



A. V. ROE CANADA LIMITED
MONTREAL - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C - 105

REPORT NO. 71/Comp 1/8

FILE NO.

NO. OF SHEETS: _____

TITLE:

EVALUATION OF DAMPER PERFORMANCE
DURING FLIGHT TEST

PREPARED BY S. Galezowski DATE Oct. 1957

Extract All7/Damper Flight Test/1 CHECKED BY DATE Nov. 1957

SUPERVISED BY DATE

APPROVED BY DATE

ISSUE NO.	REVISION NO.	REVISED BY	APPROVED BY	DATE	REMARKS



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MALTON - ONTARIO

TECHNICAL DEPARTMENT

All7/Damper Flight Test/1

REPORT NO. 71/Comp A/3

SHEET NO. 1

AIRCRAFT:

C-105

Damper, Flight Test

PREPARED BY

DATE

S. Galezowski

Nov. 1957

CHECKED BY

DATE

R. Carley

Nov. 1957

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equation inputs.
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DATE

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AILERON, ELEVATOR AND RUDDER SERVO POSITIONS

FOR ALL FLIGHT CONDITIONS

NOTATION

δ_{aDpos} AILERON DIFFERENTIAL SERVO POSITION

δ_{aPpos} AILERON PARALLEL SERVO POSITION

δ_{eDpos} ELEVATOR DIFFERENTIAL SERVO POSITION

δ_{ePpos} ELEVATOR PARALLEL SERVO POSITION

δ_{rpos} RUDDER SERVO POSITION

P ROLL RATE

P_c COMMAND ROLL RATE

q PITCH RATE

r YAW RATE

n NORMAL LOAD FACTOR

n_c COMMAND NORMAL LOAD FACTOR

δ_a AILERON ANGLE

$F_{clateral}$ LATERAL STICK FORCE

A_y } LATERAL ACCELERATION
.. }



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NOTATION CONT:

δ_{ray}
 δ_{rsa}
 δ_{rsag}
 δ_{rr}
 δ_{ap}
 δ_{ap_1}
 δ_g
 δ_n
 δ_{fn}

} DAMPER GAIN SCHEDULES

δ_{LANDING}
 δ_{LANDING}

} CONSTANTS FOR ANY GIVEN FLIGHT

B_T OUTPUT OF AILERON TRIM MOTOR

C_T OUTPUT OF PITCH INTEGRATOR

N_T OUTPUT OF TRIM MOTOR IN PITCH

$F_{\text{LONGITUDINAL}}$ LONGITUDINAL STICK FORCE



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NOTATION CONT:

K_1 CONSTANT FOR ANY GIVEN FLIGHT

q_c COMPRESSIBLE DYNAMIC PRESSURE

Δn }
 $n-1$ }
 A_z }
 $\ddot{z}$ }
SYNONYMOUS NOTATION
FOR
NORMAL ACCELERATION

h PRESSURE HEIGHT (ASAC DATA R2, ISSUE 2)



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F. F. Carley

Nov / 57

I N T R O D U C T I O N

The purpose of this report is to prepare a method for evaluating the performance of the damper system during flight test.

The performance of the damper can be divided into three parts as follows:-

- (a) Damper sensor outputs
- (b) Commands to Differential and Parallel Servos
- (c) Motion of control surfaces

The method of evaluating each of these parts is presented in the following paragraphs.

A. Sensor Outputs

The performance of the sensors can be evaluated by comparing the calculated sensor output obtained from flight test instrumentation raw data with the measured sensor output presented on the same graph.

B. Commands to Differential and Parallel Servos

The performance of the damper can be evaluated by computing the servo commands based on the measured sensor outputs and then comparing these computed commands with the measured commands.



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The measured sensor outputs and the measured servo commands will be recorded on the data tape.

Damper computations can be broken into two sets of equations, corresponding to two separate parts of the damper, that is, normal damper operation and emergency damper operation. Both normal and emergency damper operation are subdivided into two subsections called the gear up and the gear down modes.

I Normal Damper

Pitch	gear up	1
	gear down	2
Roll	gear up	3
	gear down	4
Yaw	gear up	5
	gear down	6

II Emergency Damper

Yaw	gear up	7
	gear down	8

When the gear is up, the equations for modes 1, 3, 5, and 7 should be solved and plotted. When the gear is down, the equations for modes 2, 4, 6 and 8 should be solved and plotted.



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C. Motion of Control Surfaces

The performance of the parallel and differential servos can be evaluated by comparing the commanded servo positions with the measured servo positions. The comparison is accomplished by graphical methods as shown in the section "Presentation of Data".

The use of this method of evaluating damper performance provides a method of evaluating some aspects of the damper performance even when the damper modes are not engaged. The engage or disengage of any mode is accomplished by controlling the supply of hydraulics to the parallel or differential servos associated with the mode. This means that the operation of the sensors and the computations for the differential and parallel servo commands can be assessed when the modes are not engaged.

It is desirable that these equations be programmed for all Mach numbers and altitudes. Flight test data should be taken at the rate of 20 readings per second where the flight test schedule so states; otherwise a lesser rate will be accepted. The values of S used in the equations for any given flight condition are determined from the period of aircraft motion in that particular flight condition.



