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PROGRESS REPORT ON /-//
HIGH ALTITUDE PLASTIC BALLOONS
CONTRACT NONR-710(01)
JANUARY 20, 1953 to FEBRUARY 4, 1953
VOLUME VIII
CONFIDENTIAL SECURITY INFORMATION

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Contract Nonr 710(01) Volume VIII

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

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CONDUCTED UNDER
CONTRACT NONR-710(01), NR 211 002
FOR PERIOD 20 JANUARY 1953 TO 4 FEBRUARY 1953
WITH THE
OFFICE OF NAVAL RESEARCH

AND SPONSORED JOINTLY
BY THE ARMY, NAVY AND AIR FORCE

Prepared by the
Department of Physics
University of Minnesota
Minneapolis 14, Minnesota

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PROGRESS REPORT ON CONTRACT # 710 (01)

From 20 January 1953 to 4 February 1953

VOLUME VIII

CONFIDENTIAL SECURITY INFORMATION

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Section IJOINT OPERATION WITH WINZEN RESEARCH, INC. FOR SKYHOOK FLIGHTS AT
PYOTE AIR FORCE BASEIntroduction

The thirteen flights described in this report were made during a joint operation with Winzen Research, Inc. of St. Paul for the dual purpose of carrying cosmic ray scientific gear to high altitudes at a 40° geomagnetic latitude, and to give information of value to the balloon research program in the nature of flight performance of the various balloons, meteorological trajectories, etc. The operation was set up on a cooperative basis with Winzen Research through ONR with the understanding that the balloons, including the packing, would be provided by Winzen Research to the specifications of the University of Minnesota. The University of Minnesota would furnish the control instrumentation for the balloons including pressure telemetering by the Olland Cycle method developed at the University. Down cameras to measure trajectories accurately and the usual CAA safety devices and flight termination devices would also be furnished by the University. Winzen Research would assume responsibility for tracking and recovery along with the University and would participate in the launching in order to become familiar with the launching method developed at the University. The cost of the balloon and the necessary packing using the University of Minnesota launching technique would be carried by the project SKYHOOK. Other costs would be assumed by the University of Minnesota High Altitude Balloon Project and the Cosmic Ray Project as required. The operation took place at Pyote Air Force Base, Pyote, Texas. during the period 20 January 1953 to 4 February 1953. The balloons were launched from the apron near the first hangar on the northeast end of the air field very close to the shed in which working space was provided for the scientific apparatus. Helium was obtained from a helium tank car on a siding adjacent to the launching area. The Air Force Base provided

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vehicles for the members of the project and housing facilities in the barracks. The excellent cooperation of Lt. Col. Max L. Piper, commanding officer, and various members of the base are acknowledged. Besides the 13 flights reported herein, two other flights were made by Winzen Research using the Minnesota launching technique but using instrumentation provided by Winzen Research. These flights are reported separately in a Winzen report. The University of Minnesota Balloon Project was represented for all or part of the operation by Drs. Edward Ney and John Winckler; Messers. Raymond Maas, Robert Howard, Charles France, Carl Ebner, pilot, and Donald Hanson. Scientific investigators present included Nahmin Horwitz, Kinsey Anderson, Leland Bohl, John Linsley and Frank McDonald, these from the University of Minnesota. Winzen Research, Inc. was represented by Mr. Otto C. Winzen, Vern Baumgartner, electronics chief; Herbert Ballman, electronic technician; Robert Clark, electronics technician; and Glen Hovland, pilot and camera man. Seven of the 13 balloons were specified as double-wall 1-mil type equipped with a duct appendix, as experience on the balloon project had shown that this type of balloon was a very reliable vehicle and some sacrifice in ceiling altitude was accepted in order to use this heavier balloon which would increase reliability. Also it would give comparative data with similar flights at higher latitudes for balloon flight information. Five of the balloons were 1.5-mil single wall where maximum altitude was a prime consideration. The other balloon was a type 734-AH manufactured by General Mills, 2-mil in thickness and was flown for balloon project information to compare with a similar balloon at higher latitude. Duct appendices were used on all of the flights to study the performance of the duct and to assure that the balloon would descend at sunset and to be sure the balloon would reach its initial theoretical ceiling. The effect of the duct in excluding air which might cause some increase in instability over an open bottom balloon was to be compensated for by ballasting continuously by evaporating a cake of dry ice. The results of this particular form of ballast are discussed in this report. The details

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of the flights are presented in the balloon flight data chart and in the flight summaries, but in general it may be said that the operation was very successful both from the balloon stand point and the scientific standpoint. It was economical in time and expense and valuable data was obtained on meteorological trajectories as well as cosmic ray data and balloon performance data. Furthermore experience was gained in launching balloons on a field trip. The balloons and scientific equipment were transported from Minneapolis to Pyote by commercial moving van under government bill of lading, which procedure turned out to be extremely satisfactory. The equipment could be carefully packed by the movers at each end and transported with a minimum of rough handling, and in fact all equipment arrived at the launching site in perfect condition. Personnel went by commercial airline, in one of the balloon project vehicles and in the tracking planes operating under the University and Winzen Research. With the exception of one severe dust storm which held up the operation one day, the period chosen for the operation gave very favorable weather with clear skies most of the time and low winds at sunrise to favor the launching. The upper winds were also moderate and westerly and the flights which reached an altitude of between 80,000 and 90,000 feet in general, dropped from 150 to 300 miles from the launching site in an easily accessible part of Texas.

The trajectories and a discussion of meteorology are included in this report. The report also includes a discussion of the instrumentation furnished by the balloon project. The description of the scientific apparatus and the results are reported as usual in the scientific journals and meetings of the American Physical Society in accordance with the practice under the cosmic ray project.

Hitch-hike loads were flown on many of the flights for Princeton University, University of Chicago, University of Rochester, and the Canadian National Research Council.

Also included is a section summarizing the principal characteristics of the time-altitude curves, in which these flights are compared with summertime flights at Minnesota.

Use is made in this analysis of the data obtained on step flights which constitutes a very powerful way to measure the effect on the balloon of the radiation field at various altitudes and to measure the thermodynamic and aerodynamic drags at various rates of rise. This technique will be discussed in detail in a later volume of this series but because of its importance it has been applied to these flights and preliminary results are included in this report, Section XI.

Section II

INSTRUMENTATION

The majority of the instrumentation flown on the Texas flights was new, the result of improved design on older apparatus, and therefore some of it was unproven in flight. The chart in Table I shows the equipment flown on each flight.

The Olland Cycles used were the type described in Volume V¹. These were the first flights made with this type of Olland Cycle and because of experience gained from them immediately after the series further improvements were made in this instrument. The need for a high impedance relay and high voltage between the pen arm and the rotor became apparent when on several flights the Olland Cycle became stuck open by microscopic dirt or possibly corrosion on the surface of the rotors. Flights 109 and 113 were very bad in this respect, and the records of flights 101, 102, 104, 108 and 112 each had sections of varying length obscured. Flight 107 evidenced the opposite effect - the relay failed to open properly on a few cycles. This was probably due to a permanently magnetized relay and the solution to this problem is careful adjustment of the armature core spacing of each relay during preflight preparation. Despite these troubles, sufficient altitude information was obtained on all flights.

The secondary Olland Cycles listed in column 2, Table I, were cycles with special circuitry to allow them to be flown in certain pieces of cosmic ray gear so that their data was recorded with the cosmic ray information. One of these cycles was recalibrated in the laboratory in order to check its reproducibility after the equipment was returned. It was found that after shipment to and from Texas, after it had been flown, after a considerable amount of handling and storage for three months, the calibrations were identical within the scatter of points about the line on the original calibration, or approximately

¹University of Minnesota PROGRESS REPORT ON HIGH ALTITUDE BALLOONS covering period June 22, 1952 to December 15, 1952. Volume V, pp. VII-261 - 267.

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Table I

Flight No.	1 Olland Cycle	2 Secondary O.C.	3 Transmitter	4 Antenna Dropper	5 Telemeter Recorder	6 Down Camera	7 Camera Blowdown	8 Timers	9 Low Altitude Release	10 Flasher	11 Ballast Drop, pressure	12 Gondola Frame	13 Dry Ice
101	X		X	X	X	X	X		X			X	X
102	X		X	X	X	X	X		X	X		X	X
103	X		X	X	X	X	X		X			X	X
104	X	Z	X	X	X	X		X	X			X	X
105	X	Z	X	X	X	X		X	X			X	X
106	X	Z	X	X	X	X		X	X			X	X
107	X		X	X	X	X		X	X			X	X
108	X		X	X	X	X		X	X			X	X
109	X			X	X	X		X	X			X	X
110	X		X	X	X	X		X	X			X	X
111	X		X	X	X	X		X	X	Z	X	X	
112		Z			Z	Z		X	X				
113	X		X	X	X	X		X	X			X	

X = Apparatus flown in balloon project gondola

Z = Apparatus flown in cosmic ray gondola

1/5 mb at altitude.

The transmitters listed in column three, Table I, are discussed in another section of this report along with telemetering results. The antenna dropper used on these flights was the same discussed in Volume V¹. No modifications were made and in all cases the dropper worked without fault. All pressure-operated equipment, including droppers, was tested after shipment to Texas and before flight in a special portable plastic bell jar designed and built here.

The telemeter recorder used on all flights is described in Volume V² and for the most part functioned well. The pinhole in the camera used on flight 103 was too large allowing considerable spread of the light on the film and while this reduced accuracy, it still furnished a readable record. This camera contained the first flight film telemetering recorder made and the other models were considerably improved. Probably because of circuit inaccuracies no record was made on flight 101. In flight 112 the camera was mounted directly in the cosmic ray gondola and noolland cycle record was made as the proper circuits were not readily available. Unfortunately it was not possible to check the circuitry on flight 101.

The cameras listed in column 6 are the same as those described in Volume V³. On flight 104 the film slipped in the camera for about the last eighth of the flight and the first 1/5 of flight 112 was similarly faulty. This error is traceable to the tension on the take-up spring belt and results in an unreliable time base for the down pictures. The trouble on flight 104 could be blamed directly on preflight adjustments, but the camera on flight 112 had been used on one flight and on a film-load duration test, without a careful mechanical checkup such is regularly given between flights, and a lack of perfect adjustment is understandable under those conditions. The other cameras worked

¹PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume V, pp.VII-244 - 247.

²Ibid, pp.VII-224, 232 - 233.

³Ibid, pp. VII-224, 231 - 233.

without fault and an adequate film was derived from every flight.

The camera blowdown listed in column 7, Table I, is described in Volume V¹. Flights 101, 102 and 103 which used this method of timing exclusively did not come down as expected and it was thought that the timers were failing, so the camera blowdown timers were cut out on all succeeding flights. It was later found that the timers were in operating condition but that the film load had been made too long in expectation of a lengthy check out period, whereas actually the check out time, at least on the cameras, was kept to a minimum.

The clock work timers (column 8) substituted for the camera timers were a pair of Minneapolis Honeywell timers used previously by this project, which were incorporated in a box with a dry cell and a low altitude blowdown mentioned in Volume I². This combination was flown as a unit in a glass wool insulated bag external to the project gondola at the point in the equipment train where separation from the balloon was to be made at blowdown. In all cases this blowdown box functioned as planned.

The flashers flown on flights 102 and 111 were new with these flights and consisted of three No. 47 lamp bulbs connected in parallel and enclosed in a thick plastic container with a thin red plastic filter, which were driven by an electromagnetic oscillator made in the Physics Department shop and copied after the element in the Dayco flasher mentioned in Volume V³. These flashers had a light output measured at 6.5 foot candles at one foot, and an oscillation rate of $1\frac{1}{2}$ per second. As far as is known these flashers worked well on these flights. On flight 111 the flasher was located in the cosmic ray gondola for convenience.

The ballast dropper used on flight 111 was the pressure operated type described in Volume V⁴. It worked during the flight as intended and released a load of cosmic ray gear flown as ballast.

¹ PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume V, pp. VII-233

² Ibid, covering period December 13, 1951 to June 15, 1952, Volume I, pp. 5-1, 5-3.

³ Ibid, covering period June 15, 1952, to December 22, 1952, Volume V, pp. VII-208, 211.

⁴ Ibid, Volume V, pp. VII-218 - 221.

The gondola frame (column 12) was a solid rectangle 12" square and 10" high topped by a pyramid 45° in cross section, and was constructed of 1/16 x 1/2 x 1/2 aluminum angle with corner webs. The gondola frame was encased in a four inch styrofoam box and this was covered with a heavy canvas case with zipper closures and dyed bright orange. A metal reward tag was riveted to this case and a Spanish translation fastened below it. This assembly was used on all flights except flight 112 where all flight control equipment was located in the cosmic ray gondola.

A block of dry ice was flown on the flights indicated in column 13 as a ballasting device. This block was contained in a special fishnet bag and hung within the field of the down camera in order to record the amount of evaporation. There was a screw eye fastened to the bottom of the gondola to allow the easy attachment of this dry ice.

The preflight gondola pictured in Figure 1 is typical of flights 101 and 103. Figure 2 is the gondola flown on flight 102 and the gondolas flown on flights 104, 105, 106, 107, 108, 110 and 111 were similar to that shown in Figures 3 and 4. The timer and low altitude release box is also shown in these pictures. There are no preflight pictures of the gondolas flown on flights 109 and 113, and there was no gondola on flight 112. The wiring diagrams follow on the next few pages. They are intended to show the various units included on each flight and the interconnections in graphic form. Detailed circuits are given under the description of the individual components in this report and in other volumes of this series as footnoted.

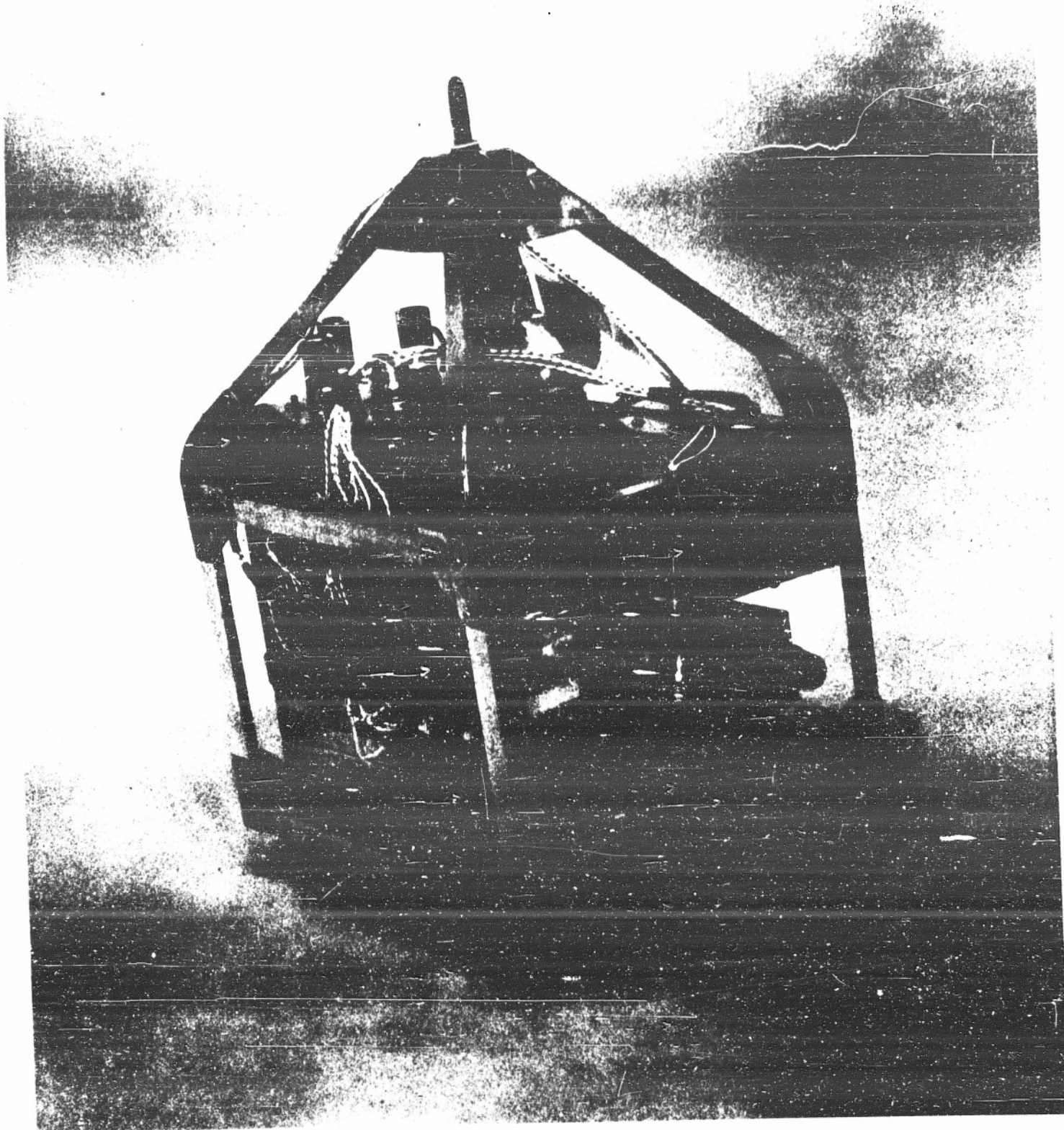


Figure II-1. Preflight gondola picture - typical of flights 101 and 103.

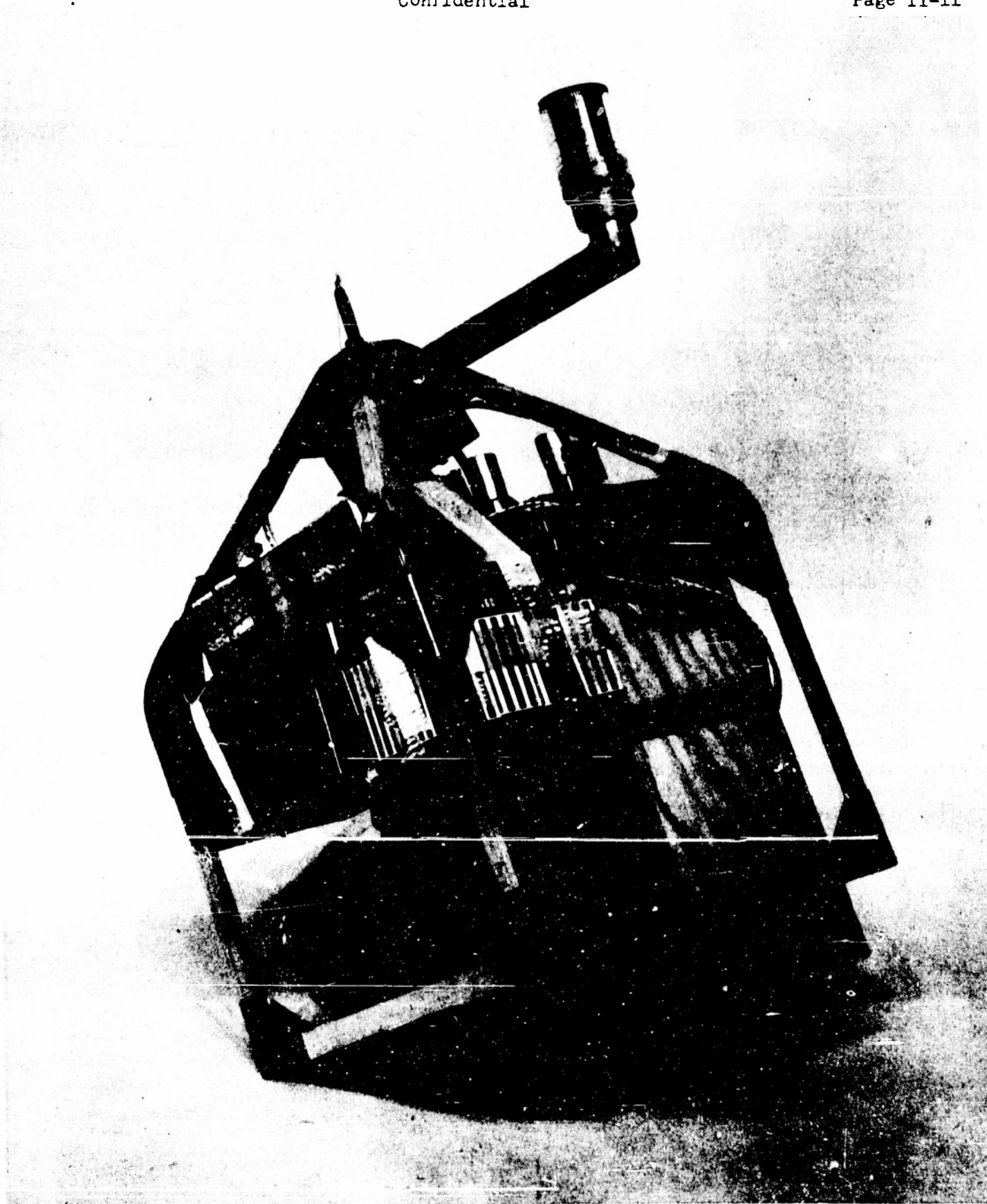


Figure II-2. Preflight gondola picture of gondola flown on flight 102.

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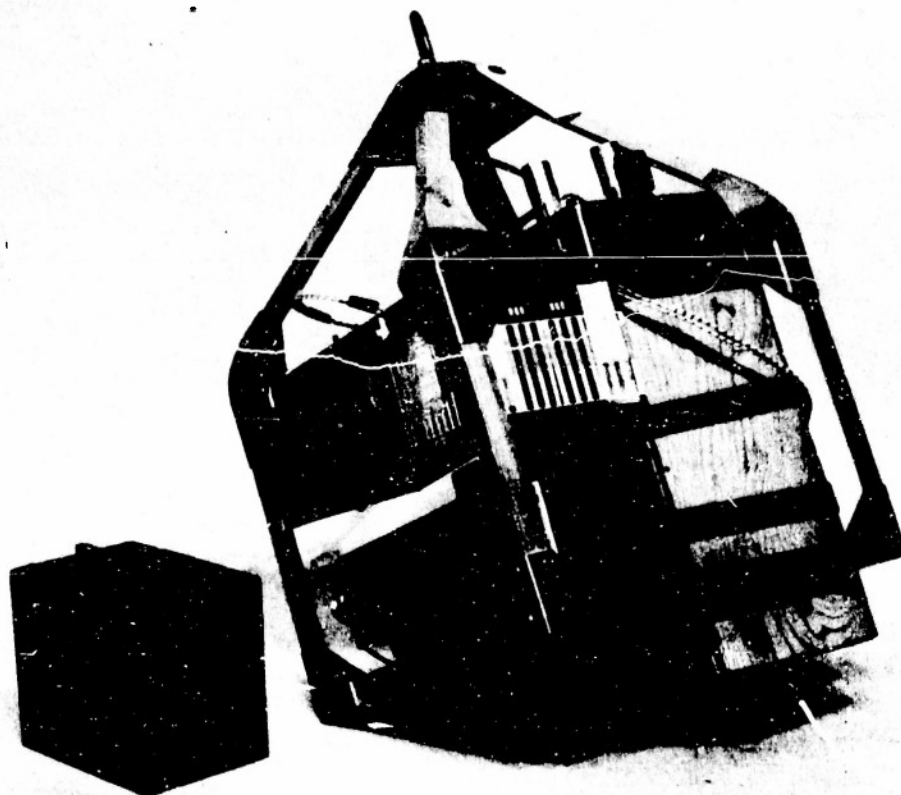


Figure II- 3

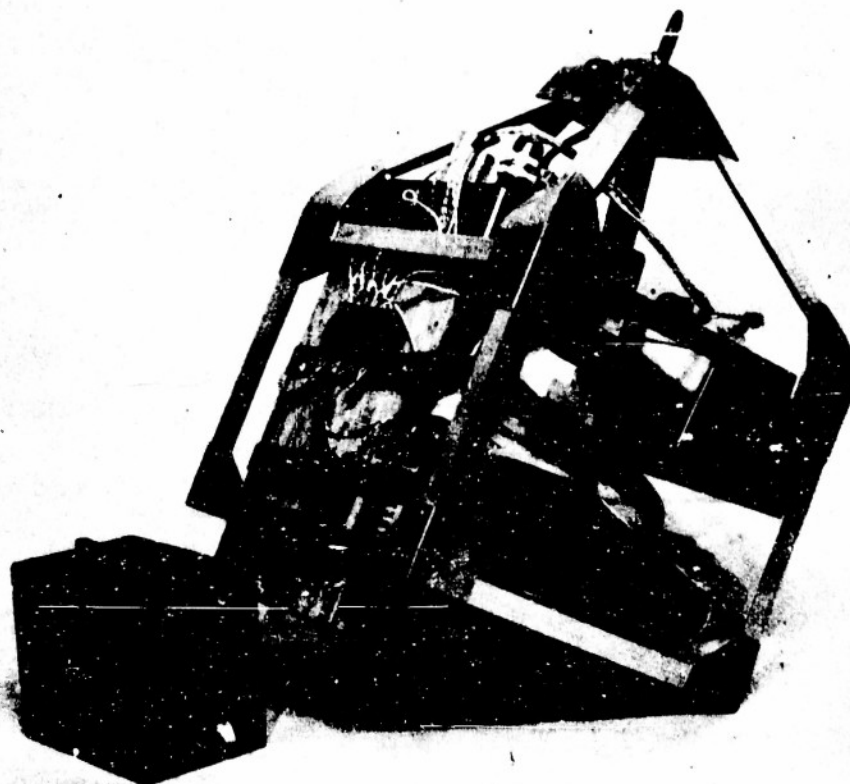
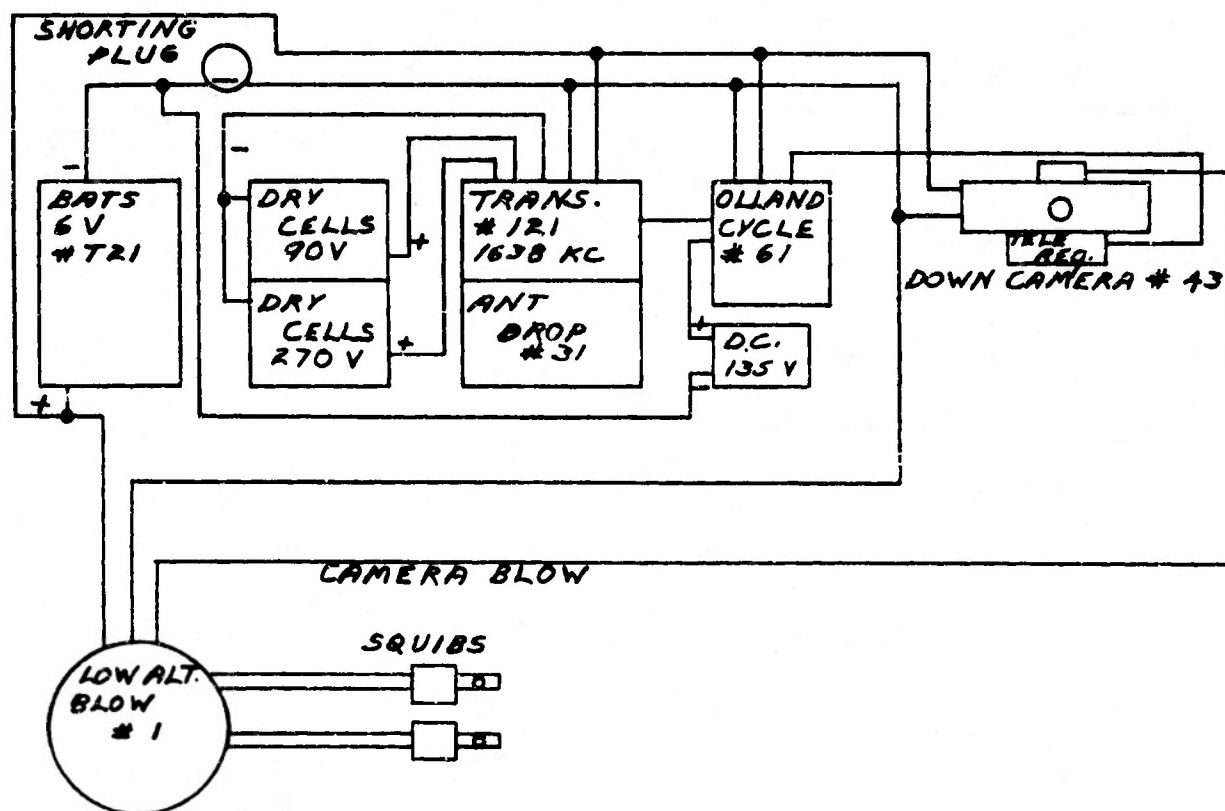


Figure II-4

Figure II-3,4. Preflight gondolas similar to those flown in flights, 104, 105, 106, 107, 108, 110 and 111.

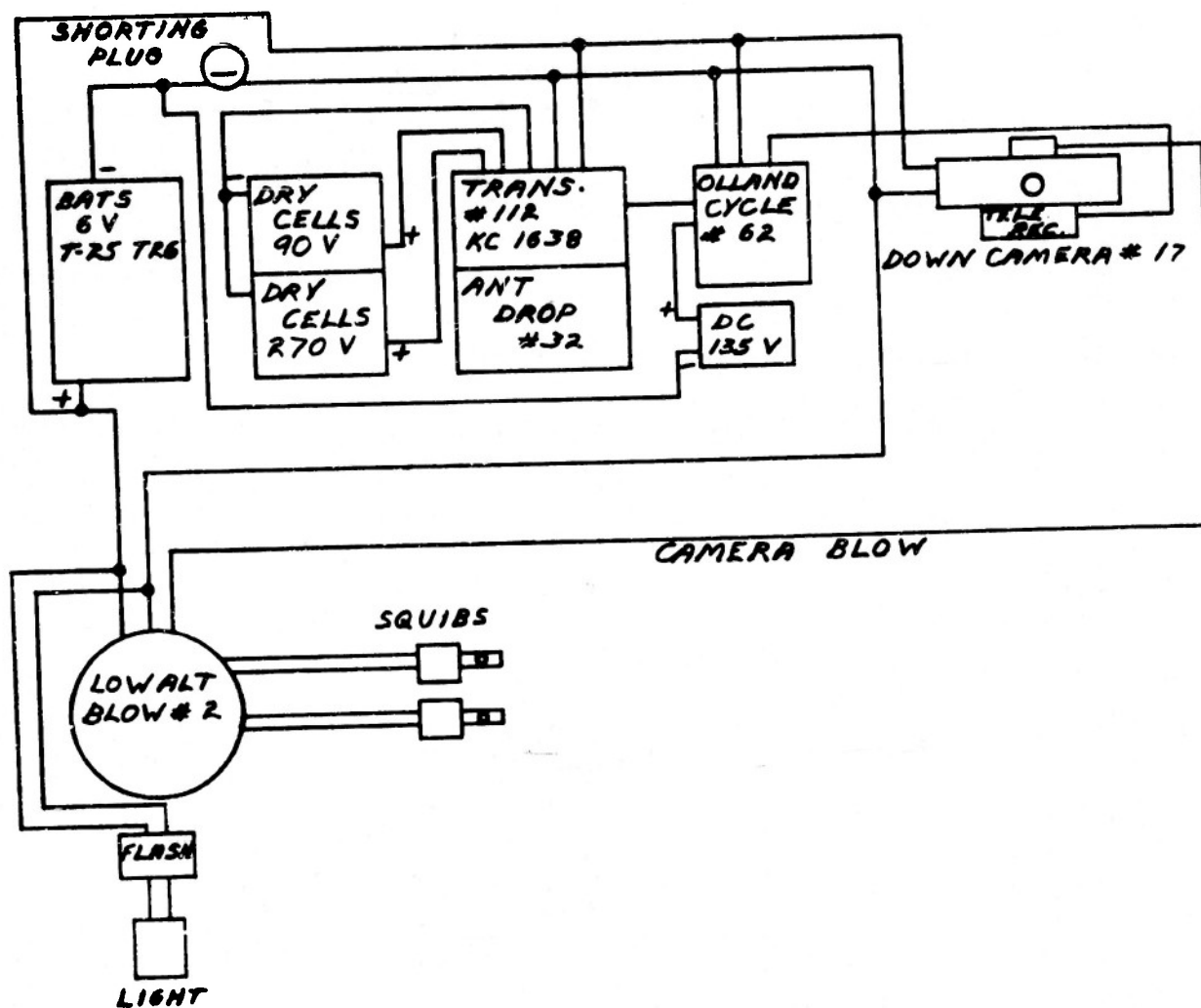
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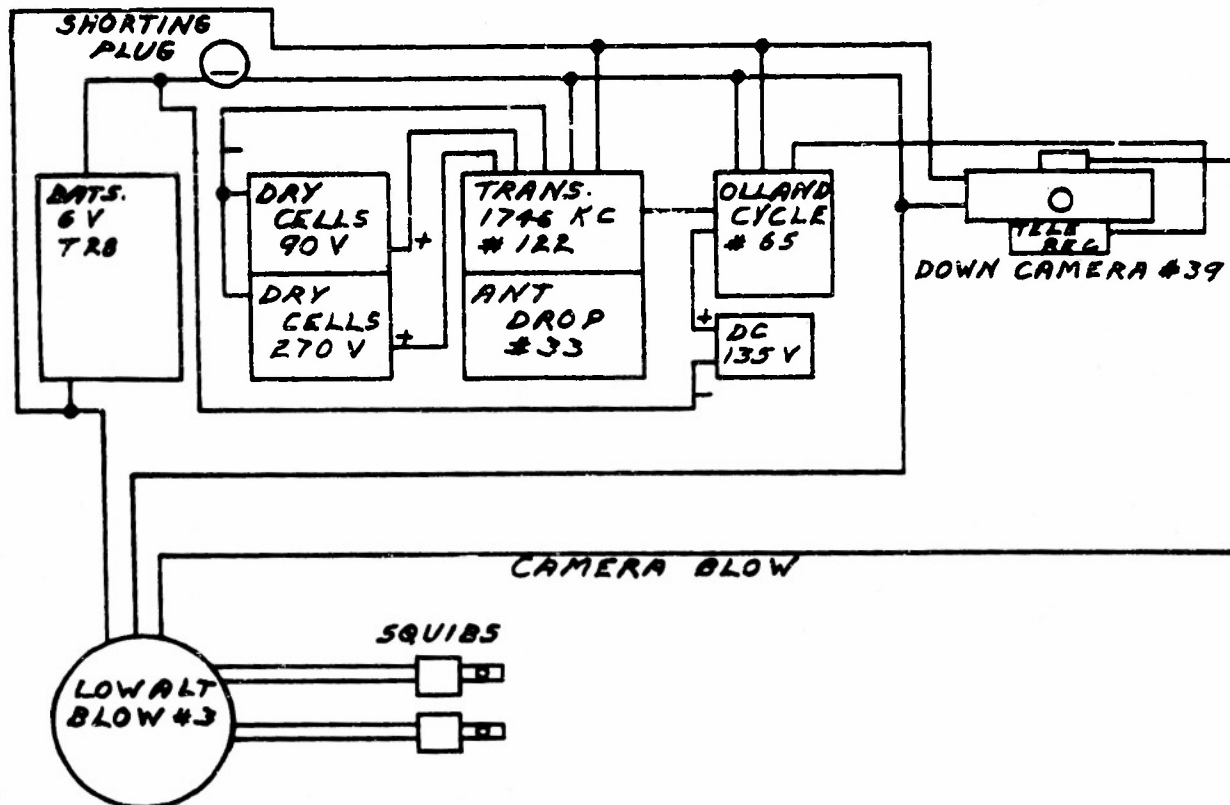
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FLIGHT #101 (TEXAS) GONDOLA # 151			MOD. 1	
			MOD. 2	
			MOD. 3	

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GANDOLA #152			MOD. 2	
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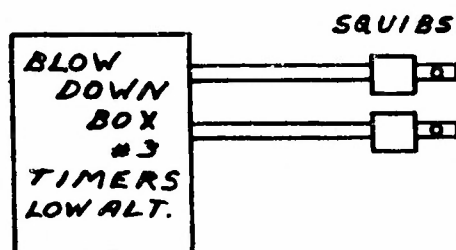
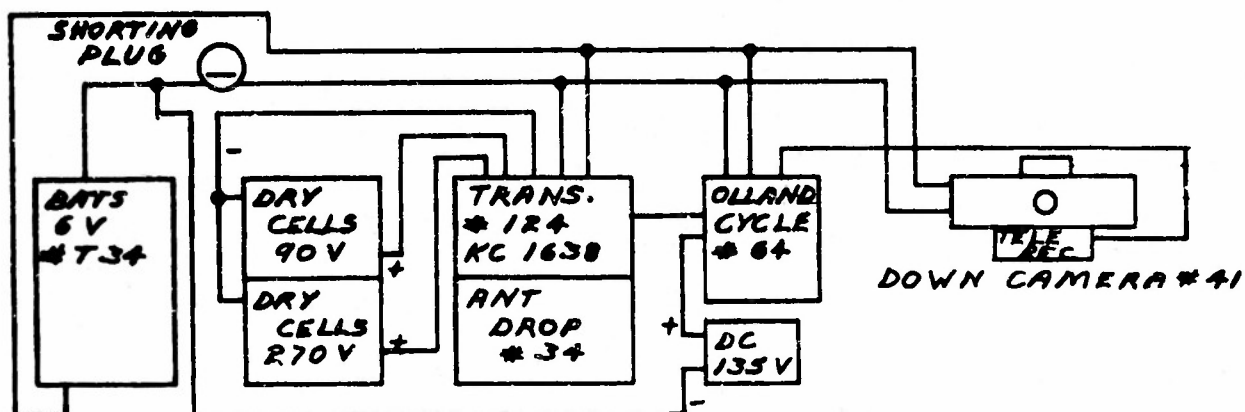


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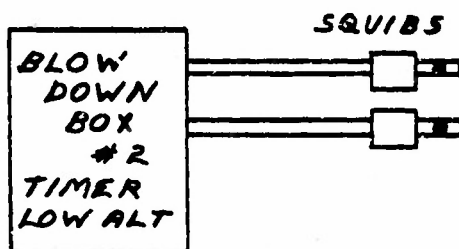
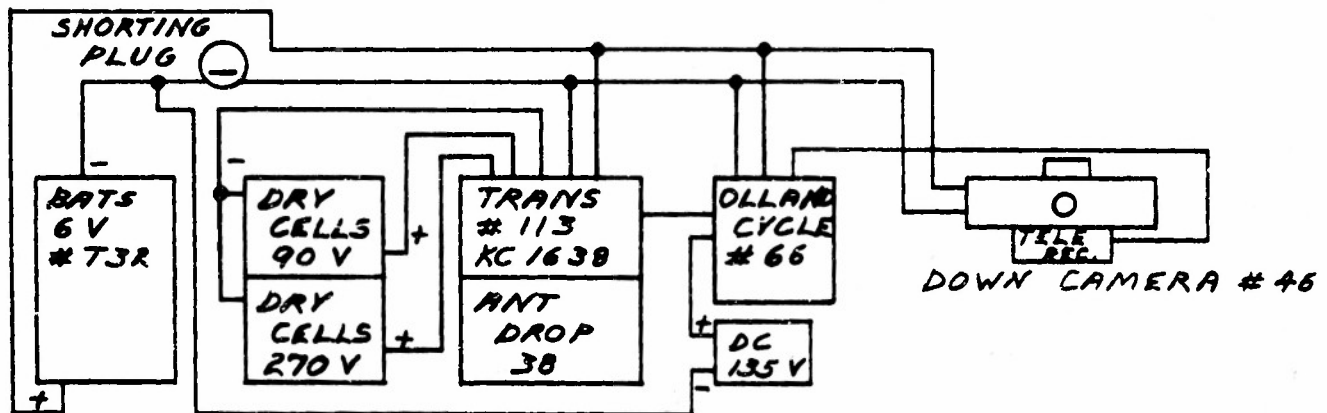
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			MOD. 2	
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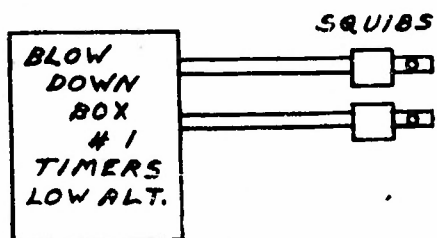
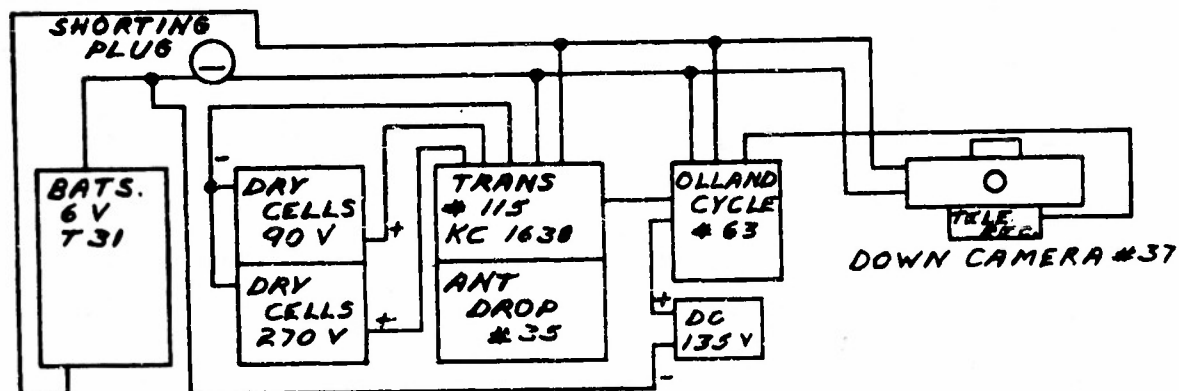


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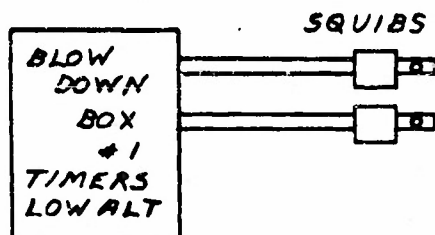
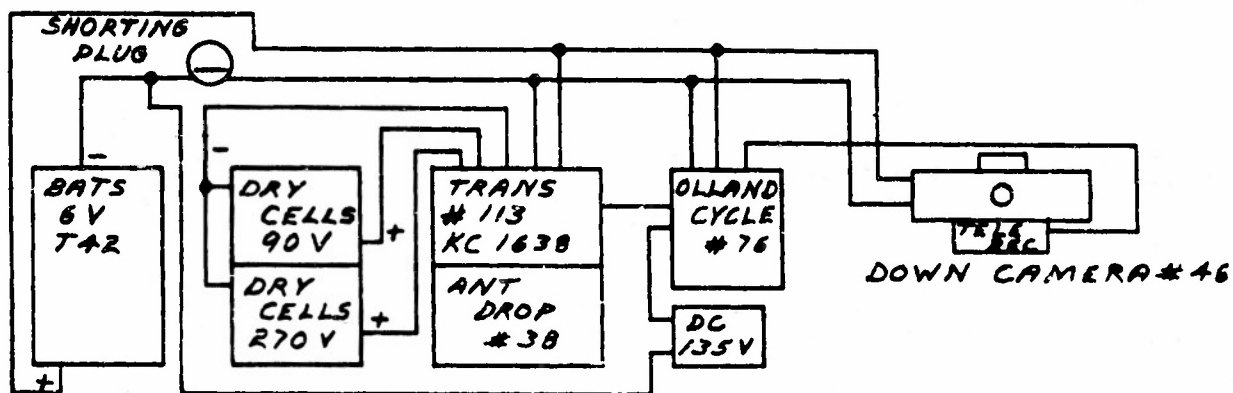
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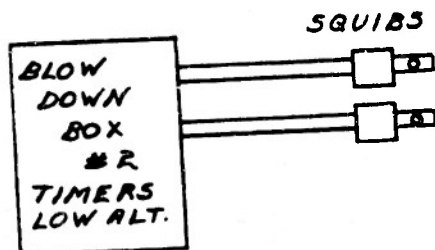
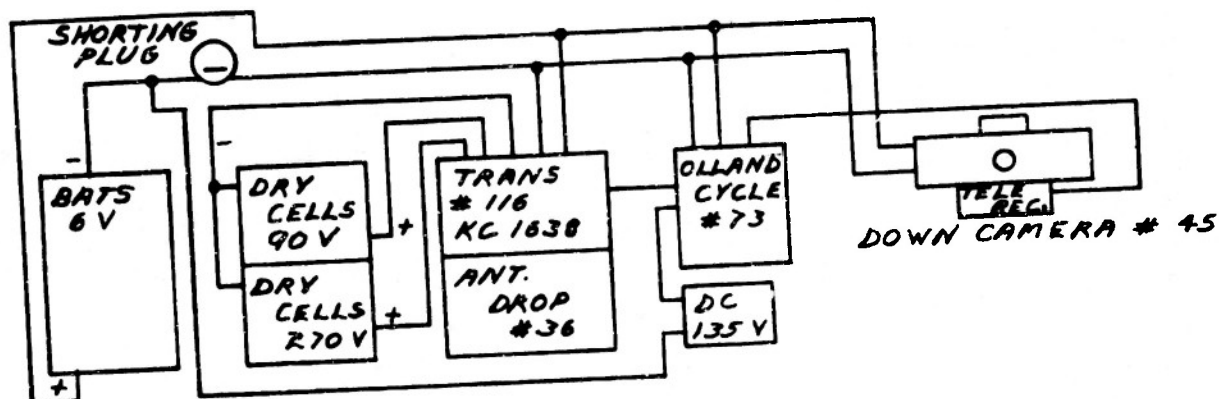
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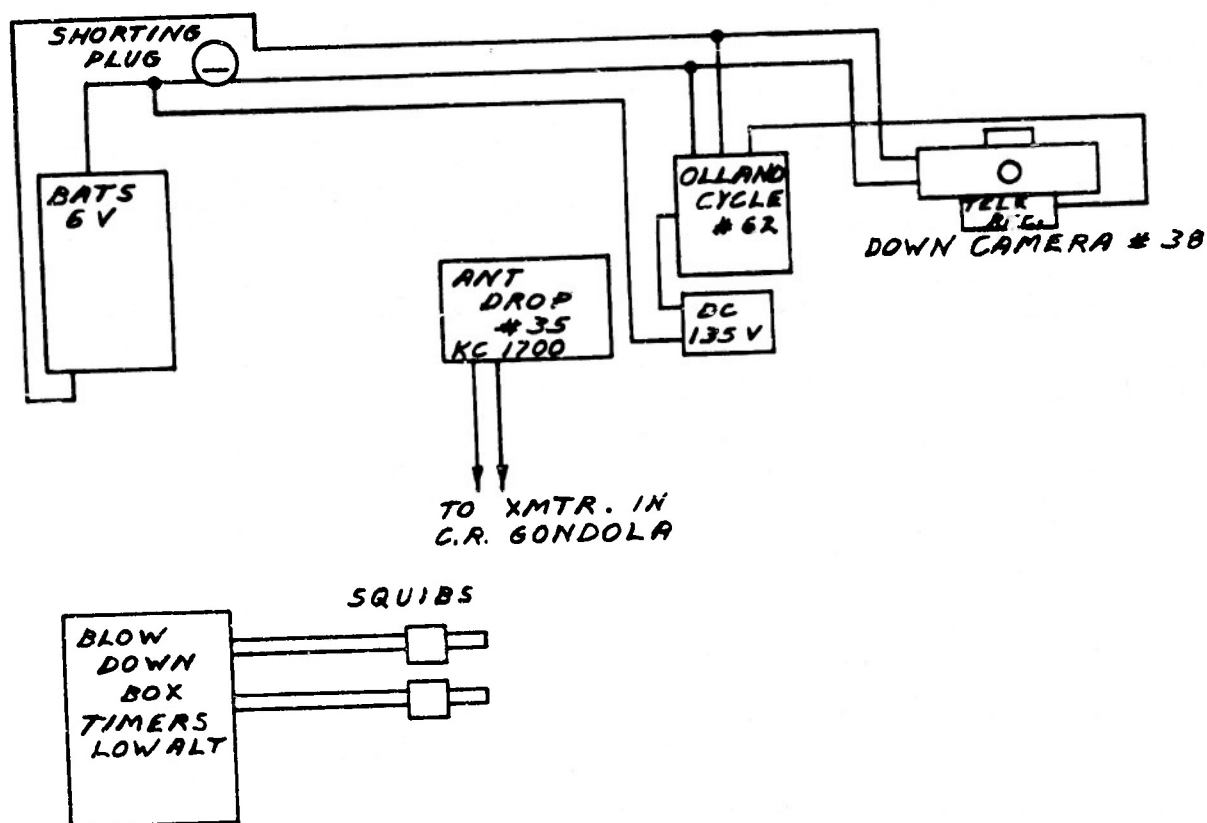
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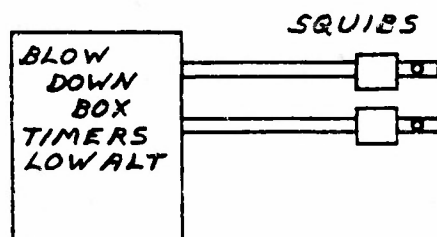
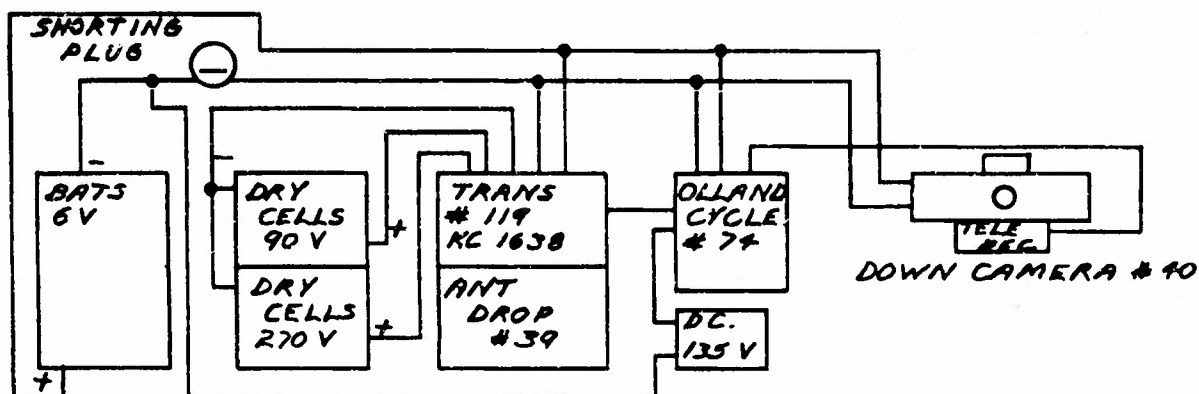


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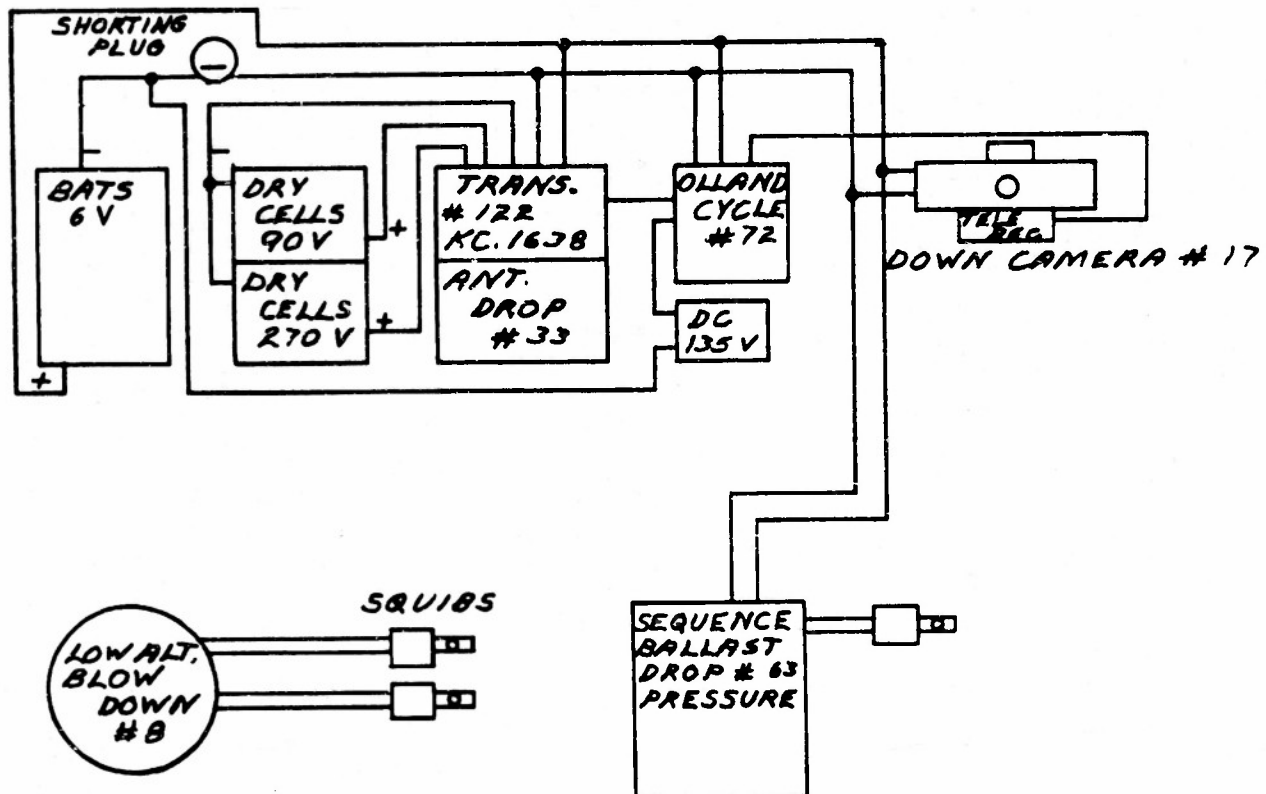
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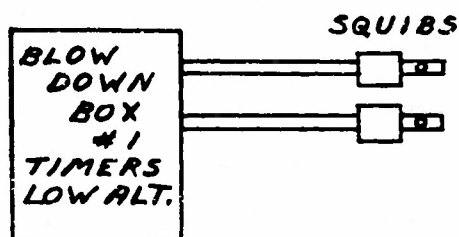
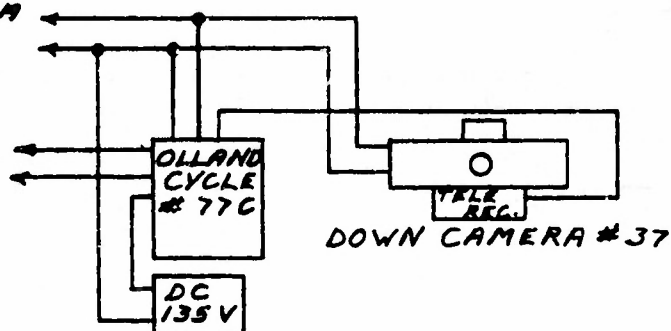
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			MOD. 3	

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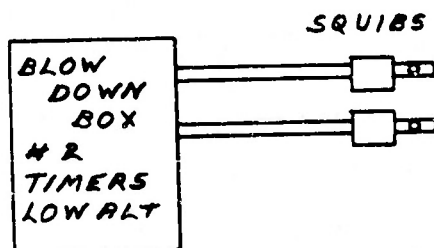
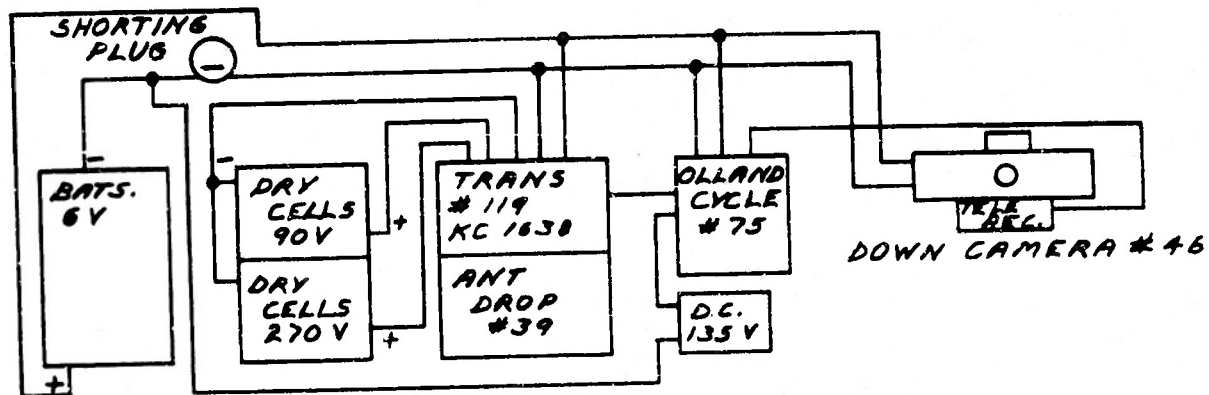
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POWER (6V)

O.C. SIGNAL TO
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DWG. NO.	SHOP DWG. NO.	DRAWN BY	CHECKED BY	DATE
		<i>HA</i>	<i>SM</i>	2-3-53
FLIGHT #112 (TEXAS) NO B.P. GONDOLA Confidential Security Information			MOD. 1	
			MOD. 2	
			MOD. 3	



DEPT. OF PHYSICS U. OF MINN.
BALLOON PROJECT SECT. INST.

