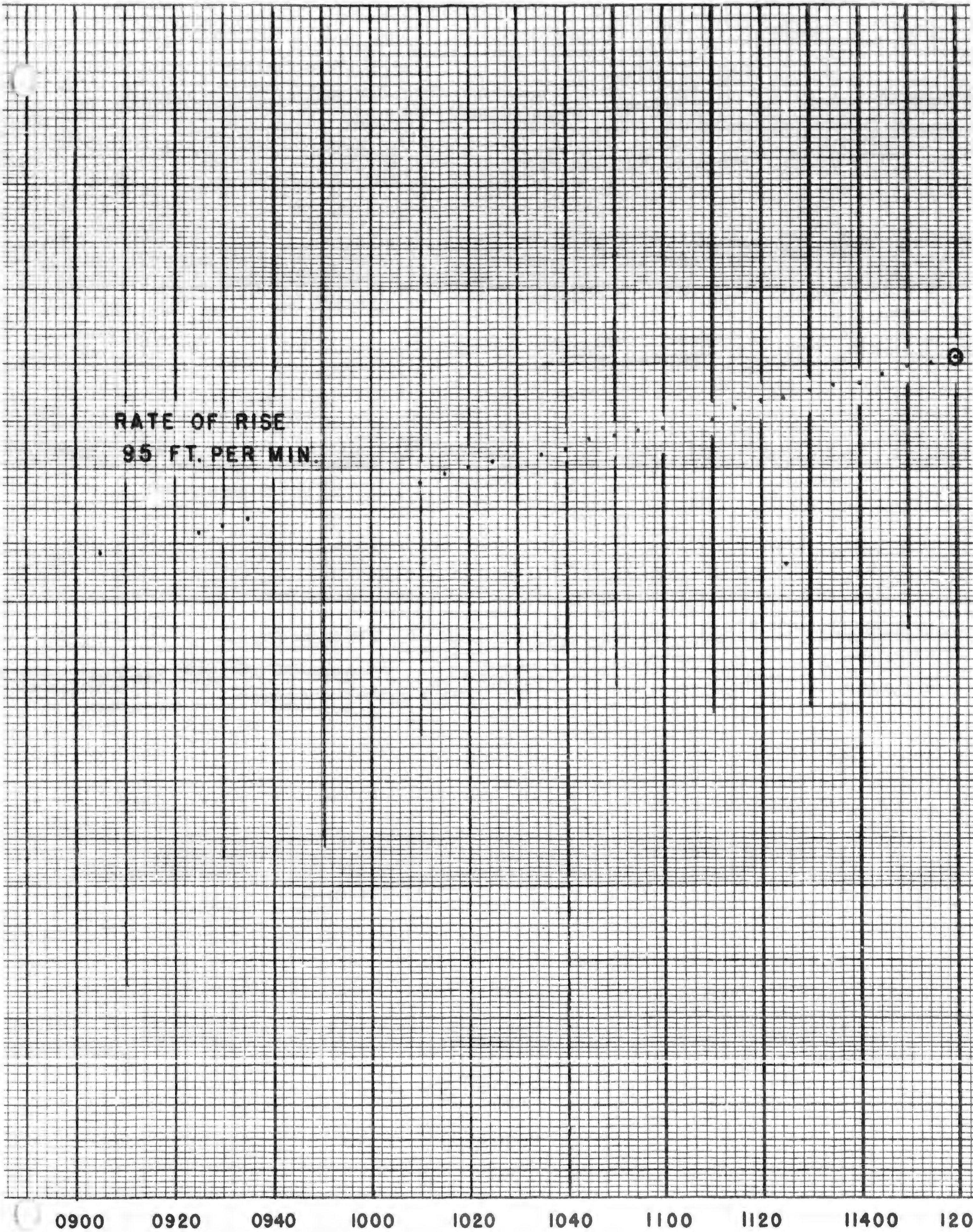

END OF BATTERY LI
BALLOON SUNS
GROUND SUNSET
1740
1800
1820
1840
1900
1920
1940
2000
2020

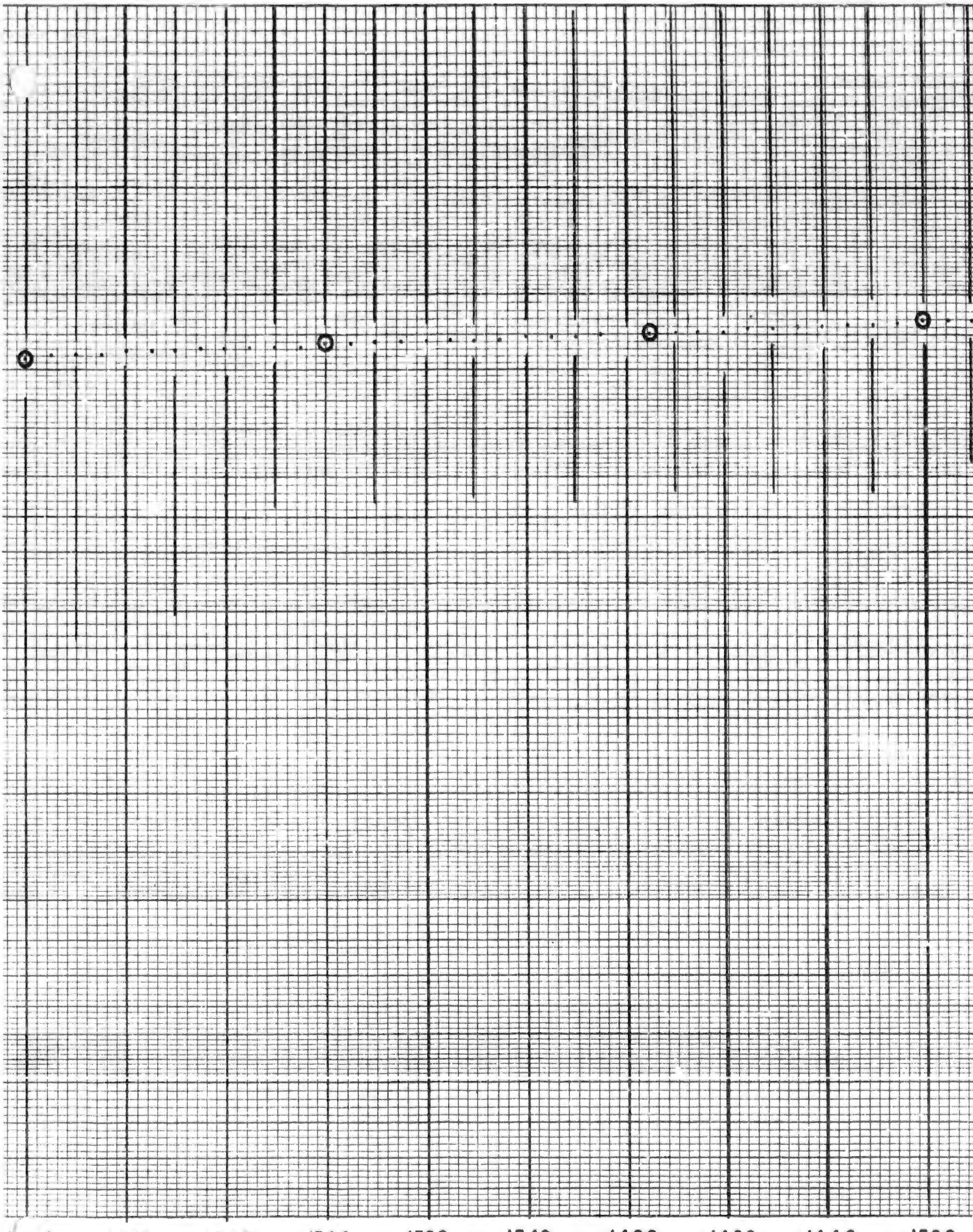

LIFE
NSET
2040
2100
2120
2140
2200
2220
2240
2300
2320

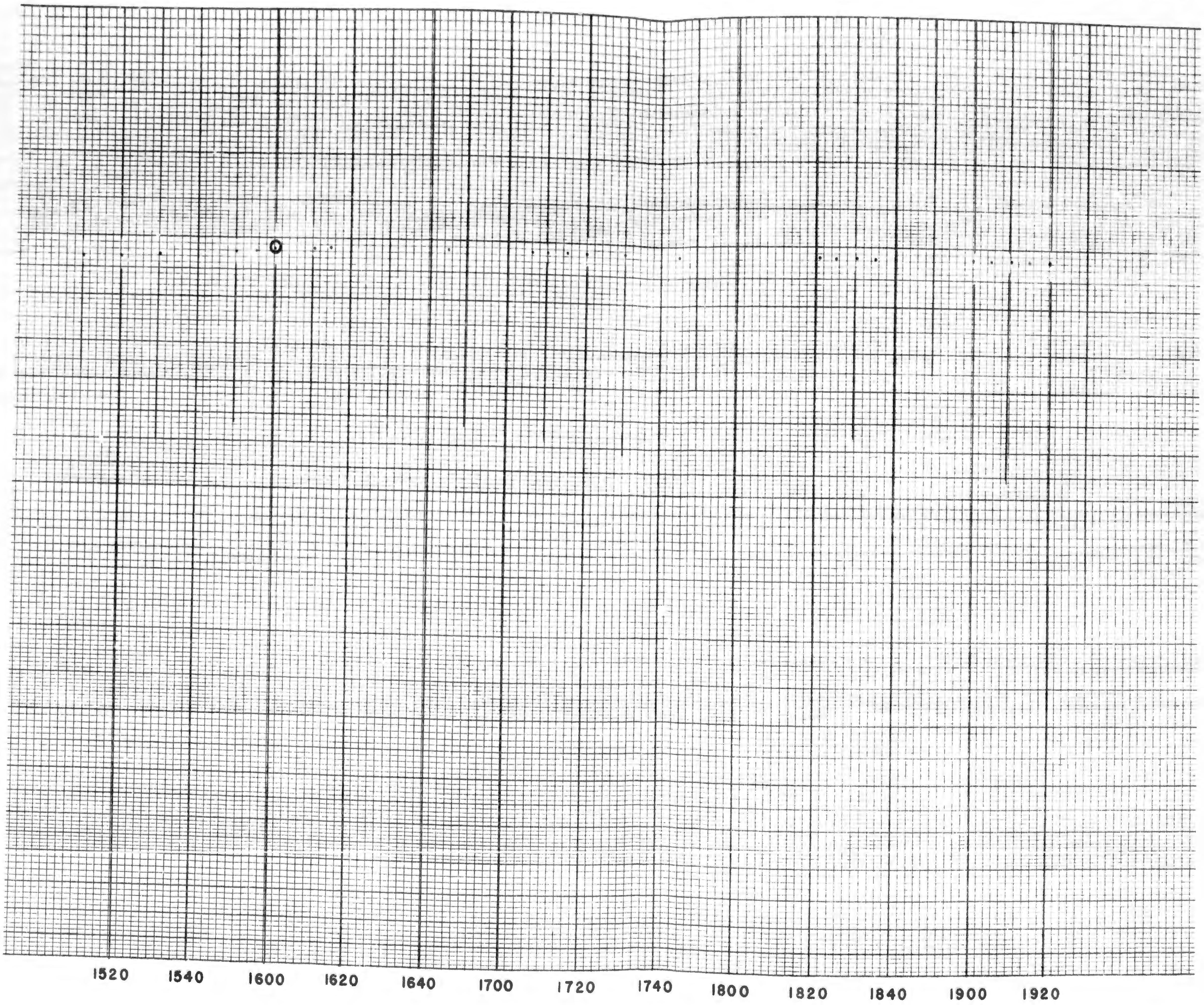

ALTITUDE DATA FOR 13 MAY
DETERMINED FROM-
SUBTENDED ANGLES AND
DOUBLE THEODOLITE READINGS
2340
2400
0020
0040
0100
0120
0140
0200
0220
0240
MAY 13 - 1952

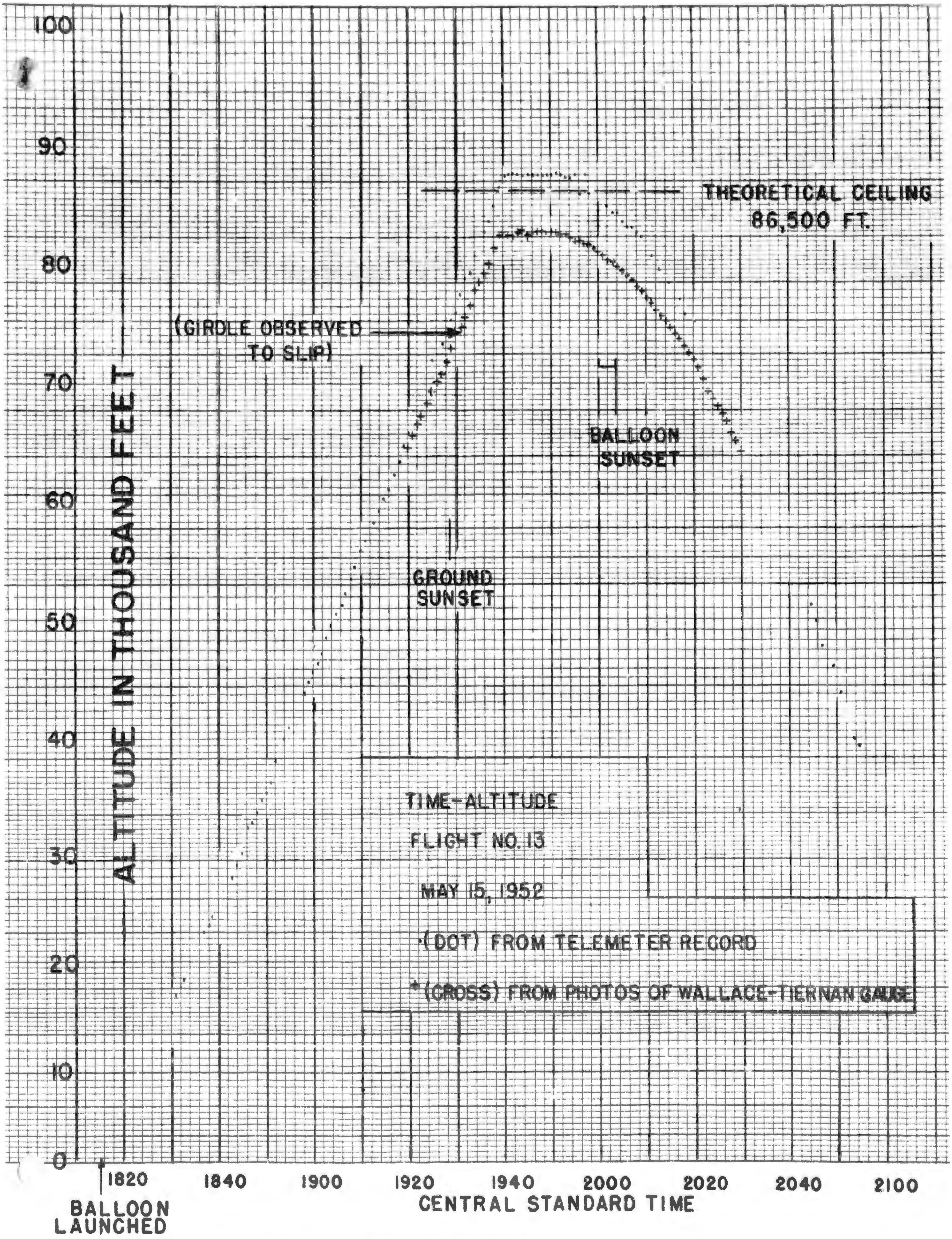

0
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
PRESSURE IN MILLIBARS
GROUND SUNRISE
BALLOON SUNRISE
0240
0300
0320
0340
0400
0420
0440
0500
0520
0540