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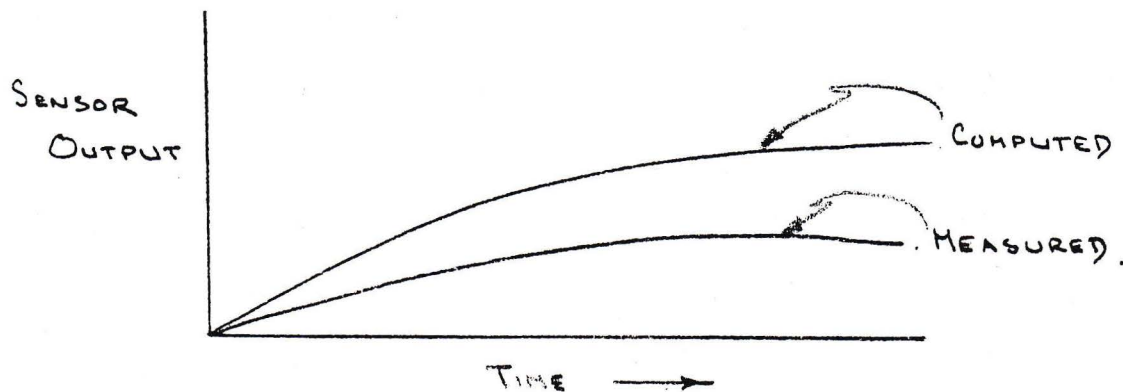
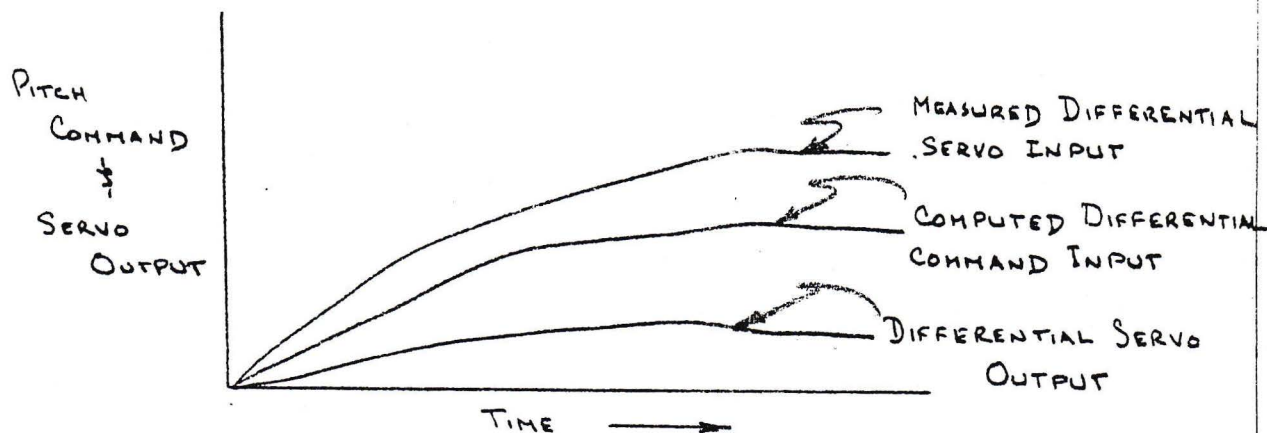
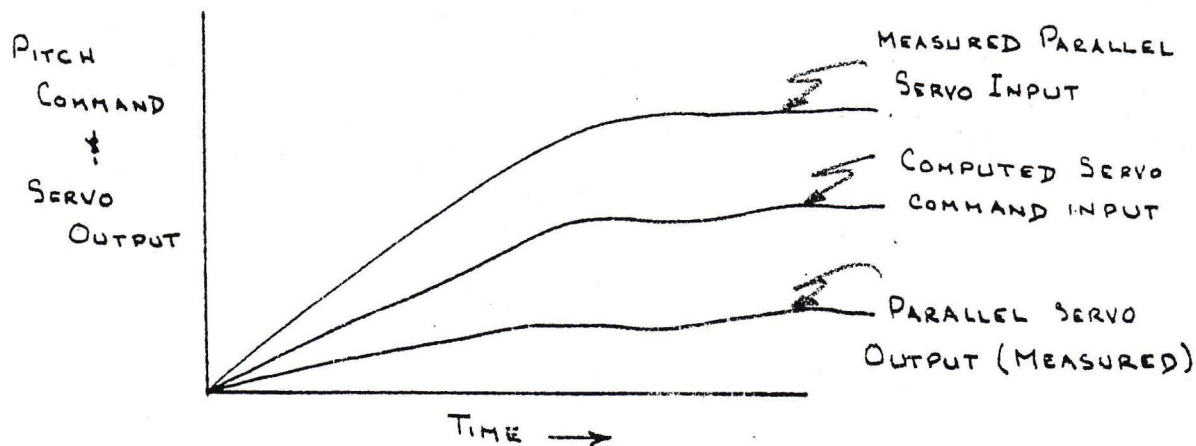
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P. P. Cady

GRAPHICAL PRESENTATION OF DATA.



NOTE: THE ABOVE CURVES SHOULD BE PRESENTED FOR BOTH THE
1/2 EXTENDED AND RETRACTED CASES IN THE NORMAL MODE.



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R. B. O'Leary

The derivation of the equations given herein are based on the circuit diagrams given in C.E.L.,

As an appendix damper gain schedules are included in this report as functions of the dynamic pressure q_c .

Presentation of Data and Sources of Equation Inputs

The measured flight data should be presented as a time history plot of servo input and output. For comparison purposes the computed inputs from the equations given in this report should be plotted on the same graph. For the first flight the calculated values of the servo input should be based on computed values of sensor output obtained from equations found in P/Aero Data/92, Issue 2, or the latest subsequent issue. Calculated values of servo input in further flights will be based on measured sensor outputs under flight conditions. Measured data will be obtained from the flight test data tape.



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Sto. Aubg

	COMPUTED SENSOR OUTPUTS (FIRST FLIGHT)	DATA OBTAINED FROM FLIGHT TEST TAPE
<u>ROLL</u>	P (P/AERO DATA 92, $E_Q^N 2.5$) δ_a (" , $E_Q^N 1.14$)	P_c B_T F_c (U/C DOWN ONLY) LATERAL PARALLEL AND DIFFERENTIAL SERVO INPUT AND OUTPUT
<u>PITCH</u>	q (" , $E_Q^N 2.4$) η (" , $E_Q^N 2.7$)	C_T n_c n_T F_c (U/C DOWN ONLY) LONGITUDINAL PARALLEL AND DIFFERENTIAL SERVO INPUT AND OUTPUT
<u>YAW</u>	r (" , $E_Q^N 2.6$) A_y (" , $E_Q^N 2.15$)	DIFFERENTIAL SERVO (2) INPUT AND OUTPUT.
<u>GENERAL</u>	h (" , $E_Q^N 1.5$) M (" , $E_Q^N 1.6$) q_c (" , $E_Q^N 1.7$)	U/C POSITION NORMAL OR EMERGENCY MODE S

