

UNCLASSIFIED

ARROW

PERIODIC PERFORMANCE REPORT

74

NO. 11

Oct. 1957.



A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

SECRET
UNCLASSIFIED

AIRCRAFT: ARROW

REPORT NO. 11

FILE NO.

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(date) _____
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Signature _____ Rank _____

UNCLASSIFIED

ARROW PERIODIC PERFORMANCE REPORT

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PREPARED BY Performance Group DATE Oct. 1957

CHECKED BY _____ DATE _____

SUPERVISED BY A. Roberts DATE _____

APPROVED BY J. Macca DATE Nov 6/57

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ARROW PERIODIC PERFORMANCE REPORT - 11

INTRODUCTION

This is the eleventh of a series of periodic performance reports for internal usage, to be issued from the Technical Design Department.

This report is divided into three major sections :-

- 1) Performance
- 2) Drag
- 3) Propulsion

PERFORMANCE

1 : ARROW 1 PERFORMANCE WITH J 75 ENGINES

C.G. AT 29.5% M.A.C.

The following Arrow 1 performance estimate is based on drag data of Periodic Performance Report No. 9, see section 2, and revised J 75 installed engine data, see section 3. It should be noted that the performance shown is for an aircraft fitted with a 45" divergent ejector, and 4° up-aileron deflection above 45,000 ft. The 45" divergent was selected, instead of the 39" cylindrical, since it is intended to equip the aircraft with this ejector for the major part of the test programme, subsequent to the first few flights. The 4° up-aileron deflection above 45,000 ft. has been shown since it is planned to fix the ailerons in this position for the high altitude portion of the test programme, in order to evaluate the effect and behaviour of this aileron deflection prior to the installation of the more complex system on the Arrow 2.

Aircraft weights used in this report are from Weights Report No. 7-0400-44, issue 10, suitably modified for the divergent ejector. This includes test equipment and ballast to limit the aft C.G. to 31% M.A.C., and is therefore applicable to the early stages of the "Phase 1" test programme.

Since the Arrow 1 is a test vehicle, rather than operational, the form of presentation has been altered from previous reports, in the interests of flight programming and correlation of results.

ARROW 1 PERFORMANCE - 11

PERFORMANCE UNDER I.C.A.O. STANDARD ATMOSPHERIC CONDITIONS

WEIGHT:-

Take-off Weight with full Internal Fuel.....	LB.	68,765
Operational Weight Empty.....	LB.	48,922
Half Fuel Weight.....	LB.	58,892
Normal Design Landing Gross Weight AIR 7-4 : MIL-5-5701...	LB.	53,892
Wing Loading at Take-off Weight with full Internal Fuel.....	LB/SQ.FT.	56.1
Power Loading at Take-off Weight with full Internal Fuel.....	LB/LB.Thrust.	1.82

SPEED:-

True Airspeed in Level Flight at Sea Level at Half Fuel Weight		*
Maximum Thrust (A/B Lit).....	KTS.	700
Military Thrust (A/B Not Lit).....	KTS.	645
Max True Airspeed in Level Flight at 40,000' at Half Fuel Weight Maximum Thrust (A/B Lit).....	KTS.	1,040

CEILING:-

500 F.P.M. Rate of Climb Ceiling at Half Fuel Weight Maximum Thrust at 1.5 M.N. (A/B Lit).....	FT.	50,300
---------------------------------------------------------------------------------------------------	-----	--------

RATE OF CLIMB:-

Steady Rate of Climb at Sea Level Half Fuel Weight Maximum Thrust at .92 M.N. (A/B Lit).....	F.P.M.	37,600
Military at 527 KTS.(A/B Not Lit).....	F.P.M.	10,530
Steady Rate of climb at 50,000 ft. Half Fuel Weight Maximum Thrust at 1.5 M.N. (A/B Lit).....	F.P.M.	800

TIME TO HEIGHT:-

Time to Reach 45,000 ft. and 1.5 M.N. from Engine Start at Take-off Weight with full Internal Fuel Maximum Thrust (A/B Lit).....	MINS.	6.0
----------------------------------------------------------------------------------------------------------------------------------------	-------	-----

MANOEUVRABILITY:-

Combat Load Factor at Half Fuel Weight Maximum Thrust at M.N. = 1.5 at 45,000 ft.(A/B Lit)		1.52
-----------------------------------------------------------------------------------------------	--	------

TAKE-OFF DISTANCES:-

Take-off Distances over 50 ft. Obstacle at Sea Level at Take-off Weight with full Internal Fuel Maximum Thrust (A/B Lit).....	FT.	4,700
Military Thrust(A/B Not Lit).....	FT.	11,800
Maximum Thrust Hot Day(A/B Lit).....	FT.	7,500

*
PLACARD SPEED OF AIR 7-4

LANDING DISTANCES:-

Landing Distance over 50 ft. Obstacle at Sea Level at Normal Design Landing Gross Weight.....	FT.	6,600
--------------------------------------------------------------------------------------------------	-----	-------

STALLING SPEED:-

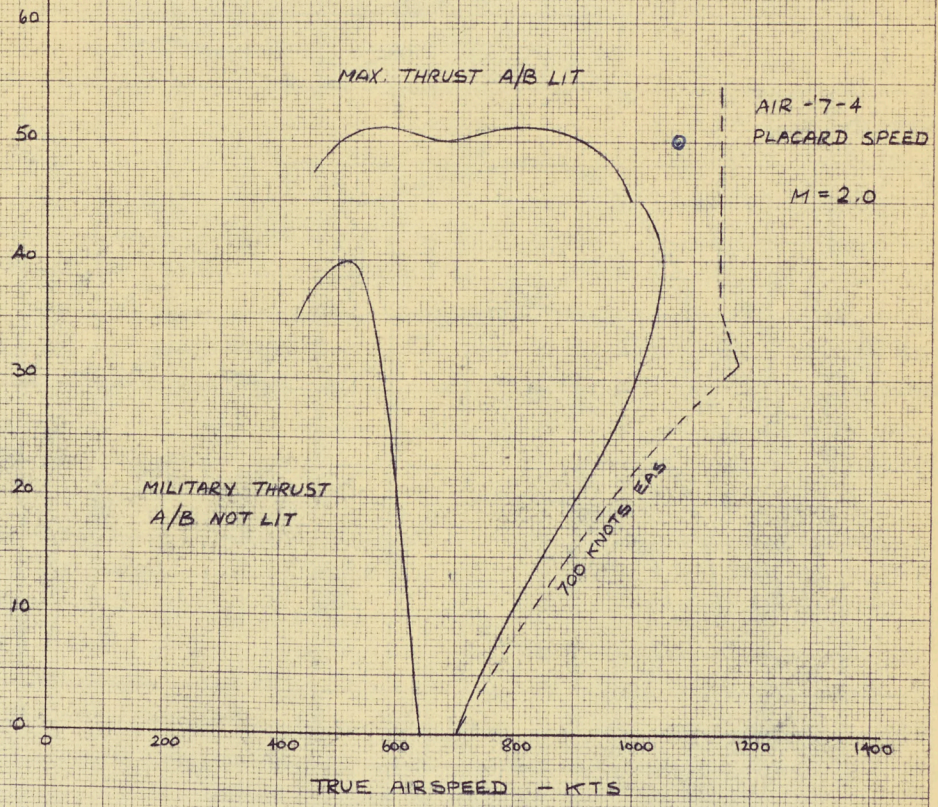
True Stalling Speed in Landing Configuration at Half Fuel Weight at Sea Level.....	KTS.	119
---------------------------------------------------------------------------------------	------	-----