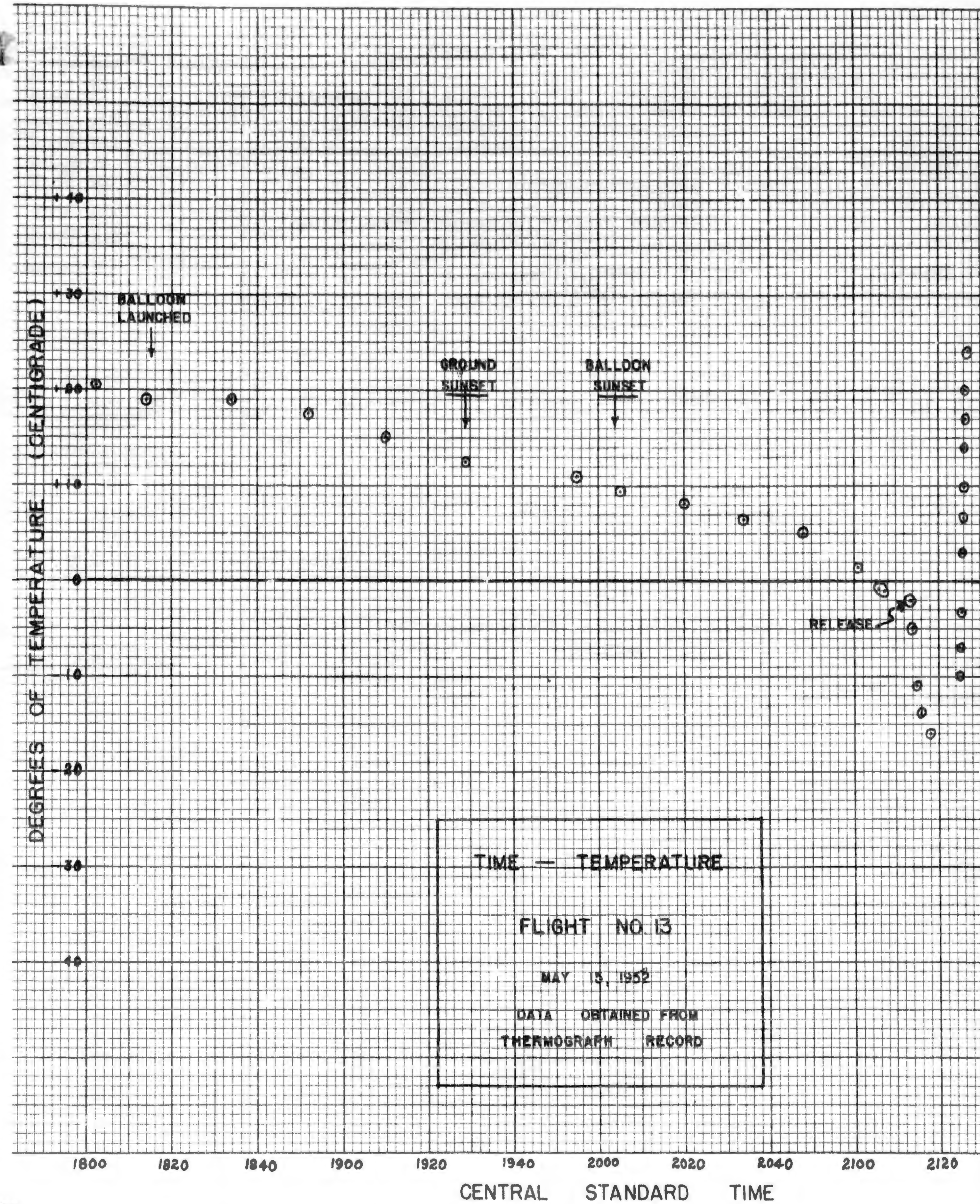

0600
0620
0640
0700
0720
0740
0800
0820
0840


RATE OF RISE
95 FT. PER MIN.
0900
0920
0940
1000
1020
1040
1100
1120
11400
120

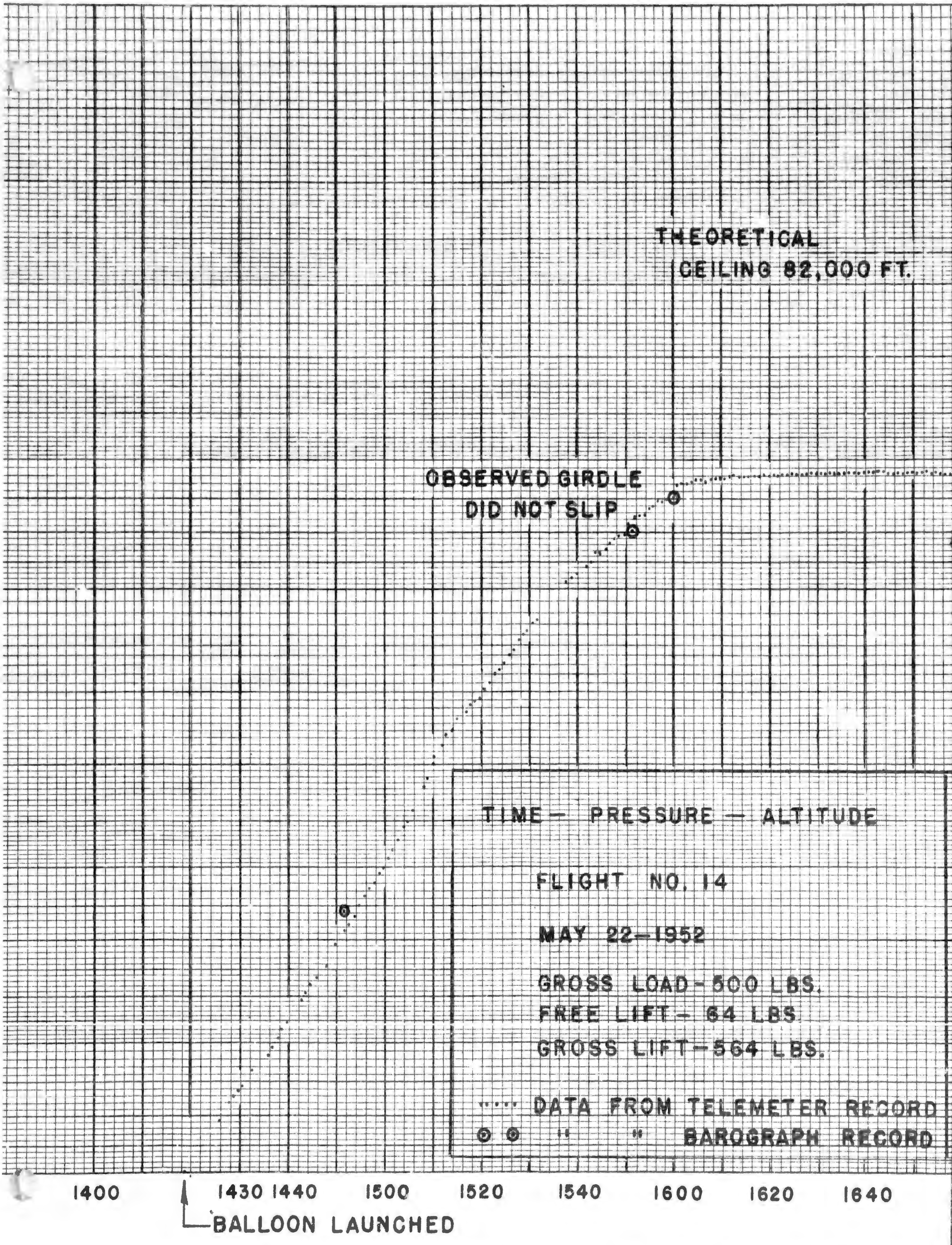

1220
1240
1300
1320
1340
1400
1420
1440
1500

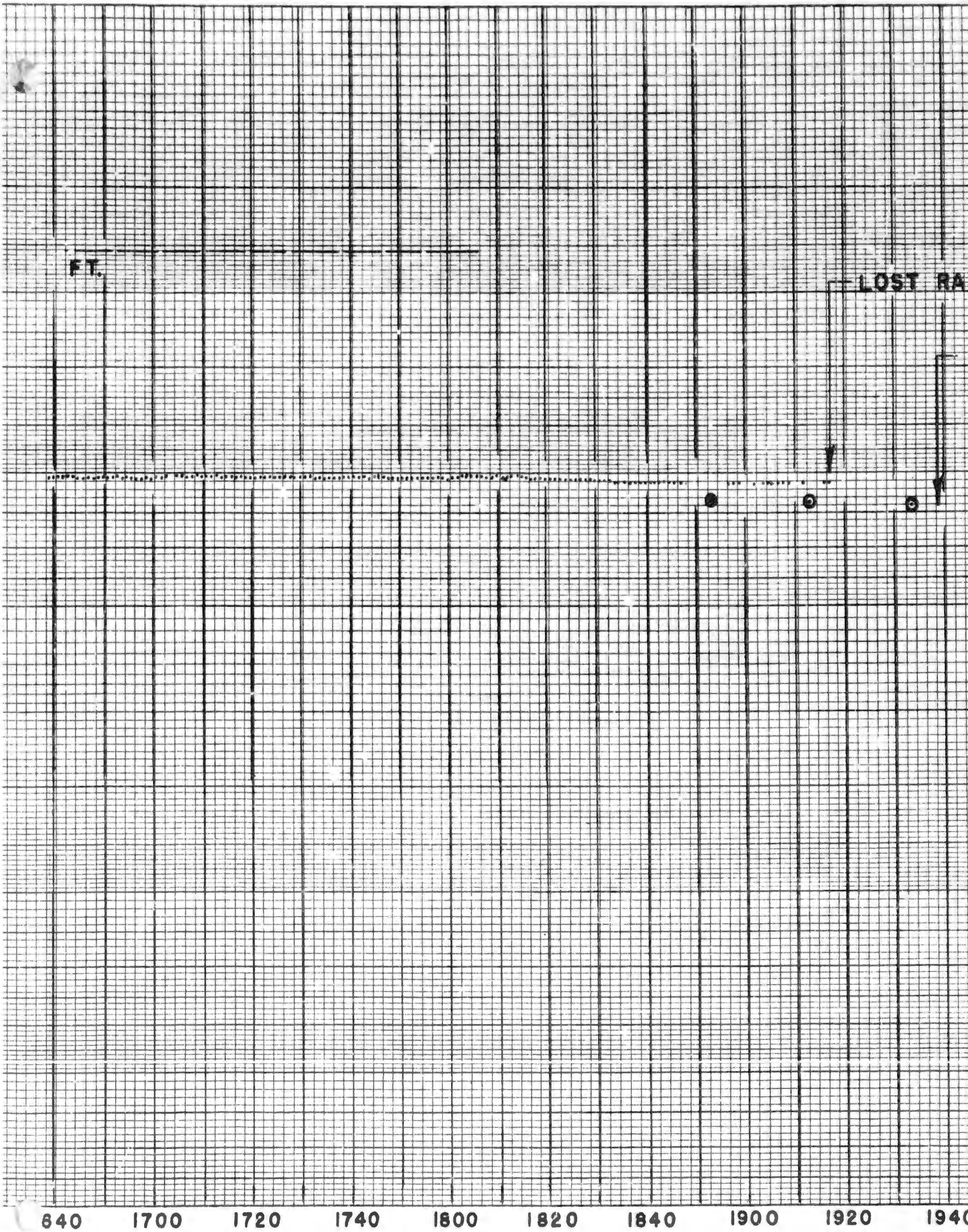

1520
1540
1600
1620
1640
1700
1720
1740
1800
1820
1840
1900
1920

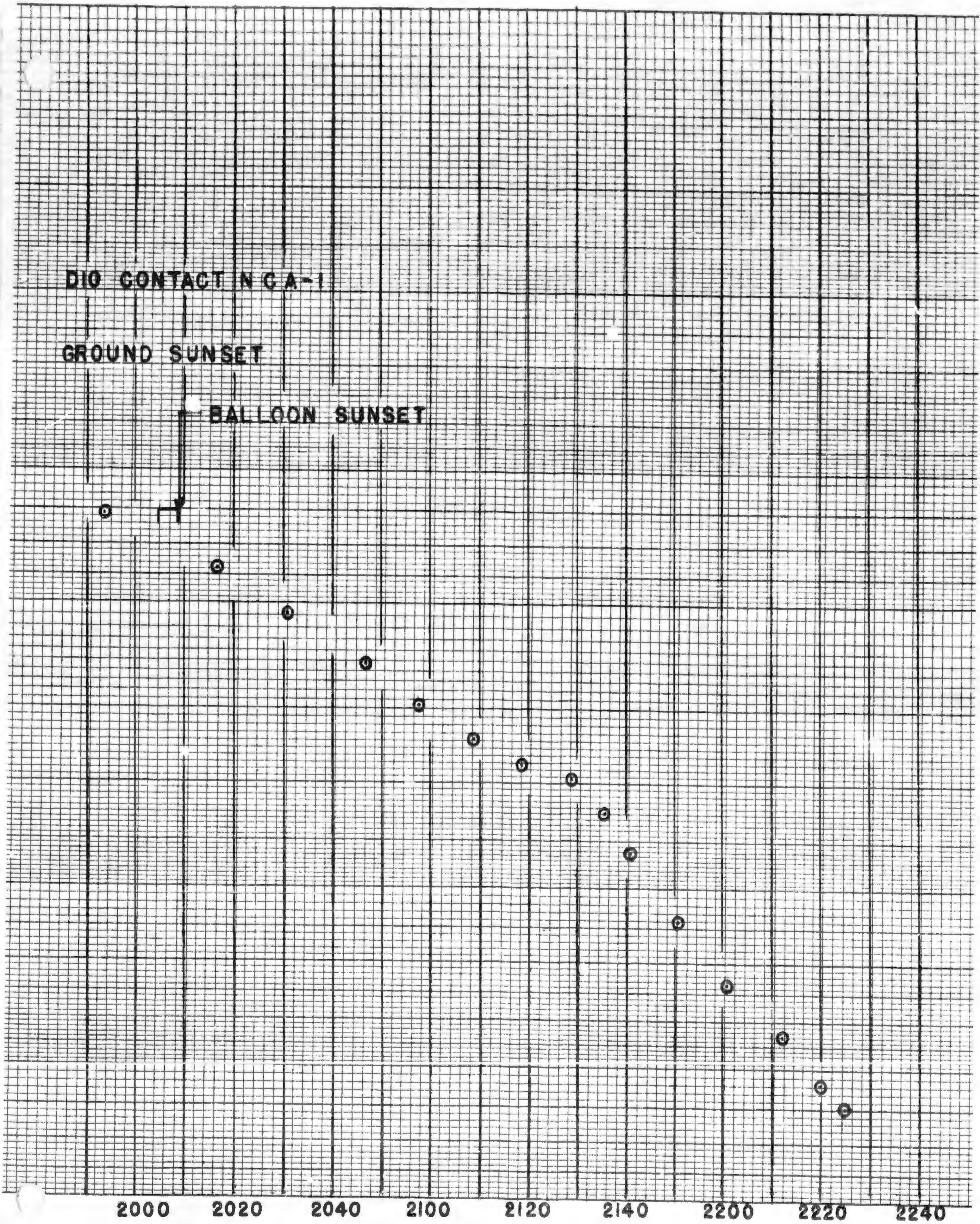

THEORETICAL CEILING 86,500 FT.
(GIRDLE OBSERVED TO SLIP)
BALLOON SUNSET
GROUND SUNSET
ALTITUDE IN THOUSAND FEET
TIME-ALTITUDE
FLIGHT NO. 13
MAY 15, 1952
·(DOT) FROM TELEMETER RECORD
+(CROSS) FROM PHOTOS OF WALLACE-TIERNAN GAUGE
100
90
80
70
60
50
40
30
20
10
0
1820
1840
1900
1920
1940
2000
2020
2040
2100
BALLOON LAUNCHED
CENTRAL STANDARD TIME

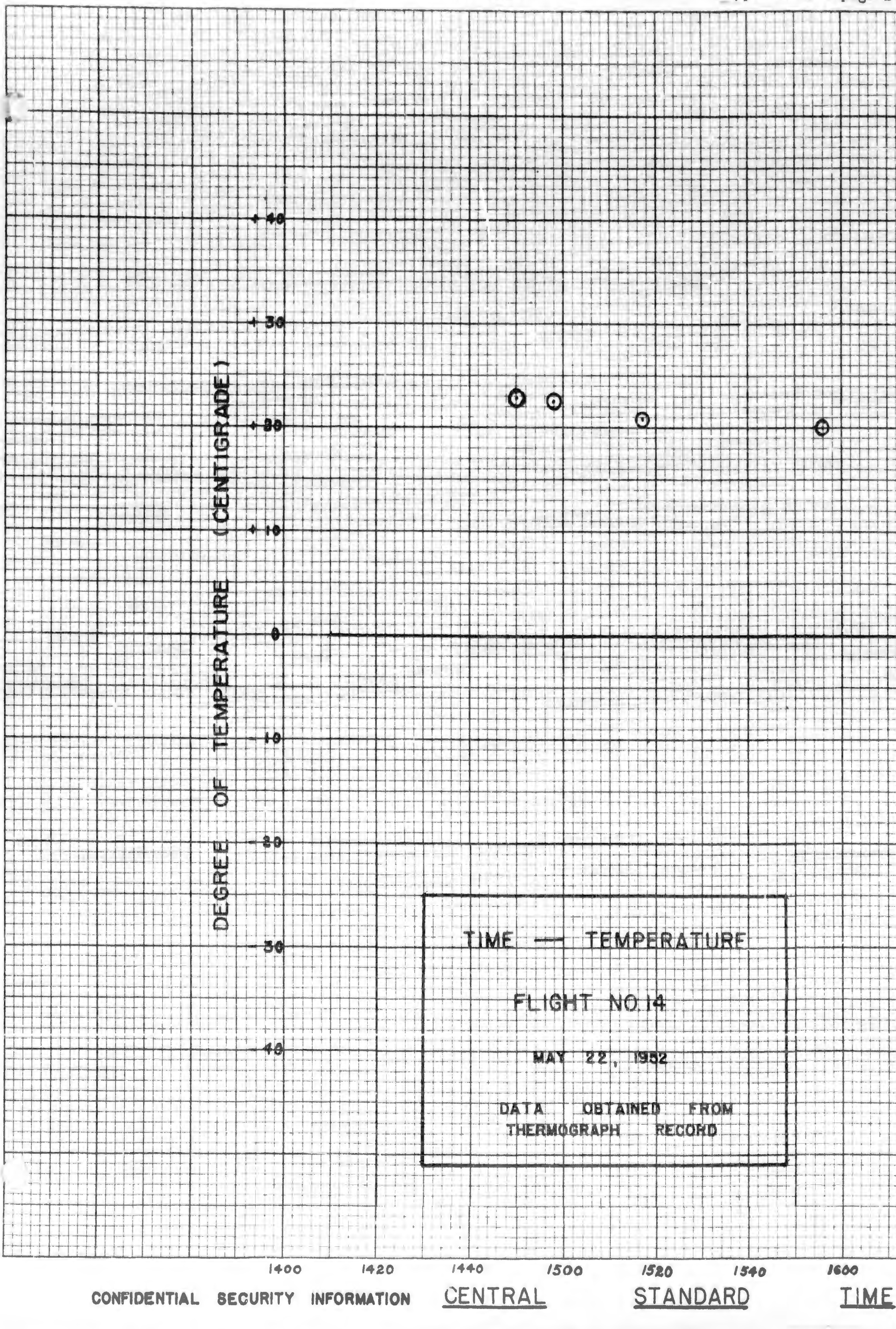


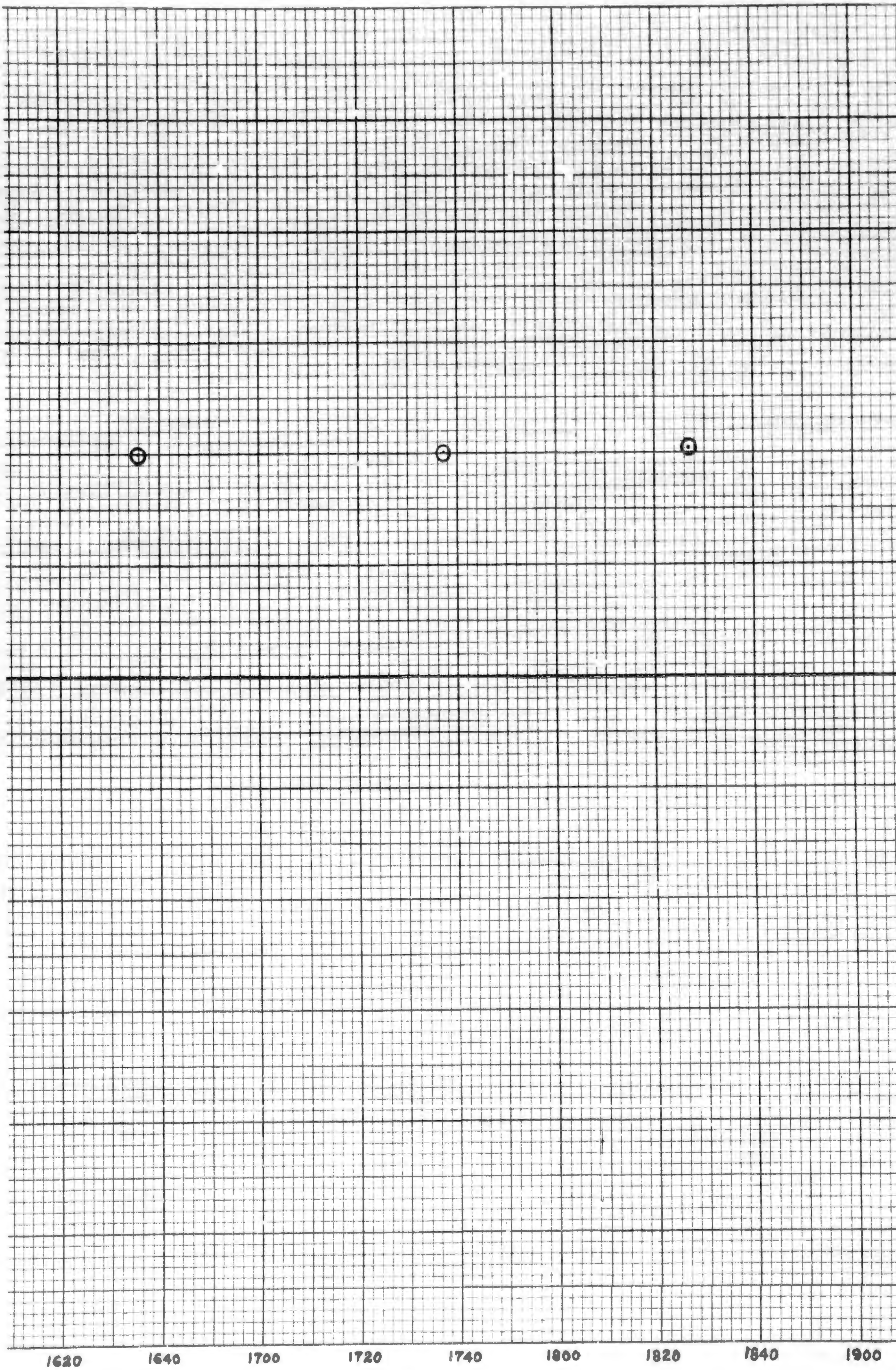
DEGREES OF TEMPERATURE (CENTIGRADE)
+40
+30
+20
+10
0
-10
-20
-30
-40
BALLOON LAUNCHED
GROUND SUNSET
BALLOON SUNSET
RELEASE
TIME — TEMPERATURE
FLIGHT NO. 13
MAY 15, 1952
DATA OBTAINED FROM THERMOGRAPH RECORD
1800
1820
1840
1900
1920
1940
2000
2020
2040
2100
2120
CENTRAL STANDARD TIME