DWG. NO.	SHOP DWG. NO.	DRAWN BY	CHECKED BY	DATE
		<i>[Signature]</i>	<i>[Signature]</i>	2-4-53
FLIGHT #113 (TEXAS) GONDOLA #159			MOD. 1	
			MOD. 2	
			MOD. 3	

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Section III

RADIO TELEMETERING (TEXAS FLIGHTS)

The telemetering furnished by the U. of M. for the series of flights consisted of single-channel C.W. pulse transmission. The information telemetered was the air pressure at the balloon altitude as encoded by the Olland Cycle¹ mechanism.

The type transmitter² used, in this series, consisted of a push-pull crystal- controlled oscillator and a push-pull final power-amplifier stage. The peak power delivered to the antenna³ terminals was approximately 4-watts. Keying was accomplished by opening and closing the 90V D.C. supply to the screen grids of the final amplifier. The keying relay was controlled by the Olland Cycle mechanism, in this case, but this transmitter could be used for telemetering any slow pulse-code information.

The frequencies used in this series of flights were 1638 K.C. and 1746 K.C. It was possible to monitor two flights simultaneously on these frequencies by tape-recording one signal and observing the other on the strip chart recorder in the usual manner.

Although the pulse-type signal is not at all ideal for radio direction-finder tracking, the transmitted signal was used on several occasions by the tracking plane to locate the balloon.

As the slow pulse-code signal employed required only a very narrow band of frequencies for transmission, the signal was received in the same manner as C.W. code. The audio-frequency output at the receiver was fed into a narrow band audio filter-⁴

¹ University of Minnesota PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume V, p. VII-259

² Ibid, p. VIII-351 and Figure VIII-7

³ Ibid, p. VIII-351

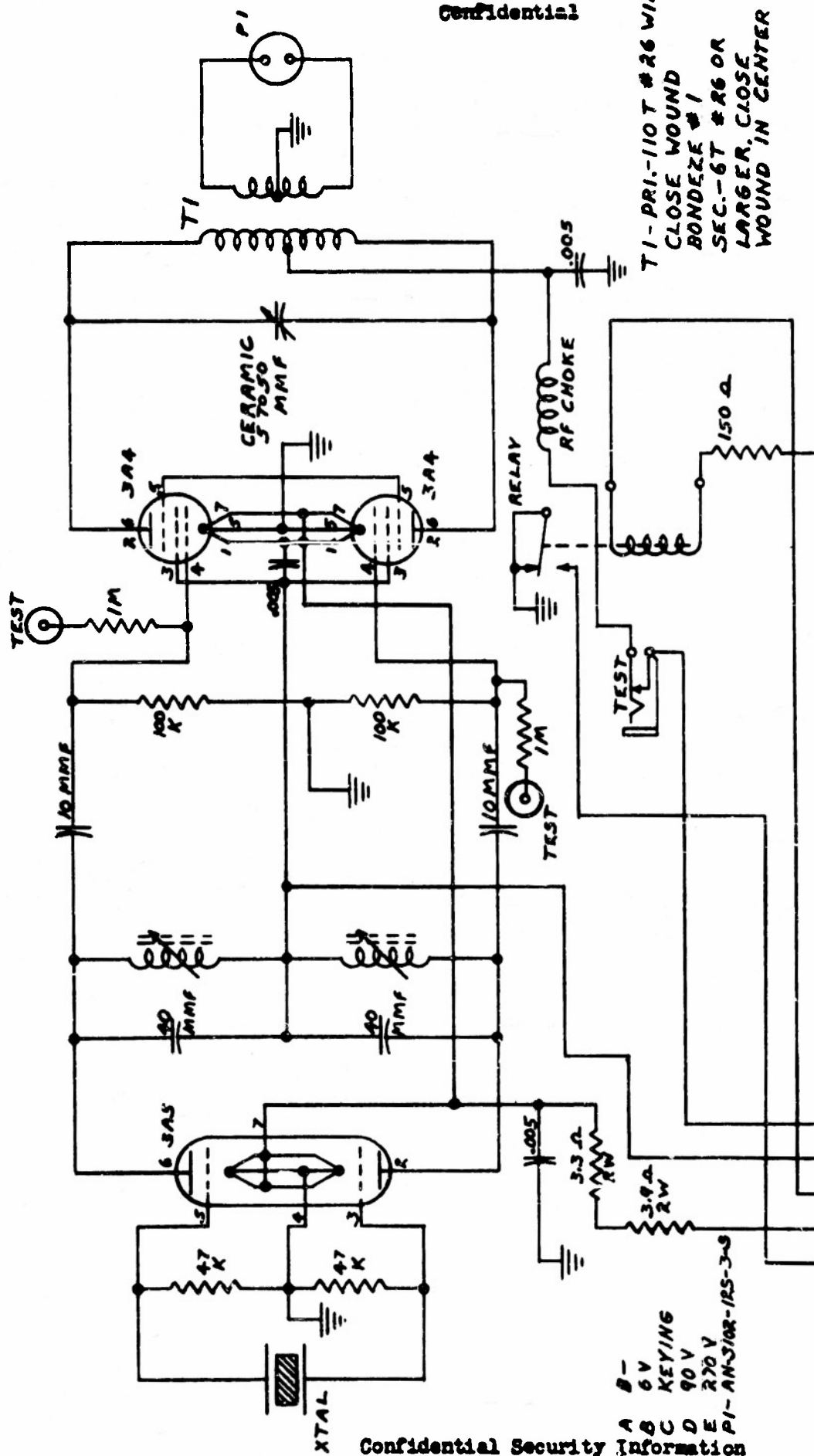
⁴ Ibid, pp. VIII-345, 346 Fig. 3

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amplifier where a large portion of noise could be removed.

The transmitted power appeared to be adequate for good reception for at least 90% of the total flight time during the series. The distances involved were not long, but in some cases the balloon was over line-of-sight range. The following page is a schematic diagram of the transmitter used in the 13 Texas flights.

T1 - PRI.-110 T #26 WIRE
CLOSE WOUND
BONDEZE #1
SEC.-6T #26 OR
LARGER, CLOSE
WOUND IN CENTER



Confidential Security Information

DEPT. OF PHYSICS U. OF MINN.
BALLOON PROJECT SECT. B+T

DWG. NO.		SHOP DWG. NO.	DRAWN BY	CHECKED BY	DATE
R6-TL-202			<i>AK</i>	<i>AK</i>	11-13-52
TRANSMITTER- MED.				MOD. 1	
FREQ. 4 WATTS - B-				MOD. 2	
KEYING				MOD. 3	

Figure III-1

Section IV

FLIGHT SUMMARIES

Flight 101

The first flight of the Pyote operation was launched January 20, 1953, at 0814 CST. This flight was to carry a cosmic ray plate mover with nuclear emulsions and it was desired to get as good an altitude as possible. To meet this specific requirement a 1.5-mil balloon, Winzen no. 73-150V-266 with glass filament tapes and a duct appendix was used. In addition to Naugle's plate mover the balloon carried balloon project gondola #151 containing transmitter, antenna dropper, Olland Cycle, down-camera and camera blow-down with the usual low altitude release for cutting off the balloon if it descended below 30,000 feet to meet CAA requirements. Twenty-four pounds of dry ice was also carried as ballast. A Geiger counter sonde was also carried as hitch-hike load from Princeton University. The balloon was weighed off somewhat light although it was not realized that it was dangerously so until the flight had been released and the balloon rose into the stratosphere. The rate increased from an initial value of 910 to 1600 feet per minute and when the balloon reached ceiling the rate exceeded this. The time-altitude curve shows that the balloon began an immediate descent upon reaching ceiling and descended to about 50 mb at which time it decelerated and leveled off at about 70 mb where it remained for the rest of the flight. The indication from the time-altitude curve is that the high rate of ascent super-pressured the balloon enough to make it rupture near the bottom, probably where the cone-sphere junction occurs. This allowed an escape of gas and the balloon descended so that the lifting gas zero pressure level moved above this point. The balloon then continued to descend and air came in through the opening finally stabilizing the balloon so that it leveled again. The balloon was found floating in the gulf near Port Arthur, Texas. The apparatus was not found despite extensive air search,

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but was reported in about four months after the launching time in the city of Nemo, Texas. The load upon recovery was in excellent condition but the time-altitude curve did not meet the requirement of the cosmic ray experiment, which was to investigate the β spectrum of heavy nuclei in the primaries. These are not present at the altitude at which the balloon floated for most of the day.

Conclusions

We are confronted here with a large increase in velocity as the balloon ascends. It was suspected that there was a considerable increase in superheat as the balloon gained altitude and that weigh-offs would have to be kept low at Pyote in order to insure the balloon having a safe velocity at reaching ceiling.

Flight 102

Flight 102 of the Texas series was launched also on 20 January 1953 at 1734 CST. The purpose of this flight was to carry an emulsion stack with lead and paraffin for 24 hours at high altitude. The balloon used was a Winzen double wall #73-2x100-V-260 with glass filament tapes and duct appendix. The balloon was weighed off with a free lift of 8% of the displaced air. Due to a failure of the Olland Cycle and apparently also of the down camera, no record was obtained on ascent. The Olland Cycle came on when the balloon leveled following sunset but it was then found that the balloon had leveled well below its ceiling at 86,000 feet. It floated at 70,000 feet (47 mb) at a very constant level from 1900 until 0100 the next morning when it began a very slow descent. At 0500 it speeded up and went through the tropopause at 0700 and came rapidly down. The load with the balloon attached was recovered six miles south of Peacock, Texas. It was found that the low altitude release had operated but the squibs had not blown apparently because the wires leading up to the squibs had twisted off as the gondola rotated under the balloon. Some dry

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ice was still on the load and vapor was seen as the balloon descended. Despite the fact that the flight was shorter than anticipated and did not go to quite as high an altitude it was a useful flight for the purpose and the plates are to be analyzed.

Conclusions

The balloon was weighed off with insufficient free lift for the purpose. In other words, the sunset effect was worth at least 8%, which was the ground weigh-off, unless there were changes in this free lift as the balloon rose due to the time of day. There is also indication on this flight that the tape construction on the top of the balloon may have failed when the heat of the sun warmed up the tapes the next morning permitting them to slide somewhat and open a hole in the balloon top, because the descent at sunrise instead of the expected ascent is indicative of a leak. The initial failure of the Olland Cycle was supposedly due to poor contact by the reference arm which interrupted the circuit and kept the transmitter on all the time. This corrected itself.

Flight 103

Flight 103 was launched the 21 of January 1953 at 0832 CST and like flight 102 used a double wall balloon no. 73-2x100-V-258 made with #890 tapes with a duct appendix. The flight was to carry a counter hodoscope constructed by John Linsley and the flight time was supposed to be 10 hours. The balloon was launched with a free lift of 40 pounds or 6.5% of the air displaced and it rose at 730 feet/minute initially. At ceiling it was moving at 1330 feet/minute but it reached the correct theoretical ceiling, leveled off and remained level at 26 to 28 mb until 1600 when it began a slow descent. At 1820 it began a rapid descent at 292 feet/minute, went through the tropopause at 1920 increasing its rate to 639 feet/minute. The load cut loose on the low altitude release at 2000 and was recovered at Altus, Oklahoma, just over the Texas border. In this case the termination timer failed to operate

but it was quite clear that the operation of the duct appendix brought the balloon down, and the load on the ground not very far from the point at which it would have dropped from high altitude.

Conclusions

This is an excellent scientific flight in which the balloon floated level at theoretical ceiling most of the day. There was a failure of the release timer which was traced back to the camera blow down not operating but the load was recovered and it is therefore a very satisfactory operation. The sunset rate of descent is approximately that observed in Minneapolis in similar balloons. The change in velocity at the tropopause is also in agreement with expectation.

Flight 104

Flight 104 was launched January 23, 1953, for the purpose of carrying a large cosmic ray telescope furnished by Winckler. A double wall balloon was used, no. 73-2x100-V-269 and the theoretical ceiling was 81,000 feet which was reached following a good launching and ascent curve which reached 1200 feet/minute. The balloon descended right after reaching ceiling from 26 to 35 mb where it floated level until released by the timers at 1640. The leveling off may have been due to the dry ice ballast evaporating. This was a very excellent scientific flight.

Flight 105

Flight 105 was launched January 24, 1953, at 0755 CST. The purpose of the flight was to obtain albedo and geomagnetic data with the Čerenkov counter of Winckler and Anderson. The balloon was a 1.5-mil #73-150V-265 made with glass filament tapes. The theoretical ceiling was 84,000 feet. The free lift was weighed off to 4.6% of the displaced air and the flight had a very satisfactory

ascent curve. After reaching ceiling it floated level until 1500 when it began a slow descent until it was released by the timers at 1715. This was a very excellent flight for the scientific requirement. The balloon was equipped with a duct appendix. The flight carried actually two Olland Cycle instruments, one in a cosmic ray gondola and one in the balloon project gondola and both of these are plotted on the time-altitude chart. It is believed that the one in the cosmic ray gondola, in this case, gives the correct readings from a number of independent bits of evidence about this flight. This Olland Cycle indicated a pressure which is two to three mb lower than the one in the balloon project gondola. It is interesting that for the first two hours of flight the Olland Cycles were in perfect agreement. Towards the end of the ascent portion of the flight they separated and seemed to come together more towards the end of the flight where it had settled somewhat. They also follow together over a number of fluctuations particularly right after the balloon reached ceiling, showing that often these fluctuations often observed in Olland Cycle records are real and not associated only with the instrument itself. This flight carried 23 pounds of dry ice ballast.

Flight 106

Flight 106 was launched 26 January 1953 with a one day loss in time due partly to instrumentation difficulties with a scientific load and partly to an overcast condition. This flight carried the other Čerenkov apparatus and used a 1.5-mil balloon #73-150V-268 with glass filament tapes. The theoretical ceiling was 86,500 feet. The balloon had a normal ascent curve to about 67,000 feet where it apparently opened a hole, began a rapid descent and came all the way back to the ground again. The balloon was observed through the theodolite and on the descending part was swinging with a large amplitude of perhaps $\pm 30^\circ$. The load was eventually released on the low altitude blow down and was recovered after an air search near Big Lake,

Texas. The balloon drifted on and was sighted at the San Angelo area where it was spotted by an air force plane which established contact at 19,000 feet. The balloon then descended and was picked up by the air force personnel. The scientific apparatus was in excellent condition and was subsequently reflown on a later flight. The cause of the balloon failure is not known.

Flight 107

Flight 107 was launched on the 30 of January, 1953, at 0845. Intervening days were occupied with several other flights sent up by Winzen Research for other universities. Flight 107 used a 1.5-mil balloon #73-150V-263 with a ceiling altitude of 88,000 feet and a plate mover supplied by Naugle. The balloon reached the theoretical ceiling at 88,000 feet and floated nearly level throughout the day with a very slight downward rate from 21 mb from the start of the flight to 27 mb at the end of the flight. At 1731 it was released by timers. This flight is representative of the best in SKYHOOK flights throughout the series. The balloon was weighed off to 10% of the displaced air and had a velocity, upon reaching ceiling, of 1120 feet per minute. The flight carried 29 pounds of dry ice as ballast.

Flight 107 was one of a pair of twin flights which were launched simultaneously on January 30. The plates have now been analyzed and data is being assembled. The results may be described as completely successful.

Flight 108

Flight 108 was also launched the 30 of January and was the second member of the twin launch. The pay load was a scintillation counter prepared by Horwitz and the balloon was a double wall #73-2x100V-249 with duct appendix and nylon filament tapes. This flight was weighed off to a free lift of 7½% of displaced air and was an excellent flight. It leveled off at theoretical ceiling and then descended from the initial

24 mb to 28 mb by 1300, climbed back again to 26½ at 1500 and then dropped to 33 mb by release time at 1730. It is noteworthy that the two balloons in the twin launch left the ground together and remained practically together up to about 40,000 feet, where they were still separated by not more than one or two balloon diameters. At this point flight 107 which was lighter in gross went on ahead of 108 and, as a matter of fact, passed directly over it and photographed 108 from the camera tied on 107. This photograph is included in this report. (Figure XII-2). Photos of the twin balloon launch are shown in Figure XII-1.

Flight 109

Flight 109 was launched on February 1, 1953 at 0750 and was followed in one hour by flight 110 of the same date. Flight 109 used a double wall balloon #73-2x100V-270 with duct appendix and carried Bohl's scintillation counter with theoretical ceiling of 86,000 feet. Flight 109 reached the theoretical ceiling of 83,300 feet or approximately 20½ mb where it remained very level from 0930 until 1200. The balloon then began a slow descent and at 1620 had reached 50 mb. The signal was lost at 1650 at 80 mb. The girdle catcher was inadvertently left off of this flight but the girdle dropping apparently did not damage any of the equipment. The parachute was observed to open but both gondola and the instrumentation gondola broke loose and free fell. This is believed to be due to the fact that the chute had opened at low altitude. This behavior has been borne out in a number of other cases in which the packed chute is opened by the low altitude release at 30,000 feet. From the stretching of the load ring which was recovered and a broken 3,000 pound nylon rope it was estimated that the acceleration of the chute opening must have been about 10 g. The flight was a valuable one from a scientific standpoint despite the fact that the balloon descended somewhat prematurely.

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Flight 110

Flight 110 was launched on the same day as 109, February 1, 1953, at 0850 and carried McDonald's cloud chamber on a 1.5-mil balloon, #73-150V-264, with #890 tapes and a duct appendix. The flight did not show the large acceleration encountered on some of the previous flights. It started at 775 feet/minute and reached ceiling at 933 feet/minute. It leveled at theoretical ceiling, floated extremely level throughout the day until 1700. At 1730 the cut down actuated and the load descended on the parachute. It was recovered in good condition. This is another example of a very excellent scientific flight. The free lift was 8.6% of the air displaced.

Flight 111

Flight 111 was launched for the purpose of studying the performance of a General Mills, Inc. balloon, #734-AH, equipped with a duct appendix. The Linsley gondola flown was to be dropped as ballast following the descent after sunset. Theoretical ceiling was 84,000 feet and the balloon reached 79,000 feet according to the pressure record using the standard atmosphere. The folded bubble was too small to get all of the gas in it so that the corset had to be removed and the inflation completed. However, everything went smoothly and the flight was a good flight constants experiment for the balloon project. The balloon on ascent increased its rate from 288 feet/minute to 575 feet/minute with a slight break just ahead of reaching ceiling at 50 mb. The flight was launched at 1410 and floated level from the time it reached ceiling at 1640 until 1819 when it began the pre-sunset descent. It established a rate of 440 feet/minute and by 1840 increased to 520 feet/minute and again increased at the tropopause to 760 feet/minute. After Linsley's gondola was dropped the balloon rose at 1300 feet/minute but ruptured when it began valving and then descended at the same rate. The signal was then lost. Linsley's gear was recovered near Big Lake, Texas.

The initial ascent curve on this flight has been analyzed to determine the alt-

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altitude warning using the drag nomographs. This is discussed in Section XI. The ascent rate at night after ballasting is in very good agreement with the values predicted by these same nomographs.

Flight 112

Flight 112 was launched February 3, 1953, at 0813 and used a double wall balloon #73-2x100-V-259 with #890 tapes and duct appendix. The flight carried the second Čerenkov gondola and had a theoretical ceiling of 84,200 feet. It was weighed off with a free lift of 8.1% of the air displaced. In ascent, this balloon accelerated from 590 feet/minute to 1000 feet/minute and floated level at 26 mb until 1510 when it began a very slow descent and had reached 29.5 mb when the load was released by timers at 1710. This is a very excellent SKYHOOK flight and the load was recovered in very good condition.

Flight 113

Flight 113, the last of the present series, was made 4 February 1953 and launched at 0828. A double wall #73-2x100V-247 balloon was used equipped with a duct and #880 tapes. Theoretical ceiling was 81,700 feet. This flight was launched on a cloudy day and rose at 730 feet/minute initially following a weigh off of 4.5% of the air displaced. Between 300 and 100 mb the rate was 580 feet/minute which increased somewhat to 655 feet/minute up to 60 mb but then curved off and leveled considerably below theoretical ceiling at 33 mb, theoretical ceiling being 26 mb. The balloon floated quite level from 1040 until 1230 when it began a descent with a rate of about 200 feet/minute. The signal was lost at the Pyote Air Force Base at 1447. The tracking plane lost the signal at 1510. The load was presumably dropped from the balloon by the low altitude release. It was subsequently established that the load snapped off the parachute much the same as flight 109 and

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that the load free fell. It was later recovered and the film record of the cloud chamber was in excellent condition. Snapping off of the parachute came about due to the release at low altitude with the result of high acceleration. We have here definitely a case of a leaky balloon but there are several features of this flight which are not clear. One is that its initial rate being higher than its final rate on the ascending portion is not characteristic of any of the other flights. The fact that it floated level makes the leakage presumably not very high but was complicated by warming during the period from 1100 to 1230, although this is not certain. This is a rather long period for warming to take place.

The following pictures, Figures IV-1, 2, 3 and 4, show various steps in the launching of one of the Texas series.

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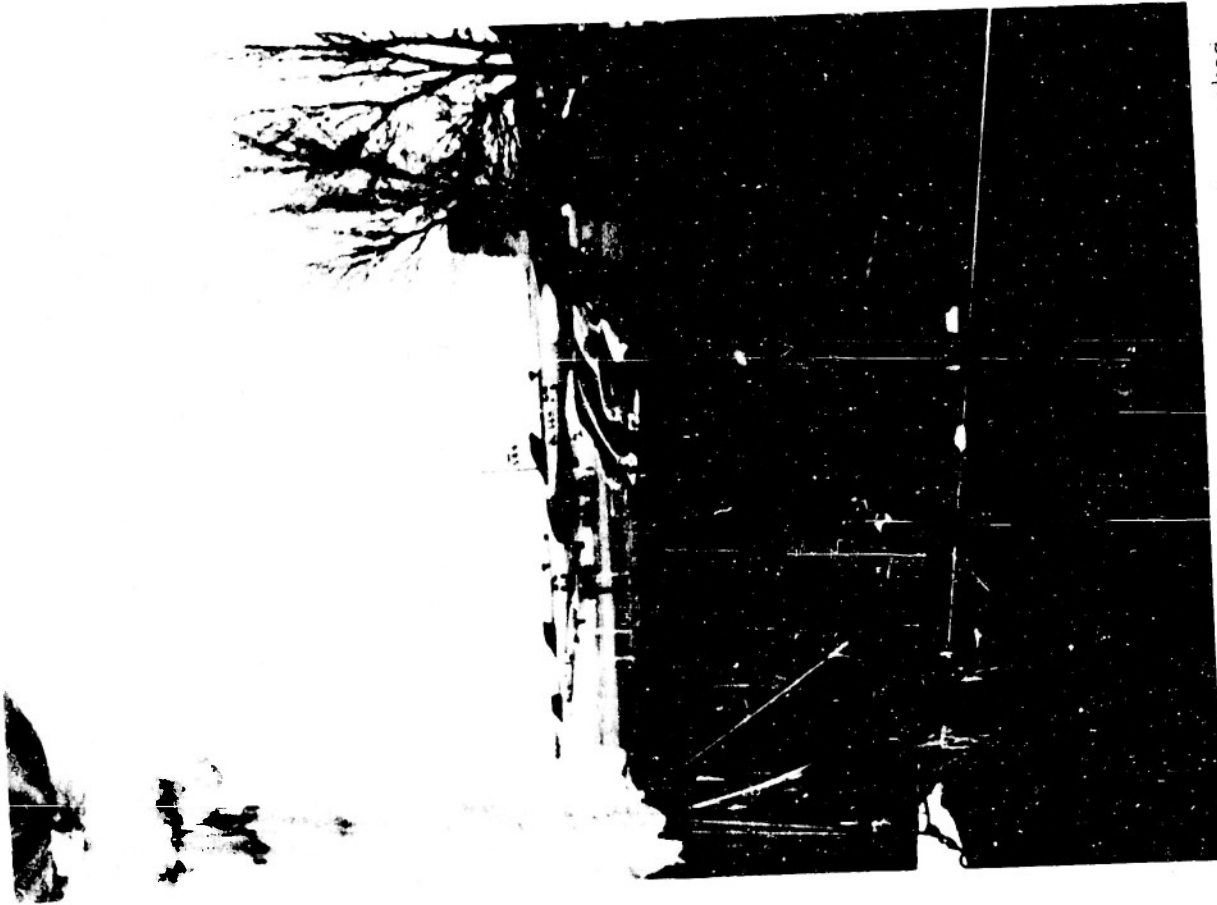


Figure IV-2. Close-up of anchor point showing packed balloon and tied off appendix, left. Girdle catcher ring and timer release, lower left. Scientific apparatus being secured and turned on, right.

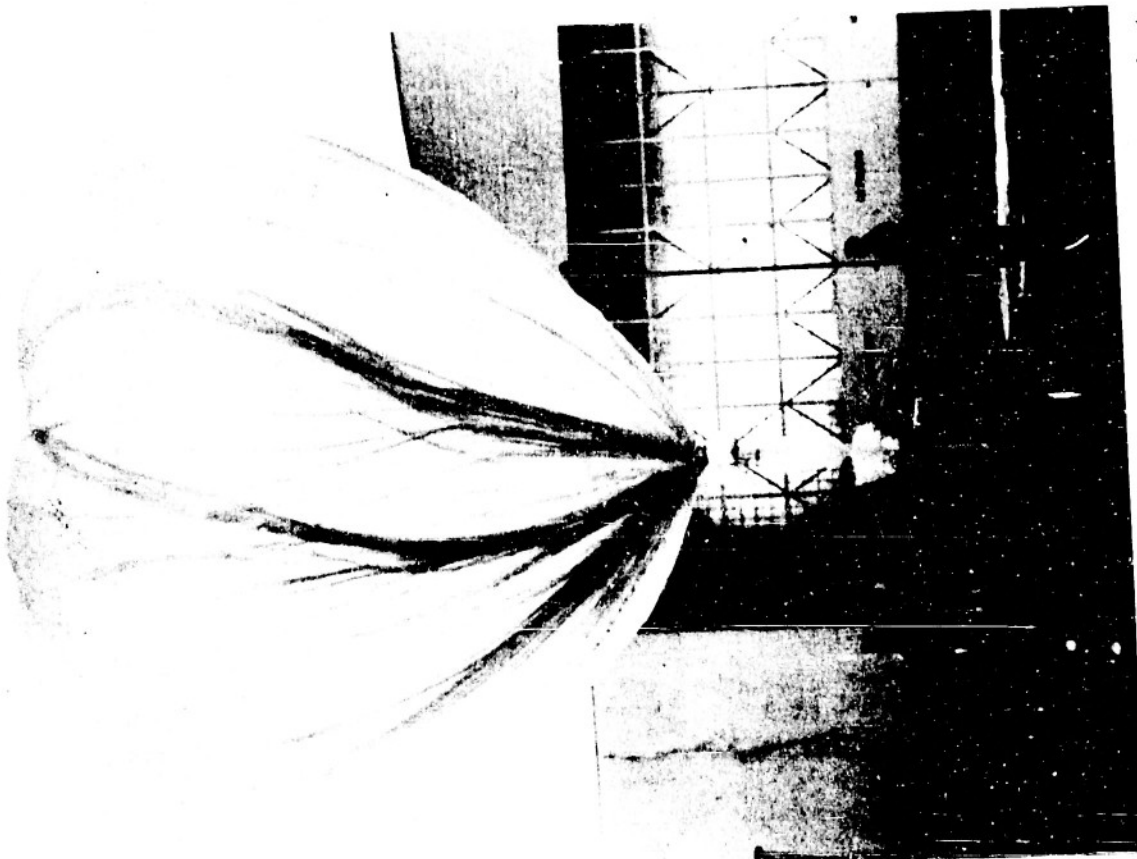


Figure IV-1. View of packed balloon inflated, weighed-off and with final adjustments being made on rigging.

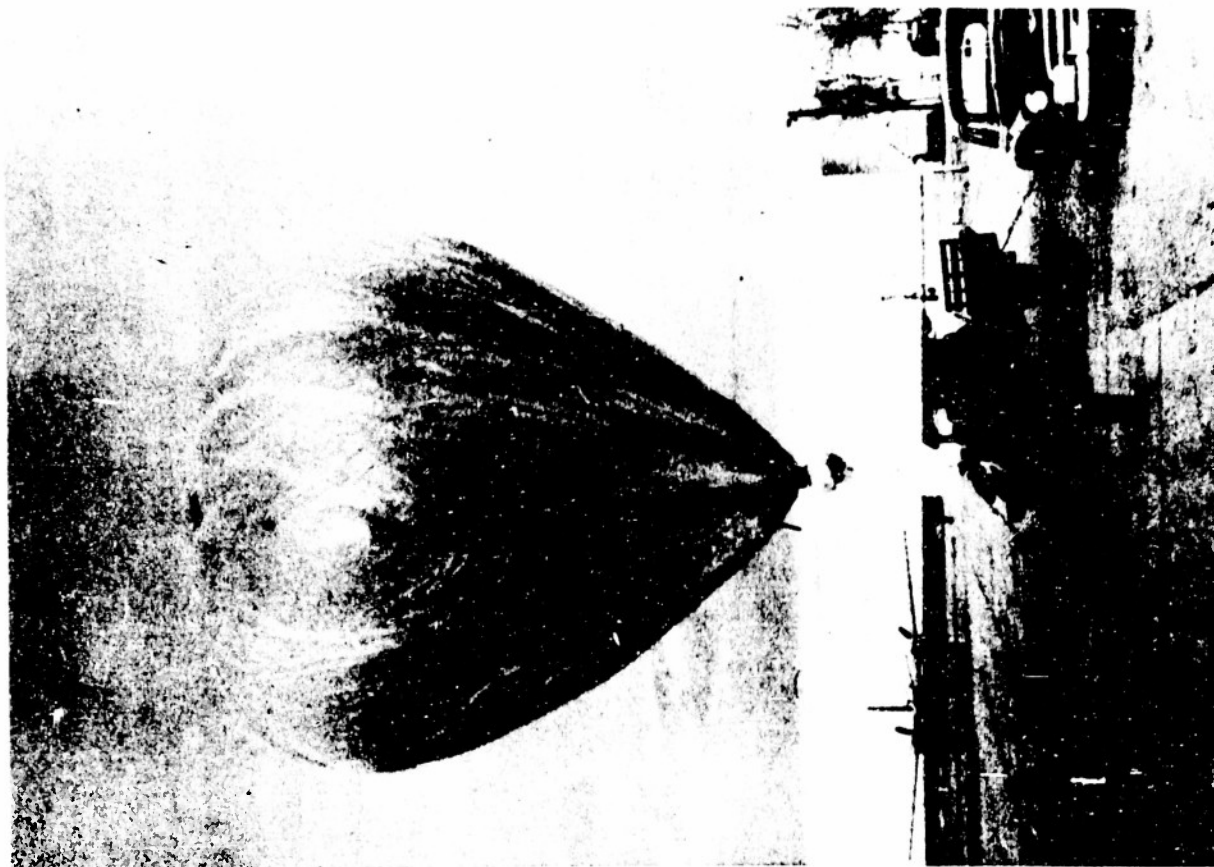


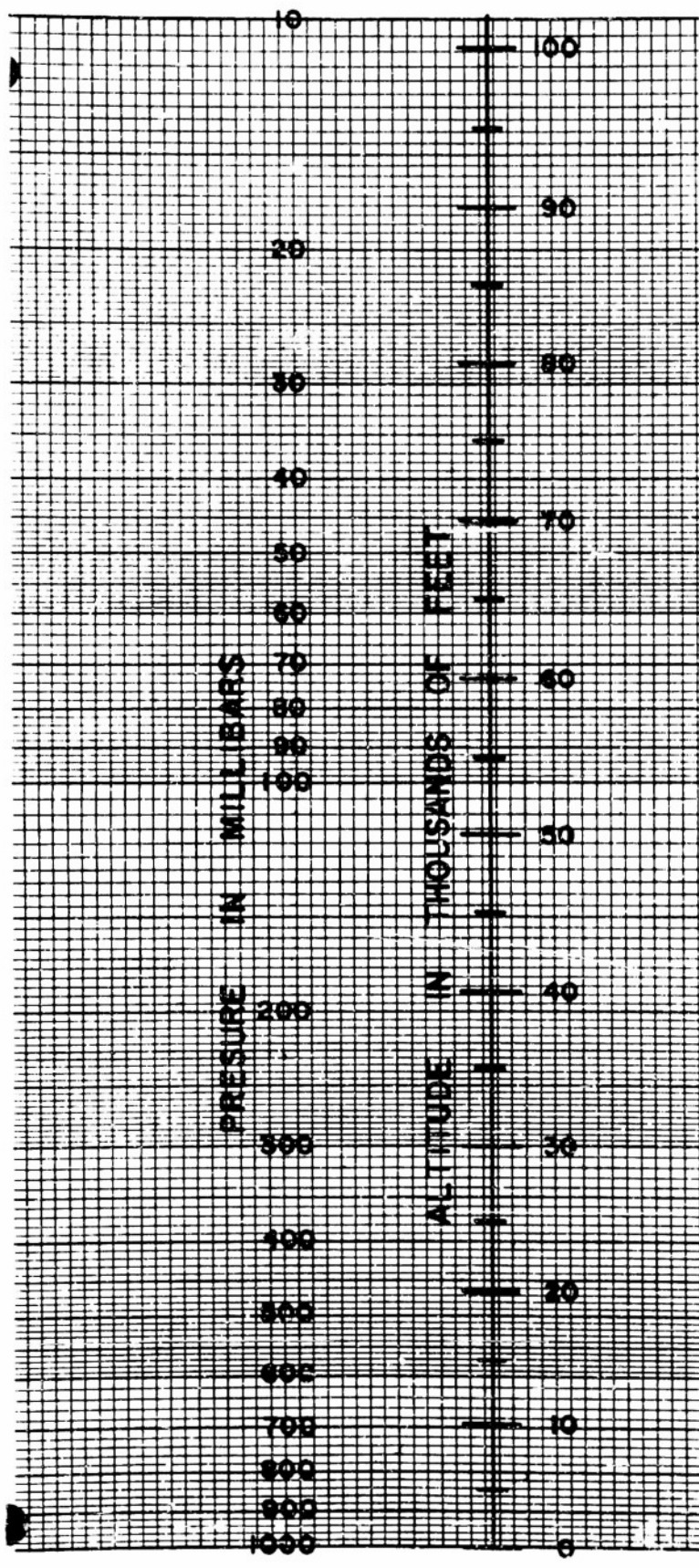
Figure IV-4. Inflated balloon being transferred by truck to hangar for storage following cancellation of flight because of difficulties with scientific apparatus. This balloon was launched the following morning and had not lost appreciable lift due to leakage during the day.

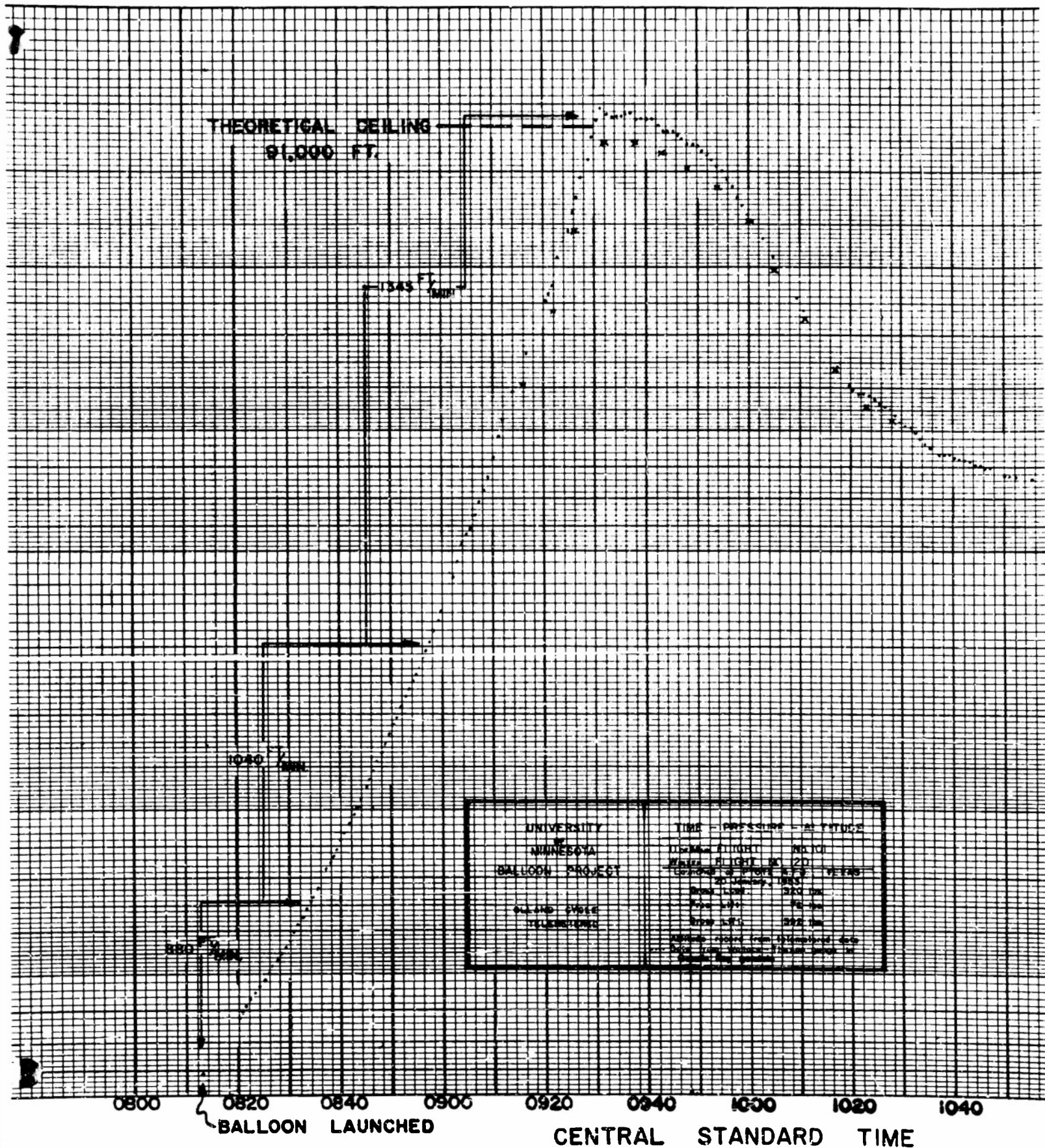


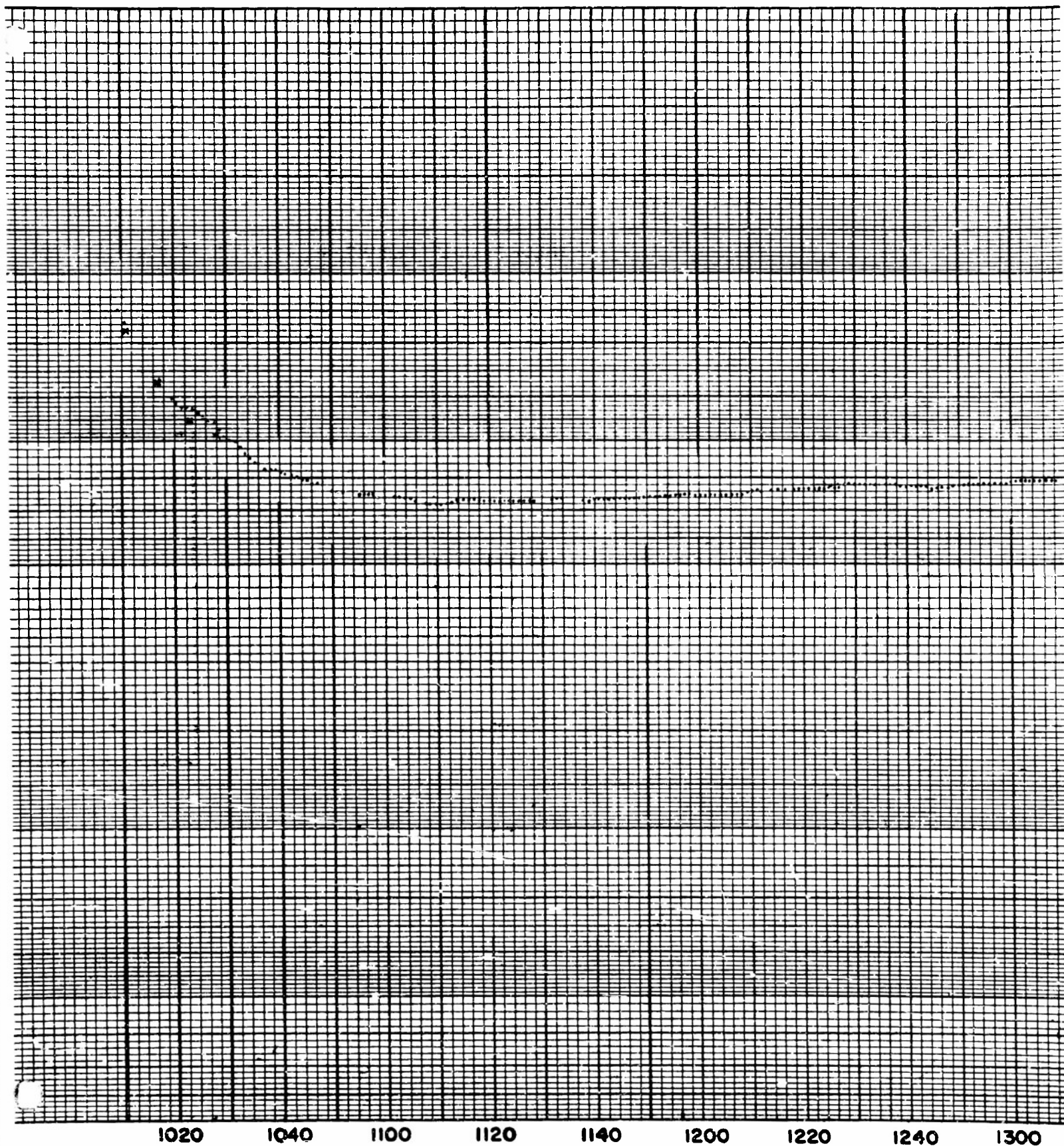
Figure IV-3. Inflated packed balloon ready for erecting showing mooring line and inflation hose, left. The mooring line at the upper end is out of camera view.

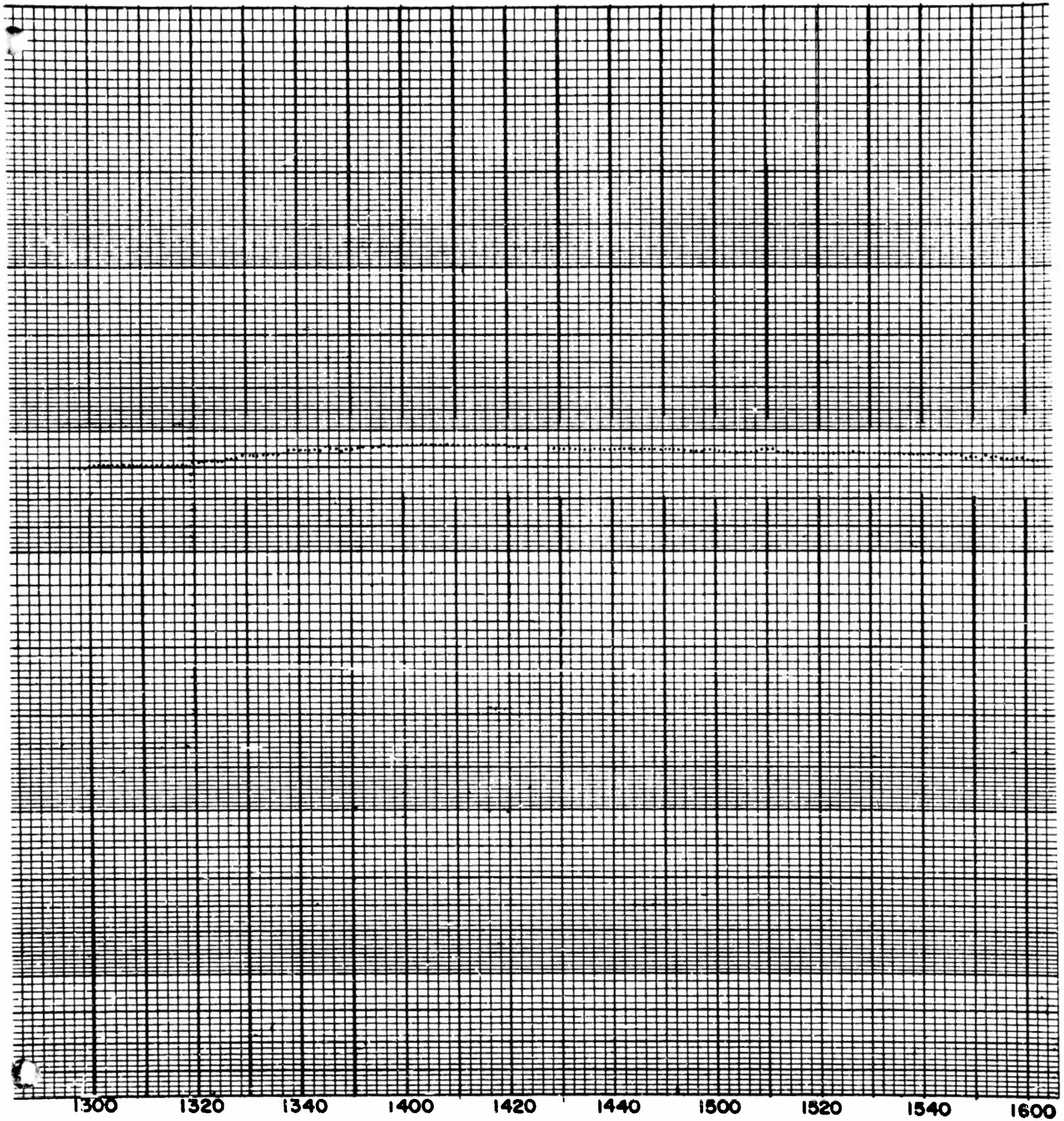
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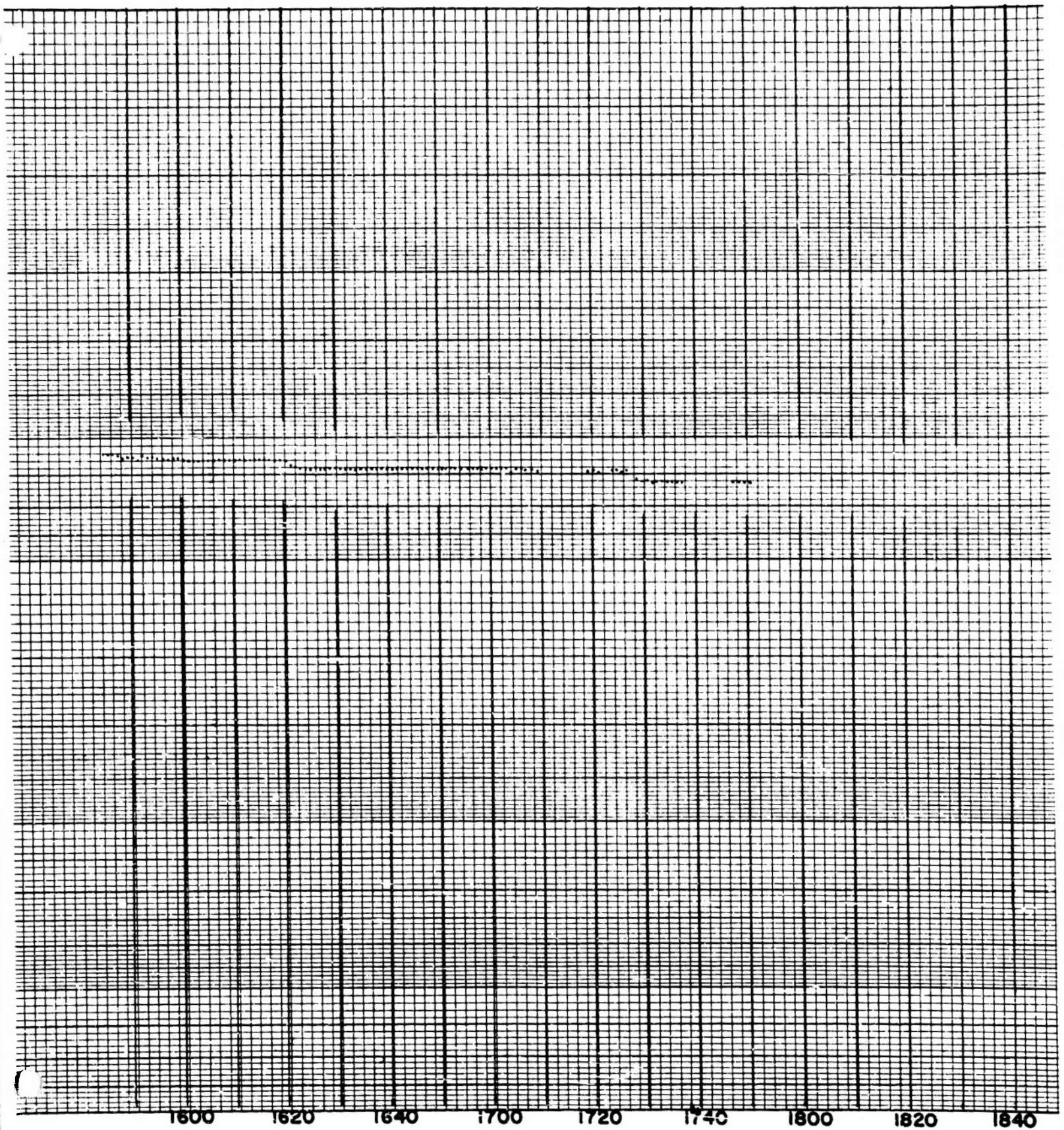
1470 1480 1490 1500 1510 1520 1530 1540 1550 1560 1570 1580 1590 1600 1610 1620 1630 1640 1650 1660 1670 1680 1690 1700 1710 1720 1730 1740 1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100 2110 2120 2130 2140 2150 2160 2170 2180 2190 2200 2210 2220 2230 2240 2250 2260 2270 2280 2290 2300 2310 2320 2330 2340 2350 2360 2370 2380 2390 2400 2410 2420 2430 2440 2450 2460 2470 2480 2490 2500 2510 2520 2530 2540 2550 2560 2570 2580 2590 2600 2610 2620 2630 2640 2650 2660 2670 2680 2690 2700 2710 2720 2730 2740 2750 2760 2770 2780 2790 2800 2810 2820 2830 2840 2850 2860 2870 2880 2890 2900 2910 2920 2930 2940 2950 2960 2970 2980 2990 3000 3010 3020 3030 3040 3050 3060 3070 3080 3090 3100 3110 3120 3130 3140 3150 3160 3170 3180 3190 3200 3210 3220 3230 3240 3250 3260 3270 3280 3290 3300 3310 3320 3330 3340 3350 3360 3370 3380 3390 3400 3410 3420 3430 3440 3450 3460 3470 3480 3490 3500 3510 3520 3530 3540 3550 3560 3570 3580 3590 3600 3610 3620 3630 3640 3650 3660 3670 3680 3690 3700 3710 3720 3730 3740 3750 3760 3770 3780 3790 3800 3810 3820 3830 3840 3850 3860 3870 3880 3890 3900 3910 3920 3930 3940 3950 3960 3970 3980 3990 4000 4010 4020 4030 4040 4050 4060 4070 4080 4090 4100 4110 4120 4130 4140 4150 4160 4170 4180 4190 4200 4210 4220 4230 4240 4250 4260 4270 4280 4290 4300 4310 4320 4330 4340 4350 4360 4370 4380 4390 4400 4410 4420 4430 4440 4450 4460 4470 4480 4490 4500 4510 4520 4530 4540 4550 4560 4570 4580 4590 4600 4610 4620 4630 4640 4650 4660 4670 4680 4690 4700 4710 4720 4730 4740 4750 4760 4770 4780 4790 4800 4810 4820 4830 4840 4850 4860 4870 4880 4890 4900 4910 4920 4930 4940 4950 4960 4970 4980 4990 5000 5010 5020 5030 5040 5050 5060 5070 5080 5090 5100 5110 5120 5130 5140 5150 5160 5170 5180 5190 5200 5210 5220 5230 5240 5250 5260 5270 5280 5290 5300 5310 5320 5330 5340 5350 5360 5370 5380 5390 5400 5410 5420 5430 5440 5450 5460 5470 5480 5490 5500 5510 5520 5530 5540 5550 5560 5570 5580 5590 5600 5610 5620 5630 5640 5650 5660 5670 5680 5690 5700 5710 5720 5730 5740 5750 5760 5770 5780 5790 5800 5810 5820 5830 5840 5850 5860 5870 5880 5890 5900 5910 5920 5930 5940 5950 5960 5970 5980 5990 6000 6010 6020 6030 6040 6050 6060 6070 6080 6090 6100 6110 6120 6130 6140 6150 6160 6170 6180 6190 6200 6210 6220 6230 6240 6250 6260 6270 6280 6290 6300 6310 6320 6330 6340 6350 6360 6370 6380 6390 6400 6410 6420 6430 6440 6450 6460 6470 6480 6490 6500 6510 6520 6530 6540 6550 6560 6570 6580 6590 6600 6610 6620 6630 6640 6650 6660 6670 6680 6690 6700 6710 6720 6730 6740 6750 6760 6770 6780 6790 6800 6810 6820 6830 6840 6850 6860 6870 6880 6890 6900 6910 6920 6930 6940 6950 6960 6970 6980 6990 7000 7010 7020 7030 7040 7050 7060 7070 7080 7090 7100 7110 7120 7130 7140 7150 7160 7170 7180 7190 7200 7210 7220 7230 7240 7250 7260 7270 7280 7290 7300 7310 7320 7330 7340 7350 7360 7370 7380 7390 7400 7410 7420 7430 7440 7450 7460 7470 7480 7490 7500 7510 7520 7530 7540 7550 7560 7570 7580 7590 7600 7610 7620 7630 7640 7650 7660 7670 7680 7690 7700 7710 7720 7730 7740 7750 7760 7770 7780 7790 7800 7810 7820 7830 7840 7850 7860 7870 7880 7890 7900 7910 7920 7930 7940 7950 7960 7970 7980 7990 8000 8010 8020 8030 8040 8050 8060 8070 8080 8090 8100 8110 8120 8130 8140 8150 8160 8170 8180 8190 8200 8210 8220 8230 8240 8250 8260 8270 8280 8290 8300 8310 8320 8330 8340 8350 8360 8370 8380 8390 8400 8410 8420 8430 8440 8450 8460 8470 8480 8490 8500 8510 8520 8530 8540 8550 8560 8570 8580 8590 8600 8610 8620 8630 8640 8650 8660 8670 8680 8690 8700 8710 8720 8730 8740 8750 8760 8770 8780 8790 8800 8810 8820 8830 8840 8850 8860 8870 8880 8890 8900 8910 8920 8930 8940 8950 8960 8970 8980 8990 9000 9010 9020 9030 9040 9050 9060 9070 9080 9090 9100 9110 9120 9130 9140 9150 9160 9170 9180 9190 9200 9210 9220 9230 9240 9250 9260 9270 9280 9290 9300 9310 9320 9330 9340 9350 9360 9370 9380 9390 9400 9410 9420 9430 9440 9450 9460 9470 9480 9490 9500 9510 9520 9530 9540 9550 9560 9570 9580 9590 9600 9610 9620 9630 9640 9650 9660 9670 9680 9690 9700 9710 9720 9730 9740 9750 9760 9770 9780 9790 9800 9810 9820 9830 9840 9850 9860 9870 9880 9890 9900 9910 9920 9930 9940 9950 9960 9970 9980 9990 10000











THEORETICAL CEILING
86,000 FT.

