1. I.C.E. Chassay SE4

TO: B. French/W. E. McAllum, SE4	DATE: 6. 11/13/81
FROM: G.W. Belshaw, Project Engineer	CONTRACT: NAS9-15629 5.

SUBJECT: Life Sciences Passive GN_2 Freezer Thermal Performance Test Summary

2.

NASA-CR-167546

SUMMARY

The purpose of this report is to summarize the thermal performance testing that has been conducted on the Life Sciences Passive GN_2 Freezer project as well as discuss the improvements to the freezers to improve the thermal performance of the containers.

Procedures were developed, based upon these tests, to initially charge the freezers with LN_2 and verify that the freezer performance will be adequate for the mission duration.

Improvements were made to the Corvac sample tube to limit the amount of breakage due to thermal expansion of the liquid during freezing.

A method of verifying the freezer vacuum insulative integrity was defined as well as a procedure for refurbishment of the internal vacuum level. Freezer modifications were made to ease the re-evacuation of the containers.

It was also determined that the orientation of the freezer in a 1-G environment, after being charged, had to remain in a vertical position. The LN_2 boiloff rate increased significantly in a horizontal position. This resulted in a stowage definition in the spacecraft prior to launch.

Functional testing, using the SL-1 mission timeline showed that the freezer will maintain samples in the frozen state for the duration of the mission.

In general, confidence has been established that the passive GN_2 freezer performance is consistent, predictable and will satisfy the mission requirements.

INTRODUCTION

The Life Sciences Passive GN_2 freezer is constructed by Cryogenics Associates (CA) of Indianapolis, Indiana. Four (4) freezers received from CA have been utilized in the testing and evaluation.

The passive GN_2 freezer, as shown in the sketch of Figure 1, is a vacuum insulated container with an inner container lined with a calcium silicate absorbant material. The screw-on cap contains a urethane foam neck plug to reduce heat leakage through the cap.

GENERAL ELECTRIC

4.

Charging of the freezer is accomplished by filling the center container with LN_2. As the LN_2 boils, the container is maintained full for a period of 24 hours. During this period, approximately 12 pounds of LN_2 is absorbed by the calcium silicate.

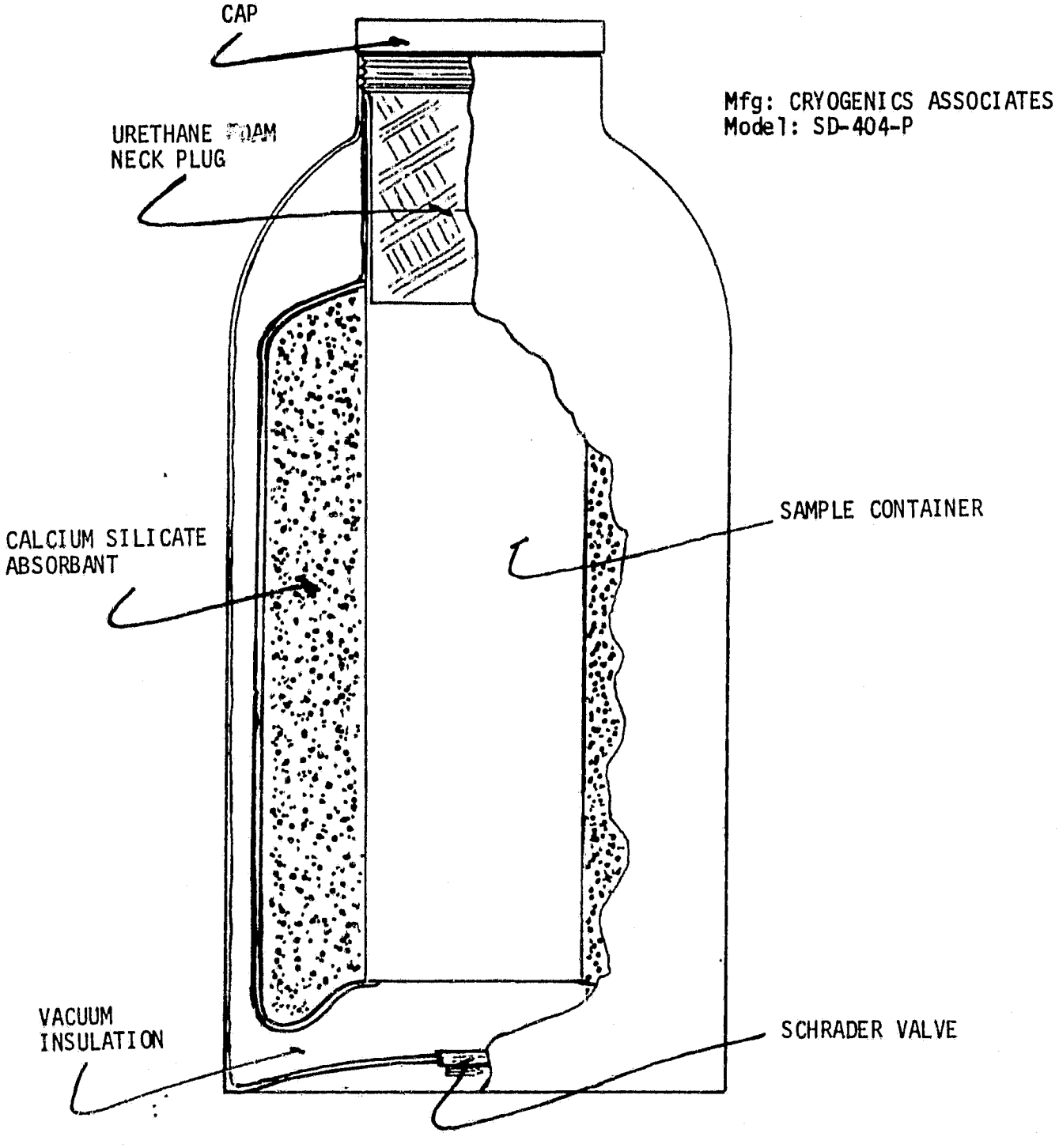
At the end of the charging period, the LN_2 in the center cylinder is poured out of the container, leaving the center cylinder dry. The absorbed LN_2 will then boiloff at a constant rate, based upon the amount of heat leakage into the container, maintaining the internal cylinder temperature at approximately LN_2 temperature (-195°C, -230°F).

The LN_2 boiloff rate can be easily determined by measuring the weight loss of the container with time.

During the time period between February, 1980 and the present, a total of six (6) tests were conducted on the containers. Table 1 presents a summary of the testing configurations and general results. All units, with the exception of one, were tested more than once.

The following are copies of the original test reports for the six tests conducted. They provide the details of each test, samples used, and test results.

George W. Belshaw



LIFE SCIENCES PASSIVE GN_2 FREEZER

FIGURE 1

LIFE SCIENCES PASSIVE GN_2 FREEZER TEST SUMMARY

TEST NO.	DATES	SERIAL NO.	TEST DURATION (HRS)	BOILOFF RATE (#/HR)	NO. OF SAMPLES	LOCKER USED	SAMPLE HOLDER USED	EXPERIMENT HOLDER USED	INITIAL DRY WEIGHT
1	2/26/80 - 3/6/80	1358-79	200	.045	36	NO	NO	NO	14.06#
2	11/17/80 - 11/26/80	1359-79	200	.054	36	NO	NO	NO	13.625#
3	12/1/80 - 12/12/80	987-80	200	.064	6+ESA	NO	-	YES	14.42#
		988-80	216	.050	36	NO	YES	-	14.52#
4	1/27/81 - 2/17/81	988-80	312	.046	NO	NO	NO	NO	14.52#
5	2/26/81 - 3/9/81	988-80	144	.049	6+ESA	YES	-	YES	14.52#
6	8/10/81 - 9/2/81	1358-79	336	.044	NO	No	NO	NO	14.21#
		1359-79	144	.045	6+ESA	NO	-	YES	13.86#

TABLE 1

TO: D. R. White, SE4	DATE: 8/12/80
FROM: G.W. Belshaw, Project Engineer	CONTRACT: NAS9-15629
SUBJECT: Life Sciences GN_2 Passive Freezer Thermal Performance Test Report	

Enclosed are four (4) copies of Test Report No. PETX177 documenting the testing performed at JSC to evaluate the thermal performance under a simulated mission timeline condition of the Cryogenic Associates Model SD-404-P GN_2 Passive Freezer.

George W. Belshaw

GENERAL ELECTRIC

LIFE SCIENCES GN_2 PASSIVE FREEZER

THERMAL PERFORMANCE TEST

GENERAL ELECTRIC

SPACE DIVISION

HOUSTON, TEXAS

UNDER CONTRACT: NAS9-15629

REPORT NO. PETX177

LIFE SCIENCES GN_2 PASSIVE FREEZER

PERFORMANCE TEST REPORT

AUGUST, 1980

Prepared by: George W. Belshaw
Project Engineer
General Electric Company

Under contract: NAS9-15629

SUMMARY

This report provides the results of testing performed at NASA Johnson Space Center (JSC) to evaluate the thermal performance of the Cryogenic Associates Model SD-404-P GN_2 freezer. Results indicate that the freezer will provide freezing capability for an eight day period for the sample insertions timeline investigated. Significant sample breakage did occur due to thermal expansion during freezing and should be investigated further.

PURPOSE

The purpose of the testing was to evaluate the thermal performance of the Cryogenic Associates (CA) Model SD-404-P GN_2 freezer under simulated mission timeline conditions. All prior testing had been done with the freezer empty and the passive freezer life is reduced by the insertion of samples to be frozen.

It was required to determine the freezer life maintaining the internal temperature below -10°C (14°F) with insertion of samples into the freezer.

TEST CONFIGURATION AND SET UP

Two (2) freezers were received by JSC from CA (Serial numbers 1358-79 and 1359-79). Both containers had been tested empty by CA prior to shipment and these test reports are presented in Figures 1 and 2.

The unit to be tested at JSC was 1358-79. Two thermocouples were inserted through the cover and located as shown in Figure 3.

Thirty six (36) 15 ml Venoject vacuum blood collection tubes, filled with a water/sodium heparin solution were utilized for the test. These tubes were filled to a level as shown in Figure 4.

The freezer test timeline to be utilized is shown in Figure 5. Three sample insertion periods were established to include 12 samples at approximately

24 hours, 6 samples at approximately 72 hours and then 18 samples at approximately 144 hours. These samples were to be placed in plastic bags and inserted into the freezer.

The freezer container was placed on a scale and the weight of the freezer was monitored throughout the test period. An initial container dry empty weight of 14.06# was recorded.

The freezer was then filled with LN_2 and allowed to stand. During the charging period it was required to maintain the LN_2 level for a period of approximately 24 hours. This would allow for the absorbant material in the freezer to become charged with LN_2.

The level of LN_2 within the freezer was maintained at a level approximately 2" below the fill level for the period.

The LN_2 was poured out at 0900 2/26/80 and the weight was recorded at 25.75#. This weight is .36# less than that recorded by CA during their testing (Figure 1) and was due to the low level of LN_2 within the freezer during the charging period.

TEST RESULTS

During the testing period the freezer internal temperature and total weight was monitored at regular intervals.

Testing began at 0900 2/26/80 with internal temperatures at -314°F (-192°C) and -308°F (-189°C). The initial weight was 25.75#.

Figure 6 presents the temperature-time history of the freezer during the testing period. Figure 7 presents the freezer total weight of the freezer during the period.

At 0912 2/27/80 (24 hr) 12 room temperature samples were placed in a plastic bag and this weight recorded at .821#. The freezer was opened and the samples placed into the freezer. Figure 8 presents the thermal response of the internal portion of the freezer during this period. It should be noted that when the freezer was opened the thermocouples had to be removed also. The internal temperature returned to LN_2 temperature level after approximately 2 hours. The freezer remained open for a period of approximately 2 minutes.

Again at 0920 (72.5 hrs) 2/29/80 the freezer was opened and 6 samples of weight .39# was inserted into a bag containing the original 12 samples. The first 12 were removed and all 18 were placed in a new plastic bag due to breakage of the first bag. At LN_2 temperature the plastic bag is extremely fragile and was destroyed upon removal. The freezer remained open for a period of 2 minutes during this period. Figure 9 presents the temperature response during this insertion period and the freezer recovery.

At 0833 3/3/80 (143 hours) the freezer was again opened and 18 additional samples of weight 1.21# were placed in a plastic bag and inserted into the

freezer above the original 18. This insertion almost completely filled the internal portion of the freezer. As before, the insertion period was approximately 2 minutes and the thermal recovery is shown in Figure 10.

Thermal decay began to occur at approximately 1400 3/4/80 (170 hours) at which point the freezer weight was 16.875# or approximately 5 oz of LN_2 remaining. Temperatures continued to rise as shown in Figure 11 until the test was terminated at 1700 3/5/80 (200 hours) with the freezer internal temperatures ranging between -8°F and -25°F (-22°C and -32°C).

It was estimated that the testing limits would be reached within 2 hours after termination of testing and would result in a total decay time of 32 hours.

The container remained closed until 0830 3/7/80 at which time the samples, now completely thawed, were removed.

Upon removal of the plastic bags, there were several samples that were broken. Each bag contained 18 samples and the upper bag had seven (7) unbroken tubes. The lower bag had only two (2) unbroken tubes.

This breakage was due to the thermal expansion of the liquid during freezing.

CONCLUSIONS

The CA GN_2 freezer maintained temperatures of 36 samples below test limits for a period of approximately 200 hours. If the initial charging had been to

the 26.11# level instead of 25.75#, the time would be extended by approximately 8 hours since the static boiloff rate was calculated to be .045 #/hr which remained fairly consistent throughout the testing.

The breakage of the sample tubes needs to be investigated and sample tubes need to be utilized that will withstand the LN_2 temperature and the rapid freezing rates.

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Rec'd 12/18/79

CRYOGENIC ASSOCIATES
6565 Coffman Road
Post Office Box 68443
Indianapolis, Indiana 46268

CA. 407-19

JSC TEST UNIT #6

MODEL # SD-404-P

SERIAL # 1358-79

EMPTY WEIGHT 14.06

EVAPORATION RATE .468 Kgs/DAY.

DATE	TIME	WEIGHT	REMARKS
11-27-79	2:36P	31.22	3½" Dia. Bore is Full
11-27-79	5:00P.	26.11	Bore Dumped 11.89 Kgs
11-28-79	7:04 A	25.63	$\frac{.48}{14.06}$ = .819#/DAY = .46 Kg/DAY = 14.73 DAYS
11-28-79	1:10P	25.38	$\frac{.69}{24.266}$ = .88#/DAY = .494 Kg/DAY = 13.72 DAYS
11-29-79	7:20 A	24.74	
11-30-79	7:00 A.	23.87	$\frac{.87}{23.666}$ = .80#/DAY = .495 Kg/DAY
12-3-79	7:05 A	21.38	$\frac{2.49}{72.06}$ = .824#/DAY = .465 Kg/DAY
12-4-79	7:40 A.	20.46	$\frac{.92}{24.583}$ = .898#/DAY = .504 Kg/DAY
12-5-79	7:13 A	19.60	$\frac{.86}{23.550}$ = .876#/DAY = .492 Kg/DAY
12-6-79	7:55 A.	18.69	$\frac{.91}{24.700}$ = .844#/DAY = .496 Kg/DAY : 15.01 DAYS AVG.
12-6-79	5:00 P.	18.34	$\frac{.35}{9.083}$ = .924#/DAY = .519 Kg/DAY END OF 10 DAY TEST.

TEST CONDUCTED BY: D. Fish

CUSTOMER NASA

TYPE OF INSULATION SUPER INSULATION

NUMBER OF WRAPS 45

METHOD APPLIED

TRUNION No

WITNESS:

EVALUATION PROCEDURE: 1 DAY RAISING 3 DAY ACT. PUMP.

12-7-79	8:30 A.M.	17.80	.034 #/HR = .015 Kg/HR = .469 Kg/DAY
12-10-79	7:16 A.M.	15.27	.035 #/HR = .0204 Kg/HR = .481 Kg/DAY
12-10-79	4:46 P.M.	14.95	
12-11-79	8:18 A.M.	14.37	$\frac{.58}{15.533}$ = .037 #/HR = .869 #/DAY = .503 Kg/DAY
12-11-79	2:50 P.M.	14.18	EMPTY

FIGURE 1

RECD 12/18/79

WEIGHT OF BLOOD TUBE RACKING DEVICE & SPACER — 391 GMS FOR RAY HOOKER 2/15/80

CRYOGENIC ASSOCIATES
6565 Coffman Road
Post Office Box 68443
Indianapolis, Indiana 46268

CA .407-19

MODEL # SD-404-P

SERIAL # 1359-79

EMPTY WEIGHT 13.82

EVAPORATION RATE .480 AVG #/DAY

DATE	TIME	WEIGHT	REMARKS
11-26-79	2:35 p.m.	31.61	3.5" DIA. BORE IS FULL
11-27-79	5:02 P	25.47	PUMPED BORE. 11.58
11-28-79	7:02 A	24.92	$\frac{5.5}{14.00}$ .942 #/DAY = .52 #/DAY 12.37 DAYS
11-28-79	1:11 P.	24.68	
11-29-79	7:21 A	24.06	$\frac{.86}{24.316}$ = .848 #/DAY = .476 #/DAY 13.7 DAYS
11-30-79	7:00 A	23.20	$\frac{.86}{23.650}$ = .872 #/DAY = .490 #/DAY
12-3-79	7:07 A	20.67	$\frac{2.53}{72.116}$ = .841 #/DAY = .473 #/DAY
12-4-79	7:40 A.	19.81	$\frac{.86}{24.550}$ = .840 #/DAY = .472 #/DAY
12-5-79	7:13 A	18.95	$\frac{.86}{23.550}$ = .876 #/DAY = .492 #/DAY
12-6-79	7:55 A.	18.05	$\frac{.90}{24.700}$ = .874 #/DAY = .491 #/DAY
12-6-79	5:00 P.	17.75	$\frac{.30}{9.083}$ = .792 #/DAY TEST CONDUCTED BY: = .445 #/DAY END OF 10 DAY TES