QUANTITIES THAT ARE CONSTANT FOR ANY GIVEN FLIGHT

K_i

$\delta_{e \text{ LANDING}}$

δ_a



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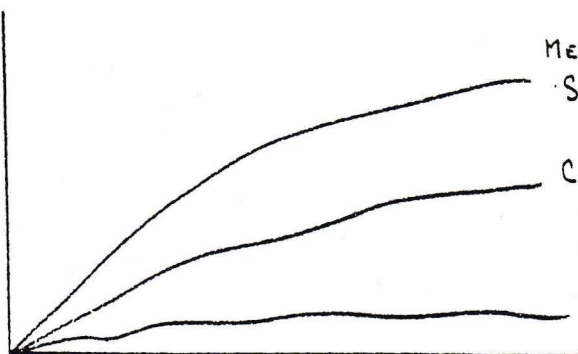
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[Signature]

Roll
COMMAND
§
SERVO
OUTPUT



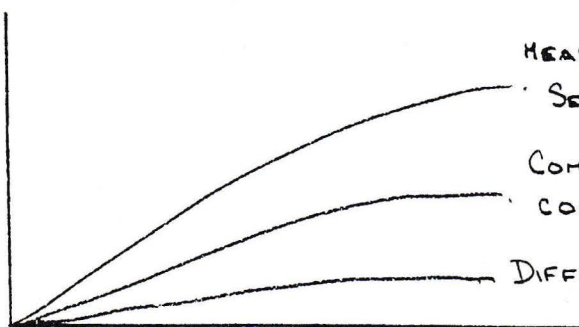
MEASURED PARALLEL
SERVO INPUT

COMPUTED SERVO
COMMAND INPUT

PARALLEL SERVO OUTPUT
(MEASURED)

TIME →

Roll
COMMAND
§
SERVO
OUTPUT



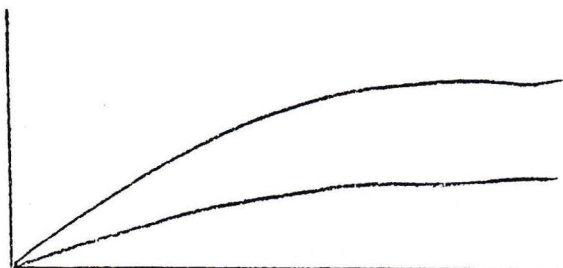
MEASURED DIFFERENTIAL
SERVO INPUT

COMPUTED DIFFERENTIAL
COMMAND INPUT

DIFFERENTIAL SERVO OUTPUT
(MEASURED)

TIME →

SENSOR
OUTPUT



COMPUTED

MEASURED

TIME →

NOTE: THE ABOVE CURVES SHOULD BE PRESENTED FOR BOTH THE

U/C EXTENDED AND RETRACTED CASES IN THE NORMAL MODE.



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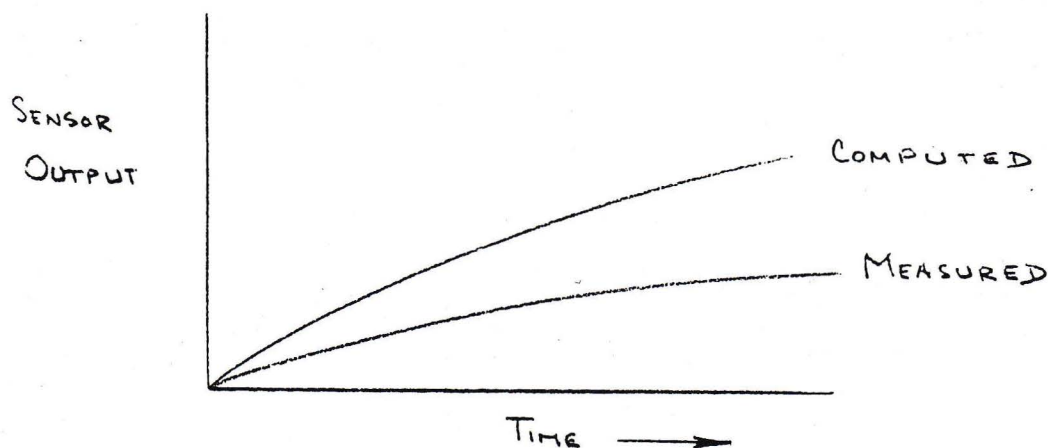
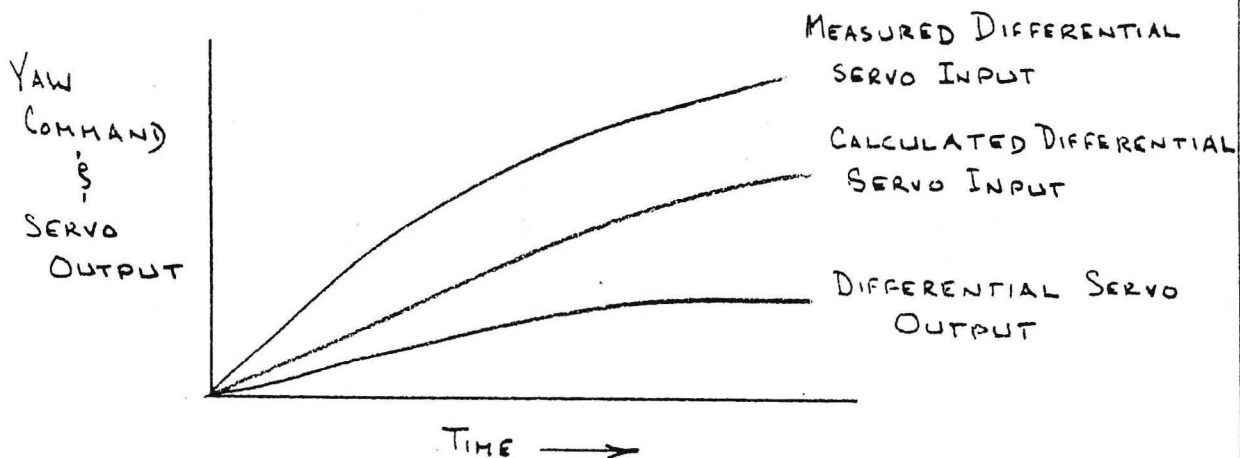
GALEZOWSKI

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NOTE: THE ABOVE CURVES SHOULD BE PRESENTED FOR BOTH
THE $\frac{1}{2}$ C EXTENDED AND RETRACTED CASES IN THE NORMAL AND
THE EMERGENCY MODES.