Oiland cycle failed to
function properly during
descent.

Pressure (inches of mercury) vs. Time (hours)

UNIVERSITY
OF
MINNESOTA
BALLOON PROJECT

DESIGN: C-100
REGISTERED

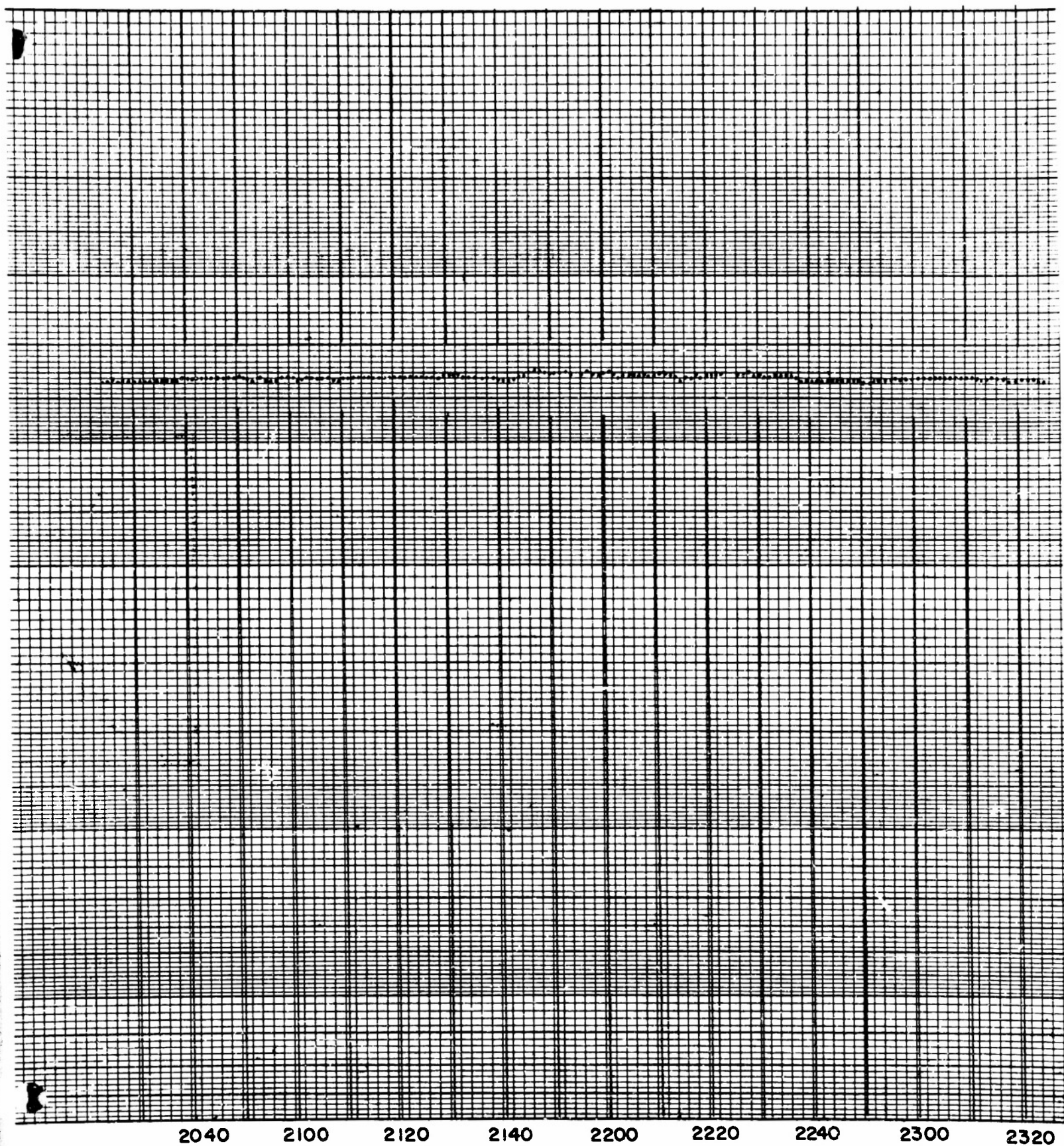
TIME - PRESSURE - ALTITUDE

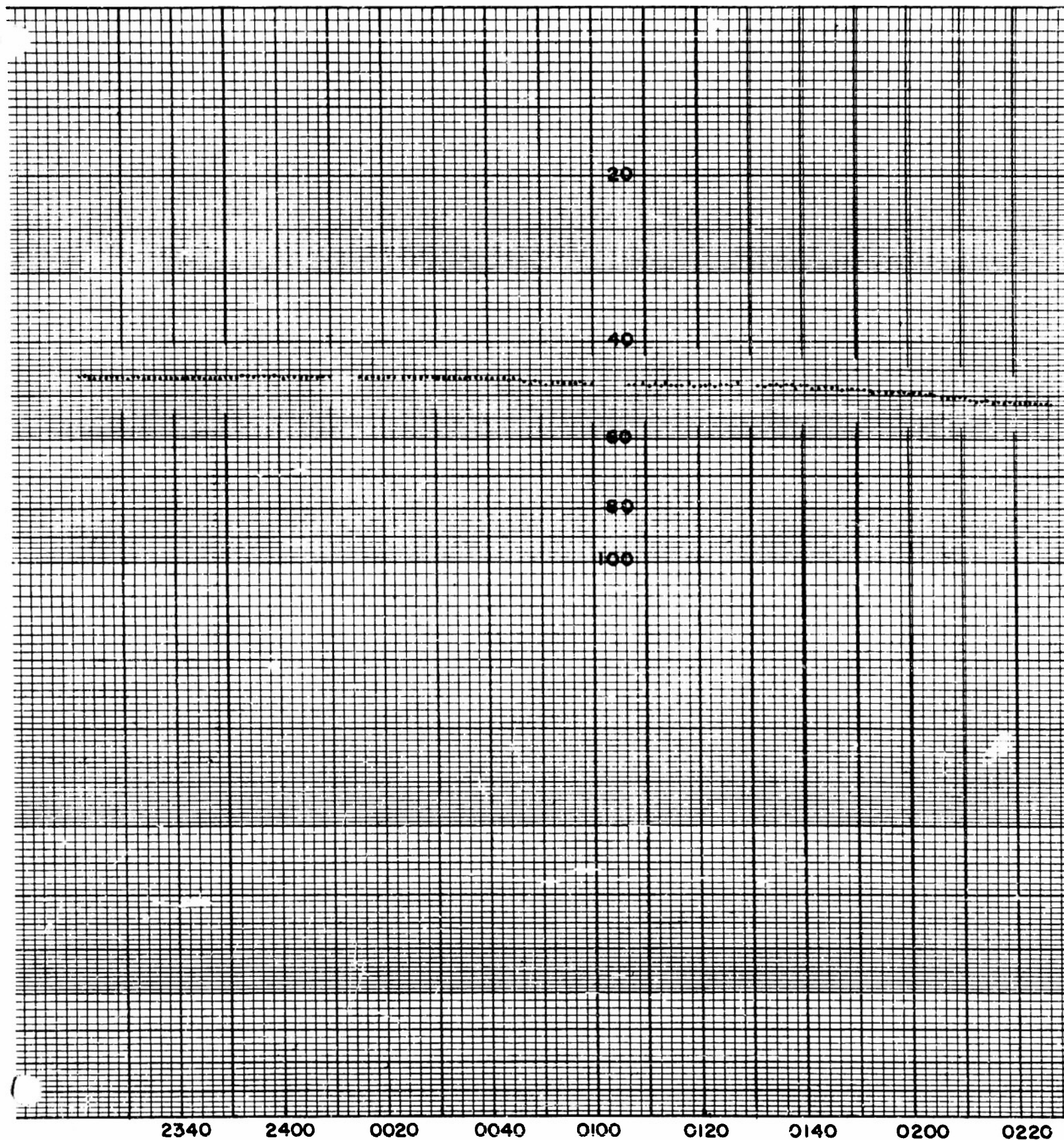
U OF MINN. FLIGHT NO. 102
WINDEN FLIGHT NO. 21
LAUNCHED AT PAVO AFB, TEXAS
20 JANUARY, 1955
GROSS WEIGHT 31,000
NET WEIGHT 20,000
GROSS WEIGHT 31,000
ALTITUDE: 86,000 FT. (estimated)

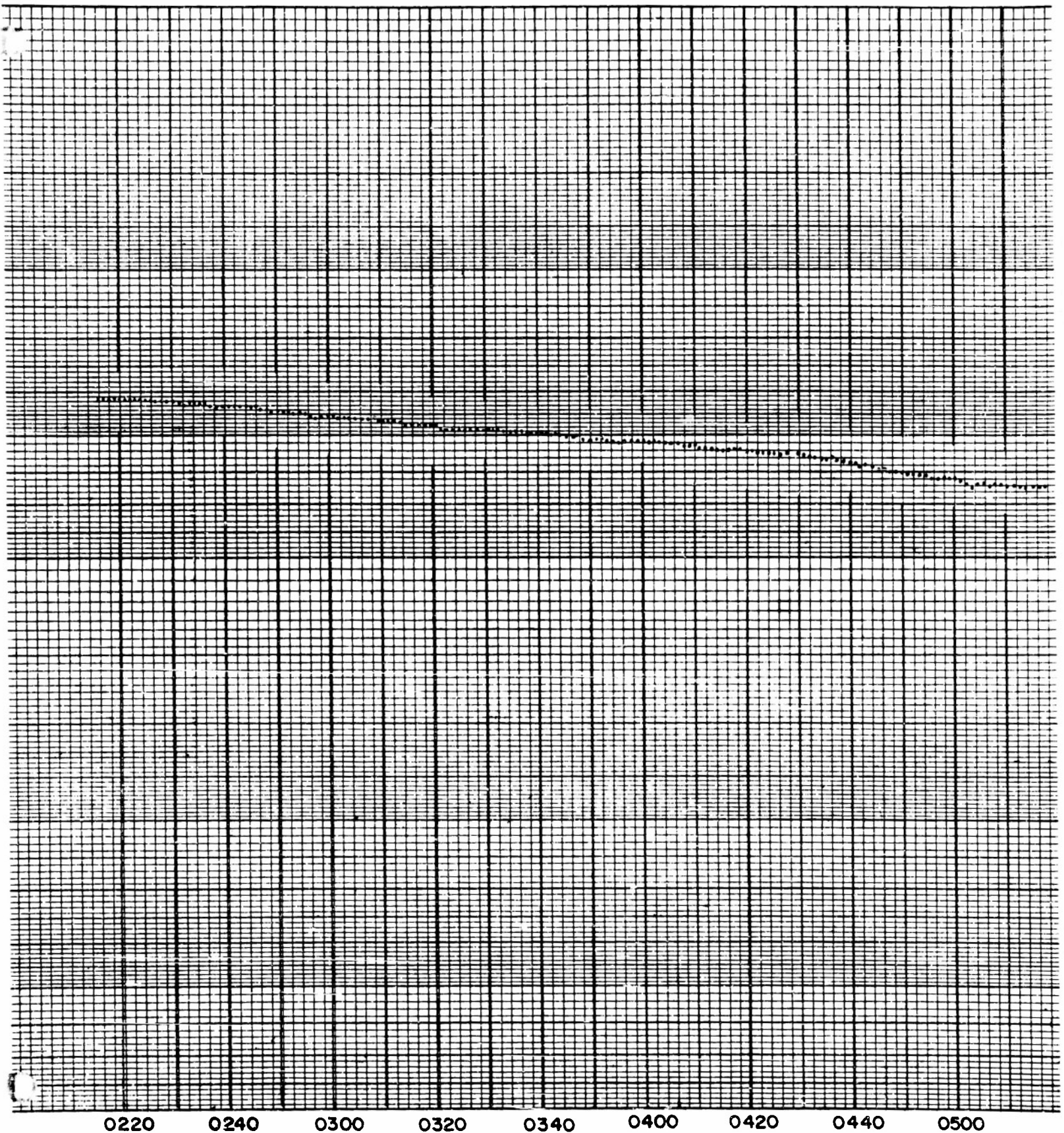
1740
BALLOON
LAUNCHED

CENTRAL STANDARD TIME

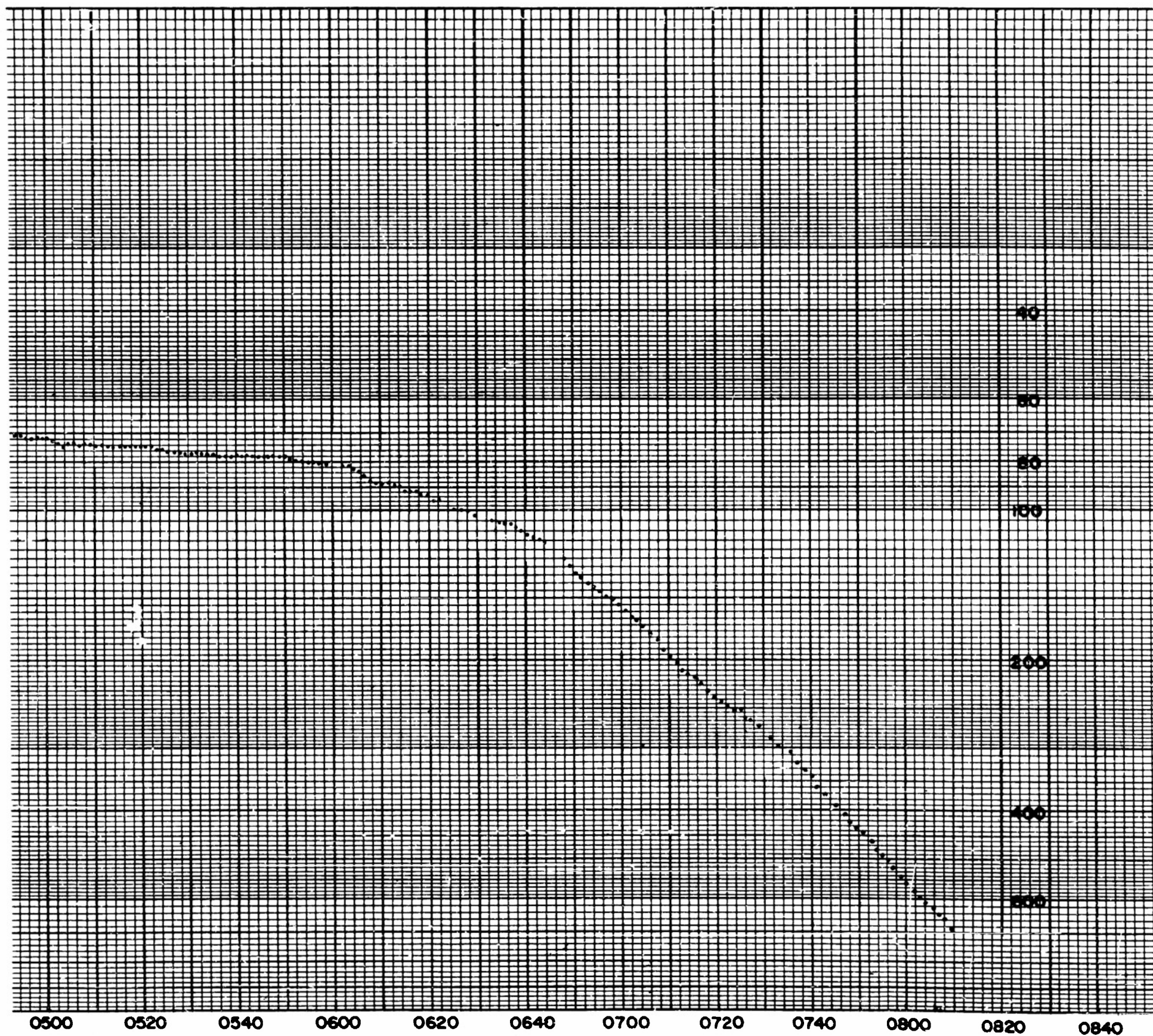
Confidential Security Information

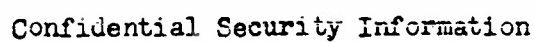


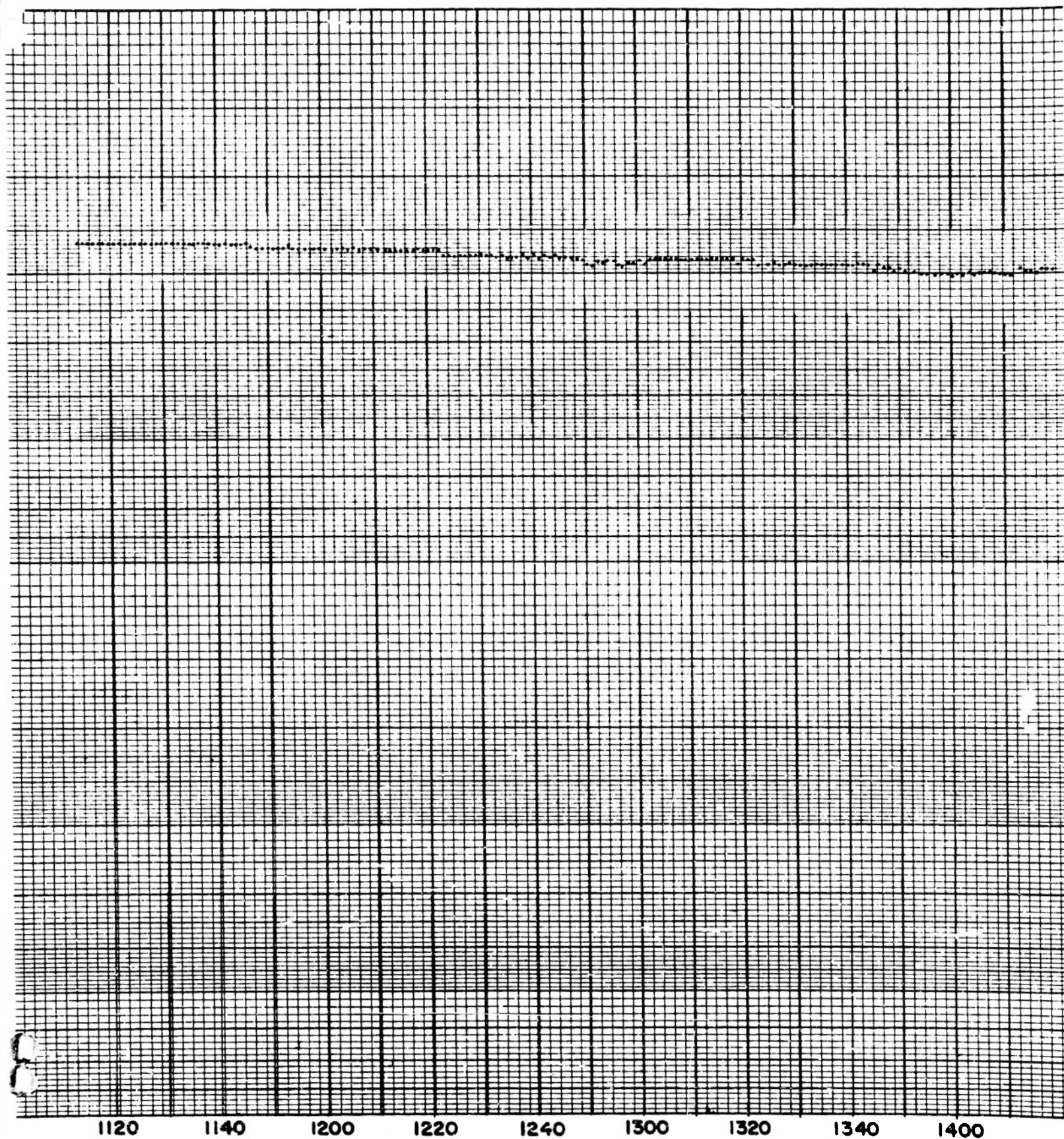


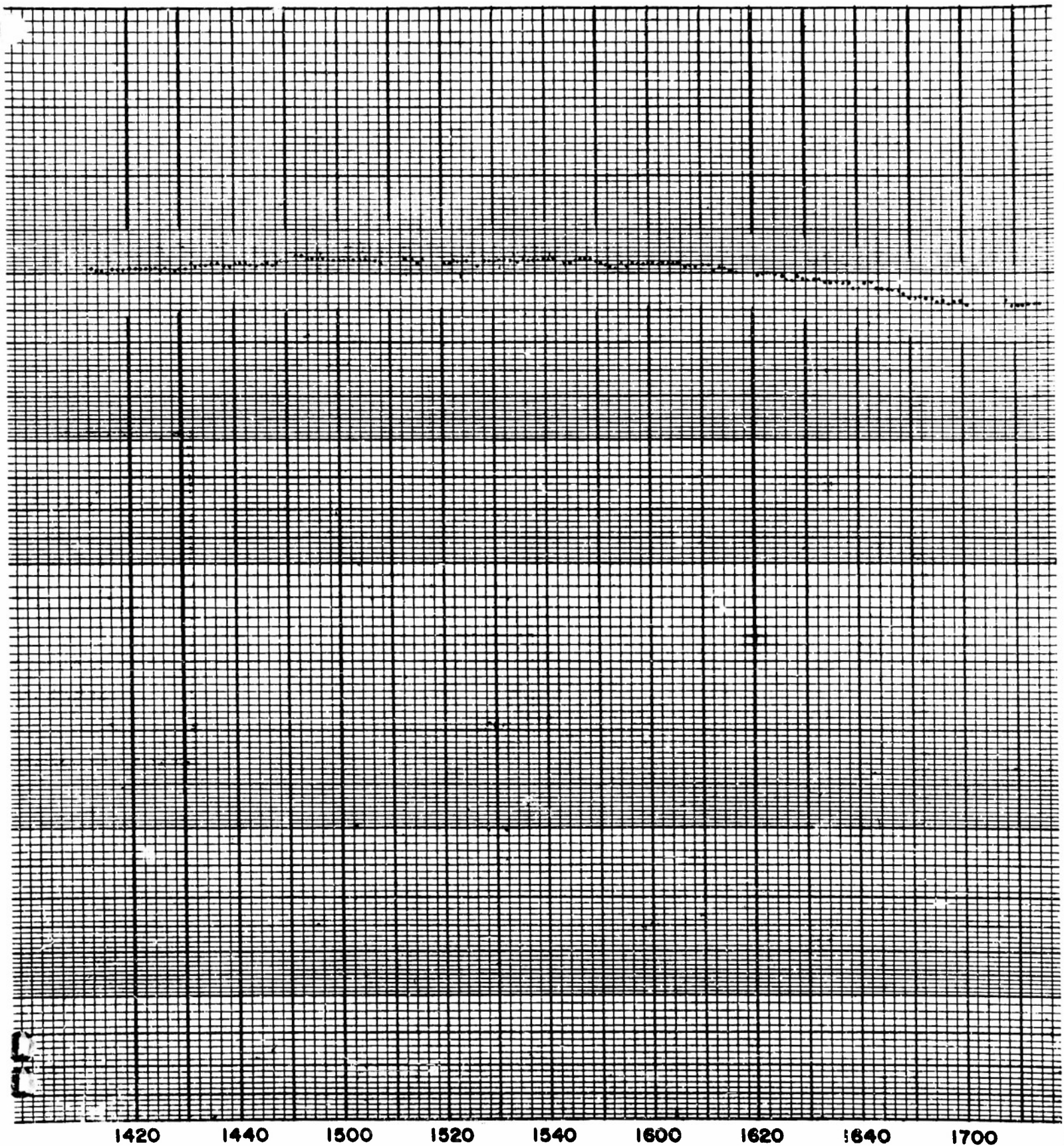


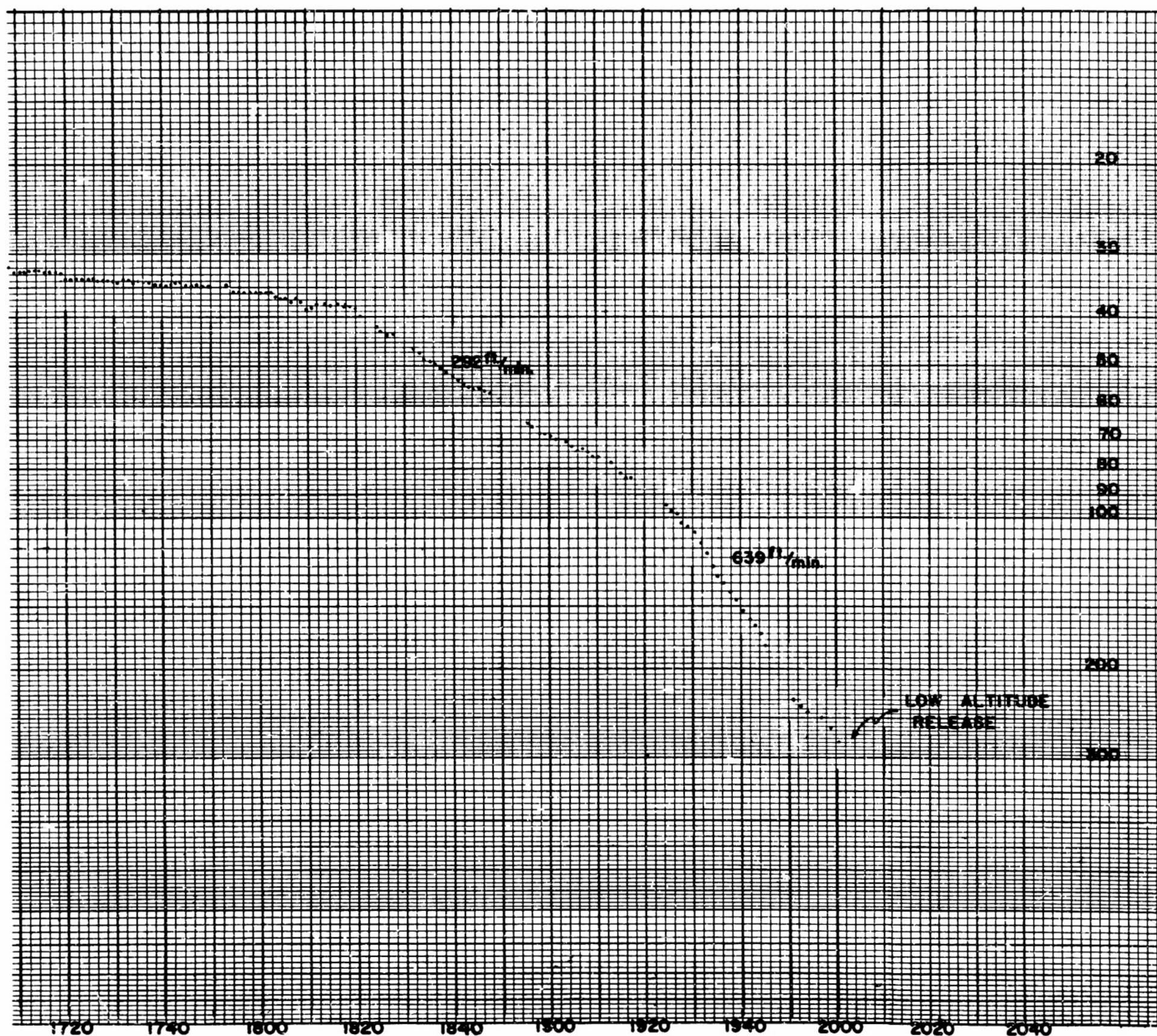
Confidential Security Information

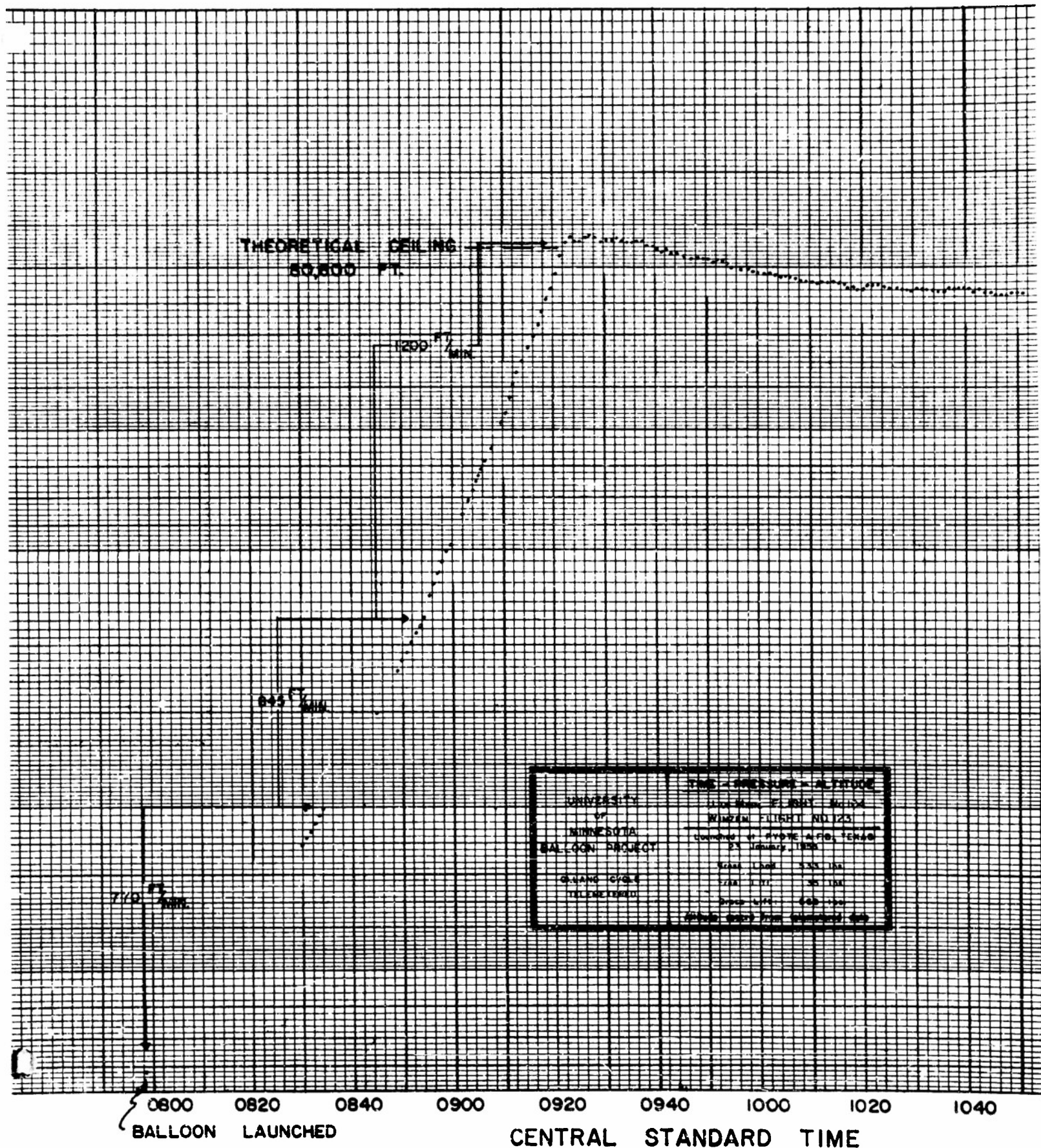


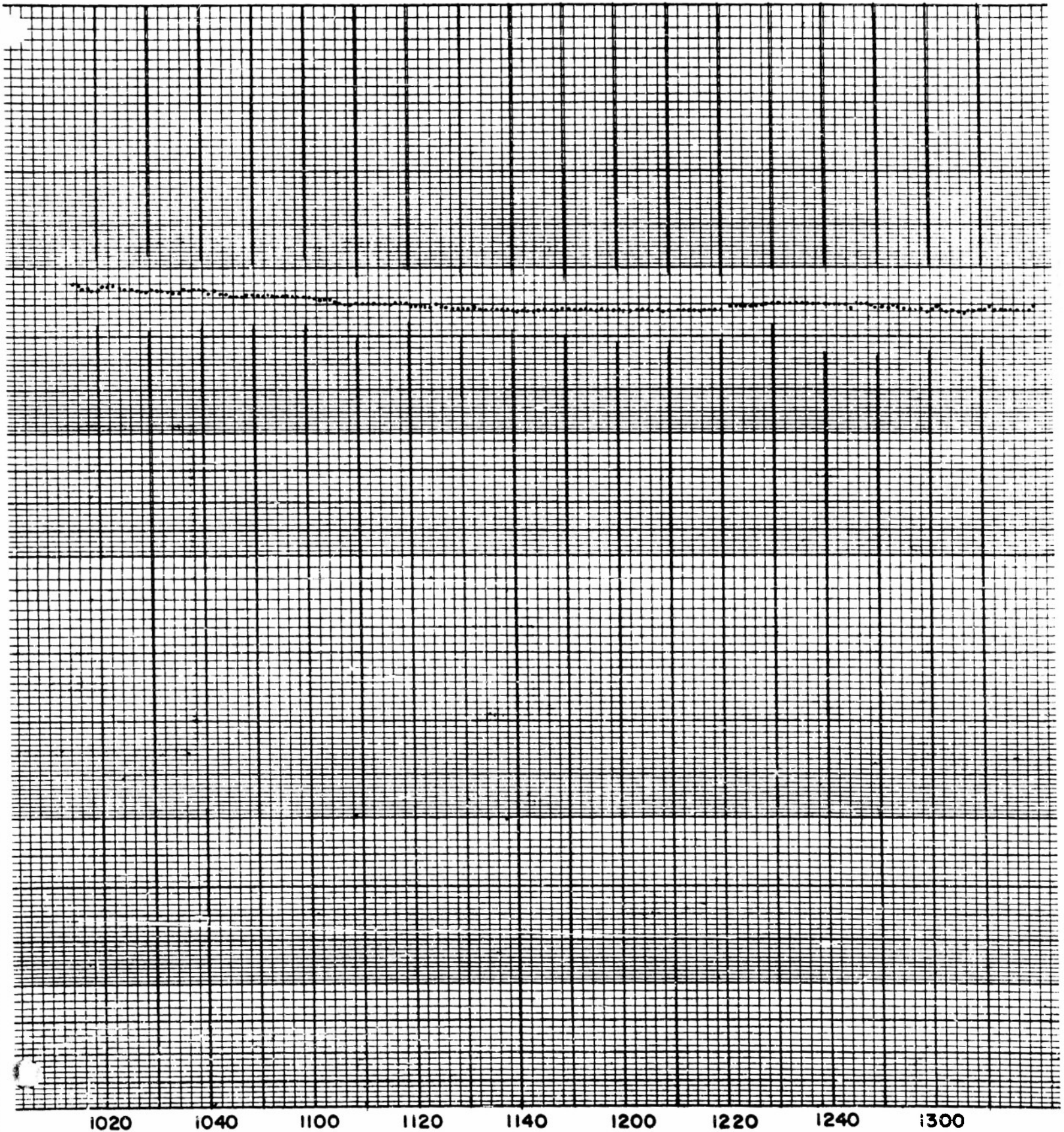






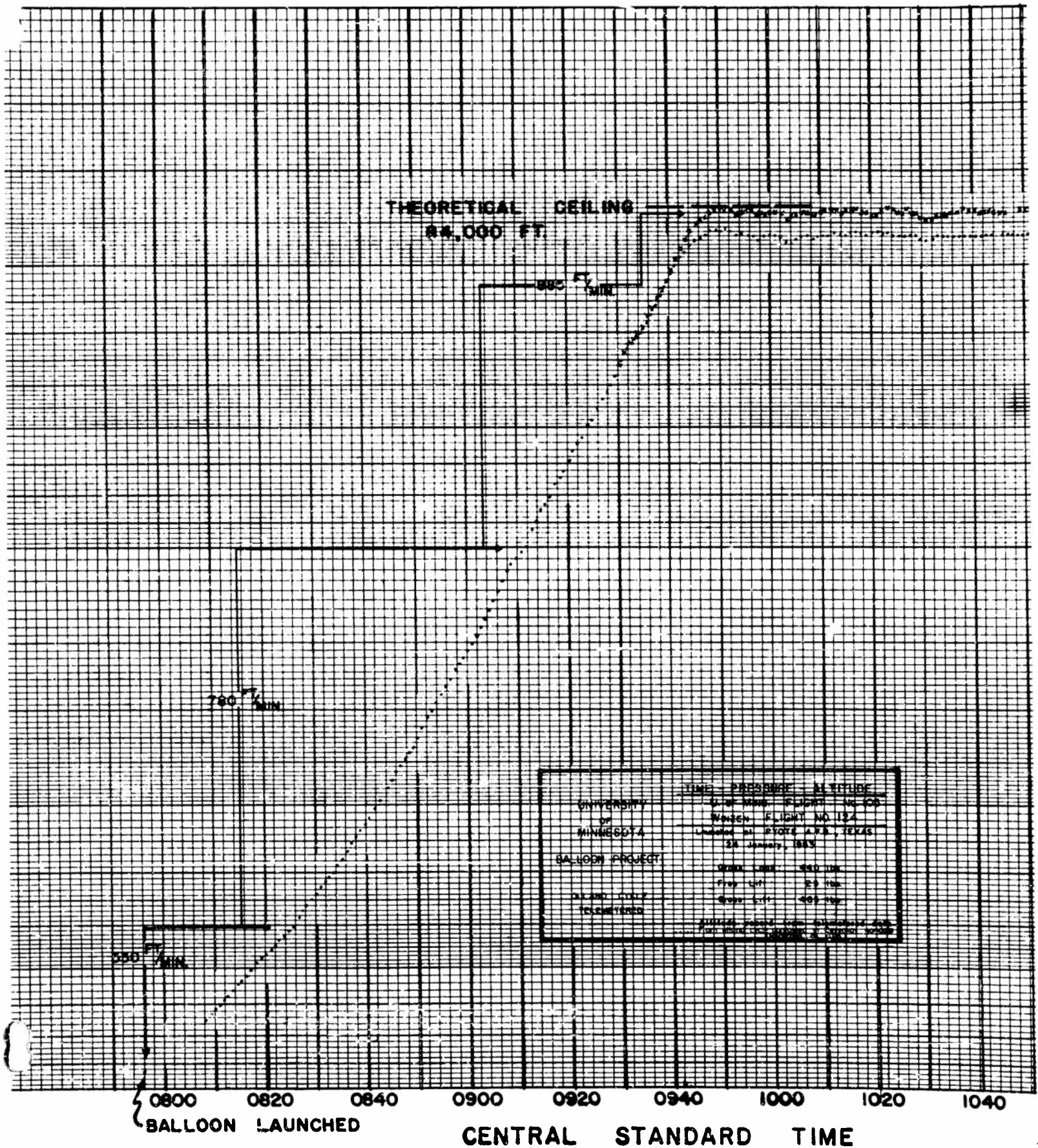


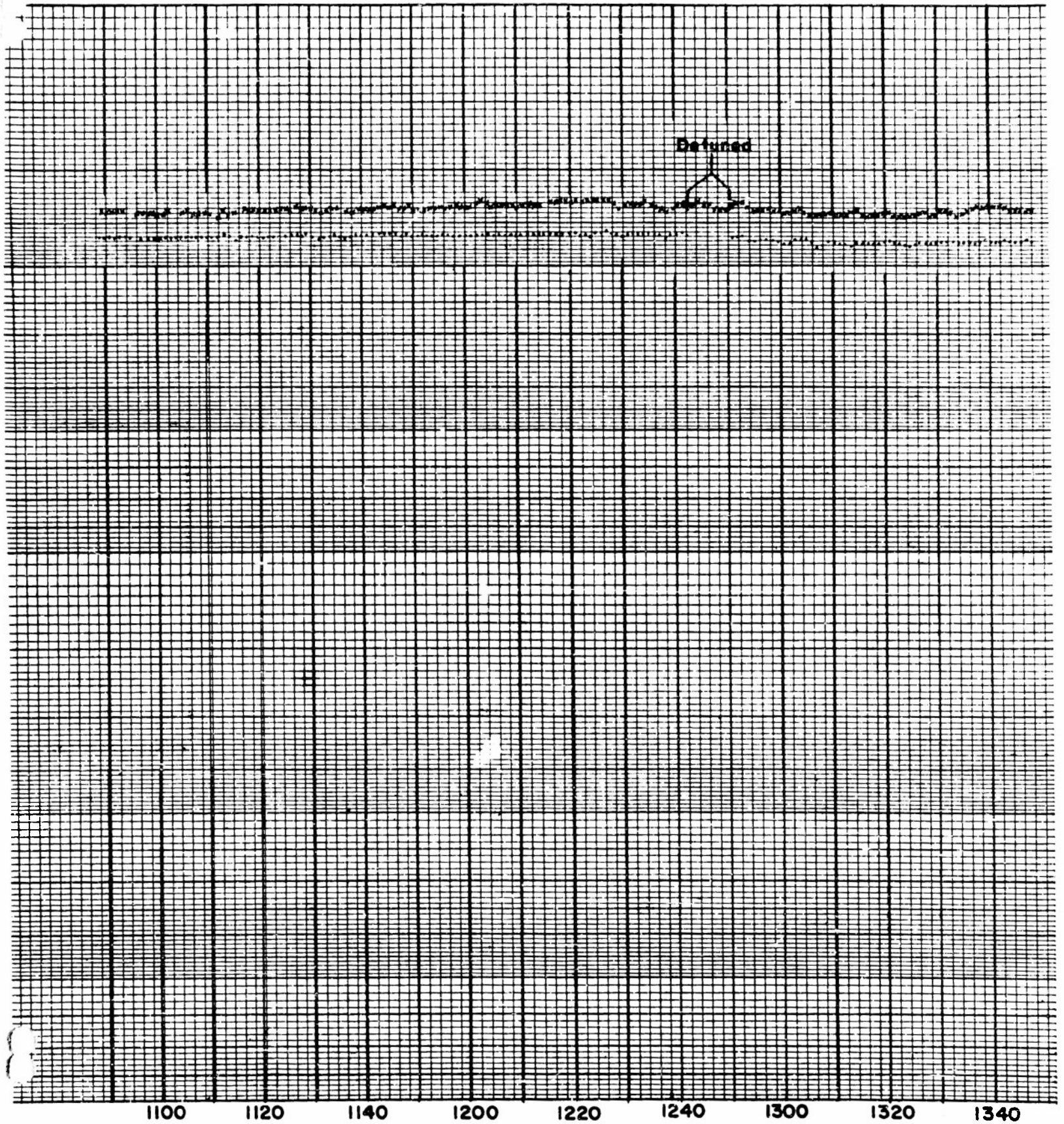


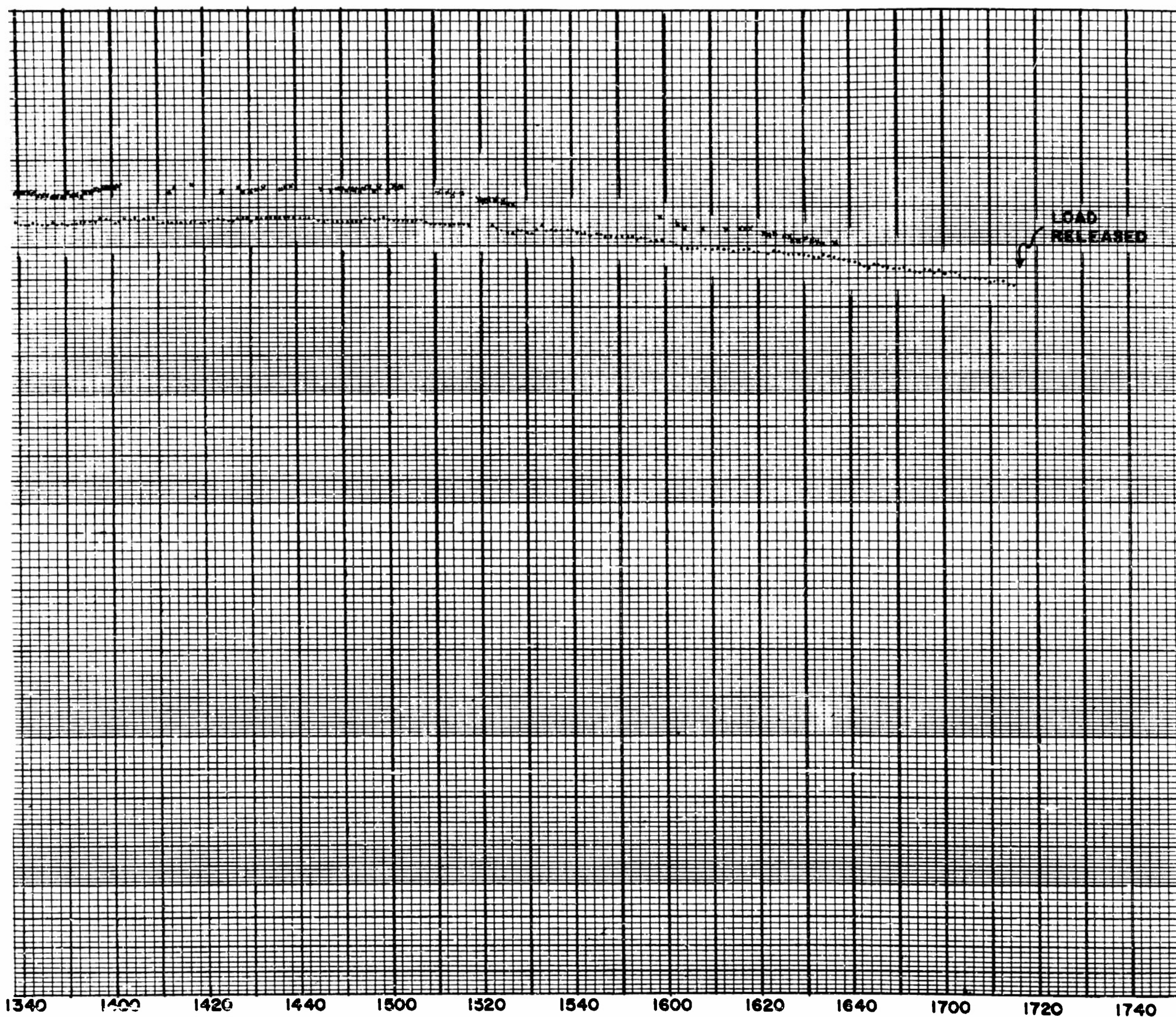


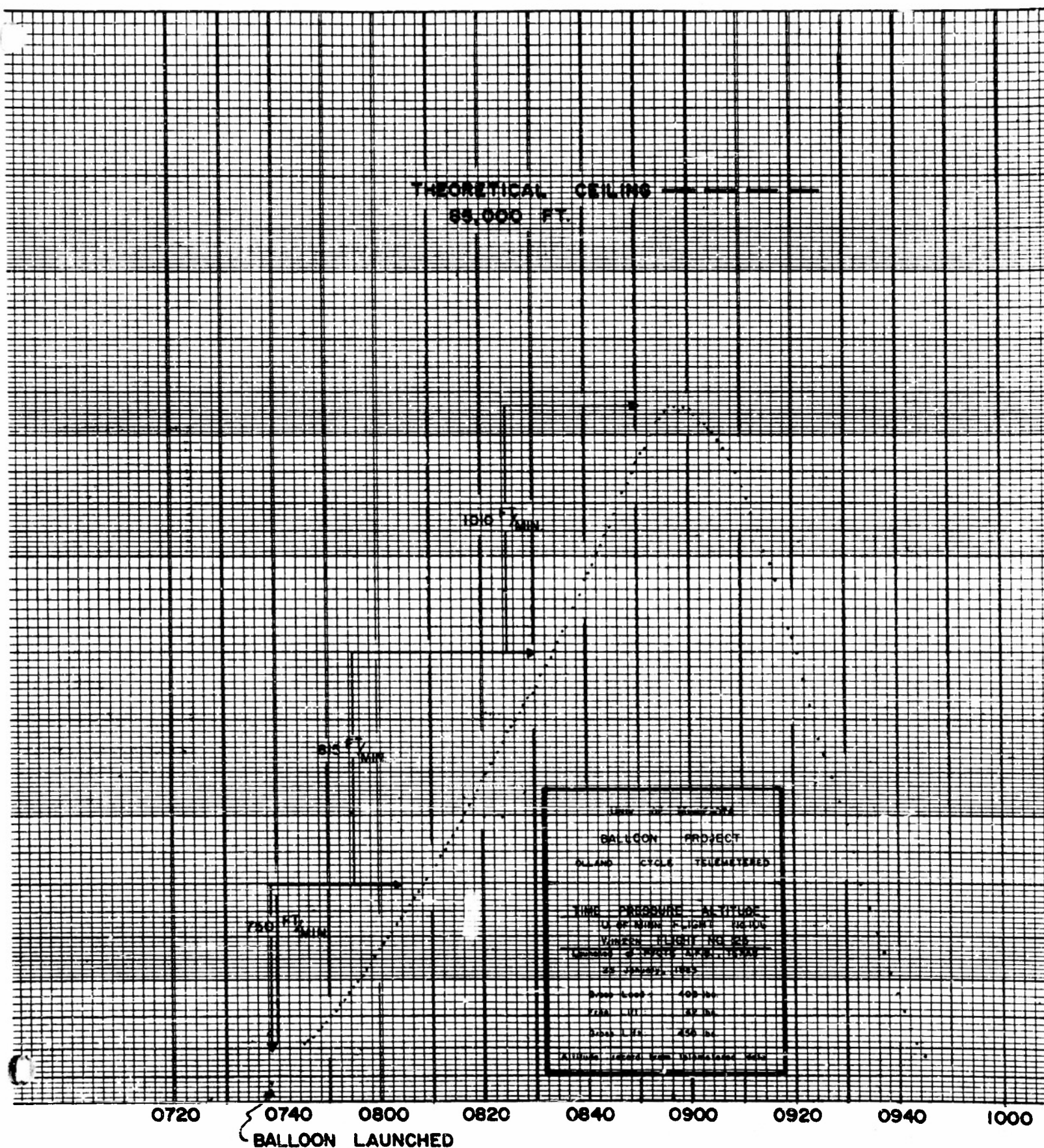
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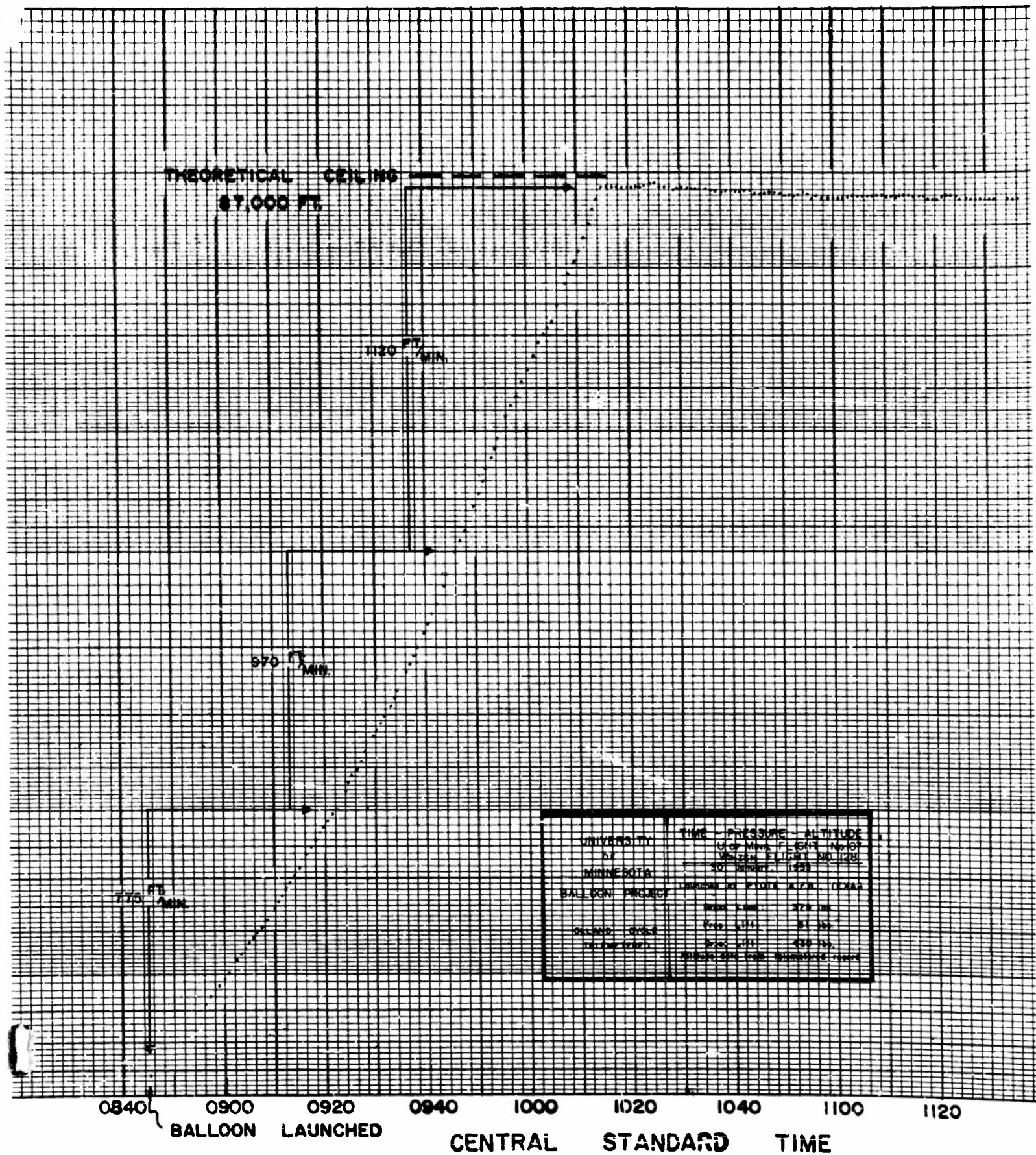