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CUSTOMER NASA — A Fish

TYPE OF INSULATION SUPER INSULATION

NUMBER OF WRAPS 45

METHOD APPLIED

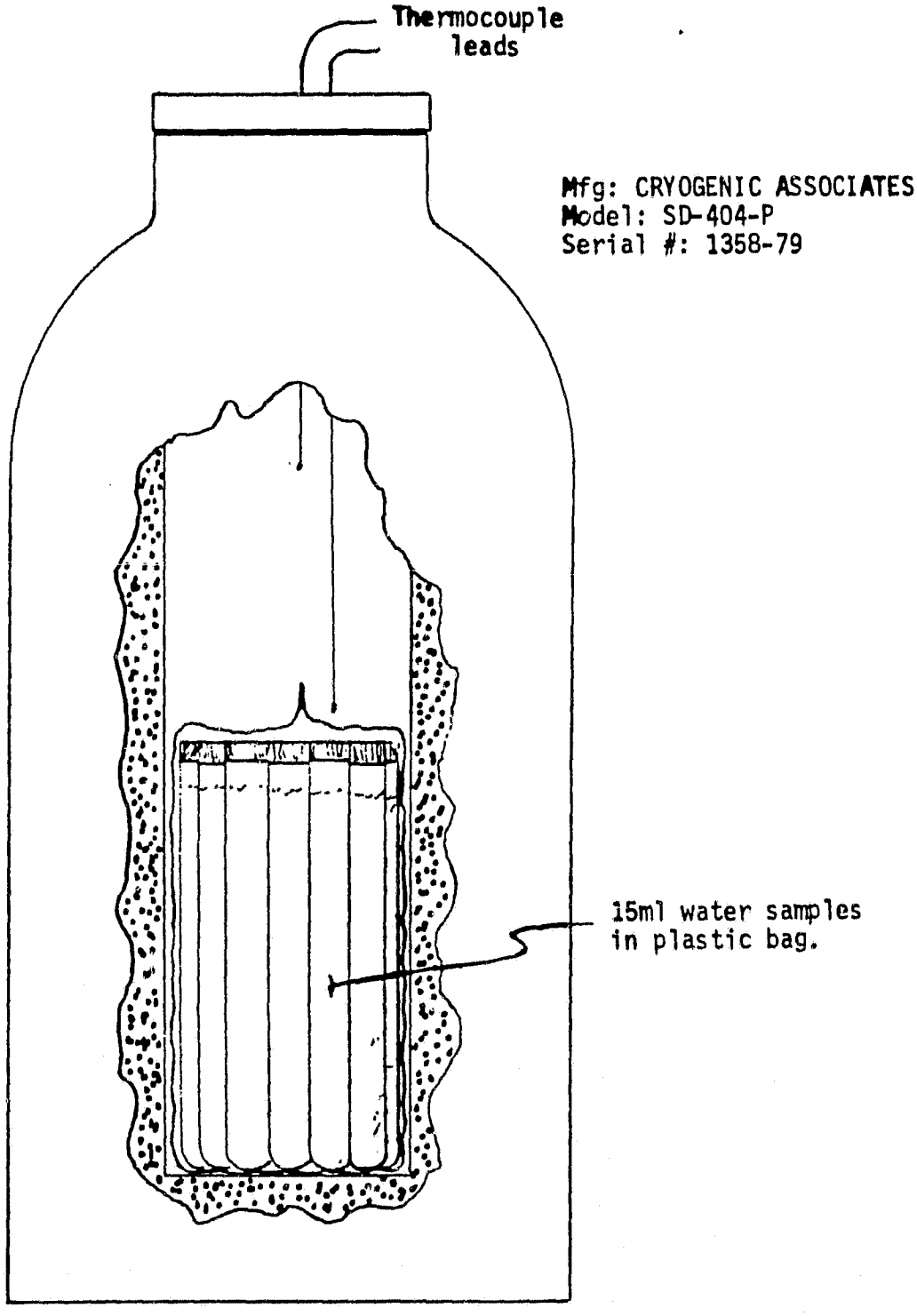
TRUNION No

WITNESS:

EVALUATION PROCEDURE 1 DAY ROUGHING 3 DAY DIFF. PUMP.

12-7-79	8:25 A.M.	17.21	.034 #/HR. .019 #/HR. .469 #/DAY
12-10-79	7:21 A.M.	14.70	.035 #/HR. .019 #/HR = .477 #/DAY
12-10-79	4:46 P.M.	14.37	
12-11-79	8:19 AM	13.93	$\frac{.40}{15.550}$ = .028 #/HR = .679 #/DAY = .381 #/DAY
12-11-79	2:50 P.M.	13.82	EMPTY

FIGURE 2



PASSIVE GN_2 FREEZER TEST CONFIGURATION

FIGURE 3

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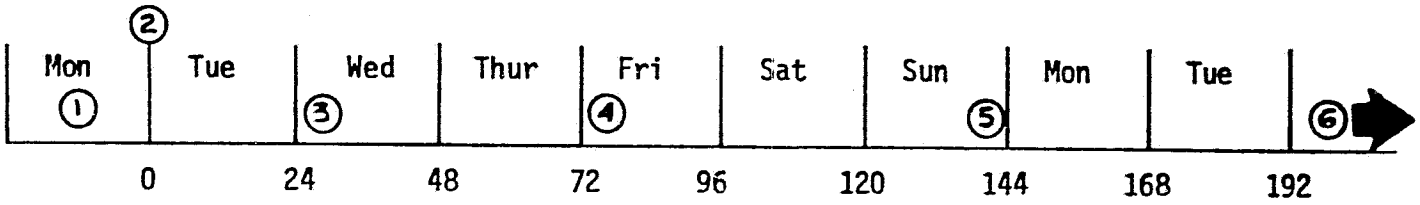
FIGURE 4

-195°C PASSIVE GN_2 FREEZER SAMPLE INSERTION TIMELINE



NOTES:

① Prepare freezer for test start

② Test Start 0900 Tuesday - LN_2 poured off and weight recorded

③ 12 Glass tubes inserted at 0915 Wednesday (Sample # 1)

④ 6 Glass tubes inserted at 0920 Friday (Sample # 2)

⑤ 18 Glass tubes inserted at 0830 Monday (Sample # 3)

⑥ Continue test until inside temperature reaches -10°C (14°F)

FIGURE 5

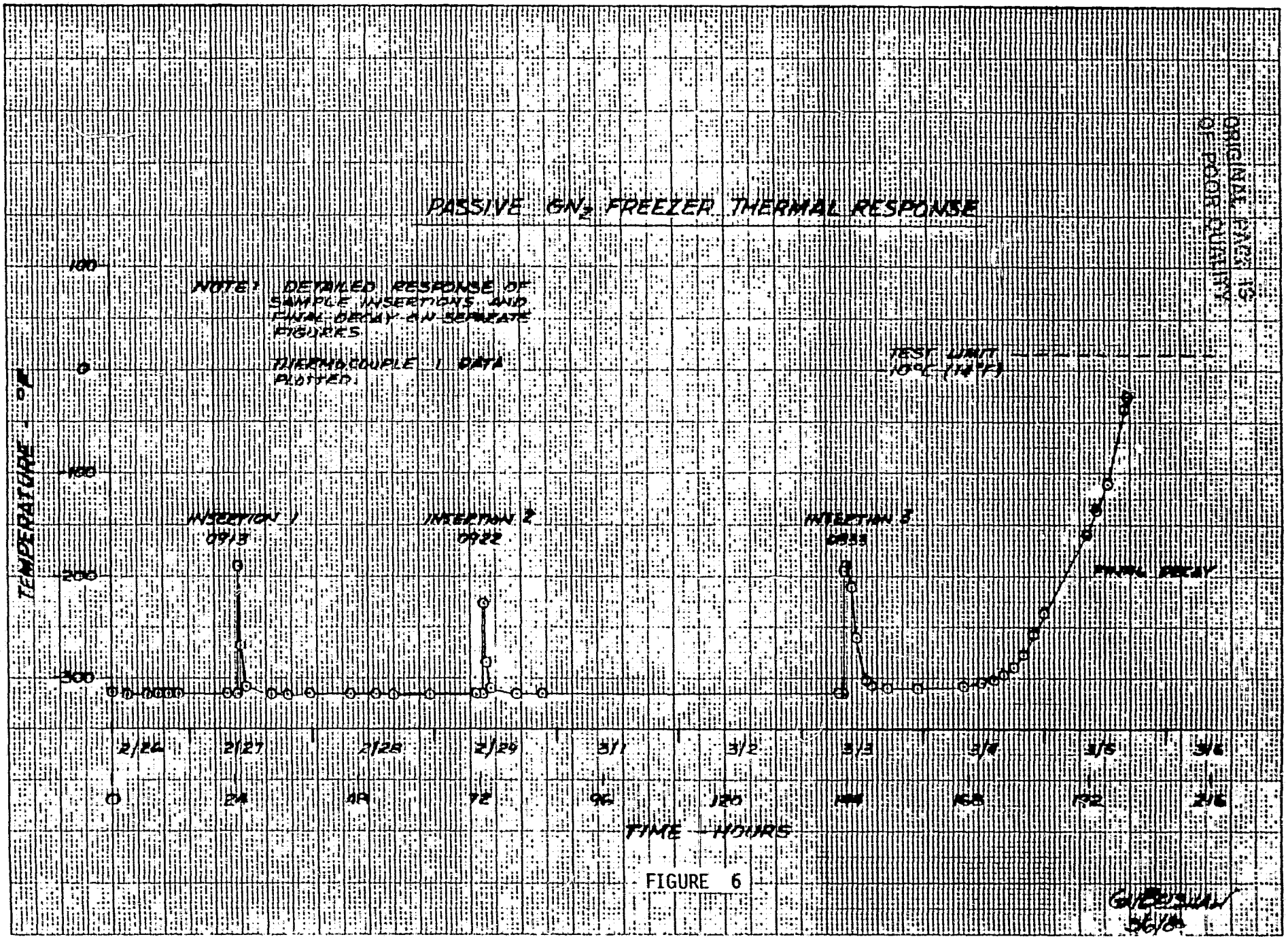


FIGURE 6

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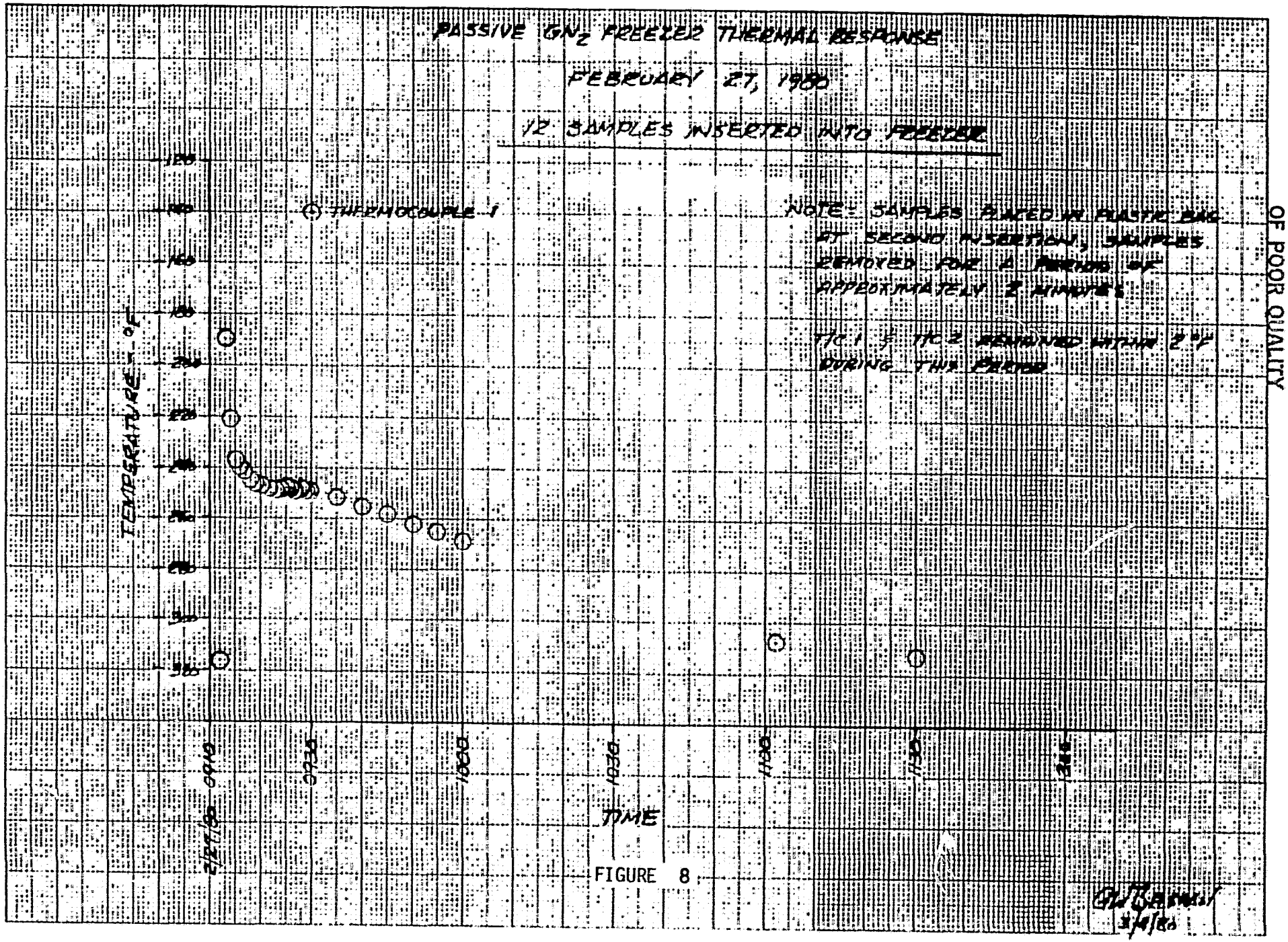

FIGURE 8

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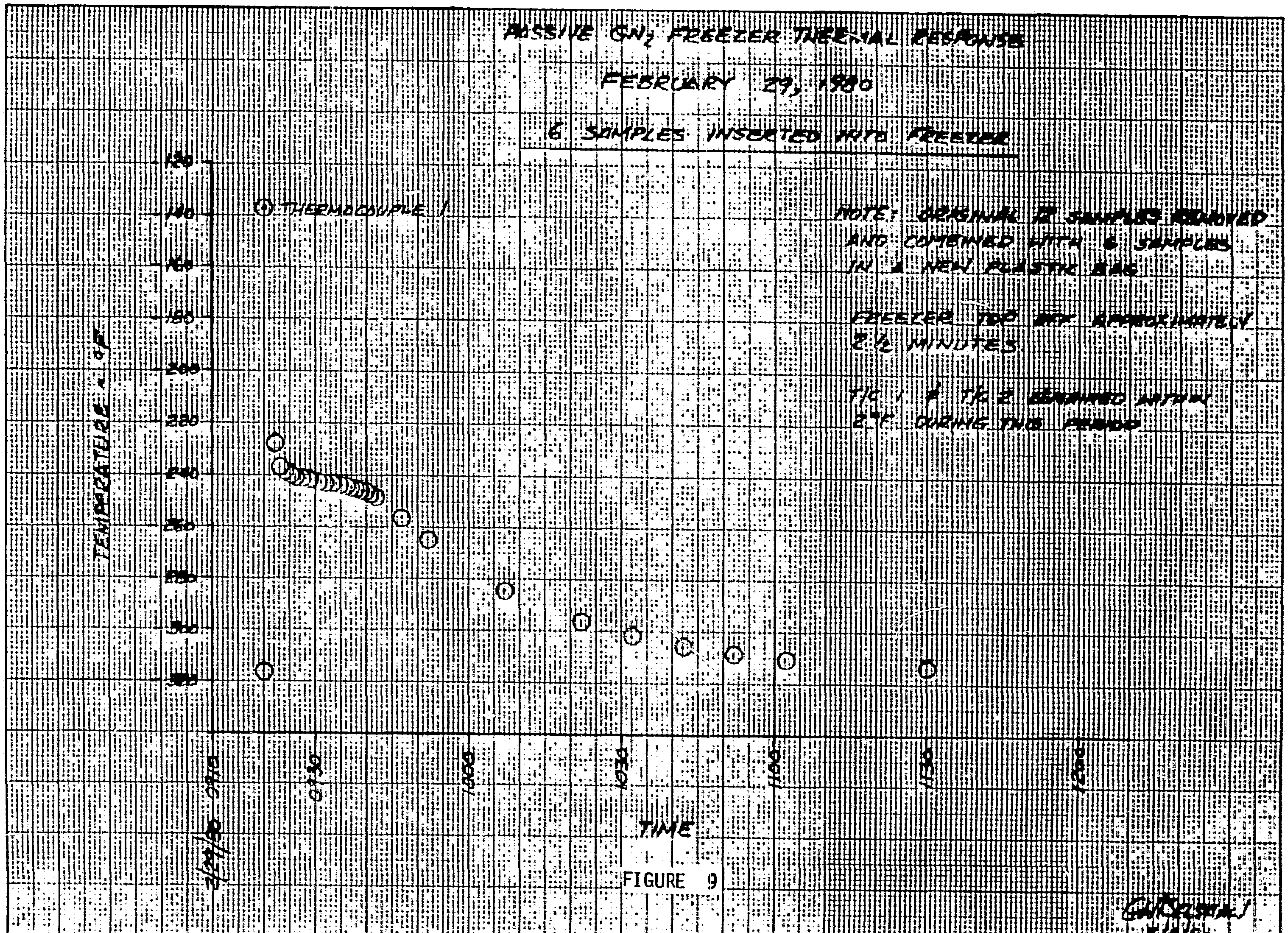

FIGURE 9

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FIGURE 10

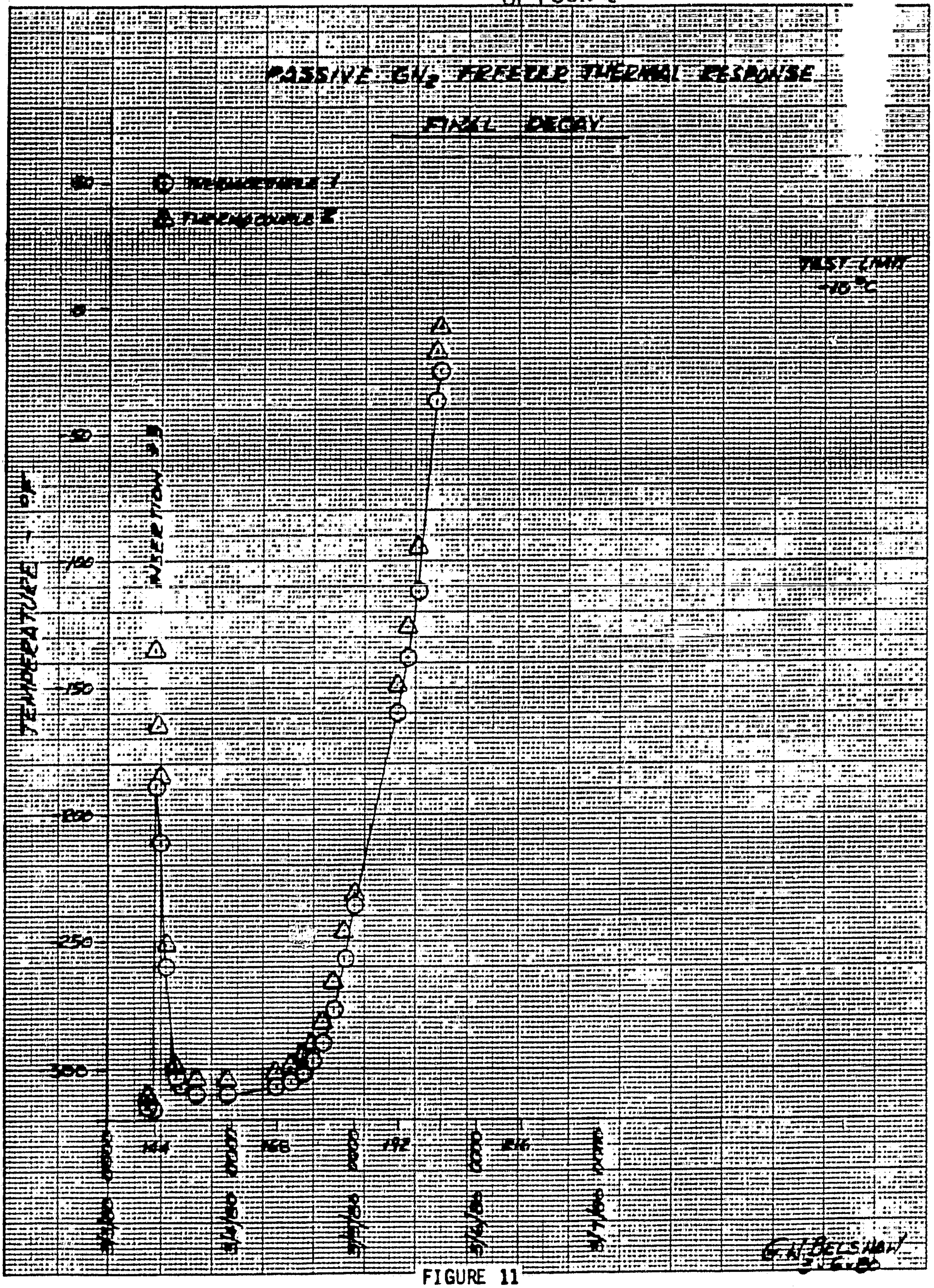


FIGURE 11

TO: B. French, SE4	DATE: 12/1/80
FROM: G.W. Belshaw, Project Engineer	CONTRACT: NAS9-15629
SUBJECT: GN_2 Passive Freezer Thermal Test, November, 1980	

Enclosed are the results of the thermal testing of the GN_2 Passive Freezer (serial no. 1359-79) conducted from November 17-26, 1980.