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DATE

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DATE

Servo Positions Normal Mode $\frac{1}{2}$ Up

AILERON DAMPER SYSTEM (ROLL)

$$\delta_{a_{pos}} = \delta_{a_p} P - \delta_{a_p} R_c + B_r$$

$$\delta_{a_{pos}} = \frac{\delta_{a_p} P - \delta_{a_p} R_c + B_r}{5}$$

ELEVATOR DAMPER SYSTEM (PITCH)

$$\delta_{e_{pos}} = \delta_n (n - n_c + n_T) + g \delta_g \frac{1.55}{1.55 + 1}$$

$$\delta_{e_{pos}} = \delta_n \frac{(n - n_c + n_T)}{5} + g \delta_g \frac{2.25}{1.55 + 1}$$

RUDDER DAMPER SYSTEM (YAW)

$$\delta_{r_{pos}} = \left\{ \delta_{R_r} r + \delta_{R_a} \delta_a \right\} \frac{25}{25 + 1} + \delta_{R_{AY}} A_Y + \delta_{R_{a \cdot g}} \delta_a \cdot g$$



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P. P. Carley

Servo Positions Normal Mode 1/2 Down

AILERON DAMPER SYSTEM

$$\delta_{a_{pos}} = P_{\delta a} - P_c \delta_{a_p} + B_T$$

$$\delta_{a_{pos}} = \delta_{a_{LANDING}} F_{c_{LATERAL}}$$

ELEVATOR DAMPER SYSTEM

$$\delta_{e_{pos}} = f \delta_g$$

$$\delta_{e_{pos}} = F_{c_{LONGITUDINAL}} \delta_{e_{LANDING}} + C_T$$

RUDDER DAMPER SYSTEM

$$\delta_{r_{pos}} = \left\{ \delta_{r_r} \cdot r + \delta_{r_{\delta a}} \delta_a + \delta_{r_{\delta \dot{a}}} A_y K_1 \right\} \frac{25}{25 + 1} \\ + \delta_{r_{\dot{a}}} A_y (1 - K_1) + \delta_{r_{\delta \dot{a}}} \delta_a \cdot f$$



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SERVO POSITIONS EMERGENCY MODE

1/2 UP

$$\delta_{R_{pos}} = \left\{ \delta_{R_r} \cdot r + \delta_{R_{\delta_a}} \cdot \delta_a \right\} \frac{25}{25+1} + A_y \delta_{RAY}$$

1/2 DOWN

$$\delta_{R_{pos}} = \left\{ \delta_{R_r} \cdot r + \delta_a \cdot \delta_{R_{\delta_a}} + K_1 A_y \delta_{RAY} \right\} \frac{25}{25+1} + A_y (1-K_1) \delta_{RAY}$$

YAW RATE GAIN
NORMAL AXIS

TURNING POINTS

6.0 1 80
1.78 1 260
2.4 1 540
1.5 1 1000

6.0

5.0

4.0

3.0

2.0

1.0

0

0

500

400

300

200

100

0

1000

1200

1400

1600

1800

2000

$\frac{18}{\text{ft}^2}$

Yaw rate gain

18

Van Ruse Creek

EMERGENCY AHS

60

50

40

30

20

10

0

CH₄ (mole/m³)

