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L.O. 18638A FILE 3515-2 PREPARED BY H.S.F. CHECKED BY E.H.D.	NATIONAL RESEARCH COUNCIL OF CANADA DIVISION OF MECHANICAL ENGINEERING OTTAWA, CANADA LABORATORY MEMORANDUM SECTION ENGINE LABORATORY	NRC-ENG-100 NO. PAGE OF COPY NO. DATE February 1979
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SECURITY CLASSIFICATION UNCLASSIFIED

SUBJECT The Calibration of a Blower for the A.C.V.
Heave Test Rig ("Bouncer")

PREPARED BY H.S. Fowler

ISSUED TO

THIS MEMORANDUM IS ISSUED TO FURNISH INFORMATION
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MECHANICAL ENGINEERING
LABORATORY MEMORANDUM

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1.0 INTRODUCTION

The ACV Heave Test Rig ("BOUNCER") will be powered by a 2-stage centrifugal blower driven by a Ford V-8 engine. For the operation of the rig it is essential to know the capacity of the blower, and for the analysis of heave data the slope of the constant speed blower curves must be known. A calibration of blower and drive has therefore been carried out. The results have been expressed primarily in non-dimensional form, to permit analysis at any atmospheric conditions. However, results are also presented in the simplified "standard day inlet" manner.

2.0 EXPERIMENTAL SET-UP

The blower and drive unit was a commercially supplied package, with a centrifugal clutch connecting engine and blower.

A 14" I/D x 6' long plastic pipe was fitted to the inlet throttle body, with a standard metering bellmouth on the inlet end.

The exit volute of the blower was fitted with an adjustable blanking plate, which could be bolted in any position to vary the outlet area available. The set-up is shown in Figure 1.

3.0 INSTRUMENTATION

The instrumentation is shown in Figure 1.

Inlet total temperature and pressure (atmospheric) were measured by an altimeter (set to zero altitude and reading in millibars) and an electric resistance thermometer.

Airflow was measured from inlet total temperature and pressure, and bellmouth throat static depression, displayed on a manometer connected between four static throat taps and atmosphere. Fluid of 0.795 sp. gr was used in the manometer.

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Delivery total pressure was measured as the average reading of three Kiel probes in the exit volute, displayed on a mercury manometer backed off to atmosphere, and delivery temperature was measured by a second resistance probe, also in the delivery volute.

Fan speed was measured by a 60-tooth wheel on the shaft between clutch and fan, in conjunction with a magnetic pick-up and a digital Eput meter.

4.0 PROCEDURE

The volute exit plate was adjusted to a set exit area, and the inlet throttle locked fully open (in all cases). The locking open of the inlet throttle was necessary for the calibration running because it was physically impossible to measure pressure after the throttle at the true blower inlet. It was therefore assured that with the inlet butterfly throttle fully open, the blower inlet conditions were atmospheric (i.e. zero loss).

The blower was then run over a series of speeds from idle to maximum attainable, limited only by the available power of the engine.

Speeds were set approximately to a set series, and after stabilising and reading the inlet temperature a value of Speed N (RPM) was calculated to give a required N/\sqrt{T} , which would result in all runs having points on a series of constant N/\sqrt{T} lines.

This procedure was repeated at a number of exit area settings.

The results of these runs could then be plotted, and lines of constant N/\sqrt{T} cross-plotted through the appropriate points on the several runs.

Absolute pressure ratio was then plotted against non-dimensionalised weight-airflow, to give a blower characteristic map applicable to any operating conditions.

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5.0 CONCLUSION

At the maximum pressure ratio attained (1.355:1) the adiabatic efficiency is calculated (from Temperature Ratio) to be approximately 61%. This low value (corresponding to a total pressure loss of some 2900 Pa, or 4.2 psi) is largely due to the severe loss incurred in transferring the air from 1st stage delivery to 2nd stage inlet.

6.0 BLOWER AND DRIVE

The blower was Serial E.15999, (special unit, No. 1 of 2) built by Joy Manufacturing Co. (Canada) Ltd.

The drive was a Ford 429 V-8 engine in an industrial pack.

7.0 NON-STANDARD CALIBRATION SET-UP

It is noted that the calibration set-up was designed specifically for subsequent correlation with the A.C.V. Heave Test Rig, and did not conform to ASME or other test codes. The calibration can therefore not be regarded as standard.