Results indicate a static boiloff rate of approximately .05 #/hr. The test was terminated 184 hours after LN_2 pour-off, which was four hours after landing on the mission timeline. The samples removed at this time were still frozen. Four samples were cracked, however, the breakage rate was significantly reduced from previous testing by using the tempered, wrapped tubes.

Also included is a curve representing the initial testing by Cryogenics Associates in November, 1979. This test indicated a static boiloff rate of .036 #/hr.

George W. Belshaw

GN_2 PASSIVE FREEZER TEST PROCEDURES

UNIT TO BE TESTED: Cryogenics Associates S/N 1359-79

11/17/80	° Record container weight with cover. Note: All weights to include cover in place.
Prior to 4 pm	° Begin filling with LN_2 - continue until container is full
	° Record container weight
Every 1-2 hours as needed	° Refill container with LN_2 to maintain level within one inch of top
	° Record container weight after each topping.
11/18/80	° Continue topping off and recording weight.
4 pm	° Pour-off LN_2 from container
	° Replace cover
	° Record container weight
Every 2-3 hours	° Record container weight until end of test

End of test when internal temperature reaches -10°C (14°F)

Est. at 11/28/80

GN_2 PASSIVE FREEZER TEST PROCEDURES

° Sample insertion #1 9:15 am 11/20/80

10-15ml Corvac samples - albumin solution

2-10ml Corvac samples - albumin solution

plastic bag

° Record weight of samples and bag - 369.8 grams .81542 lbs

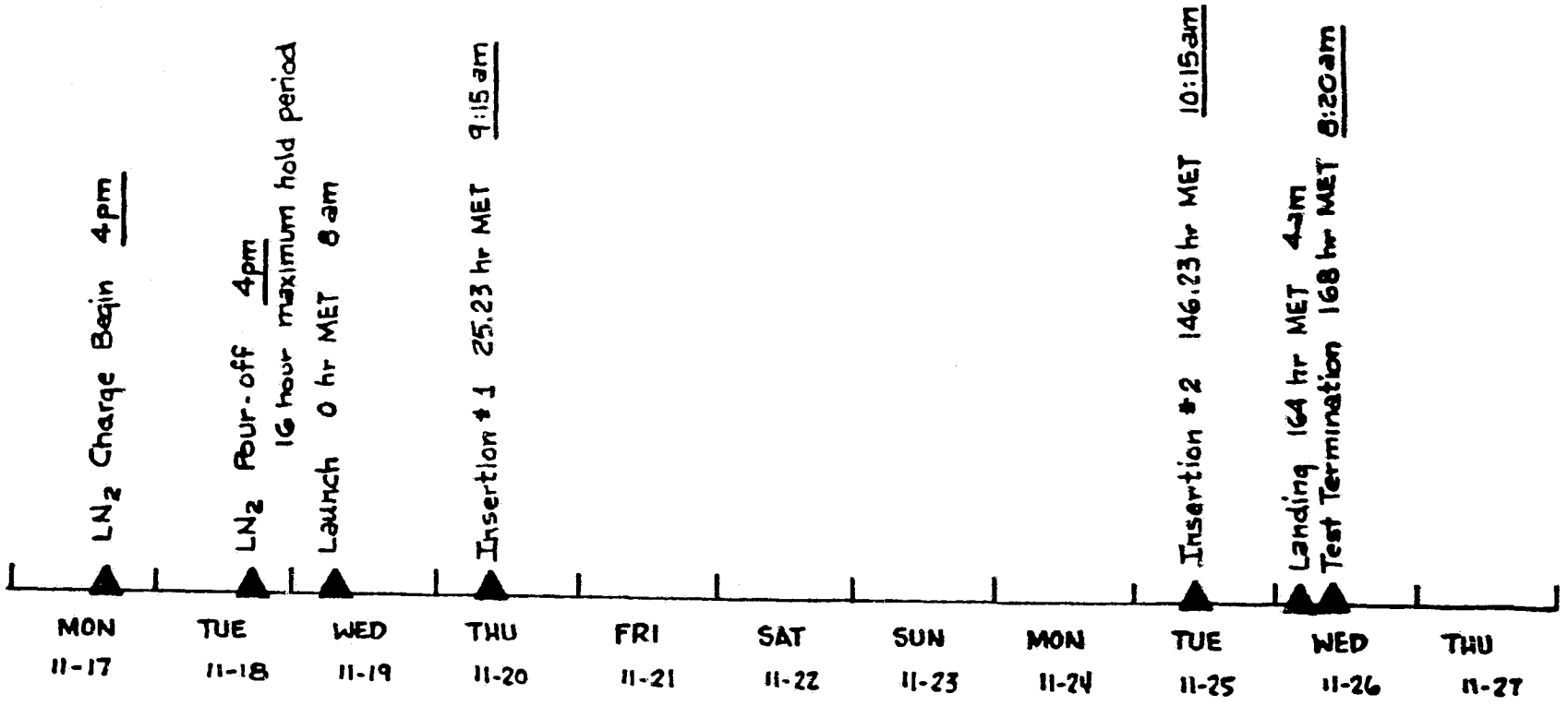
° Sample insertion #2 10:15 am 11/25/80

18-15ml Corvac samples - albumin solution
plastic bag

4-15ml Corvac samples - albumin solution

2-10ml Corvac samples - albumin solution
plastic bag

° Record weight of samples and bags 1- 588 grams
2- 179.1 grams } 1.691 lbs



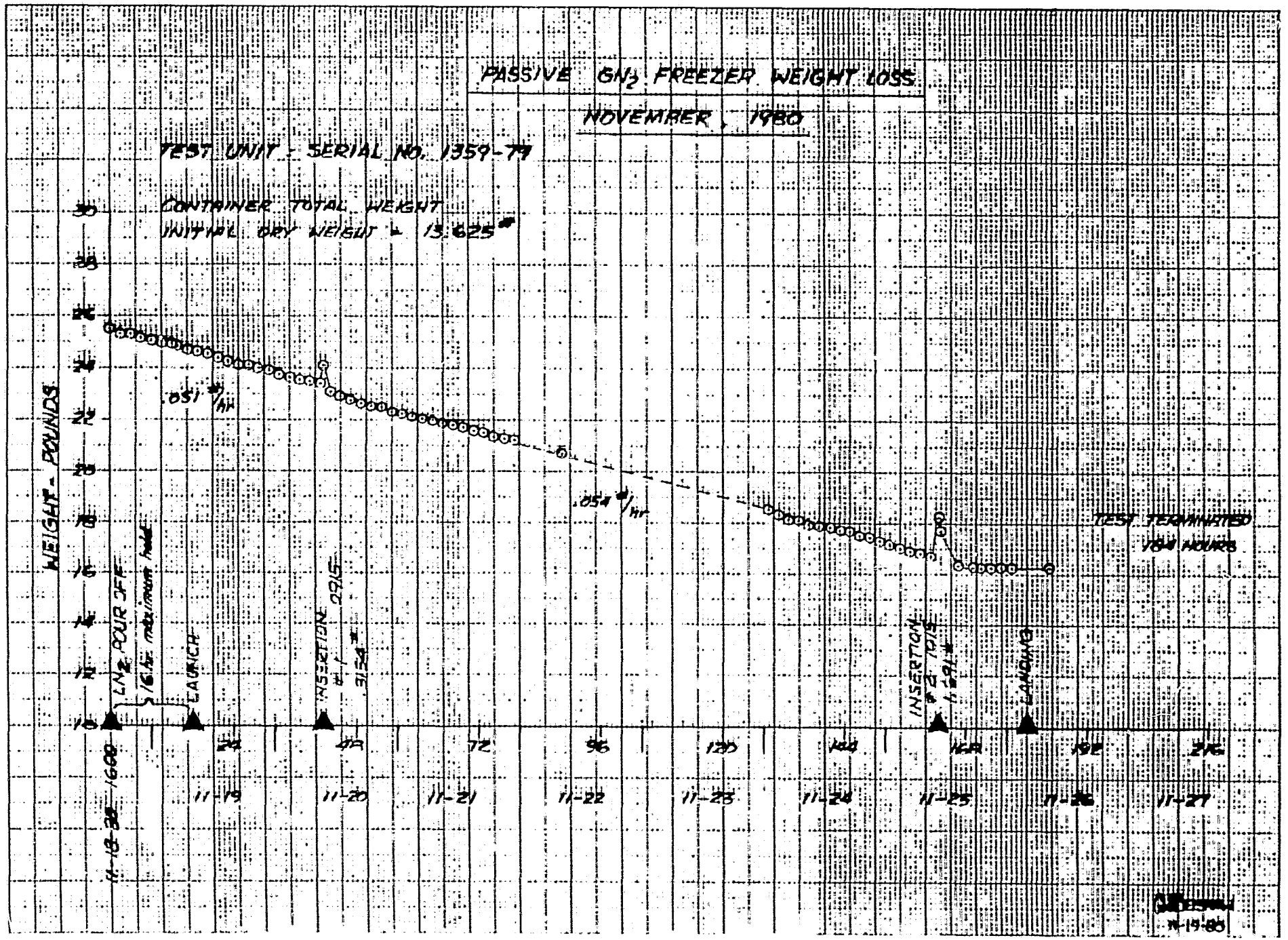
Insertion # 1 — 10 - 15ml Corvac samples
2 - 10ml Corvac samples

Insertion # 2 — 22- 15ml Corvac samples
2 - 10ml Corvac samples

PASSIVE GN_2 FREEZER
SL-1 TEST TIMELINE

SAMPLE CONTAINER

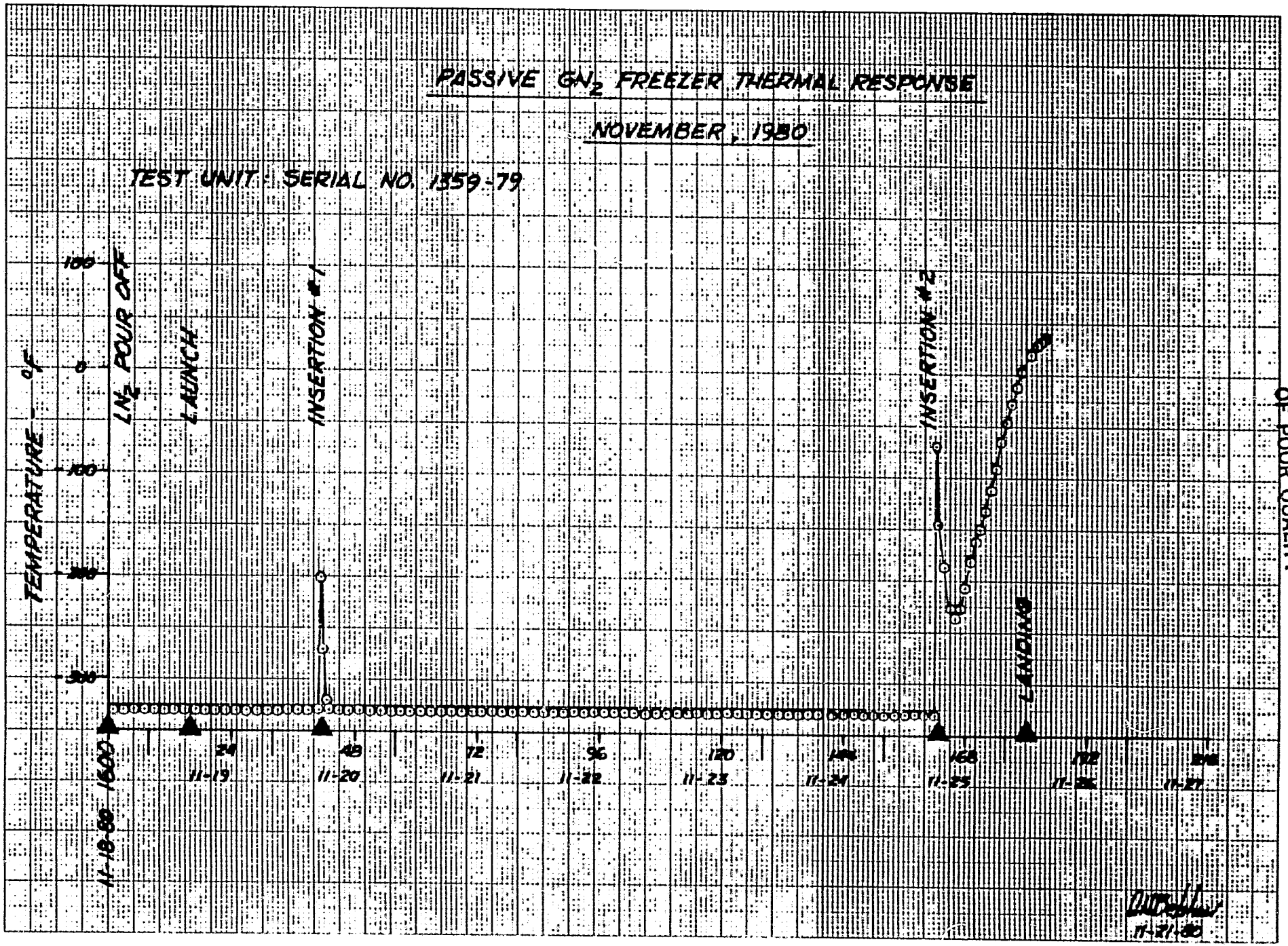
GWPeldman 11-480



PASSIVE GN_2 FREEZER THERMAL RESPONSE

NOVEMBER, 1980

TEST UNIT: SERIAL NO. 1359-79



11-26-80

CHECK OF CORVAC TUBES UPON REMOVAL FROM FREEZER - 0830 11-26-80

- SAMPLE INSERTION #1 - stowed freezer bottom
  15ml tubes - none cracked
  Tube numbers 7, 8, 12, 15, 22, 26, 27, 28, 33, 36

  10ml tubes - Tube no. 49 cracked
  43 OK

- SAMPLE INSERTION #2
  Small bag - stowed freezer bottom
  15ml tubes - Tube no. 5 cracked
  Tube no.'s 6, 9, 29 OK
  10ml tubes - Tubes 38, 46 both cracked

  Large bag - stowed freezer upper
  15ml tubes - Tube no. 2 - cracked
  Tube no.'s 1, 3, 10, 13, 16, 17, 18, 19, 20, 21, 23, 24, 25, 30, 32, 35 OK

REC'D 12/18/79

WEIGHT OF BLOOD TUBE RACKING DEVICE & SPACER — 391 GMS
FOR RAY HOECKER 2/15/80

CRYOGENIC ASSOCIATES
6565 Coffman Road
Post Office Box 68443
Indianapolis, Indiana 46268

CA 407-19

MODEL # SD-404-P

SERIAL # 1359-79

EMPTY WEIGHT 13.82

EVAPORATION RATE .480 AVG #/DAY

DATE	TIME	WEIGHT	REMARKS
11-26-79	2:35 p.m.	31.61	3.5" DIA. BORE IS FULL
11-27-79	5:02 P	25.47	DUMPED BORE. 11.58
11-28-79	7:02 A	24.92	$\frac{5.5}{14.00}$ .942 #/DAY = .52 #/DAY 12.37 DAYS
11-28-79	1:11 P.	24.68	
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12-4-79	7:40 A.	19.81	$\frac{.86}{24.550}$ = .840 #/DAY = .472 #/DAY
12-5-79	7:13 A	18.95	$\frac{.86}{23.550}$ = .876 #/DAY = .492 #/DAY
12-6-79	7:55 A.	18.05	$\frac{.90}{24.700}$ = .874 #/DAY = .491 #/DAY
12-6-79	5:00 P.	17.75	$\frac{.30}{9.083}$ = .772 #/DAY TEST CONDUCTED BY: D. Fish = .445 #/DAY END OF 10 DAY TE

