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AD842100

REPORT NO 27A589
DATE 11 August 1960
NO OF PAGES 15

CONVAIR ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS CORPORATION

REPORT NO. 27A589
4C & 11D Failure Analysis
of
HELIUM PRESSURE REGULATOR
(FUEL TANK)

DWR. NO. 27-08217-3

PREPARED BY D. J. Melvin
D. J. Melvin, Test Engineer

CHECKED BY C. F. Johnson
For R. T. Tutsobene, Lead Engineer

APPROVED BY F. C. Camp, Jr.
Test Lab Group Engineer

APPROVED BY R. S. Campbell
Chief Of Test Lab.

Checked By: A. Mollenkopf
A. Mollenkopf
Qualification Coordinator

REVISIONS

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INTRODUCTION: This test was conducted at the Gas Flow Laboratory to analyze failures that occured in the airborne pressurization system of missiles 4C and 11D.

OBJECT: The object of this test was to determine if the heating of the motor section pressure/bleed line on the regulator would result in a condition similar to that which caused the failures.

CONCLUSION: Although the heating conditions that were suspected of causing the failures were not duplicated exactly, the regulator functioned properly under the heating conditions that were obtained which were near the temperature desired.

TEST SPECIMEN: The test specimen was a Hadley "C" Series regulator, Specification Number 7-08217-3, Hadley P/N 10542-3. A coil designed to heat the motor section pressure/bleed tube to a temperature of 1500°F within 110 seconds of the program start was put on the regulator. The regulator was installed in the pressurization system of the 7-31-34 Fuel Battleship Tank. A schematic of this system is shown in Figure 1.

TEST PROCEDURE: The following is an outline of the procedure used during the test:

1. The fuel tank was filled with water to an ullage volume of 27±5 cu ft.

2. The tank was pressurized by means of the Facility pressurization control unit to a pressure between 62.0 and 63.3 psig.

3. With the specimen locked-up, the pressurization control unit was secured and 3100 ±100 psig helium was applied to the inlet port of the specimen.

4. The specimen was allowed a minimum of three leakage fills prior to the start of the flow program.

5. At the end of this period, the inlet pressure, altitude water flow, and altitude programs per figures 2,3, and 4 were started along with the tube heater and the helium heat exchanger. The temperature of the helium was to reach +450°F within 90 seconds and the tube was to reach +1500°F within 110 seconds of the start.

DISCUSSION OF RESULTS:

It was suspected that the failures were caused by the heating of an external tube on the airborne fuel tank pressure regulator. This tube was the meter section pressure/bleed line from the pressurization duct to the metering cavity of the regulator. It was thought that the heating of the tube would cause the gas to expand and indicate to the metering device that there was a higher than desired pressure in the duct. This would cause the regulator to completely close with a resulting decrease in tank pressure.

Conversely, with the tube vented to ambient conditions, the regulator would go wide open to compensate for what seemed to be an extremely low tank pressure.

There were five operating cycles run on this specimen. The first run was made without the tube heater to obtain the operating characteristics of the regulator. The band chosen for the ullage pressure (58-63 psig) was found to be too high. The ullage pressure went off scale about midway through the run but it was considered that the run accomplished its purpose. The ullage pressure band was changed first to 53-63 psig and then to 55-60 psig.

Runs No. 2 and 3 were the first attempts made to heat the tube during an operating cycle. Both runs were unsatisfactory because the tube heater melted holes in the tube at approximately 90 sec. with a tube temperature of approximately 1050°F. This allowed the regulator to go wide open on Run No. 2 and partially wide open on Run No. 3, the difference being due to the size of the melted holes. The reason the heater melted holes in the tube was that the vacuum in which the regulator was operating caused an arc to jump from the heater to the tub

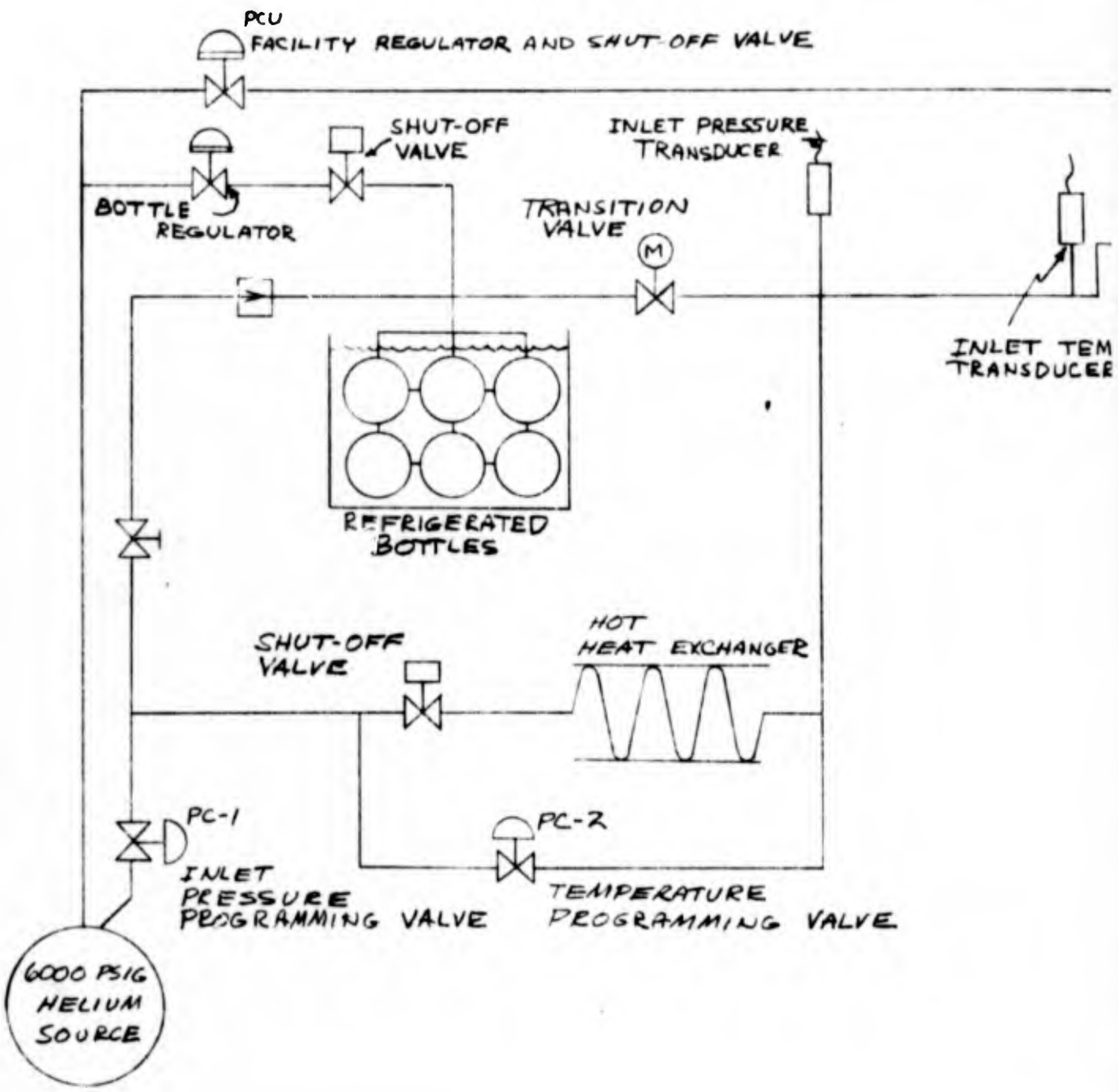
The heater was redesigned and Runs No. 4 and 5 were made. Although no holes were melted in the tube, Run No. 4 was considered unsatisfactory because the tube temperature reached only 800°F. Run No. 5, with a hole melted in the tube, was considered to have accomplished the purpose of this test. The tube temperature had reached 1340°F before arcing caused holes to be melted in the tube. Under the circumstances it was decided that the temperature was near enough to the required temperature to satisfy the objective of the test.