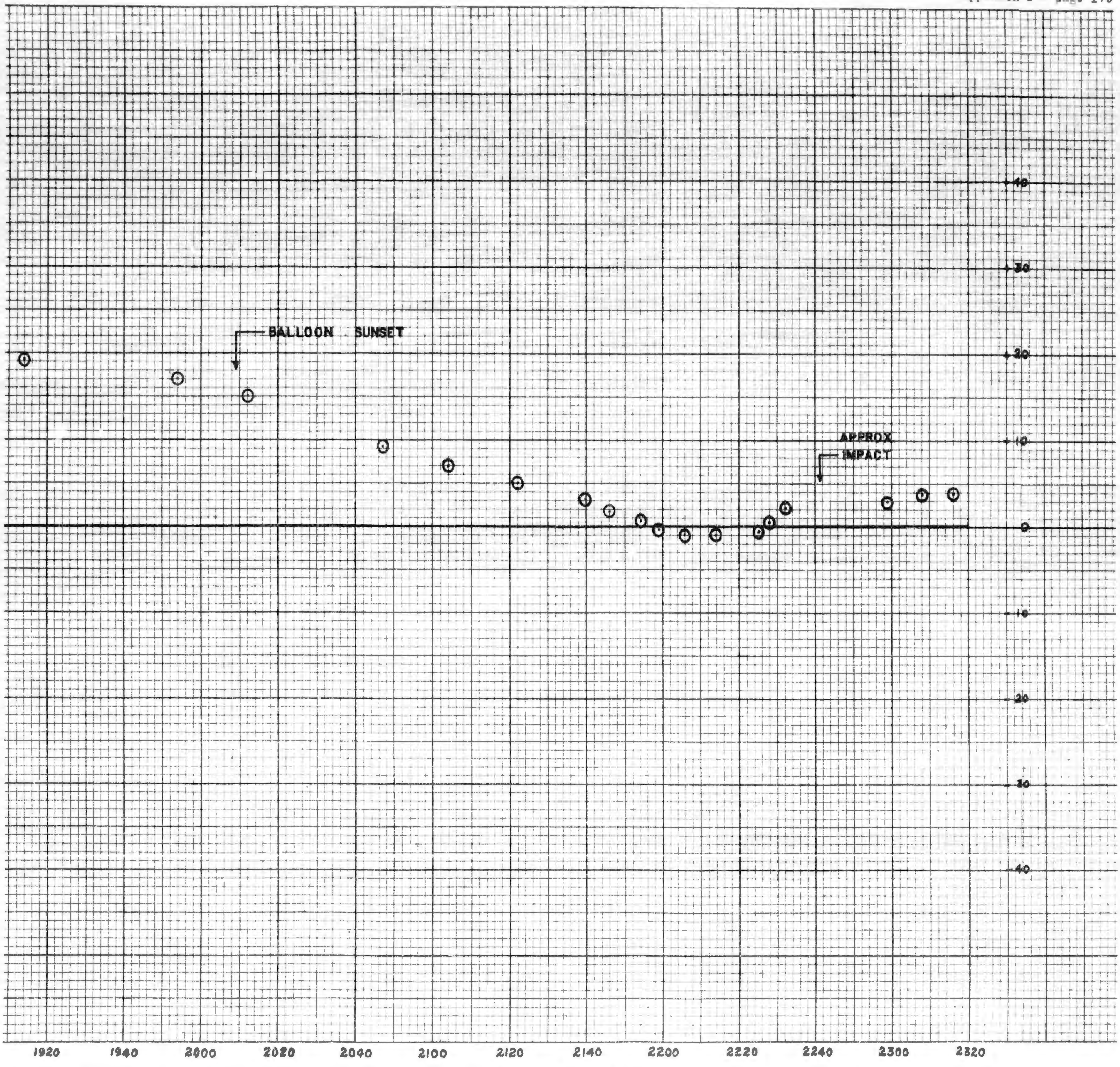

THEORETICAL
CEILING 82,000 FT.
OBSERVED GIRDLE
DID NOT SLIP
TIME — PRESSURE — ALTITUDE
FLIGHT NO. 14
MAY 22—1952
GROSS LOAD - 500 LBS.
FREE LIFT - 64 LBS.
GROSS LIFT — 564 LBS.
DATA FROM TELEMETER RECORD
" " BAROGRAPH RECORD
1400
1430 1440
1500
1520
1540
1600
1620
1640
BALLOON LAUNCHED
CENTRAL STANDARD TIME

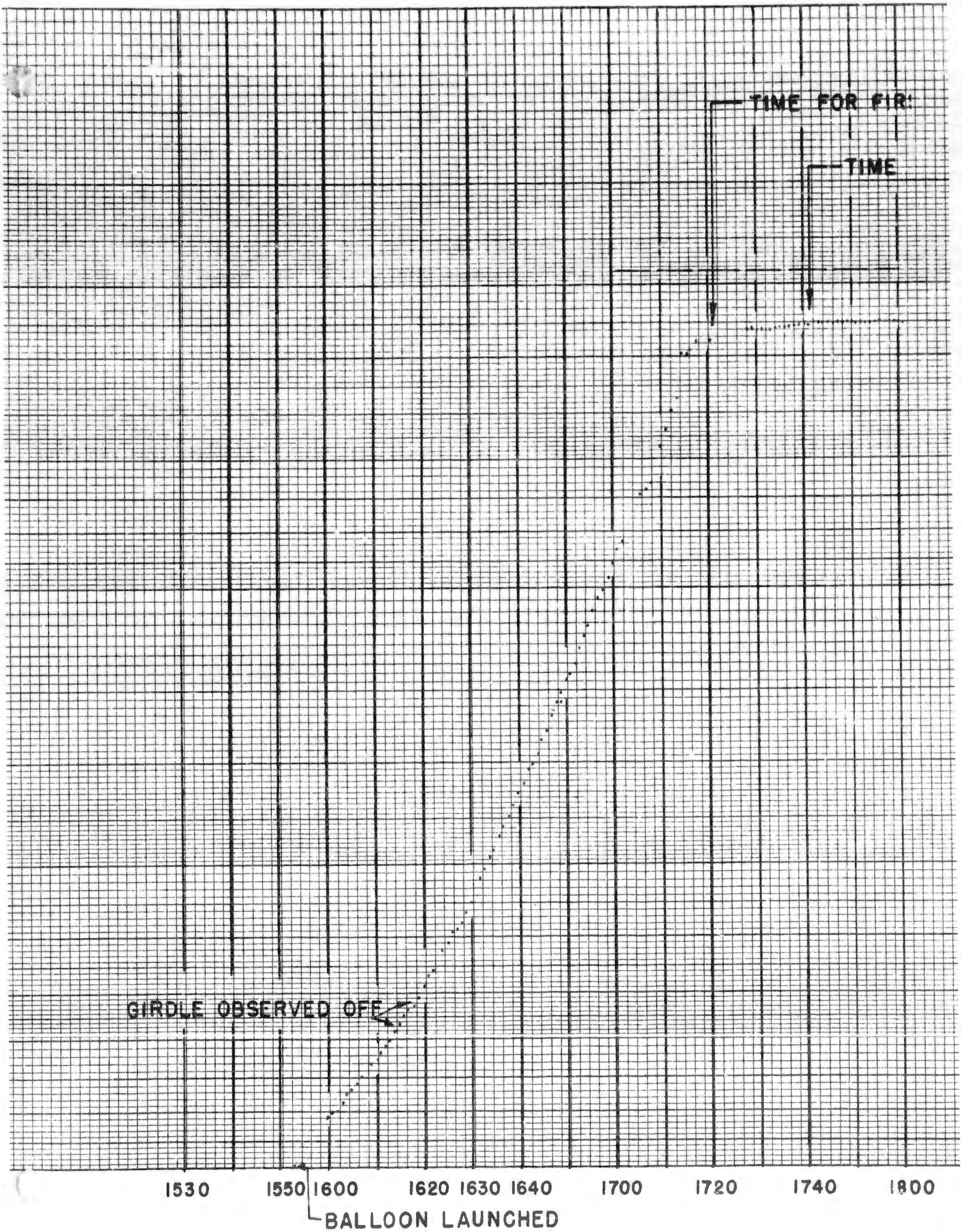

FT.
LOST RA
640
1700
1720
1740
1800
1820
1840
1900
1920
1940


DIO CONTACT N C A-1
GROUND SUNSET
BALLOON SUNSET
2000
2020
2040
2100
2120
2140
2200
2220
2240

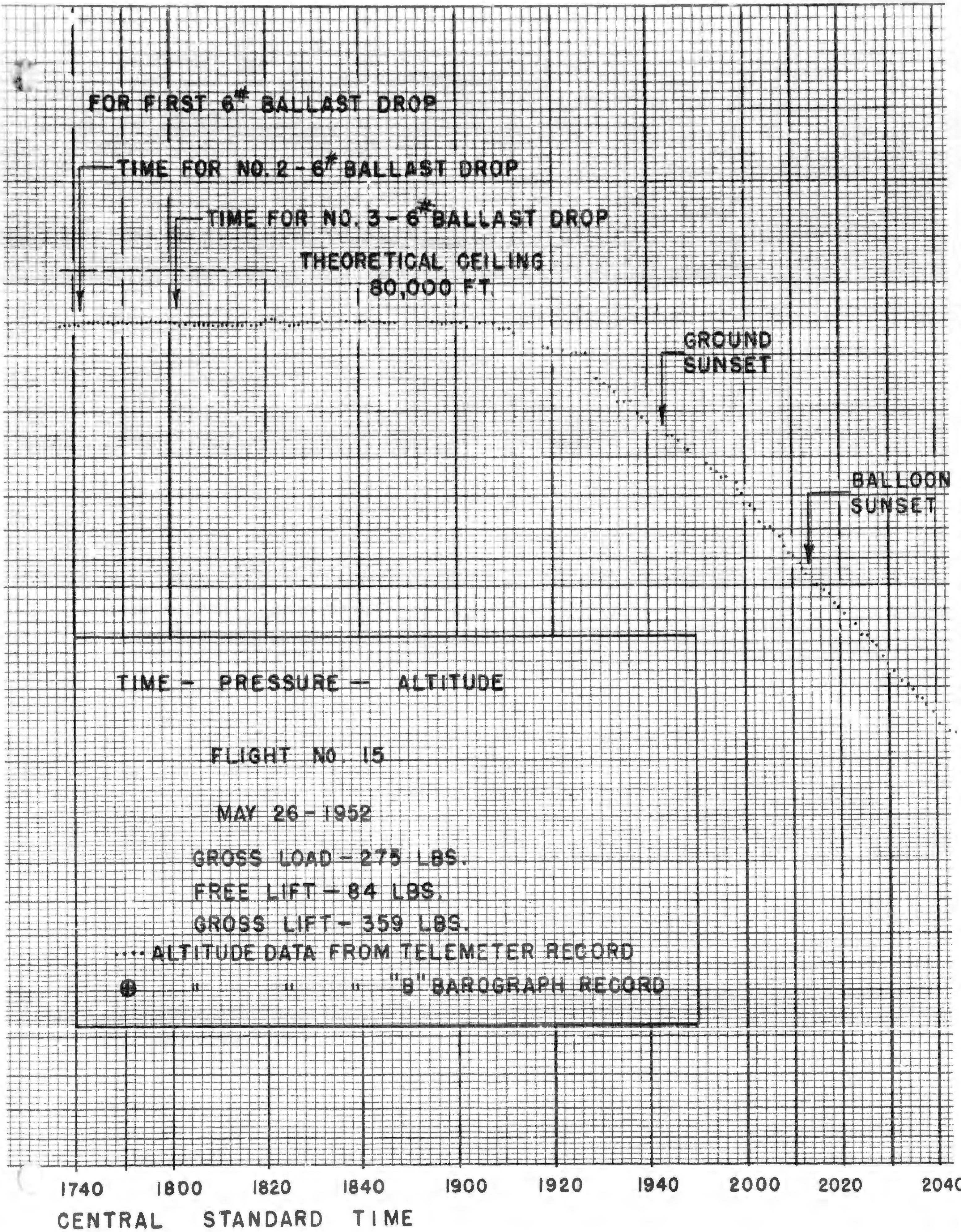

+40
+30
+20
+10
0
-10
-20
-30
-40
DEGREE OF TEMPERATURE (CENTIGRADE)
TIME — TEMPERATURE
FLIGHT NO.14
MAY 22, 1952
DATA OBTAINED FROM
THERMOGRAPH RECORD
1400
1420
1440
1500
1520
1540
1600
CENTRAL STANDARD TIME

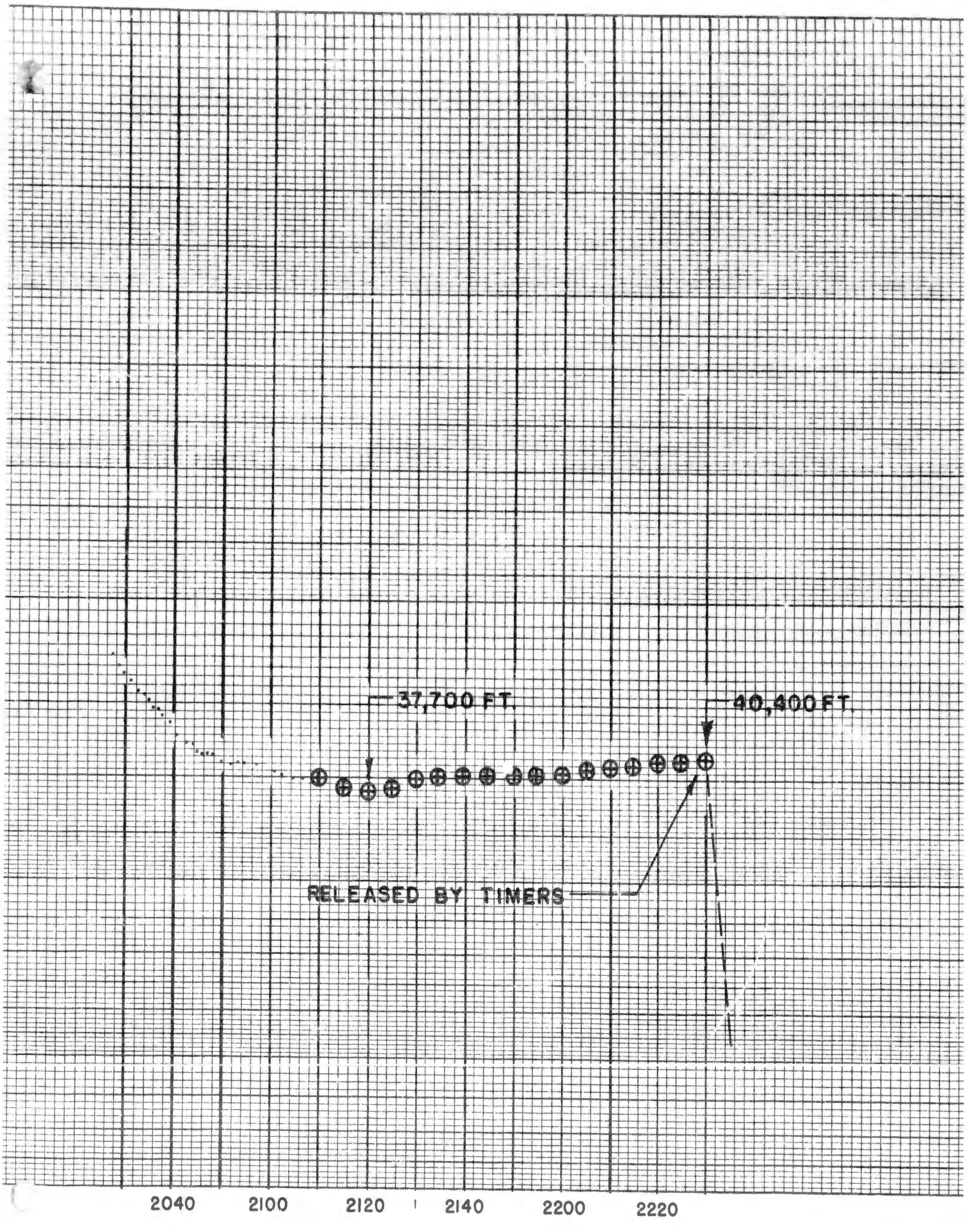

1620
1640
1700
1720
1740
1800
1820
1840
1900

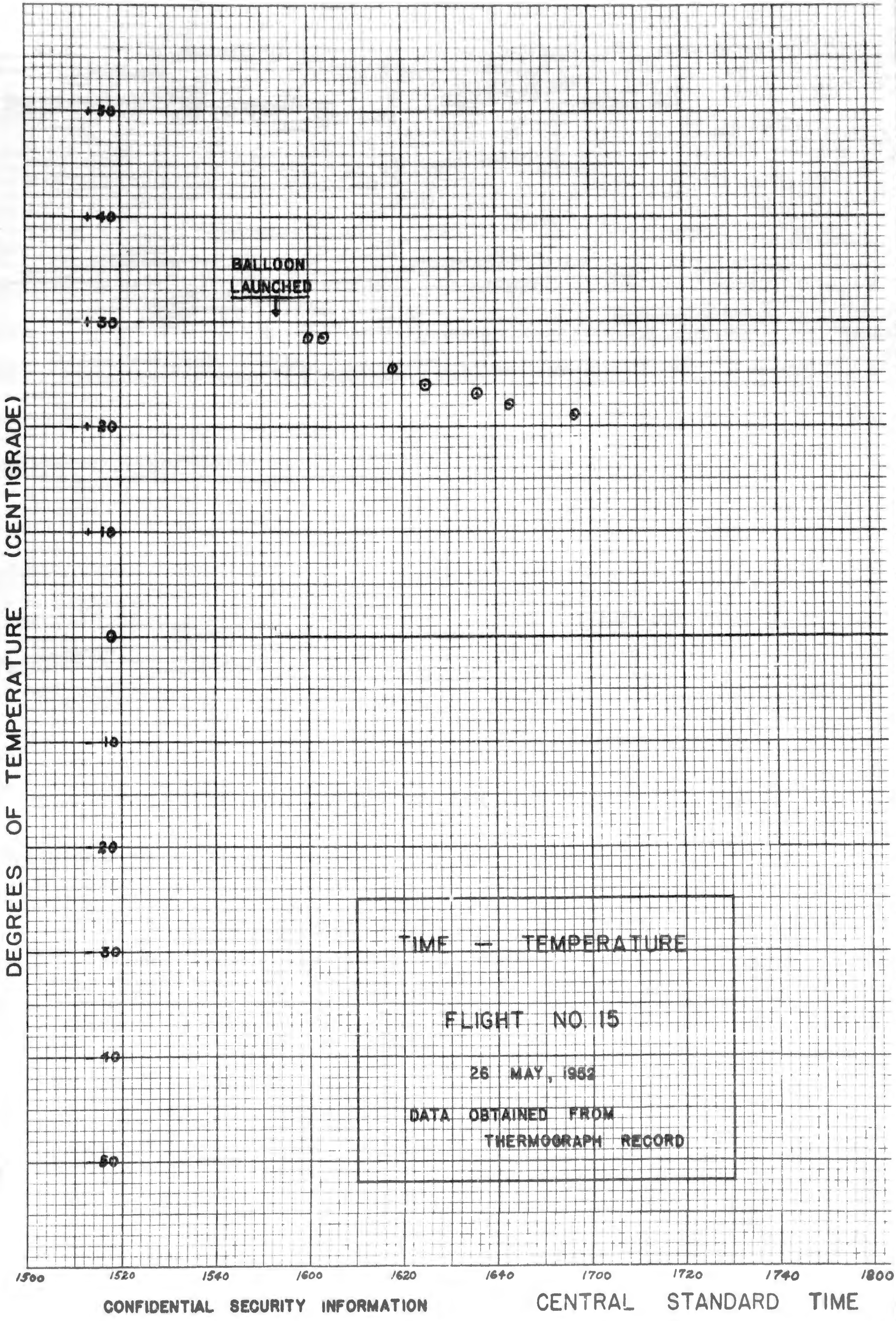

BALLOON SUNSET
APPROX
IMPACT
40
30
20
10
0
-10
-20
-30
-40
1920
1940
2000
2020
2040
2100
2120
2140
2200
2220
2240
2300
2320