8.0 CALCULATION METHOD

8.1 Speed Setting

Speed was set to a series of nominal values of: 1000, 1500, 1750, 2000, 2300, 2500, 2750, 3000 RPM. To simulate these values at a standard 288 K°T_{1t}, speeds at other inlet temperatures

T_{1t} (x) were corrected so that $N_x = N_{288} \times \sqrt{\frac{T_x \text{ } ^\circ\text{K}}{288}}$.

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8.2 Absolute Pressure Ratio

$$P_{2t}/P_{1t} = \frac{P_{2t} \text{ gauge} + \text{Barometer}}{\text{Barometer}}$$

8.3 Airflow (weight)

The corrected weight airflow was obtained as follows:

$$\begin{aligned} \text{Inlet throat area (mean of four diameters)} &= 0.10308 \text{ m}^2 \\ \text{Flow coefficient for bellmouth} &= 0.98 \\ \therefore \text{Effective inlet area} &= 0.1010 \text{ m}^2 \end{aligned}$$

$$\text{Inlet air density (weight)} = \frac{0.35 P_{1t}}{T_{1t} \text{ } ^\circ\text{K}} (\text{mb. abs.}) \times g \text{ in N/m}^3$$

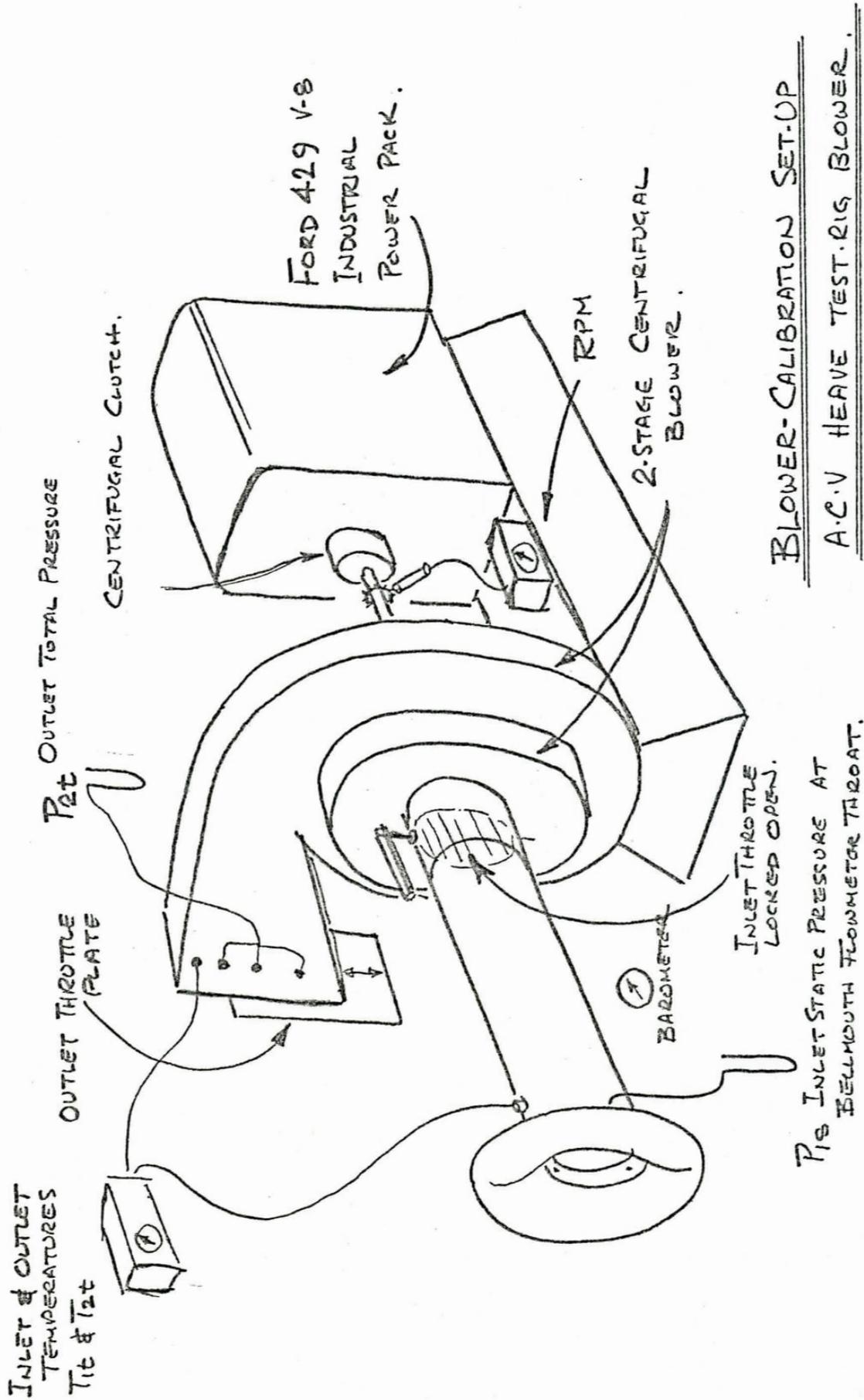
$$\text{Inlet velocity} = 23.91 \sqrt{\frac{P_{1t} \times T_{1t}}{P_{1s}}} \text{ m/s}$$