Running BARS

6.0 1.70

2.69 1.270

2.2 1.540

1.77 1.940

1.5 1.100

1000

1000

1000

1000

1000

1000

1000

1000

1000

1000

1000

1000

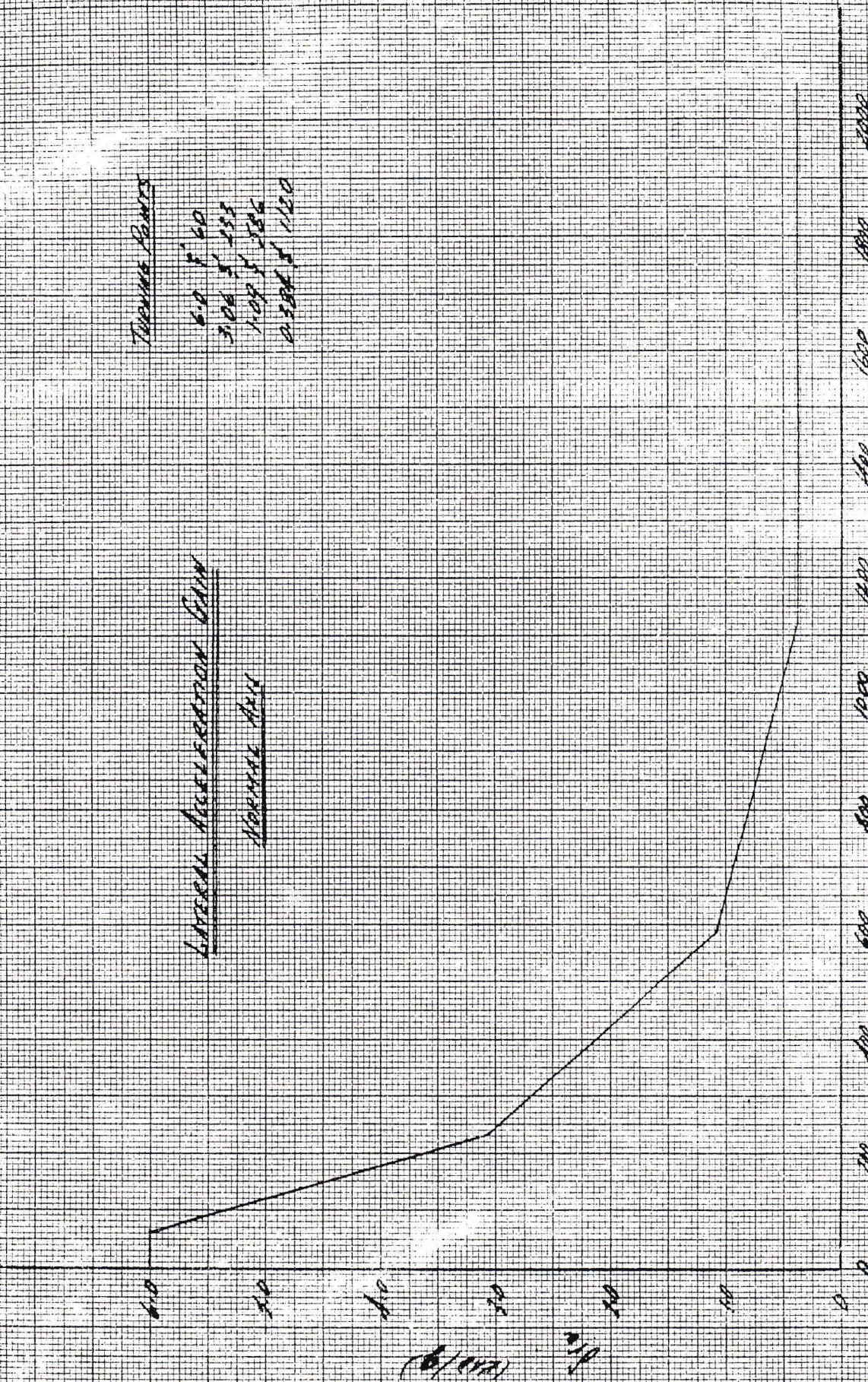
10/15/91

Greenhouse Gas

Normal Air

Turning Points