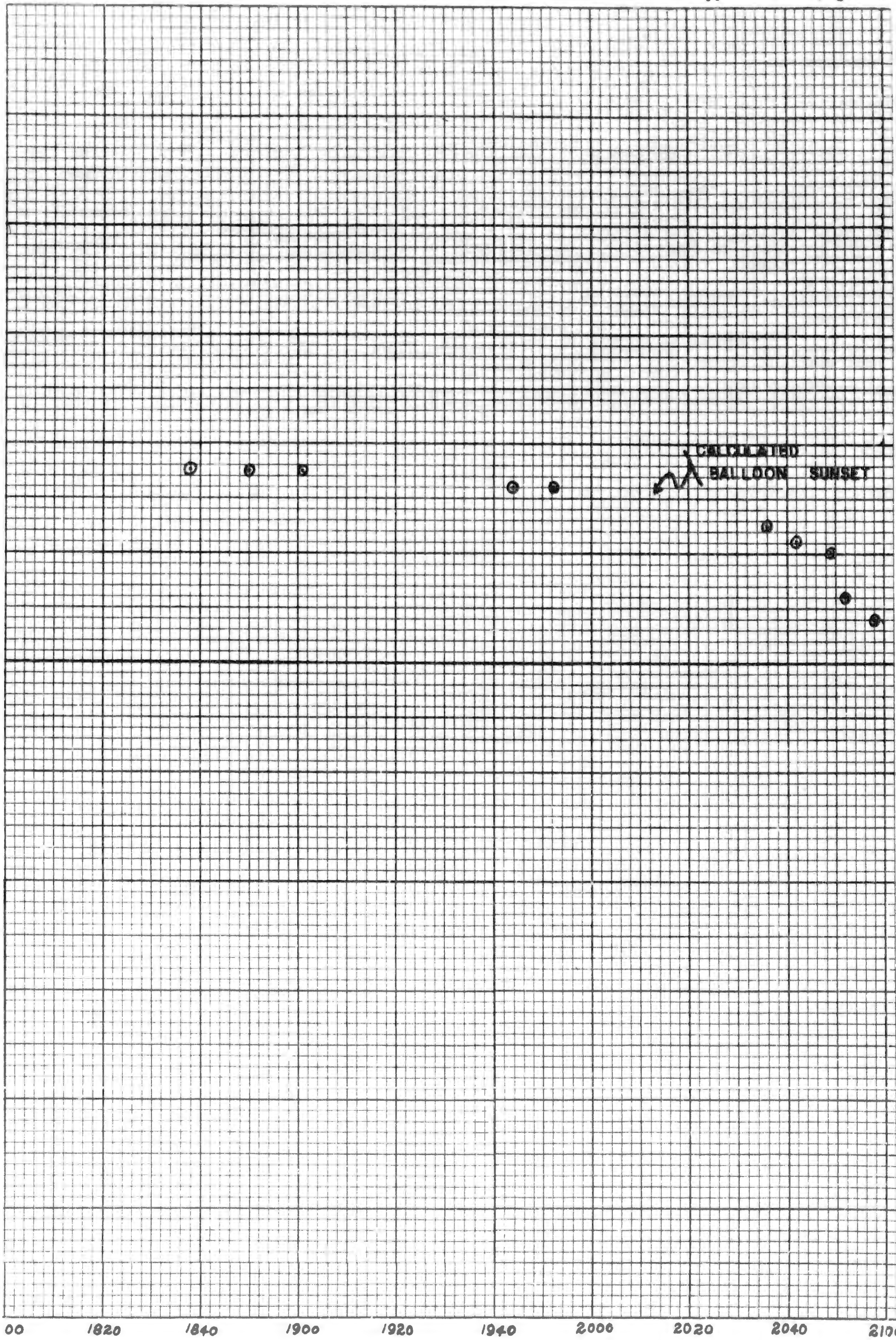


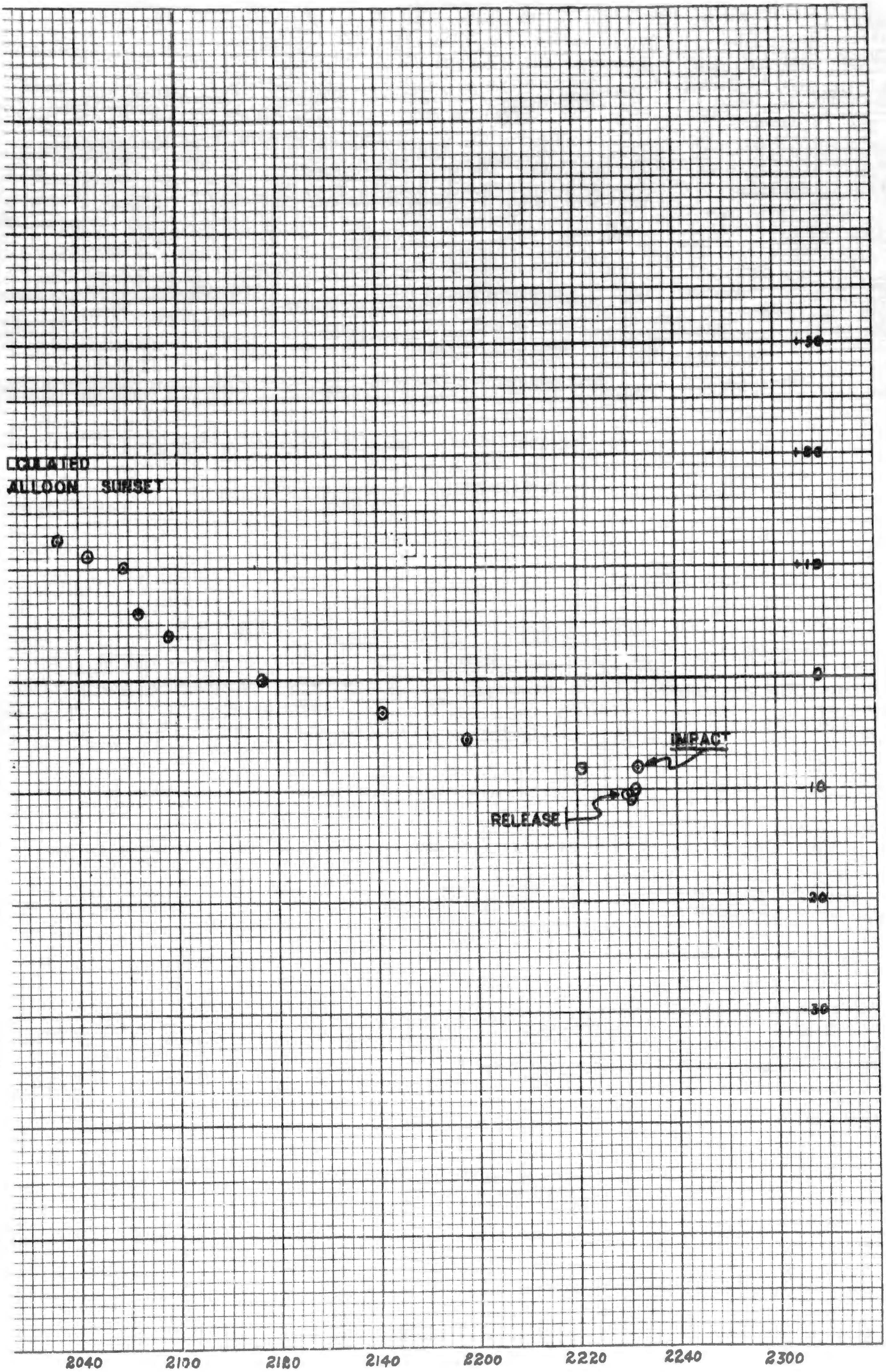
TIME FOR FIR
TIME
GIRDLE OBSERVED OFF
1530
1550
1600
1620
1630
1640
1700
1720
1740
1800
BALLOON LAUNCHED

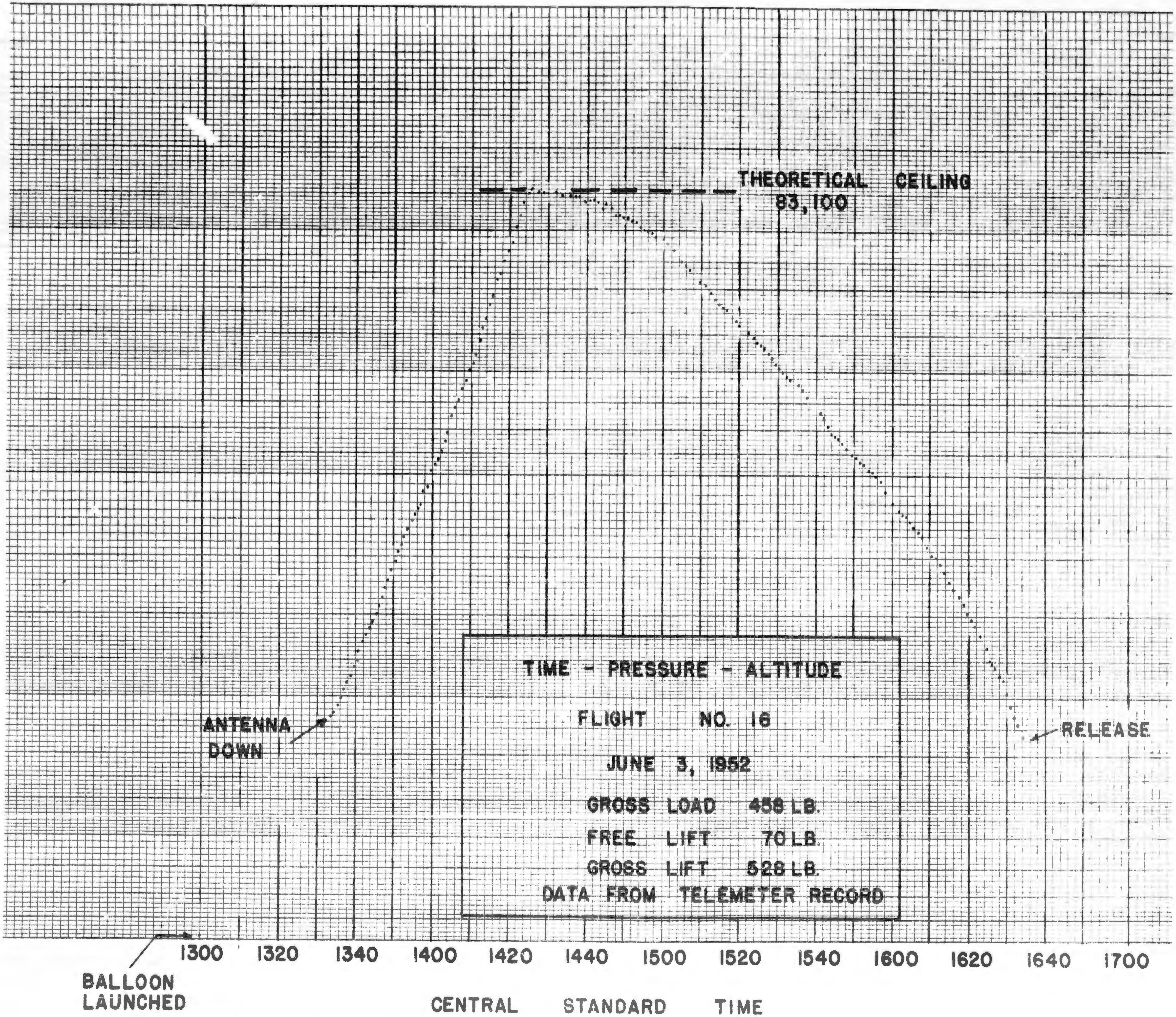

FOR FIRST 6# BALLAST DROP
TIME FOR NO. 2 - 6# BALLAST DROP
TIME FOR NO. 3 - 6# BALLAST DROP
THEORETICAL CEILING
80,000 FT.
GROUND SUNSET
BALLOON SUNSET
TIME - PRESSURE - ALTITUDE
FLIGHT NO. 15
MAY 26 - 1952
GROSS LOAD - 275 LBS.
FREE LIFT - 84 LBS.
GROSS LIFT - 359 LBS.
ALTITUDE DATA FROM TELEMETER RECORD
" " " "B" BAROGRAPH RECORD
1740
1800
1820
1840
1900
1920
1940
2000
2020
2040
CENTRAL STANDARD TIME

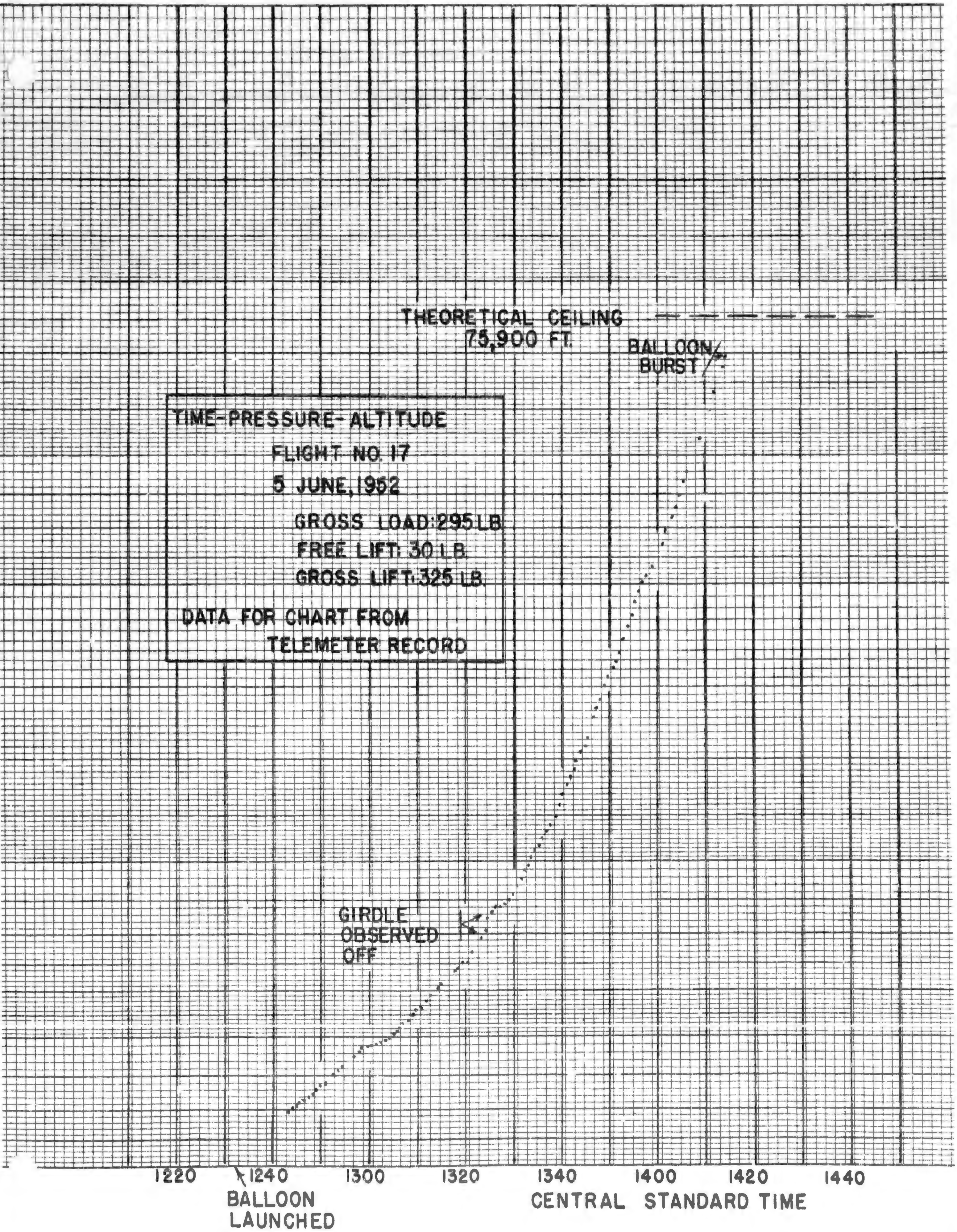

37,700 FT.
40,400 FT.
RELEASED BY TIMERS
2040
2100
2120
2140
2200
2220

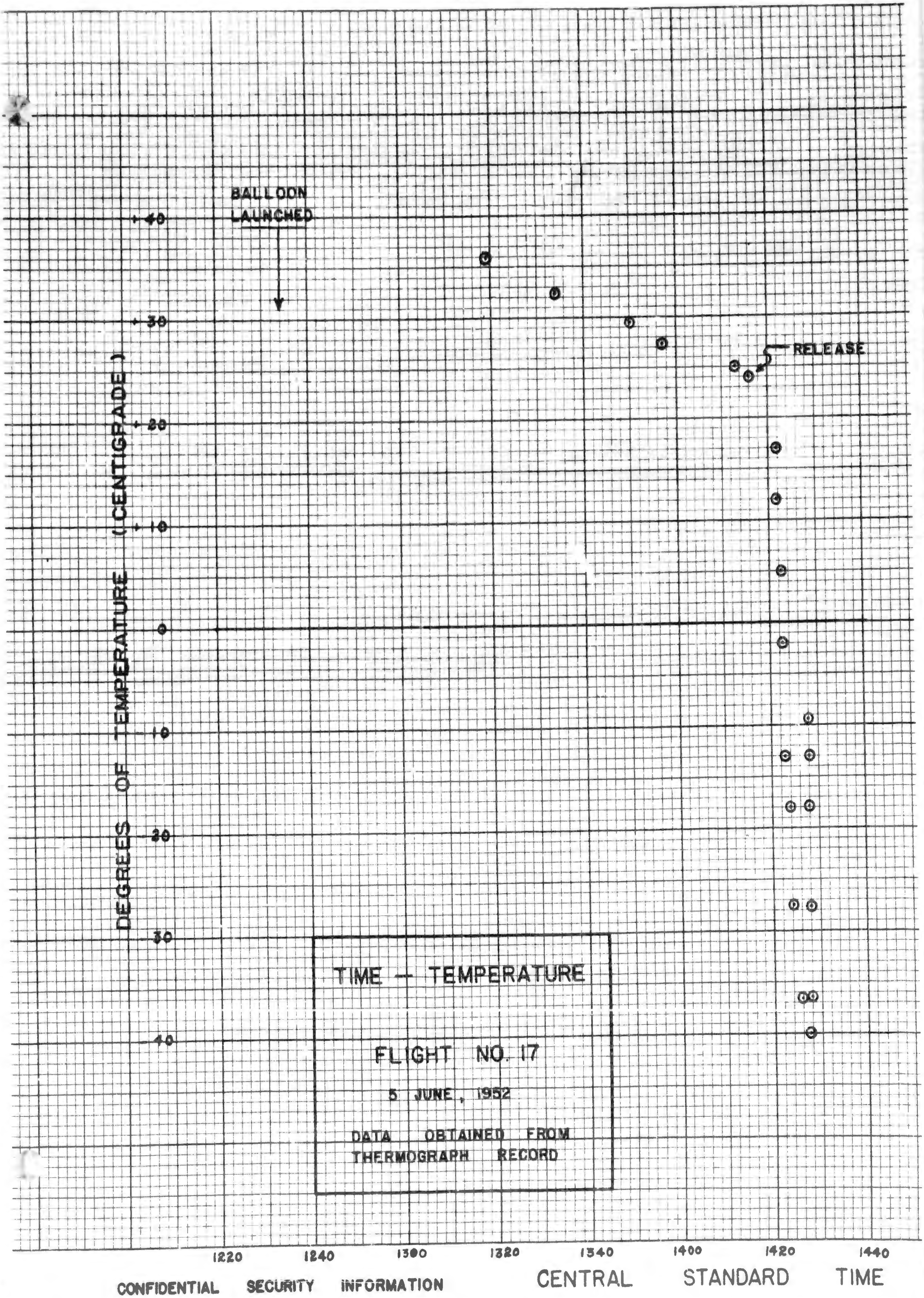

+50
+40
+30
+20
+10
0
-10
-20
-30
-40
-50
BALLOON LAUNCHED
DEGREES OF TEMPERATURE (CENTIGRADE)
TIME — TEMPERATURE
FLIGHT NO. 15
26 MAY, 1952
DATA OBTAINED FROM THERMOGRAPH RECORD
1500 1520 1540 1600 1620 1640 1700 1720 1740 1800
CENTRAL STANDARD TIME