Where P_{1t} and P_{1s} are absolute inlet total and static pressures in pascals, and T_{1t} is inlet total temperature in $^\circ\text{K}$.

Hence weight flow $Q_w = \text{Inlet Velocity} \times \text{density} \times \text{area}$.

$$\text{The non-dimensional flow plotted is } \frac{Q_w \sqrt{T_{1t}}}{P_{1t}} .$$

$$\text{The speed function plotted is lines of constant } \frac{N}{\sqrt{T_{1t}}} .$$



BLOWER-CALIBRATION SET-UP
A.C.V HEAVE TEST-RIG BLOWER.

FEB. 1979.

11512

FIG. 1.

BLOWER CALIBRATION
FOR
A.C.V. HEAVE TEST RIG.
FEB 1979.

1.4

1.3

1.2

1.1

1.0

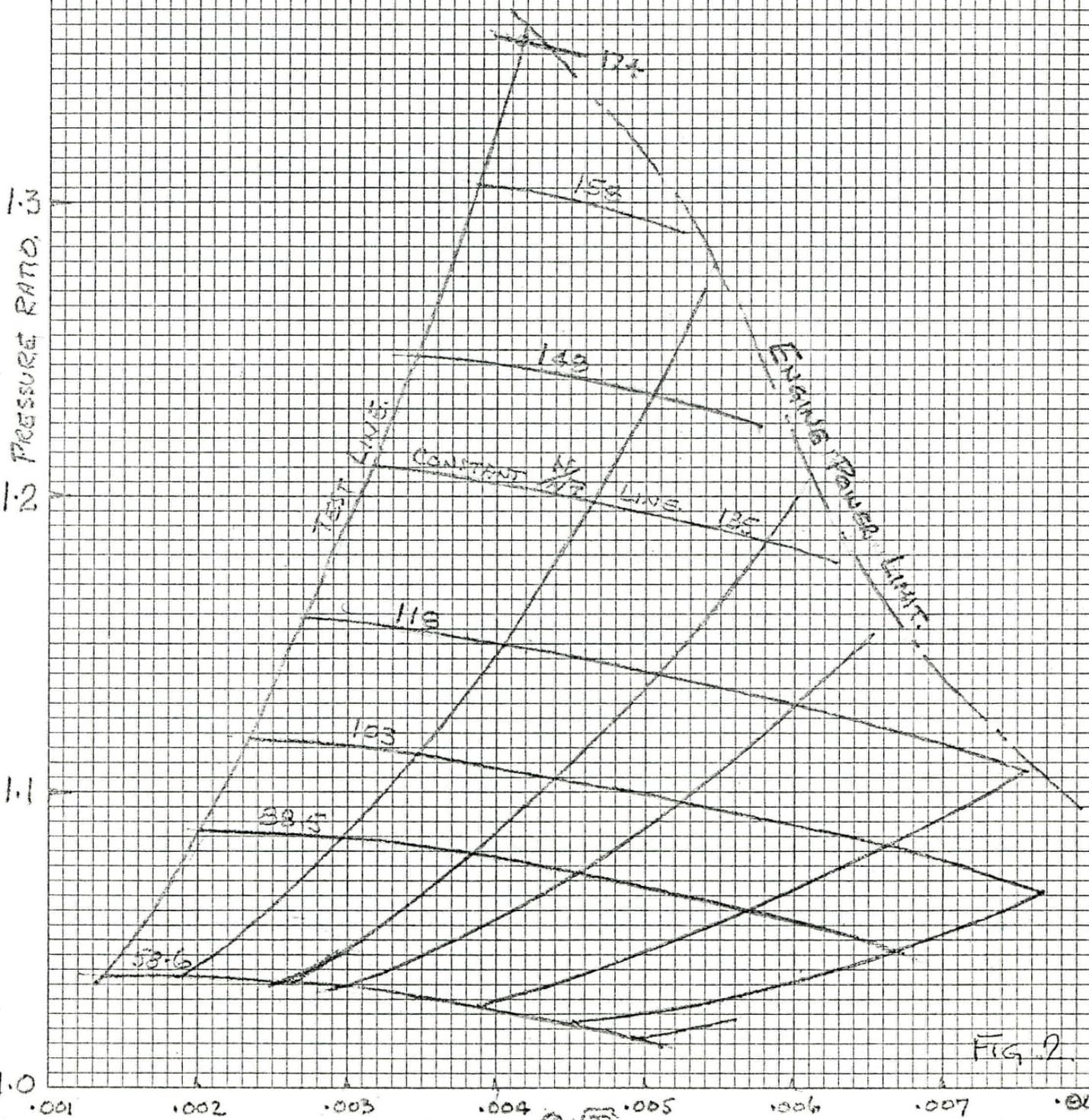


FIG. 2

46 0703

10 X 10 TO THE INCH .7 X 10 INCHES
KEUFFEL & ESSLER CO. MADE IN U.S.A.

ENGINE LIMIT WARNING MAP.

(STANDARD DAY - 288°K, 1013 mb -
OPEN INLET THROTTLE)

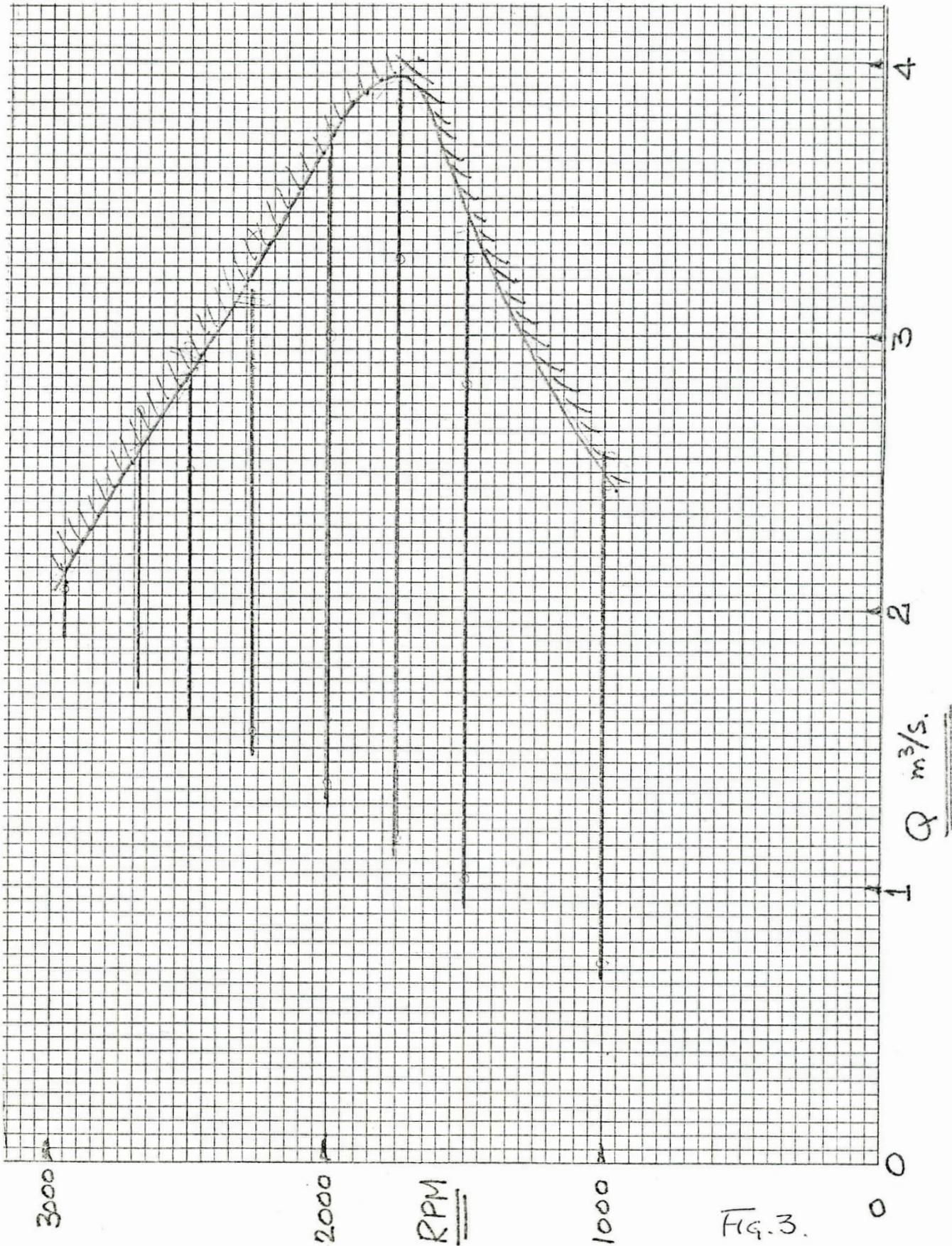


FIG. 3.