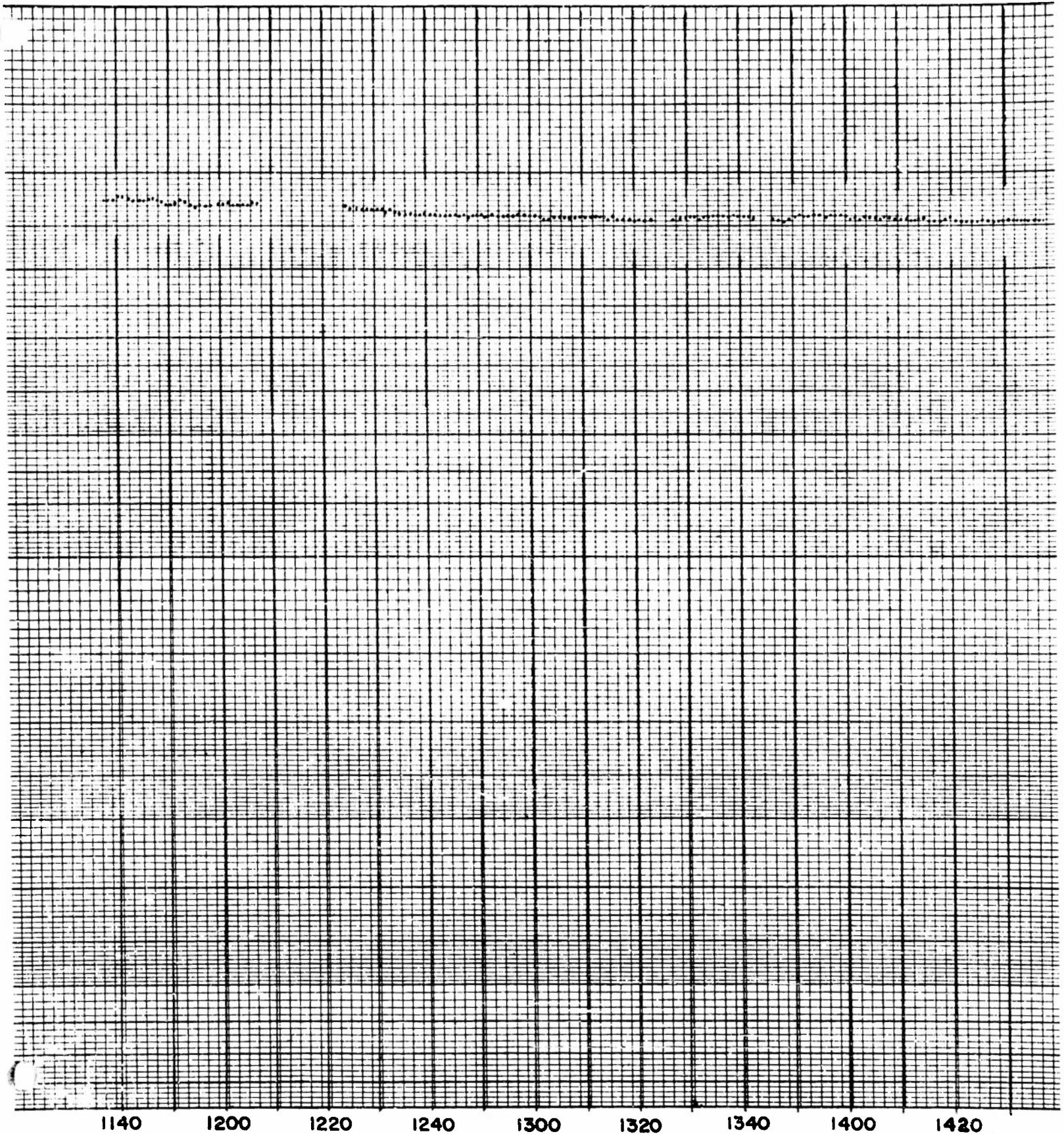


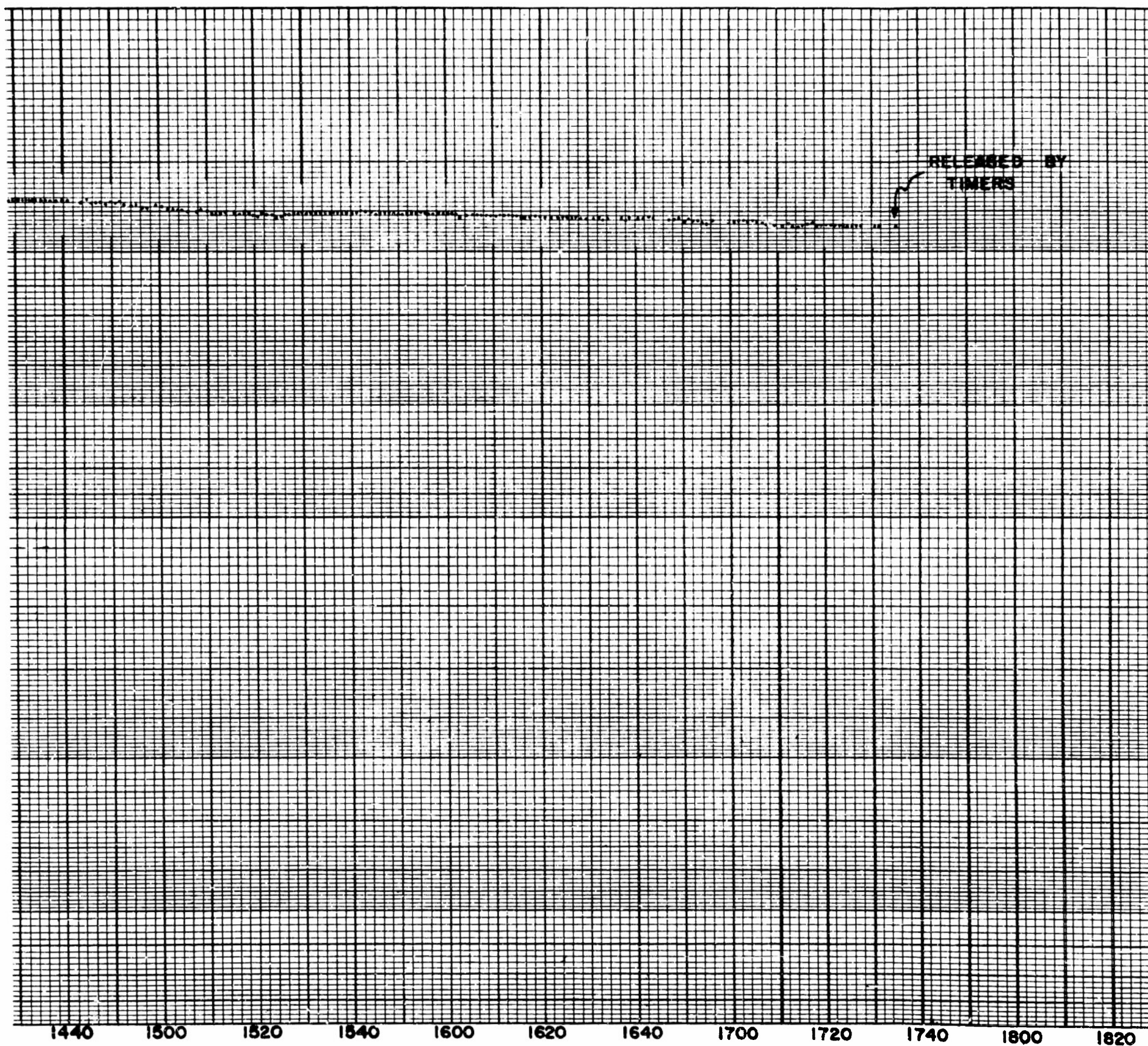


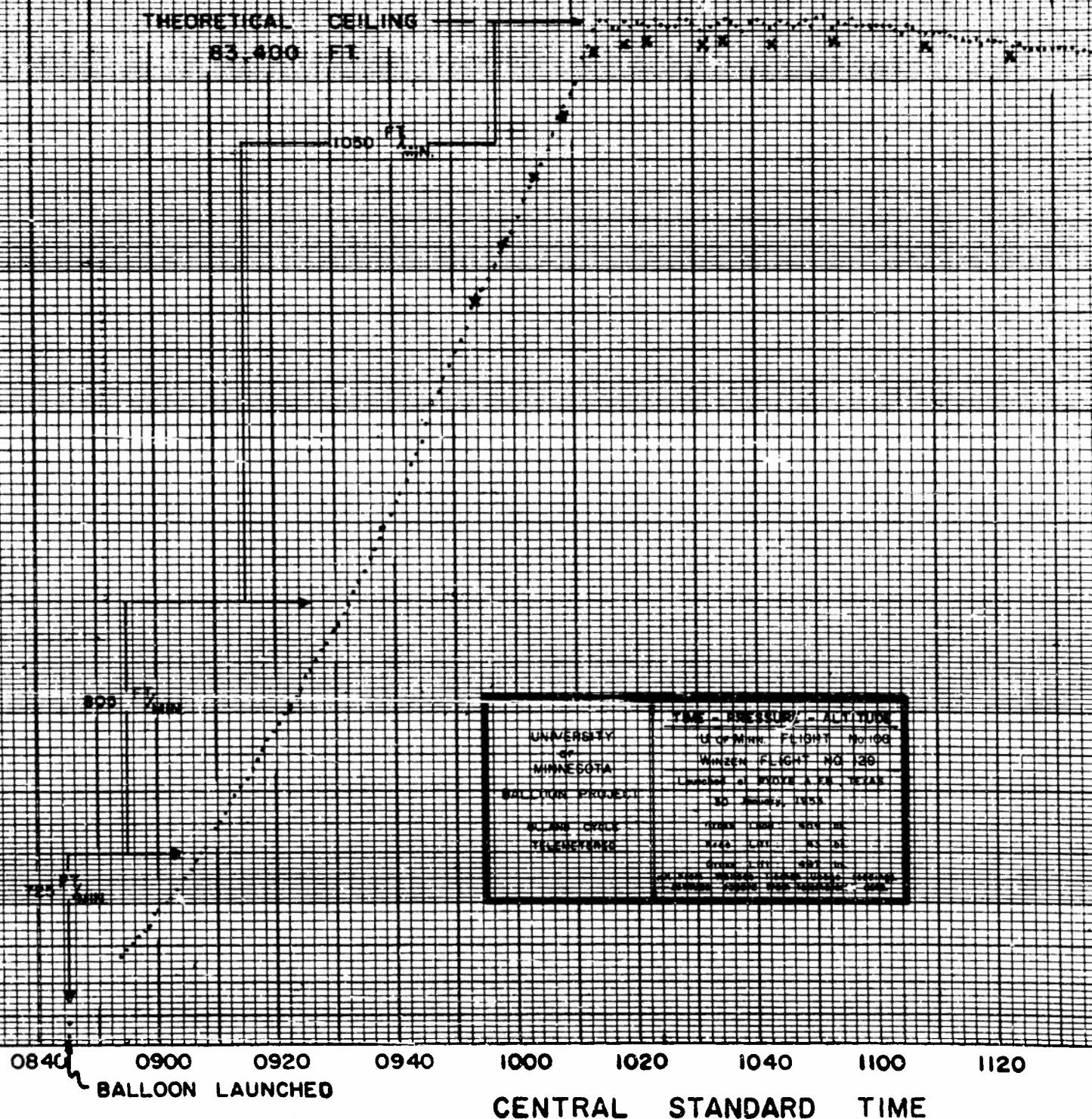
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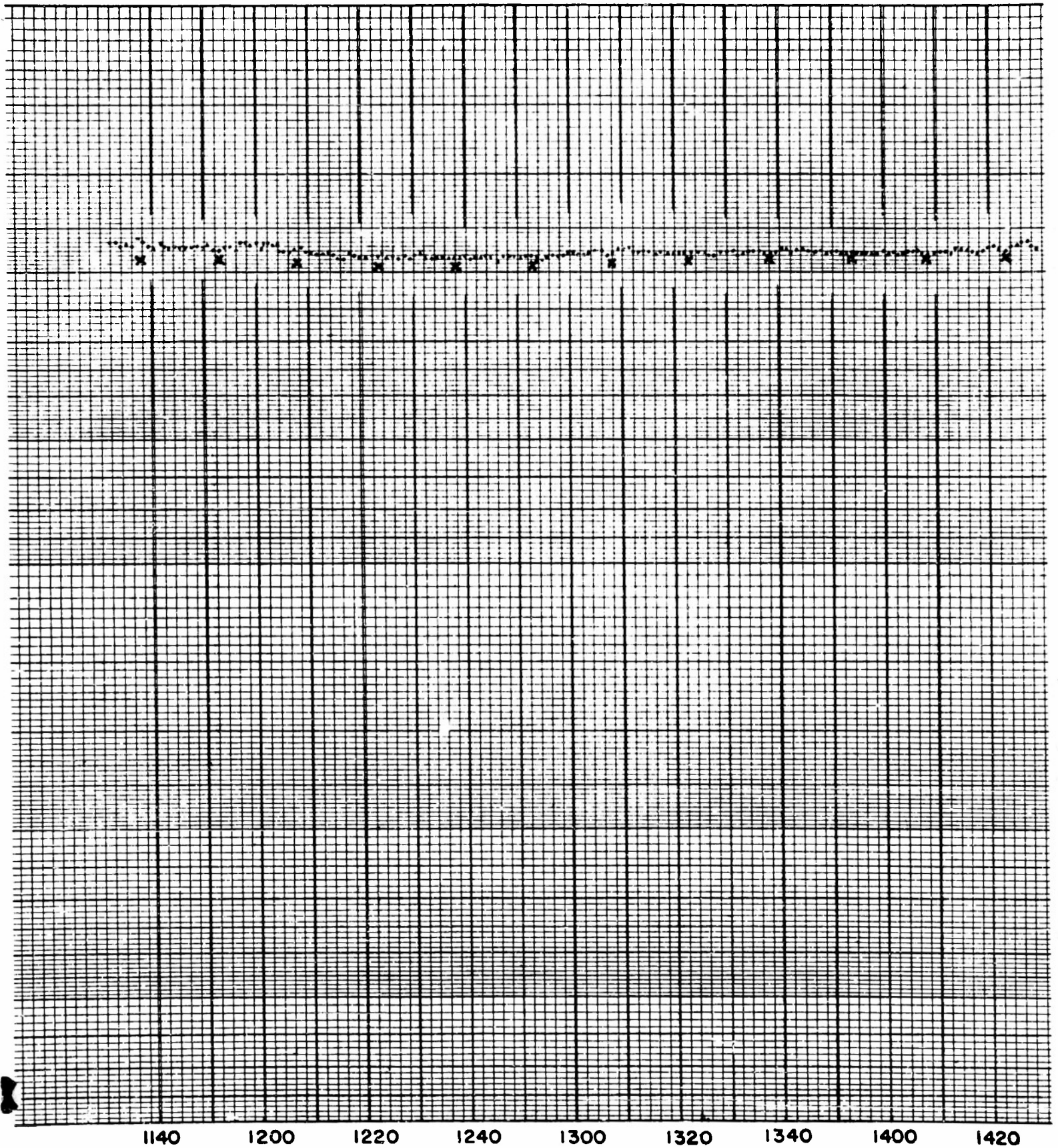
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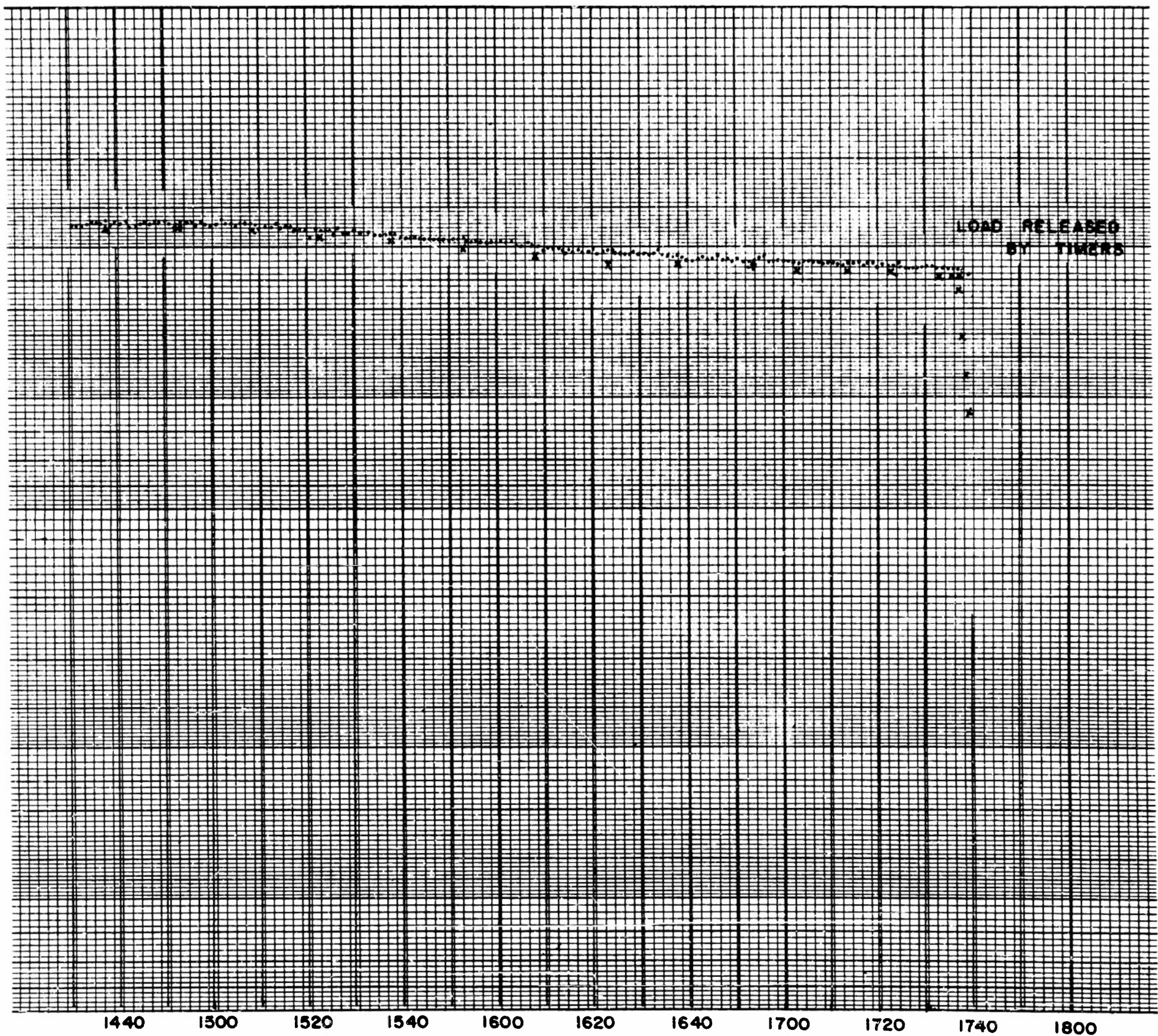