71/PERF/3

ARROW I

MAX. LEVEL SPEED AT HALF FUEL WEIGHT

STANDARD ALTITUDE — THOUSANDS OF FT



K+E
10 X 10 TO THE CM. 359-14
KEUFFEL & ESSER CO. MADE IN U.S.A.

71/PEAF/3

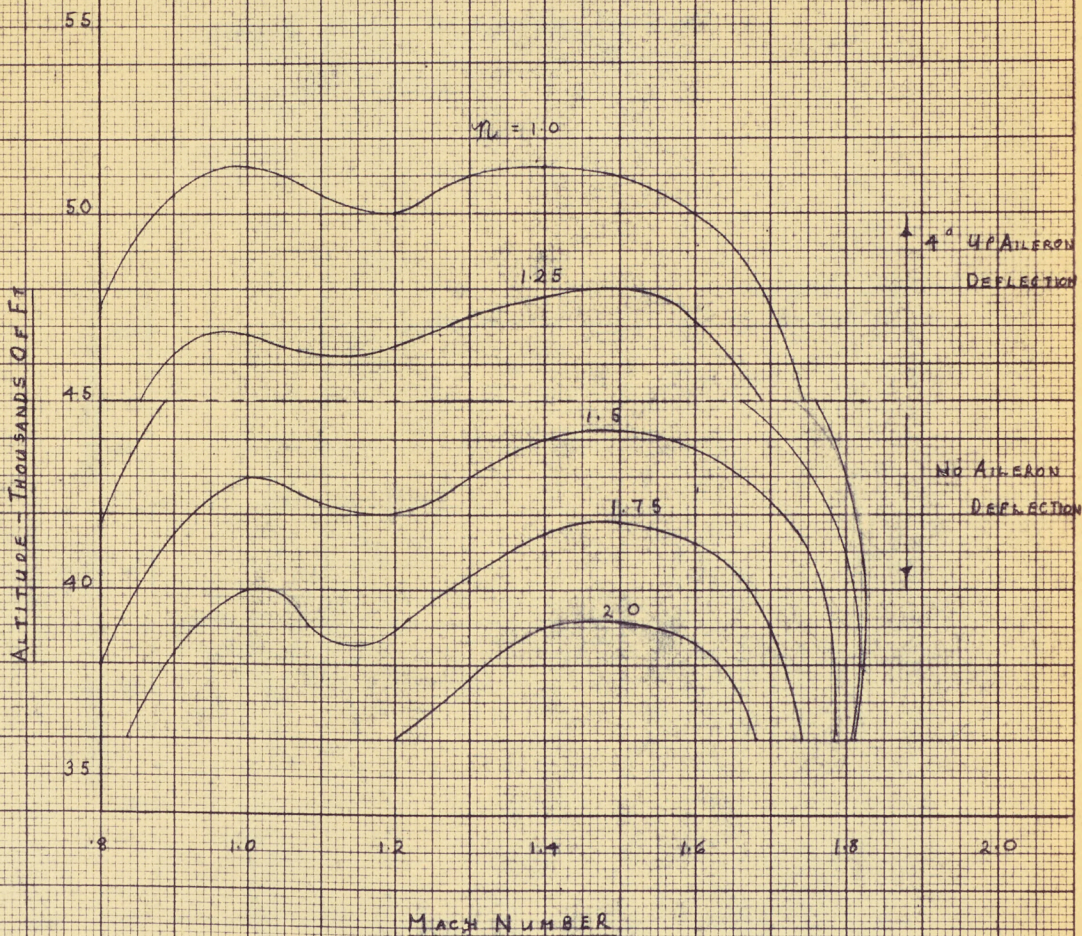
ARROW I

MANOEUVRABILITY

AVAILABLE STEADY g 's AT HALF FUEL WEIGHT

J 75 ENGINES WITH MAXIMUM THRUST

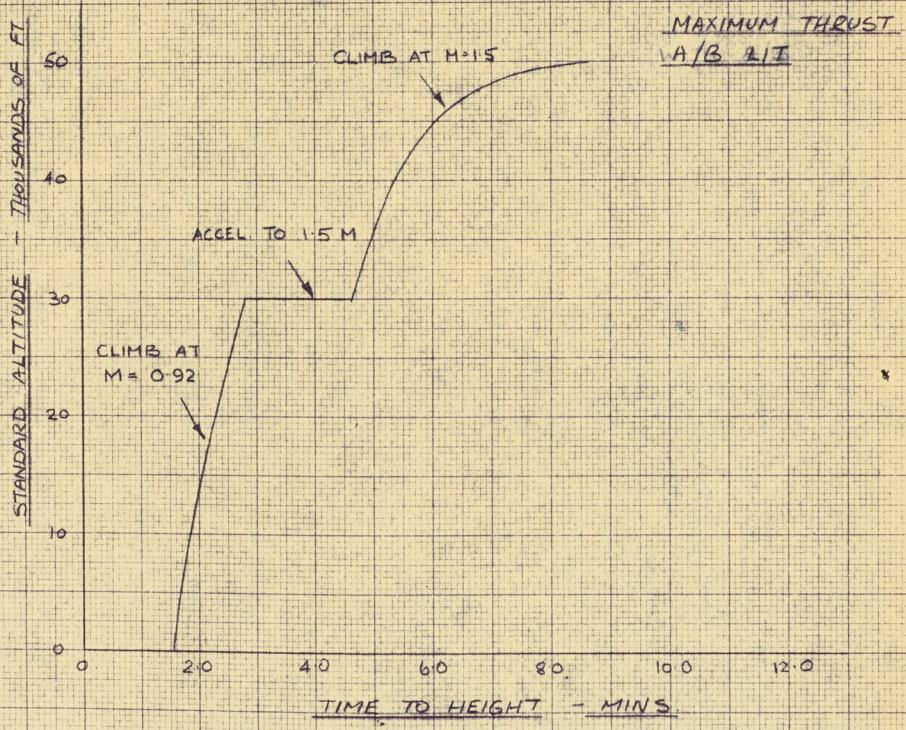
G9-12
10 X 10 TO THE 3/8 INCH
MADE IN CANADA