Run No. 5 showed a gradual decrease of tank ullage presume from 59.2 psig to about 56.5 psig. This was considered normal for this regulator because Run No. 1, the control run, showed a similar decrease. Therefore it was concluded that the heating of the tube had little or no affect upon the performance of the regulator.

THE INSTRUMENTATION USED FOR THIS TEST WAS AS FOLLOWS:

	MEASUREMENT	INSTRUMENT	CAL RANGE
1.	Ullage Pressure	Wiancko Transducer 0-100 psig	58-63 psig 53-63 psig 55-60 psig
2.	Regulator Inlet Pressure	Statham Transducer 0-5000 psig	0-5000 psig 0-500 psig
3.	Water Flow Rate	Hagan Ring Balance	0-5000 GPM
4.	Regulator Inlet Temperature	Convair Astronautics (Dept. 756) Thermocouple; Ceramo, Copper-Constantin	0-500°F
5.	Altitude Chamber Pressure	Wiancko Transducer ± 15 psid	14.7-0 psia
6.	Tube Temperature	Convair Astronautics (Dept 562-1) Thermocouple; Chromel-Alumel	0-2400°F

4C-110 FAILURE ANALY
SCHEMATIC OF



NALYSIS OF HELIUM PRESSURE REGULATOR
C OF TEST SET-UP

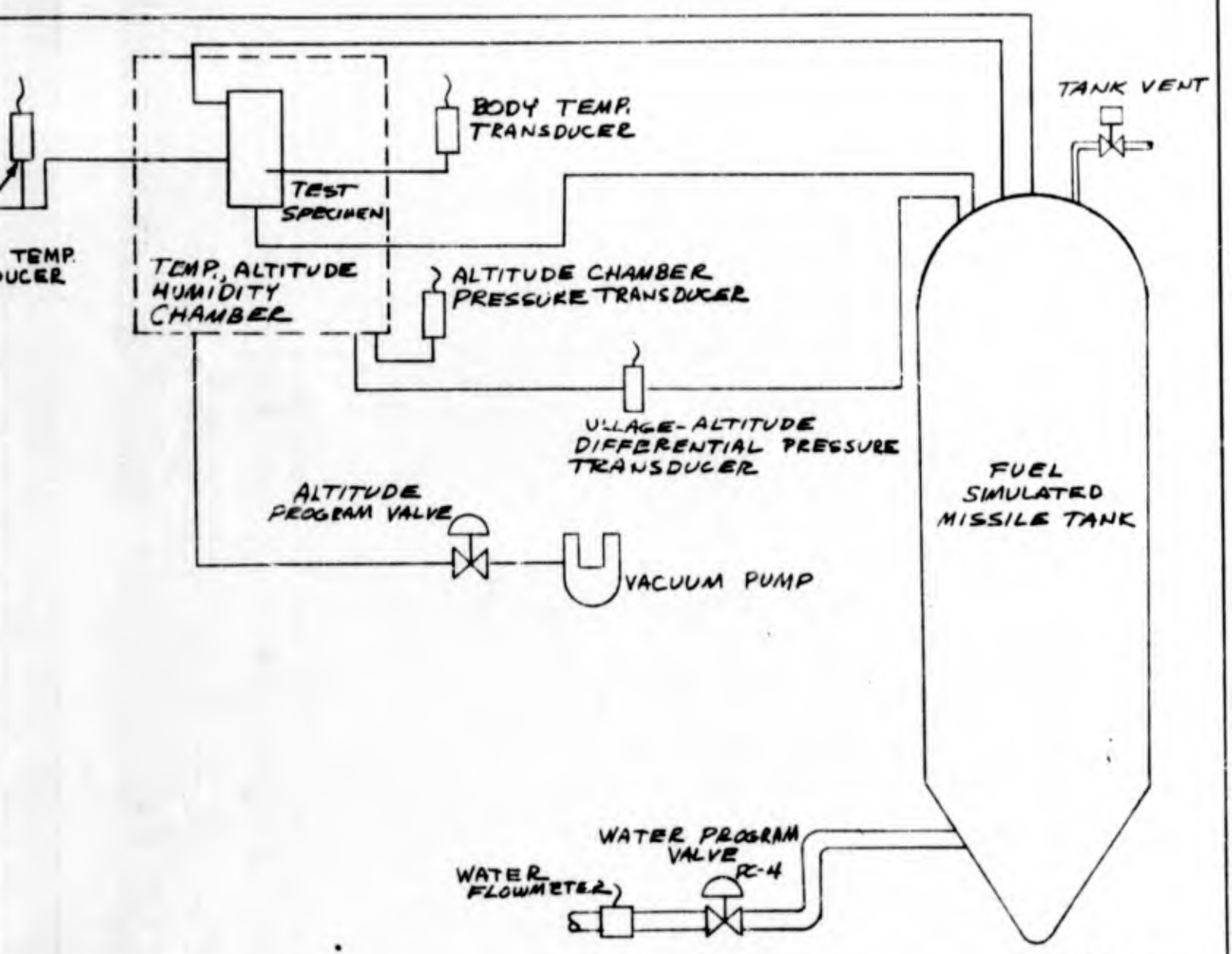