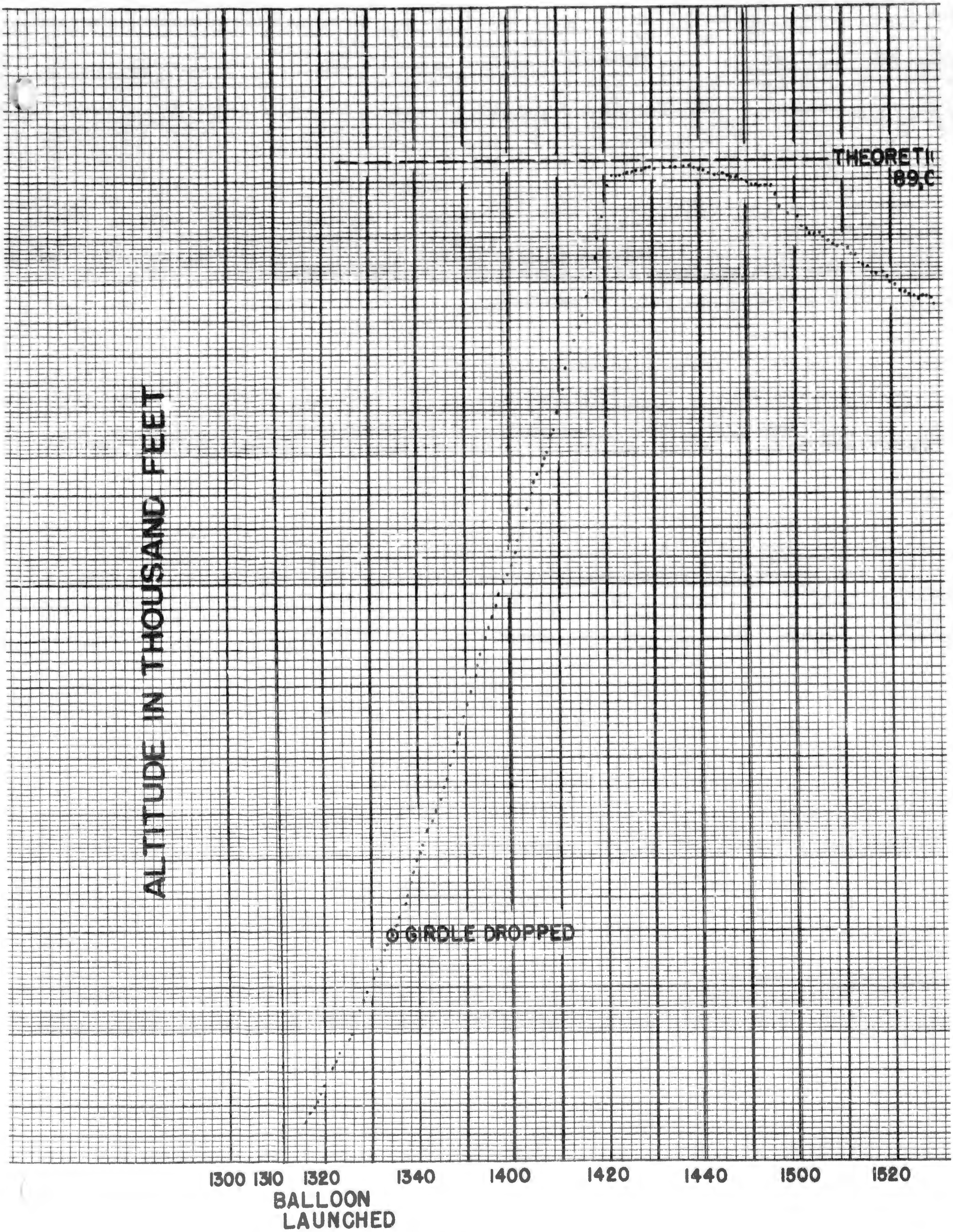

CALCULATED
BALLOON SUNSET
00
1820
1840
1900
1920
1940
2000
2020
2040
210

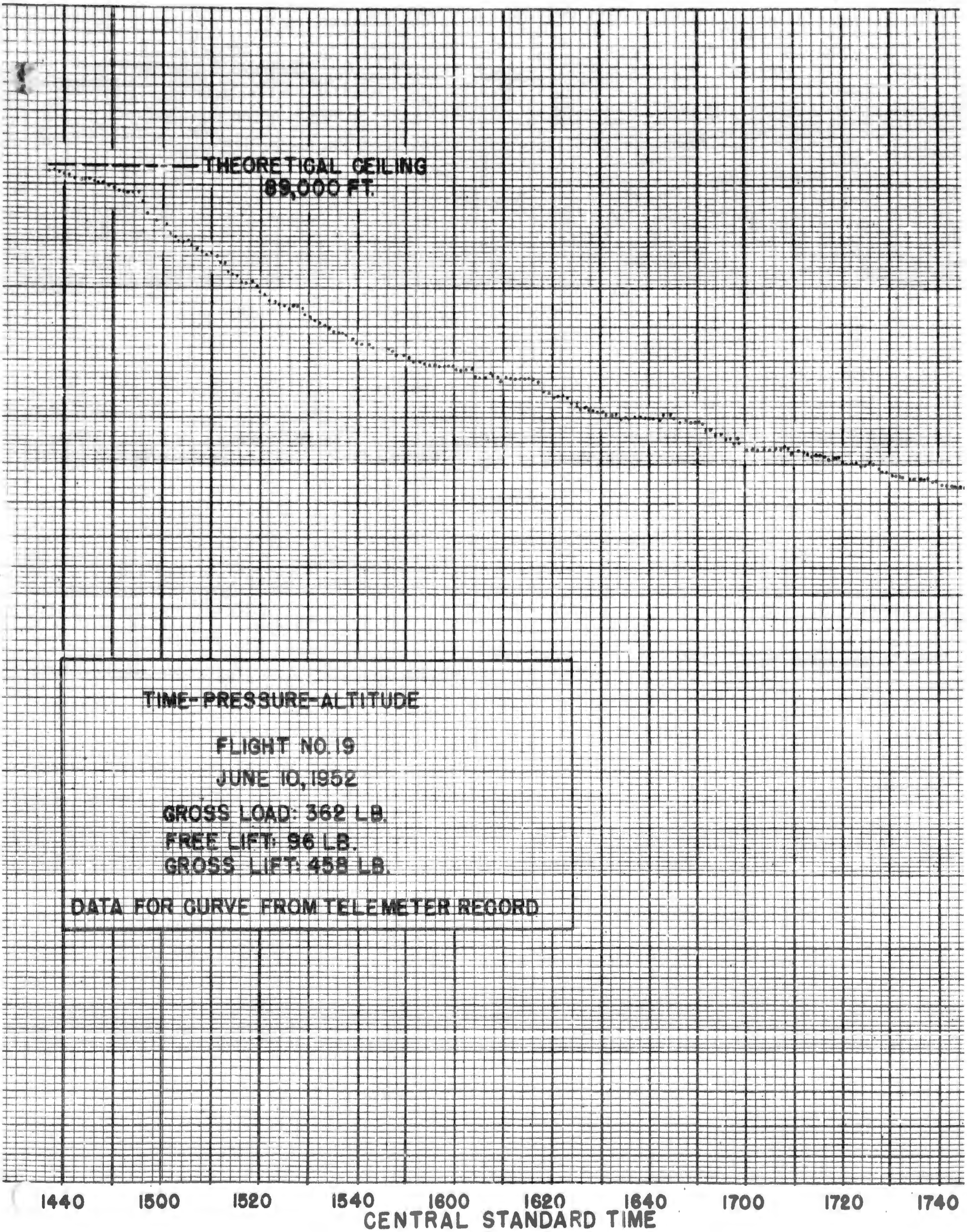

LCULATED
ALLOON SUNSET
IMPACT
RELEASE
0
10
20
30
2040
2100
2120
2140
2200
2220
2240
2300

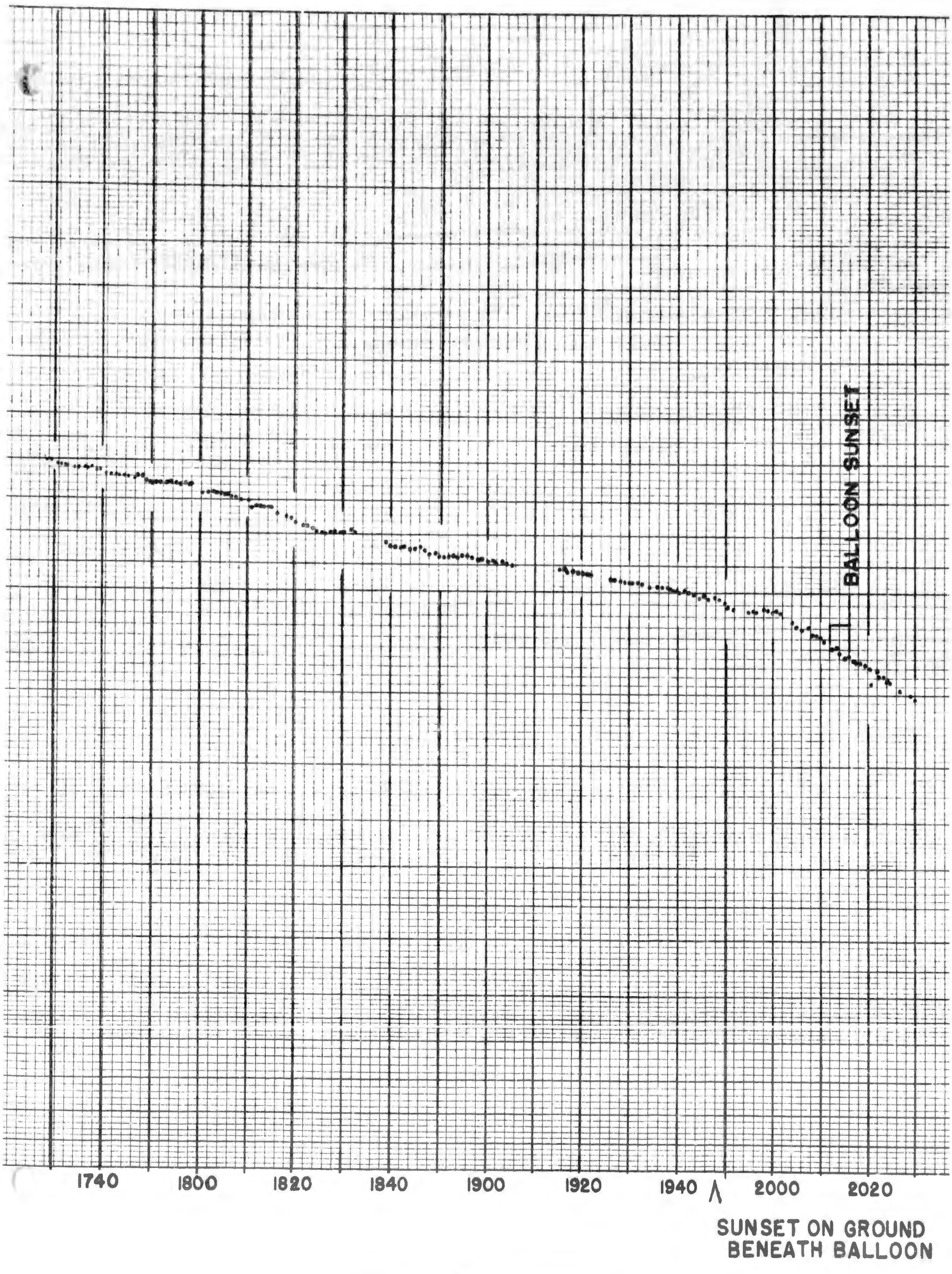

THEORETICAL CEILING
83,100
TIME - PRESSURE - ALTITUDE
FLIGHT NO. 16
JUNE 3, 1952
GROSS LOAD 458 LB.
FREE LIFT 70 LB.
GROSS LIFT 528 LB.
DATA FROM TELEMETER RECORD
ANTENNA DOWN
RELEASE
BALLOON LAUNCHED
1300
1320
1340
1400
1420
1440
1500
1520
1540
1600
1620
1640
1700
CENTRAL STANDARD TIME

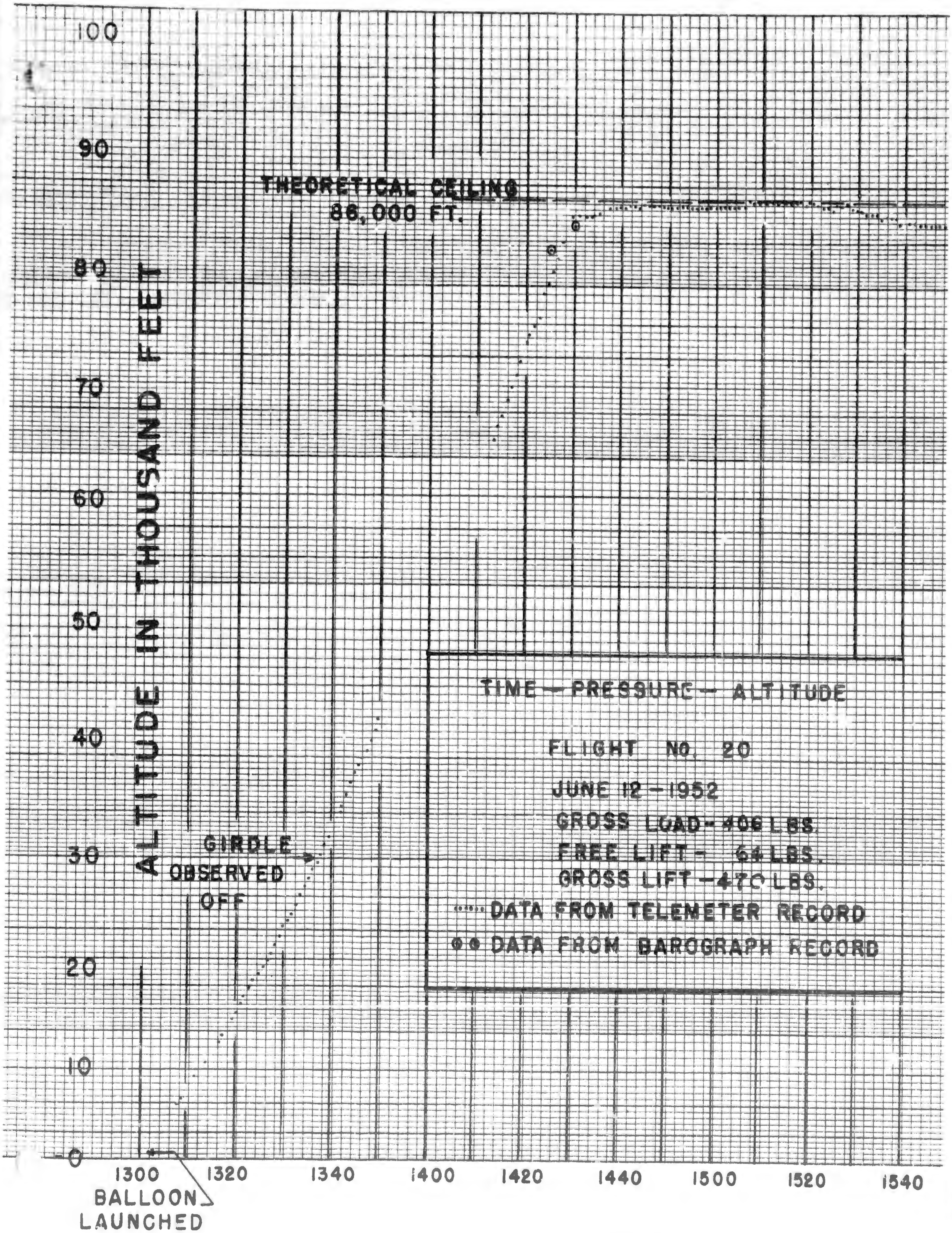

THEORETICAL CEILING
75,900 FT.
BALLOON
BURST
TIME-PRESSURE-ALTITUDE
FLIGHT NO. 17
5 JUNE, 1952
GROSS LOAD: 295 LB.
FREE LIFT: 30 LB.
GROSS LIFT: 325 LB.
DATA FOR CHART FROM
TELEMETER RECORD
GIRDLE
OBSERVED
OFF
1220
1240
1300
1320
1340
1400
1420
1440
BALLOON
LAUNCHED
CENTRAL STANDARD TIME