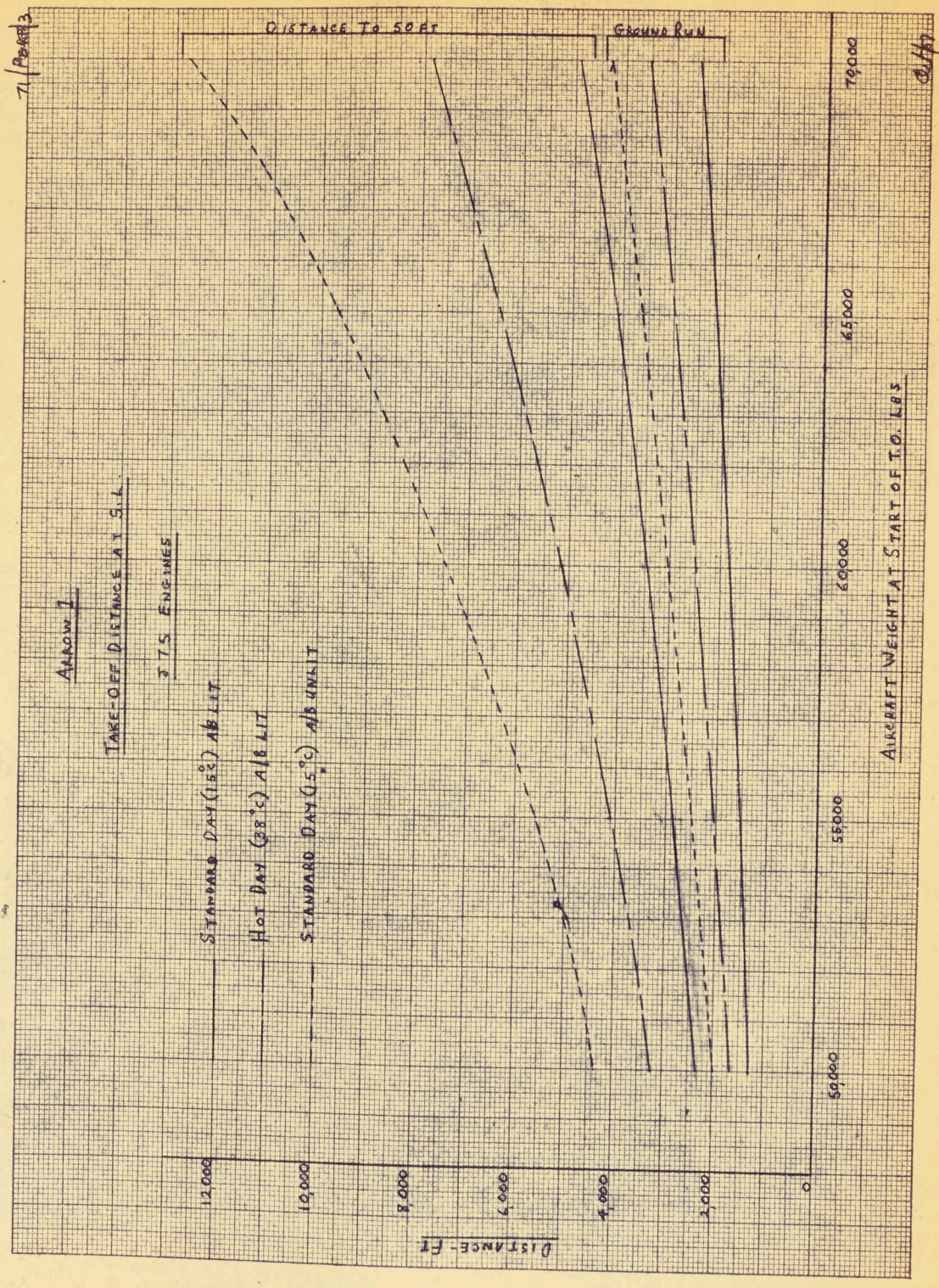
OUT 10

ARROW I
TIME TO HEIGHT

STARTING WEIGHT: 68,765 LB
ONE HALF MINUTE ALLOWED FROM
ENGINE START TO START OF TAKE-OFF



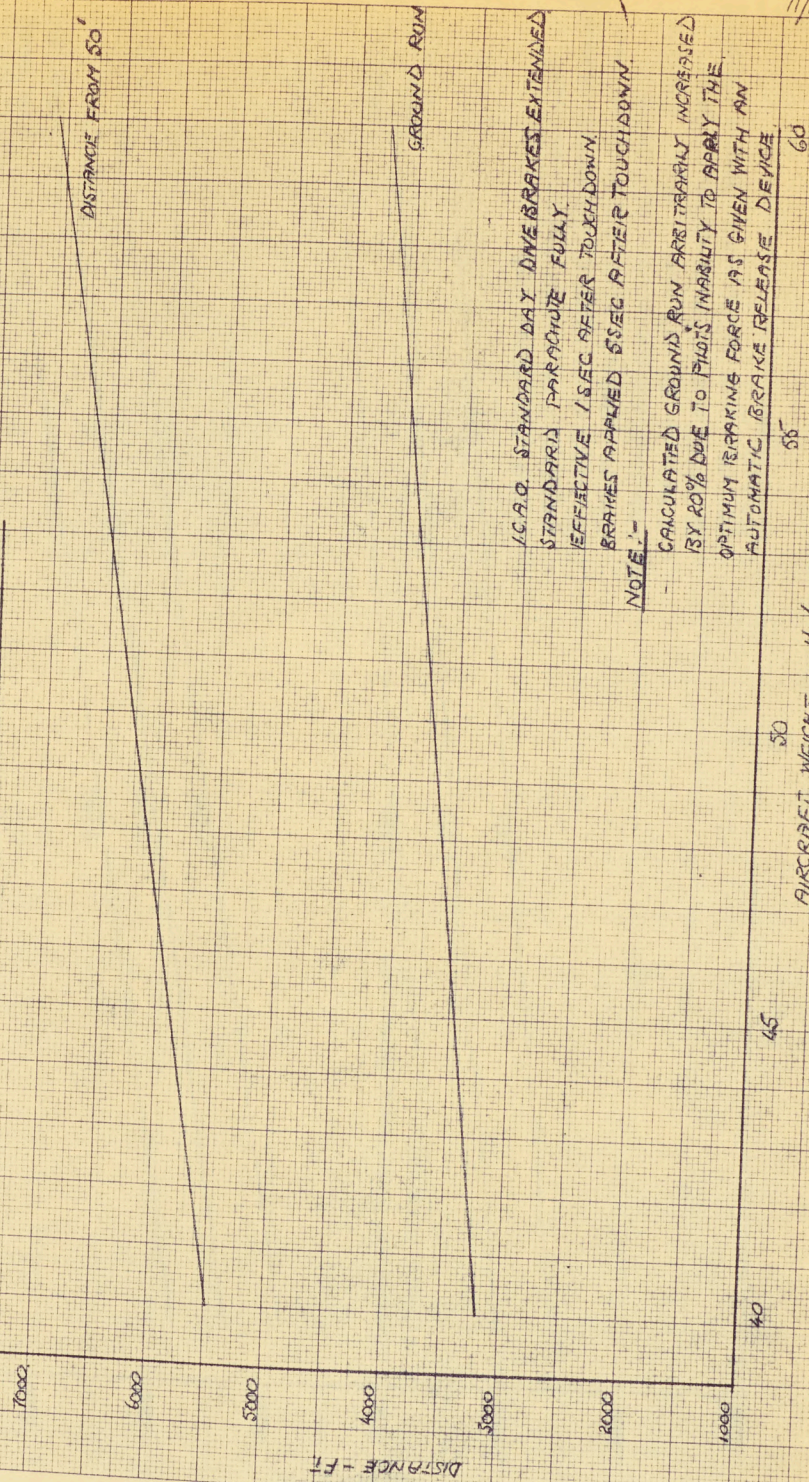
K&E
10 X 10 TO THE CM. 359-14
KEUFFEL & ESSER CO. MADE IN U.S.A.