FIGURE 1

PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE

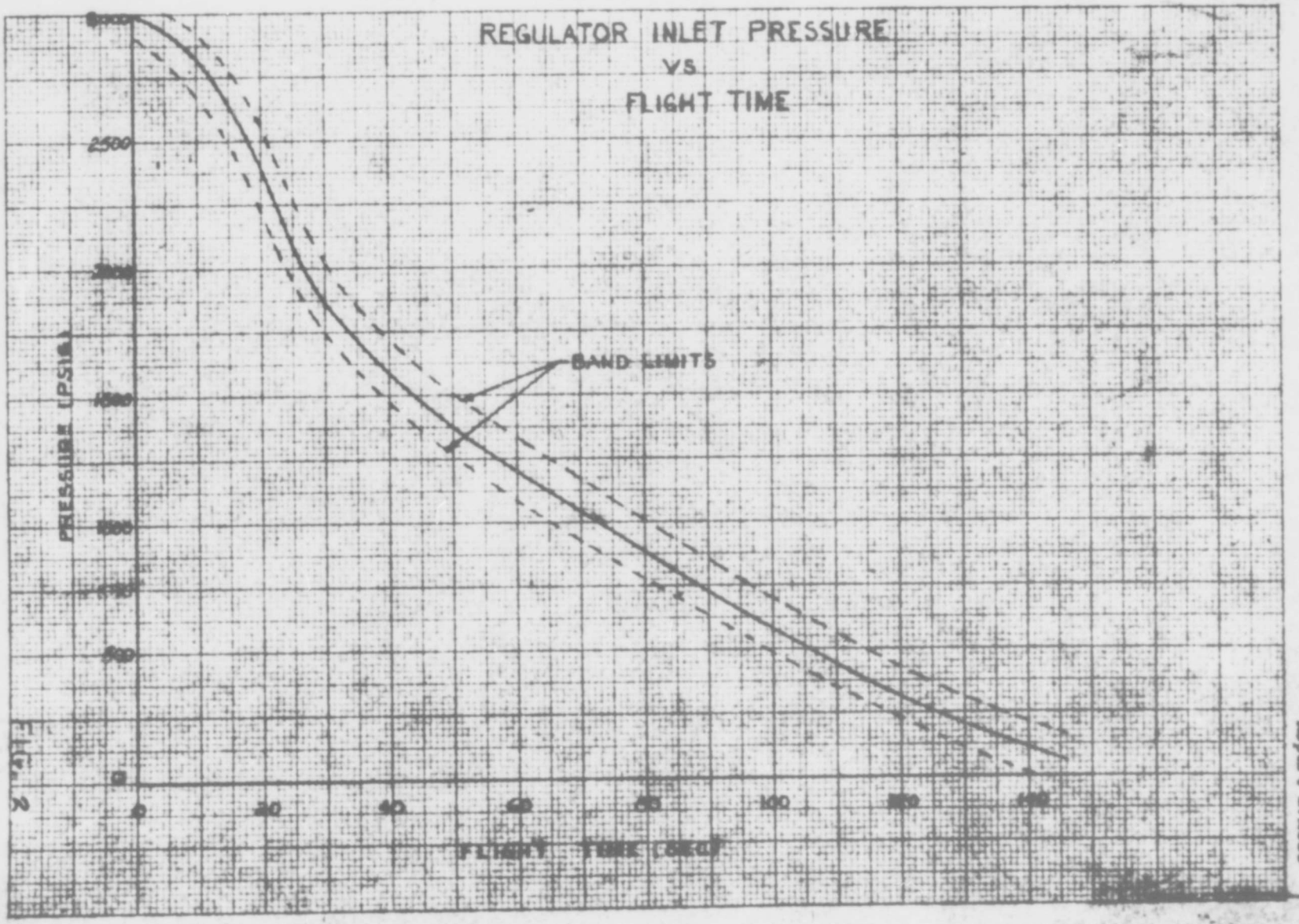


FIG. 2

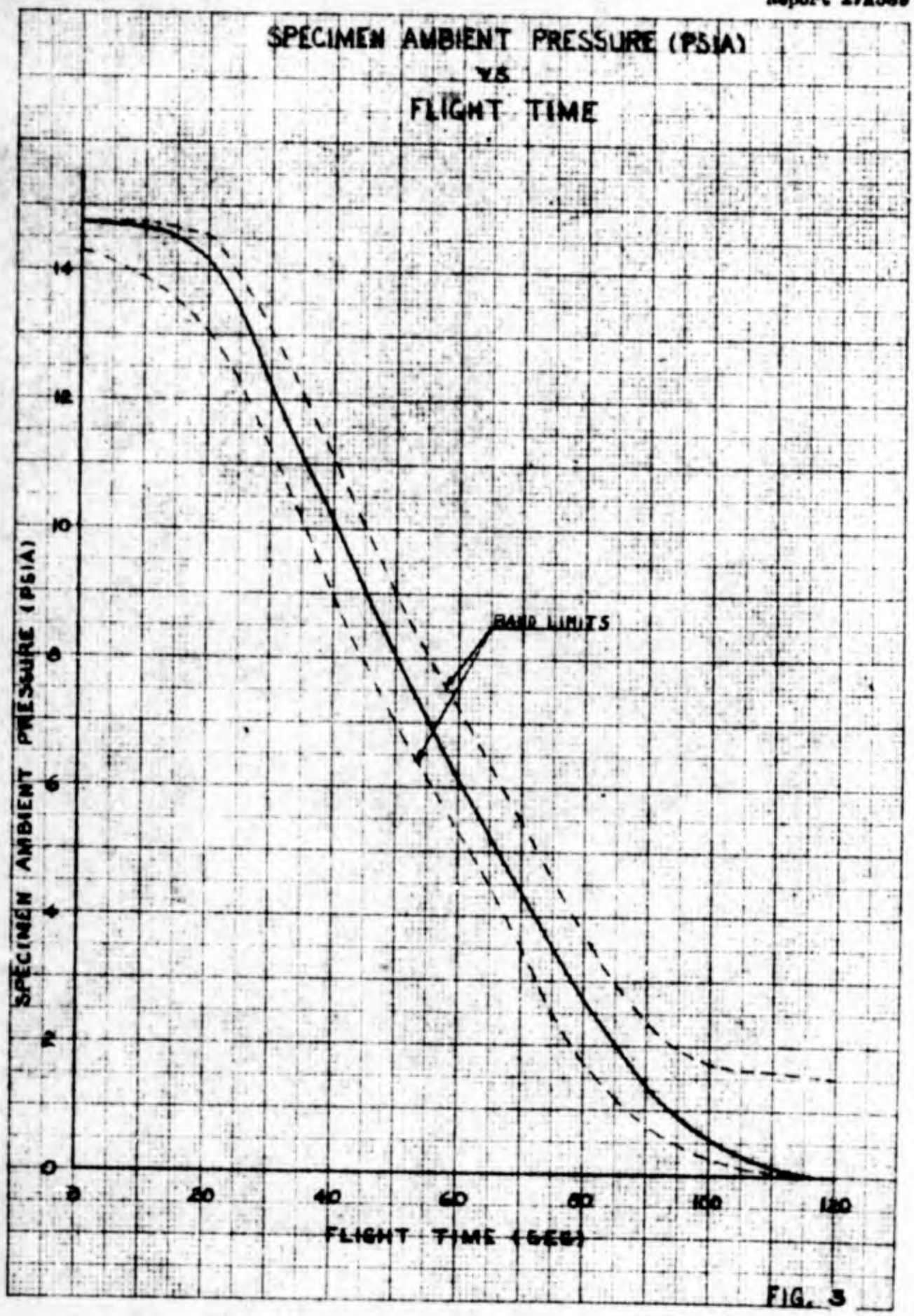

SPECIMEN AMBIENT PRESSURE (PSIA)
VS
FLIGHT TIME
BAND LIMITS
SPECIMEN AMBIENT PRESSURE (PSIA)
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
FLIGHT TIME (SEC)

FIG. 3

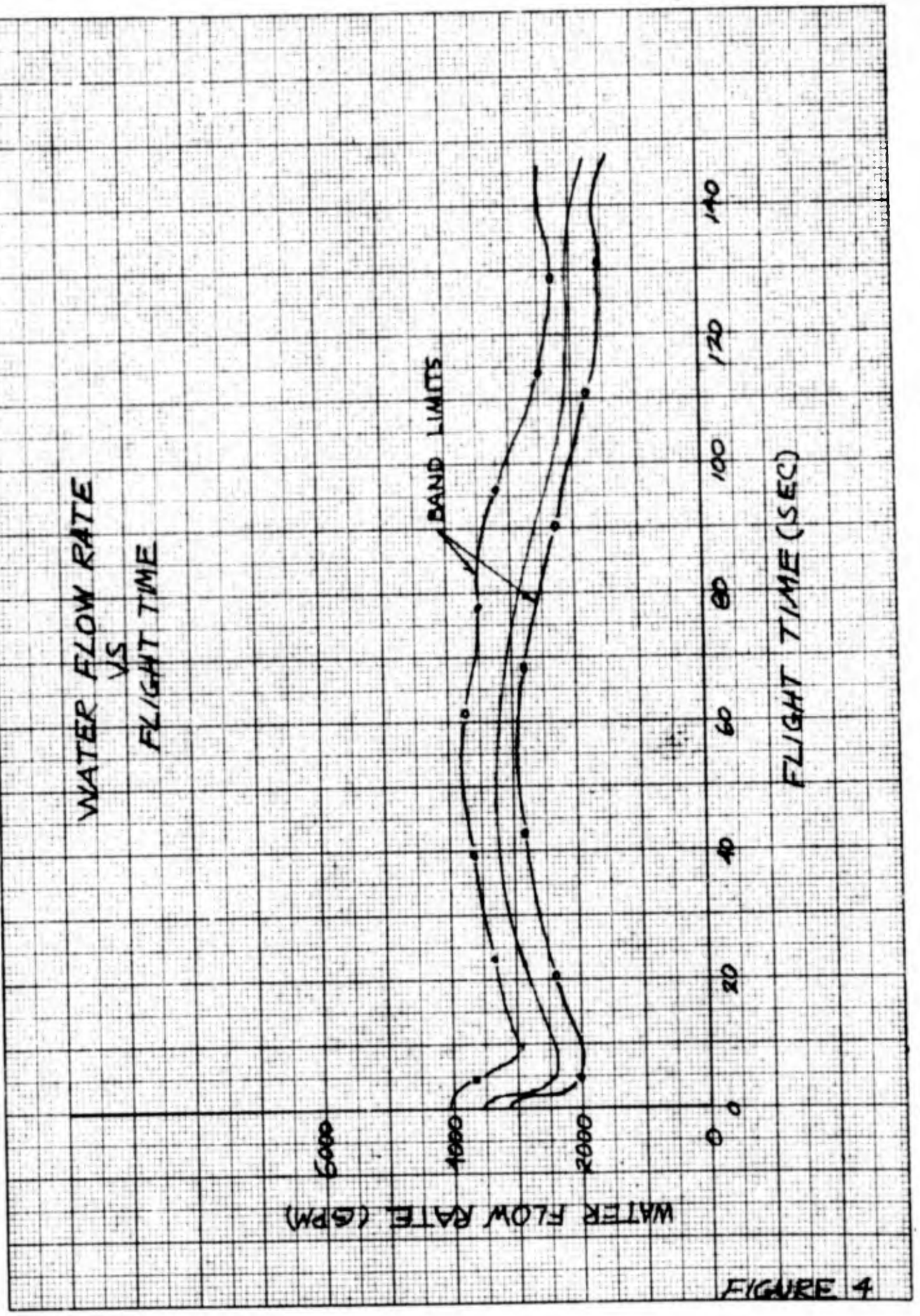

WATER FLOW RATE VS FLIGHT TIME
BAND LIMITS
WATER FLOW RATE (GPM)
FLIGHT TIME (SEC)
0
20
40
60
80
100
120
140
0
1000
2000
3000