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CUSTOMER NASA

TYPE OF INSULATION SUPER INSULATION

NUMBER OF WRAPS 45

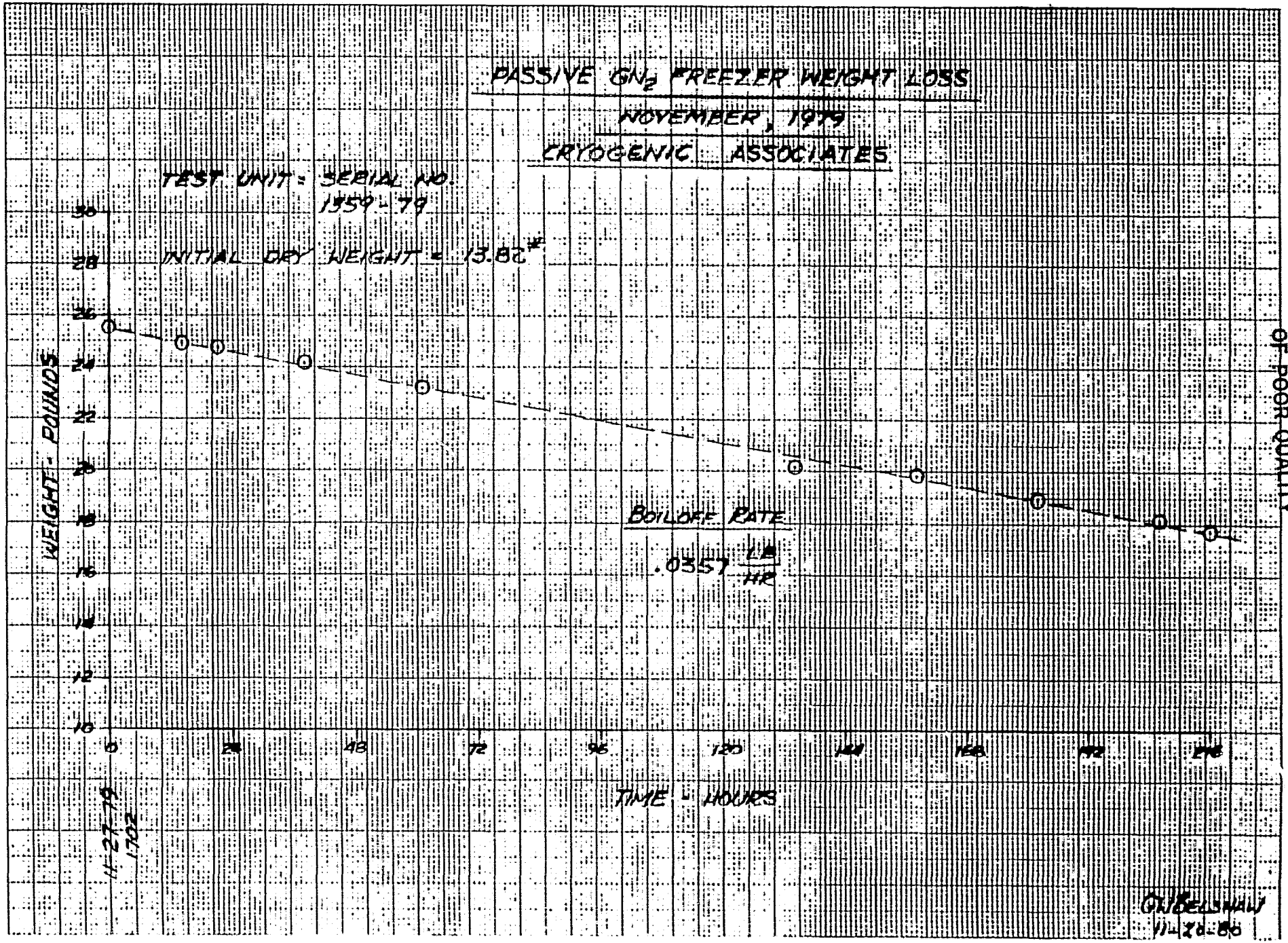
METHOD APPLIED

TRUNION No

WITNESS:

EVALUATION PROCEDURE 1 DAY ROUGHING 3 DAY DIFF. PUMP.

12-7-79	8:25 A.M.	17.21	.034 #/HR · .819 #/HR · .469 #/DAY
12-10-79	7:21 A.M.	14.70	.035 #/HR · .819 #/HR = .477 #/DAY
12-10-79	4:46 P.M.	14.37	
12-11-79	8:19 AM	13.93	$\frac{.44}{15.550}$ = .028 #/HR = .679 #/DAY = .381 #/DAY
12-11-79	2:50 P.M.	13.82	EMPTY



TO: B. French, SE4	DATE: 1/6/81
FROM: G.W. Belshaw, Project Engineer	CONTRACT: NAS9-15629

SUBJECT: GN_2 Passive Freezer Thermal Test - December, 1980

Enclosed are the results of the GN_2 Passive Freezer thermal testing conducted from December 1-12, 1980. These tests were conducted with two containers received from Cryogenics Associates (CA) and followed the SL-1 mission timeline.

The two containers tested were designated container "A" (CA serial no. 988-80) and container "B" (CA serial no. 987-80). The static boiloff rates for these two containers were approximately .05 #/hr for container "A" and .064 #/hr for container "B".

A significant difference was noted from the previous testing in the amount of LN_2 absorbed by the container during the 24 hour charge period. The November, 1980 test (CA serial no. 1359-79) absorbed 11.84# of LN_2 while these containers absorbed 12.91# of LN_2 for container "A" and 12.875# of LN_2 in container "B". For this reason, even with the higher static boiloff rate of container "B", the mission timeline was easily completed.

Testing on container "A" was terminated at 214 hours with the removal of 36 frozen samples. Container "B" testing was completed at 184 hours (4 hours after landing) with the removal of the experiment holder containing 6 frozen samples and the ESA experiment simulation. Internal temperatures at this removal time were approximately -200°F and would have easily held for over 200 hours. Upon removal of the samples, it was noted that there was only one (1) cracked tube in container "B".

Major difficulties were encountered with the sample holder, in both retaining frozen tubes and accepting the proper number of tubes. Details of the problems encountered are included in the test comments.

Also included with this report are the mission timeline test procedures, the container weight loss, the container thermal response, comments on sample holder insertion and removal and experiment holder removal, recorded weights and temperatures recorded during the test period.

G W Belshaw

George W. Belshaw

GN_2 PASSIVE FREEZER TEST PROCEDURES
MISSION TIMELINE TEST

UNITS TO BE TESTED: "A" Serial No. 988-80
"B" Serial No. 987-80

12-1-80	• Record container weight "A" with cover Note: All weights include cover in place
Prior to 4pm	• Fill container "A" with LN_2 - continue until container is full • Record container weight
Every 1-2 hrs as needed	• Refill container "A" with LN_2 to maintain level within one inch of top. • Record container weight after each topping
12-2-80	• Continue topping and recording weight
4pm	• Pour off LN_2 from container, replace cover and record weight
Every 2-3 hours	• Record container weight until end of test
12-3-80	• Record container weight "B" with cover
Prior to 4pm	• Fill container "B" with LN_2 - continue until container is full • Record container weight
Every 1-2 hours as needed	• Refill container "B" with LN_2 to maintain level within one inch of top • Record container "B" weight after each topping

12-4-80 • Continue topping "B" and recording weight

4pm • Pour off LN_2 from container "B", replace cover and record weight

Every 2-3 hours • Record container weight until end of test

End of test when internal temperature of both containers is above -10°C (14°F)

Est. at 12/15/80

GN_2 PASSIVE FREEZER TEST PROCEDURES
MISSION TIMELINE TEST

• SAMPLE INSERTION #1 – CONTAINER "A"

(THURS) 9:15 am 12-4-80

10 - 15 ml Corvac Samples
2 - 10 ml Corvac Samples

• RECORD WEIGHT OF SAMPLES - 361 gm (.795#)

• SAMPLE INSERTION #2 – CONTAINER "B"

(MONDAY) 8:30 am 12-8-80

4 - 15 ml Corvac Samples
2 - 10 ml Corvac Samples

• RECORD WEIGHT OF SAMPLES - 175 gm (.385#)

• SAMPLE INSERTION #3 – CONTAINER "B"

(MONDAY) 6:18 pm 12-8-80

ESA Experiment Simulation

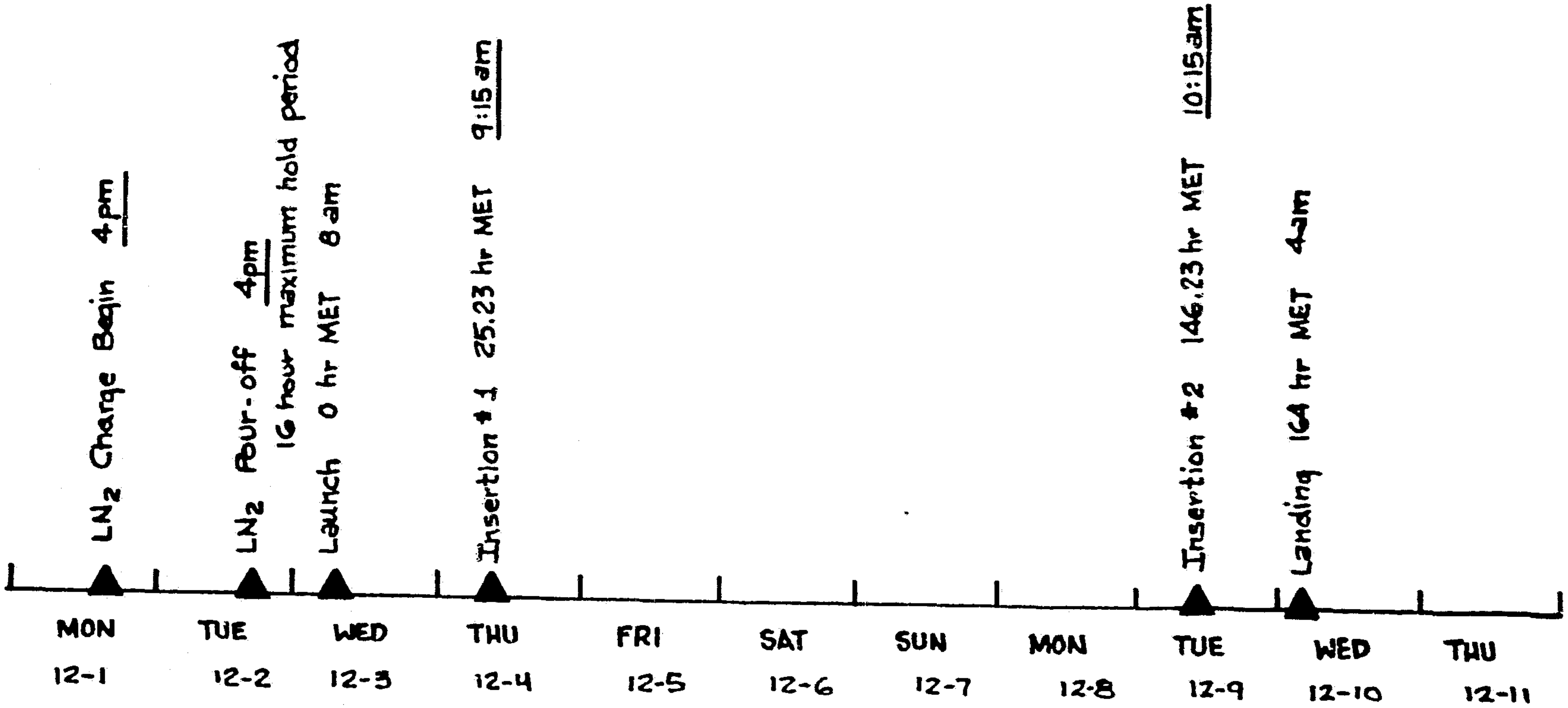
• RECORD WEIGHT - (1.075#)

• SAMPLE INSERTION #4 – CONTAINER "A"

(TUESDAY) 10:15 am 12-9-80

22 - 15 ml Corvac Samples
2 - 10 ml Corvac Samples

• RECORD WEIGHT OF SAMPLES - 728 gm
(1.6035#)

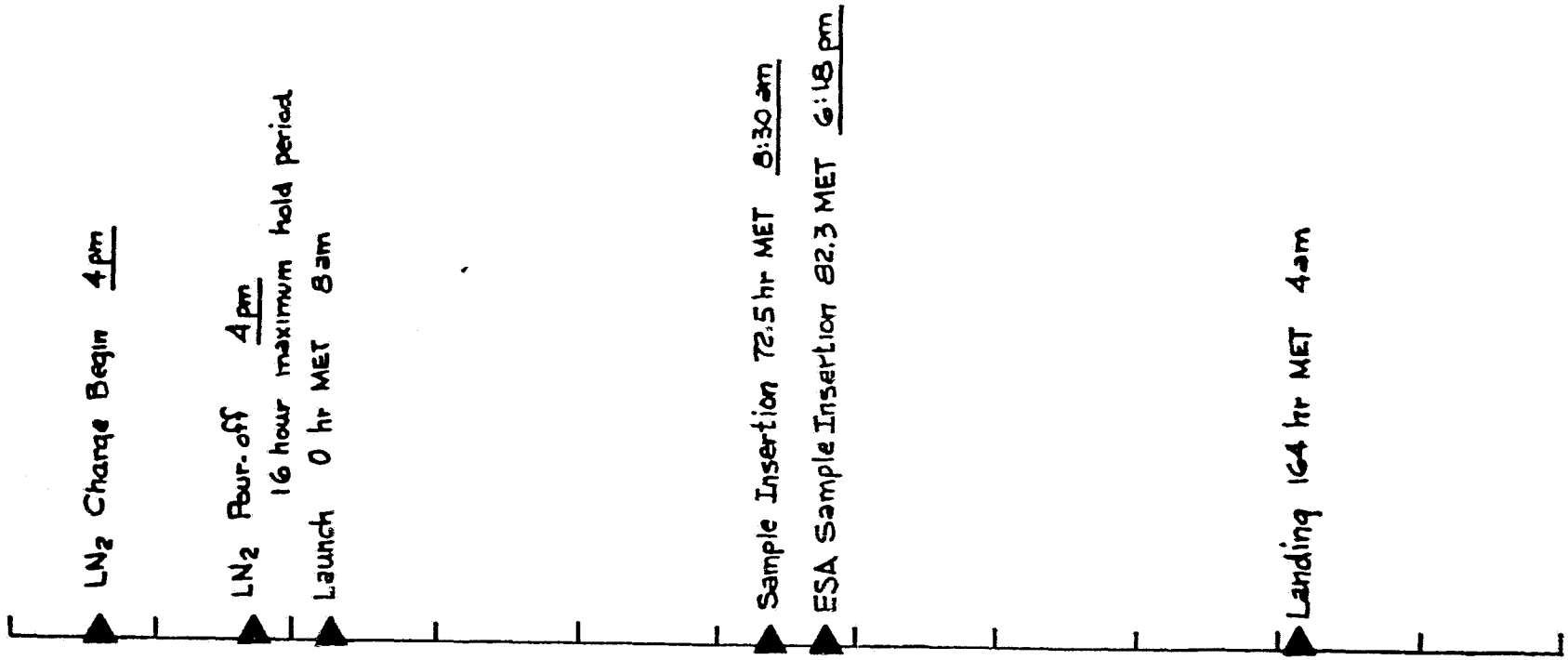


Insertion # 1	10 - 15ml Corvac samples 2 - 10ml Corvac samples
Insertion # 2	22- 15ml Corvac samples 2- 10ml Corvac samples