ARROW 1.

LANDING DISTANCE AT SEA LEVEL

J-75 ENGINES AT GROUND IDLING



ICAO STANDARD DAY ONE BRAKES EXTENDED
STANDARD PARACHUTE FULLY
EFFECTIVE 1/SEC AFTER TOUCHDOWN
BRAKES APPLIED 5/SEC AFTER TOUCHDOWN.

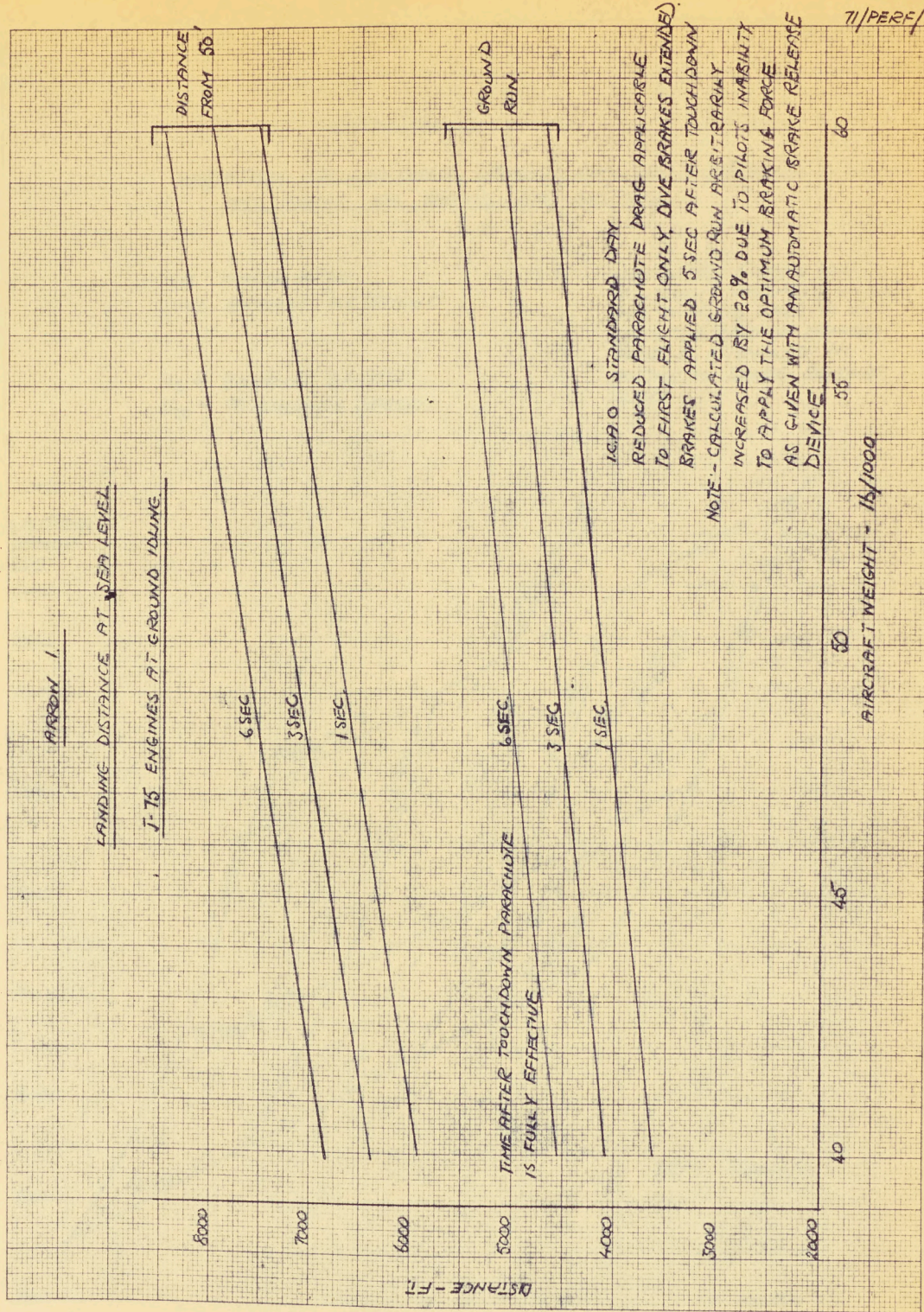
NOTE.