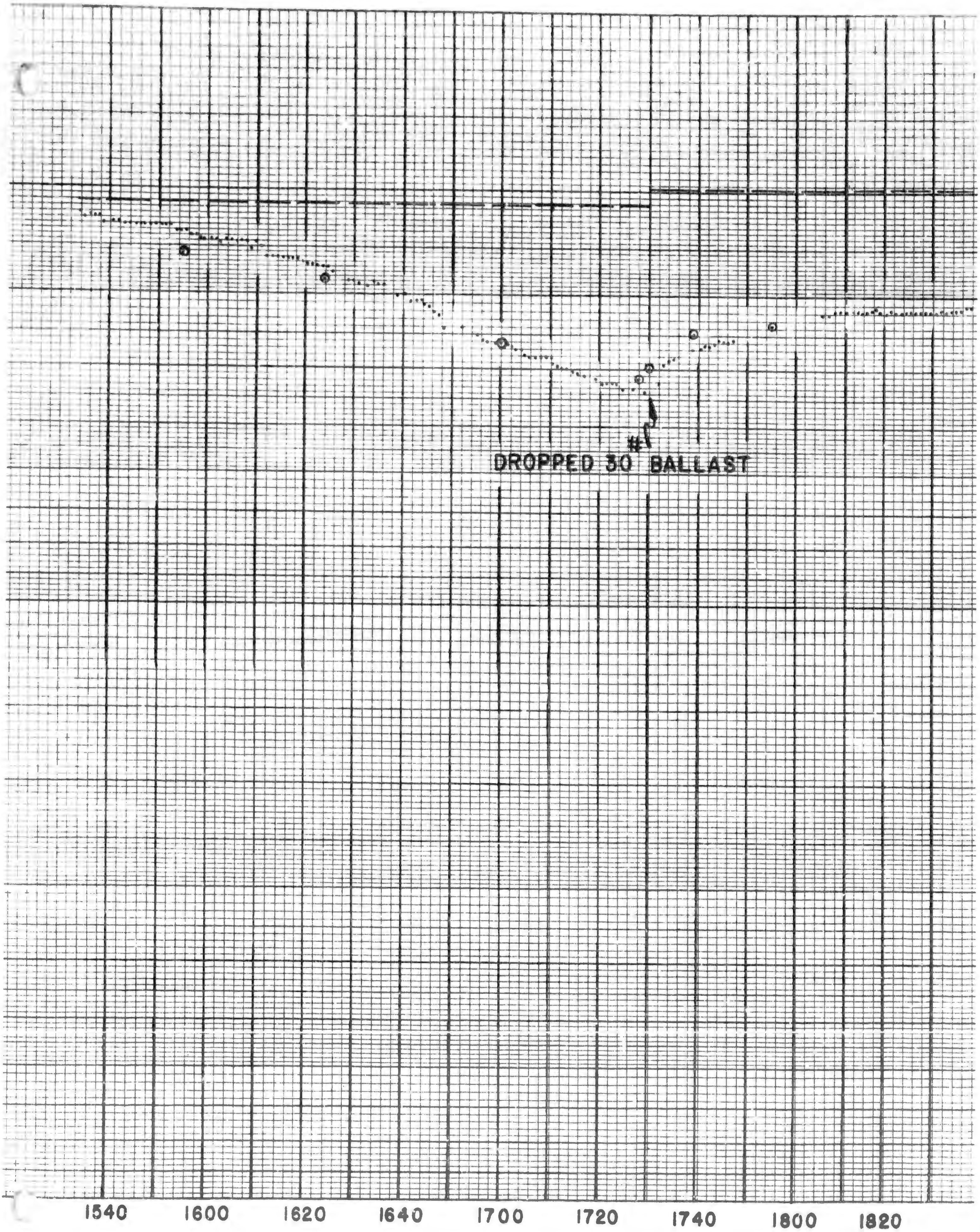

BALLOON LAUNCHED
RELEASE
DEGREES OF TEMPERATURE (CENTIGRADE)
+40
+30
+20
+10
0
-10
-20
-30
-40
TIME — TEMPERATURE
FLIGHT NO. 17
5 JUNE, 1952
DATA OBTAINED FROM THERMOGRAPH RECORD
1220
1240
1300
1320
1340
1400
1420
1440
CENTRAL STANDARD TIME

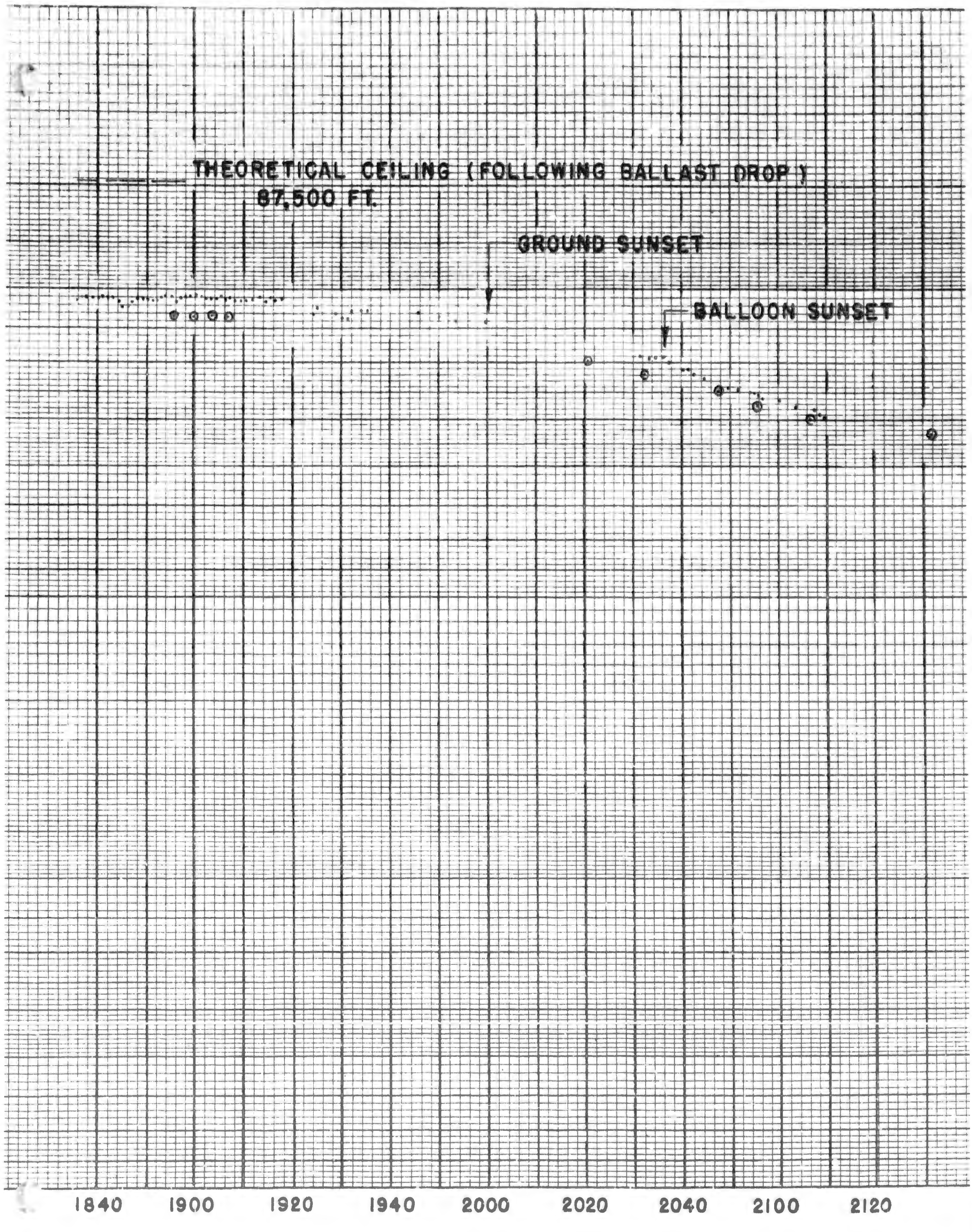

THEORETI
189,C
ALTITUDE IN THOUSAND FEET
GIRDLE DROPPED
1300
1310
1320
1340
1400
1420
1440
1500
1520
BALLOON
LAUNCHED

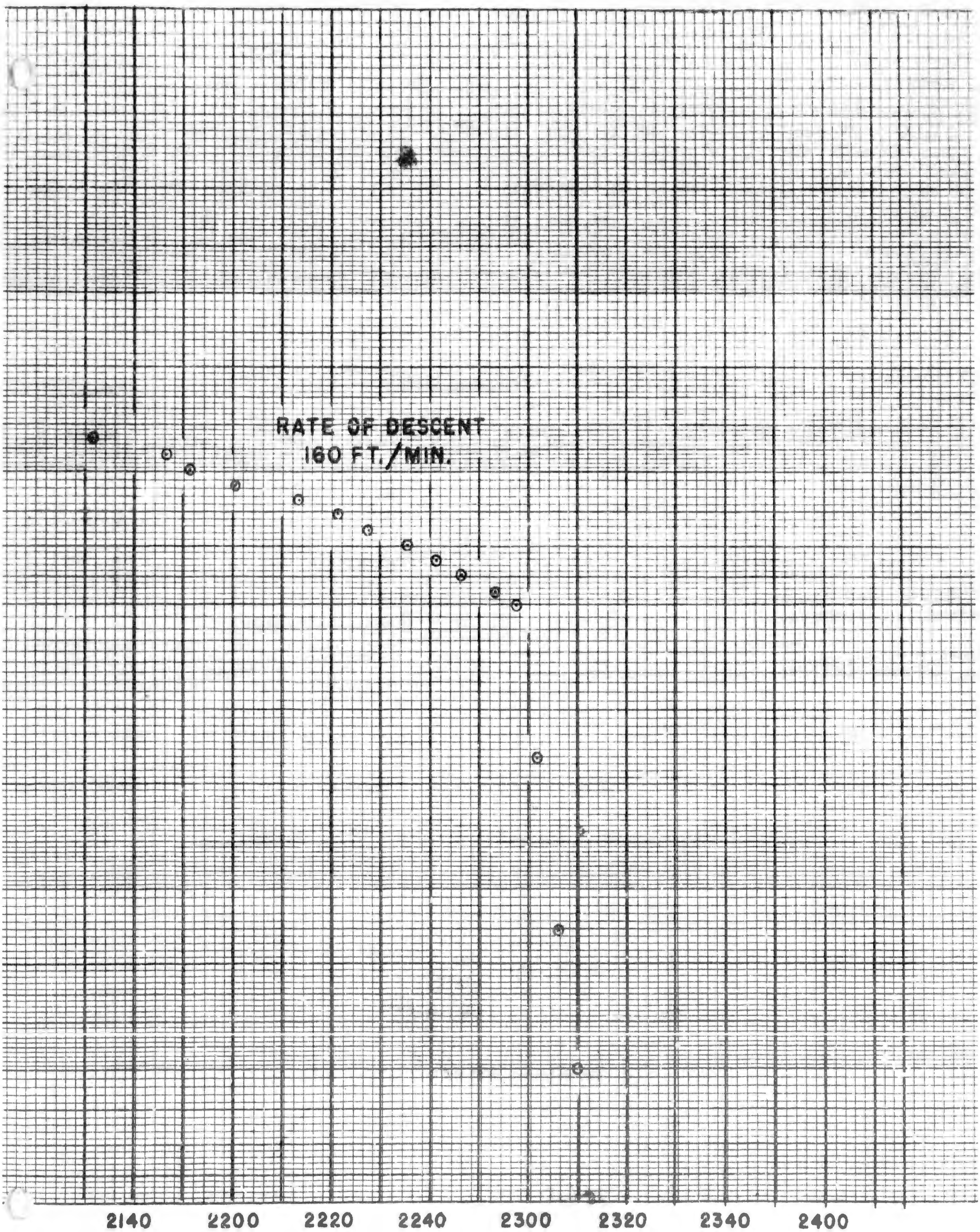

THEORETICAL CEILING
89,000 FT.
TIME-PRESSURE-ALTITUDE
FLIGHT NO. 19
JUNE 10, 1952
GROSS LOAD: 362 LB.
FREE LIFT: 96 LB.
GROSS LIFT: 458 LB.
DATA FOR CURVE FROM TELEMETER RECORD
1440
1500
1520
1540
1600
1620
1640
1700
1720
1740
CENTRAL STANDARD TIME

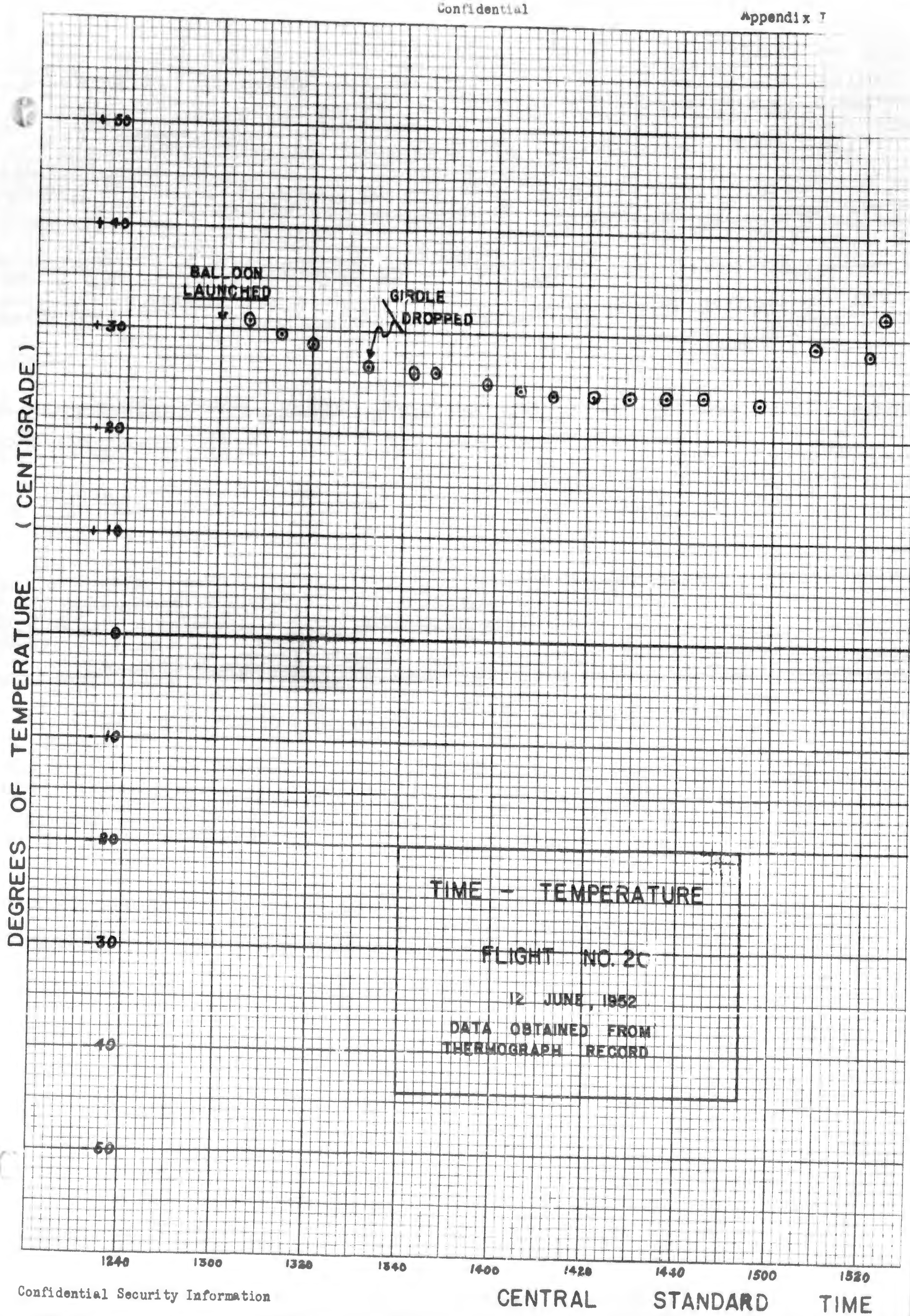

BALLOON SUNSET
1740
1800
1820
1840
1900
1920
1940
2000
2020
SUNSET ON GROUND
BENEATH BALLOON

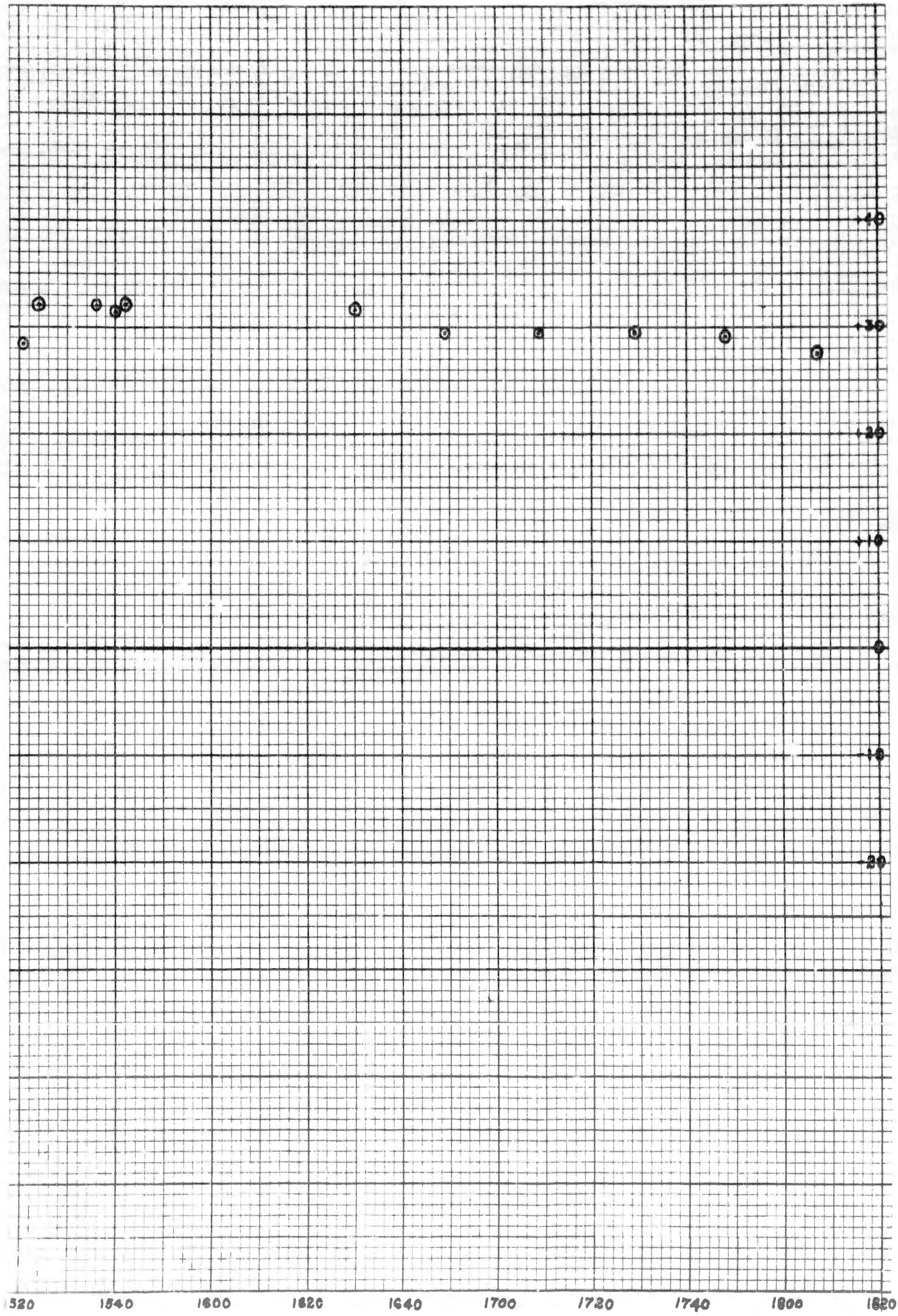

THEORETICAL CEILING
86,000 FT.
ALTITUDE IN THOUSAND FEET
100
90
80
70
60
50
40
30
20
10
0
GIRDLE OBSERVED OFF
TIME — PRESSURE — ALTITUDE
FLIGHT NO. 20
JUNE 12 - 1952
GROSS LOAD - 406 LBS.
FREE LIFT - 64 LBS.
GROSS LIFT - 470 LBS.
DATA FROM TELEMETER RECORD
DATA FROM BAROGRAPH RECORD
1300
1320
1340
1400
1420
1440
1500
1520
1540
BALLOON LAUNCHED
CENTRAL STANDARD TIME