6.0 8.60
3.04 8.133
1.09 8.106
0.388 8.1120



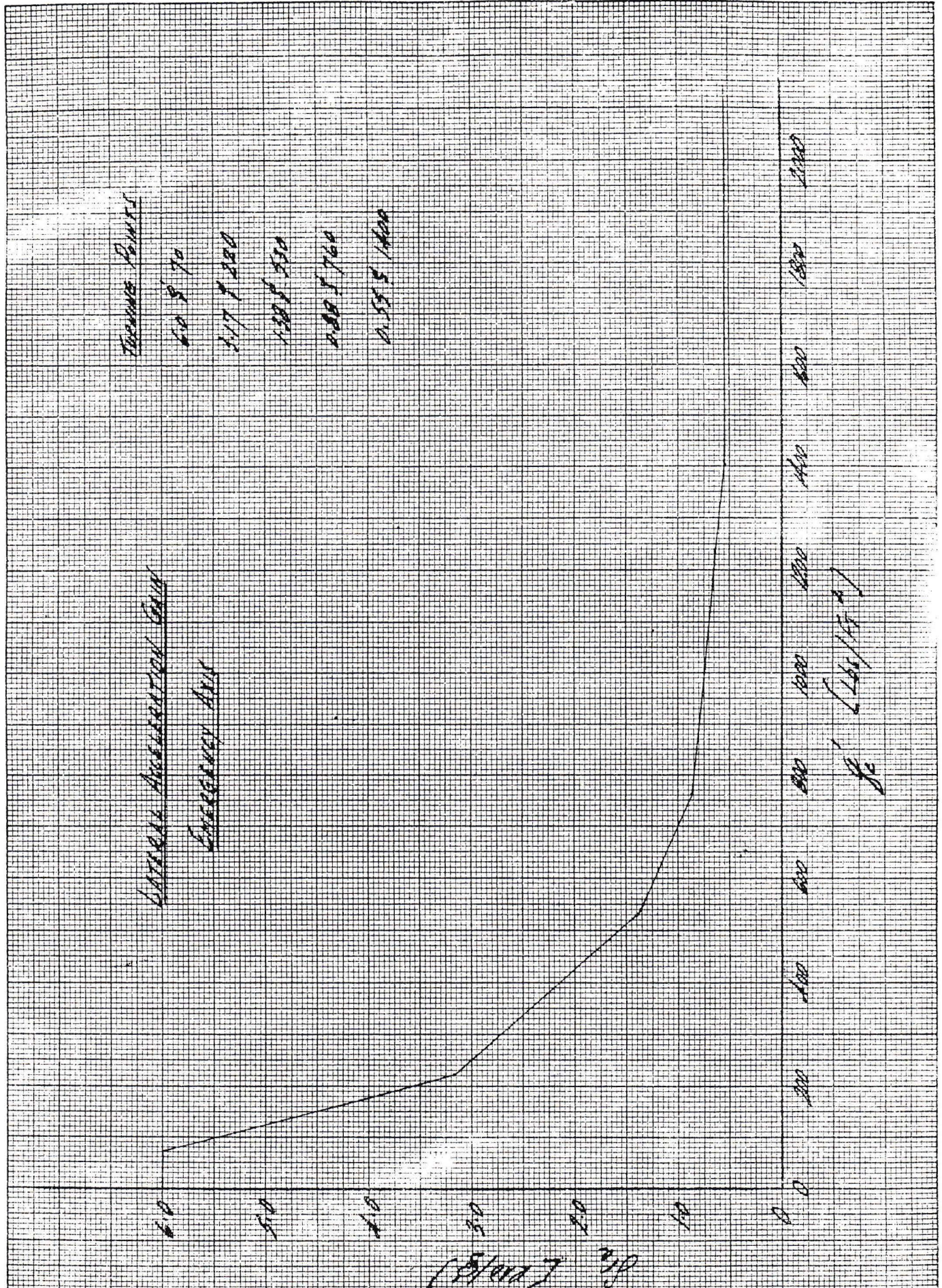
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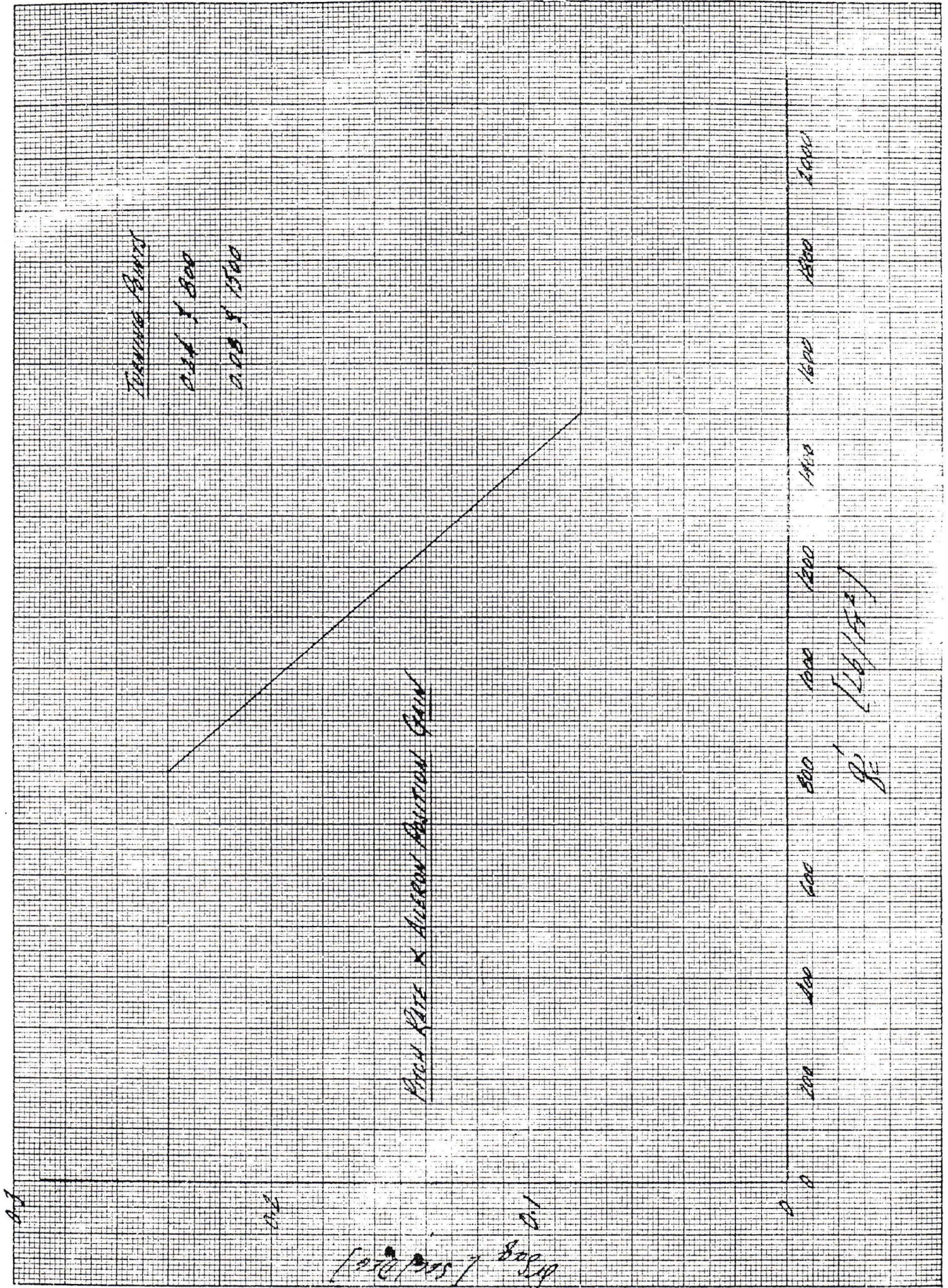
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1/11