PASSIVE GN_2 FREEZER
SL-1 TEST TIMELINE

"A"
SAMPLE CONTAINER

GWBebhaw 11-4-80



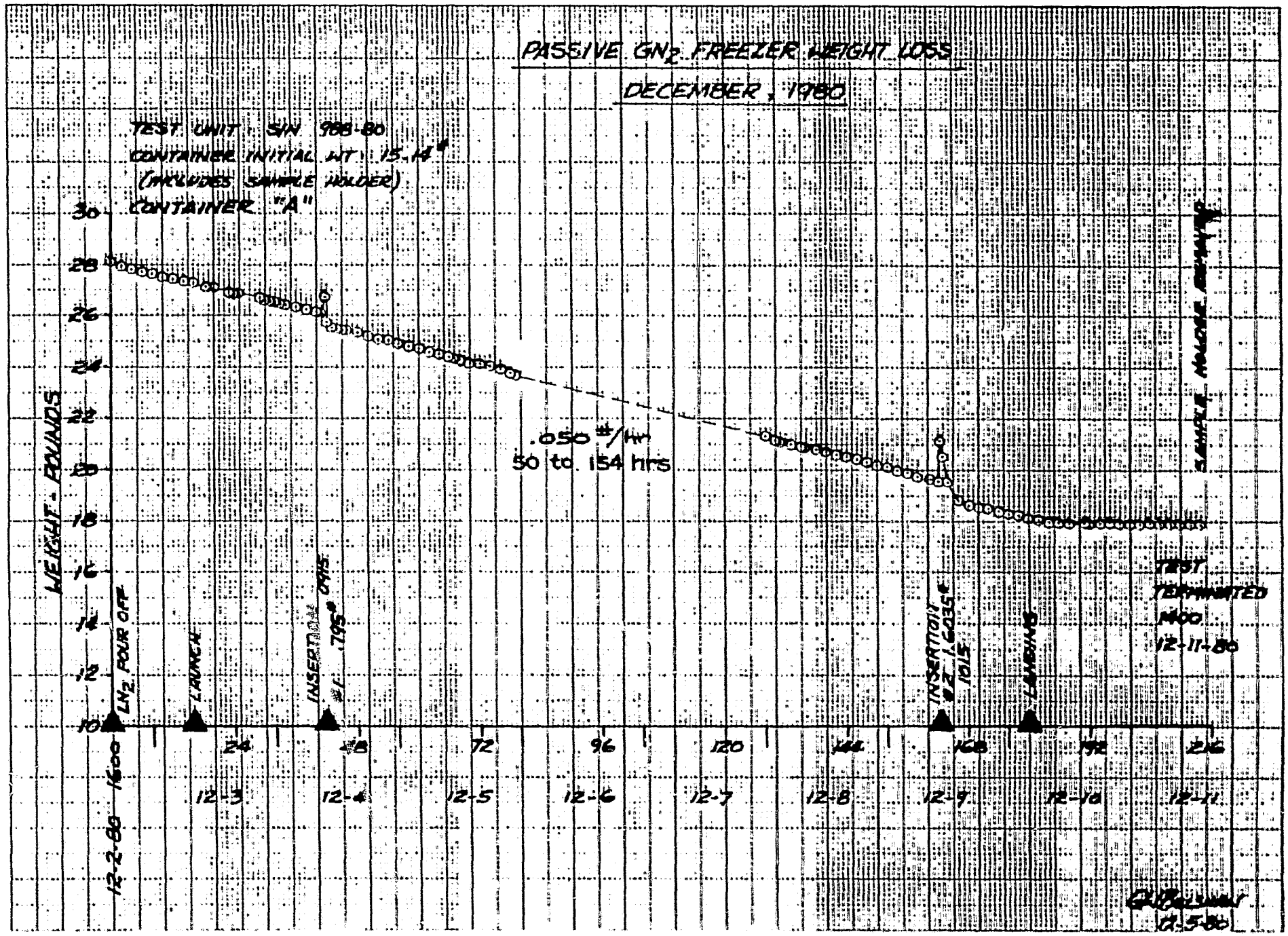
Sample Insertion

4 - 15ml Corvac samples
2 - 10ml Corvac samples

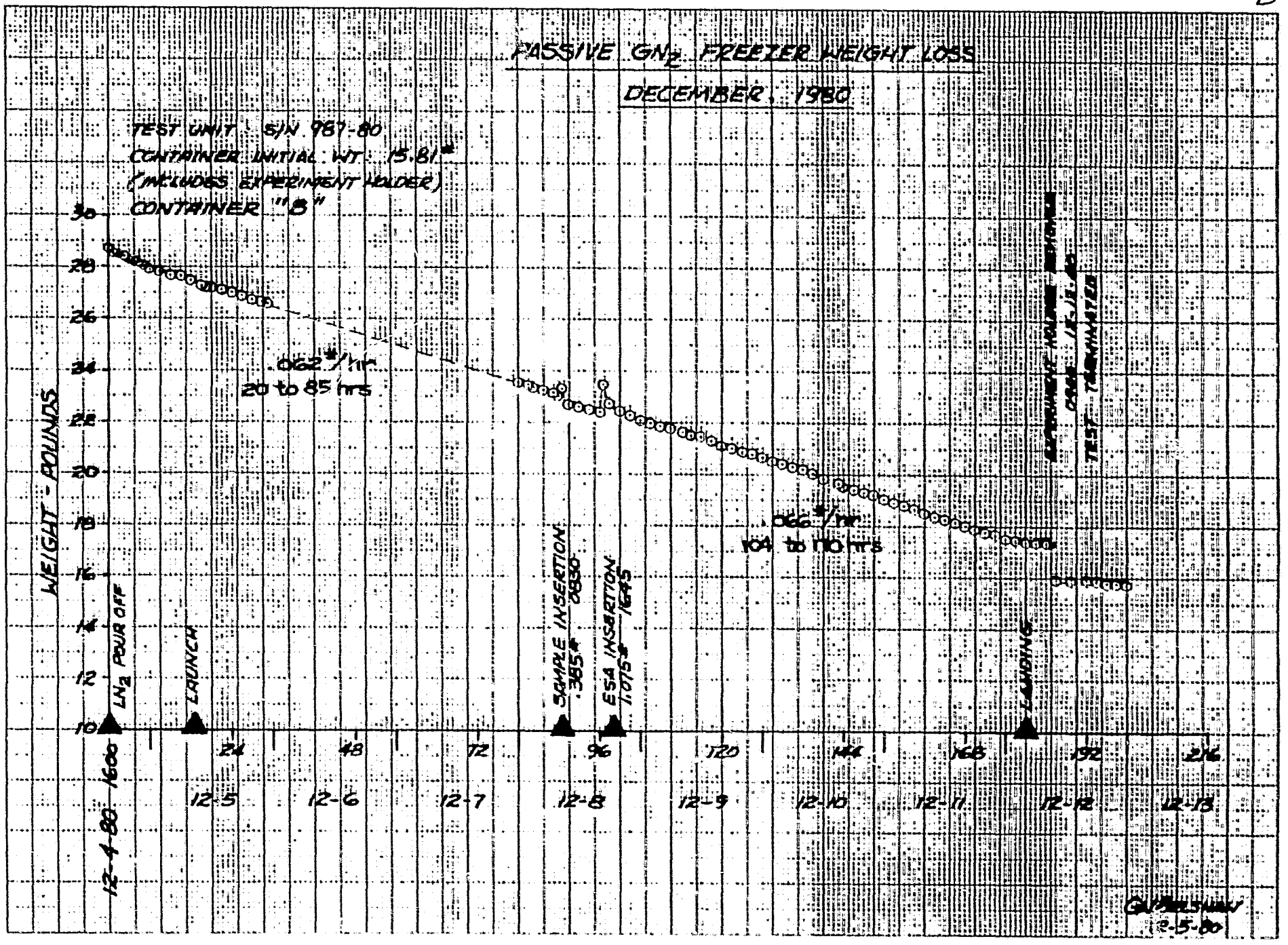
PASSIVE GN_2 FREEZER
SL-1 TEST TIMELINE

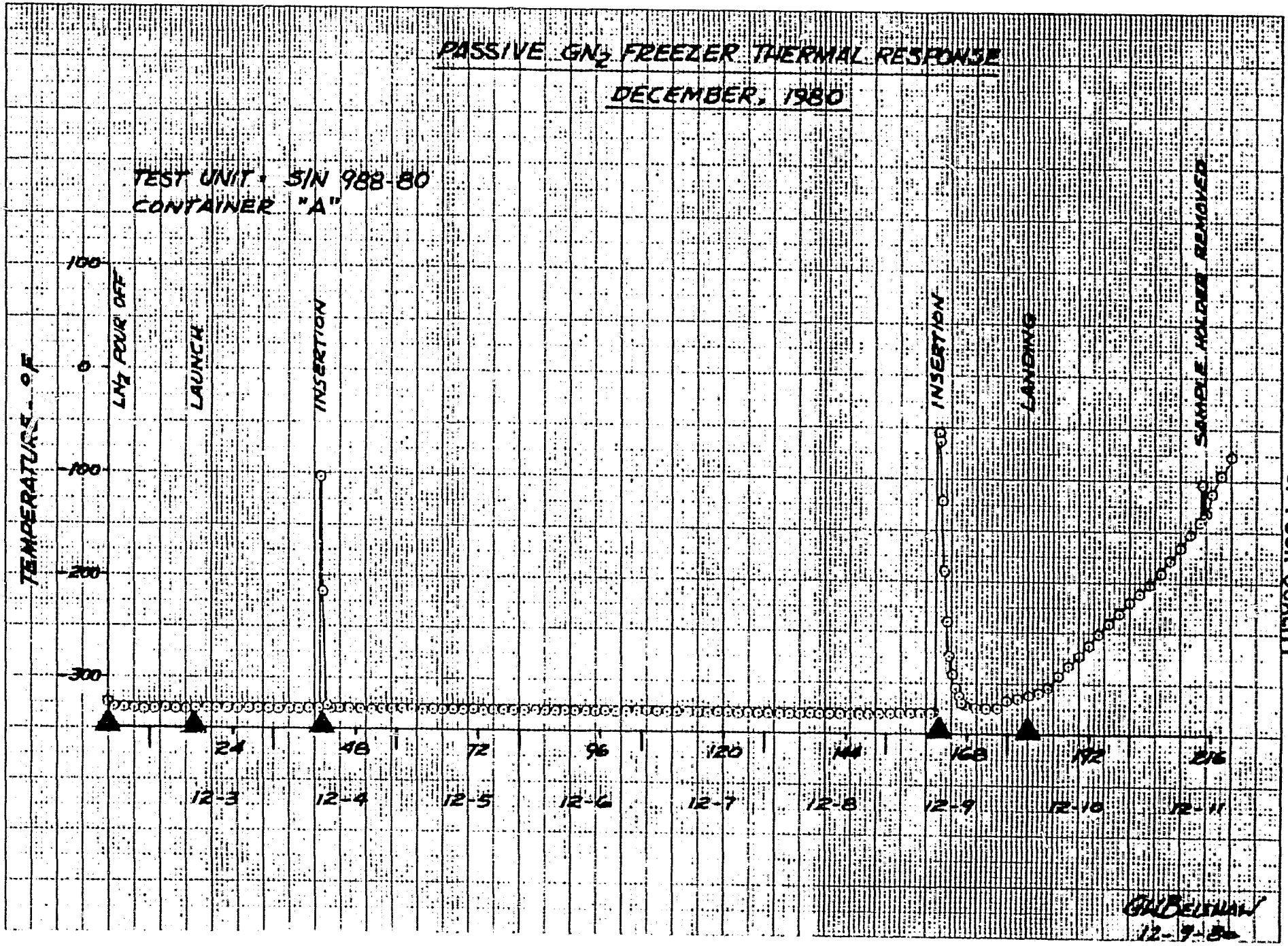
"B"
EXPERIMENT CONTAINER

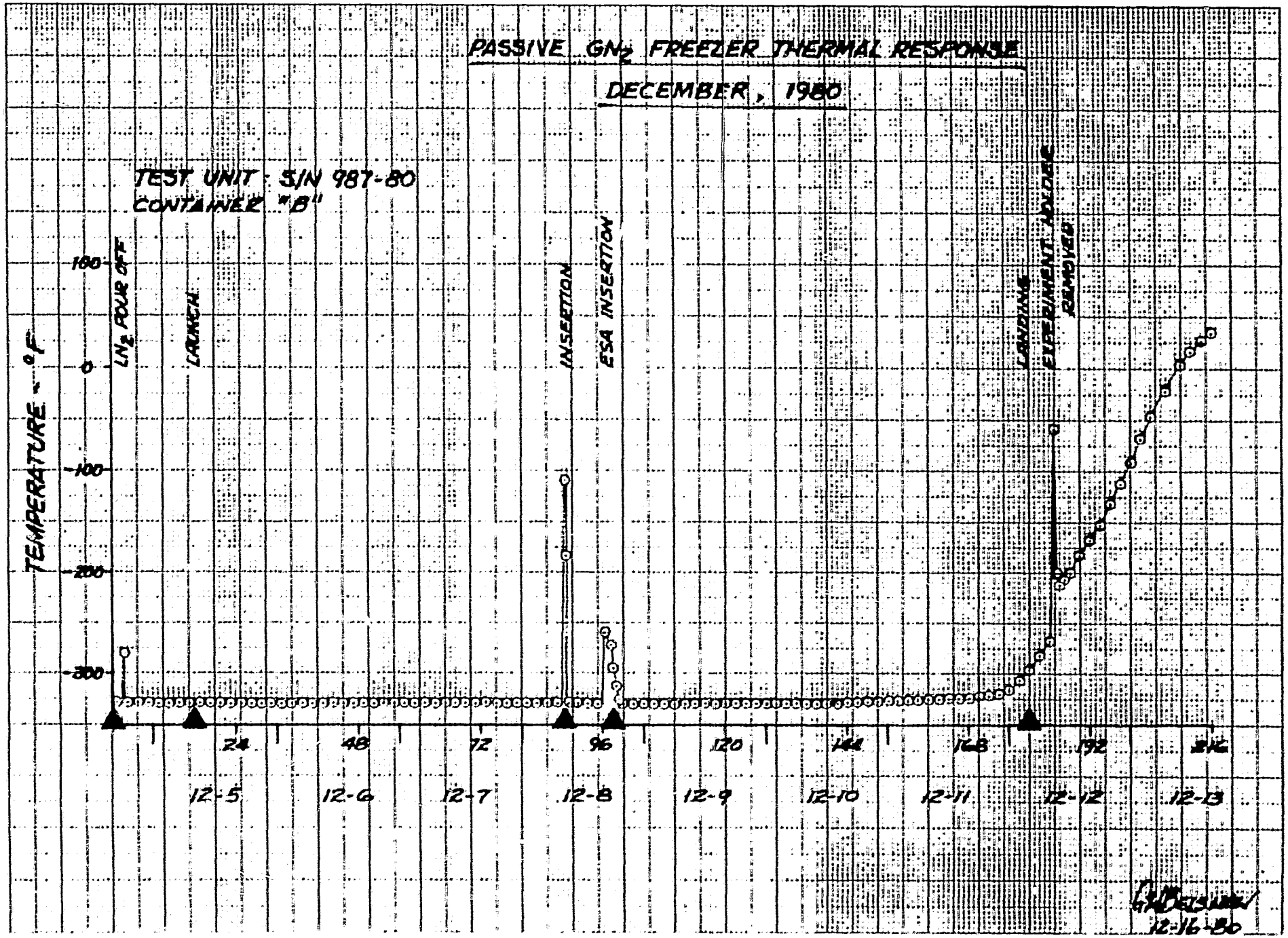
UNIT
A



UNIT B







COMMENTS

GN_2 PASSIVE FREEZER
TEST # 4

12-9-80 CONTAINER "A" INSERTION #2

1010 CONTAINER OPENED AND SAMPLE HOLDER REMOVED.

5 - 15ml tubes & 2 - 10ml tubes & spacers fell out of bottom of rack and had to be dumped from container

Tube inserted into bottom center space blocked the retraction of the handle. There is no way to distinguish the center space to remain empty.

Bottom racks completely filled with tubes, however, the top rack would not accept the proper number of tubes. - If one tube is put in the wrong location, they will all be wrong.

Tubes were forced into the container and container was closed. While working with the tube holder, the top was placed on the container.

When replacing the holder, again several tubes fell out of the bottom and had to be dumped out and reloaded.

1020 CONTAINER TOP SCREWED ON

COMMENTS

GN_2 PASSIVE FREEZER
TEST #4

12-11-80 CONTAINER "A" SAMPLE HOLDER REMOVAL

1400 CONTAINER OPENED AND ATTEMPT TO REMOVE SAMPLE HOLDER FAILED

- Tubes that were inserted 12-9-80 were jammed and would not allow removal of sample holder.

- Three tube were fished out of container which allowed removal of holder.

- It was noted that there were only 17 tubes on the lower portion which meant 19 tubes were forced into upper portion.

1410 Container top screwed back on

- All tubes removed were frozen and there was no breakage

COMMENTS

GN_2 PASSIVE FREEZER
TEST # 4

12-12-80 CONTAINER "B" EXPERIMENT HOLDER REMOVAL

0900 • Internal temperatures at approximately -160°C at time of removal

• It was noted by B. French that light gloves are better for manipulating the ESA experiment door than the large bulky gloves.

• All tubes removed frozen - there was one broken, ESA simulation removed and the holder re-inserted into freezer

0905 • Container closed and top screwed back on.

TO: B. French SE4	DATE: 3/10/81
FROM: G.W. Belshaw, Project Engineer	CONTRACT: NAS9-15629

SUBJECT: GN_2 PASSIVE FREEZER THERMAL TESTING - January-February 1981

Enclosed are the results of the GN_2 Passive Freezer thermal testing conducted during the period of January 27, 1981 to February 17, 1981. The purpose of the testing was to establish the level of vacuum in the freezer and determine the effect of the variation in this vacuum level on the LN_2 boil off rate of the freezer.

Also to be determined whether the vacuum integrity could be re-established to produce consistent boil off rates. During the testing the minimum time required for the initial LN_2 charging was also investigated.

Figure 1 presents the static weight loss of the freezer for the various vacuum conditions tested and Figure 2 presents a plot of the boil off rate as a function of vacuum level within the freezer.

Figure 3 presents the results of the LN_2 charge time estimation with the weight gain of the freezer.

Figures 4-8 present the static weight loss of the freezer from charging to depletion of LN_2.

A determination of the vacuum level in the container as manufactured showed the pressure to be in the 10^{-1} torr range. By increasing the vacuum, no significant improvement in the boil off rate was noted. Both were approximately .048 lbs/hour.

Severe degradation of boil off rate was noted at pressures higher than 10^{-1} torr, up to 2.78 lb/hour at ambient pressure as would be expected.

It was also noted that the static boil off rate increases from .048 lb/hour to .127 lb/hour with the removal of the foam cap.

From this testing it was determined that the vacuum level of 10^{-4} torr can be re-established in the GN_2 freezer without a great deal of difficulty. This will insure confidence in the consistent performance of the freezer.

The charging of the GN_2 freezer with LN_2 can be accomplished in a shorter period of time than previously used for testing. The freezer will absorb LN_2 for a period of approximately 1 1/2 hours and after that point the freezer weight remains stable.

The following test procedure timeline details the testing accomplished. Also included is the detailed weight loss records.

GN_2 PASSIVE FREEZER
TEST PROCEDURE TIMELINE

Container S/N 988-80 NASA S/N 1003

° Determination of Vacuum Level in Freezer

January 26, 1981

GN_2 freezer connected to vacuum pump on Helium Leak detector - container valve closed.

Connecting lines evacuated to 10^{-4} torr range.

1500 Container valve opened and pressure rose to the 150-200 y level (.15-.2 torr).

Continued pumping and evacuating container to the 10^{-4} range for approximately 16 hours.

° Effect of Variation in Vacuum Level

January 27, 1981

0845 Pressure level at 1.3×10^{-4} torr

0900 Closed valve and disconnected container

0905 Container dry weight 14.52#

Began LN_2 charge

1005 Full weight 31.98# and poured off

1007 Empty weight 27.09# (12.57# LN_2 absorbed)

Note: In previous test (December, 1980) there was 12.91# LN_2 loaded during the 24 hour soak.

January 28, 1981

Static boil off continued.

January 29, 1981

0900 Boil off rate = 0.48 #/hr

26.9# @ 1200 1/27/81

24.74# @ 0900 1/29/81

2.16# LN_2 boil off in 45 hours

1005 The freezer cap was removed and container allowed to stand open until 1300.

1300 Boil off rate = .127 #/hr

23.72 - (23.79 - .44)/2.91667 hr

Styrofoam block + 44# weight placed over opening. Boil off rate = .085 #/hr

(23.29 - 22.95)/4 hours

1900 Cap replaced on freezer

January 30, 1981

0900 Boil off rate = .0471 #/hr

(23.88 - 23.22)/14 hours

The container was reconnected to the vacuum pump and verification that the vacuum level was still in the 10^{-4} range.

The valve was then removed, with slight difficulty and 1 atm

pressure in the container. The container was disconnected from the vacuum lines and allowed to stand for 30 minutes.

The estimate of the boil off rate was 2.78 #/hour during this period. The top of the container frosted over and a great deal of moisture condensing on the sides of the container.

1100 The valve was replaced with difficulty. There was wear noted on the seals.

The vacuum lines were connected and the vacuum level inside the container was re-established.

1300 Vacuum level of 500 microns in the container and disconnected

Recharged with LN_2 - Wet weight 32.65#

1530 LN_2 poured off - Empty weight 27.33#

(12.81# of LN_2 loaded)

Replaced cap.

1900 Boiloff rate - .89 #/hour

(27.33 - 24.21)/3.5 hours

At this point there was frost build up around the container top and the boil off rate rose to 2.08 #/hour by 2400.

The valve had developed a leak and the vacuum level was lost.