CALCULATED GROUND RUN ARBITRARILY INCREASED
BY 20% DUE TO PILOT'S INABILITY TO APPLY THE
OPTIMUM BRAKING FORCE AS GIVEN WITH AN
AUTOMATIC BRAKE RELEASE DEVICE.

AIRCRAFT WEIGHT - 16,1000.

OCT/57

71/PERF/3



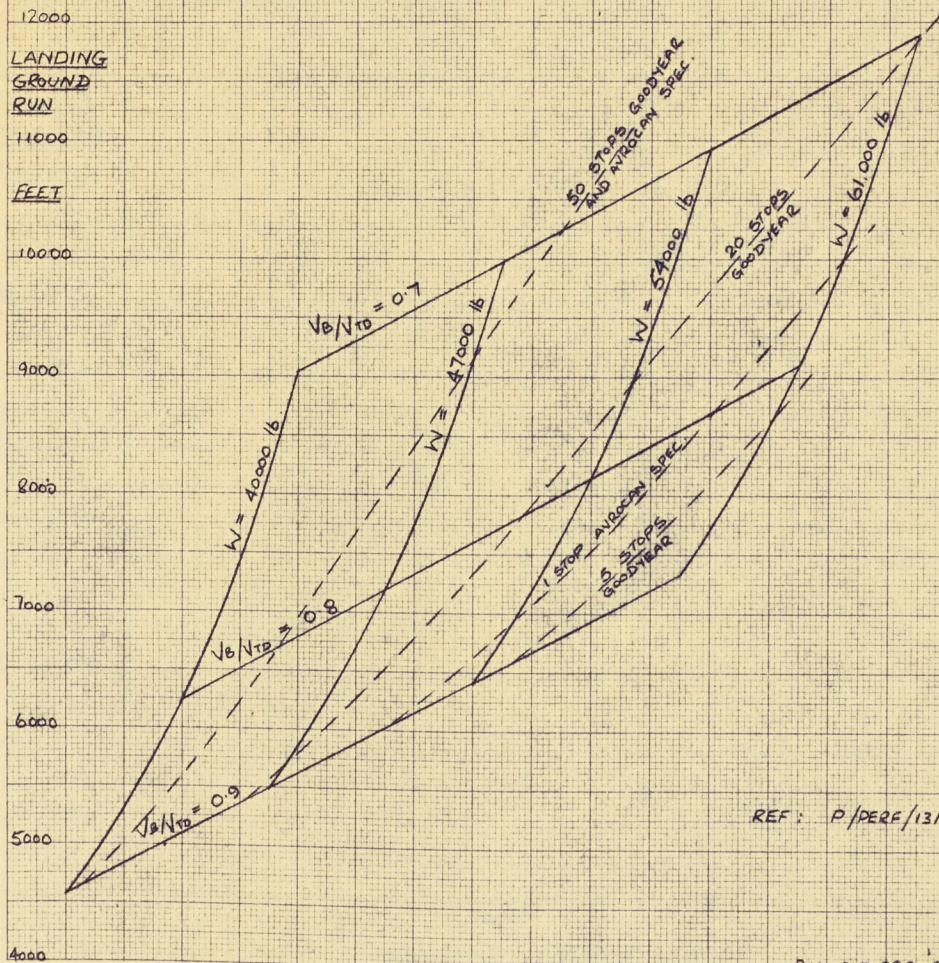
ARROW IVARIATION OF LANDING GROUND RUN WITH WEIGHT
AND POINT OF BRAKE APPLICATION