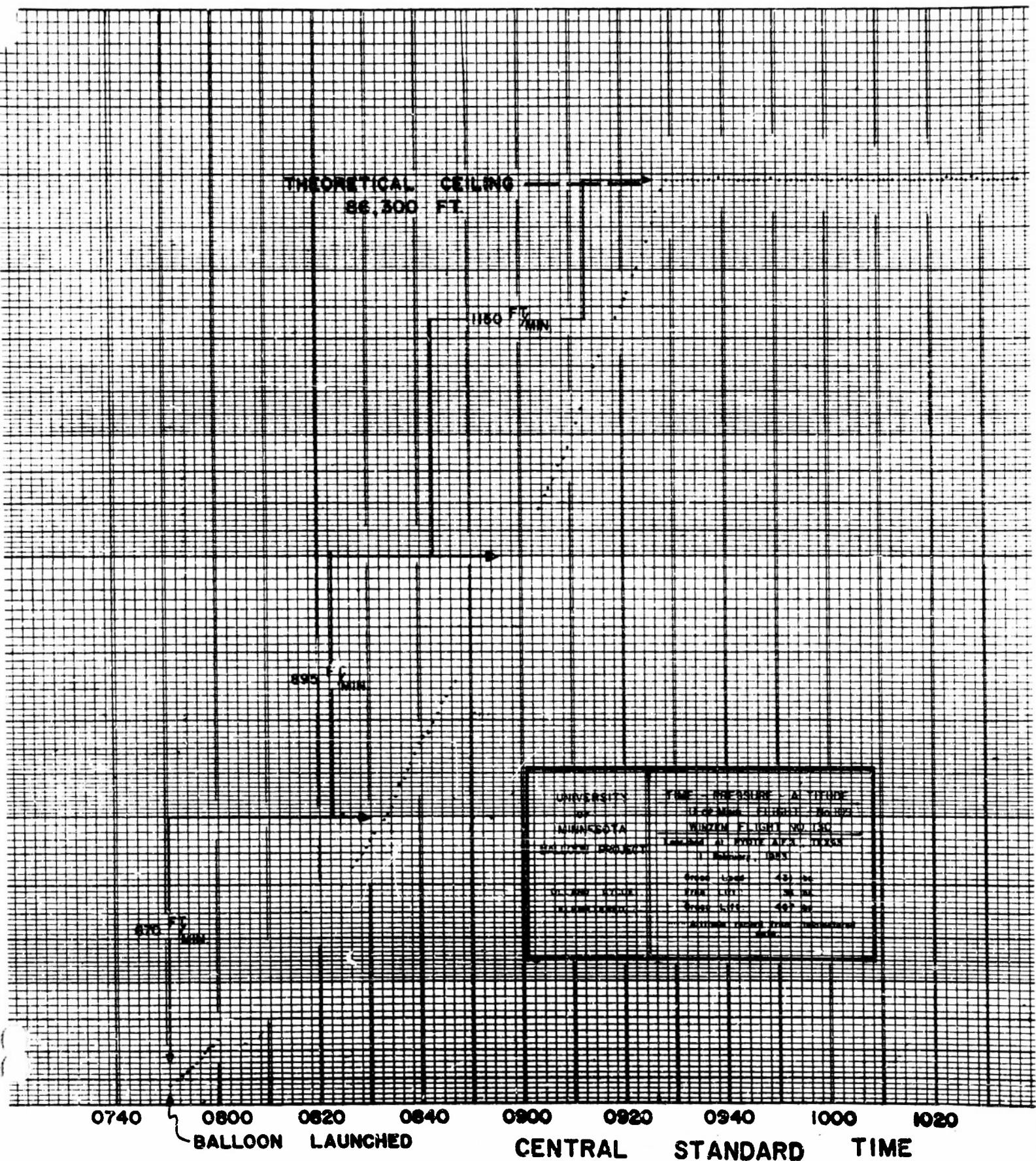


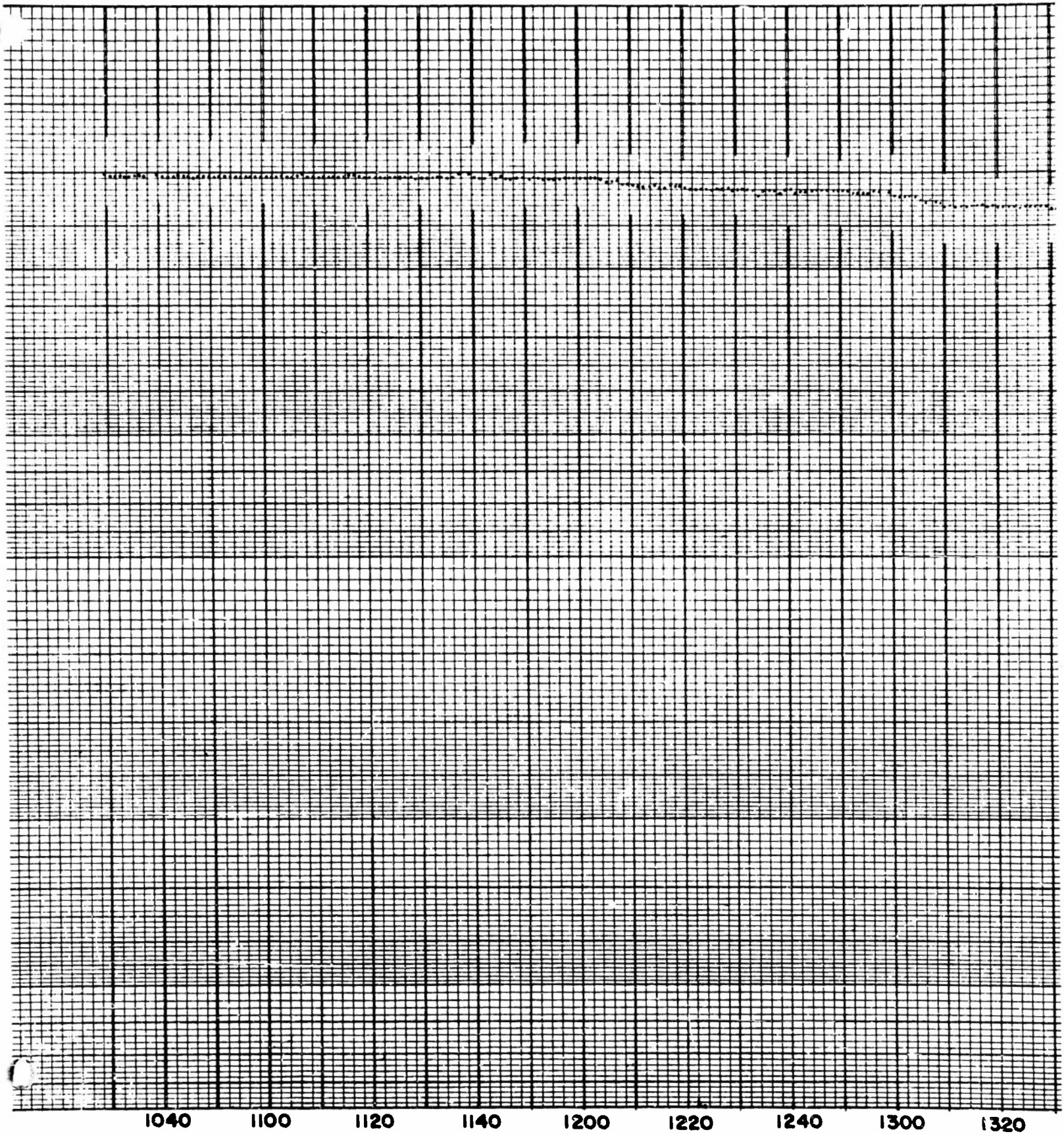


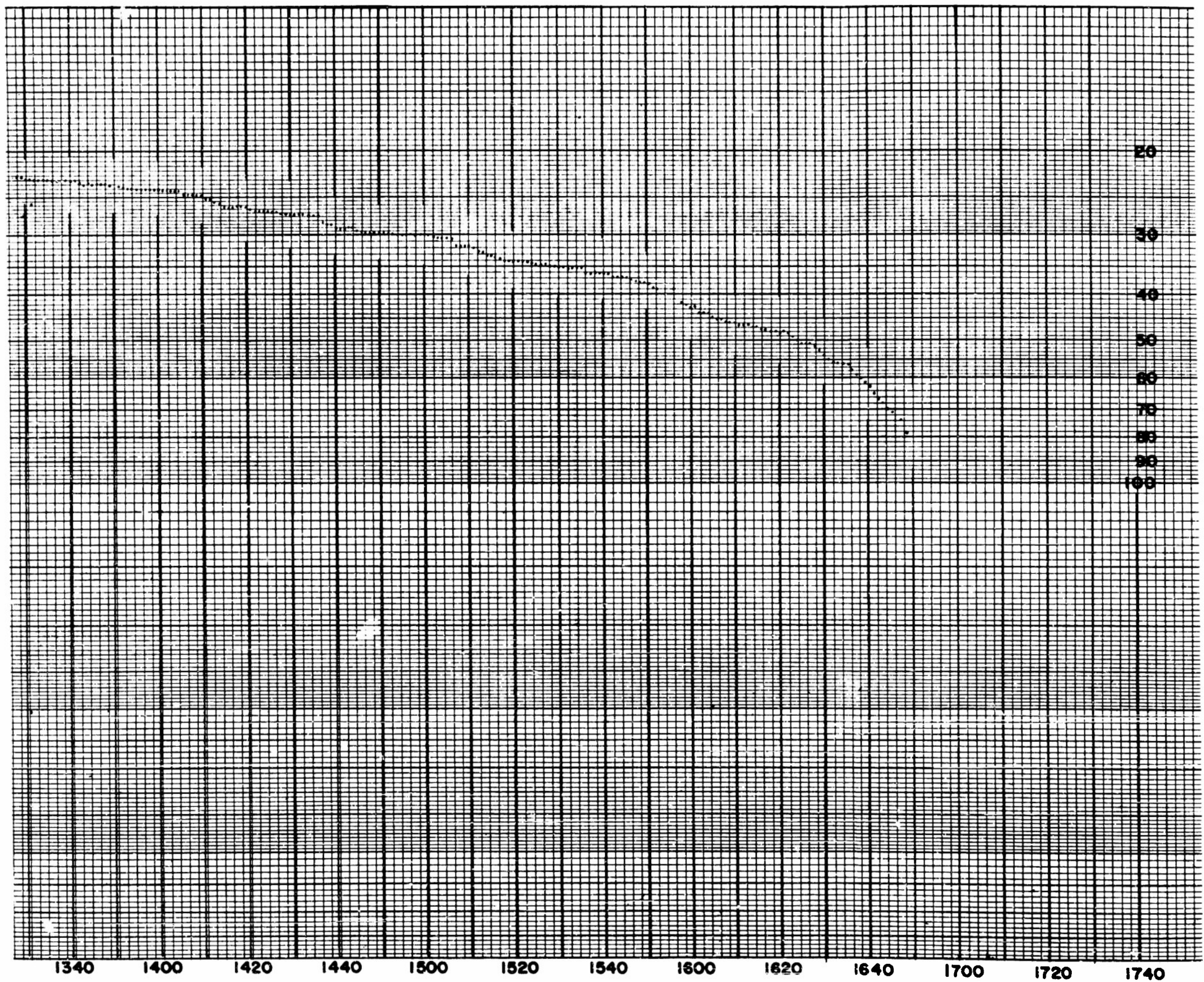


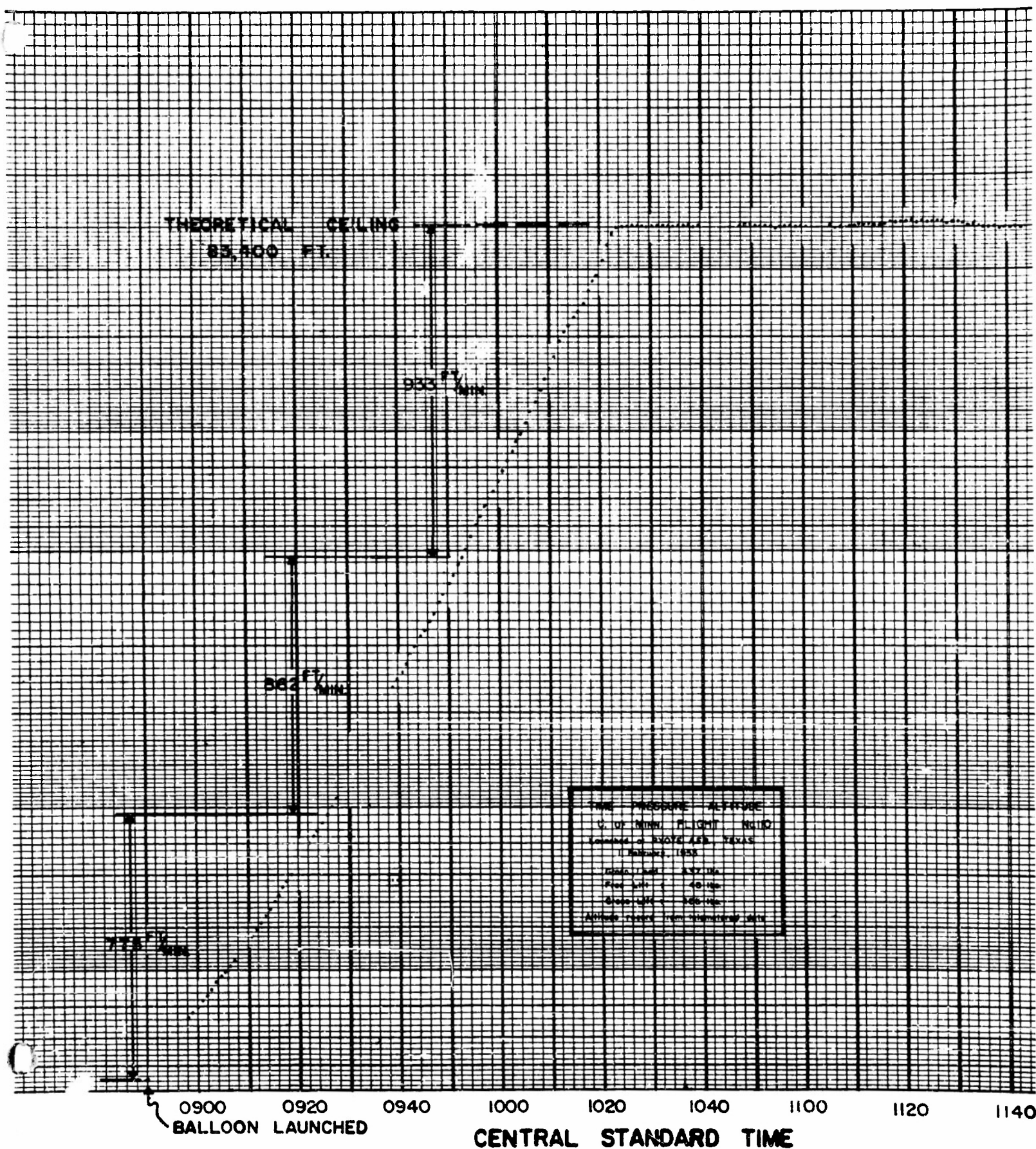


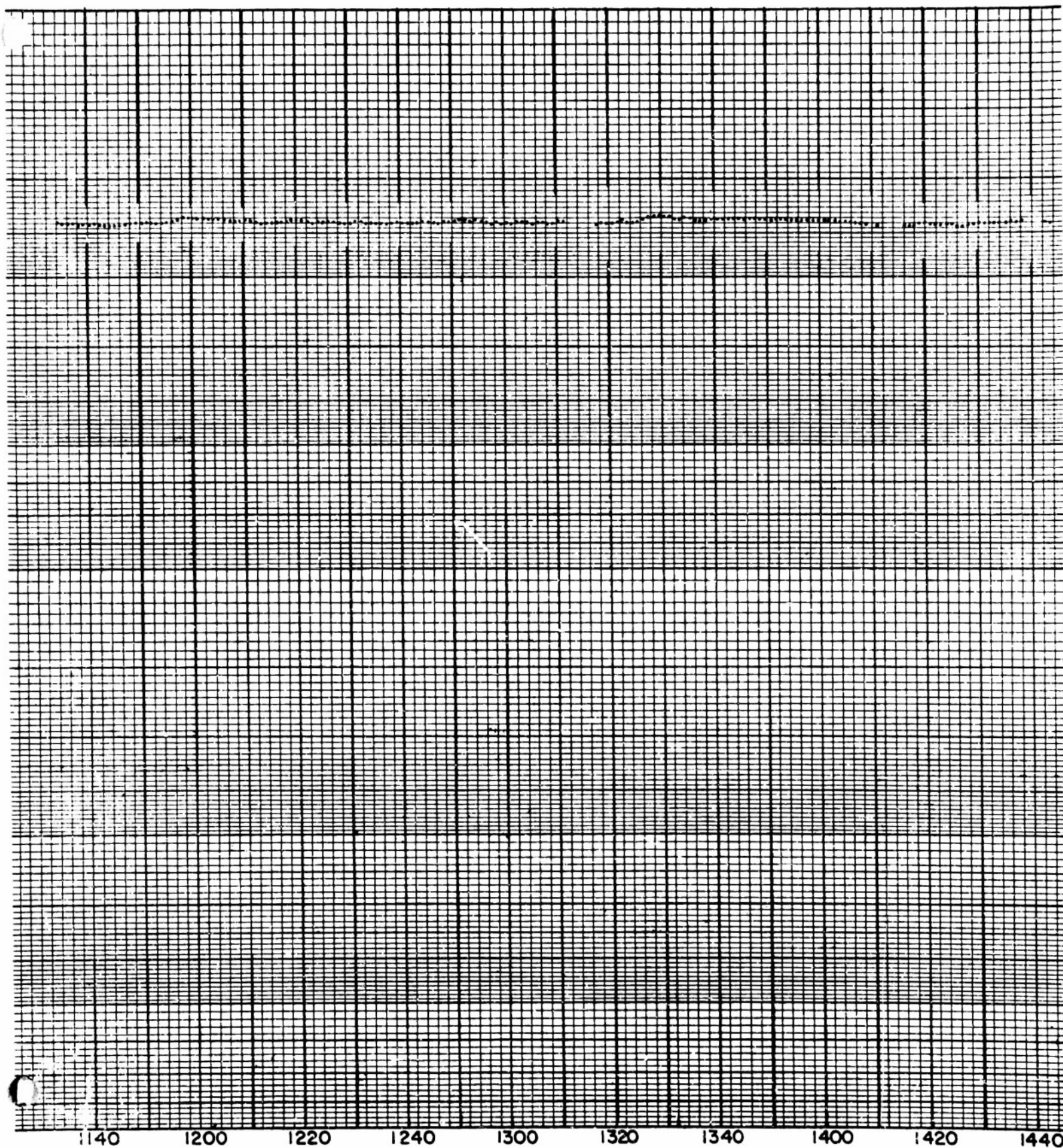


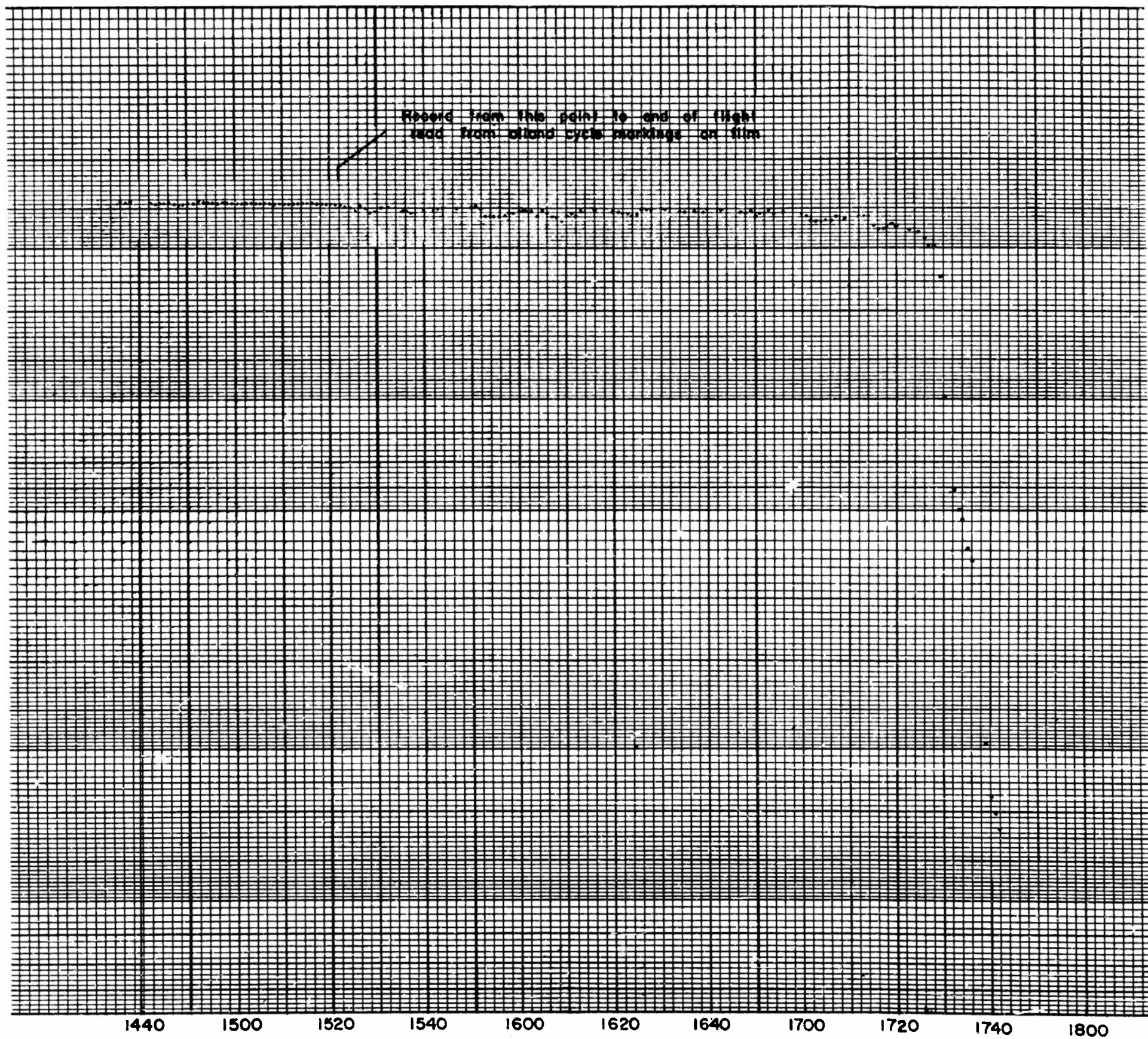


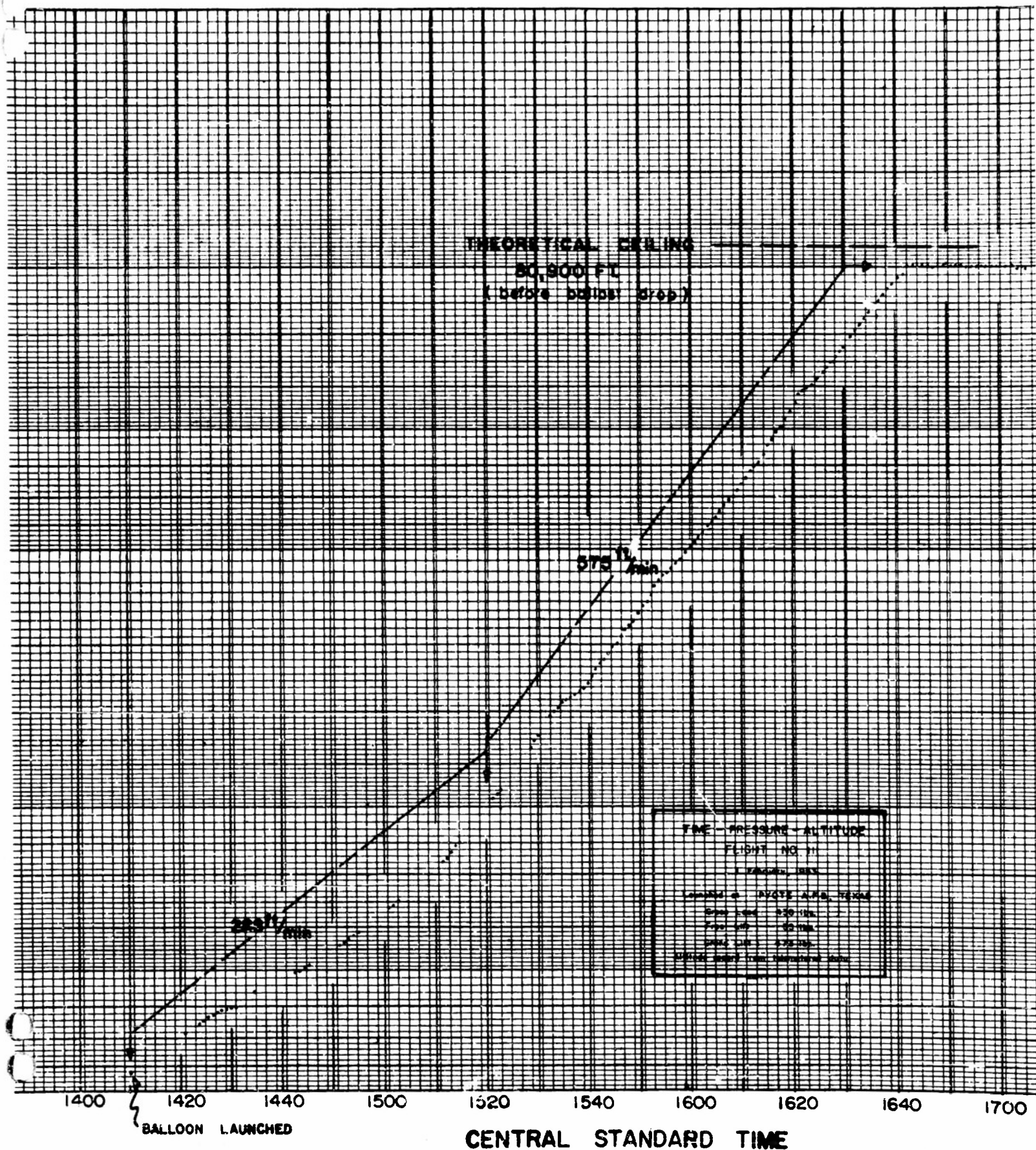




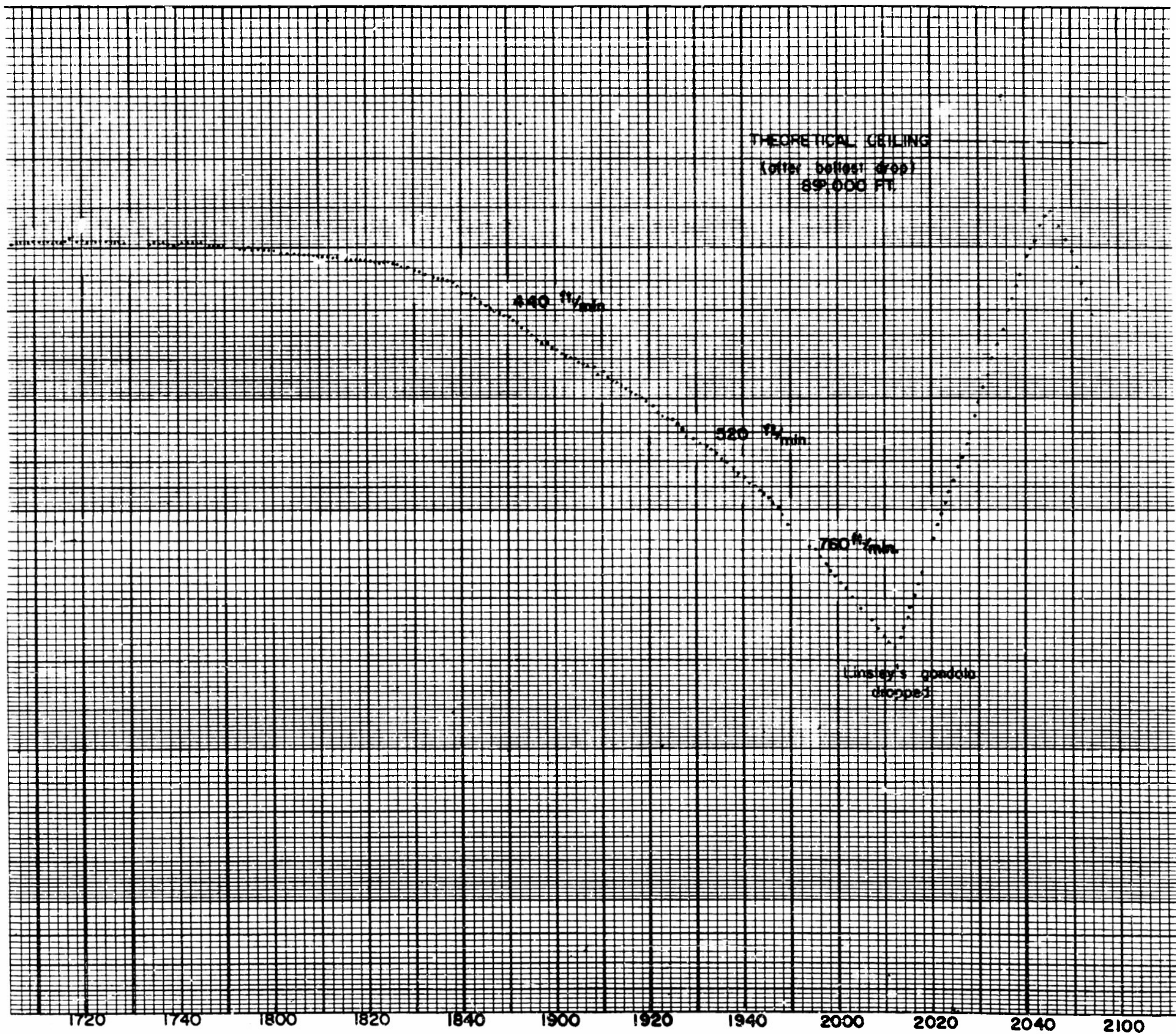


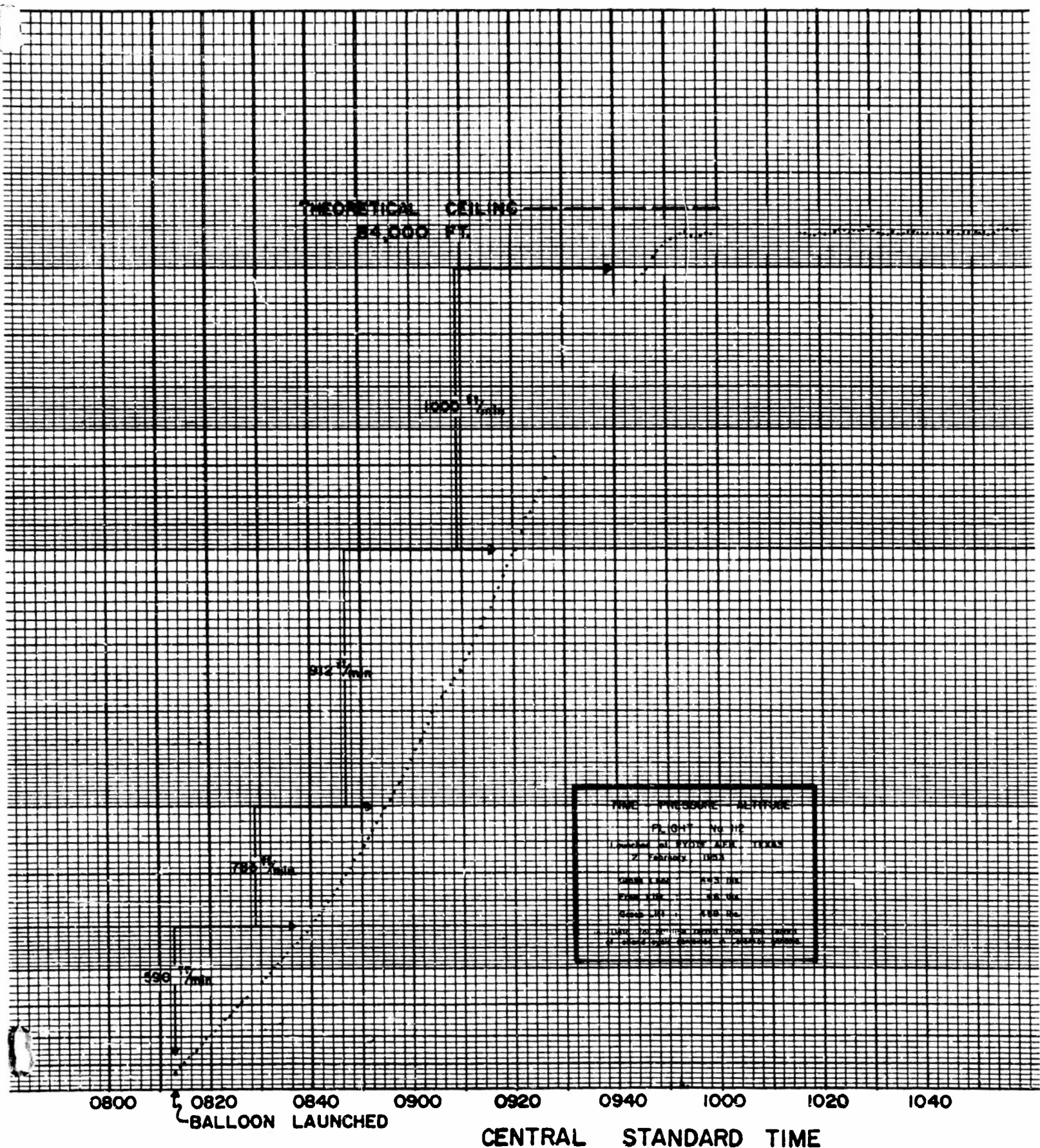


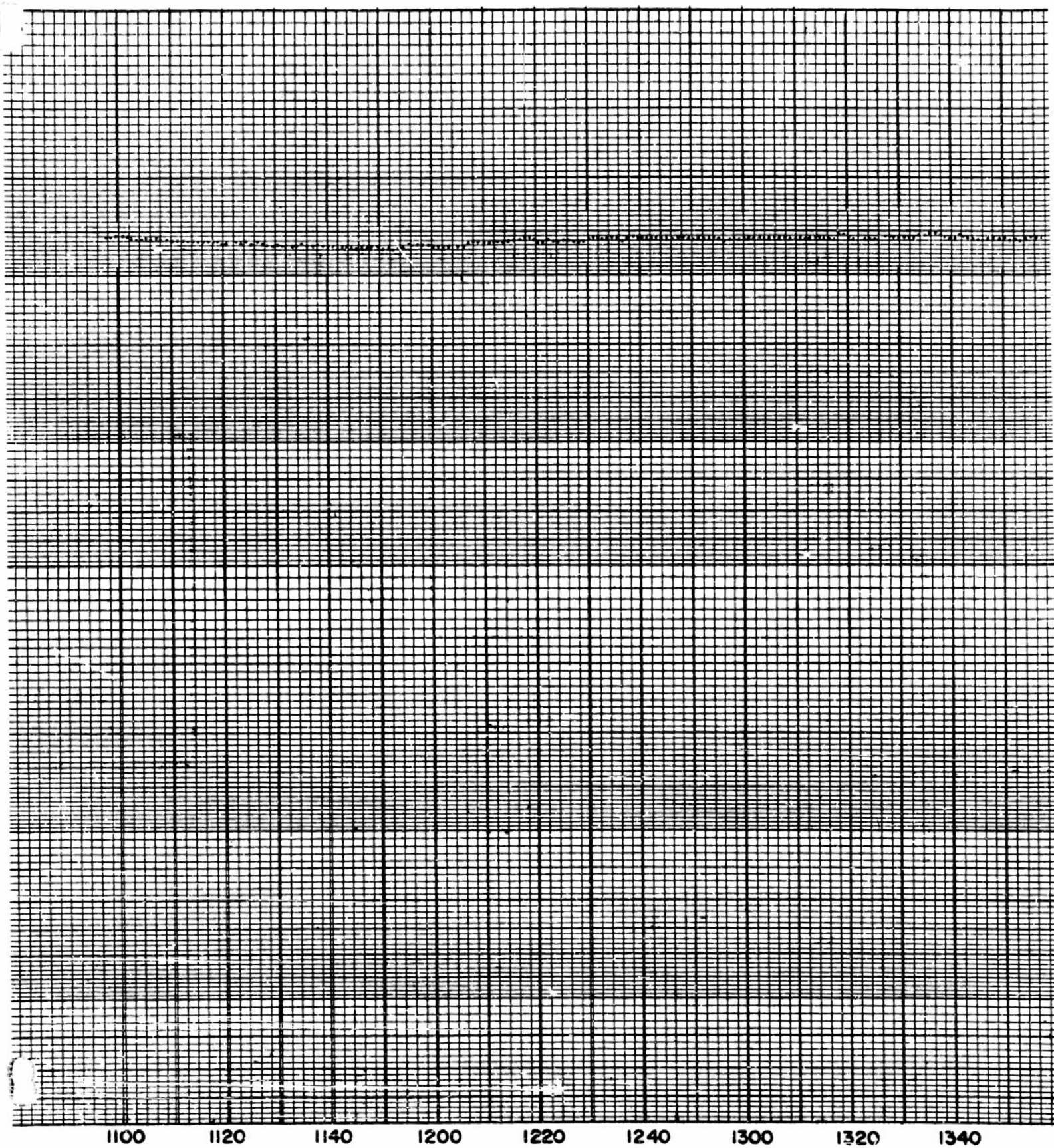


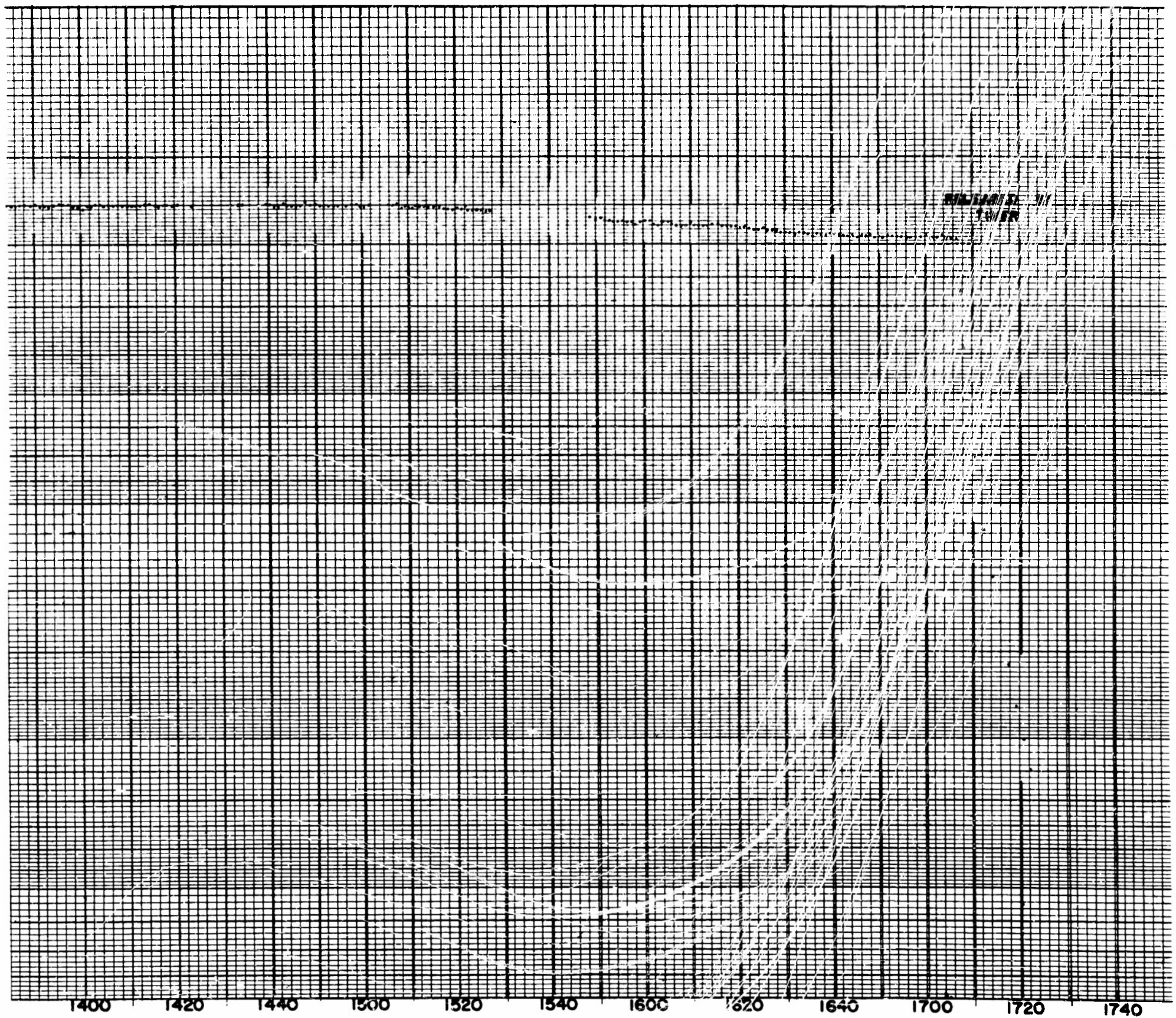


Confidential Security Information

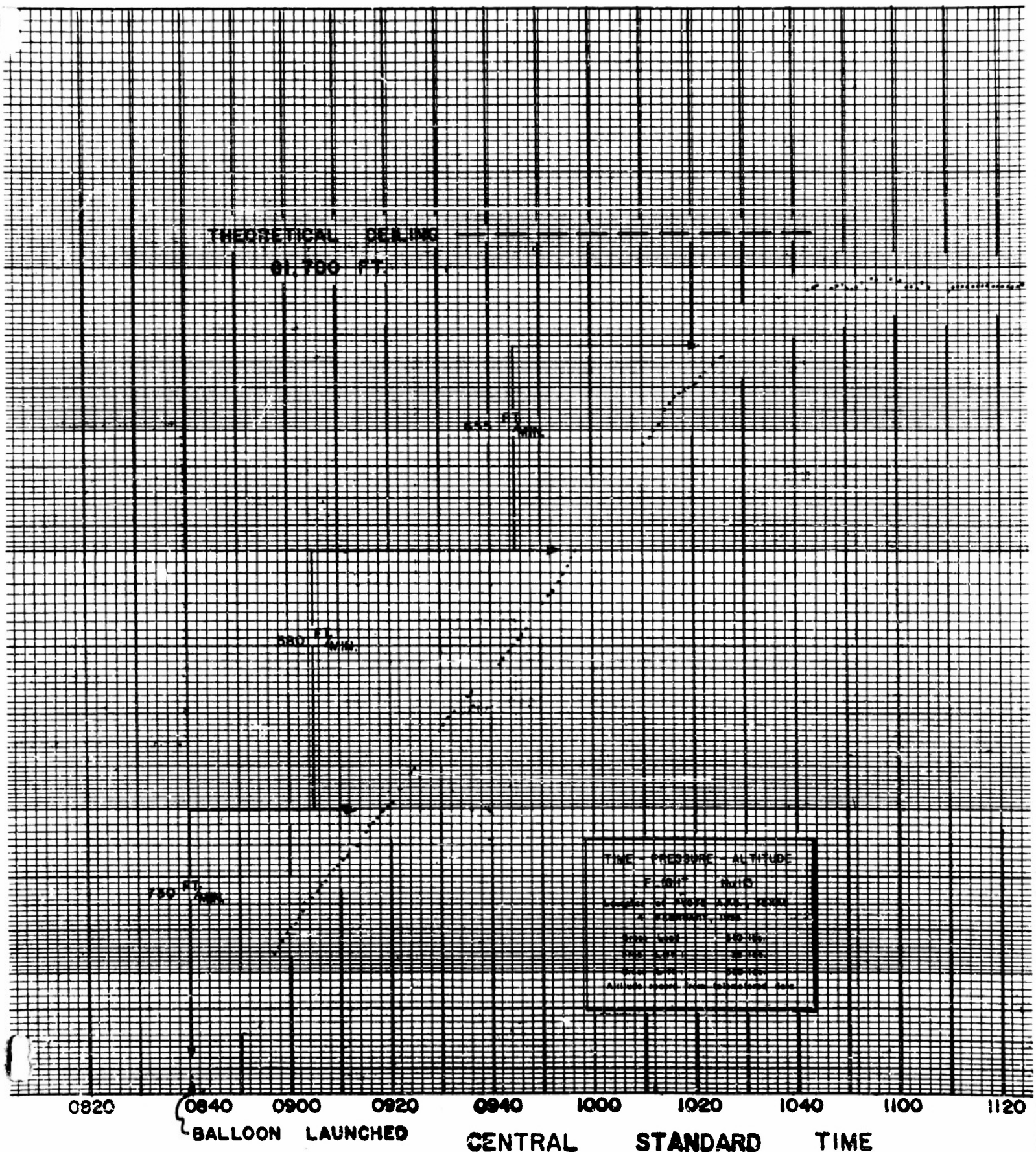


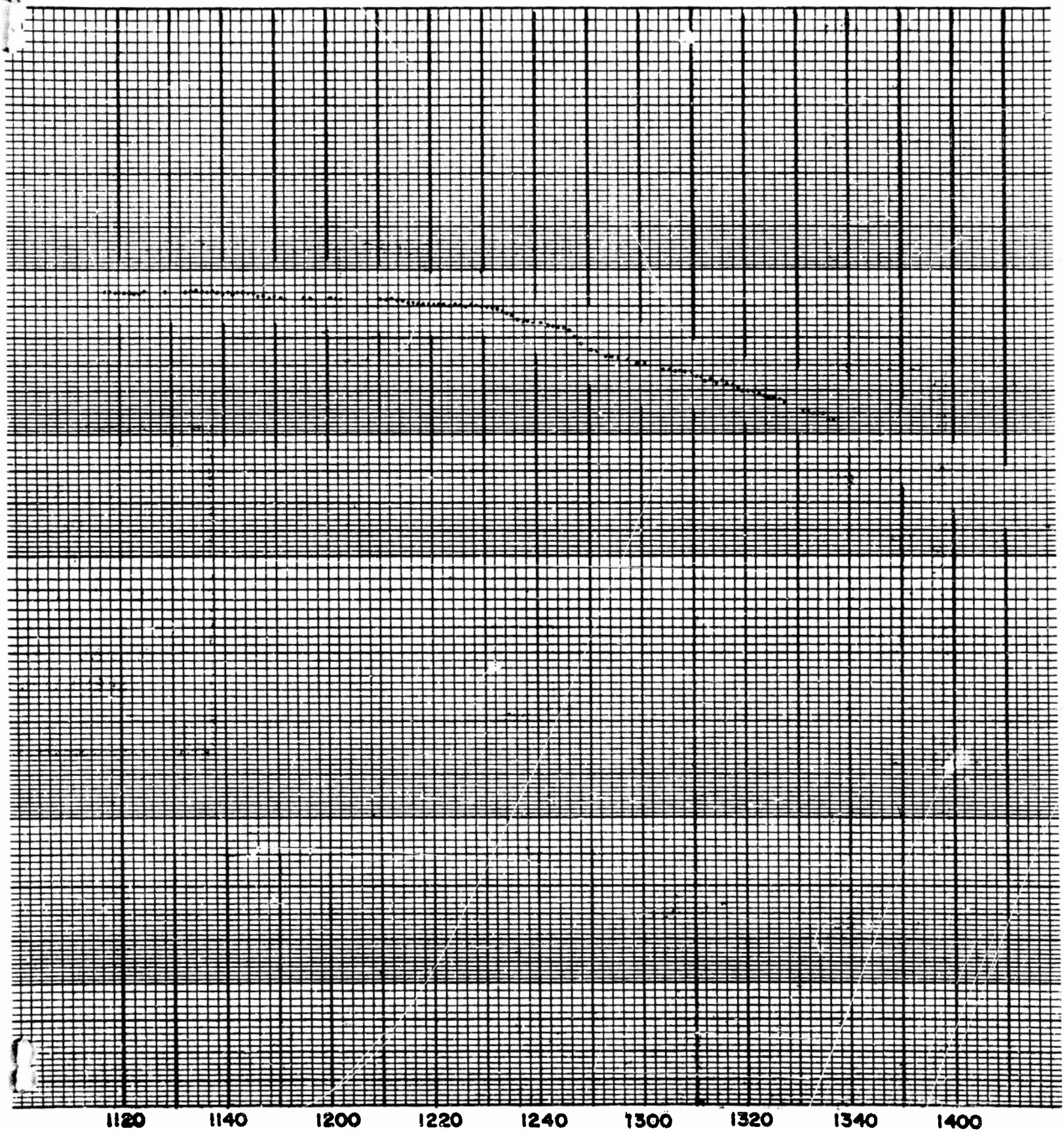


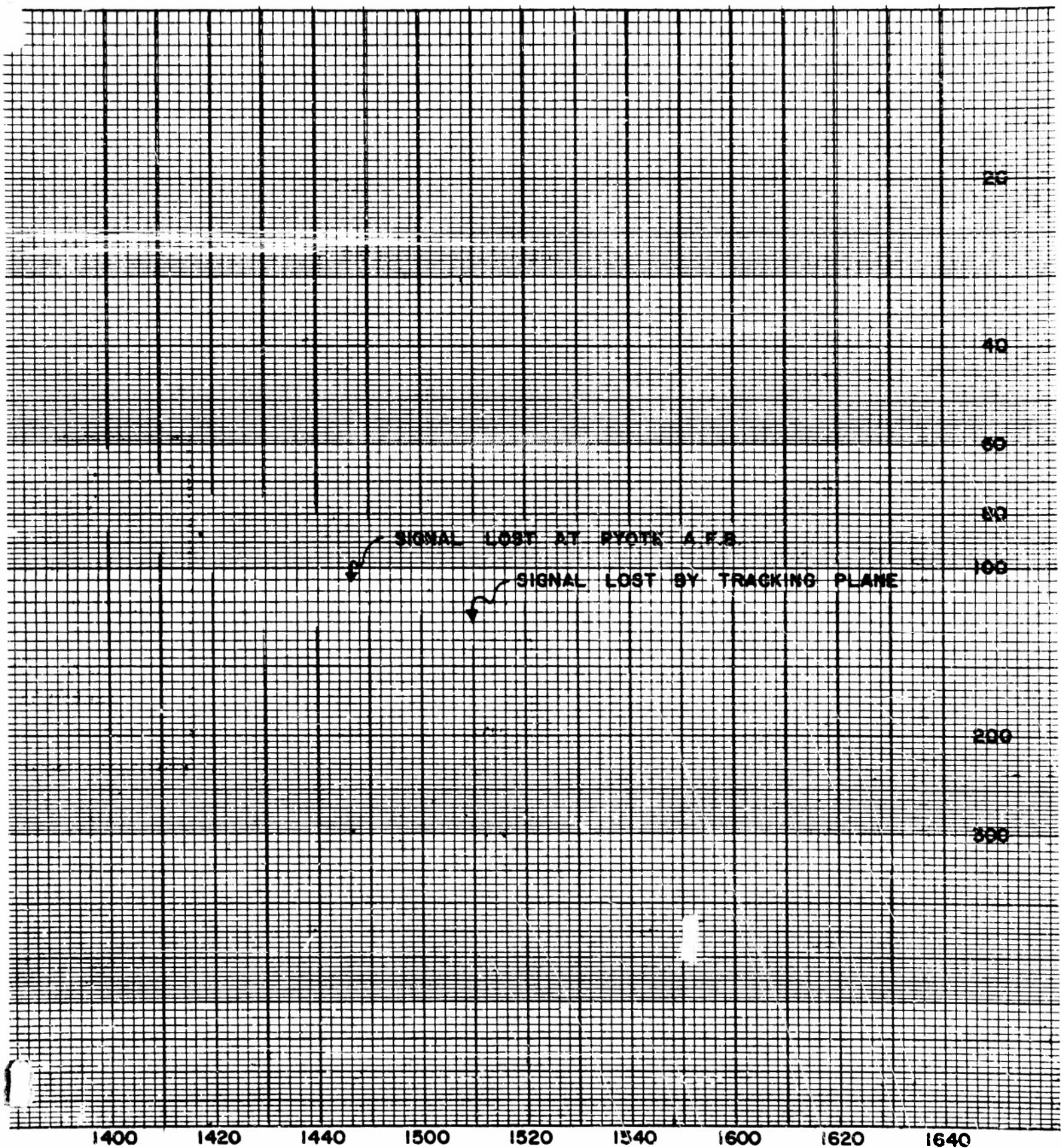




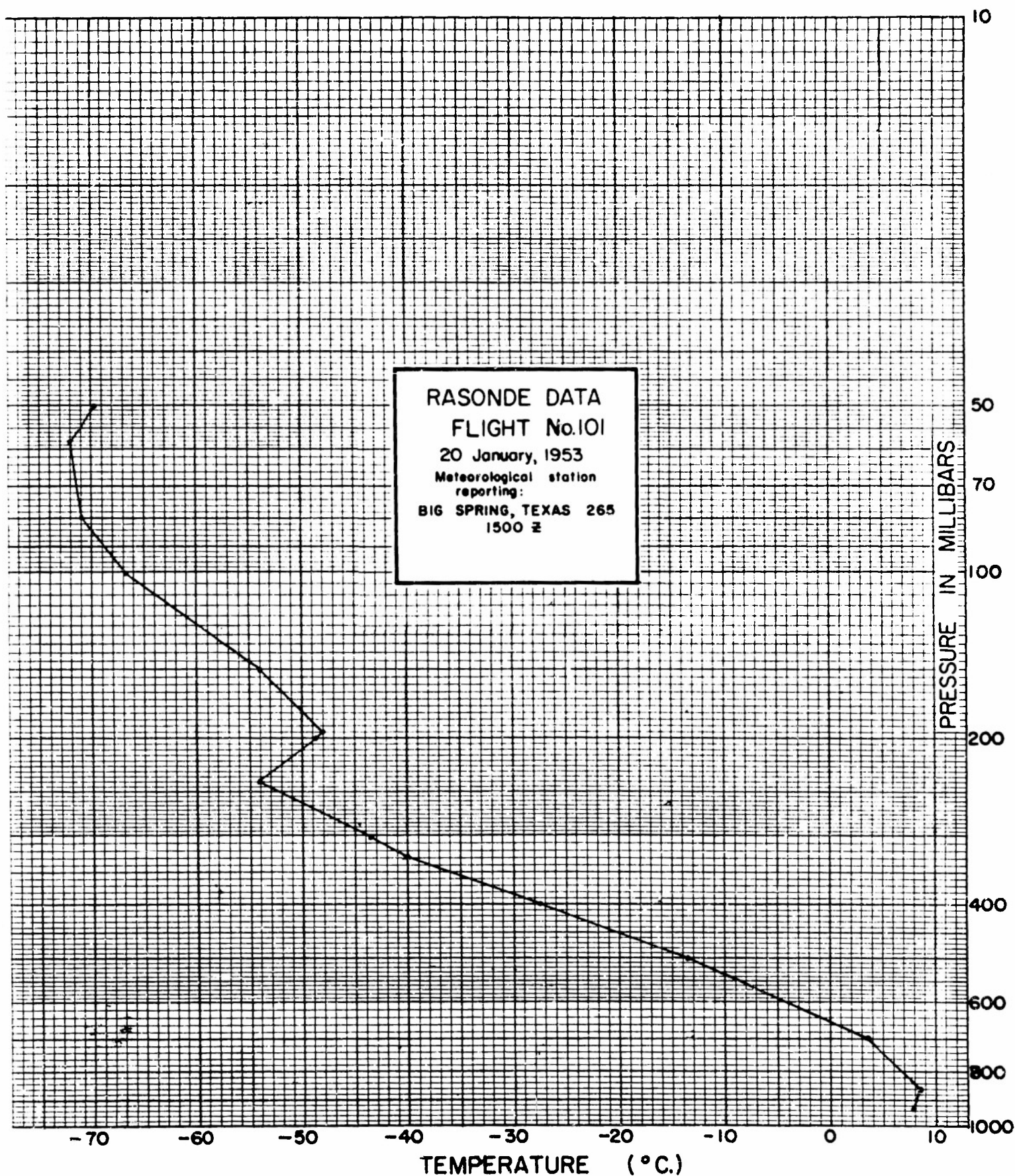
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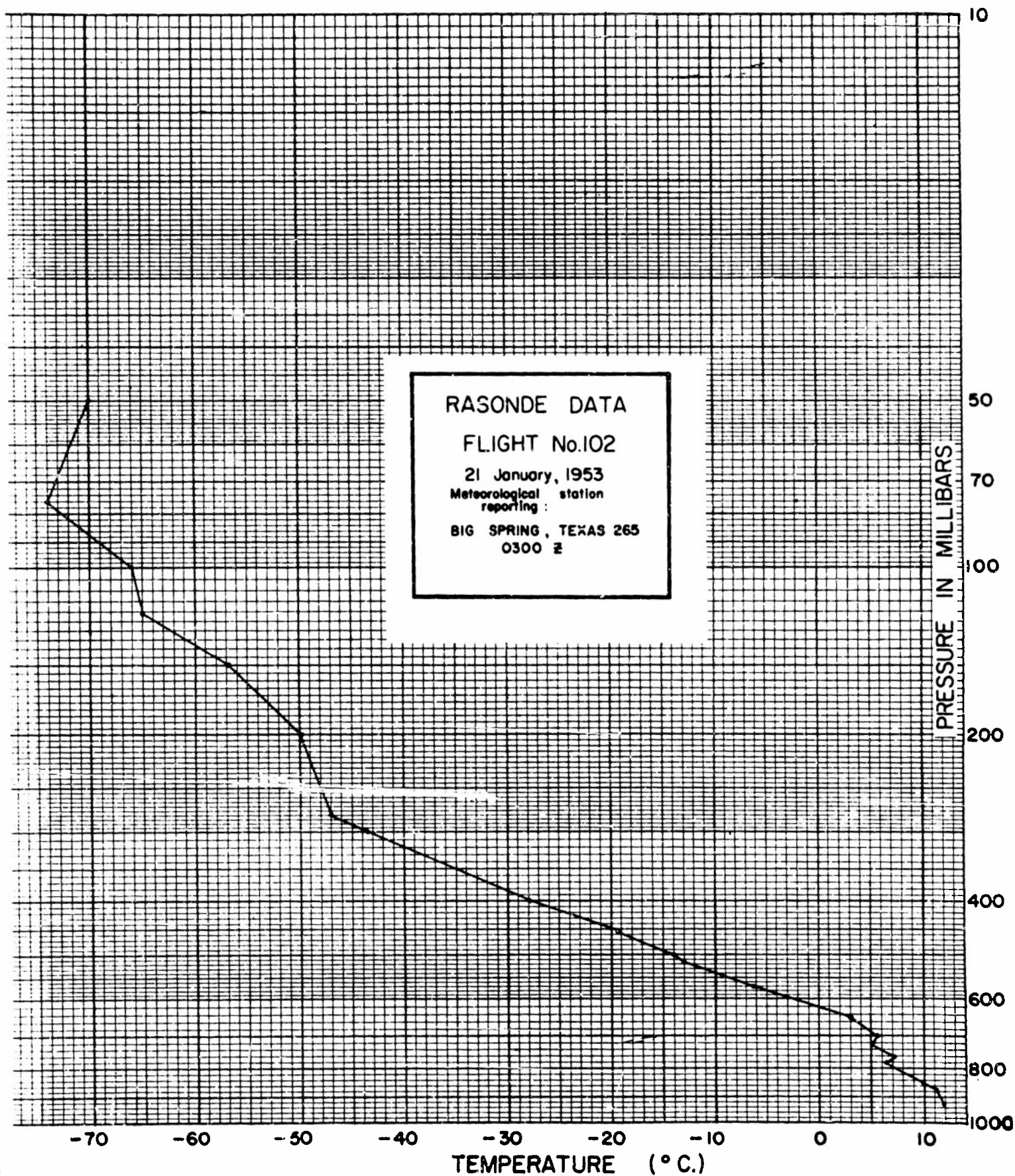
CONFIDENTIAL



RASONDE DATA
FLIGHT No. 101
20 January, 1953
Meteorological station
reporting:
BIG SPRING, TEXAS 265
1500 Z

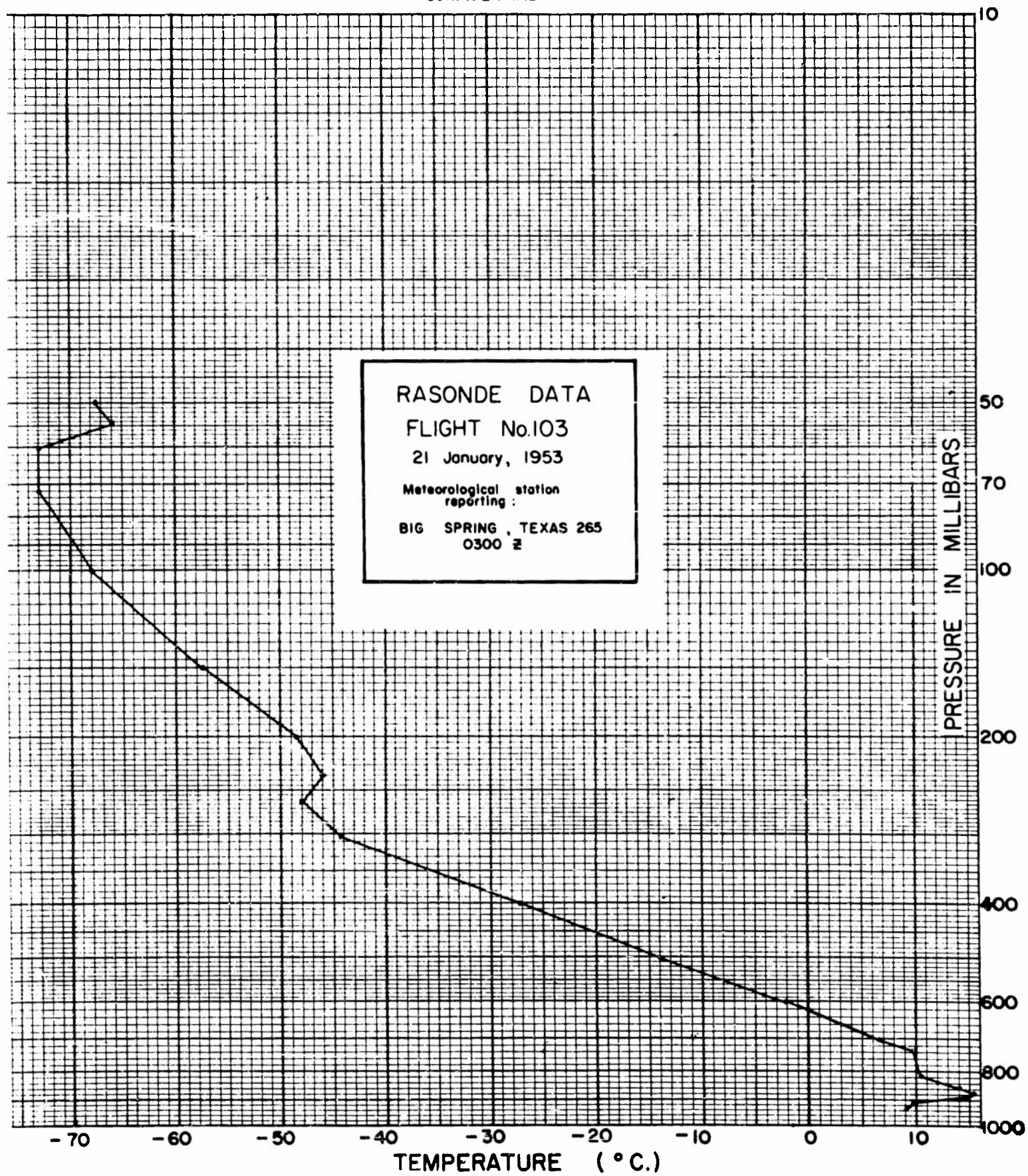
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CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



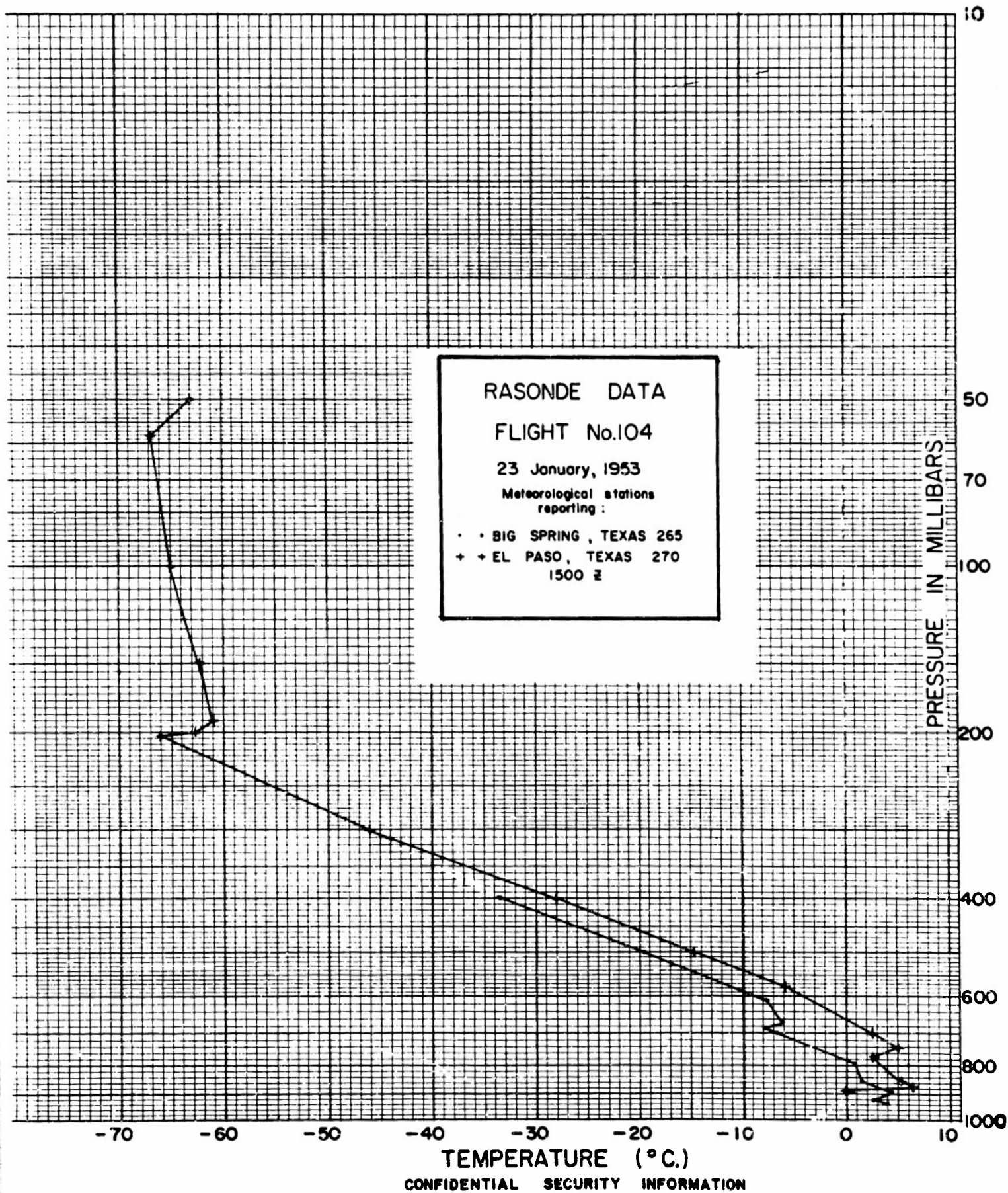
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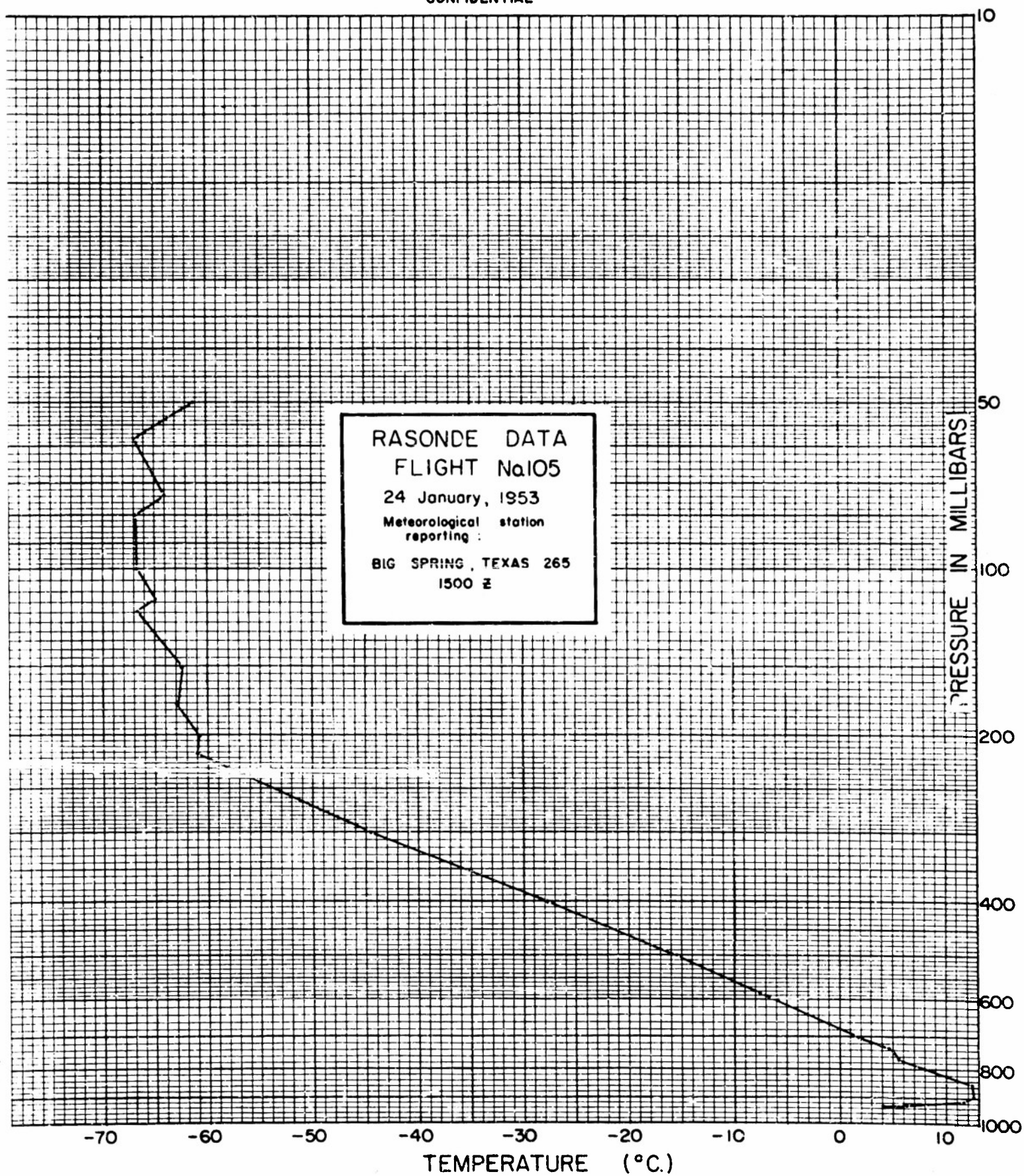


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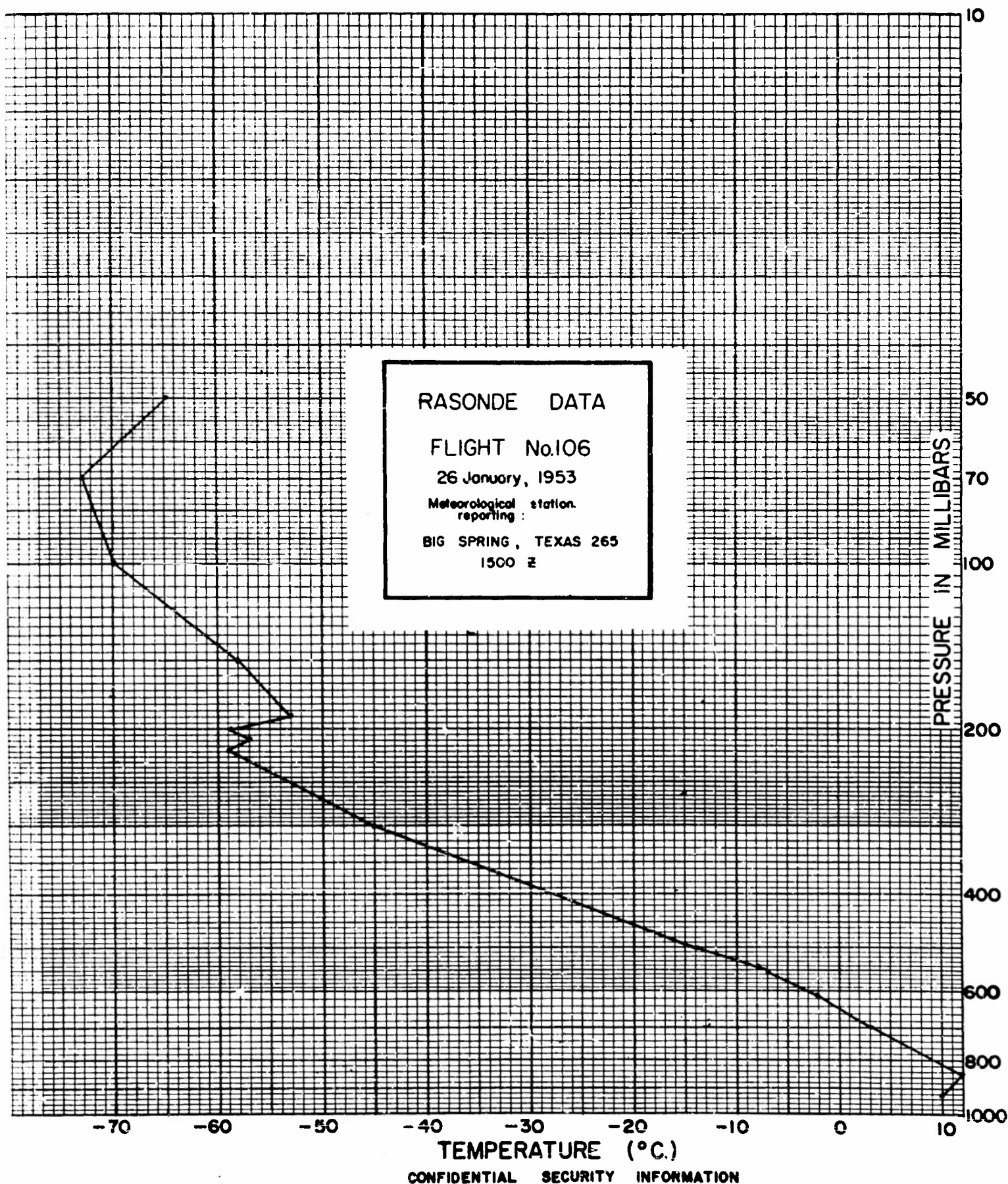


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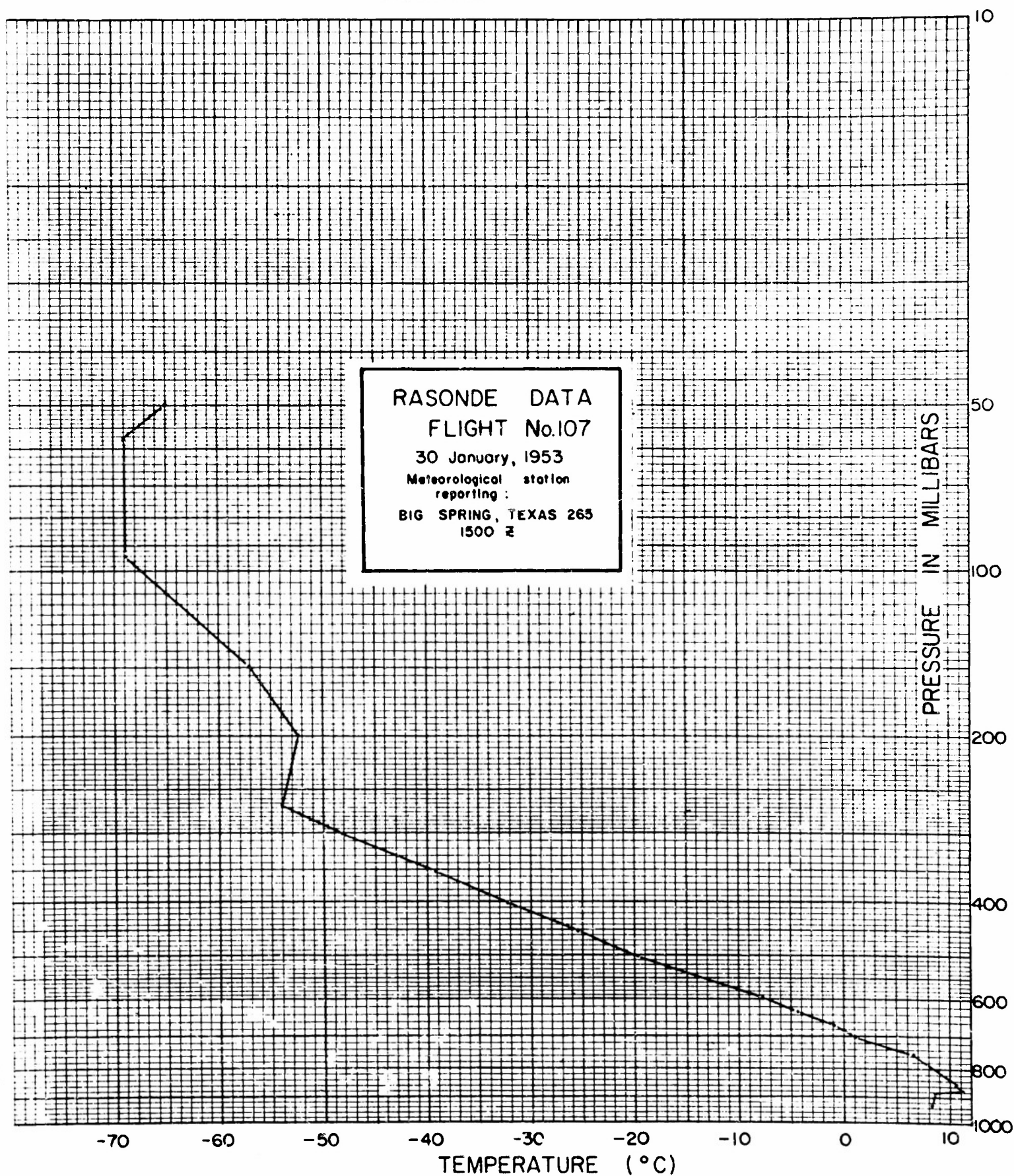
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CONFIDENTIAL SECURITY INFORMATION

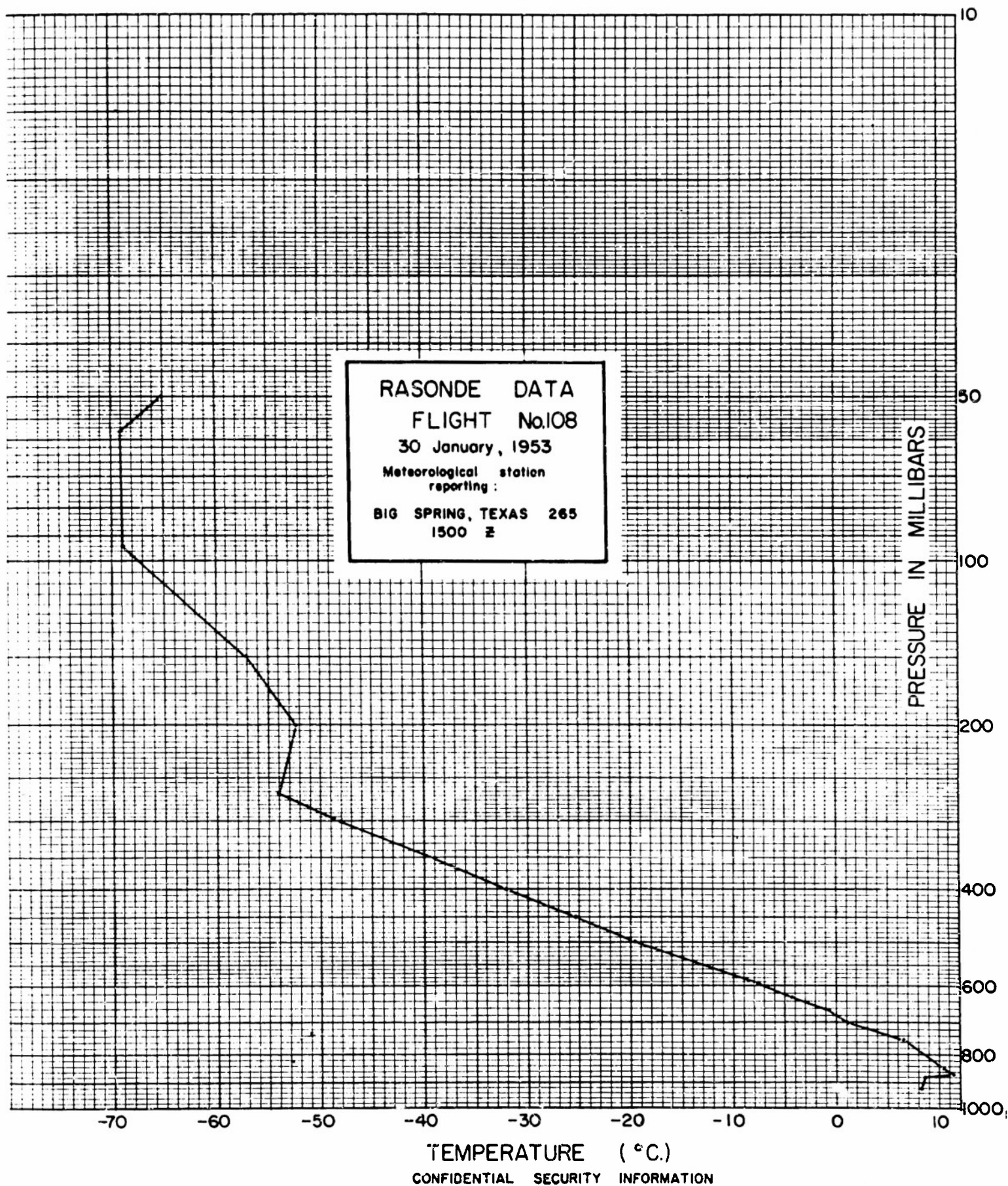
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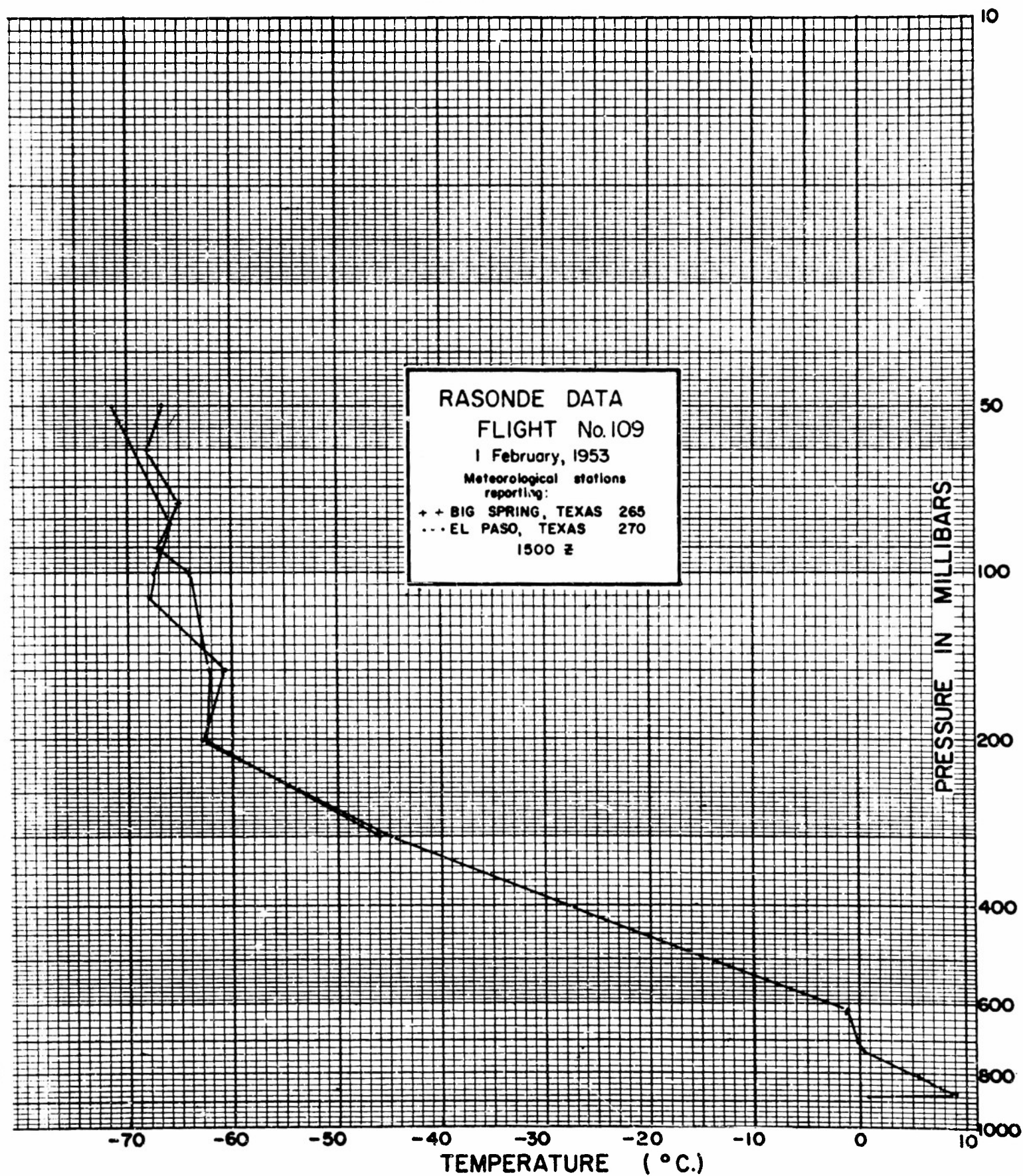
RASONDE DATA
FLIGHT No.107
30 January, 1953
Meteorological station
reporting :
BIG SPRING, TEXAS 265
1500 Z

CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL

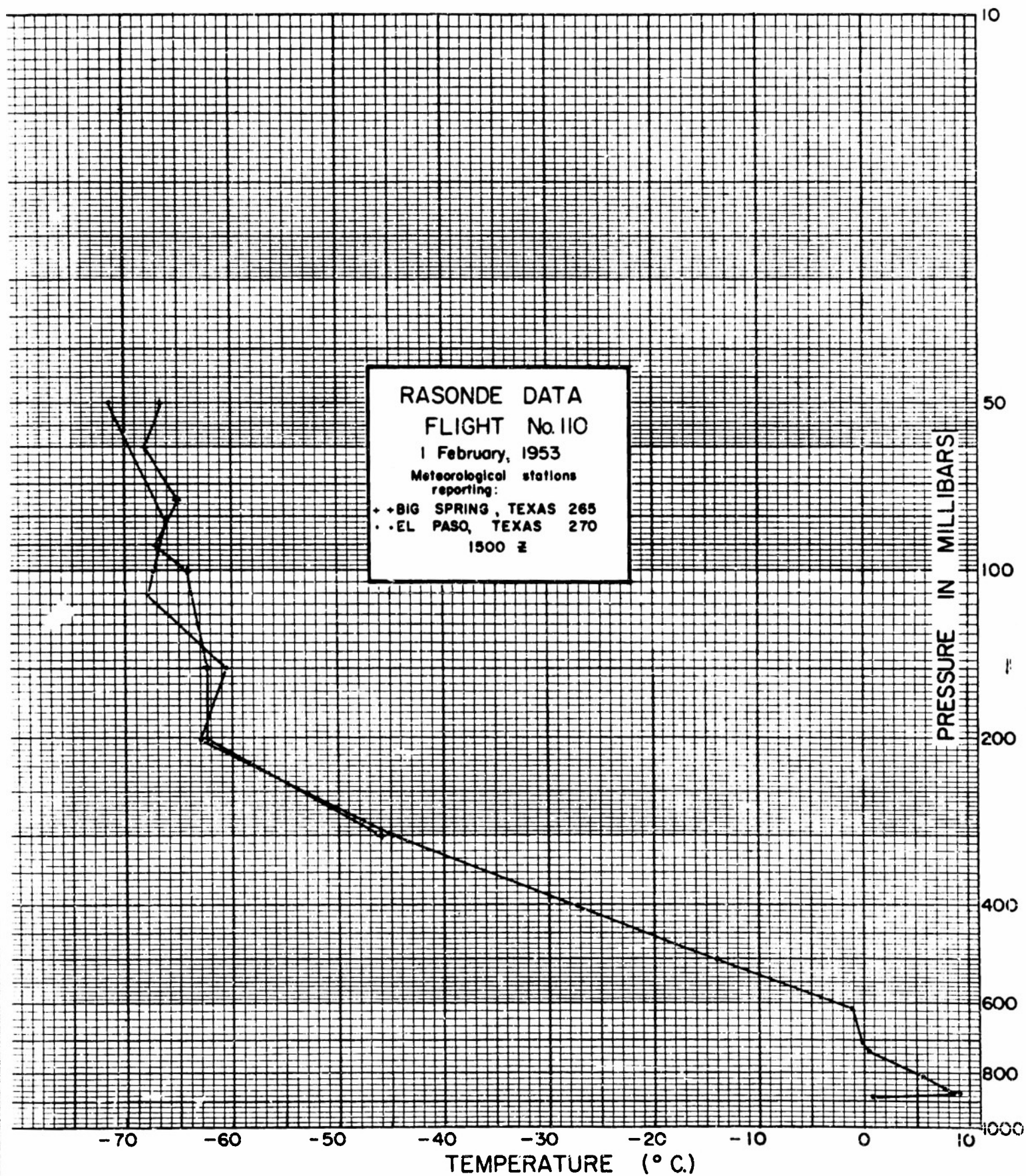


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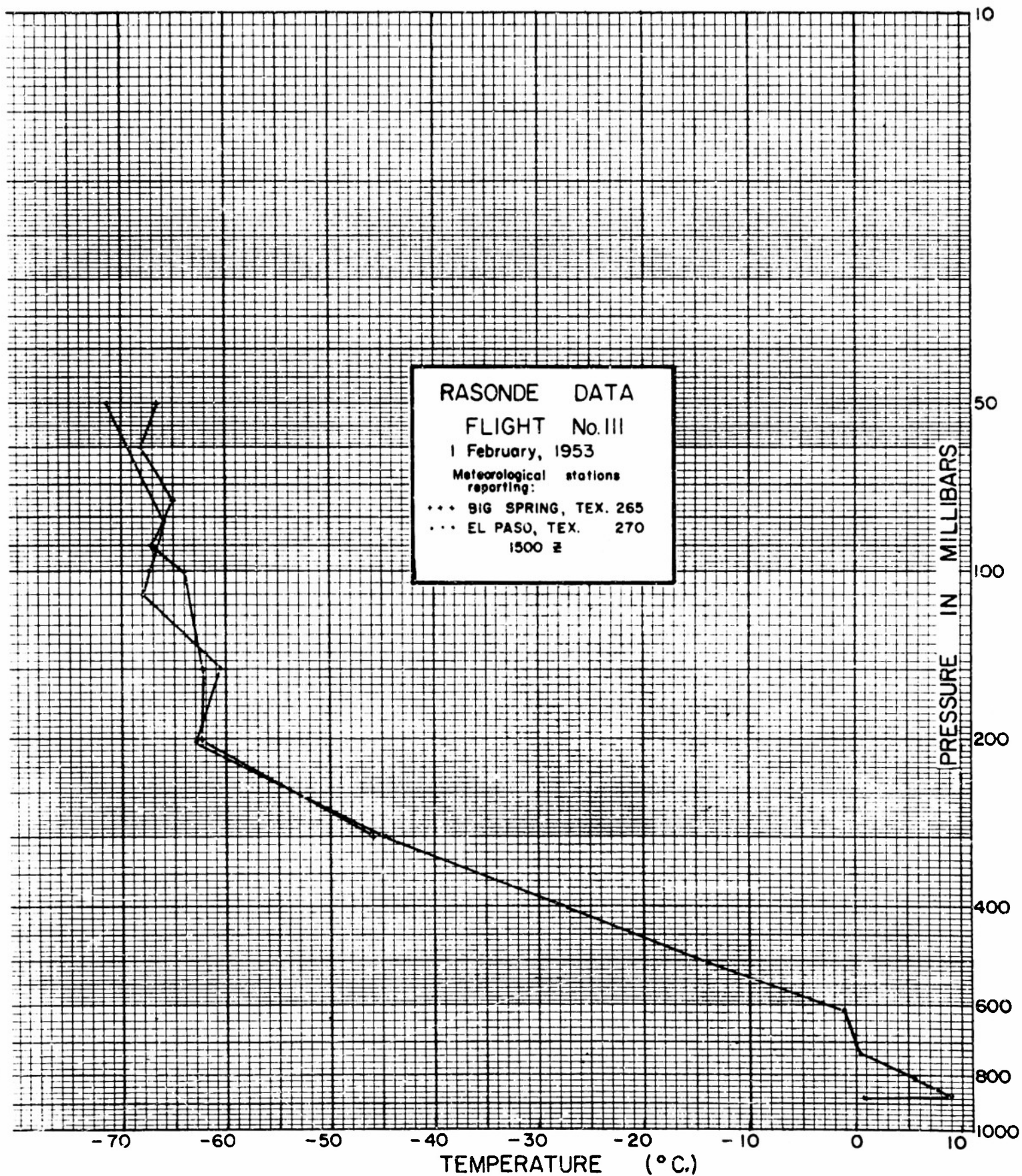
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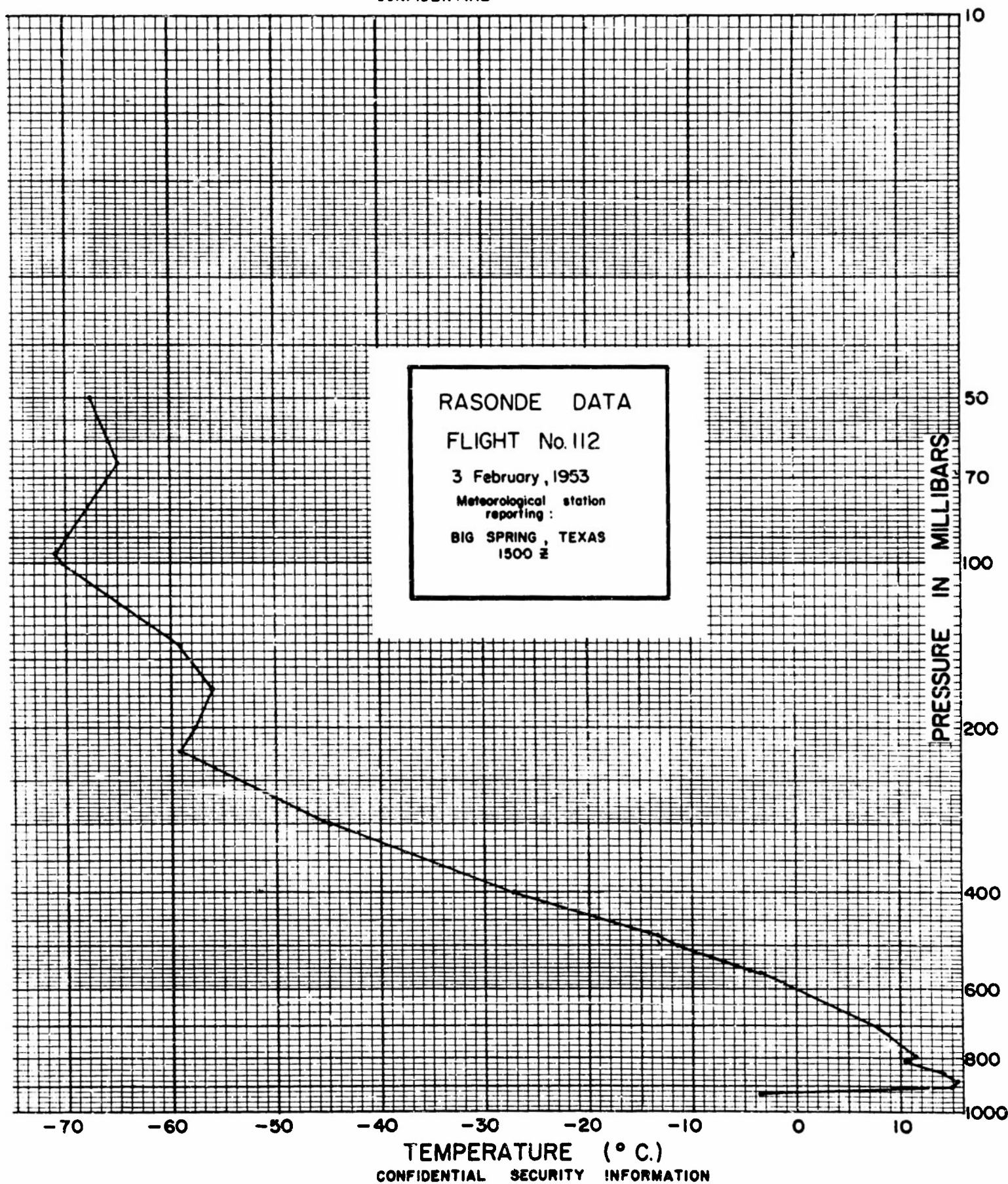
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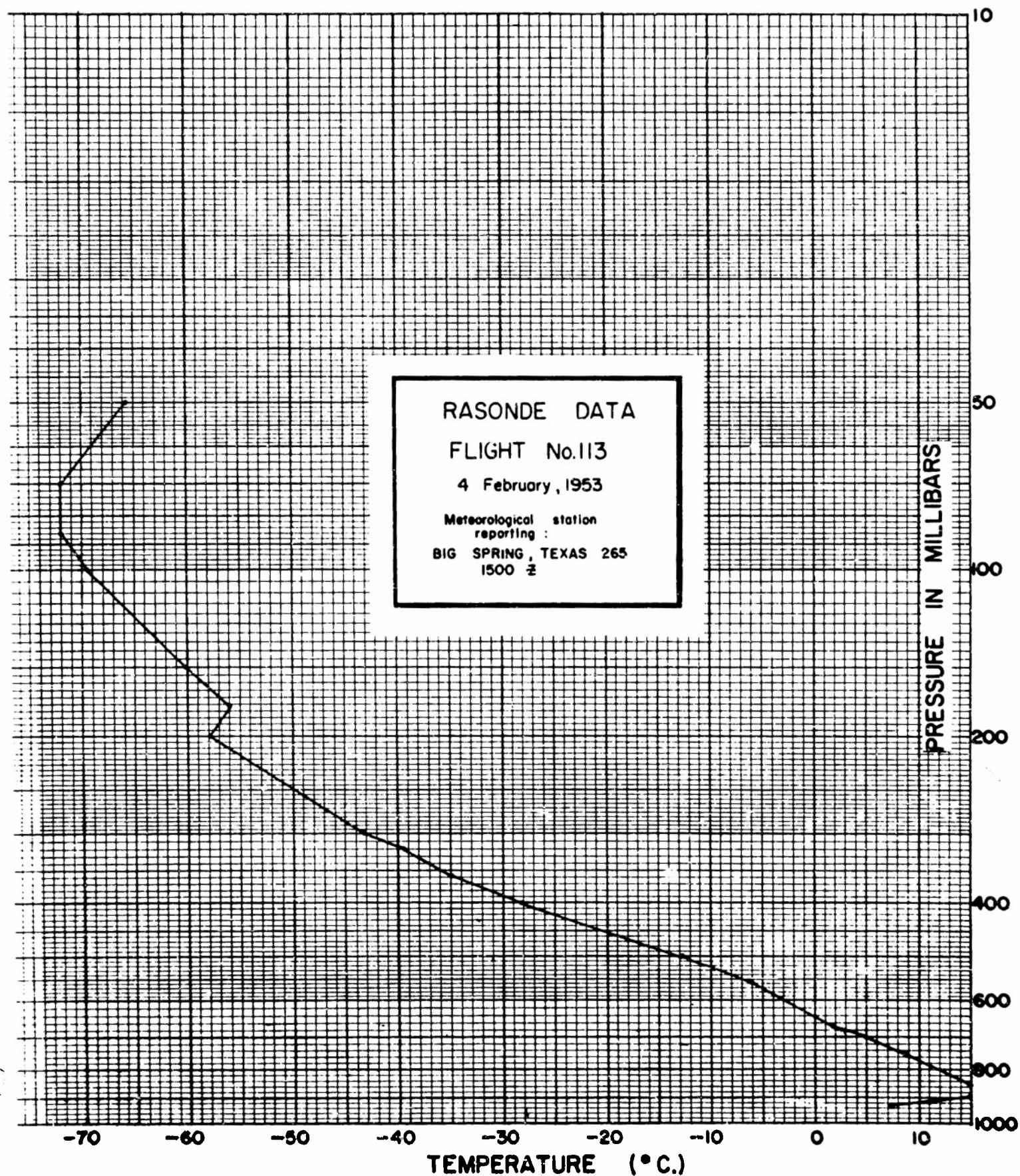


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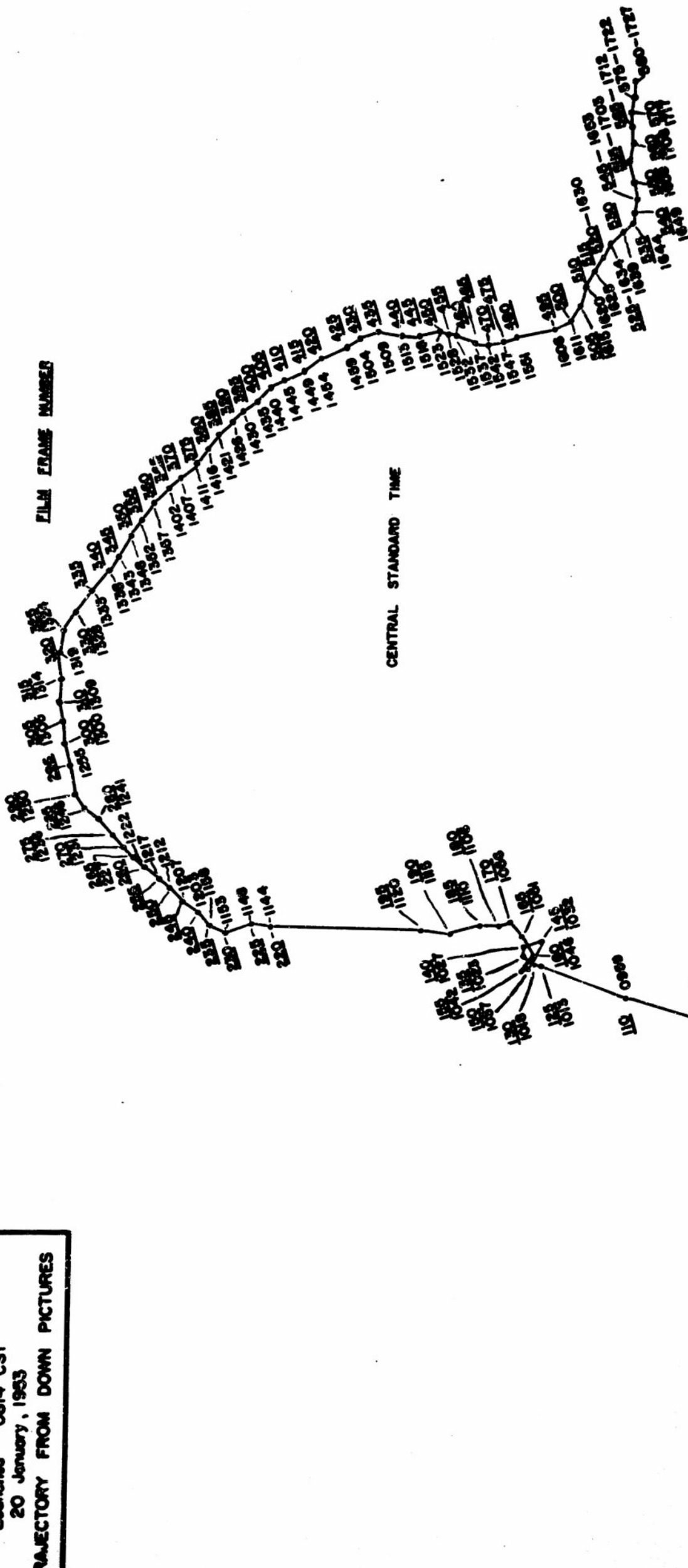


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CONFIDENTIAL SECURITY INFORMATION

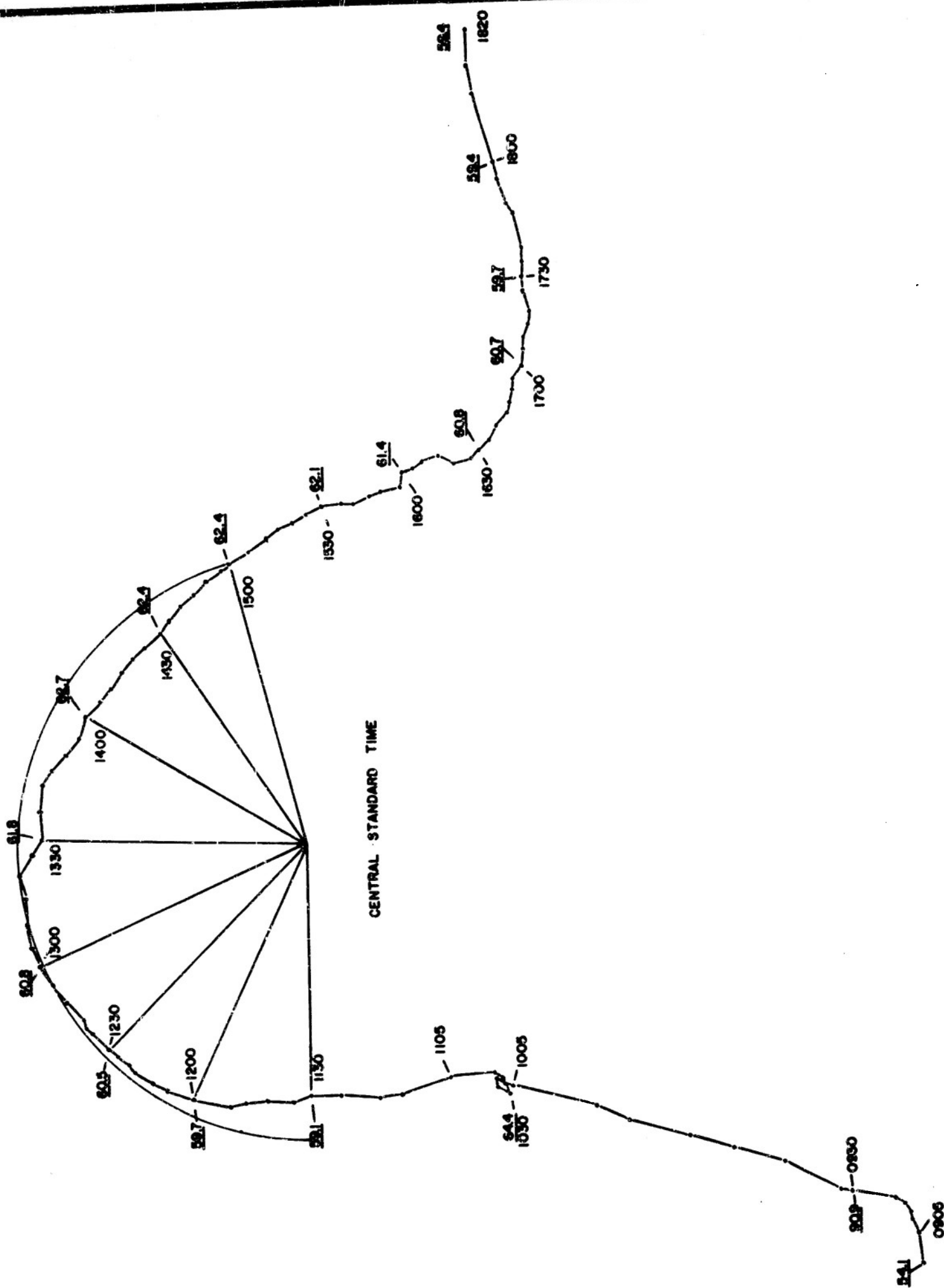
FLIGHT No. 101
 Launched 0814 CST
 20 January, 1953
 TRAJECTORY FROM DOWN PICTURES



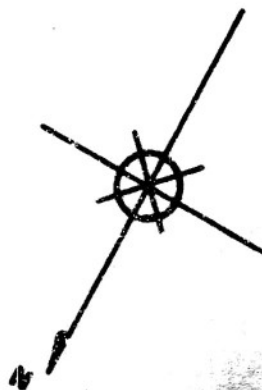
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CONFIDENTIAL

FLIGHT No.101
Launched 08:14 CST
20 January, 1963
TRAJECTORY FROM THEODOLITE FIXES



**Launched at
PYOTG, Texas**



STATUTE		MILES	
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SCALE : 1 : 5 = 10³

CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL

FLIGHT No. 103

Launched 0832 C.S.T.

21 January, 1953

TRAJECTORY FROM DOWN PICTURES



FILM FRAME NUMBER

CENTRAL STANDARD TIME

Launched at:

PLYMOUTH, TEXAS



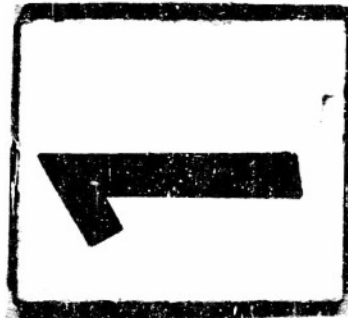
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10985 10990 10995 11000 11005 11010 11015 11020 11025 11030 11035 11040 11045 11050 11055 11060 11065 11070 11075 11080 11085 11090 11095 11100 11105 11110 11115 11120 11125 11130 11135 11140 11145 11150 11155 11160 11165 11170 11175 11180 11185 11190 11195 11200 11205 11210 11215 11220 11225 11230 11235 11240 11245 11250 11255 11260 11265 11270 11275 11280 11285 11290 11295 11300 11305 11310 11315 11320 11325 11330 11335 11340 11345 11350 11355 11360 11365 11370 11375 11380 11385 11390 11395 11400 11405 11410 11415 11420 11425 11430 11435 11440 11445 11450 11455 11460 11465 11470 11475 11480 11485 11490 11495 11500 11505 11510 11515 11520 11525 11530 11535 11540 11545 11550 11555 11560 11565 11570 11575 11580 11585 11590 11595 11600 11605 11610 11615 11620 11625 11630 11635 11640 11645 11650 11655 11660 11665 11670 11675 11680 11685 11690 11695 11700 11705 11710 11715 11720 11725 11730 11735 11740 11745 11750 11755 11760 11765 11770 11775 11780 11785 11790 11795 11800 11805 11810 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FLIGHT No. 103
Launched 0832 CST
21 January, 1953

TRAJECTORY FROM THEODOLITE FIXES

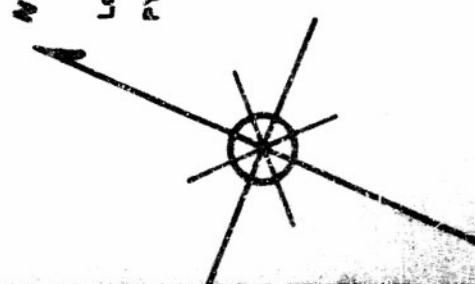


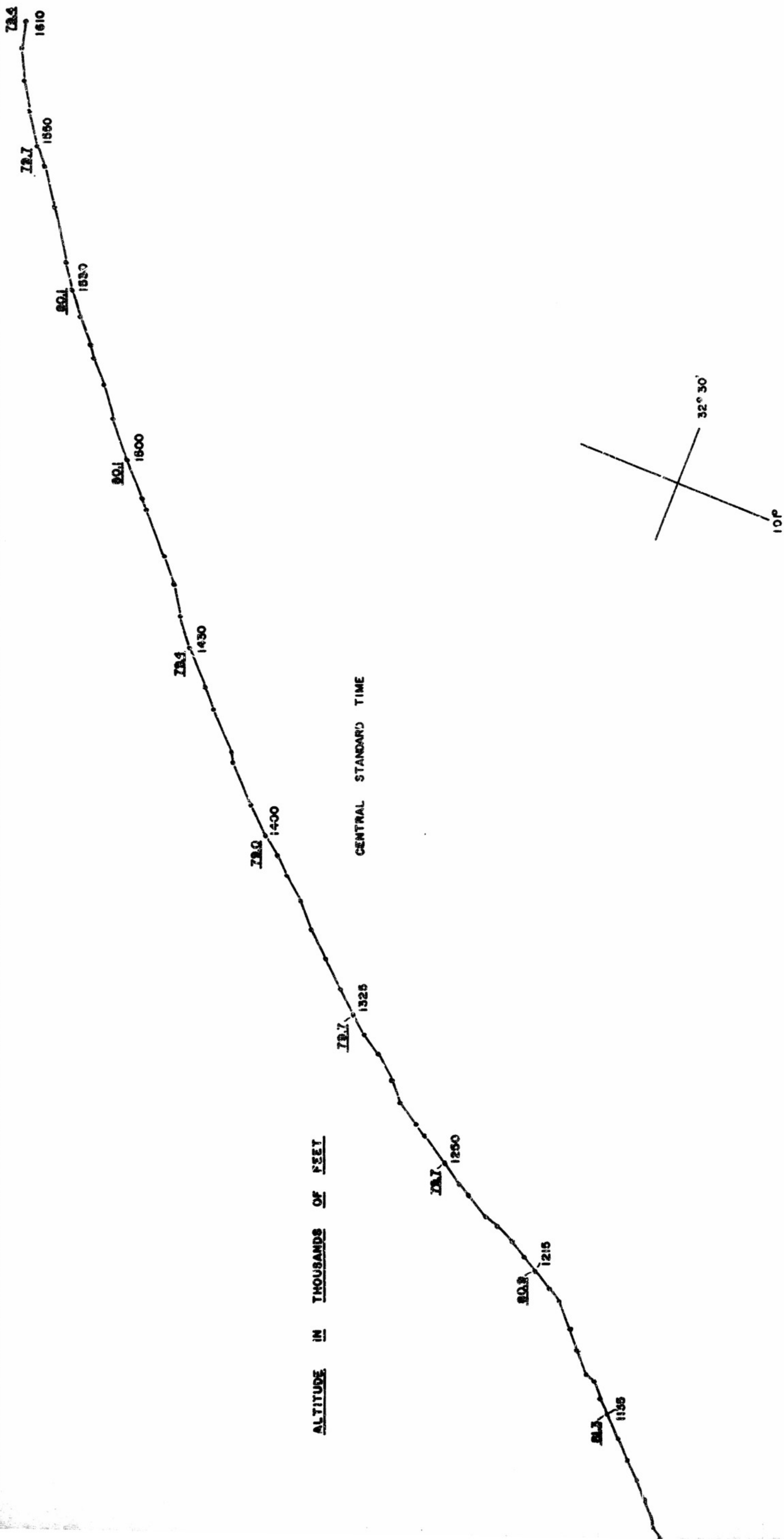
ALTITUDE IN THOUSANDS OF FEET

78.0 1400
78.7 1320
78.7 1250
80.9 1215
81.3 1155
81.3 1085
81.3 1025
82.9 0950
44.4 0825

CENTRAL

Launched at:
PYOTE, TEXAS

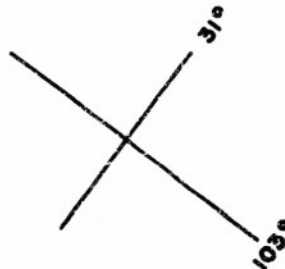
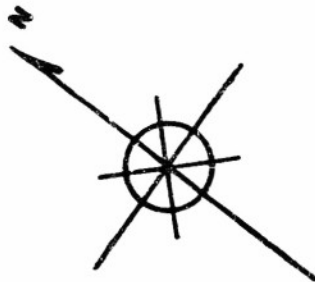




CONFIDENTIAL

FLIGHT No.104
Launched 0758 C.S.T.
25 January, 1953
Trajectory from
DOWN PICTURES

Launched at:
PYOTE, TEXAS



FILM FRAME NUMBER

CENTRAL STANDARD TIME



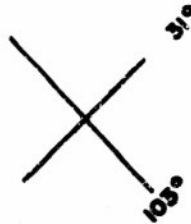
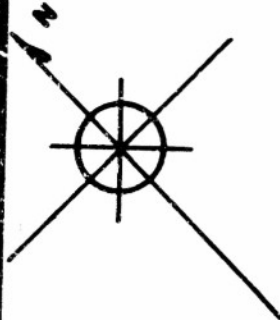
CONFIDENTIAL SECURITY INFORMATION

SCALE 1:5 x 10⁵

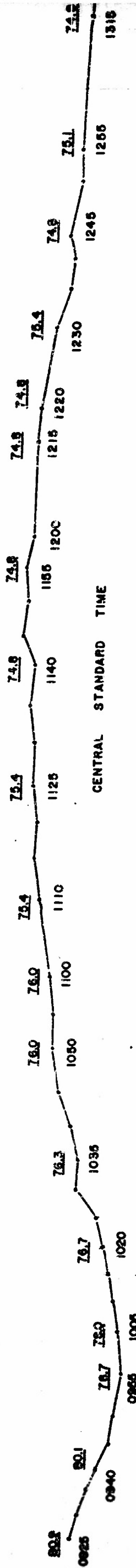
CONFIDENTIAL

FLIGHT No. 104
 Launched 0758 C.S.T.
 23 January, 1953
 Trajectory from
 THEODOLITE FIXES

Launched at :
 PYOTE, TEXAS



ALTITUDE IN THOUSANDS OF FEET

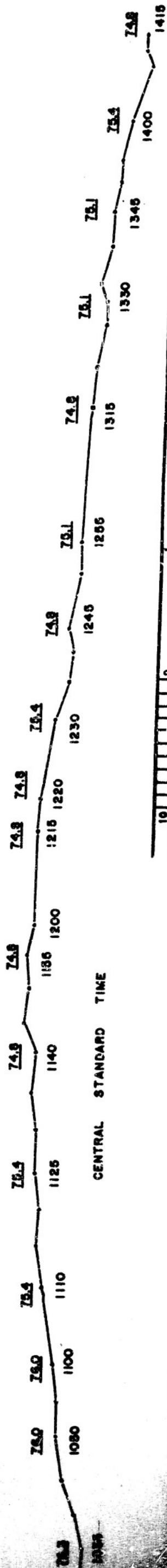


CONFIDENTIAL SECURITY INFORMATION

Launched at :
PYOTE, TEXAS

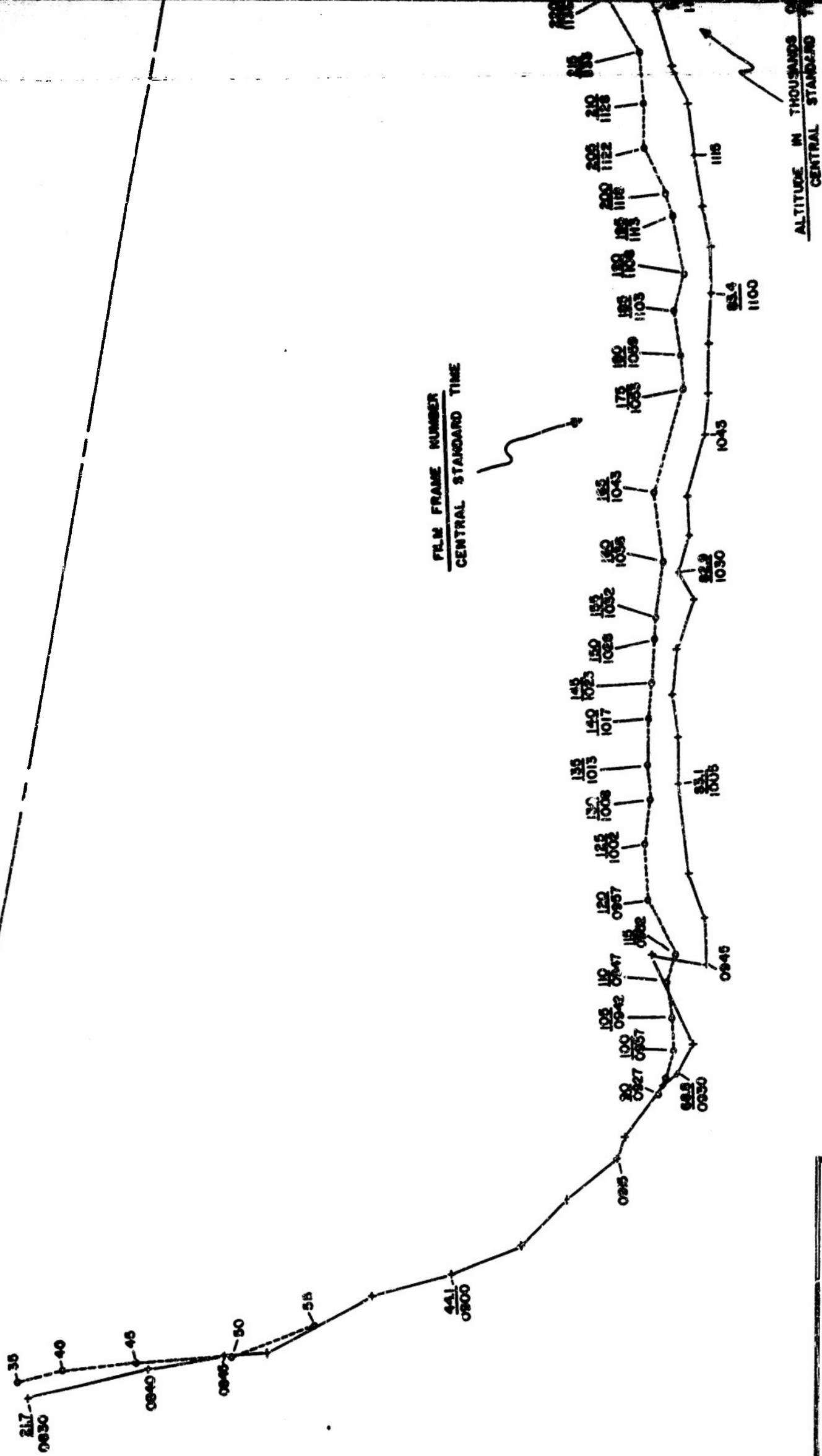


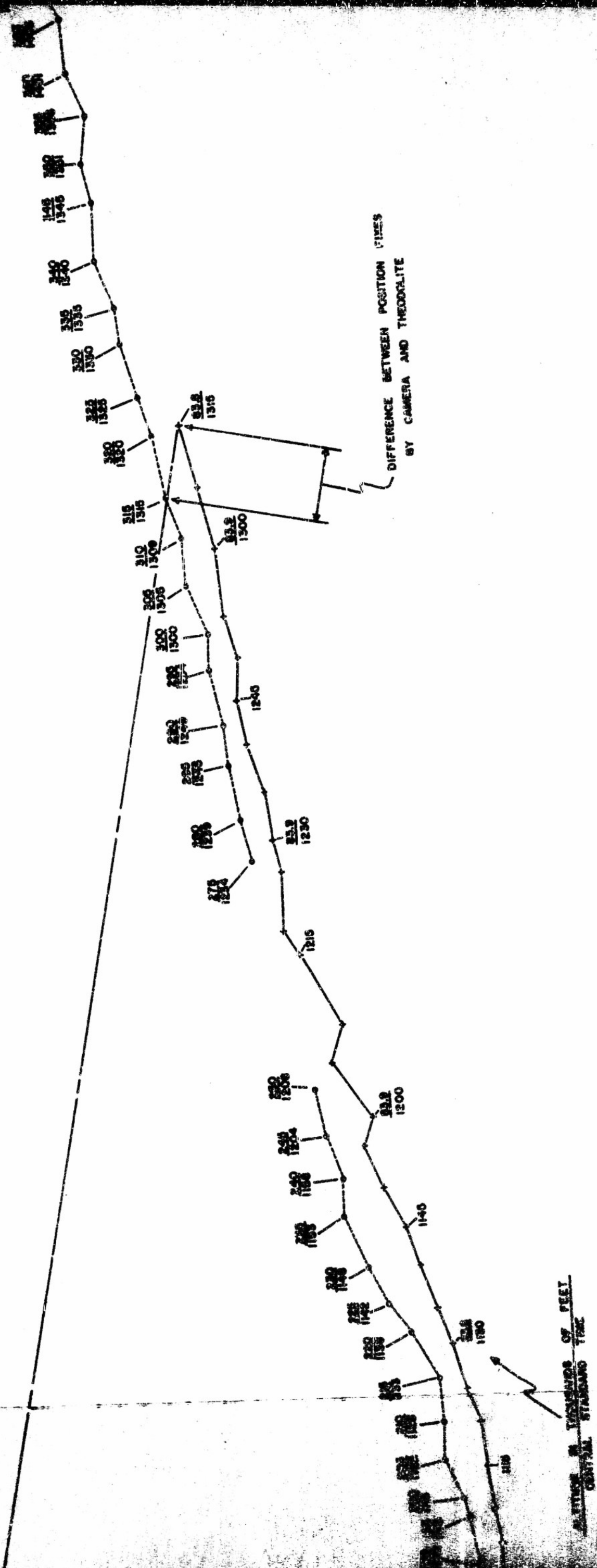
ALTITUDE IN THOUSANDS OF FEET

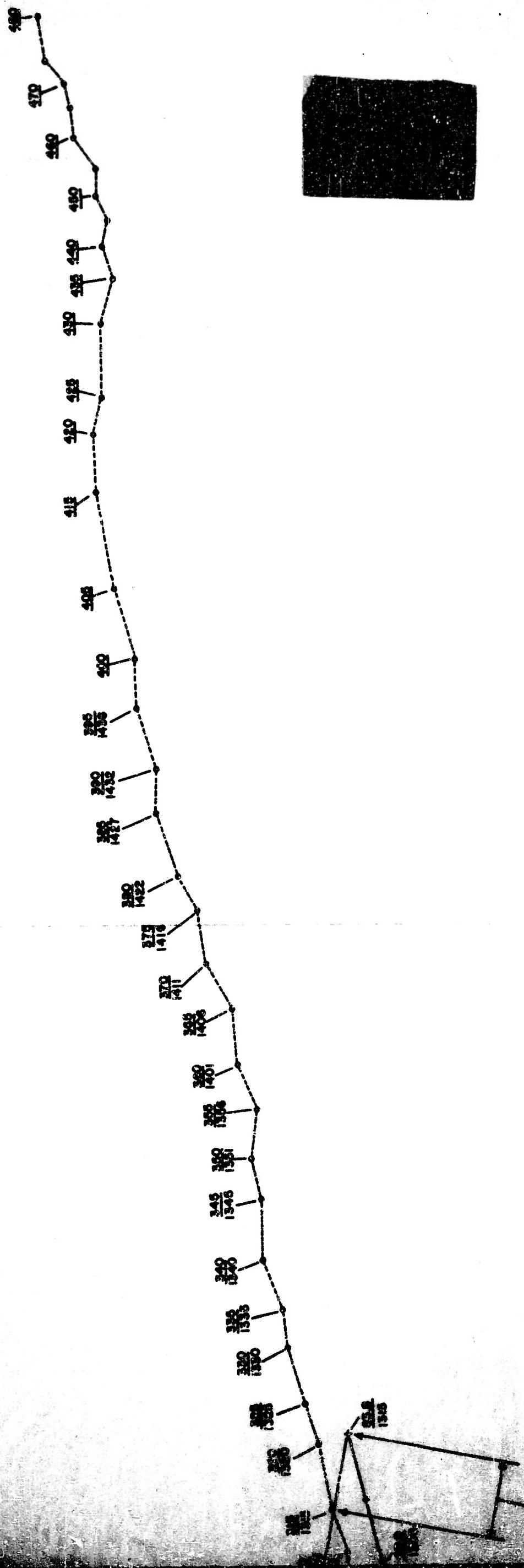


SCALE 1:5x10⁵

Launched at PYOTE, TEXAS
24 January, 1953 0753 CST





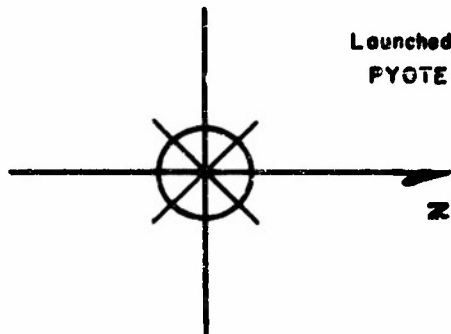


DIFFERENCE BETWEEN POSITION FIXES
BY CAMERA AND THEODOLITE



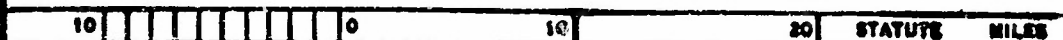
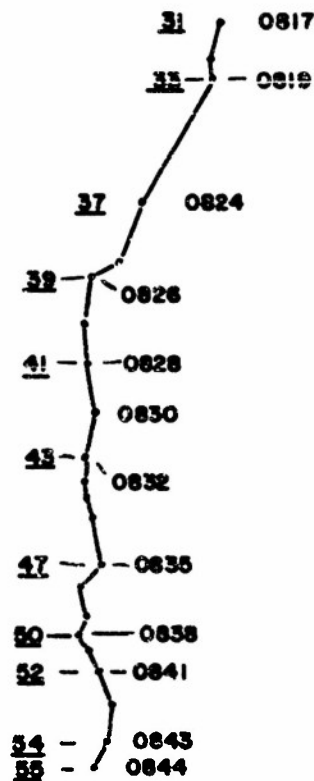
FLIGHT No. 106
 Launched 0738 C.S.T.
 29 January, 1953
 TRAJECTORY FROM DOWN PICTURES

Launched at :
 PYOTE, TEXAS



FILM FRAME NUMBER

CENTRAL STANDARD TIME

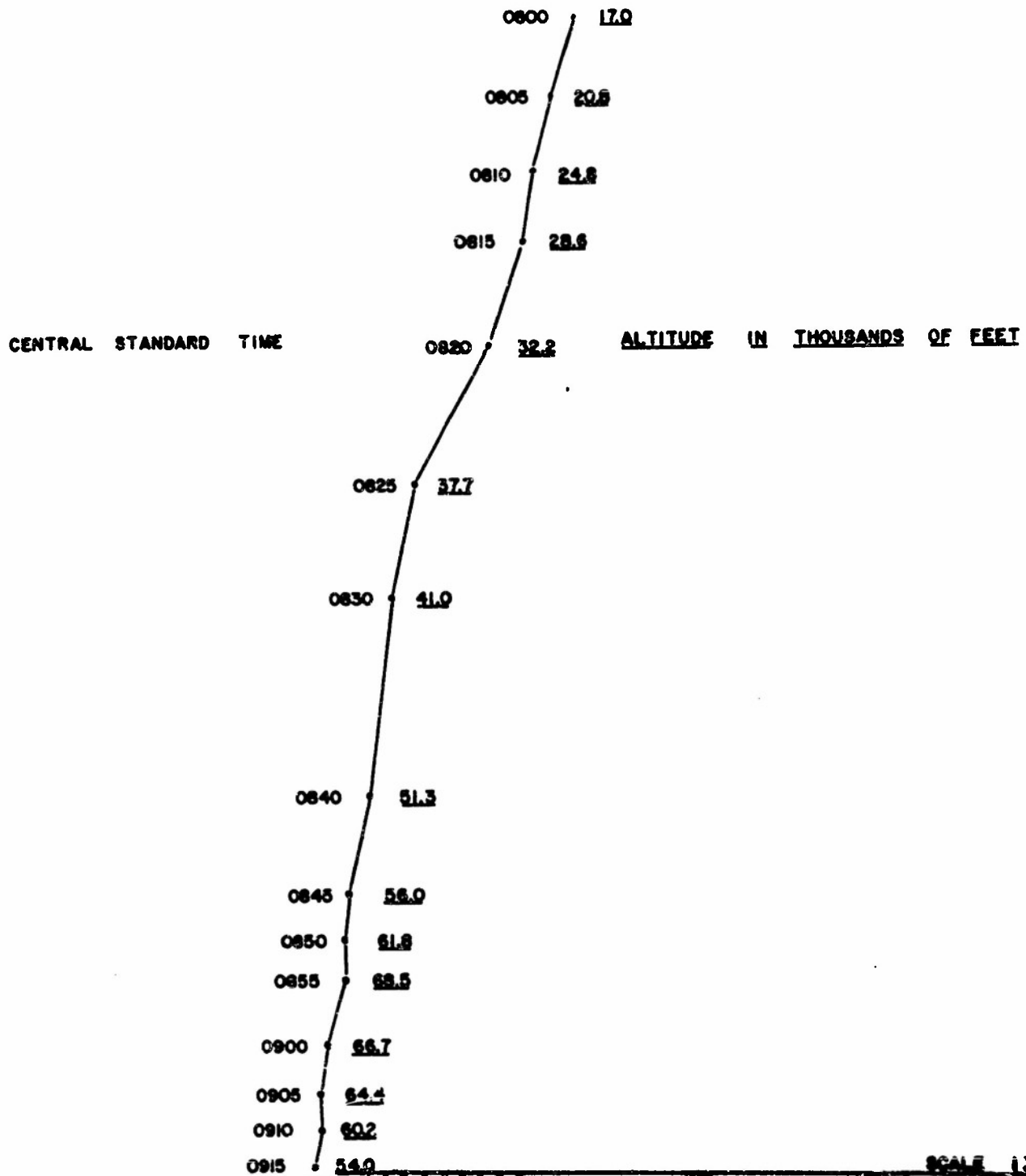
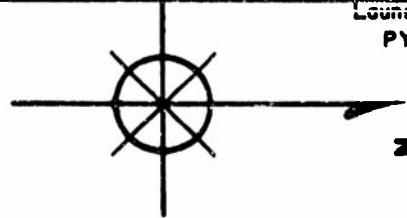


SCALE 1:5 x 10⁵

FLIGHT No.106

Launched 0738 C.S.T.

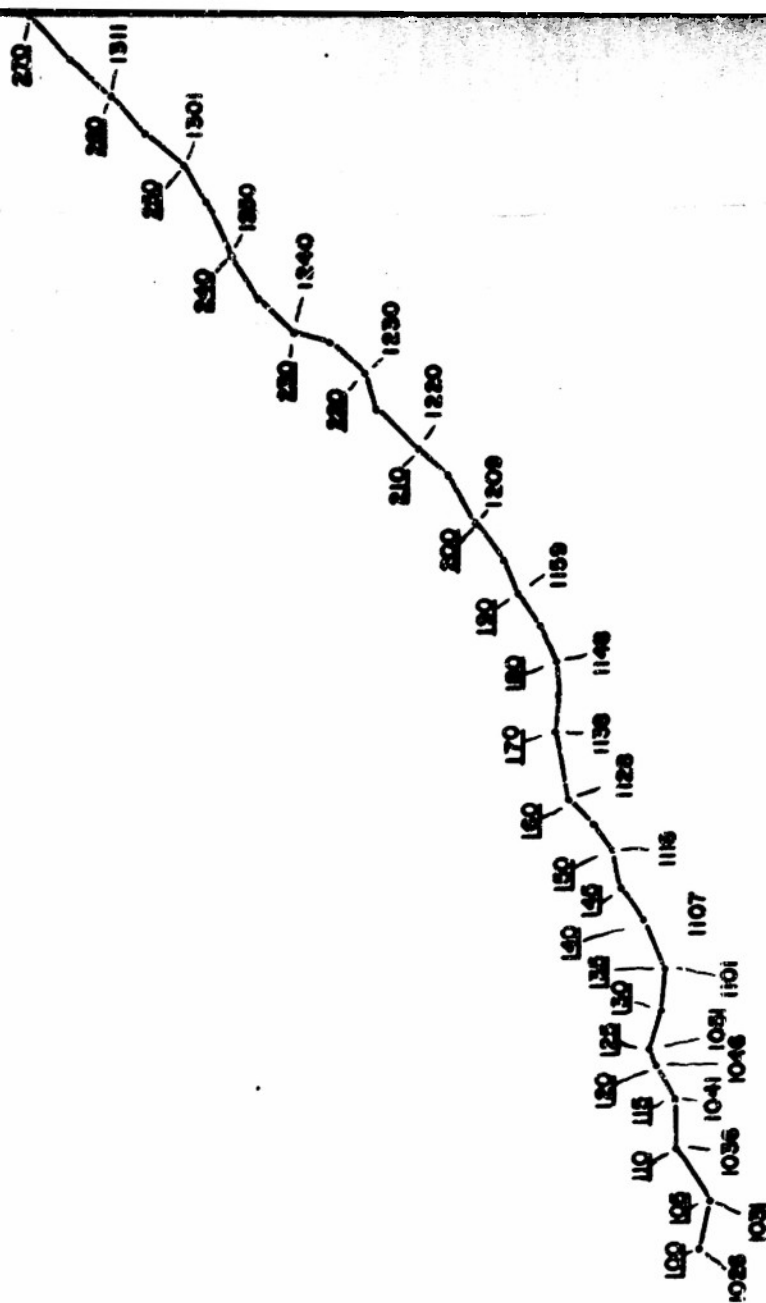
29 January, 1953

Trajectory from
THEODOLITE DATALaunched at
PYOTE, TEXAS

Page XVIII - 77

TRAJECTORY FROM DOWN PICTURES

<u>FILM</u>	<u>FRAME</u>	<u>NUMBER</u>
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9
10	10	10
11	11	11
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63	63	63
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96	96	96
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98	98	98
99	99	99
100	100	100



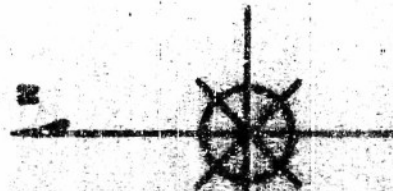
Launched at :
PYOTE, TEXAS



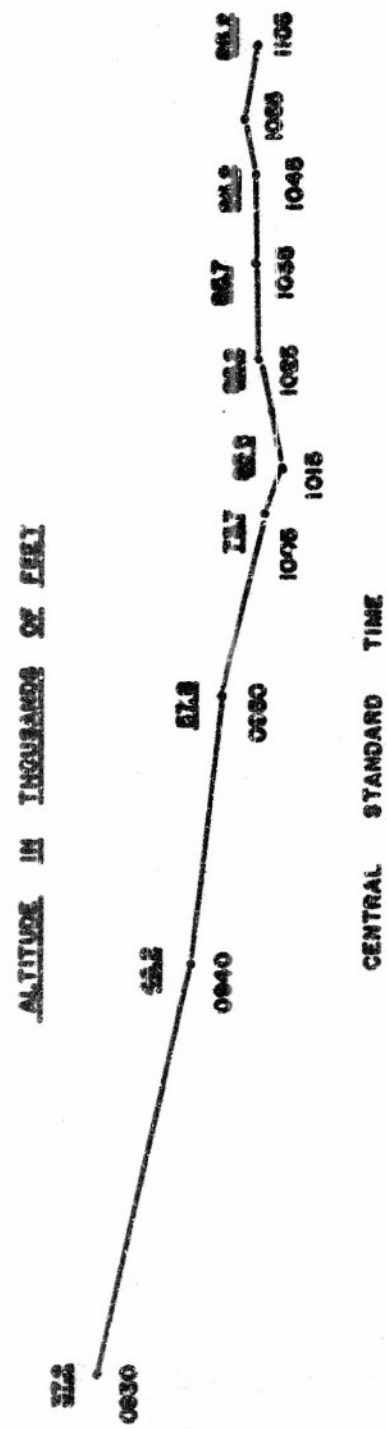
三

CONFIDENTIAL SECURITY INFORMATION

FLIGHT No. 107
 Launched 0848 C.S.T.
 20 January, 1953
 TRAJECTORY FROM THEODOLITE FIXES



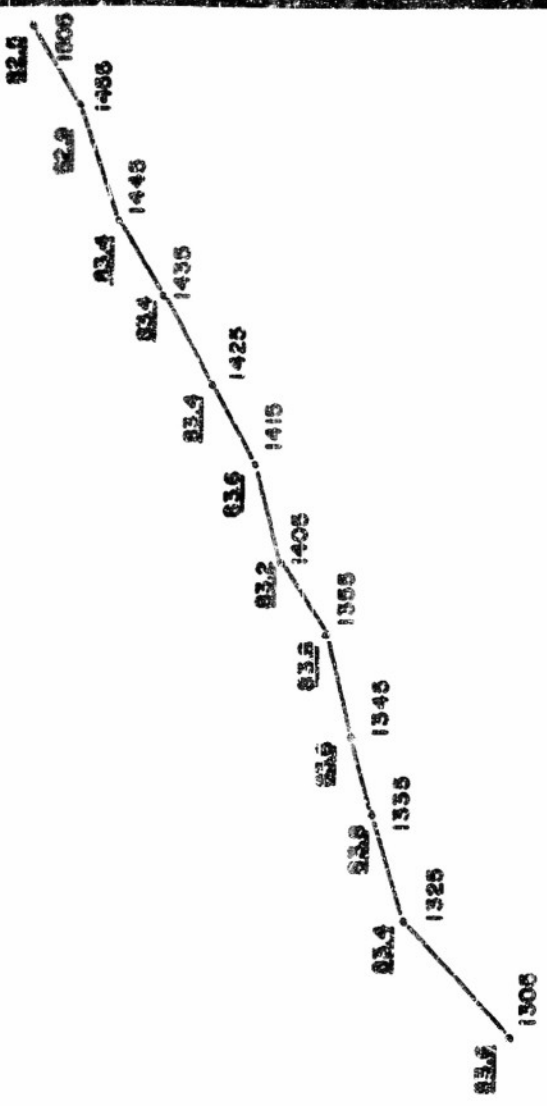
Launched at :
 PYOTE, TEXAS



ALTITUDE IN THOUSANDS OF FEET



CENTRAL STANDARD TIME

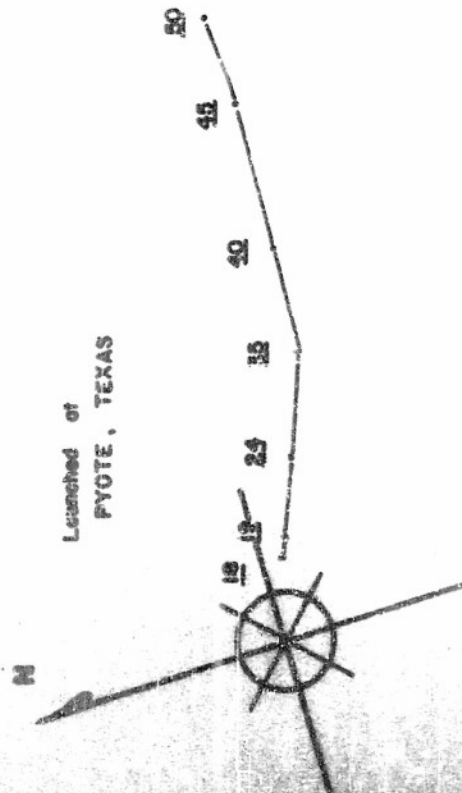


FLIGHT No.108

Launched 0845 C.S.T.