2400 Testing was terminated.

February 2, 1981

1500 The container was reconnected to the vacuum pump.

Valve seals were replaced.

Container allowed to pump overnight to bring vacuum level to the 10^{-4} range.

° Determination of Minimum Freezer Charge Time

February 3, 1981

0900 Vacuum level established and container disconnected from the vacuum pump.

0910 Begin LN_2 fill to determine the length of time required to fill the container (Figure 3).

All weights were recorded after filling with LN_2 and replacing the cover to attain a constant LN_2 level within the container.

1215 Container left full of LN_2 and allowed to stand.

° Static Freezer Boil Off

February 4, 1981

1000 Boil off rate - .0442 #/hr

(32.24# - 31.29#)/21.5 hours

1011 Container refilled with LN_2

1114 LN_2 poured off

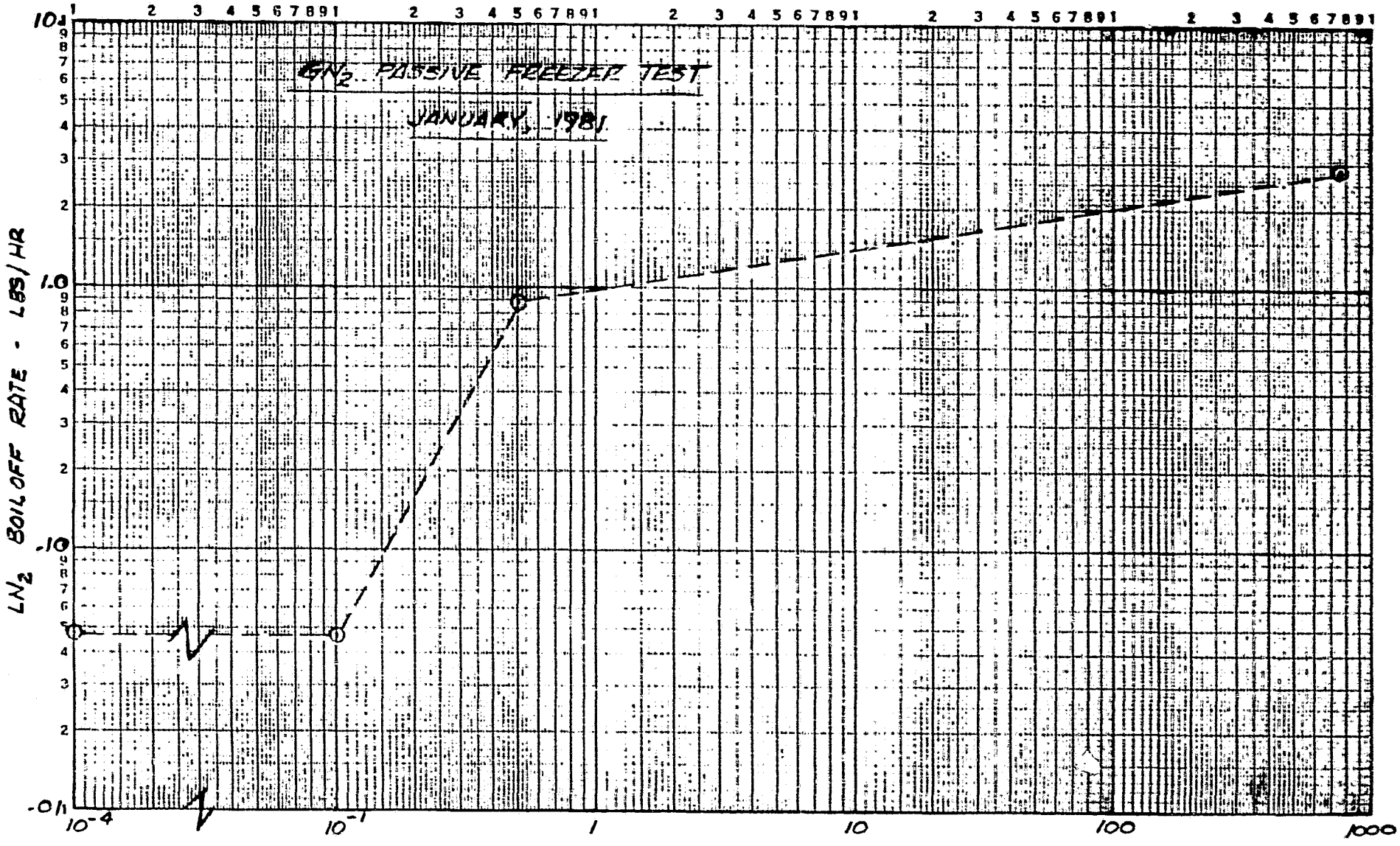
At this point the container was allowed to stand until the LN_2 was depleted.