NO PARACHUTE
DIVE BRAKES EXTENDED

V_B = BRAKING SPEED
 V_{TD} = TOUCHDOWN SPEED

NOTE

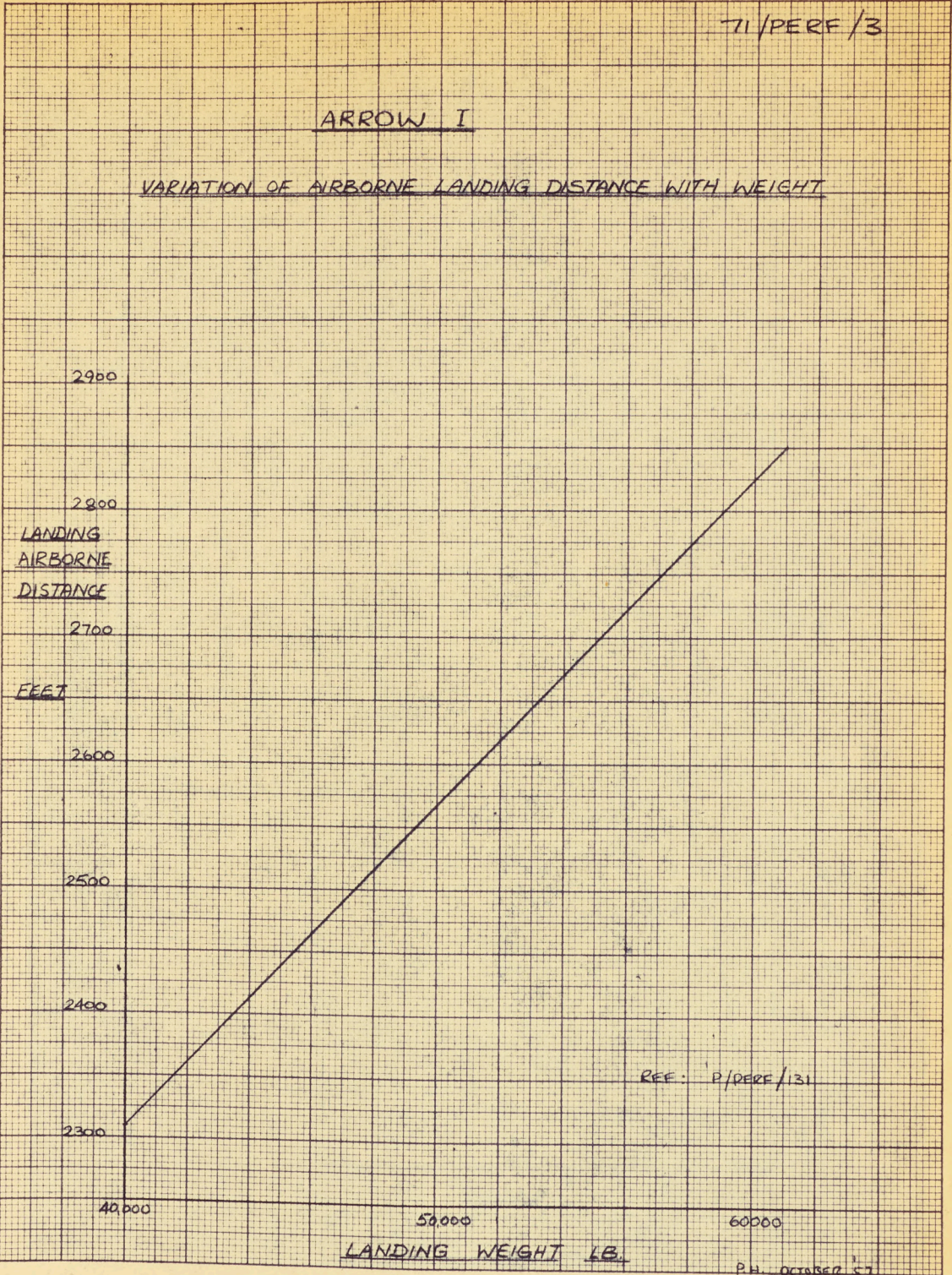
CALCULATED GROUND RUN
ARBITRARILY INCREASED BY 20%
DUE TO PILOTS INABILITY TO
APPLY THE OPTIMUM BRAKING
FORCE AS GIVEN WITH AN
AUTOMATIC BRAKE RELEASE
DEVICE



71/PERF/3

ARROW I

VARIATION OF AIRBORNE LANDING DISTANCE WITH WEIGHT

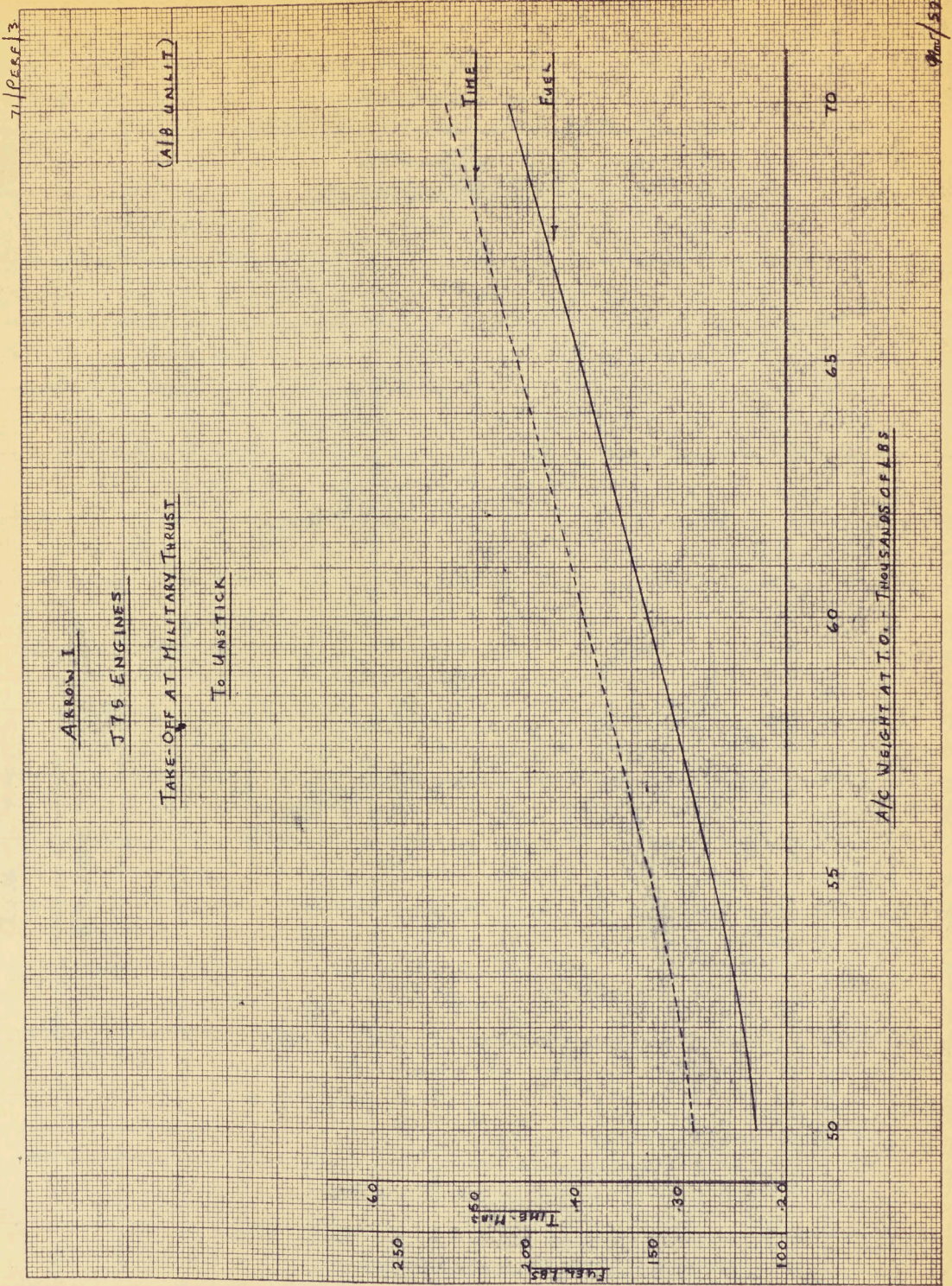


G9-12
10 X 10 TO THE 1/2 INCH
MADE IN CANADA

REF: P/PERF/131

P.H. OCTOBER 57

K&E 10 X 10 TO THE CM. 359-14
KEUFFEL & ESSER CO. MADE IN U.S.A.