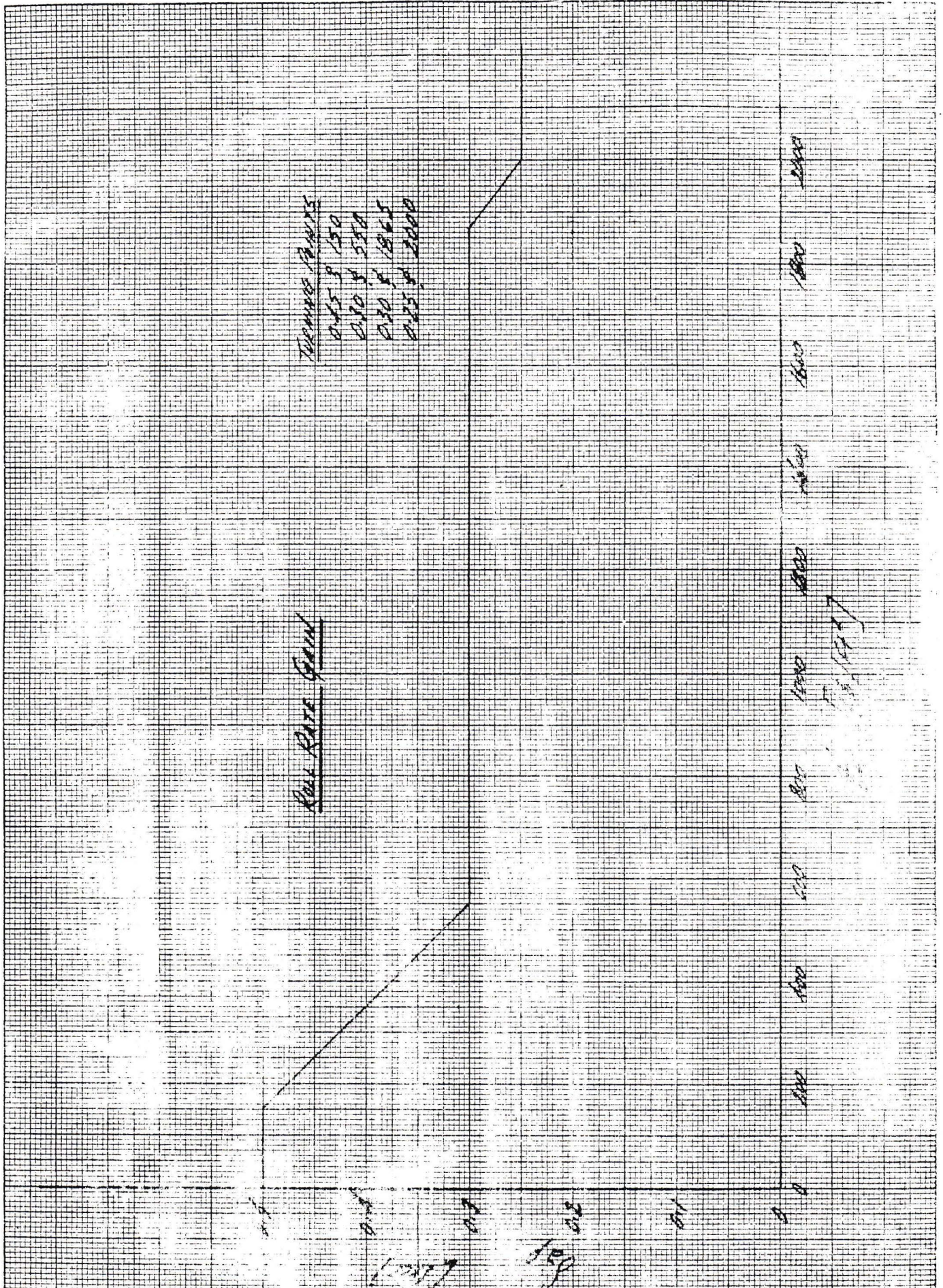
GR #5

CEL #161





GL #7 CEL #161



Gr #B CCL #161

[24/97] 38

0007

0081

0091

0097

0099

0001

0008

0009

0004

0007

0

0.0

0.0

0.0 days

0.0

0.125 \$ 2000

0.30 \$ 1780

0.30 \$ 270

0.35 \$ 130

TURNING POINTS

LOWLAND ROLL RAY GRID

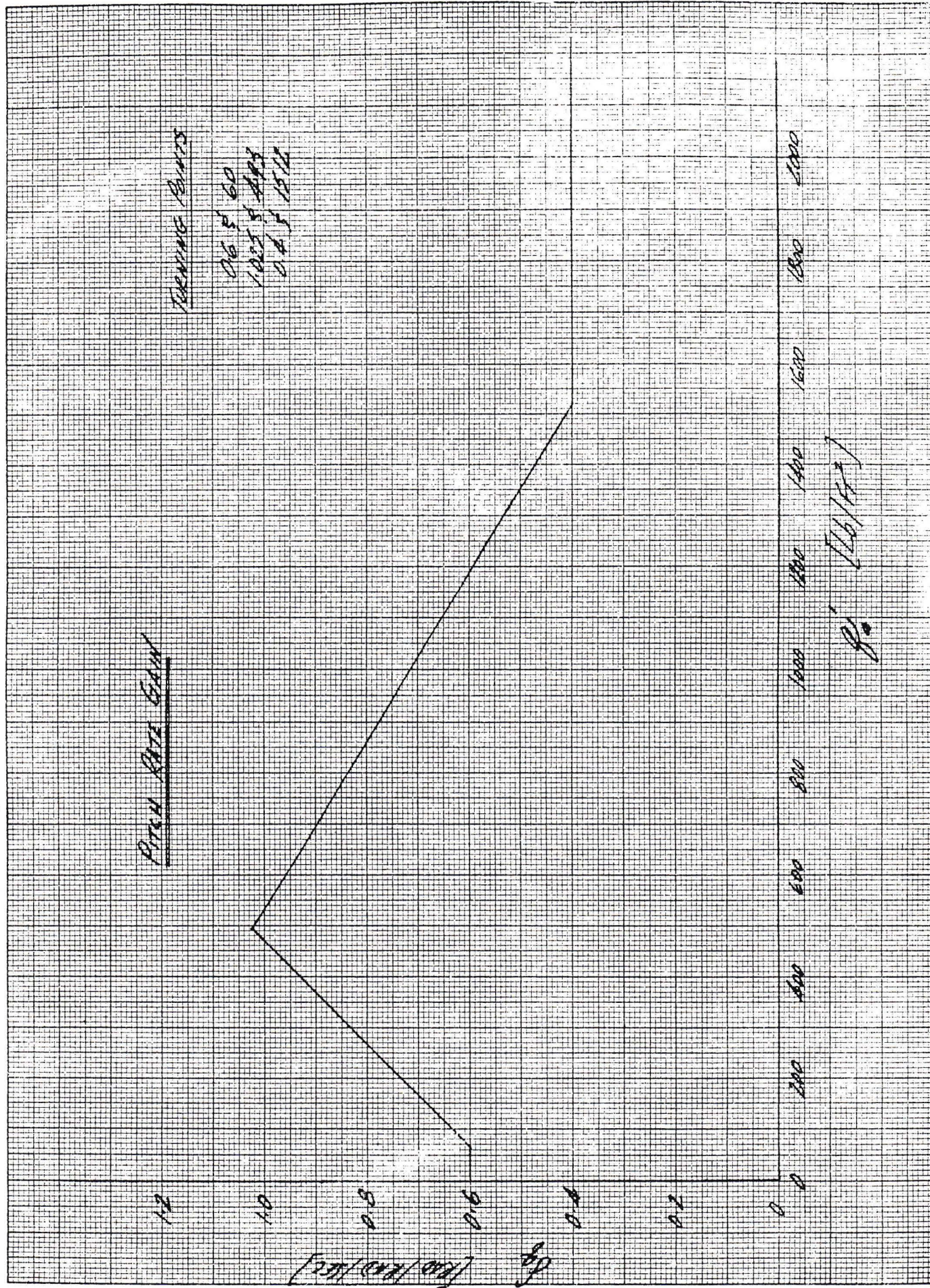
Peak Rate Graph

TURNING POINTS

06.5 60
10.5 100
06.5 150

kg (no/rev)