30 January, 1953

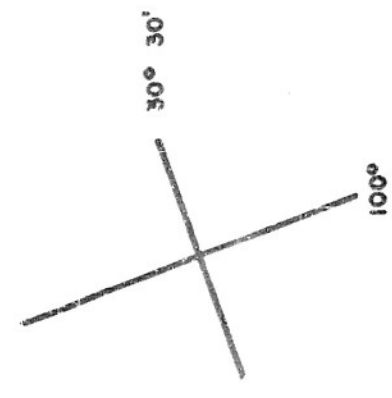
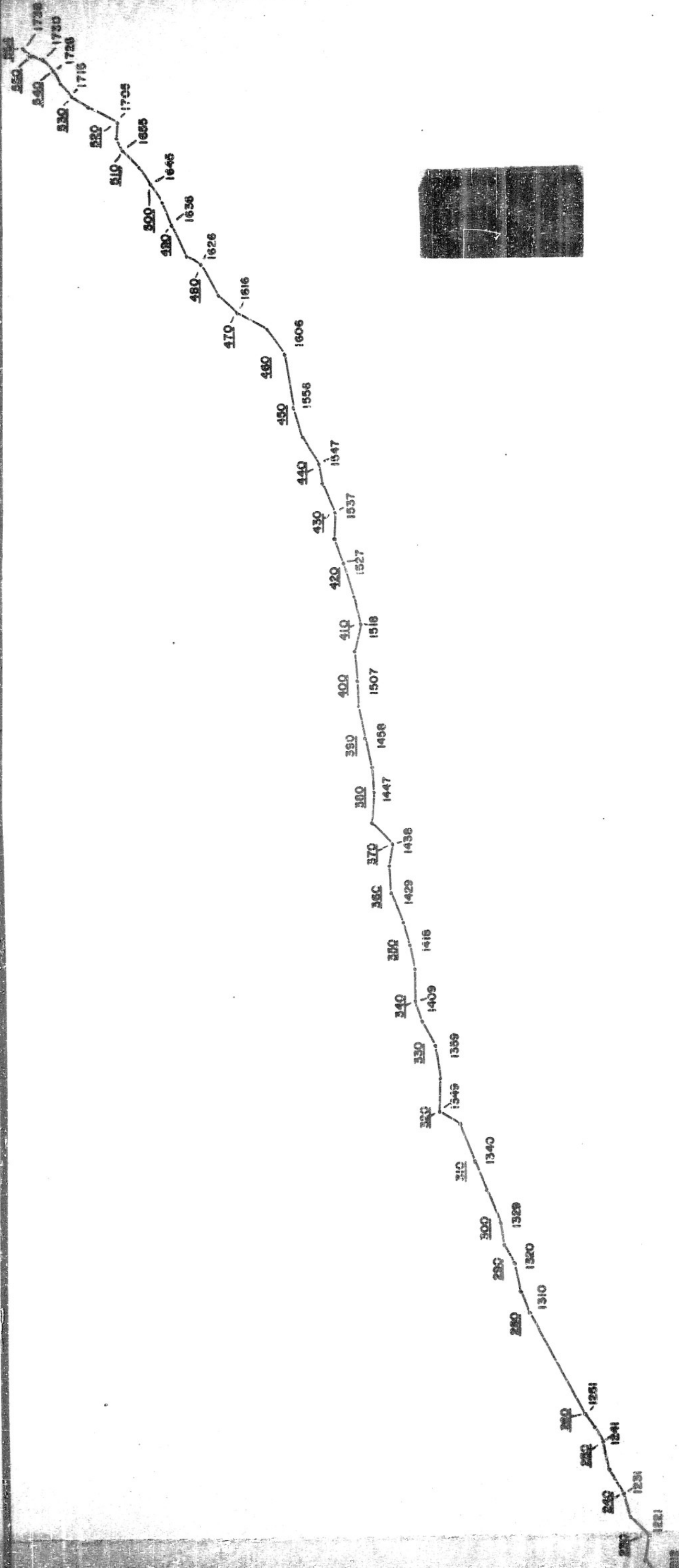
TRAJECTORY FROM DOWN PICTURES



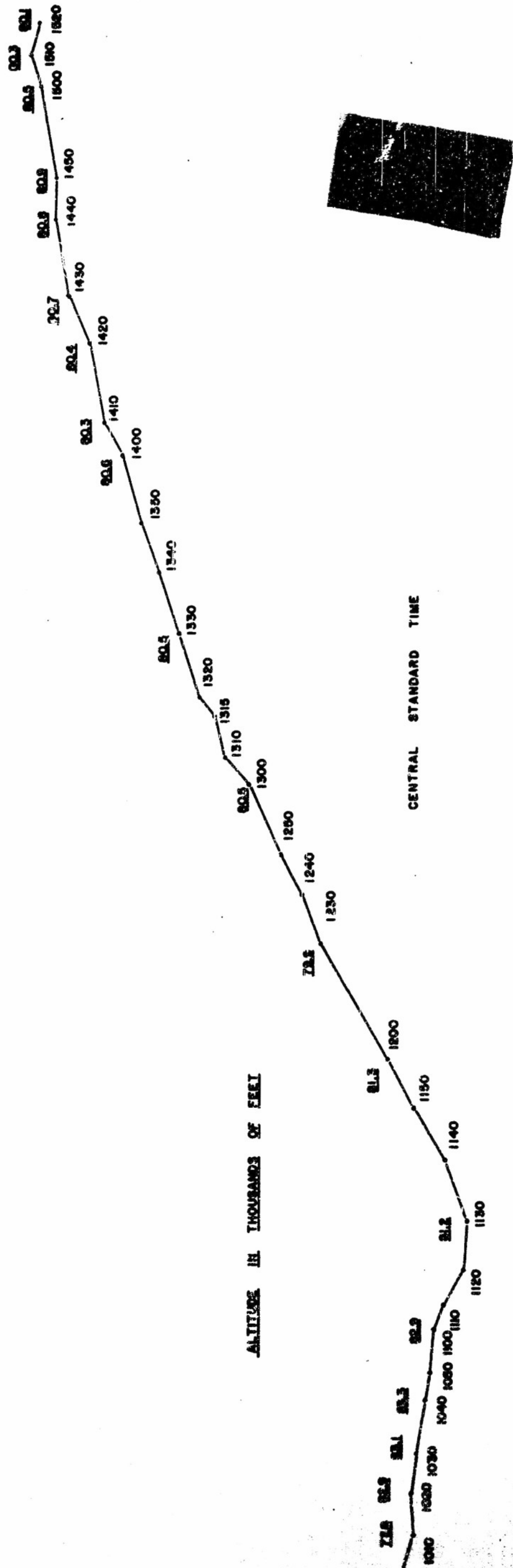
FILM FRAME NUMBERS

95 100 110
104 1025 1029
130 140 150
1054 1105 1117 1123
1043 1133
190 1143
200 1132
210 1201
220 1212
230 1221
240 1231
250 1241

CENTRAL STANDARD TIME



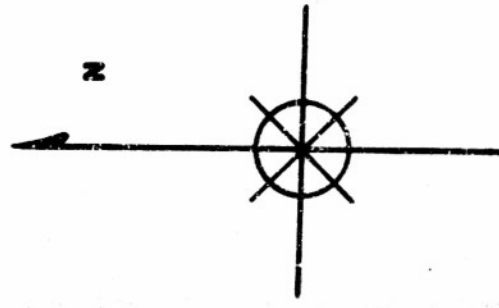
SCALE 1:5,000
STATUTE MILES
0 10 20



FLIGHT No. 109
Launched 0750 C.S.T.
1 February, 1953

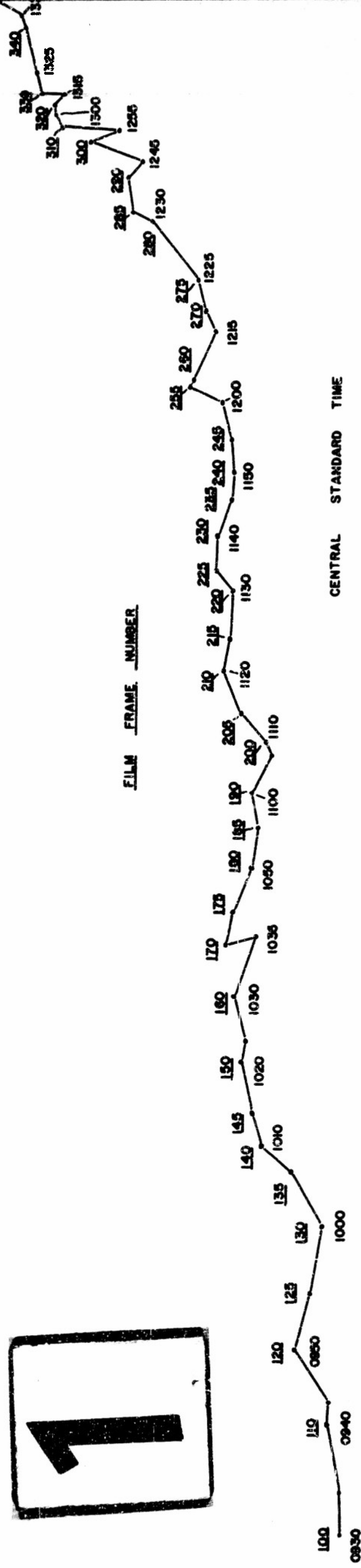
Trajectory from DOWN PICTURES

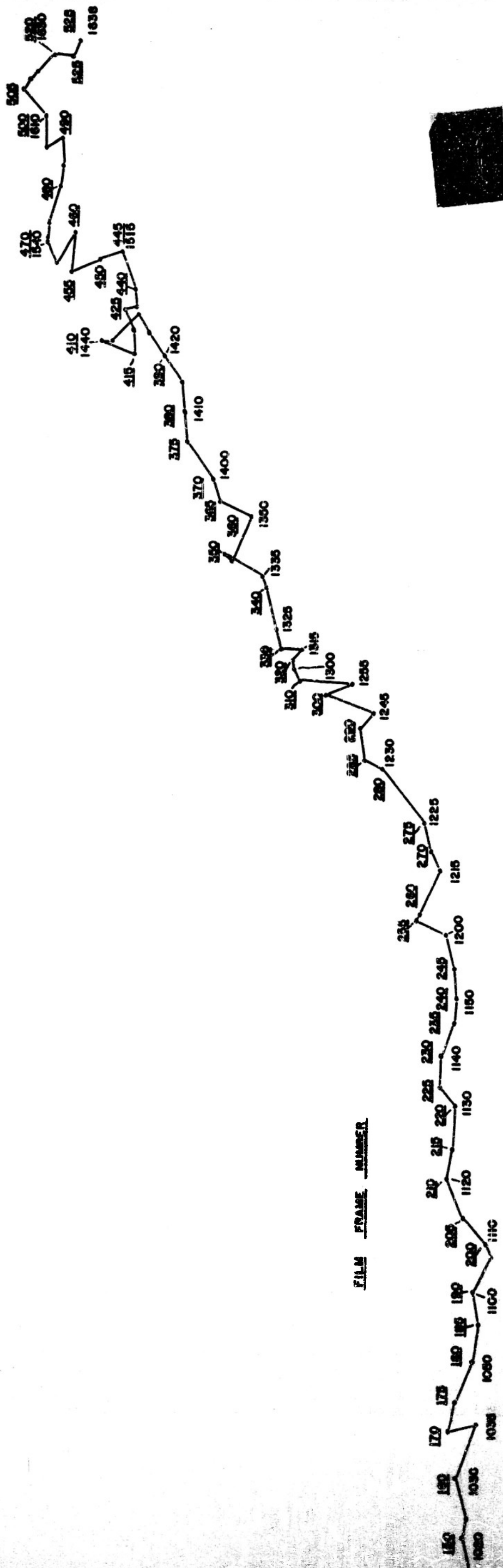
NOTE: CAMERA TILTED ~7° FROM VERTICAL



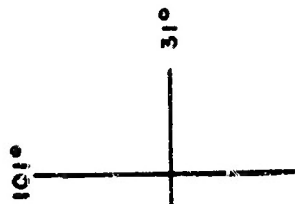
FILM FRAME NUMBER

CENTRAL STANDARD TIME





CENTRAL STANDARD TIME



SCALE 1 : 5 x 10⁵

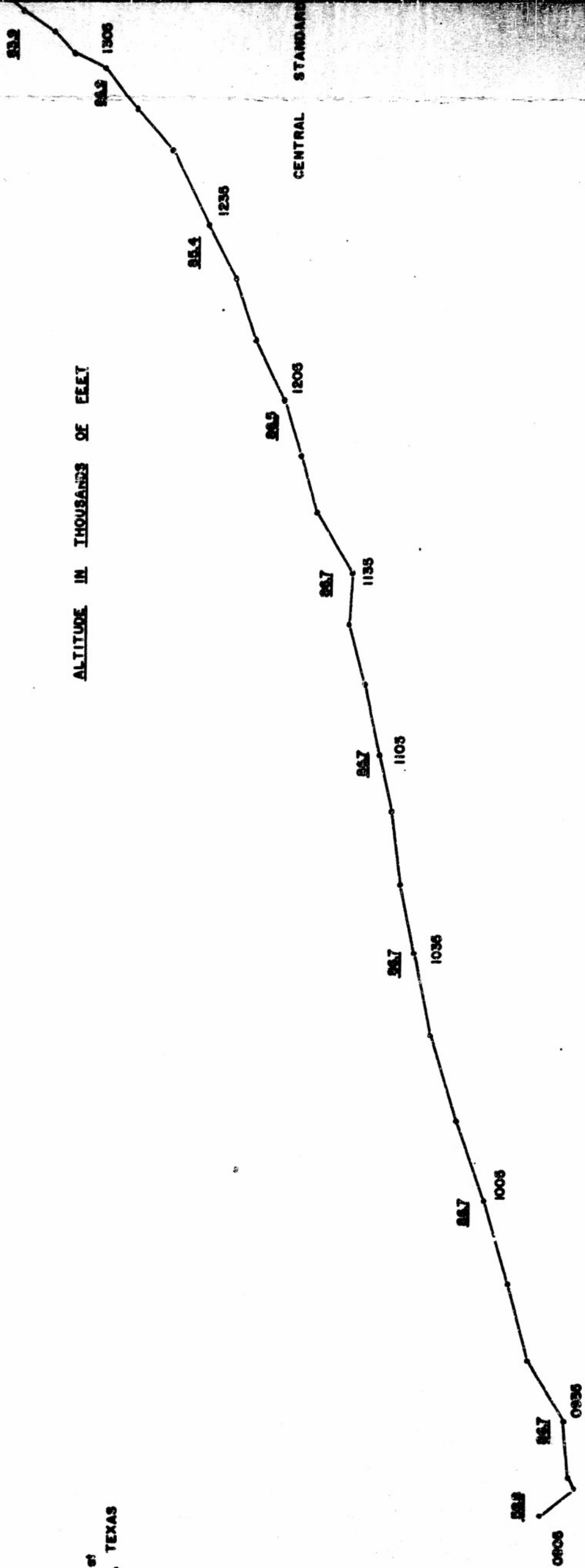
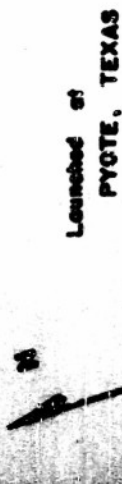
FLIGHT No. 109

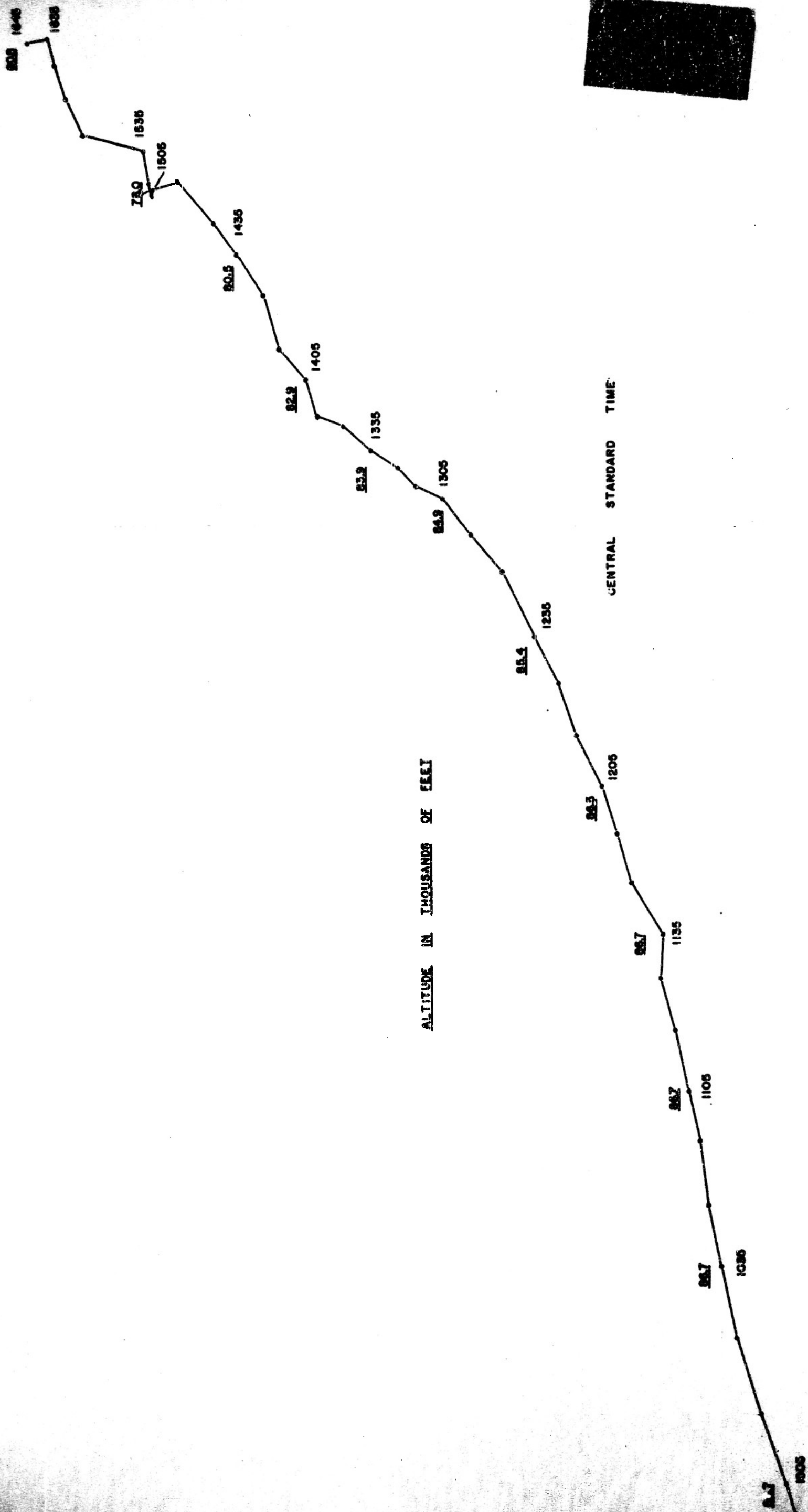
Launched 0750 C.S.T.

1 February, 1953

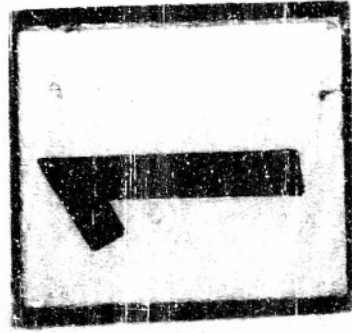
Trajectory from THEODOLITE FIXES

1





FLIGHT No. 110
Launched 0850 C.S.T.
1 February, 1953
Trajectory from DOWN PICTURES

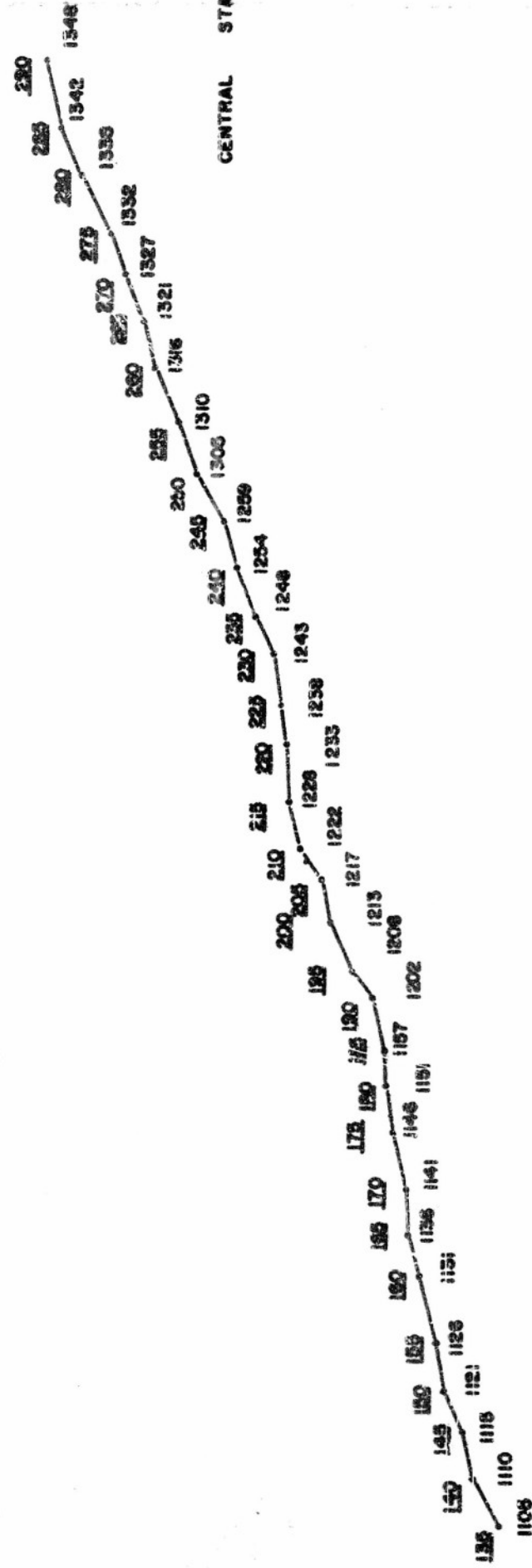


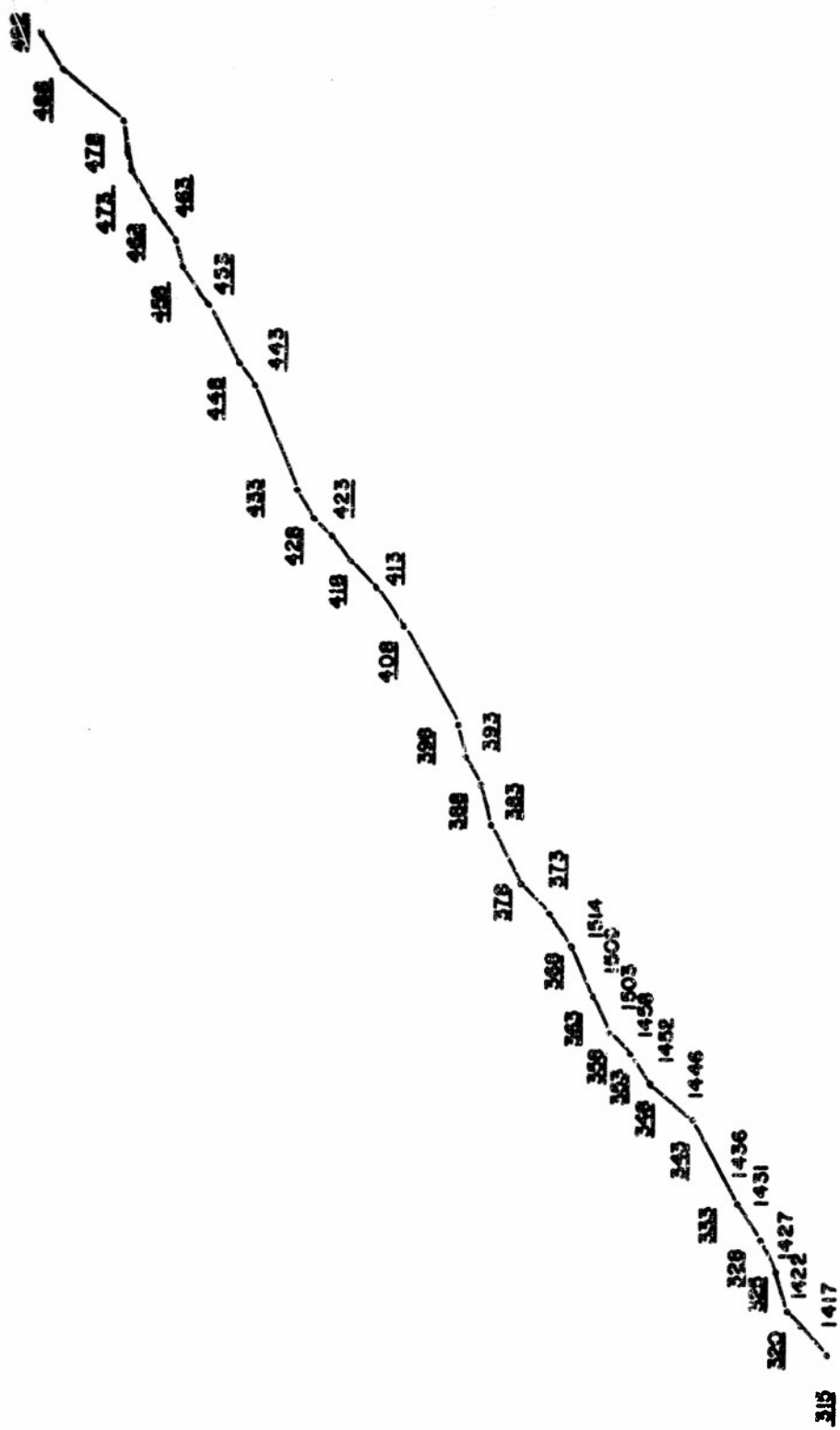
Launched at
MYOTE, TEXAS



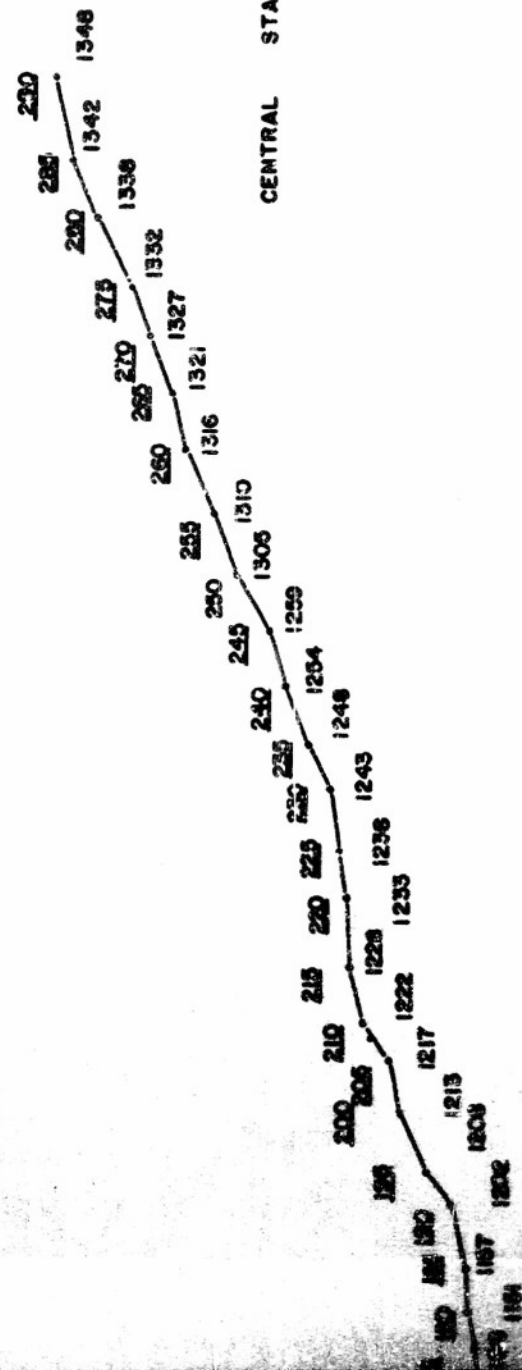
FILM FRAME NUMBER

CENTRAL STANDARD TIME





FILE FRAME NUMBER



CENTRAL STANDARD TIME

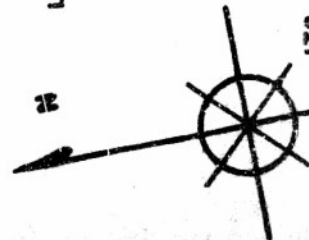


SCALE 1 : 5 x 10⁵

FLIGHT No. 110
 Launched 0850 C.S.T.
 1 February, 1953
 Trajectory from THEODOLITE FIXES

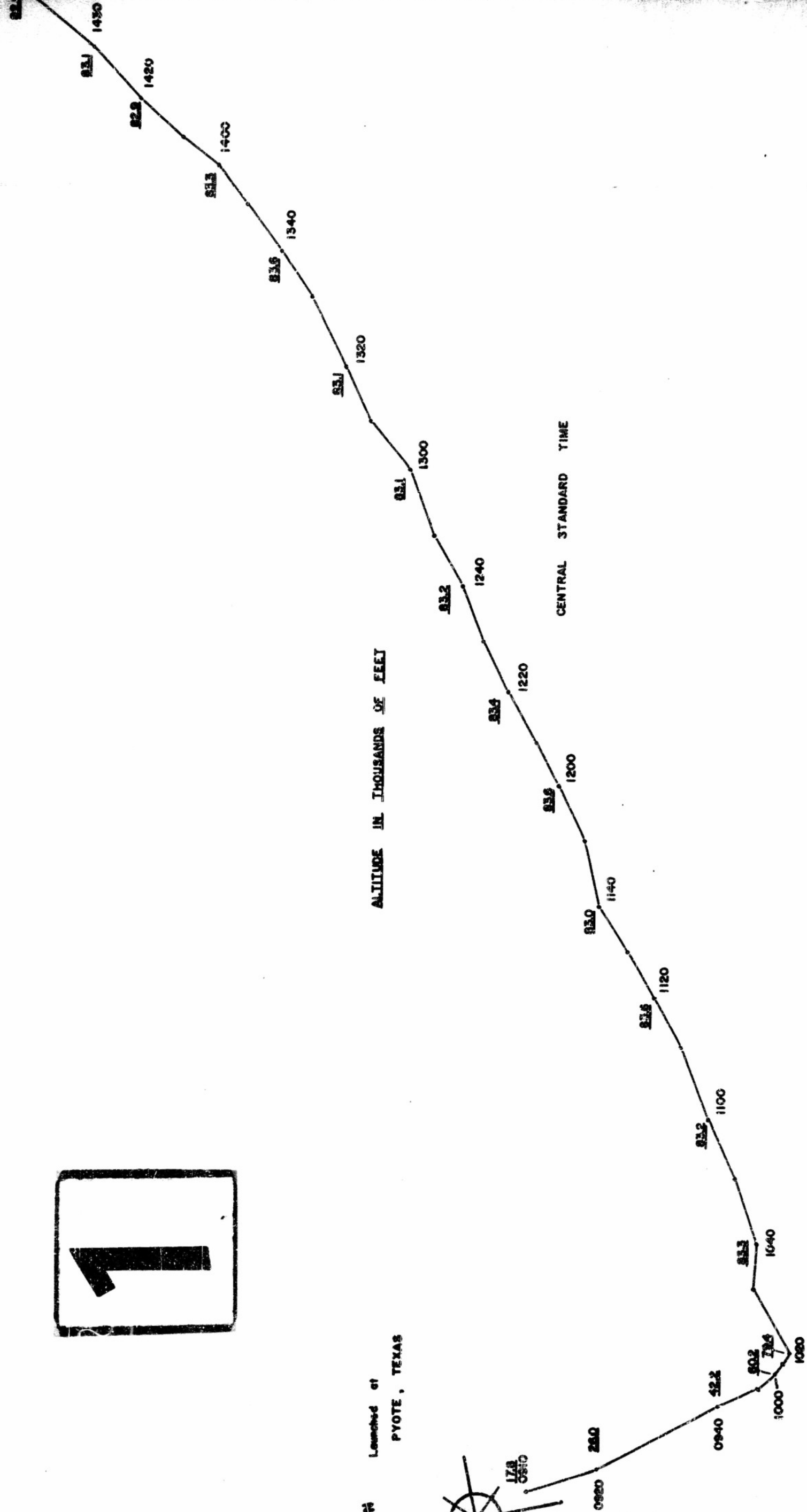


Launched at
 PYOTE, TEXAS



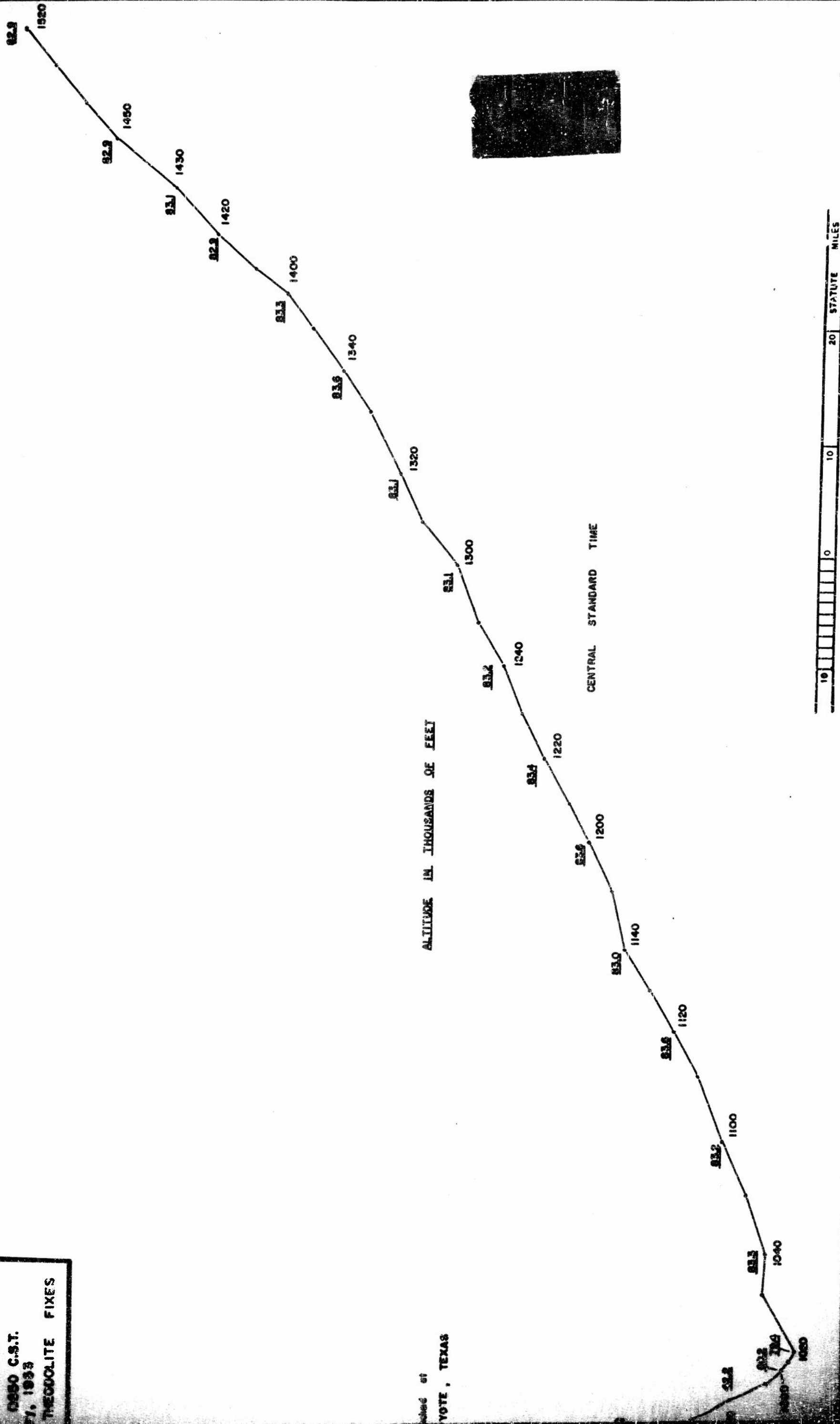
ALTITUDE IN THOUSANDS OF FEET

CENTRAL STANDARD TIME



No. 110
0850 C.S.T.
1, 1953
THEODOLITE FIXES

ended at
VOTE, TEXAS



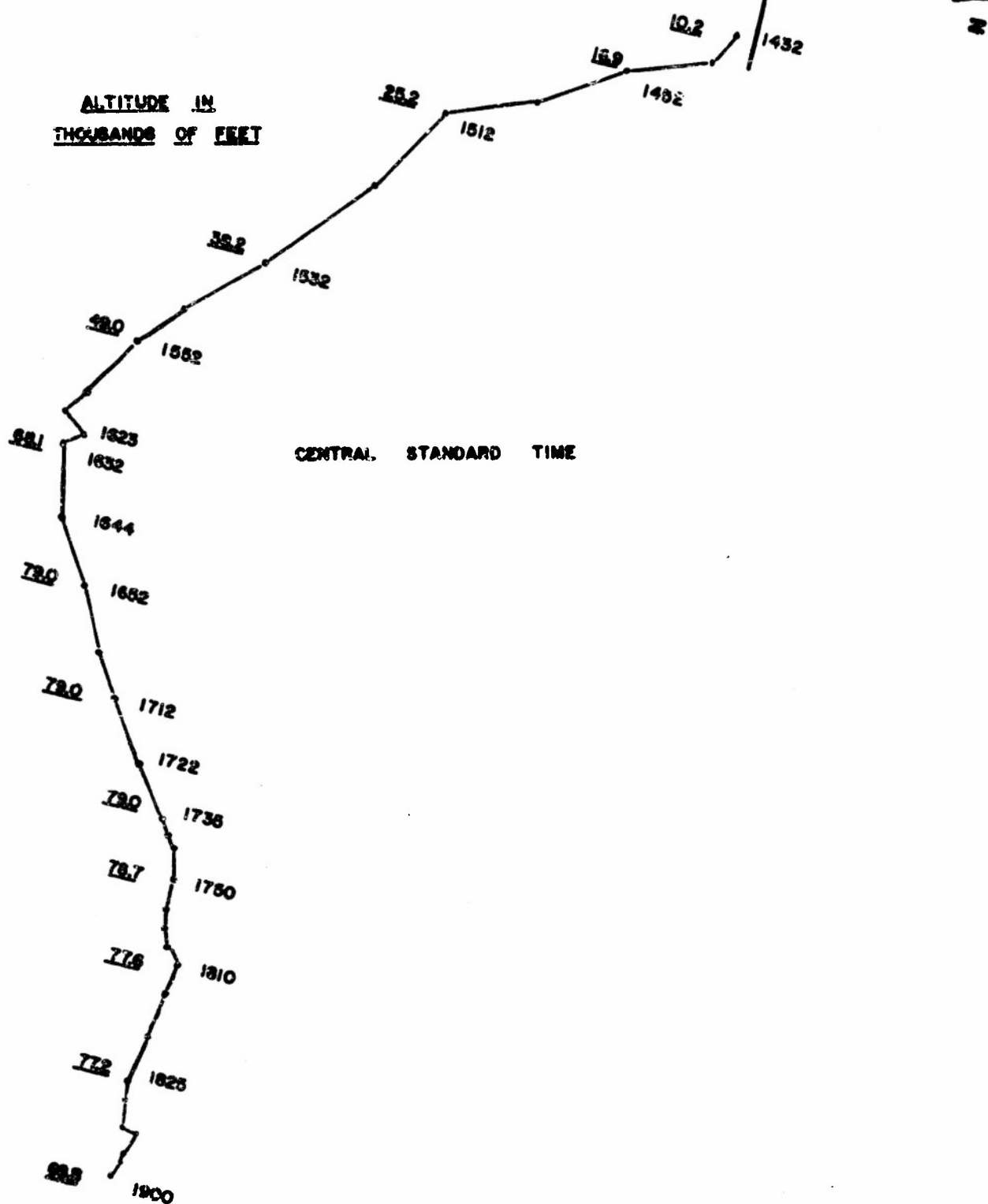
FLIGHT No. III
Launched 1410 C.S.T.
1 February, 1953

Trajectory from THEODOLITE FIXES

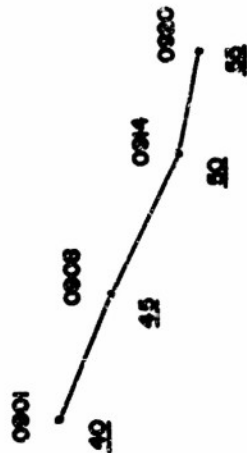
Launched at
PYOTE, TEXAS

ALTITUDE IN
THOUSANDS OF FEET

CENTRAL STANDARD TIME

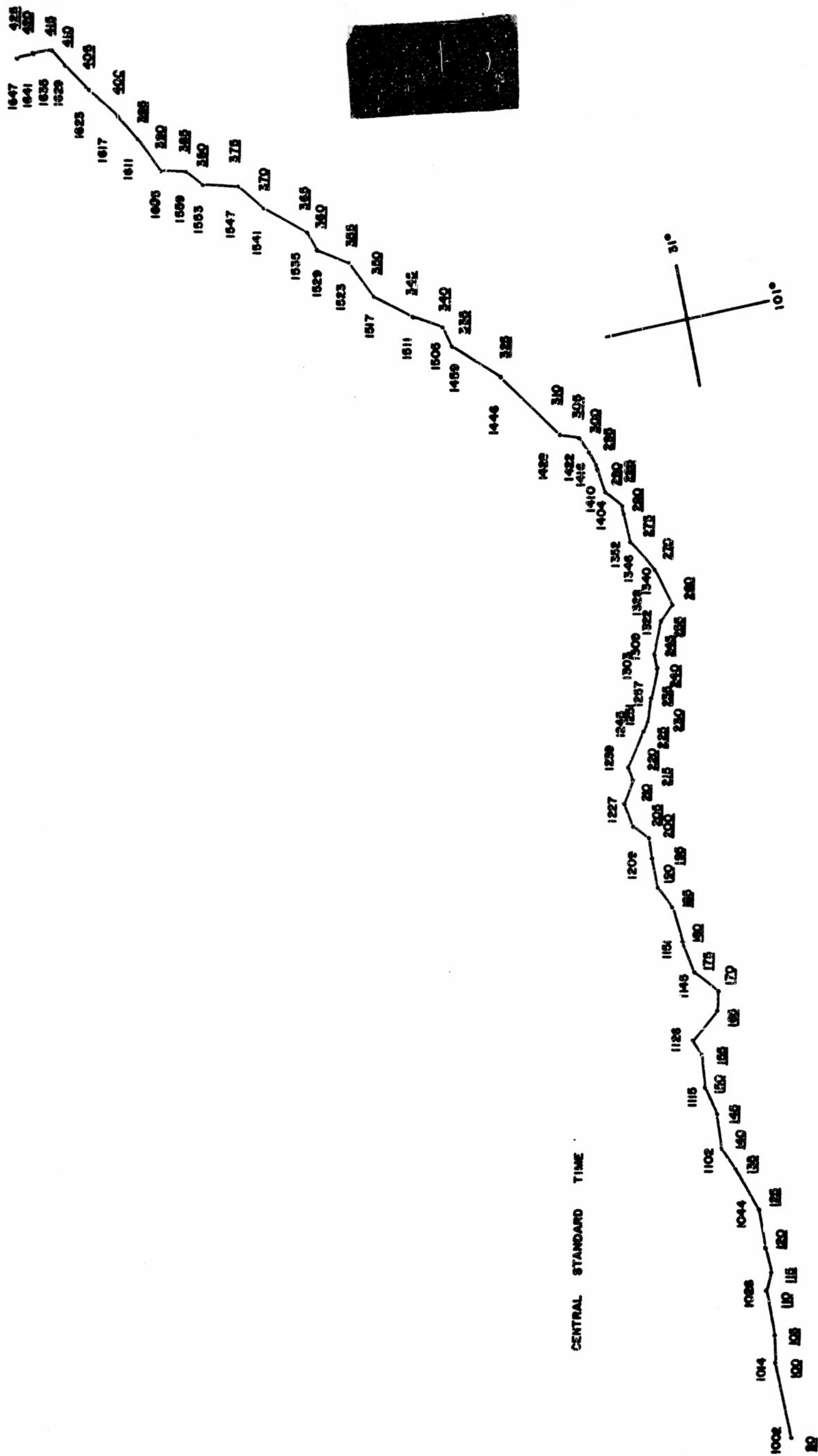


SCALE 1:5 x 10⁶



FILM	FRAME	NUMBERS
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CENTRAL STANDARD TIME

FILM FRAME NUMBERS



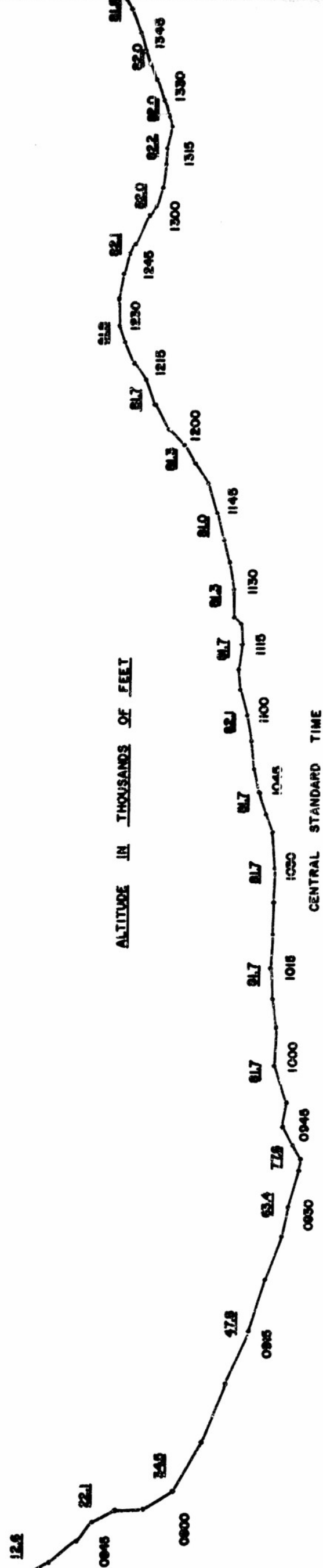
FLIGHT No. 112

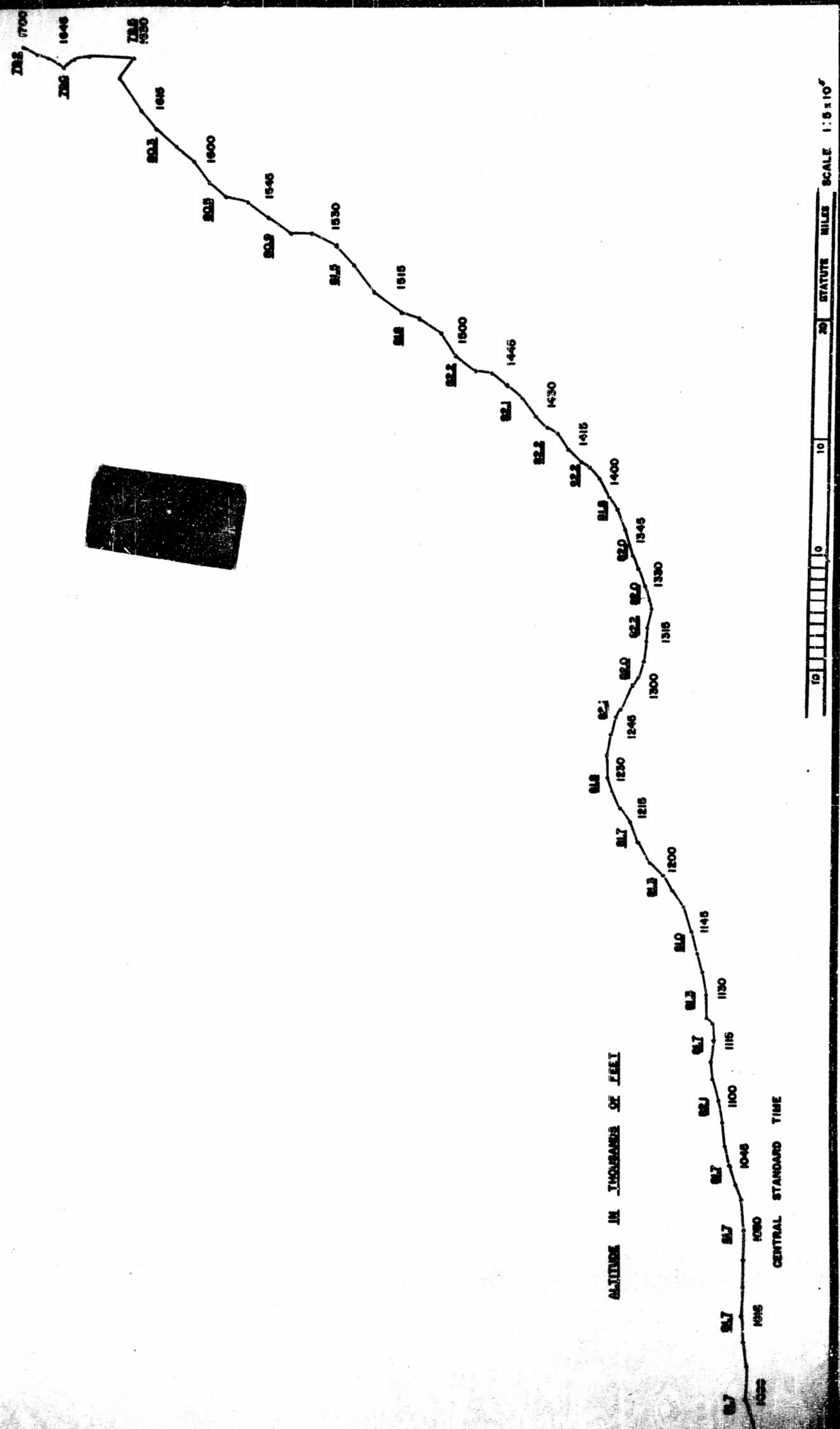
Launched 0813 C.S.T.

5 February, 1953

Trajectory from THEODOLITE DATA

1





Section IXMETEOROLOGYIntroduction

The series of cosmic ray flights made from Pyote, Texas, during January and February, 1953, provided ten trajectories which have been analyzed to determine the characteristics of stratospheric flow. Four of these flights maintained a constant altitude for the three or more hours considered necessary for a separation of motions with different period. Information on the longer period or large-scale flow can be obtained from all ten flights; some of these flights extend over a sufficiently long period to be considered as two separate determinations of the large-scale flow. Flight 101 as the result of balloon failure, floated near sixty thousand feet for most of the day. Because this trajectory displays some rather unusual characteristics which differ from the higher level flow, this trajectory will be discussed separately.

The absolute elevations of the balloon were determined where possible from measurements on the film and also by a comparison of film and theodolite trajectories. The results of the altitude computations are given in the last portion of this section of the report.

The differences which have been observed between the camera and the theodolite trajectories are illustrated by plotting both trajectories for flight 105 on the same diagram. The systematic departure of the two trajectories is readily apparent and as discussed below, this difference may be attributed to the difference between the actual balloon altitude and the pressure altitude.

Two contradictory sun shots were made during this flight. The azimuth used in the theodolite plot was based on the final sun shot which checks the azimuth determined from the film trajectory at this point. The altitude differences tend to

obscure other trajectory differences. However, rather systematic departures in azimuth can be observed in the earlier portion of the flight and this fact along with the occasional jog in the theodolite trajectory (for example at 0940 CST) makes one suspect that theodolite errors have been introduced by the temporary mounting of the instrument.

The scale of motions

The constant level balloon trajectories of the Texas flights (lat. 32°) showed flow characteristics which are very similar to those observed at latitude 45° . Flights of eight hours duration often appear to span at least a half period of the largest scale of detectable motions. The trajectories also clearly show evidence of motion with periods of an hour or two which, as before, will be called intermediate-scale. Four theodolite trajectories were of sufficient duration at constant altitude to enable the relative "power" in the various scales of motion to be estimated. As described in the preceeding progress report,¹ the velocities, measured between observation fixes, were fitted by a linear trend for the entire interval at constant altitude. The linear function is interpreted as the description of the motion of largest scale. Motions of intermediate scale are detected by the regions of consistent departure from the linear trend; the final deviations from a linear fit are attributed to motion of smaller scale and also to error.

In Table I are listed the results of the analysis of the four Texas flights. For comparison the corresponding values derived for the stratospheric flow at northerly latitudes (45°) have been averaged for cases of easterly and westerly flow and entered in the same table. The average wind speed in these four cases was greater than that determined during either periods of east or west winds at latitude 45° . This result is corroborated by the data from all flights given in the following section. The wind fluctuations of largest scale seem significantly larger than those at 45° but in view of the higher wind speed this result does not

¹PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume VII, p. II-119.