7/PERE/3

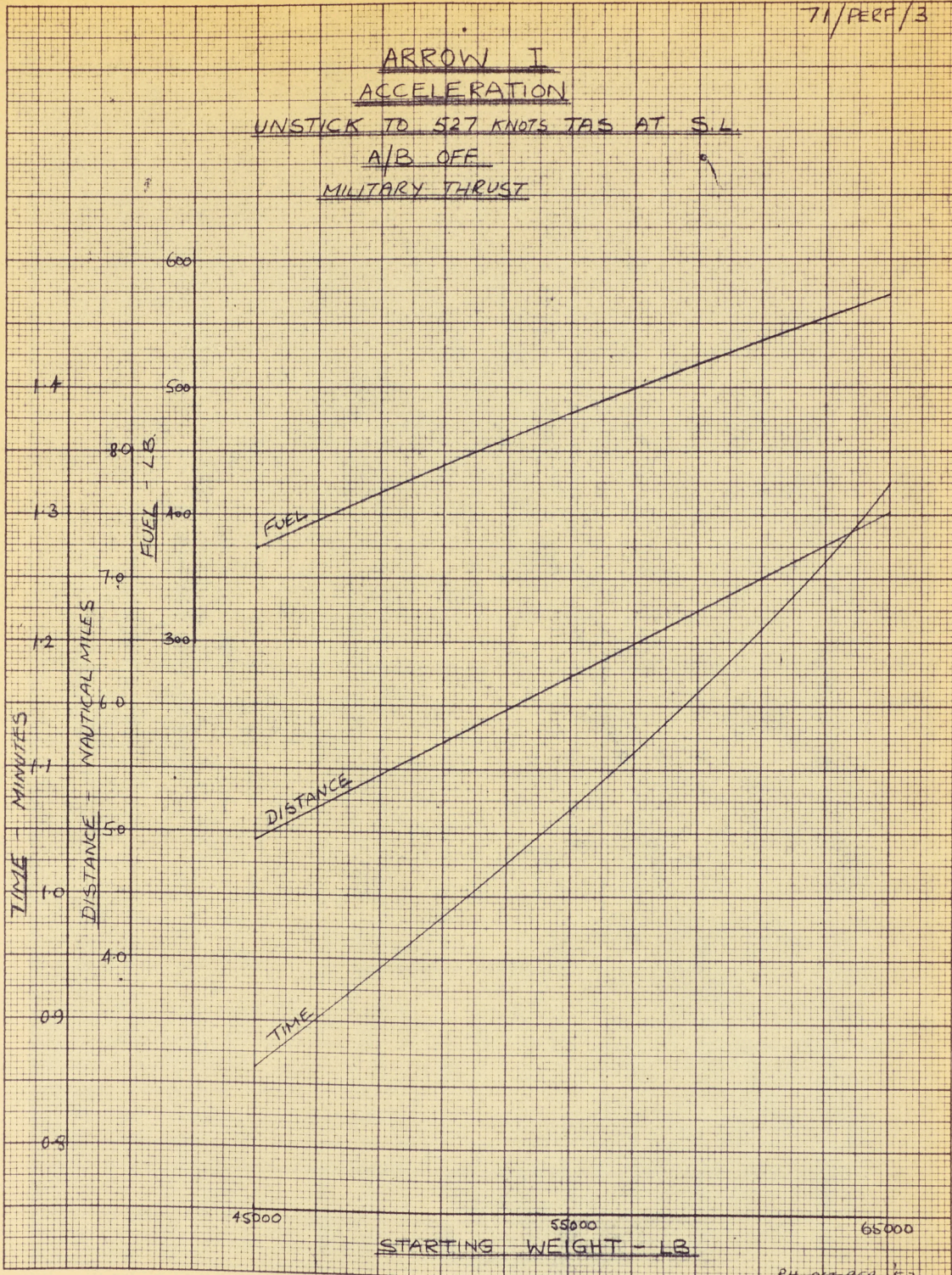
71/PERF/3

ARROW I ACCELERATION

UNSTICK TO 527 KNOTS TAS AT S.L.