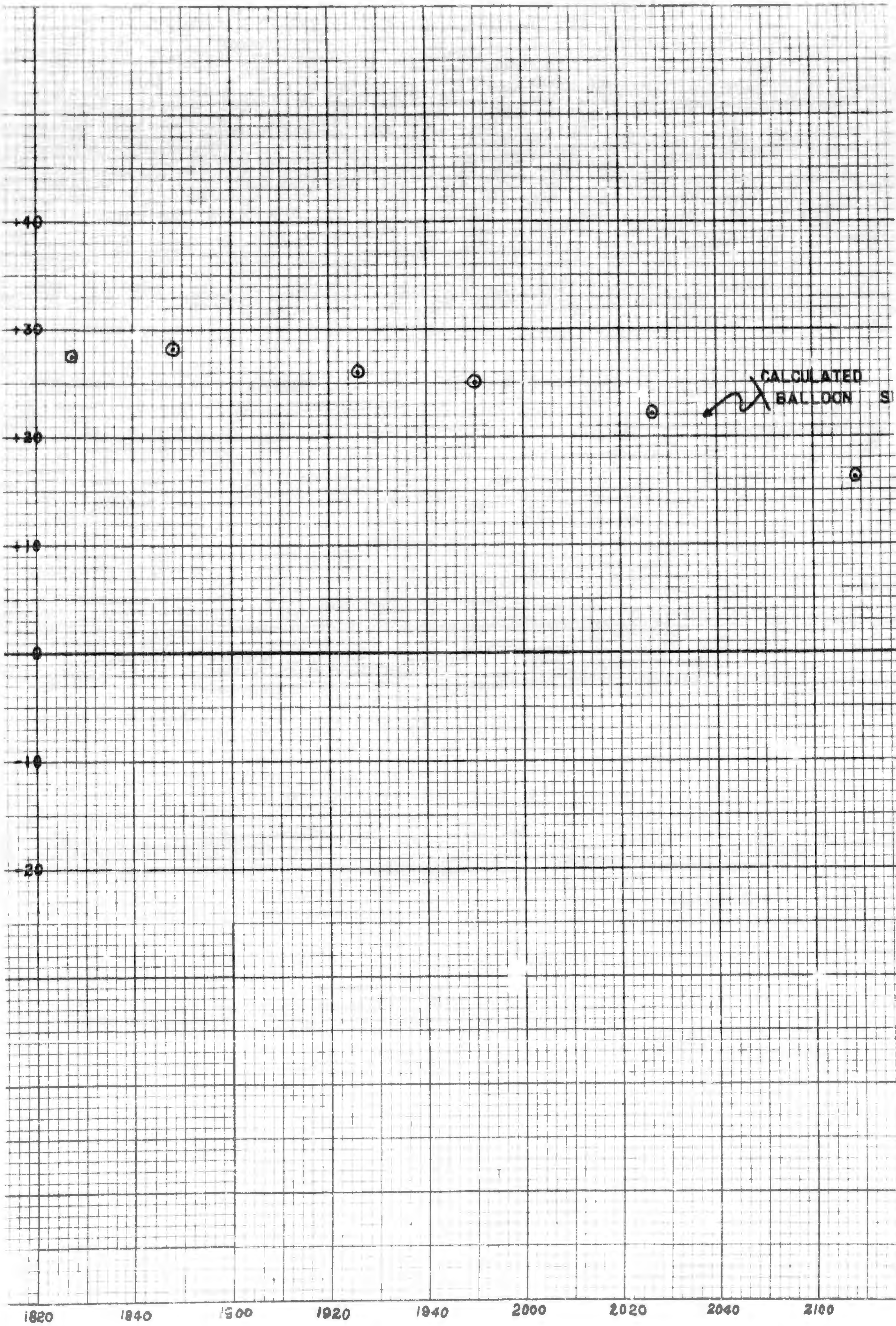

DROPPED 30# BALLAST
1540
1600
1620
1640
1700
1720
1740
1800
1820

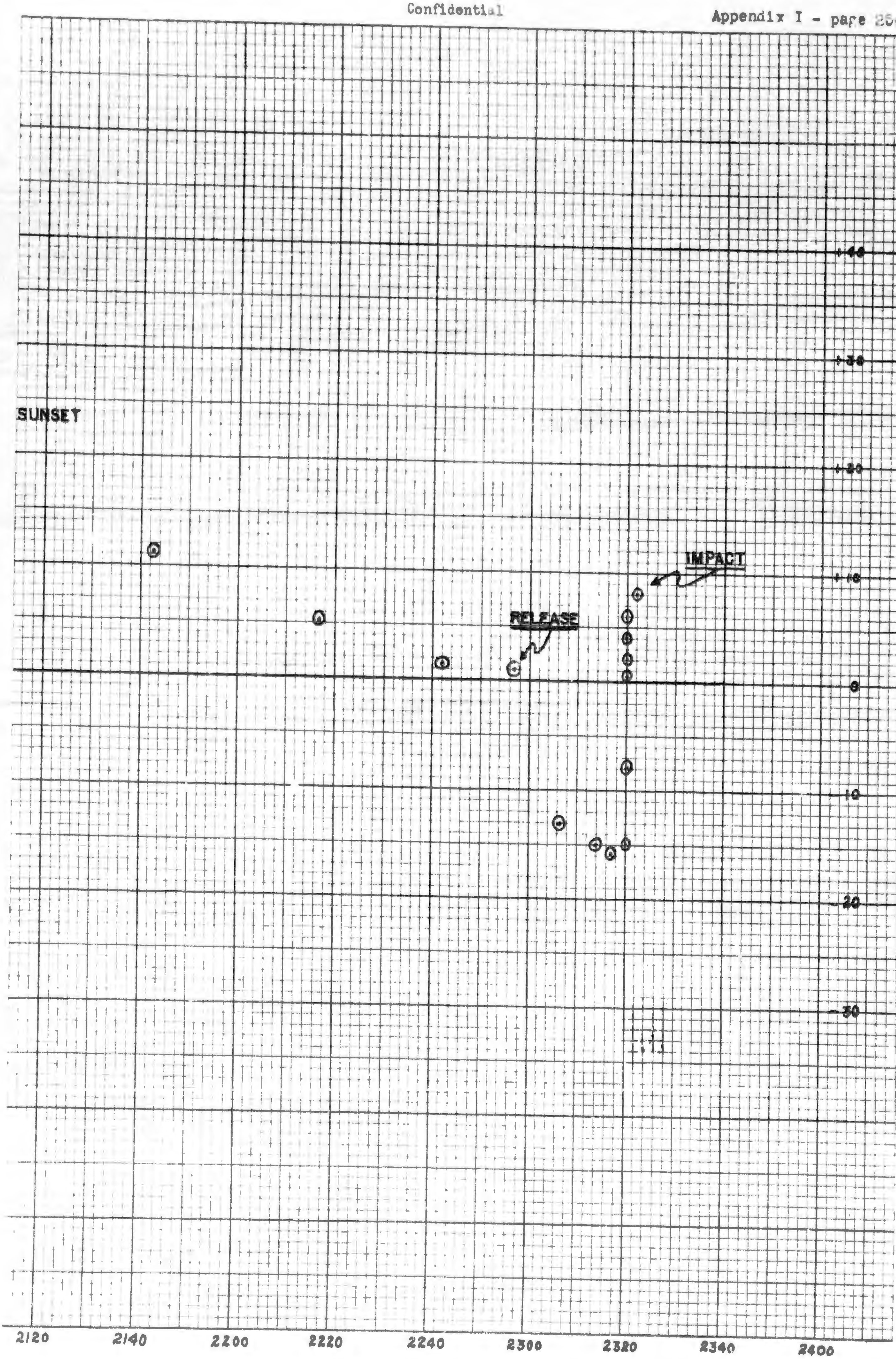

THEORETICAL CEILING (FOLLOWING BALLAST DROP)
87,500 FT.
GROUND SUNSET
BALLOON SUNSET
1840
1900
1920
1940
2000
2020
2040
2100
2120


RATE OF DESCENT
160 FT./MIN.
2140
2200
2220
2240
2300
2320
2340
2400


DEGREES OF TEMPERATURE (CENTIGRADE)
+50
+40
+30
+20
+10
0
-10
-20
-30
-40
-50
BALLOON LAUNCHED
GIRDLE DROPPED
TIME - TEMPERATURE
FLIGHT NO. 2C
12 JUNE, 1952
DATA OBTAINED FROM THERMOGRAPH RECORD
1240
1300
1320
1340
1400
1420
1440
1500
1520
CENTRAL STANDARD TIME


+40
+30
+20
+10
0
-10
-20
520
1540
1600
1620
1640
1700
1720
1740
1800
1820

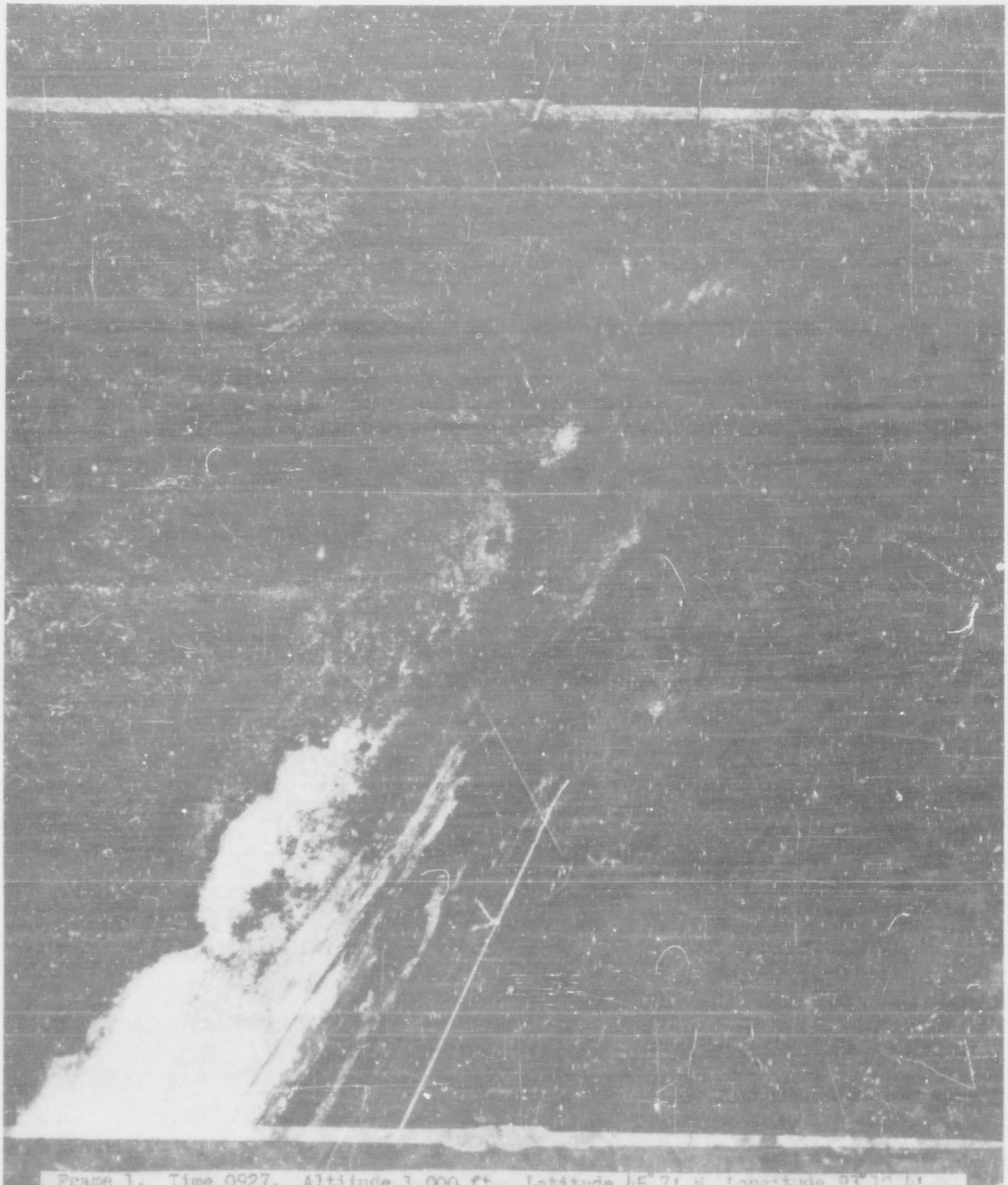

+40
+30
+20
+10
0
-10
-20
CALCULATED
BALLOON
1820
1840
1900
1920
1940
2000
2020
2040
2100


SUNSET
IMPACT
RELEASE
+40
+30
+20
+10
0
-10
-20
-30
2120
2140
2200
2220
2240
2300
2320
2340
2400

APPENDIX X

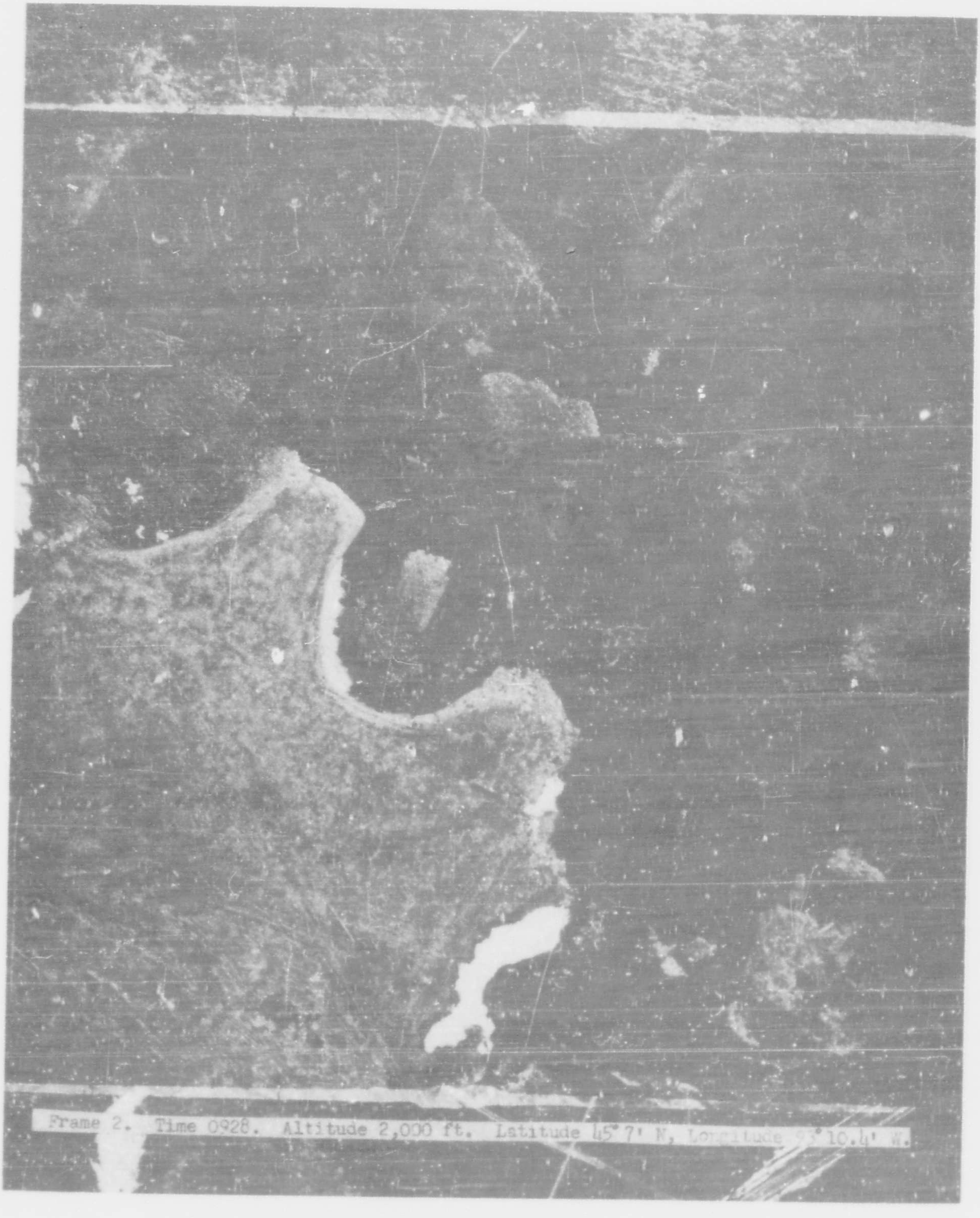
DOWN PHOTOGRAPHS FROM FLIGHT 8

These photographs are pictures taken looking down from the gondola at the ground in Flight 8. The complete set of pictures has been used to obtain an accurate trajectory for the flight. The pictures taken during the ascent of the balloon are being used to evaluate the atmospheric temperature.



Frame 1. Time 0927. Altitude 1,000 ft. Latitude 45° 7' N, Longitude 93° 10.4' [illegible].


Frame 7. Time 0933. Altitude 6,000 ft. Latitude 45°5.5' N, Longitude 93° 10.3' W.



Frame 2. Time 0928. Altitude 2,000 ft. Latitude 45°7' N, Longitude 93°10.4' W.

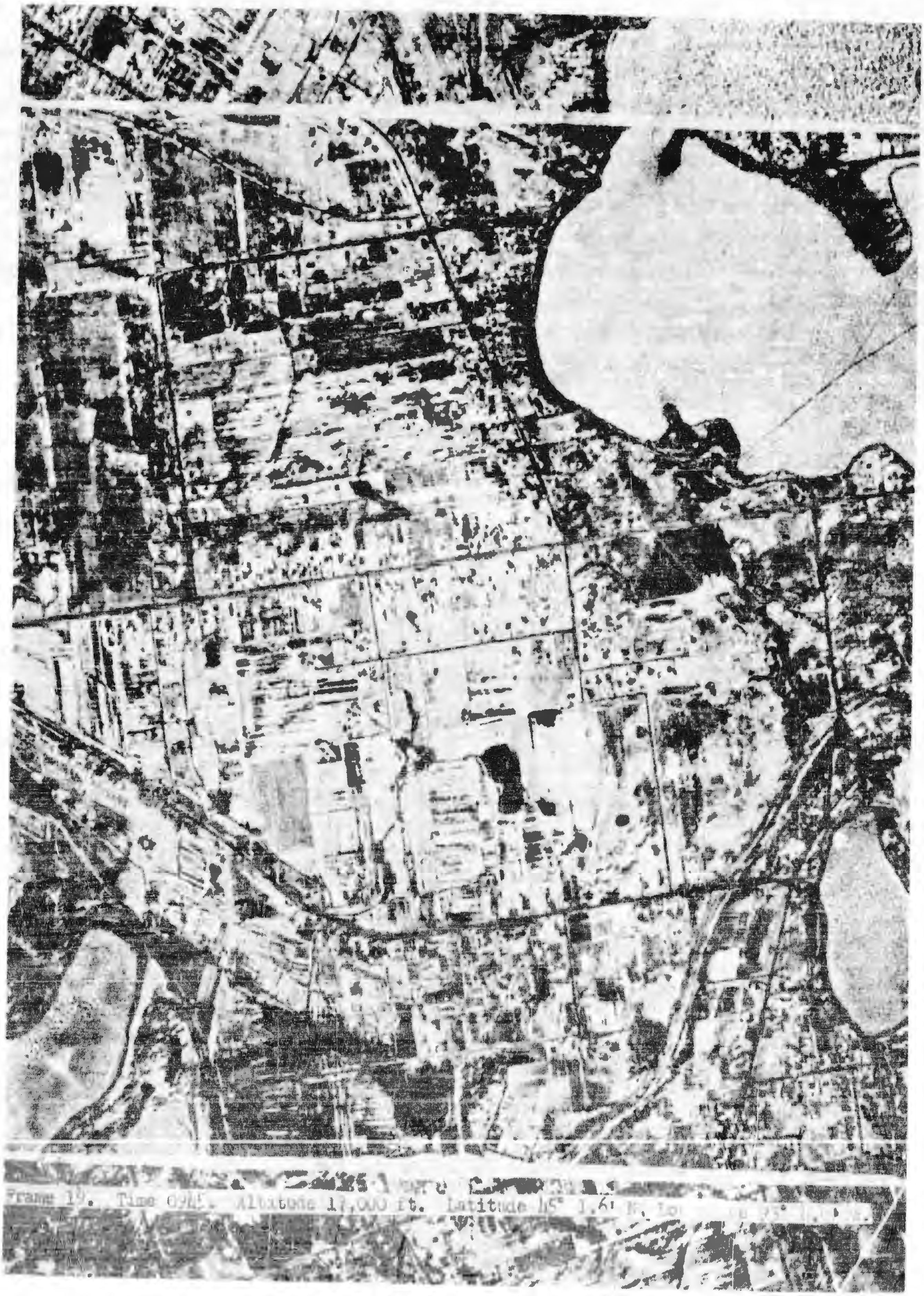
CONFIDENTIAL

CONFIDENTIAL

Restricted Security Information

Frame 7. Time 0933. Altitude 6,000 ft. Latitude 45°5.5' N, Longitude 93° 10.3' W.