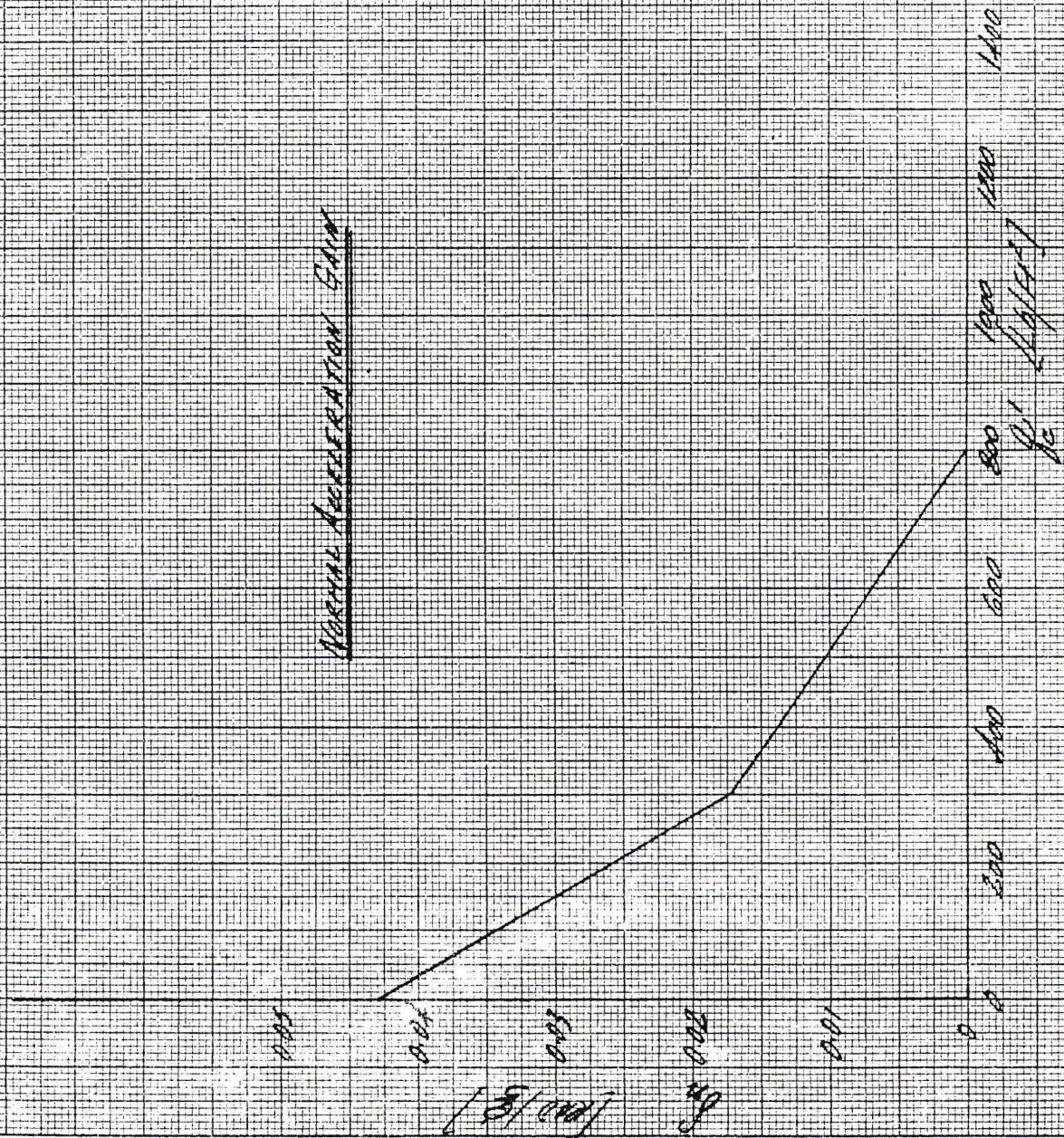
g. (lb/ft²)



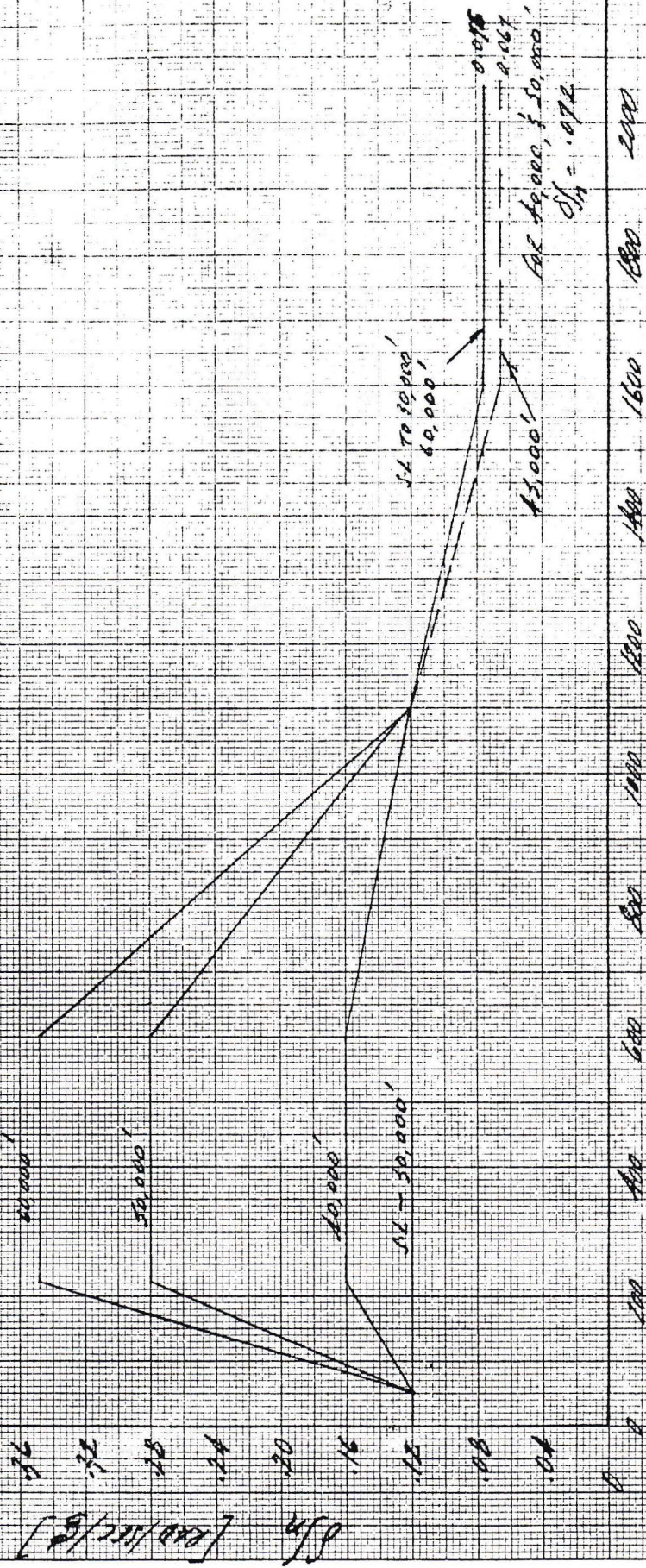
Running Balance

0.0/72 \$300

NORMAL ACCELERATION GAIN



INTERFERED THERMAL ACCURATION



84 [16/13-2]