February 15, 1981

2200 Estimation of LN_2 depletion

February 17, 1981

0900 Termination of testing. The internal temperature at this point was -141°F.



FREEZER INTERNAL PRESSURE - torr

FIGURE 2

GW Bobhour

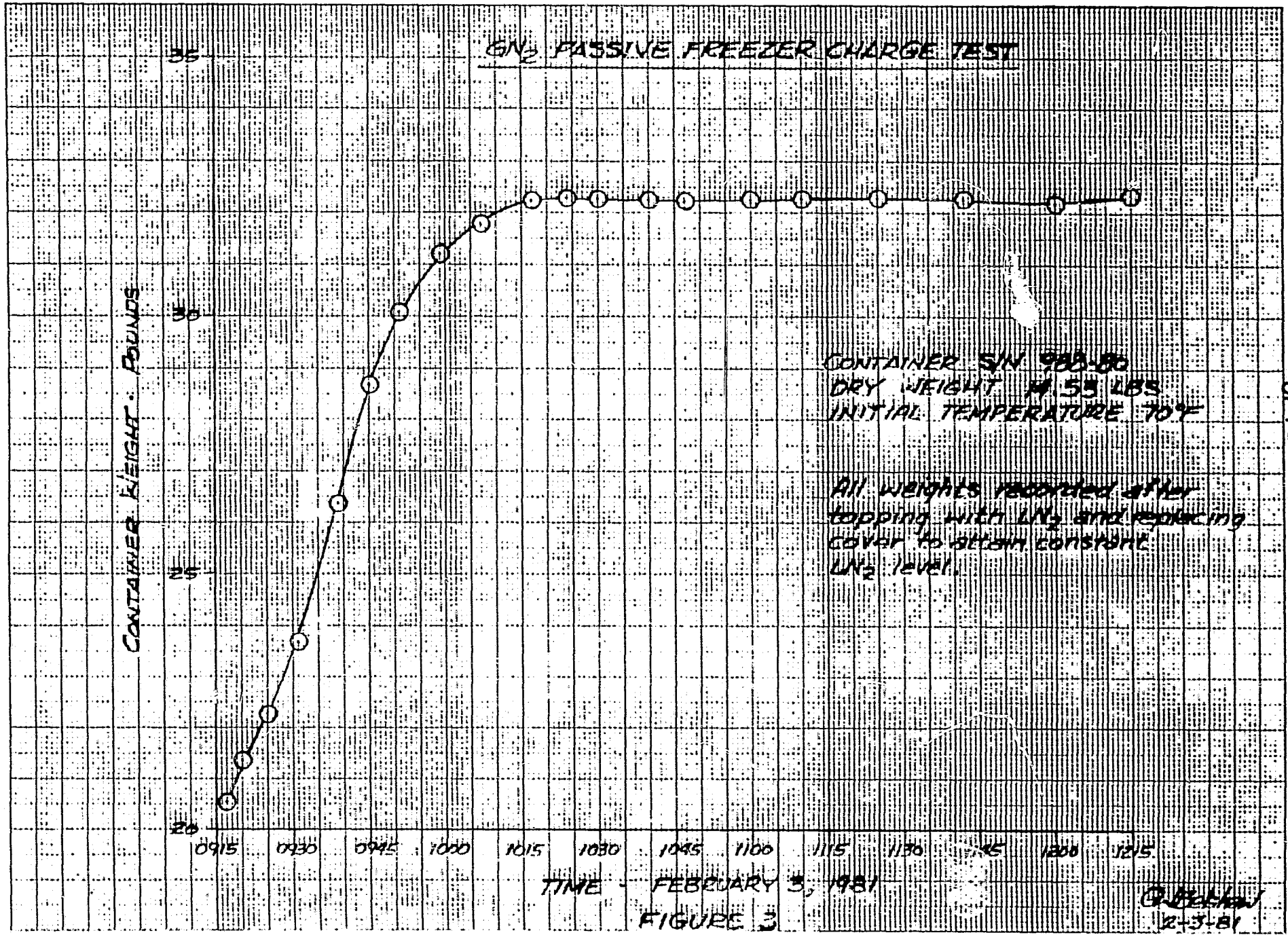


FIGURE 3

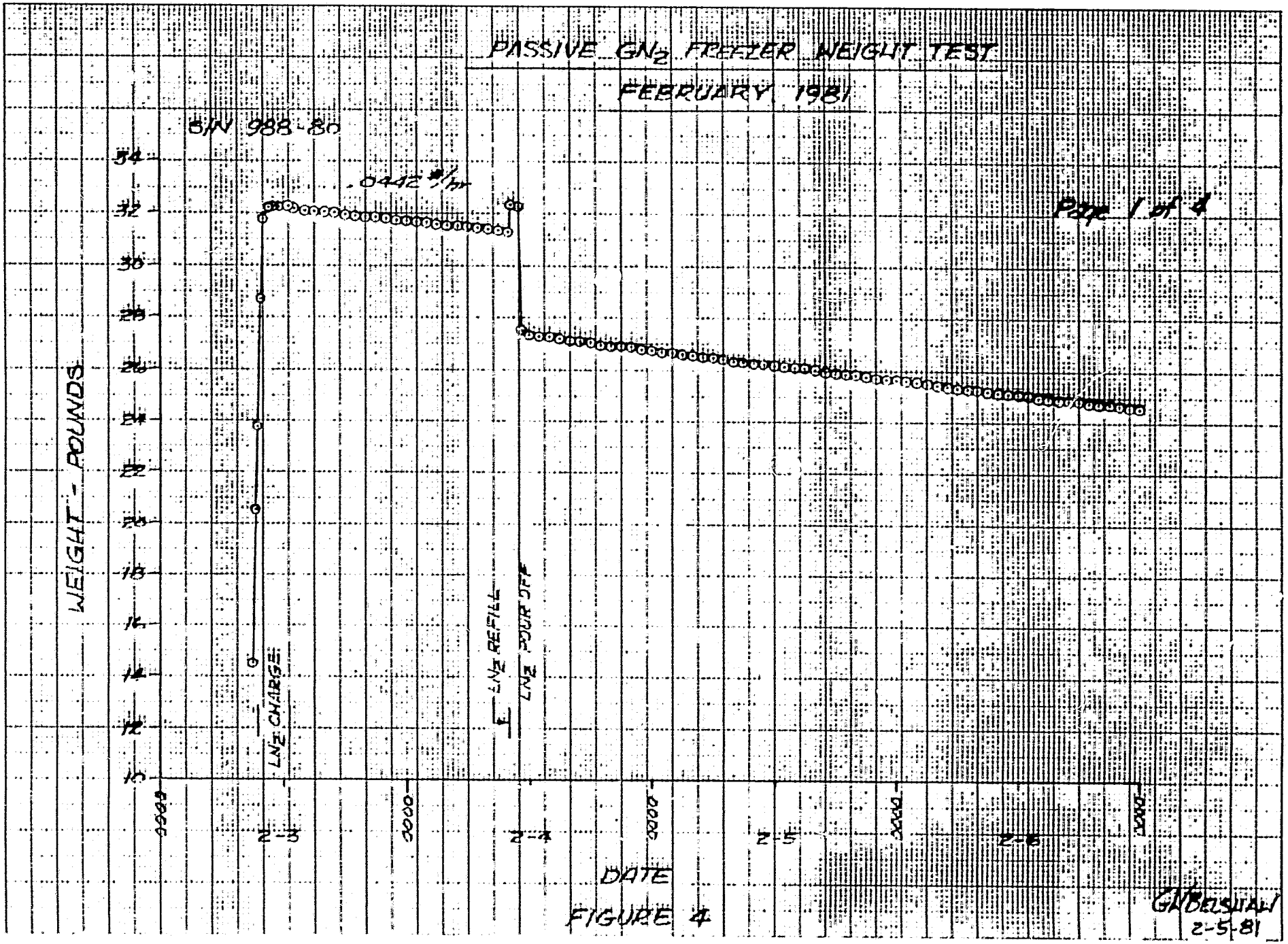


FIGURE 4

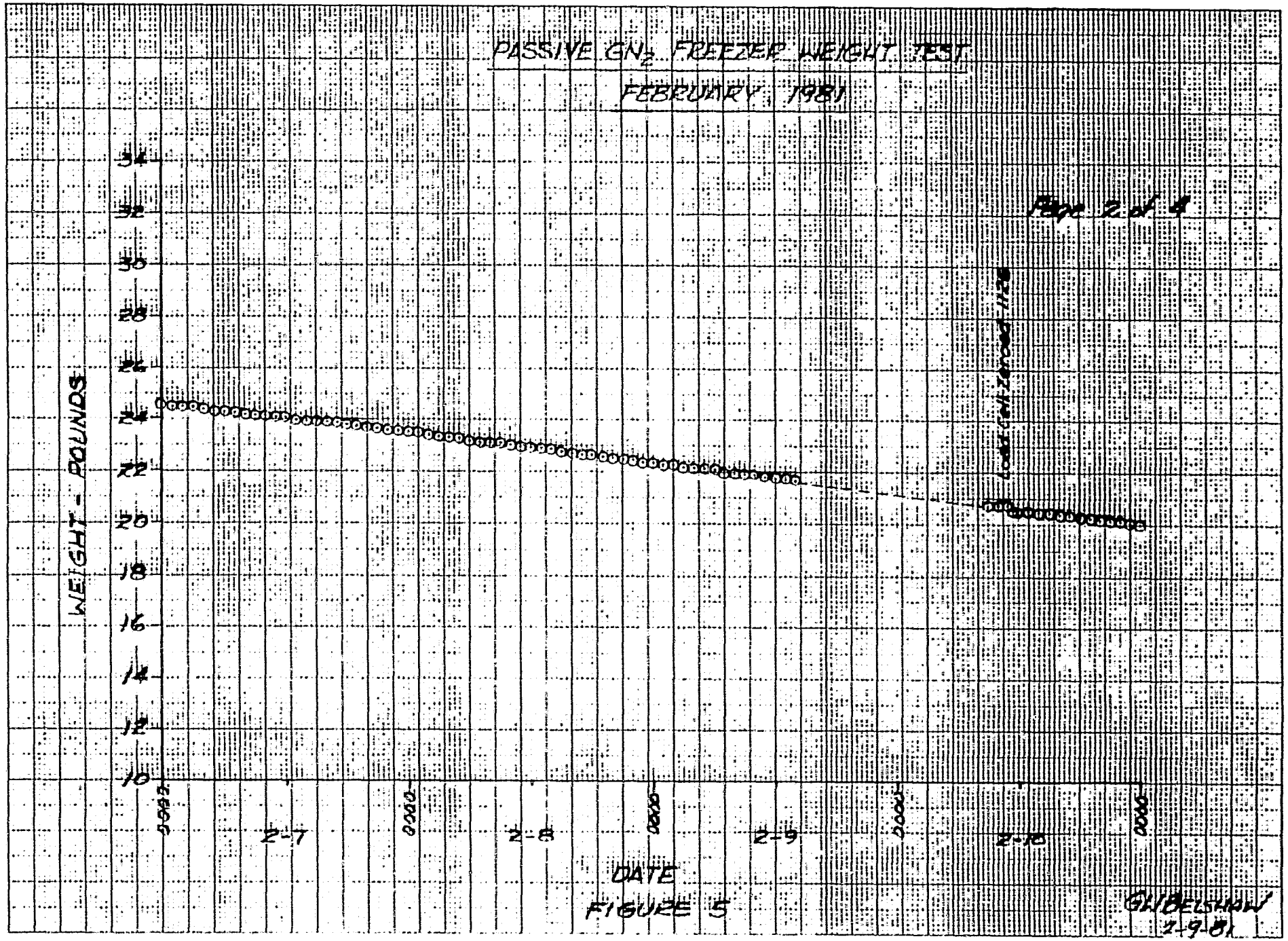


FIGURE 5

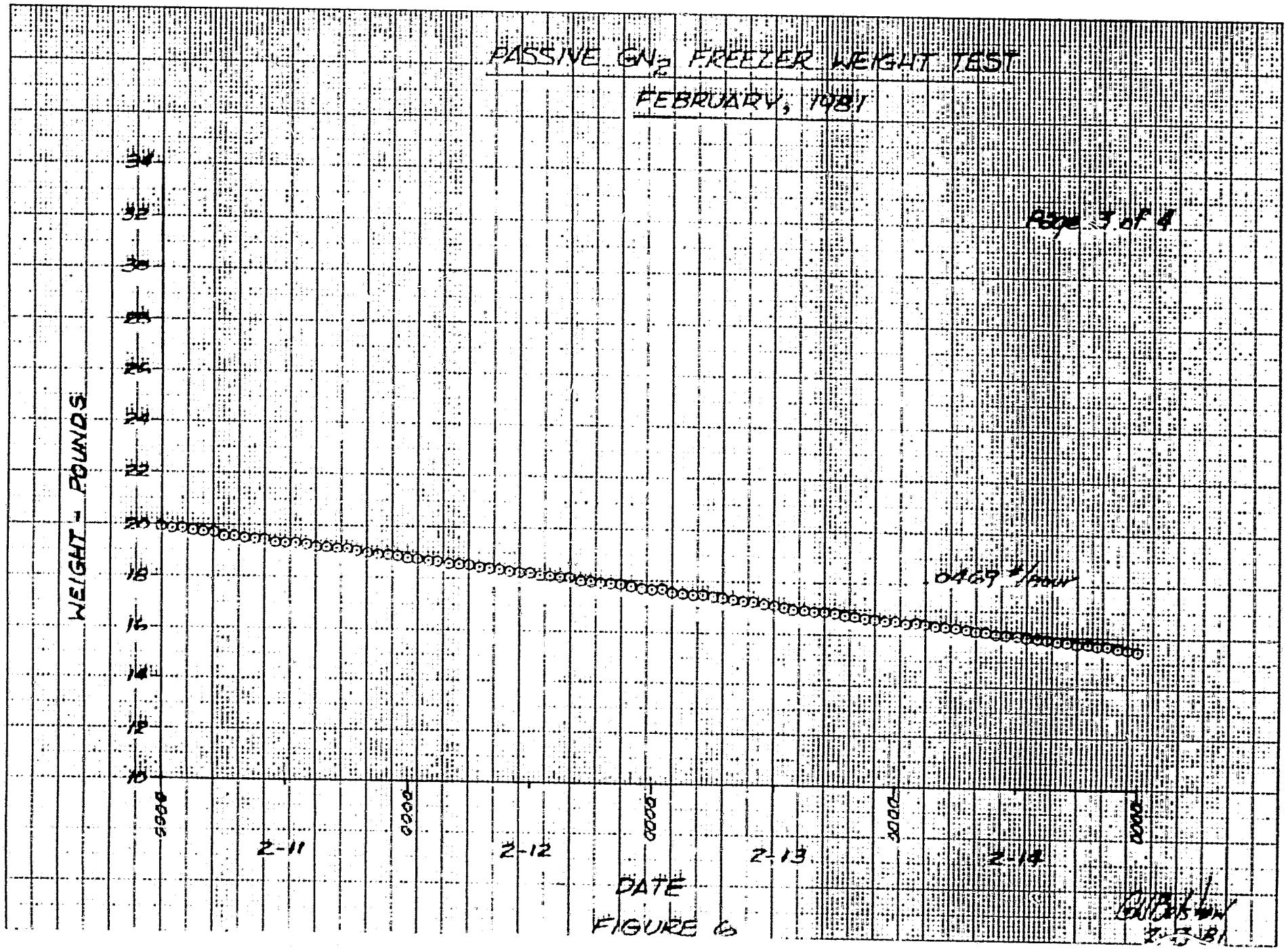
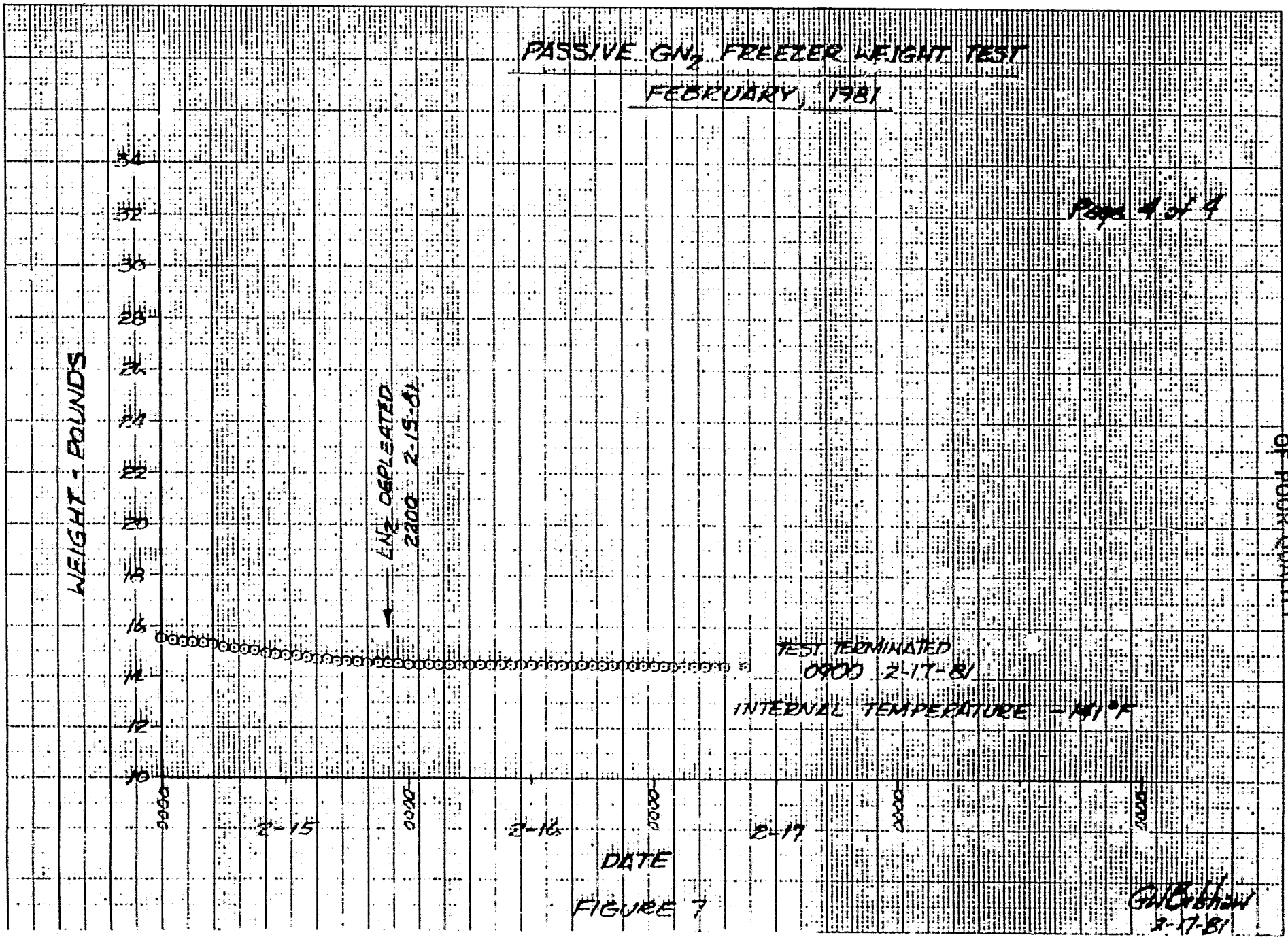


FIGURE 6



TO: B. French, SE4	DATE: 3/10/81
FROM: G.W. Belshaw, Project Engineer	CONTRACT: NAS9-15629

SUBJECT: GN_2 PASSIVE FREEZER THERMAL TEST - VIBRATION CERTIFICATION - March, 1981

Enclosed are the results of the thermal response of the Passive GN_2 Freezer during the Vibration Certification Test conducted at Bldg. 15 during the period of February 26, 1981 to March 9, 1981.

Figures 1 through 4 present the locker/freezer weight loss as a function of time.

A major result of this testing was the dramatic increase in the freezer boil off rate when the freezer is oriented in the horizontal position. The boil off rate ranged from .25 #/hr to .32 #/hr in the horizontal position to .046 #/hr in the vertical position. This is due to the increased convective flow with the freezer vent holes to the side.

The vibration shock testing on all six axes of the freezer had no effect on the boil off rate of the freezer. The samples inserted into the experiment holder were frozen at the time of the landing vibration and showed no signs of breakage or dislocation during the vibration test.

The load cell device for the measurement of the locker/freezer weight was very sensitive to slight position changes on the load cell assembly. At the conclusion of the testing, the range of weights recorded by slight position changes ranged between 31.87# and 34.05#. It can be concluded from this that the load cell is not accurate for recording absolute weight, but for weight differentials with no repositioning of the article.

The samples remained in the freezer until 0830 3/10/81 and were removed still frozen. This was approximately 78 hours after LN_2 depletion.
Also included in this report is the detailed test procedure timeline and weight loss record.

GENERAL ELECTRIC

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K&E 10 X 10 TO THE CENTIMETER 25 X 25 CM
KEUFFEL & ESSER CO. MADE IN U.S.A.

TO: B. French/SE4	DATE: 9/22/81
FROM: G.W. Belshaw, Project Engineer	CONTRACT: NAS9-15629

SUBJECT: GN_2 PASSIVE FREEZER FUNCTIONAL TESTING - August, 1981

This report documents the testing conducted on the Passive GN_2 Freezer during the period of August 10, 1981 to September 2, 1981. The containers tested had been refurbished by Cryogenics Associates and modified to include a Schrader vacuum valve on each container. The containers were designated Container "A", serial number 1358-79 and Container "B", serial number 1359-79.

The same test procedure timeline was utilized as for prior testing including the appropriate sample insertions as per the SL-1 timeline. Figures 1 and 2 present the test procedures with mission timelines relative to the testing are shown in Figures 3 and 4. It should be noted that the staggered starting times for the two containers were used to facilitate sample insertion times.

G.W. Belshaw

GENERAL ELECTRIC

TEST RESULTS

The results of the testing during this period is described in the following paragraphs with the two containers described separately. Figures 5 through 9 present the weight loss curves for Container "A" and Figures 10 and 11 show the weight loss for Container "B". The Appendix provides the weight record for the testing period.

CONTAINER "A"

Testing begain August 10, 1981 with the initial weighing of Container "A" at 14.21 pounds. The container was then filled with LN_2 to begin charging. During this period, excessive frost buildup on the container exterior was noted. The container was topped off and allowed to stand overnight. During this period a boiloff rate of 0.22 lb/hr was noted (see Figure 5). The container was topped off several more times and LN_2 pouroff occurred at 1550 August 11. At this point the sample holder was inserted into the container. Weight loss remained significantly high at a value of approximately 0.24 lb/hr during the next 20 hours. At this point the boiloff was increasing until 0700, August 13 where it was noted that the LN_2 had been depleted. Further testing with this container was terminated at 1100.

The probable cause for this excessive boiloff rate in this container would be vacuum level in the container not sufficient enough to provide proper insulative properties. To determine this, plans were formulated to open the vacuum valve, re-evacuate the container and test again.

On August 18, the Schrader valve was removed from the container, and by the ease of removal, noted that there was very little vacuum in the container. Inspection of the O-Ring on the Schrader valve showed that the O-Ring was too small which did not provide a good seal in the container. The O-Ring was then replaced with a larger one.

Vacuum connections were than set up and on August 19,the container was evacuated to approximately 10^{-3} torr level. The Schrader valve was reseated and the container was again charged with LN_2 (see Figure 6-9). As done previously, the container was allowed to stand overnight, full of LN_2. Boiloff rate for this period was now 0.047 lb/hr.

At 0900, August 20, the LN_2 pouroff occurred and the container allowed to stand until August 31 at which time the LN_2 was depleted. The average boiloff rate for this period was 0.044 lb/hr.

From this is can be concluded that the Container "A", as received from Cryogenics Associates was constructed with a Schrader valve O-Ring seal that was too small, allowing for a loss of vacuum. Resealing the evacuation of the container then produced the acceptable boiloff rates.

CONTAINER "B"

Testing on Container "B" began August 12 with the initial container weighing 13.86 pounds. The container was filled with LN_2 and topped off until 1600 August 13, at which time the LN_2 was poured off (see Figure 10). Boiloff rate during this period was approximately 0.045 lb/hr.

August 17, there were two sample insertions as per the SL-1 timeline and as shown in Figure 11. At 0830 2-10 ml Corvac samples and 4-15 ml Corvac samples were inserted in the experiment holder. At 1830 the ESA simulation was also inserted. Boiloff rate after the insertion period was approximately 0.046 lb/hr through August 19 at which point the test was terminated.

The testing on this container was terminated early due to a commitment of a container for crew training. Container "A" had been designated for this purpose, however, with the Container "A" anomaly and further testing required, Container "B" had to be used for this purpose.

The data of Figure 11 was extrapolated to the end of mission (164 hr MET) and the container weight estimated at 16.3 pounds. This represents approximately 1.0 pounds of LN_2 remaining which would provide approximately 20 hours of freezer life beyond landing.

CONCLUSIONS

The testing of these two containers showed that by allowing the container to stand during charging, the boiloff rate for the containers can be verified in a short period of time to determine the freezing capability of the container. The primary cause for any degradation would be loss of vacuum which can be readily re-established. Acceptable boiloff rates should be in the 0.044 to 0.047 lb/hr range.

Container "A", as received from Cryogenics Associates, was constructed without a proper size Schrader valve O-Ring seal, which caused a loss of vacuum. Seal replacement and evacuation produced a container that would provide for mission requirements.

Container "B" performed as expected and maintained the samples and experiments for the duration of the mission.

FIGURE 1

GN_2 PASSIVE FREEZER TEST PROCEDURES

MISSION TIMELINE TEST

UNITS TO BE TESTED: "A" Serial No. 1358-79
"B" Serial No. 1359-79

8/10/81	° Record container weight "A" with cover Note: All weights include cover
Prior to 4 pm	° Fill container "A" with LN_2 until container is full.
	° Record continer weight
Every 1-2 hours as needed	° Refill container "A" with LN_2 to maintain LN_2 level within one inch of top.
8/11/81	° Continue topping and recording weight
4 pm	° Pour off LN_2 from container, replace cover and record weight.
Every 2-3 hours	° Record container weight until end of test.
8/12/81	° Record container weight "B" with cover.
Prior to 4 pm	° Fill container "B" with LN_2 until container is full.
	° Record container weight.
Every 1-2 hours as needed	° Refill container "B" with LN_2 to maintain LN_2 level within one inch of top.
8/13/81	° Continue topping and recording weight.
4 pm	° Pour off LN_2 from container "B", replace cover and record weight
Every 2-3 hours	° Record container weight until end of test.

End of test estimated 8/24/81.

FIGURE 2

GN_2 PASSIVE FREEZER TEST PROCEDURES

MISSION TIMELINE TEST

° SAMPLE INSERTION #1 - CONTAINER "A"

8/13/81	9:15 am	10 - 15 ml Corvac Samples 2 - 10 ml Corvac Samples

Weight of Samples - .795#

° SAMPLE INSERTION #2 - CONTINER "B"

8/17/81	8:30 am	4 - 15 ml Corvac Samples 2 - 10 ml Corvac Samples

Weight of Samples - .39#

° SAMPLE INSERTION #3 - CONTAINER "B"

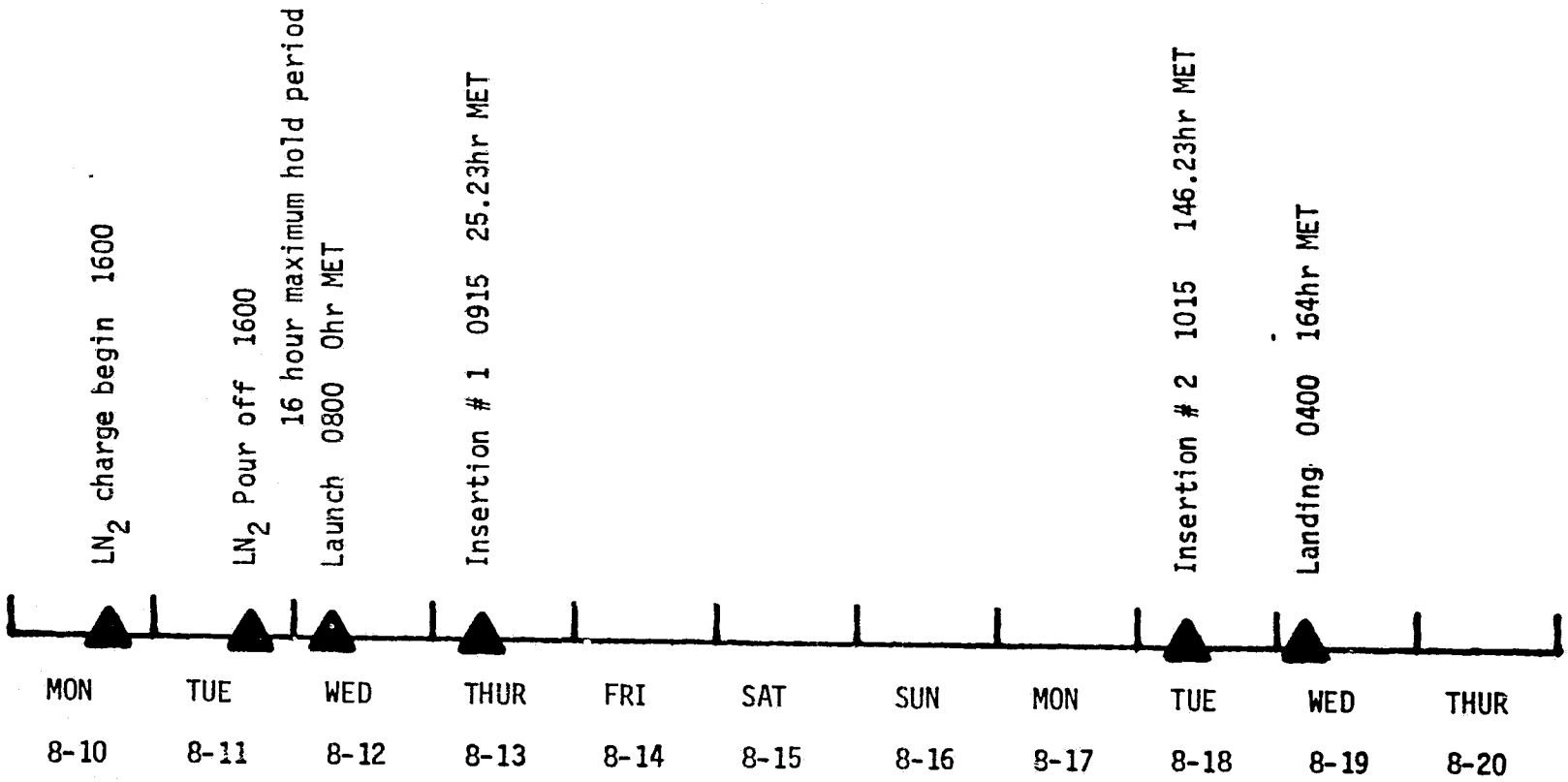
8/17/81	6:18 pm	ESA Experiment Simulation

Weight of Sample - 1.09#

° SAMPLE INSERTION #4 - CONTAINER "A"

8/18/81	10:15 am	22 - 15 ml Corvac Samples 2 - 10 ml Corvac Samples

Weight of Samples - (not recorded)