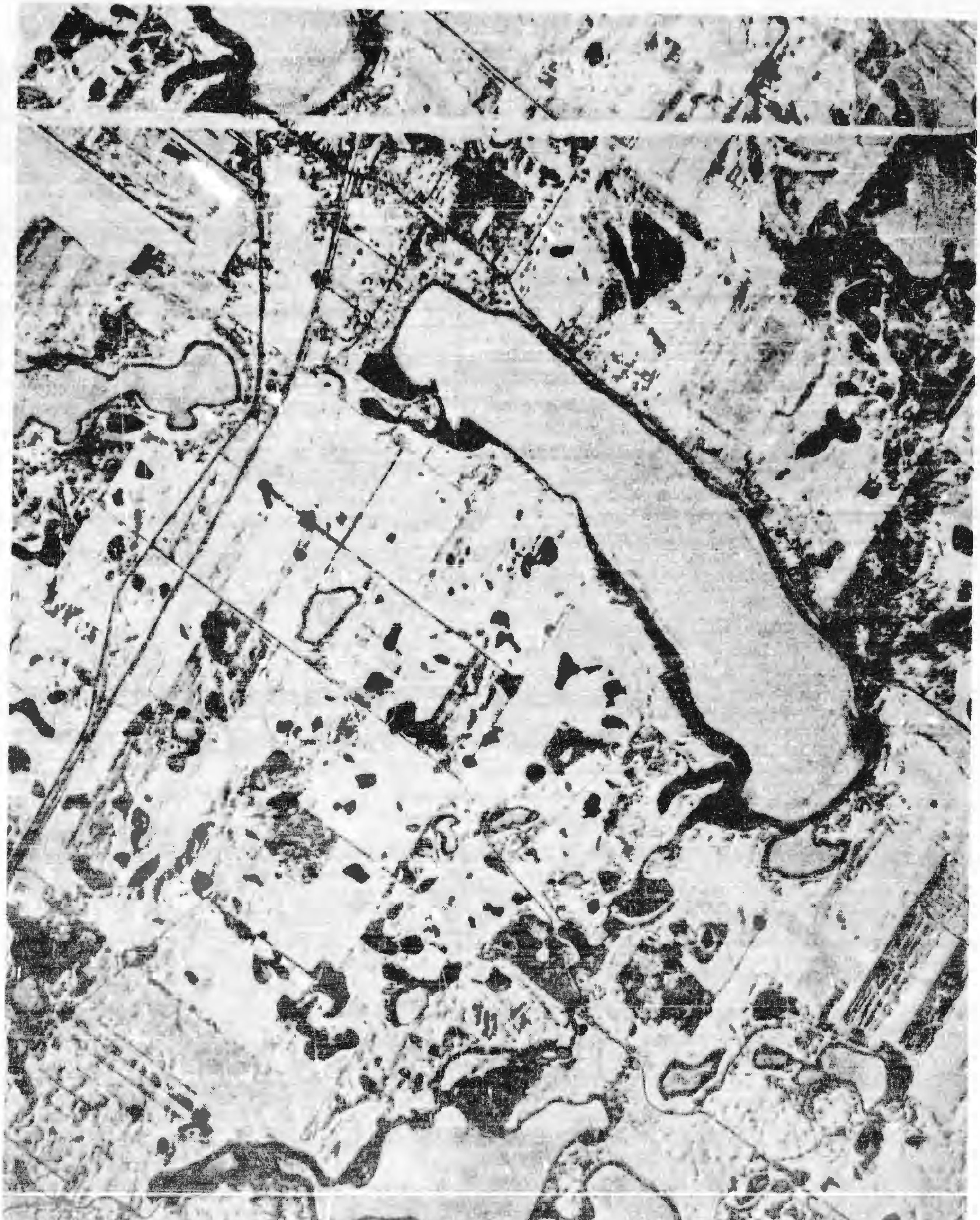

Frame 15. Time 0941. Altitude 13,000 ft. Latitude 15° 2.5' N, Longitude 93° 7.8'



Frame 19. Time 09[illegible]. Altitude 1[illegible],000 ft. Latitude 45° 1.6' N, Lo[illegible]

Frame 23. Time 0949. Altitude 21,000 ft. Latitude 45° 0.6' N. Longitude 92° 59.8' W.

CONFIDENTIAL



Frame 27. Time 0953. Altitude 25,000 ft. Latitude 44° 59.0' N, Longitude 92° 54.0' W.

CONFIDENTIAL

Restricted Security Information

Frame 31. Time 0957. Altitude 29,000 ft. Latitude 44° 58.7' N, Longitude 92° 45.5' W

Frame 33. Time 1001. Altitude 33,000 ft. Latitude 44 55.5' N, Longitude 92° 39.3' W.

Frame 39. Time 1005. Altitude 36,000 ft. Latitude 44° 55.3' N, Longitude 92° 33.4' W.

Frame 43. Time 1009. Altitude 39,000 ft. Latitude 44° 56.0' N, Longitude 92° 29.0' W.

Frame 47. Time 1013. Altitude 42,000 ft. Latitude 44° 56.2' N, Longitude 92° 24.0' W

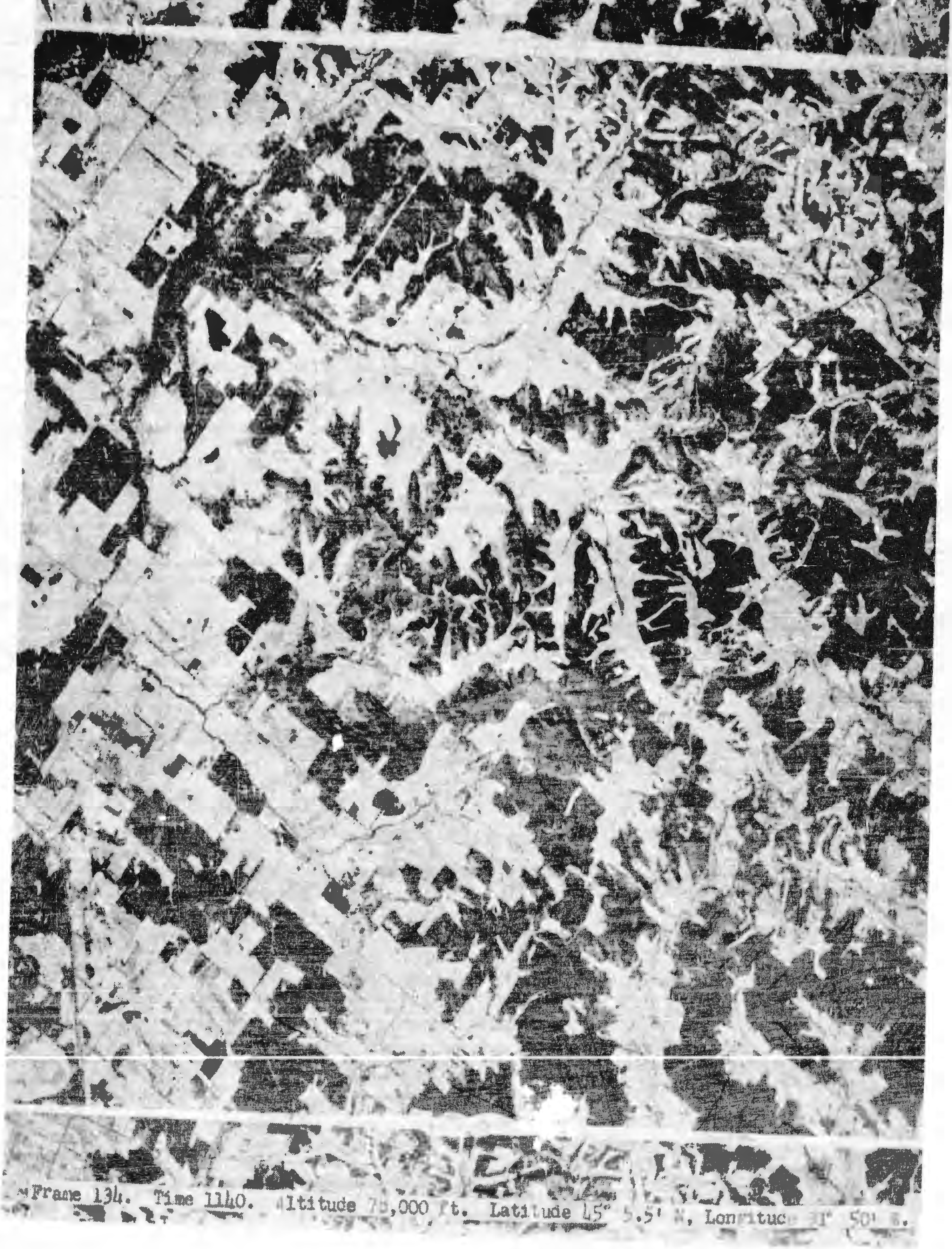
Frame 60, Time 1026, Altitude 52,000 ft. Latitude 44° 55.8' N, Longitude 92° 12.6' W.

Frame 72. Time 1038. Altitude 62,000 ft. Latitude 45° N, Longitude 92° 5.6' W.

CONFIDENTIAL

Frame 81. Time 1047. Altitude 67,000 ft. Latitude 45° .8' N, Longitude 92° 2.6' W.

Frame 104. Time 1110. Altitude 73,000 ft. Latitude 45° 2' N, Longitude 91° 56' W.

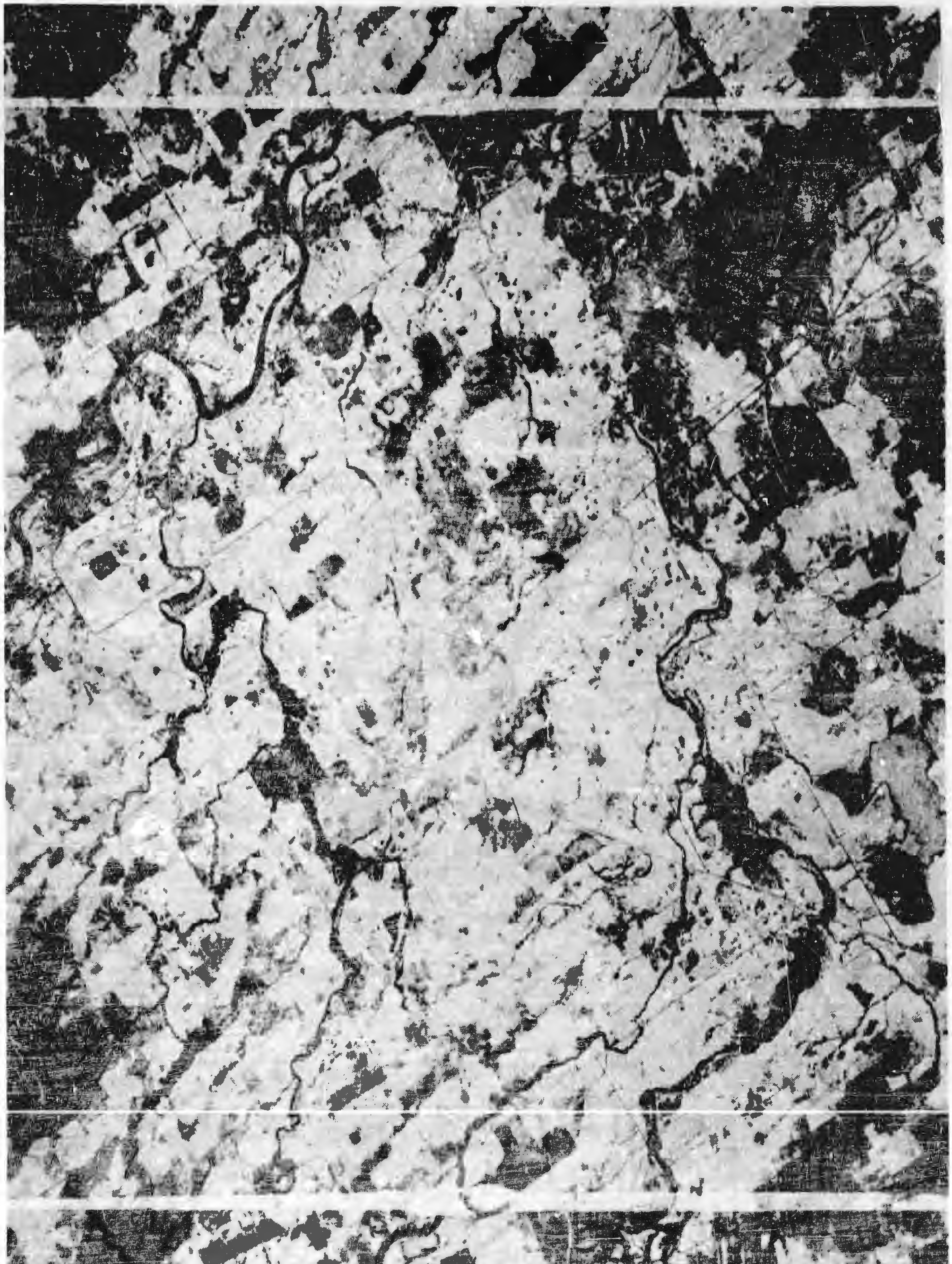


Frame 134. Time 1140. Altitude 75,000 Ft. Latitude 45° 5.5' N, Longitude 31° 50' E.

Frame 154. Time 1200. Altitude 30,000 ft. Latitude 45° 9.2' N, Longitude 91° 46.4' W.

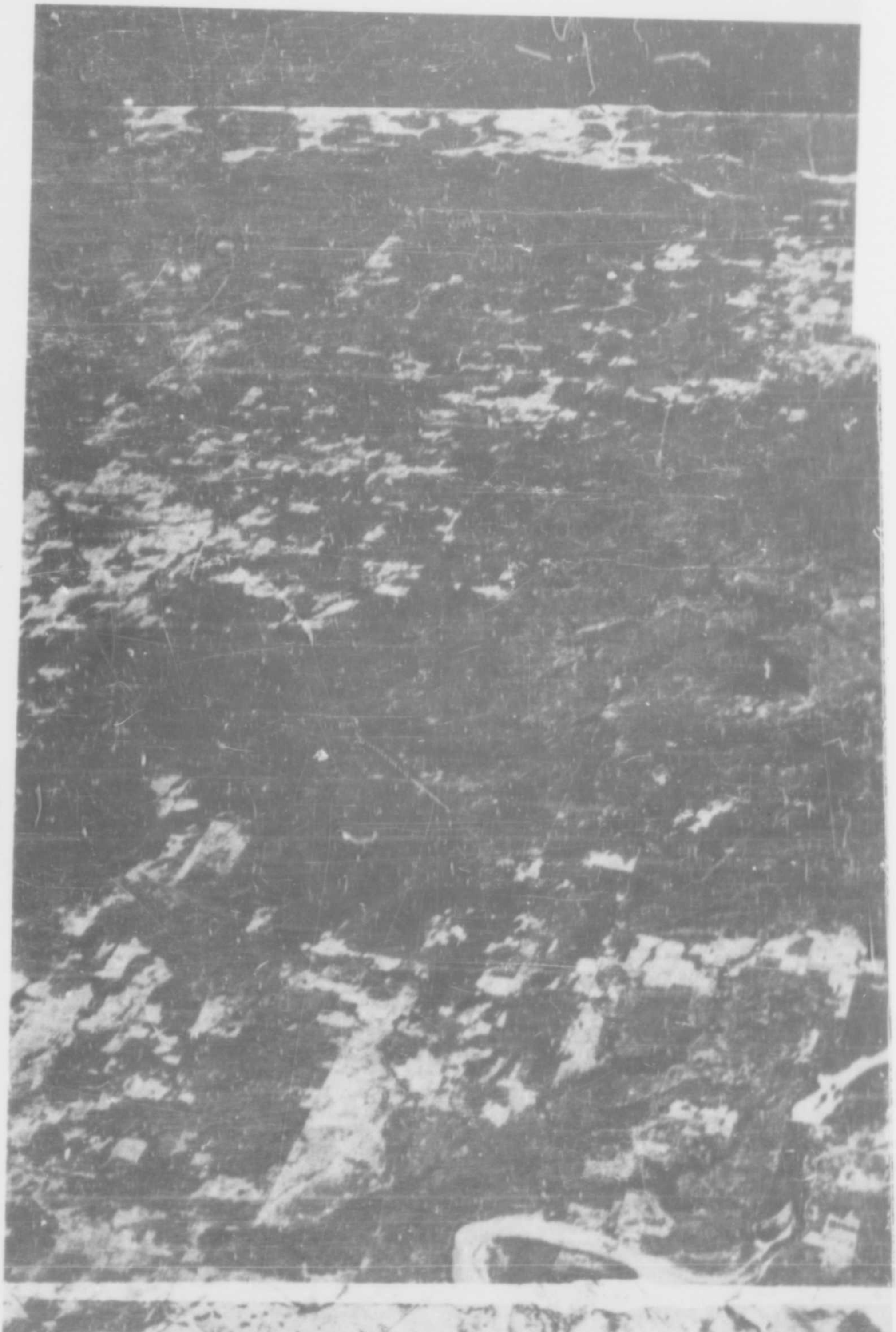
Frame 304. Time 1430. Altitude 81,000 ft. Latitude 45° 24' N, Longitude 91° 2.5' W.

CONFIDENTIAL



Frame 31[illegible]. Time 1[illegible]0. Altitude [illegible],000 ft. Latitude [illegible] 20.5' N, Longitude 90° 59.0' [illegible]

CONFIDENTIAL Restricted Security Information



First photograph after release. Parachute is swinging and down
obliquely at the ground.