FIGURE 4

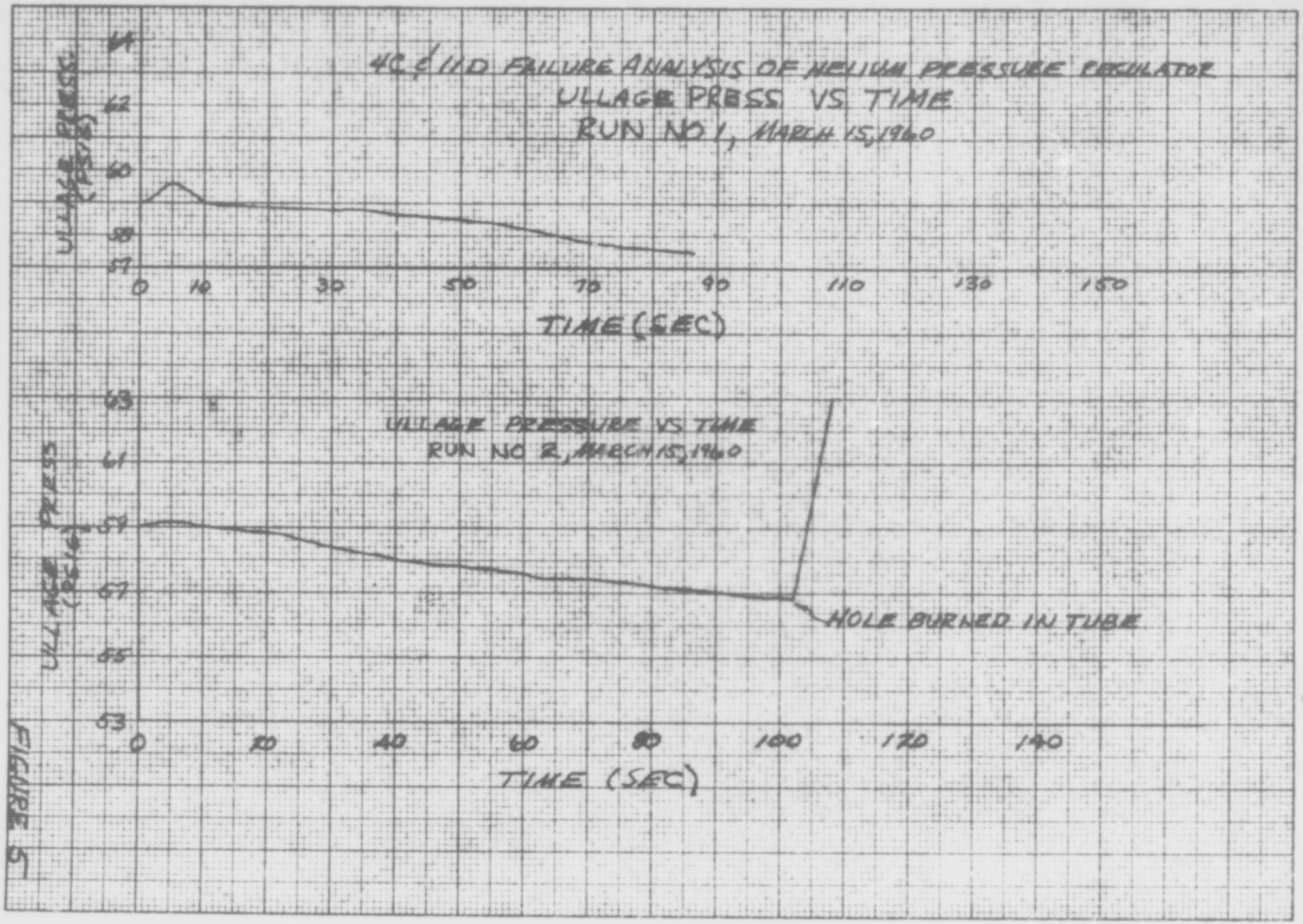


FIGURE 5

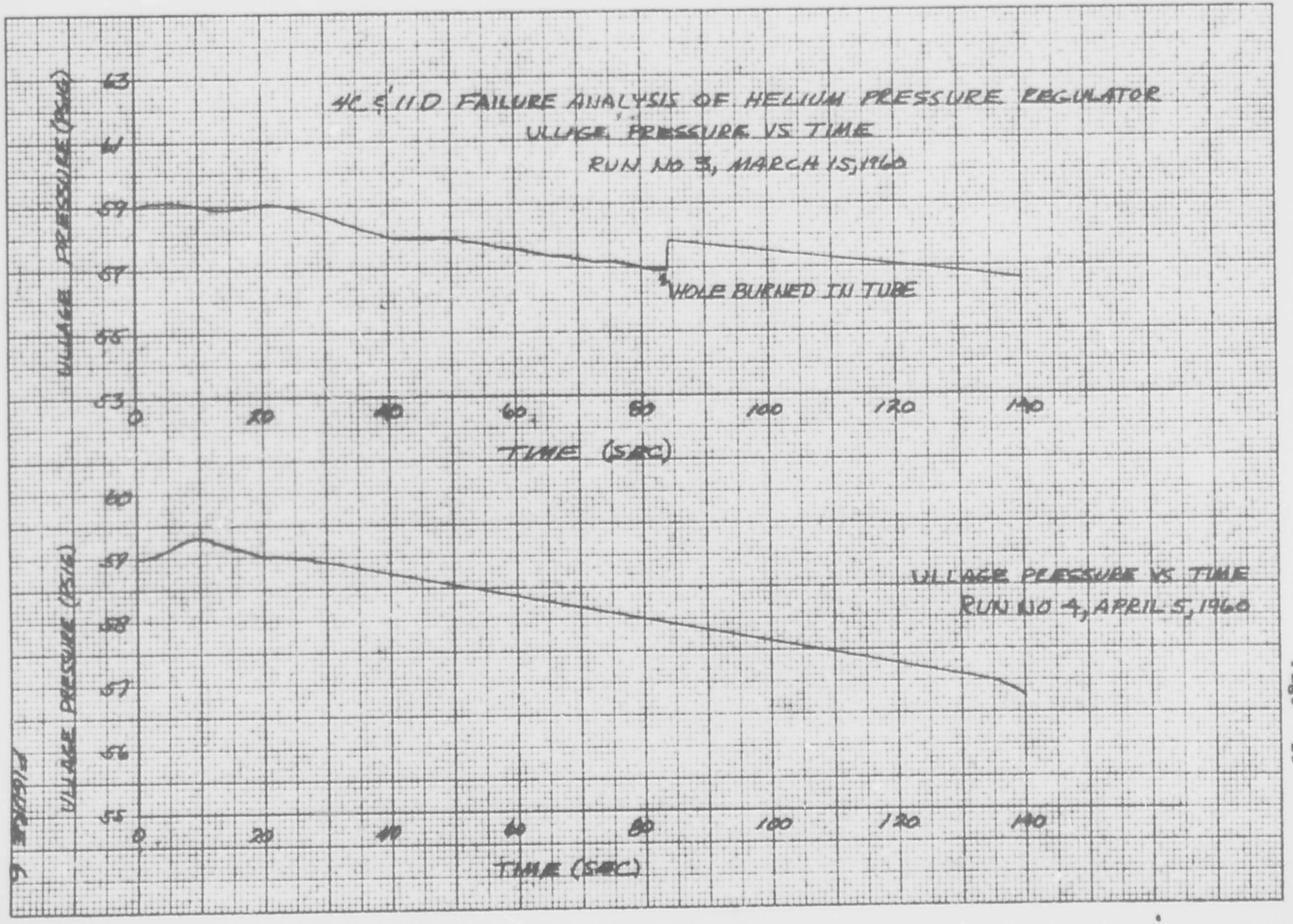

HC 5'11.0 FAILURE ANALYSIS OF HELIUM PRESSURE REGULATOR