Insertion # 1 — 10 - 15 ml Corvac samples
2 - 10 ml Corvac samples

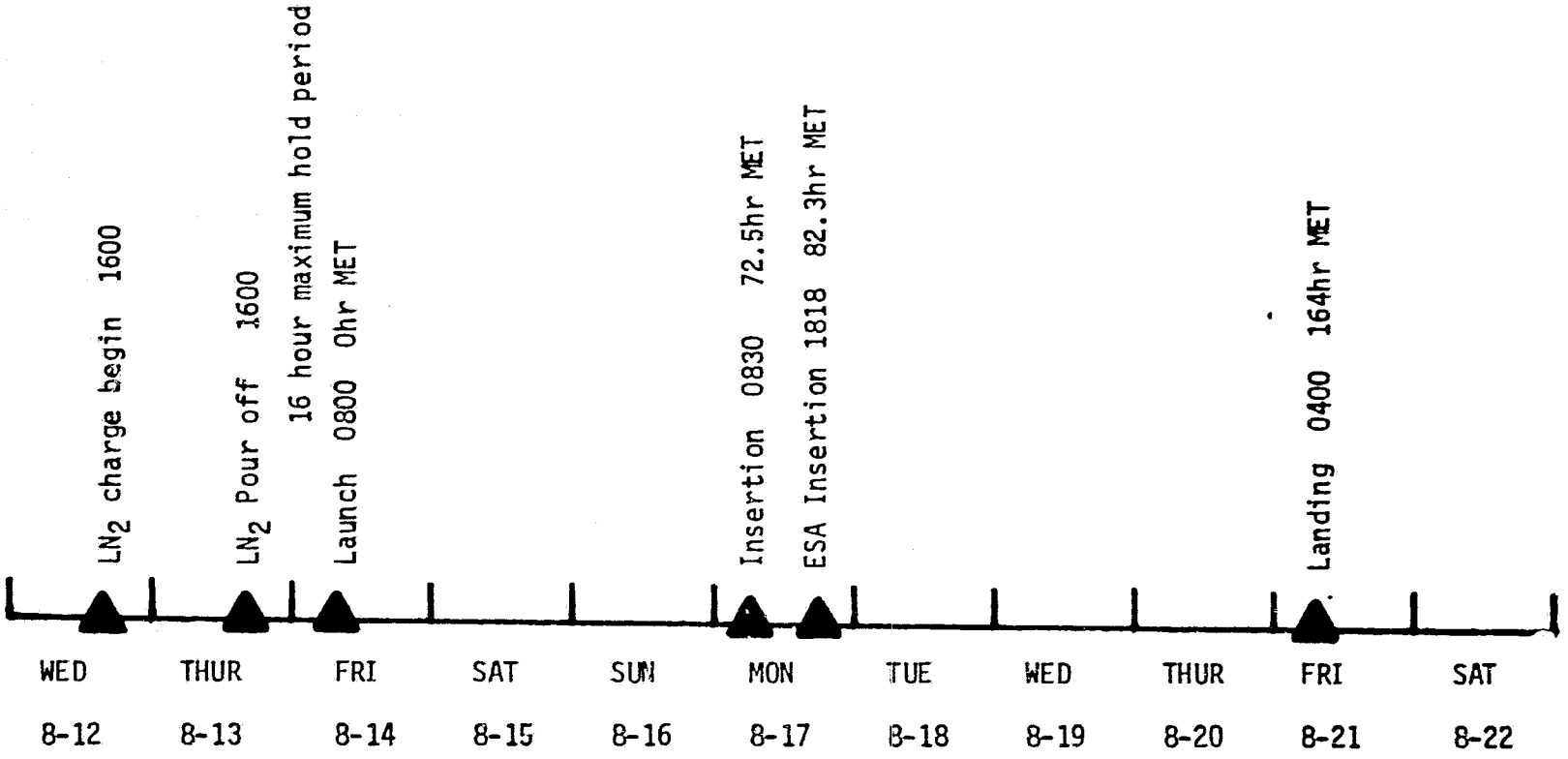
Insertion # 2 — 22 - 15 ml Corvac samples
2 - 10 ml Corvac samples

PASSIVE GN_2 FREEZER

SL-1 TEST TIMELINE

UNIT "A"

SAMPLE CONTAINER



Insertion 4 - 15 ml Corvac samples
2 - 10 ml Corvac samples

PASSIVE GN_2 FREEZER

SL-1 TEST TIMELINE

UNIT "B"

EXPERIMENT CONTAINER

46 1513

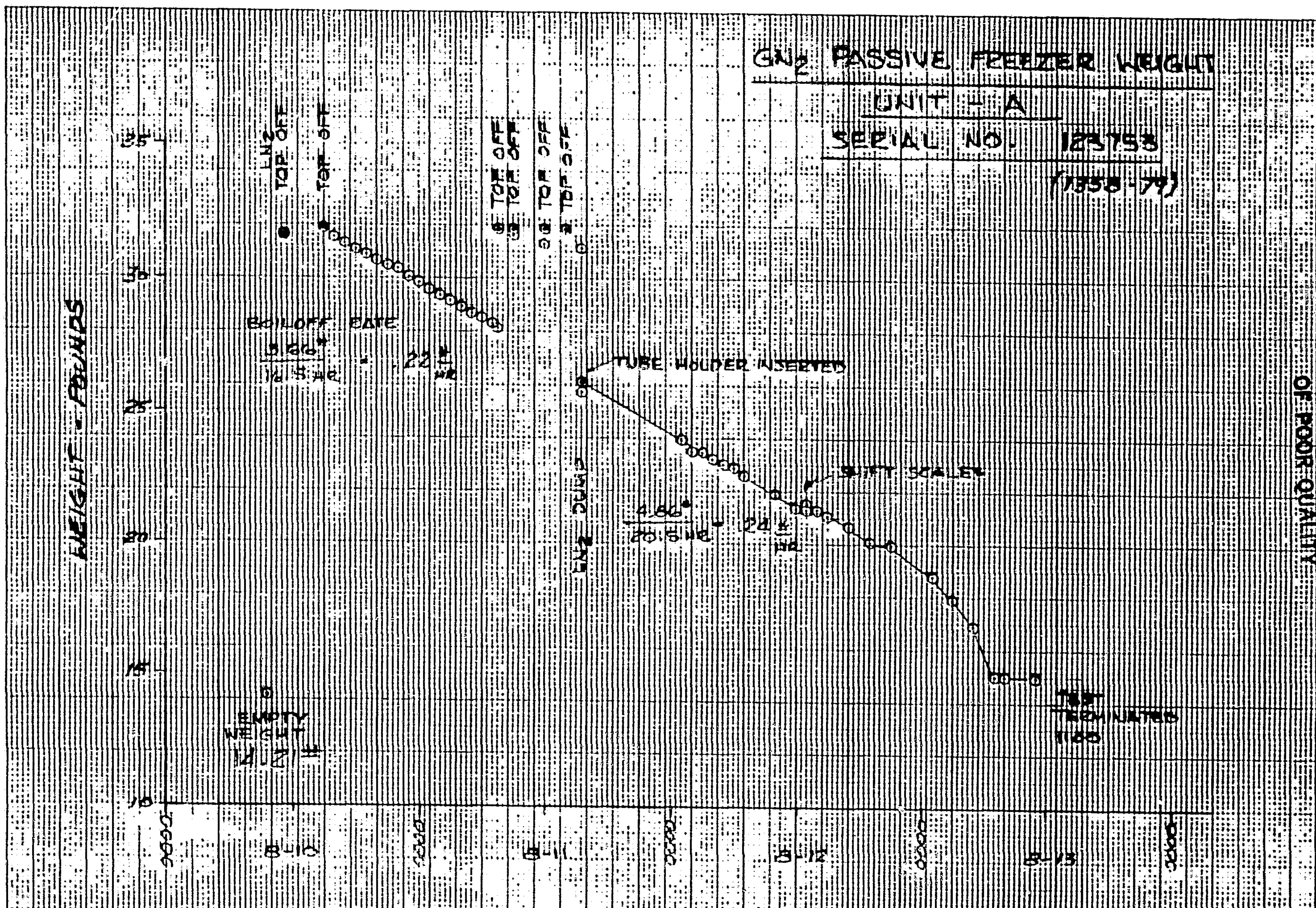


FIGURE 5

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10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFFEL & ESSER CO MADE IN U.S.A.

46 1513

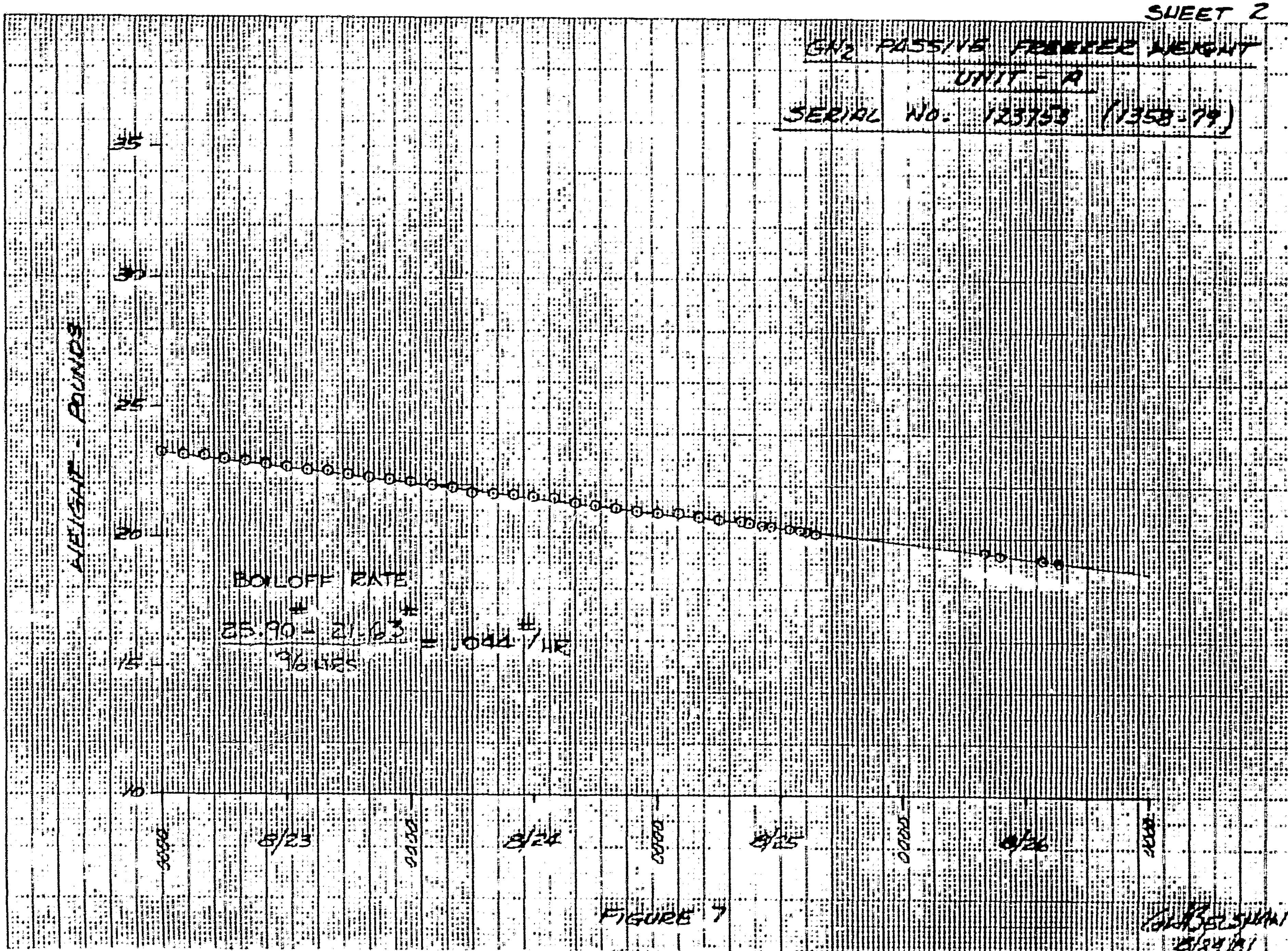

FIGURE 7

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K&E 10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO

46 1513

SHEET 4

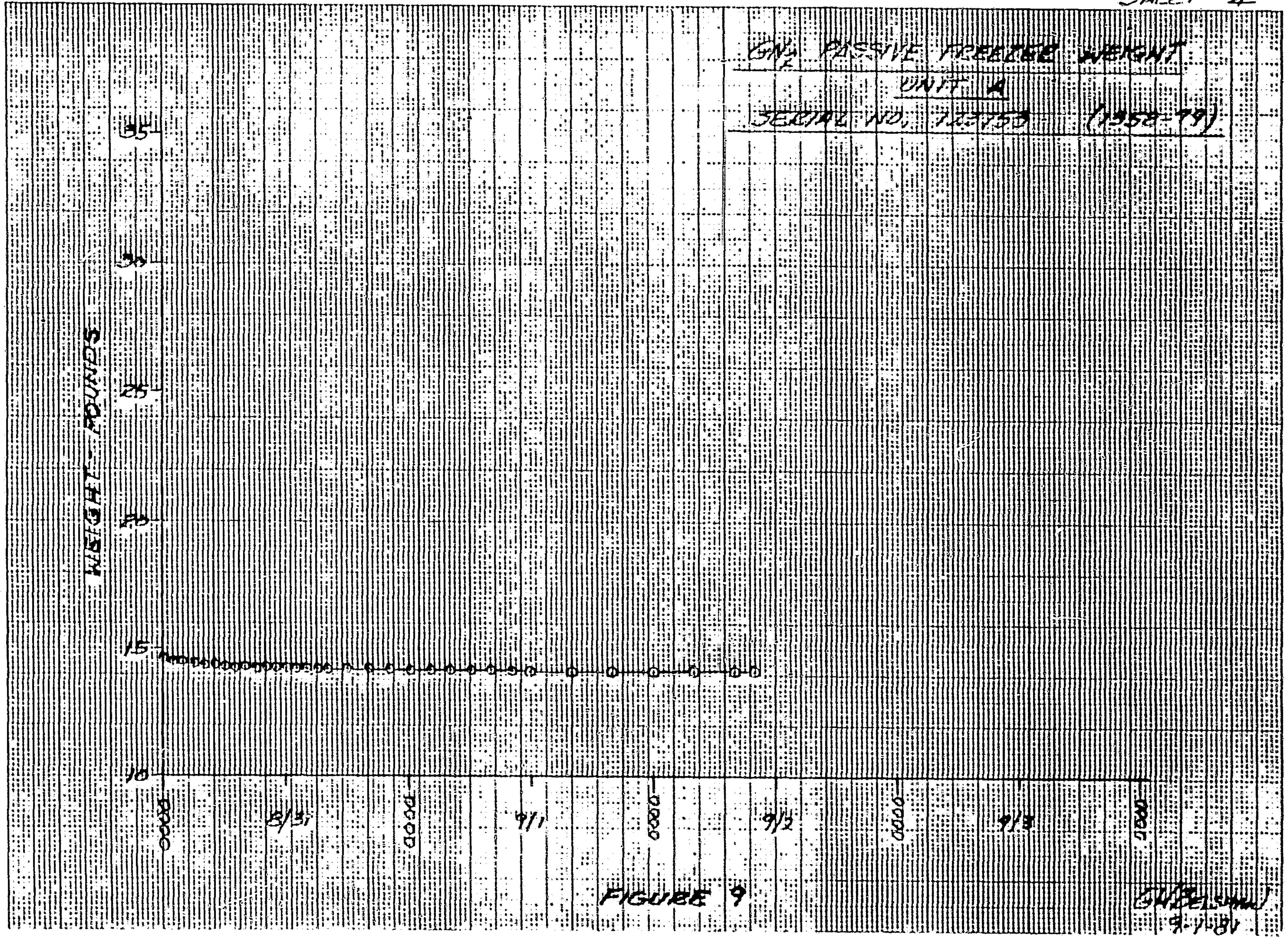

FIGURE 9

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Figure 10

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10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO. MADE IN U.S.A.

SHEET 2

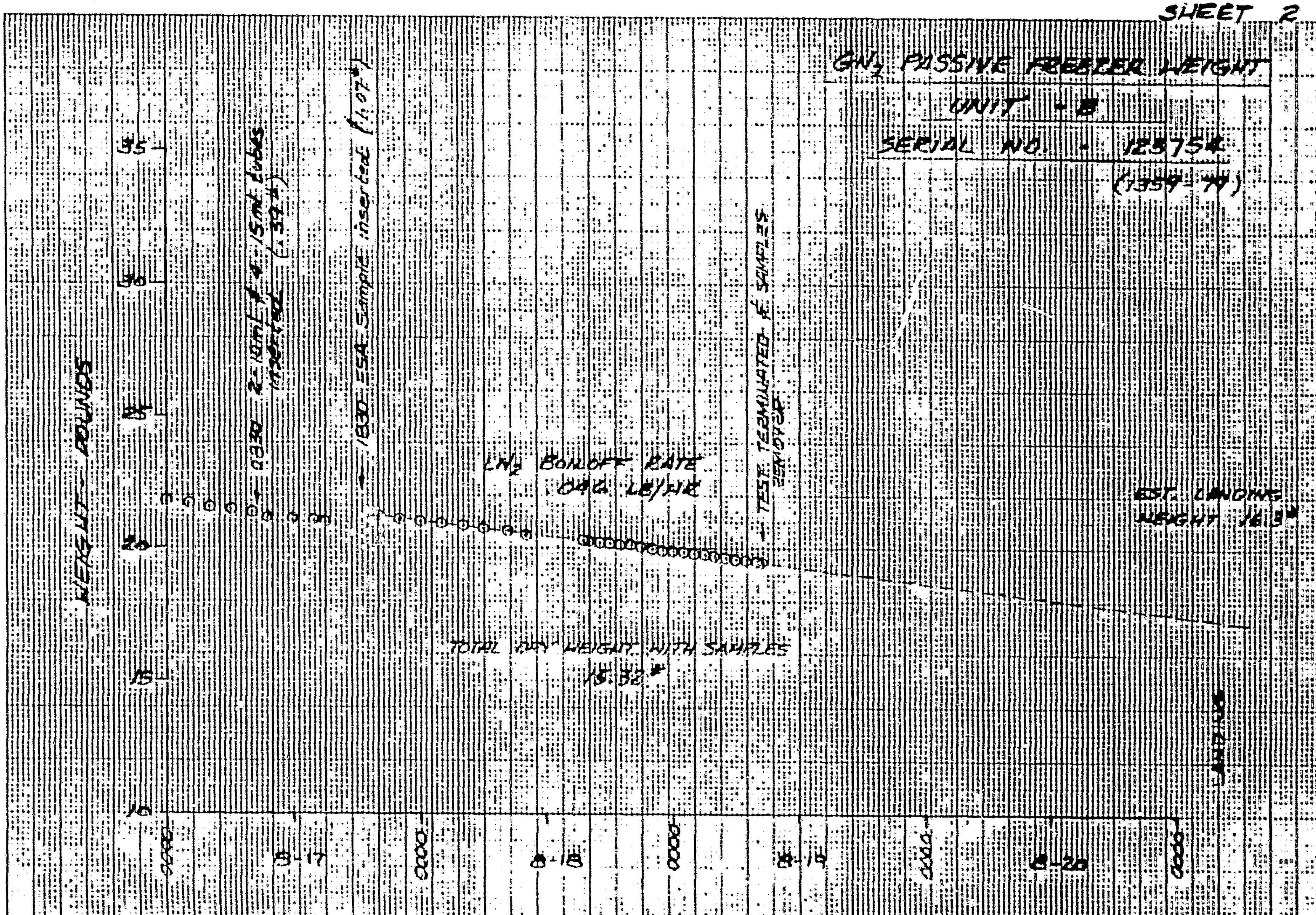

FIGURE 11