HEAVE TEST RIG BLOWER PERFORMANCE [Joy Mfg. Co. E-15999 Two Stage]

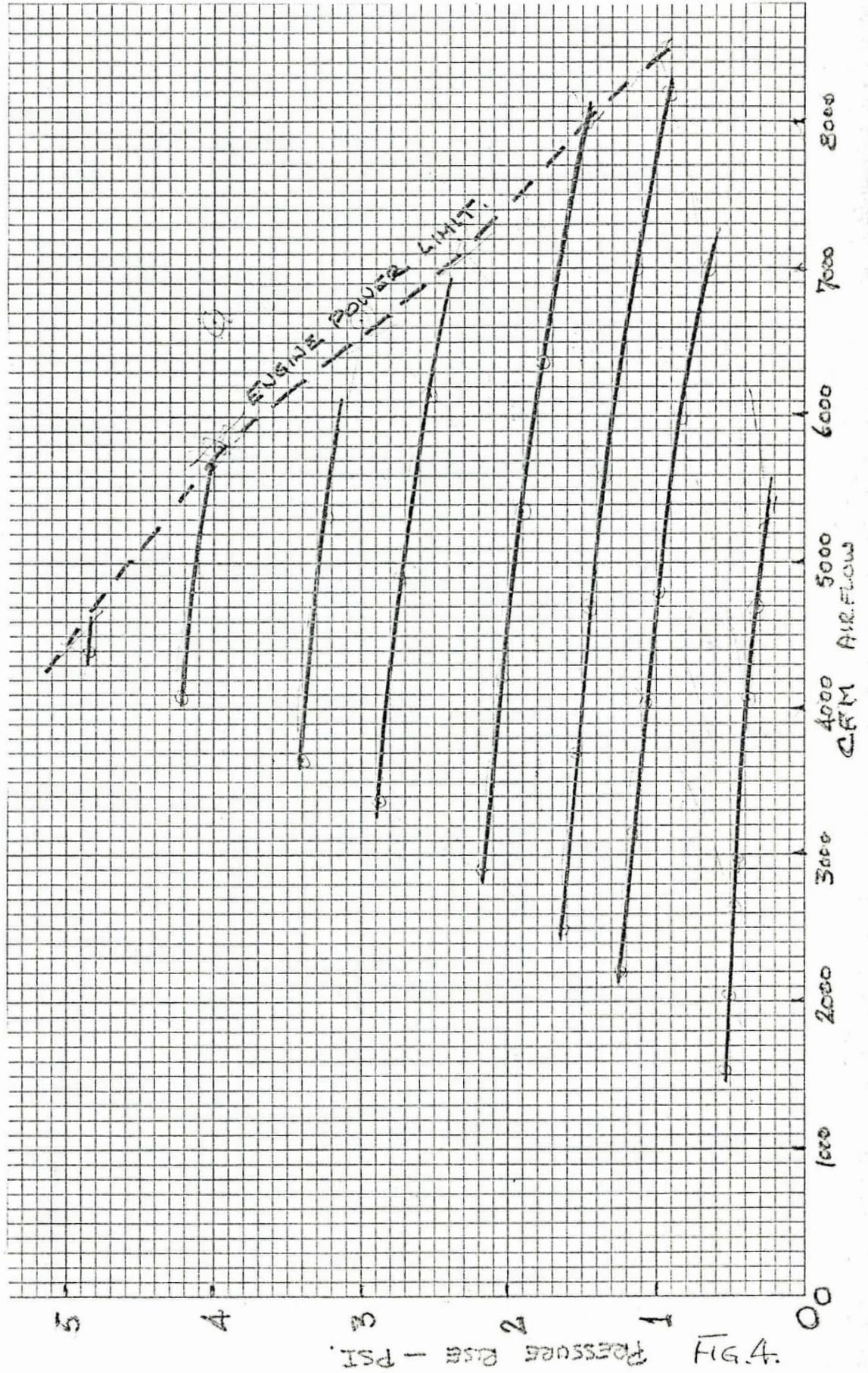


FIG. 4