ULLAGE PRESSURE VS TIME
RUN NO 3, MARCH 15, 1960
HOLE BURNED IN TUBE
ULLAGE PRESSURE (PSIA)
TIME (SEC)
ULLAGE PRESSURE VS TIME
RUN NO 4, APRIL 5, 1960
ULLAGE PRESSURE (PSIA)
TIME (SEC)

FIGURE 6

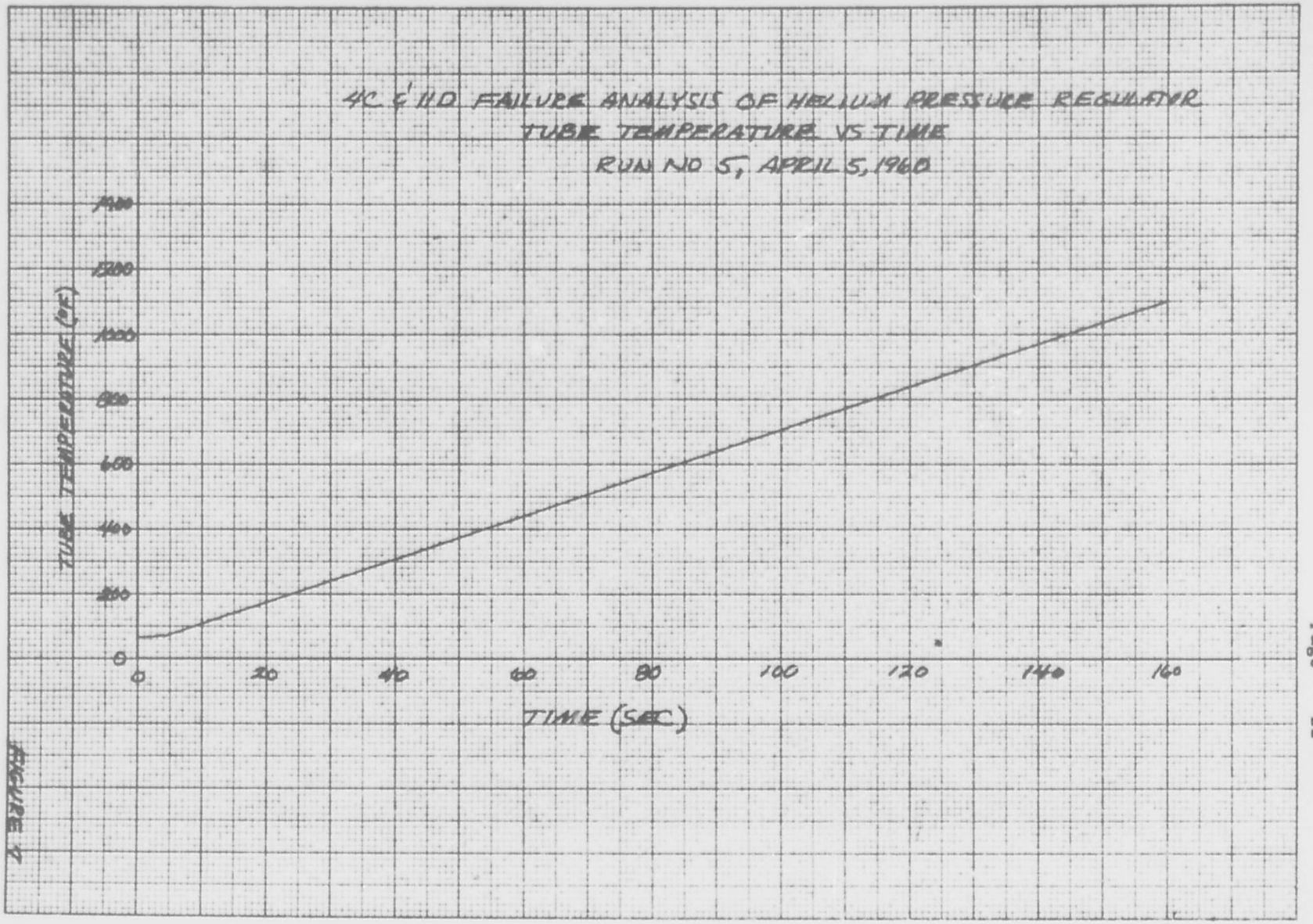
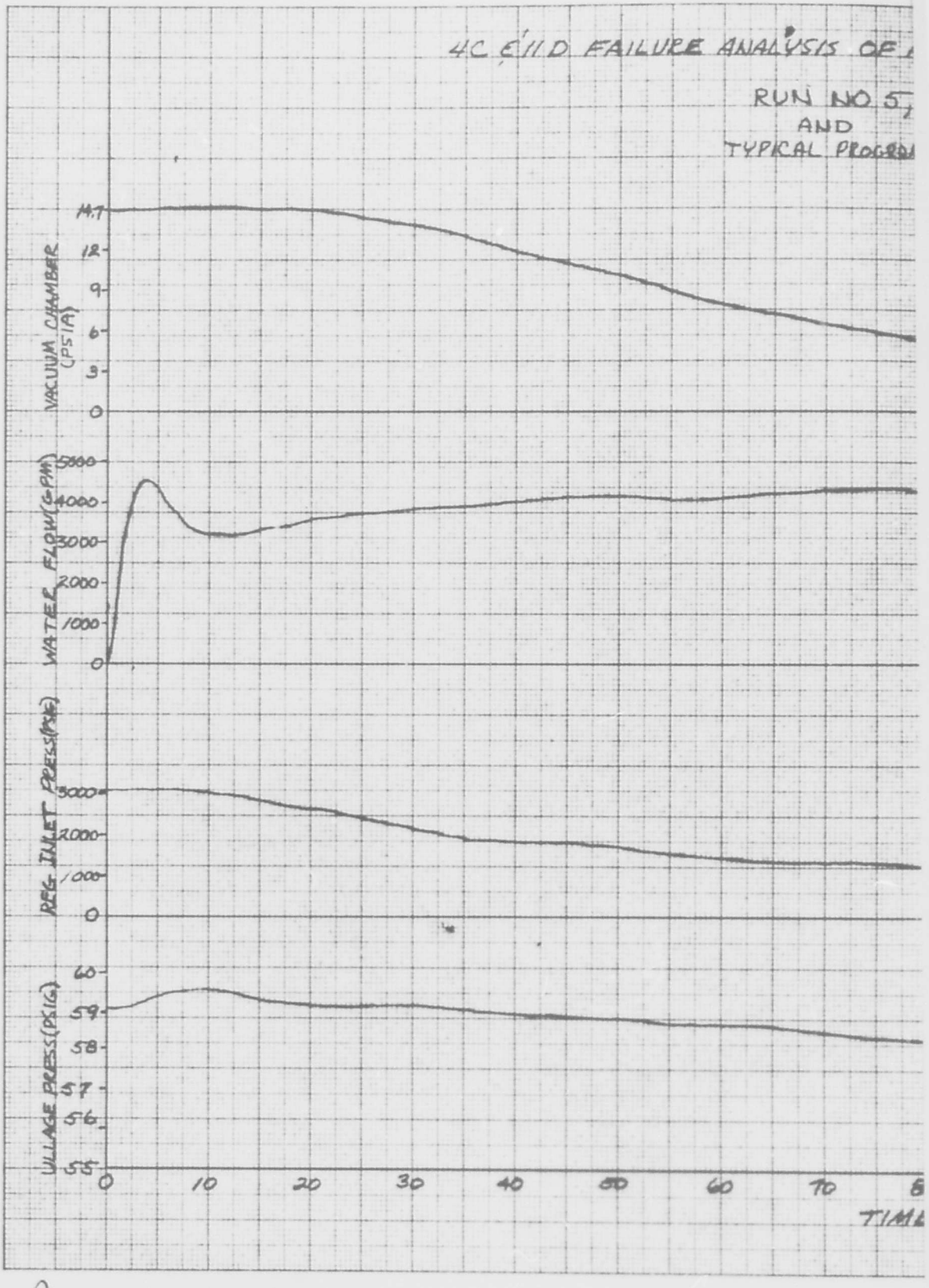