Table I
Velocity Fluctuations

	104	105	107	109	Average Pyote	Average lat 45° West winds	Average lat. 45° East winds
Flight date	1-23-53	1-24-53	1-30-53	2-1-53			
Time	12:40	11:20	11:10	10:50			
Altitude	75,100	81,400	82,500	86,700	81,400	86,800	81,900
Average distance out	105	110	93	60	92	68	53
Range, distance out	70-140	70-150	75-110	30-90			
Leg interval	5	5	10	10			
Duration of flight	185	155	100	150	148	112	130
Mean wind magnitude	14.1	17.7	8.8	13.2	13.5	8.1	8
Velocity direction	229	252	284	270	259	280	95
rms [*] velocity deviations from mean	2.22 3.73	5.76 4.41	3.14 2.36	1.75 2.30	3.22 3.20	1.67 1.29	1.64 1.92
rms velocity deviations from trend	1.67 3.73	5.10 4.25	2.28 1.82	1.73 1.61	2.70 2.85	1.47 1.09	1.35 1.50
rms long-period velocity fluctuations	1.46 0.16	2.68 1.20	2.16 1.51	0.25 1.64	1.64 1.11	1.12 .61	.81 .89
rms int-period velocity fluctuations	0.77 0.58	1.95 —	1.92 0.92	.89 .70	1.38 .73	.58 —	.89 .61
rms short period velocity fluctuations and acceleration	1.48 3.68	4.71 4.25	1.23 1.57	1.49 1.45	2.23 2.74	.84 1.09	1.00 1.00
Long period acceleration	-4.56 -1.9	10.48 4.42	12.53 8.76	-.94 -6.32	7.13 4.90	6.1 3.2	5.0
Average intermediate period acceleration	8.55 18.06	20.22 —	20.50 21.80	6.73 8.31	14.00 12.04	— —	11.0
Average length of the intermediate periods	130 80	120 —	100 80	150 140	125 100	— —	—

* rms = root mean square

necessarily indicate a higher relative variability of the wind. The wind fluctuations of intermediate scale as before are quite large compared to the total wind variation. The values for the fluctuations of smallest period includes the error in position fix. Since there is reason to suspect the accuracy of positioning in this case, it is difficult to attach much significance to the magnitude of the small scale fluctuations.

Summary of the large-scale flow

A summary of the large-scale stratospheric flow was also made following more conventional methods of climatological analysis. From a consideration of the trajectory errors and the effect of small scale motion, it was decided to require a fifty-minute period with a constant altitude maintained within a thousand feet for the determination of the wind velocity. In an attempt to increase the amount of data the velocity was determined at the beginning and at the end of the longer trajectories, since these wind observations would be hours apart corresponding to the conventional interval between upper air reports.

The results of these wind measurements are given in Table II. The mean wind vector for these seventeen cases is from 250° at 21.6 knots (11.2 m sec^{-1}). Some further significance of the observation of a mean southerly component of the wind is gained by noting that the six General Mills trajectories of winter SKYHOOK flights made in the Southwest all showed a southerly component of the flow in the layer 80,000 to 90,000 feet.

The relative variability of these observations may be described¹ by the constancy q , defined by the ratio of the mean vector wind speed to the mean wind speed $V_r/V_s \times 100$. The constancy for these cases was found to be 95%

¹Brooks, C.E.P., C.S. Durst, N. Carruthers, D. Dewar and J.S. Sawyer, "Upper Winds Over the World", Meteorological Office, Geophysical Memoir No. 88.

Table II

Measurements of Large-Scale Winds in Knots

Flight	Date	Time CST	Press Alt Thsd ft	East- west	North- south	Wind speed
101	20 Jan	1000	89	26.8	3.8	27.0
103	21 Jan	1030	81	13.9	15.4	20.8
		1500	80	20.7	16.8	26.6
104	23 Jan	1000	79	15.6	14.7	21.5
		1330	75	19.7	15.6	25.1
105	24 Jan	1000	83	27.6	8.3	28.8
		1230	84	33.0	18.2	37.7
107	30 Jan	1120	86	15.9	0	15.9
		1445	83	19.9	8.2	21.3
108	30 Jan	1030	83	11.6	-6.4	13.2
		1430	80	23.4	-2.6	23.5
109	1 Feb	1100	(81)?	23.1	2.4	23.2
110	1 Feb	1130	83	23.1	7.9	24.5
		1500	83	14.4	13.2	19.8
111	1 Feb	1715	79	14.2	8.2	16.4
112	3 Feb	1030	82	21.8	0	21.8
		1500	79	15.9	13.4	20.8
Mean				20.03	8.06	22.8

very nearly the same as for the Minneapolis cases of east winds which was 96%. Tropospheric values of q are generally much lower, usually less than 90%.

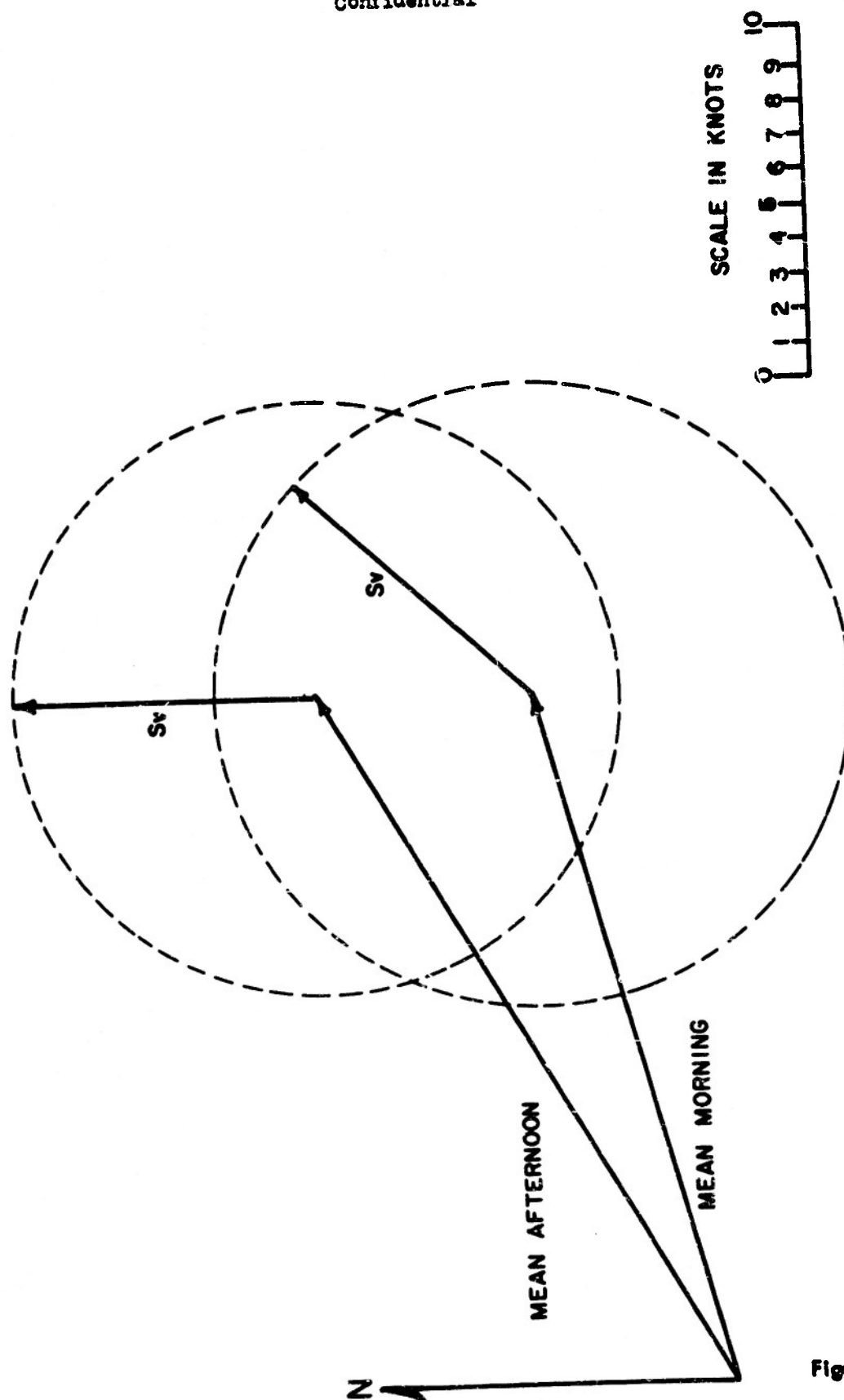
The data was examined for any systematic variation with altitude in the layer 80,000 to 90,000 feet but none was detected. Only in the region 65,000 to 80,000 feet could a definite increase in wind speed with elevation be established.

The one systematic variation of the wind which was observed, appeared in the comparison between morning and afternoon winds. The early afternoon flights showed a tendency to have a greater southerly component than the morning observations. The vector mean winds for the nine morning and eight afternoon observations are compared in Figure 1. If as assumed by Brooks, loc. cit., the wind record can be adequately represented by a vector normally distributed about the mean vector, the standard vector deviation may be derived from the constancy q and the mean wind.

The values of S_v , the standard vector deviation for the morning and afternoon observations, are also given in Figure 1. One can interpret differences between morning and afternoon winds as a possible indication of diurnal effect or merely a standing wave in the flow pattern.

Flight 101, possible anticyclonic flow about a low

The anticyclonic trajectory of flight 101 was observed in the lower stratosphere (about 60 thousand feet) and since small complex flow patterns had previously been indicated in this region the rather unusual feature of this trajectory was not immediately apparent. As may be seen from the sketch on the diagram of the theodolite trajectory, this trajectory very nearly describes a semicircle of 18 miles radius from 1130 CST to 1500 CST. The speed along this path was surprisingly constant at 7 m sec^{-1} . The centripetal acceleration of $15 \times 10^{-2} \text{ cm sec}^{-2}$ is more than twice the magnitude of the Coriolis acceleration of $6 \times 10^{-2} \text{ cm sec}^{-2}$ and is, of course, oppositely directed. A steady flow of this



COMPARISON BETWEEN MORNING AND AFTERNOON WINDS

Figure 1

type could only correspond to flow about a low pressure center. As suggested by Forsythe¹ this result is equivalent to specifying that the geostrophic wind field (or field of pressure gradient force) is linear.

The possibility that the apparent centripetal acceleration is actually an observation of vertical wind shear cannot be entirely discounted since the altitude of the balloon does not remain entirely constant. The total vertical change in balloon elevation is less than four thousand feet, however, and the wind shear would have the magnitude of 12 m sec^{-1} (or 23 kts) in four thousand feet, certainly a large value of the shear in regions of low wind speed.

Conclusions

1. Large-Scale Flow. The analysis of the trajectory data indicates that the observed large scale flow can be adequately represented by a steady westerly current (from 250°) at about 20 knots. Superimposed on this basic current are velocity oscillations with a somewhat smaller period and smaller amplitude than large-scale tropospheric flow. The amplitude of the corresponding horizontal oscillation is almost an order of magnitude smaller than for tropospheric motion. Unless larger velocity fluctuations with long periods occur (which can only be verified by a longer period of observation) the relative variability of these large scale winds is less than in the troposphere and is approximately the same as that determined for the stratospheric easterly winds.

The flow at sixty thousand feet again seems to differ from the higher level flow. The type of trajectory shown by flight 101 suggests that the pressure patterns in this region are small and change erratically.

2. Intermediate Scale of Motions. It is difficult to compare the magnitude and effects of intermediate scale motions with either stratospheric easterly flow or flow in the troposphere because of the limited data available. The effects of

¹Forsythe, G.E., 1949 "Exact Particle Trajectories for Non-Viscous Flow in a Plane with Constant Coriolis Parameter". J. Met., 6 p.3

intermediate scale velocity fluctuations will be appreciable for those cases with amplitude of about 2 m sec^{-1} . Since the total wind speed is low and the velocity fluctuations in the largest period of oscillations are not much larger than those with intermediate period, the separation of large and intermediate scale of motions in the stratosphere will be difficult. It is unlikely, for example, that it would ever be possible to chart these large scale stratospheric motions on a synoptic map because of high value of the "noise" produced by intermediate fluctuations (as well as the fact that the large-scale motion is relatively small compared to the spacing between meteorological observations).

3. Small-Scale Motions. The motions called small-scale would be fluctuations with periods of about 20 minutes. In the troposphere such motions would undoubtedly be attributed to thermal convection. While some correspondence between the small fluctuations in the theodolite and the film trajectories does verify the existence of such motions, the accuracy of the position fixes does not permit a determination of their magnitude.

DETERMINATION OF BALLOON ALTITUDE

The absolute altitude was computed for a number of the Texas flights, the altitude was computed in two ways:

- (1) From measurements on the down camera photographs; and
- (2) From the horizontal distance out to the film fix and the elevation angle read by the theodolite.

This latter method is only possible where accurate timing of the film was available from the telemetered record on the film.

The accuracy of both methods leaves much to be desired. The quality of the film was not uniformly good, possibly due to atmospheric haze. The cameras were not always suspended perpendicularly, which introduces an error in both methods. The altitude computation from film measurements depends directly on the accuracy

of the base map, which for the Texas area was not entirely satisfactory. Only a limited number of computations could be made by this method.

The accuracy of the second method was obviously decreased by the temporary mounting of the theodolite; the elevation angle could be seen to vary during the day from successive sun shots. Another error in this method is introduced by the fact that the exact theodolite location is known only to within about a half-mile. This could cause an elevation error of about 1000 feet in values taken early in the flight but only 500 feet error in some of the computations at greater distances out.

The results of the computation may be seen in Table III where computed absolute elevations are compared with pressure altitude.

The absolute altitude in all but one case (where it was equal) was lower than the indicated pressure altitude. A certain portion of this difference may be accounted for by the stratospheric temperatures which were lower than that assumed for the standard atmosphere. In all cases the mean temperature in the layer 100 to 50 mb was below -65° C. If this same temperature departure is maintained in the layer up to 30 mb, the elevation of the 30 mb surface would deviate in elevation from the standard atmosphere by:

$$25.3 \times 10/218 = 1.2 \text{ thousand feet}$$

(Since the height difference is 25.3 thousand feet.)

The difference between the pressure altitude and absolute elevation in flights 103, 104 and 107 is no greater than the error in absolute measurement plus the deviation from the standard atmosphere. Hence no error in pressure is detectable for these flights. The difference in the case of 110 is sufficiently large to suggest an error in pressure of about 1 mb. (The pressure reading is too low.) Flight 109 seems to be seriously in error although camera tilt and lack of telemetered data hinder a more complete check.

Table III

Computed Elevations for Some Texas Flights in Thousands of Feet

Flight Date	Frame No.	Time CST	Elev MSL Film Measurements	Elev MSL Film Fix	Press. Alt. MSL
103	122 210 313 453	10:30 12:00 13:45 16:10		79.1 78.6 78.6 77.6	81.3 80.9 79.4 79.4
104	80 143 147 187 195 253 310 363	9:25 10:26 10:30 11:12 11:20 12:20 13:20 14:15	74.0 73.3	76.1 73.6 71.9 73.8 73.6 72.9	80.9 76.7 76.7 75.4 75.4 74.8 75.1 74.8
105	118 187 242 300 323	9:50 11:05 12:00 13:00 13:23	78.4	79.6 80.6 80.6 81.3	(Project Gond.) (Cosmic Ray. Gond.) 82.1 81.3 81.3 81.3 80.9 83.5 83.4 83.8 83.8 83.2
107	108 182 254 331	10:35 11:47 13:05 14:25	82.9*	82.6 82.0 82.2	85.7 85.0 83.6 83.4
109	200		79.3**		86.7
110	133 140 208 227 235 259 280 326 374	11:03 11:10 12:20 12:40 12:48 13:10 13:30 14:20 15:10	80.7 78.9 80.3	76.6 79.8 81.2 80.8 80.2 79.8	83.2 83.2 83.4 83.2 83.3 83.2 83.8 82.9 82.9
112	425	16:46		77.3	79.0

* No calibration film, used same as 105

** Bad camera tilt

Since the stratospheric flow was quite similar in all these flights, it almost precludes the possibility of any great temperature fluctuations in a deep layer and therefore the departure from the standard atmosphere should remain almost constant during these flights. The close correspondence of the pressure altitude and absolute elevation in flight 105 therefore suggests that the pressure reading of the telemetered data was too high. On this flight a pressure reading was also made in the cosmic ray gondola and these values of pressure were lower and are therefore assumed to be correct.

Flight 112 absolute elevation was computed using the position just before blow-down. Camera tilt and lack of calibration prevented film measurement and the lack of timing on the film exclude other position checks.

Section X

THE USE OF DRY ICE AS A BALLASTING AGENT

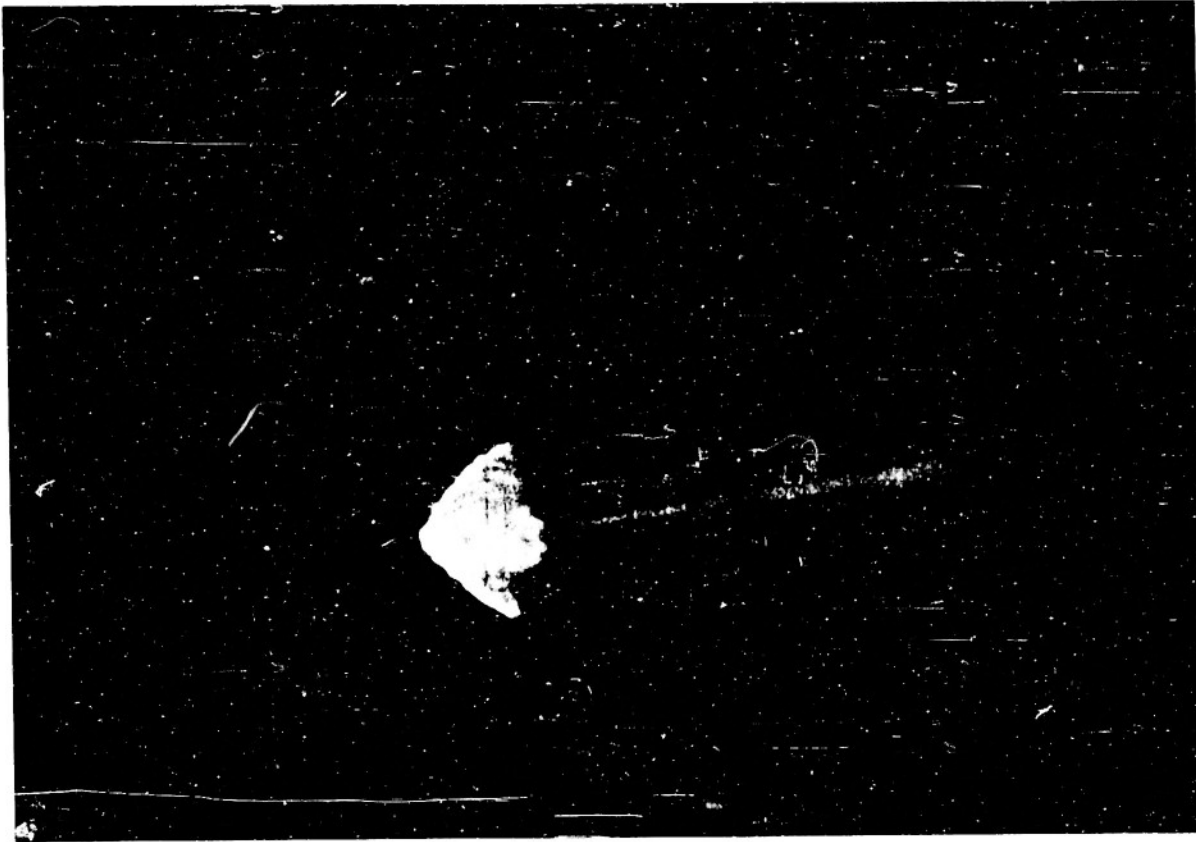
In anticipation of the fact that balloons equipped with duct type appendices would be more unstable at ceiling altitude than balloons with open bottom appendices which could take air freely on descent, some sort of ballasting seemed to be necessary. The decision was made to include on each flight a block of dry ice hung in a net bag below the gondola. The dry ice would be photographed by the down camera and the rate of evaporation could be determined. It was anticipated from previous experience that the rate would be sufficient to compensate small decreases in lift due to leakage or other sources of unbalance. This section of the report summarizes the results of the dry ice measurements during the Texas series of flights. A typical down picture showing the appearance of the dry ice hanging in the net bag is shown in Figure X-1. This photograph was taken during flight 103 from an altitude of 82,000 feet at a geographical position of 32° north latitude and 101° west longitude. The evaporation of the dry ice can be easily seen in Figure X-2 where Figure X-2a was taken shortly before the balloon reached ceiling and Figure X-2b was taken the following morning after sunrise. The amount of dry ice remaining was determined by projecting the down pictures and tracing the apparent outline of the block. The area of this tracing was determined and it was assumed that the surface area of the block was proportional to this projected area as seen in the photographs. The mass of ice was then assumed proportional to the projected area taken to the $3/2$ power. The initial weight of the block was known and a projected area was measured very close to the beginning of the flight, at which point the measurements and the actual value were normalized. Then the mass of dry ice remaining could be plotted as a function of the time of flight. These plots are given in Figure X-3a and b for all of the flights in which dry ice were included. They are very closely the same in that there is a very rapid initial loss of weight while the balloon is

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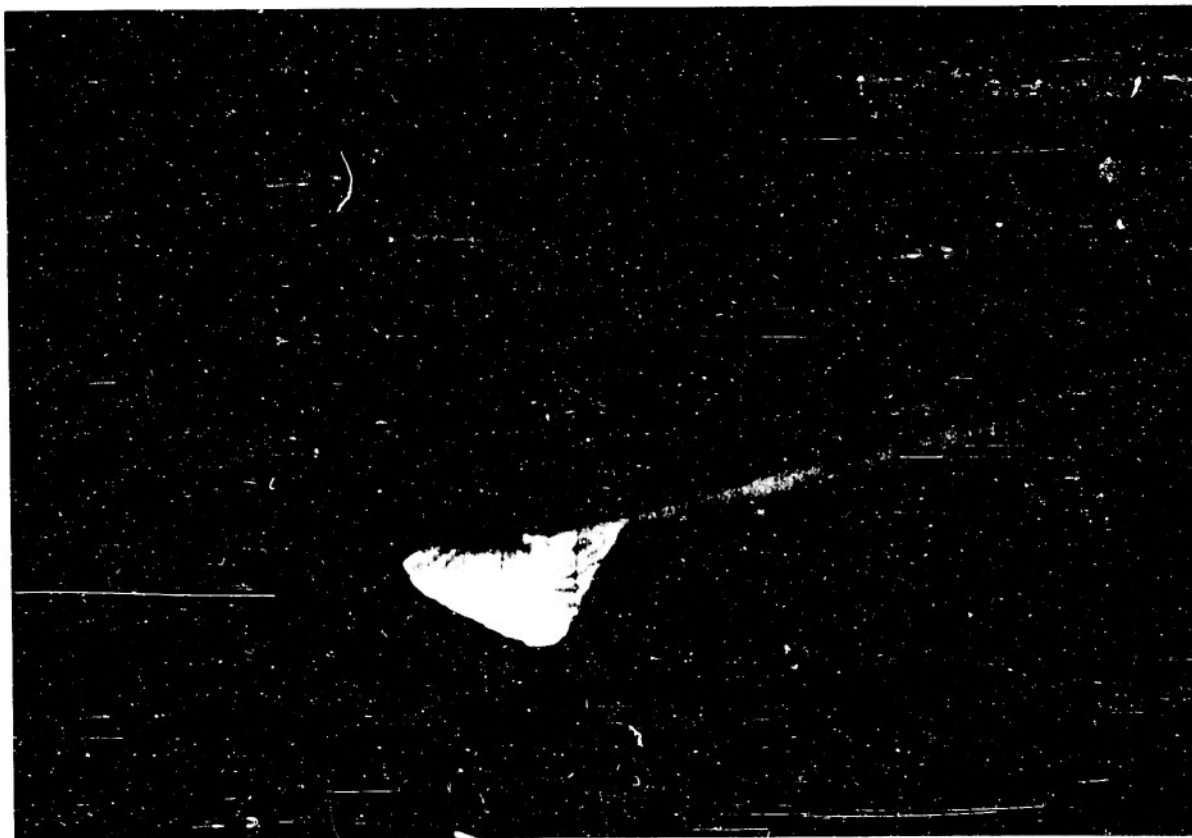
Figure X-1. A typical down picture obtained on the Texas series, flight 103, altitude 82,000 feet, 1322 CST. The white object in the foreground is the dry ice chunk hanging in a fishnet bag. Just to the right of this is the town of Sparenberg, Texas. The one mile square section lines can be used for determining the balloon altitude by referring to a calibration photograph taken before the flight. From such photographs very exact trajectories as well as balloon altitudes may be obtained. (See section IX for results of such measurements).

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0750 CST - 21 January

b



1820 CST - 20 January

a

FigFigure X-2. Comparison of the dry ice at the beginning and end of flight 102 at the times indicated under each Propicture. From such photographs the rate of evaporation of the ice was determined by assuming that the projected thearea seen in these photographs was proportionate to the surface area of the cake of ice.

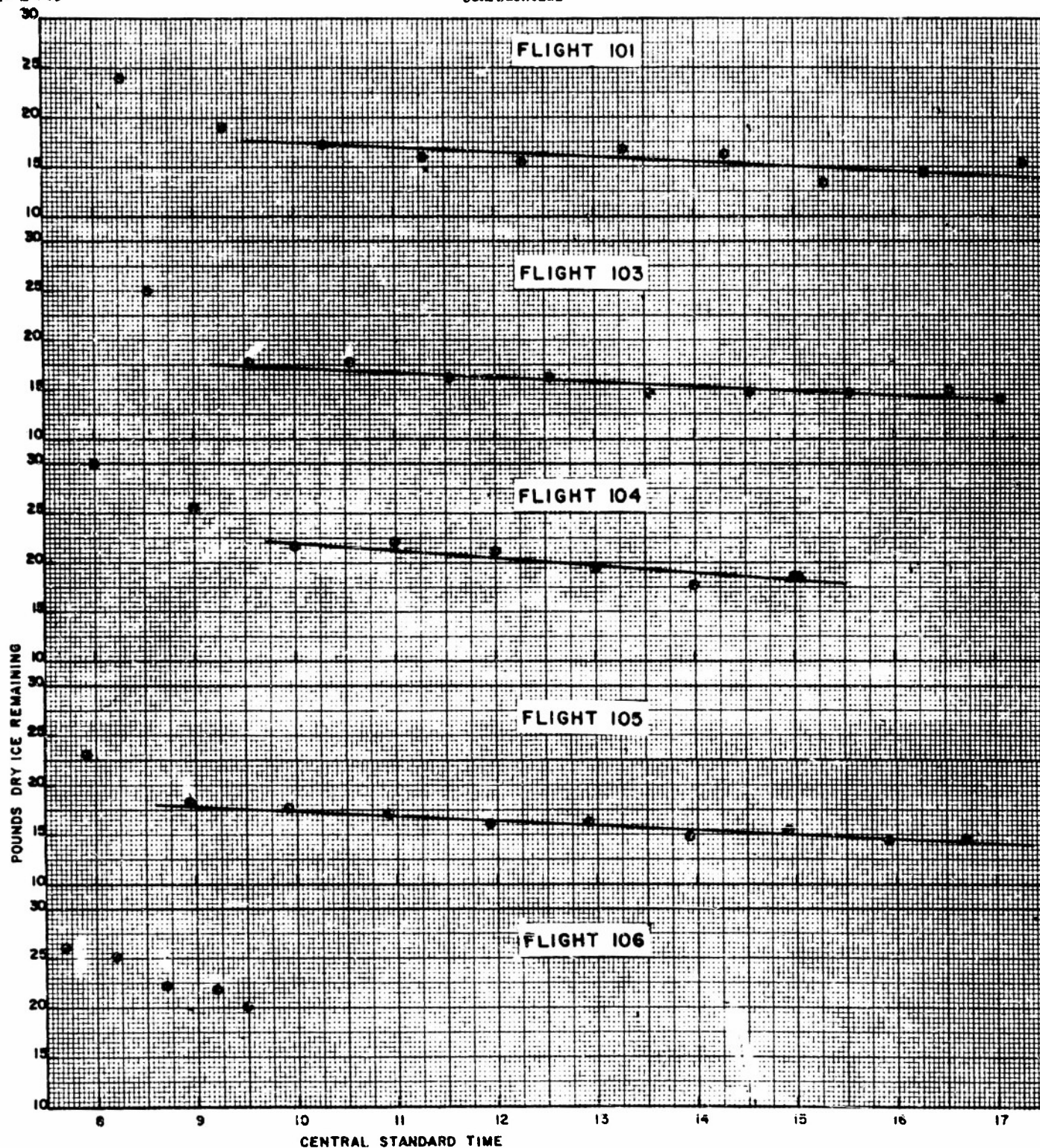


Figure X-3a. Evaporation of dry ice at high altitude. The initial rapid drop occurs at low altitude.

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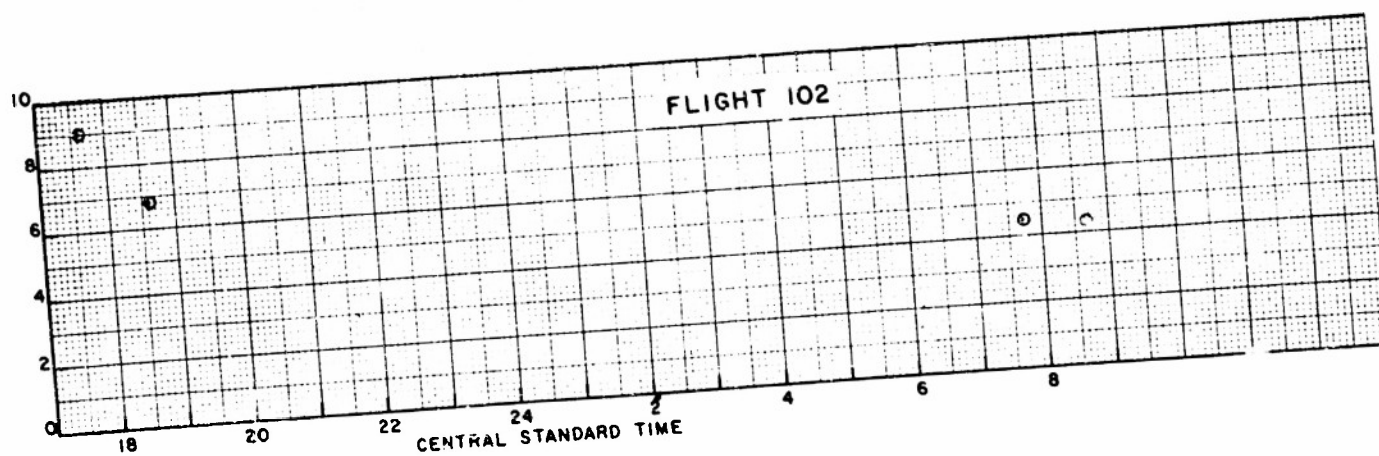
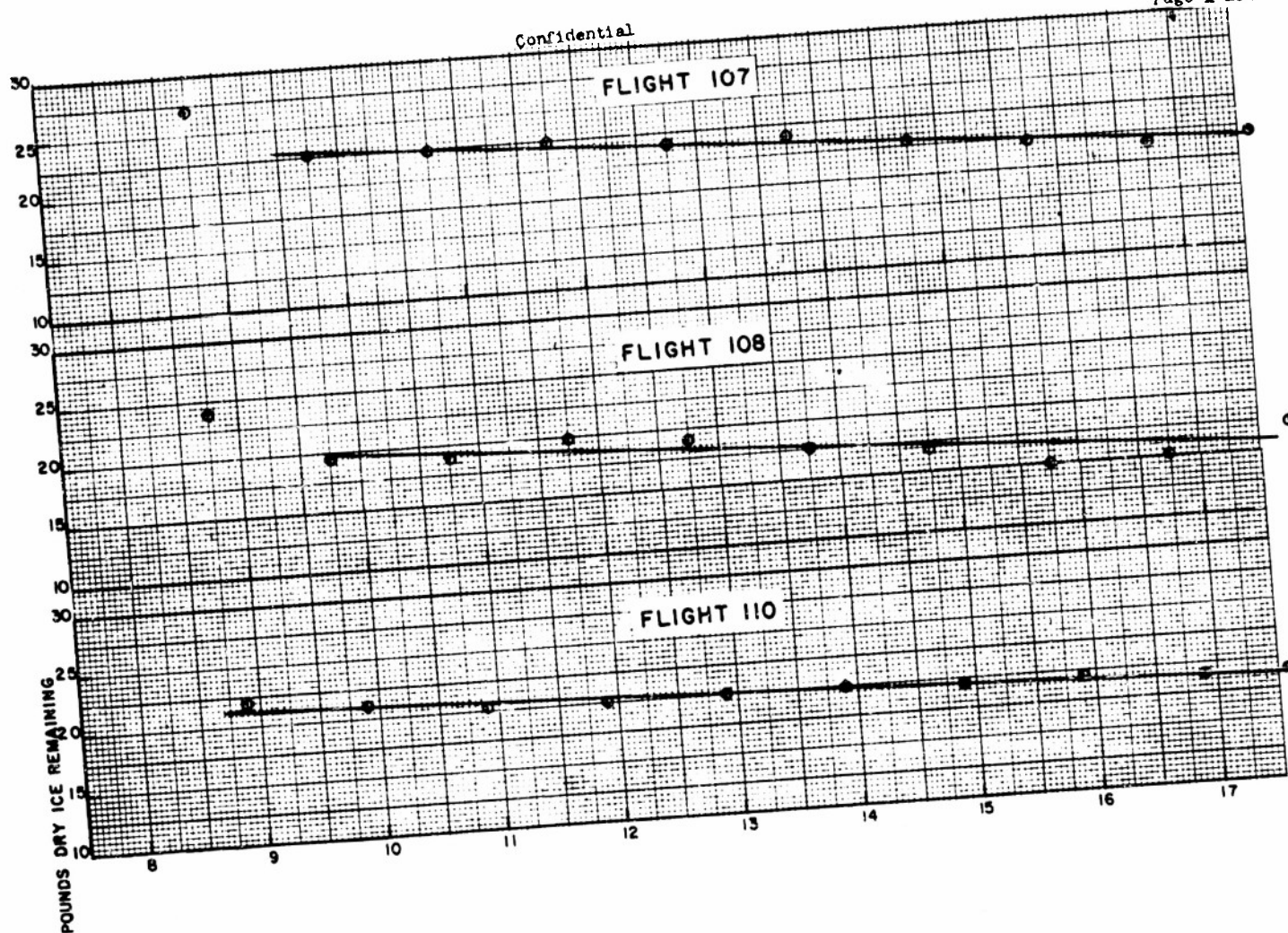


Figure X-3b. Evaporation of dry ice at high altitude.

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ascending and that during the constant level part at ceiling the rate of loss of weight is uniform but much lower. The data given on the curves are summarized in Table I. The daytime flights which had level sections between 60,000 and 85,000 feet give a mean rate of evaporation of 0.48 pounds per hour with the average mass of dry ice between 15 and 20 pounds. Flight 102 which was a night flight shows a considerably lower rate of evaporation but the mean mass was also considerably lower.

To derive an expression for the rate of evaporation so that the mass dependence may be known we assume that the rate of evaporation of mass is proportional to the surface area:

$$\frac{dM}{dt} = -C_0 M^{2/3} \quad (1)$$

Upon integrating:

$$M^{1/3} = C_1 t + C_2$$

at

$$t = 0, \quad M^{1/3} = M_0^{1/3}, \quad C_2 = M_0^{1/3}$$

and

$$M^{1/3} - M_0^{1/3} = C_1 t \quad (2)$$

$$C_0 = 3C_1$$

Using the mean rate and mass from the data

$$0.48 = 3 \cdot C_1 \cdot 17^{2/3}$$

$$C_1 = \frac{0.16}{17^{2/3}} = 0.0243$$

For this series where $\text{Av. } M_0 \approx 19.7$

$$M^{1/3} - 2.70 = 0.0243t \quad (3)$$

represents the mass as a function of time for these flights, with M in pounds and t in hours.

With the value of $C = 3 \times 0.0243 = 0.0729$ we may determine the rate for dry ice in other sizes from equation (1).

Table I
DRY ICE RATES

Flight No.	Level Altitude	W_{initial}	W_{ceiling}	T	lbs/hr rate
101	60,000	24	$17.5-14.1 = 3.4$	7 hrs	0.48
103	80,000	25	$17.1-14 = 3.1$	7 hrs.	0.44
104	75,000	25.5	$22-18.2 = 3.8$	5 hrs	0.75
105	82,000	23	$17.8-14.1 = 3.7$	8 hrs	0.46
106	-----	---	-----	-----	-----
107	85,000	27	$22.7-19.5 = 3.2$	7 hrs.	0.46
108	78,000	24	$19.6-16.1 = 3.5$	7 hrs	0.50
110	83,000	---	$21.1-18.9 = 2.2$	8 hrs	0.28
				Mean rate	0.48
				Mean mass	= 17 lbs
				Mean initial mass	= 19.7 lbs
Night flight					
102	70,000		$6.8-4.5 = 2.3$	13 hrs	0.18

$$\frac{dM}{dt} = -0.073 M^{2/3}$$

As can be seen, to meet a specific ballast rate with one block of dry ice the value of M is set. However, if many pieces may be carried, both the total M and $\frac{dM}{dt}$ may be set independently.

The evaporation rate varies with altitude, as can be seen from the high initial loss after launching. This is presumably the result of more efficient convection at low altitudes where the air density, and also temperature, are higher. The values given for the rate of loss are therefore only valid in

the range 60,000 to 90,000 feet.

The evaporation rate at night on flight 102 is 0.18 lbs/hr, somewhat lower than the value of 0.23 lbs/hr predicted by equation (1). This shows that the effect of sunlight on the dry ice is of the order of 25%. It would not be expected to be large because of the high reflectivity of the ice chunk. A large part of the visible radiation absorption may be in the net bag holding the ice cake.

The dry ice ballast has the attractive feature of a guaranteed rate of evaporation with no mechanical devices. It may be useful to compensate steady losses in lift such as gas leakage. The fact that the rate of ballasting is higher at lower altitudes is in the direction of producing stability in a balloon. system and may be worthy of further investigation.

Section XI

CHARACTERISTICS OF TIME-ALTITUDE CURVES

Recent studies on the HAB balloon flight program have lead to the conclusion that the characteristics of the time-altitude curve cannot be explained without invoking rounding of the balloon relative to the air in the daytime as it ascends to higher altitudes. The details of the altitude warming and the experiments which lead to a direct measurement of it will be reported elsewhere but this idea has a bearing on the characteristics of the time altitude curves for the Texas flights. It has been shown by other means that analysis of time-altitude curves that in the daytime, a polyethylene balloon of 2-mils thickness and with a single set of tapes will acquire something like 7% free lift by the time it has reached the stratosphere provided that it is weighed off neutral on the ground. One consequence of this altitude warming is that if a balloon is weighed off and is able to rise at all near the ground it should be able to reach ceiling provided that it does not intake air. Therefore a balloon equipped with a duct such as the Texas series should be able to reach ceiling in the daytime provided it takes off at all. In many of the Texas flights in addition to the altitude warming there was some evaporation of dry ice on the way up which leads to a small additional increase in lift on the order of 1%. This, however, is small compared to the warming with altitude which occurs for natural reasons. In order to determine quantitatively the magnitude of the warming with altitude, it is necessary to know precisely what the drag of the balloon is at a given rate, what the lapse rate of the atmosphere is and what the absolute temperature is. These data together with the rate of rise measured from the time-altitude curve can be used by means of nomographs which are included in this report to determine the free lift of the balloon at each point in its time altitude curve.

The warming with altitude produces the characteristic of the time-altitude curve, that the balloon steadily speeds up until it reaches the tropopause. At this

point the thermodynamic drag increases and remains constant throughout the stratosphere and presumably the warming with altitude ceases although at altitudes above 100 mb the warming has not been directly measured but only inferred from the time altitude curve. The normal characteristic of the time-altitude curve then is an increasing rate of rise to the stratosphere and then a slight decrease or a leveling off of the rate of rise. All of the Texas flights showed this type of behavior. The free lift which was very accurately measured in the Texas series usually amounted to something like 30 pounds free lift with air displaced on the order of 500 pounds. It is believed that the free lift could have been reduced very appreciably and apparently was very much less than this on flight 111, which took off with an initial rate of rise of about 240 feet/minute. Also because of the altitude warming one would like to avoid too high an initial free lift because in the stratosphere with the additional free lift obtained from altitude warming the rate would be excessive and the balloon might not be able to valve its gas. This apparently is what happened on our first flight, flight 101 in which the balloon acquired a high rate of rise by the time it reached ceiling, apparently tore a hole in the balloon near the bottom, descended rapidly until it took air through this hole and then floated level for a long period of time.

To show the magnitude of the altitude warming there is included in this report, a computation sheet for altitude warming on flight 111. The nomographs used to convert rate of rise to thermodynamic and aerodynamic drag, and a graph of the gain in free lift as a function of altitude on this flight is compared with that directly measured on a day flight on the HAB contract made in the summertime at Minnesota. These conditions which should be approximately equivalent to winter conditions at Pyote AFB. It can be seen that the agreement between the directly measured warming period and the warming for flight 111 inferred from the time-altitude curve is quite adequate and it should be considered that the warming with altitude is an effect

which has been experimentally demonstrated and which should be taken into account when making balloon flights.

COMPUTATION SHEET FOR ALTITUDE WARMING

Flight No. 111

Date February 1, 1953

Time of Launch 1410 CST

Location Pyote AFB, Texas

Extrapolated
Weigh-off 2.1%

Air Displaced 508

Temp	Pressure Altitude	Rate of Rise	Lapse Rate	Aero Drag	Thermo Drag	Total Drag	Altitude Warming
275°	800	240	-1.95	.45%	2.3%	2.75	.65
257°	566	330	-1.95	.79	2.95	3.74	1.64
241°	400	460	-1.95	1.40	4.1	5.50	3.40
225	283	560	-1.95	1.90	5.1	7.00	4.90
218	200	680	-1.95	2.45	6.1	8.55	6.45
218	141	540	-.14	1.40	8.4	9.80	7.70
218	100	540	-.14	1.25	8.4	9.65	7.55
218	70.7	540	-.14	1.10	8.4	9.50	7.40
218	50	540	-.14	.99	8.4	9.39	7.29
218	35.4	540	-.14	.86	8.4	9.26	7.16

Figures XI-1 and XI-2 which follow are, respectively, thermodynamic and aerodynamic drag nomographs. Figure XI-3 is a graph of the gain in free lift as a function of altitude on this flight as compared with that directly measured on a day flight on the HAB contract made in the summertime in Minnesota.

THERMODYNAMIC DRAG NOMOGRAPH

- G - AIR DISPLACED IN POUNDS
- T - AIR TEMPERATURE
- $L = \frac{dT}{dz}$ - ATMOSPHERIC TEMPERATURE GRADIENT
- V - RATE OF RISE IN FEET/MINUTE
- P - PERCENT THERMO-DRAG OF AIR DISPLACED
- THERMO-DRAG COEFFICIENT FROM FLIGHT SO



Confidential Security Information

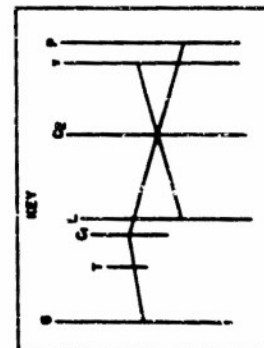
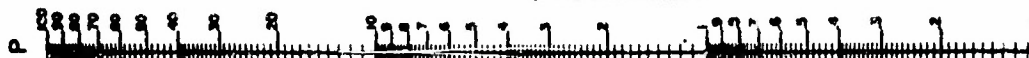
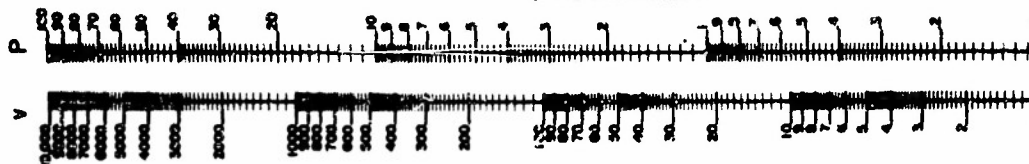


Figure XI-1



Confidential

DEPT. OF PHYSICS		U. OF MINN.	
BALLOON PROJECT		SECT. 8 & 1	
DWG. NO.	540P DWG. NO.	ISSUED BY	ISSUED IN DATE
21-8P-253			8-28-53
THERMODYNAMIC DRAG		MOD. 1	MOD. 2
		MOD. 3	

CONFIDENTIAL
SECURITY INFORMATION

AERODYNAMIC DRAG NOMOGRAPH

P = PRESSURE IN MILLIBARS (ASSUMES STANDARD ATMOSPHERE)
 P = PERCENT AERODYNAMIC DRAG OF AIR DISPLACED
 V = RATE OF RISE IN FEET/MINUTE
 G = AIR DISPLACED IN POUNDS

DRAG COEFFICIENT FROM FLIGHT SO

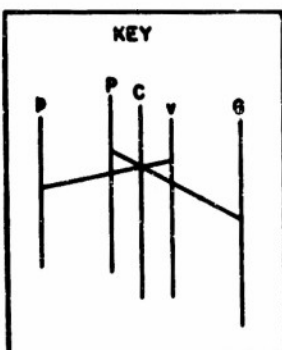
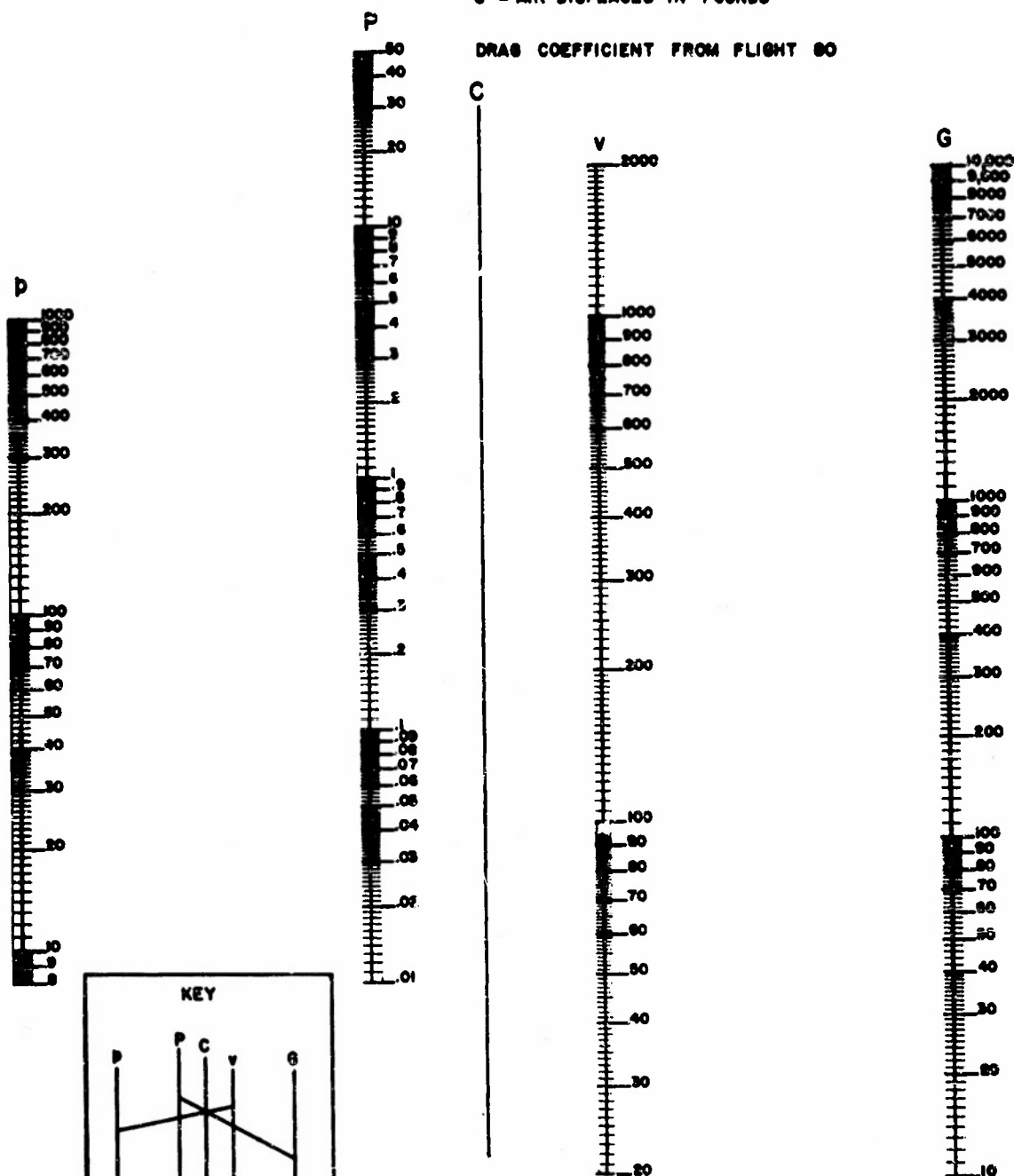
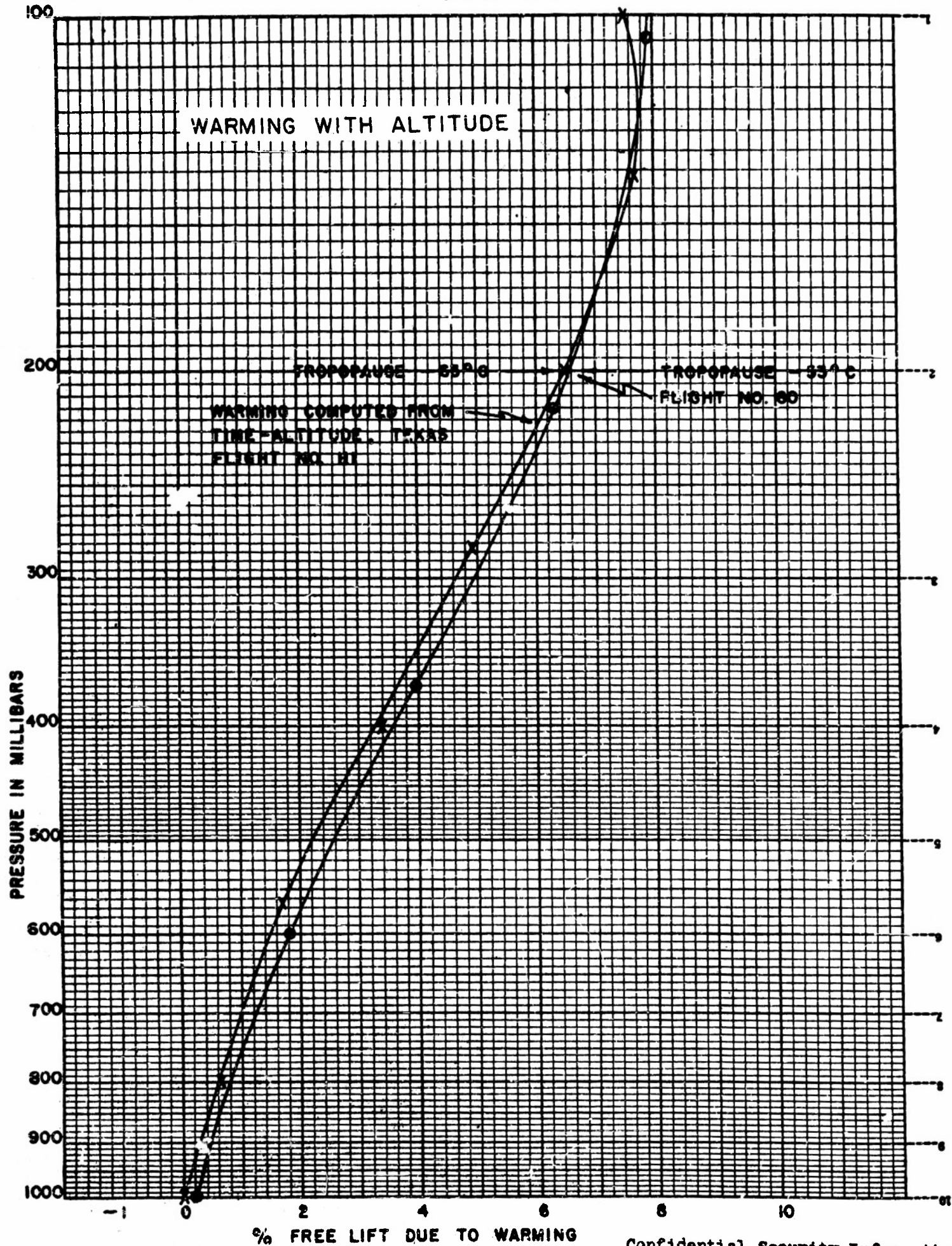


Figure XI-2

CONFIDENTIAL
 SECURITY INFORMATION

DEPT. OF PHYSICS U. OF MINN.		BALLOON PROJECT			SECT. 8 & T
DWG. NO.	SHOP DWG. NO.	DRAWN BY	CHECKED BY	DATE	
ES-RP-252		27		8-22-52	
AERODYNAMIC DRAG NOMOGRAPH			MOD. 1		
			MOD. 2		
			MOD. 3		

100

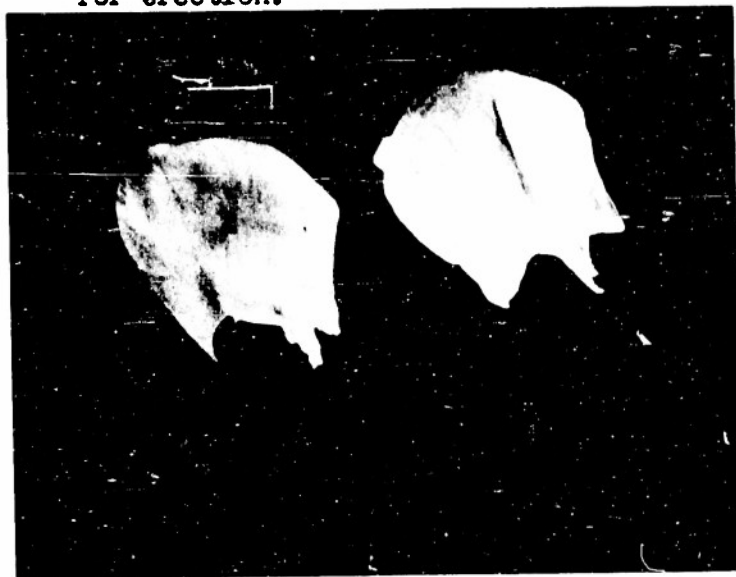




A. One twin erected. 2nd twin ready for erection.



B. Weigh-off



C. Launch and beginning of gas transfer.



D. Gas transfer continuing.



E. Gas transfer continuing.



F. Gas transfer nearly complete.

Figure XII-1. Sequence during twin launch. The balloons remained together as in 106 until an altitude of about 40,000 feet. At this time 107 passed over 108 and photographed it in the down camera. See Figure XII-2.



Figure XII-2. Photograph of the top of the balloon on flight 107. Altitude: 45,000 feet. In the immediate foreground can be seen the cake of dry ice hanging from 107 enclosed in its mesh bag. On the balloon in flight 107, below, can be seen the dust appendix coming out of the top of the balloon and the various folds in the balloon which at this altitude is only partially full.