4C & 11D FAILURE ANALYSIS OF HELIUM PRESSURE REGULATOR
TUBE TEMPERATURE VS TIME
RUN NO 5, APRIL 5, 1960
TUBE TEMPERATURE (°F)
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
140
160
TIME (SEC)

FIGURE 7


4C E'II D FAILURE ANALYSIS OF
RUN NO 5,
AND
TYPICAL PROCED
VACUUM CHAMBER (PSIA)
14.7
12
9
6
3
0
WATER FLOW (GPM)
5000
4000
3000
2000
1000
0
REG. INLET PRESS (PSIG)
3000
2000
1000
0
ULLAGE PRESS (PSIG)
60
59
58
57
56
55
0
10
20
30
40
50
60
70
TIME

A

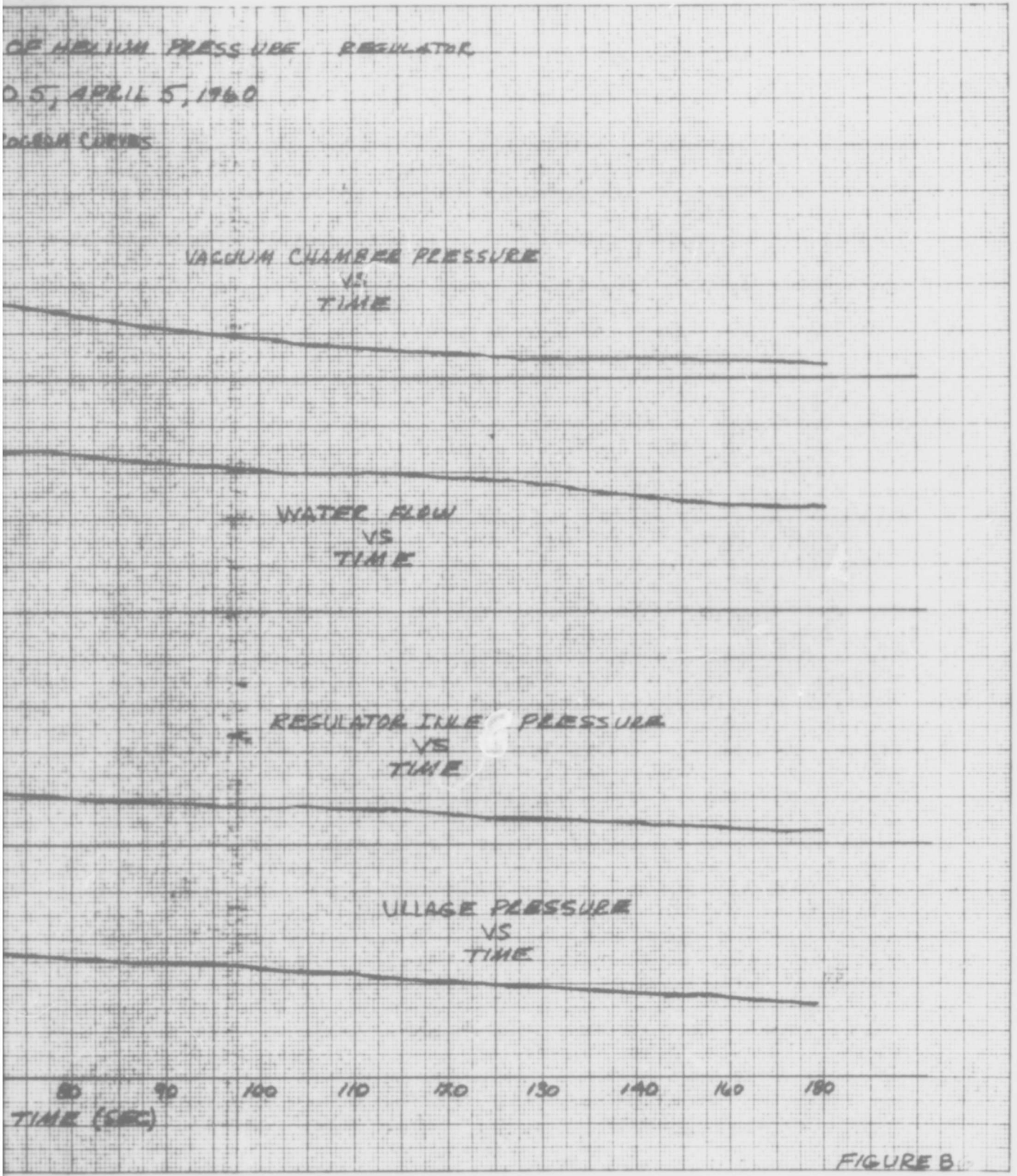

OF HELIUM PRESSURE REGULATOR
0.5, APRIL 5, 1960
VACUUM CHAMBER PRESSURE
VS
TIME
WATER FLOW
VS
TIME
REGULATOR INLET PRESSURE
VS
TIME
ULLAGE PRESSURE
VS
TIME
80
90
100
110
120
130
140
150
160
TIME (SEC)

FIGURE B

B

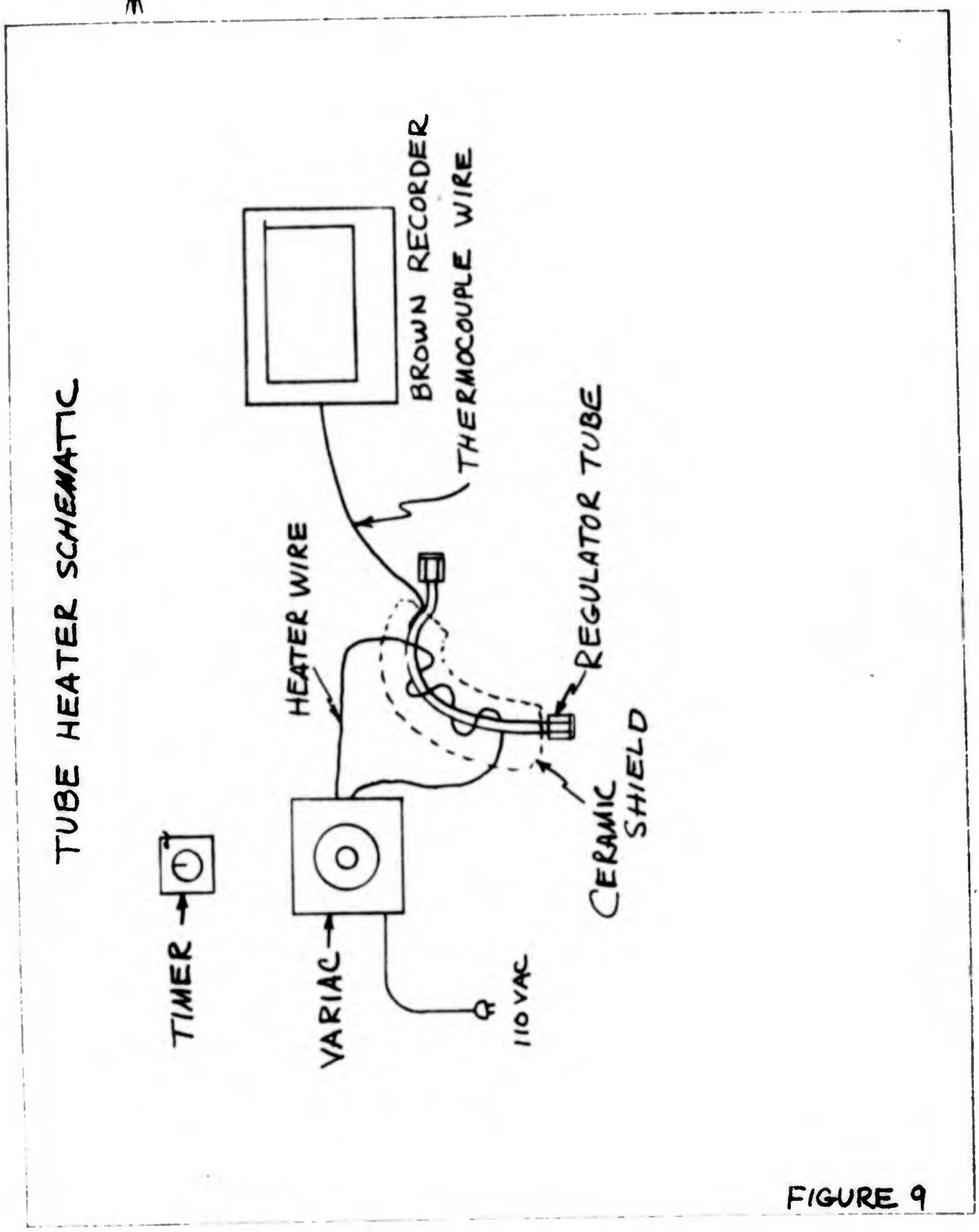

TUBE HEATER SCHEMATIC
TIMER
VARIAC
110 VAC
HEATER WIRE
BROWN RECORDER
THERMOCOUPLE WIRE
REGULATOR TUBE
CERAMIC SHIELD

FIGURE 9

PHOTO INDEX

FIGURE NO. 10