A/B OFF

MILITARY THRUST



G9-12
10 X 10 TO THE 1/2 INCH
MADE IN CANADA

STARTING WEIGHT - LB

PH. OCTOBER '57

711 PERFB

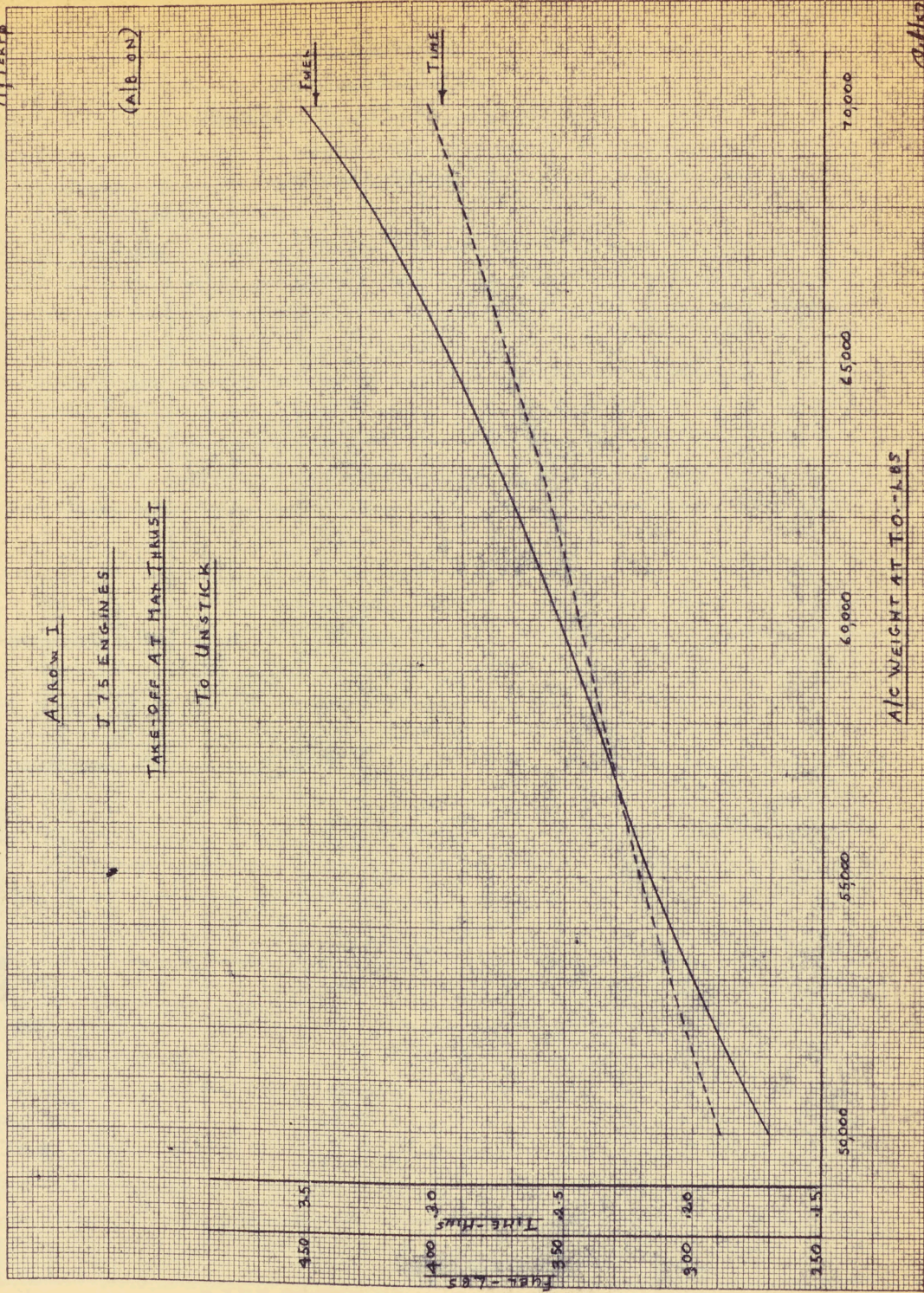
ARROW I

J 75 ENGINES

TAKE-OFF AT MAX THRUST

TO UNSTICK

(A/B ON)

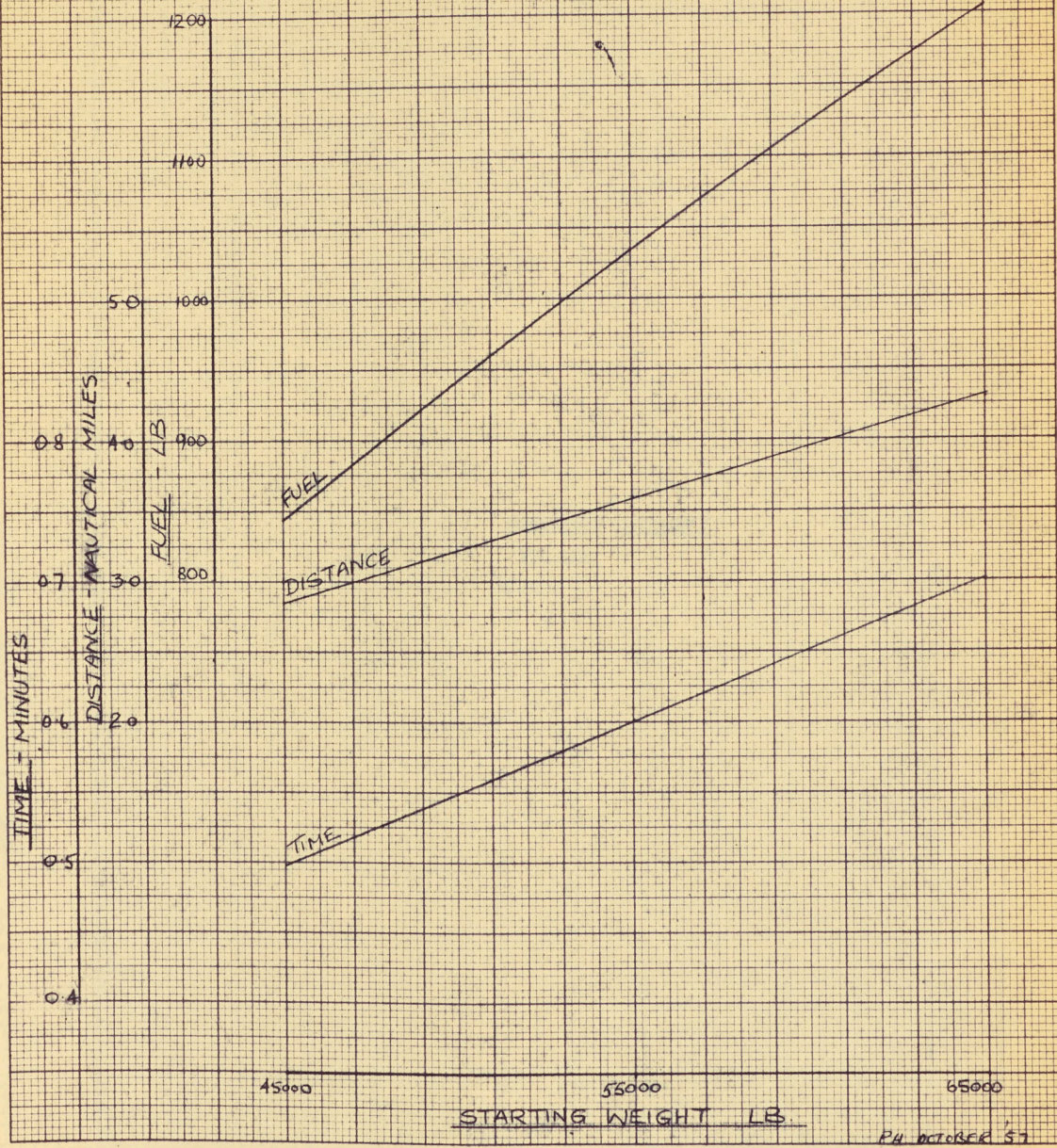


A/C WEIGHT AT T.O. - LBS

001/68

71/PERF/3

ARROW I
ACCELERATION
UNSTICK TO M=0.92 AT S.L.
A/B ON
MAXIMUM THRUST

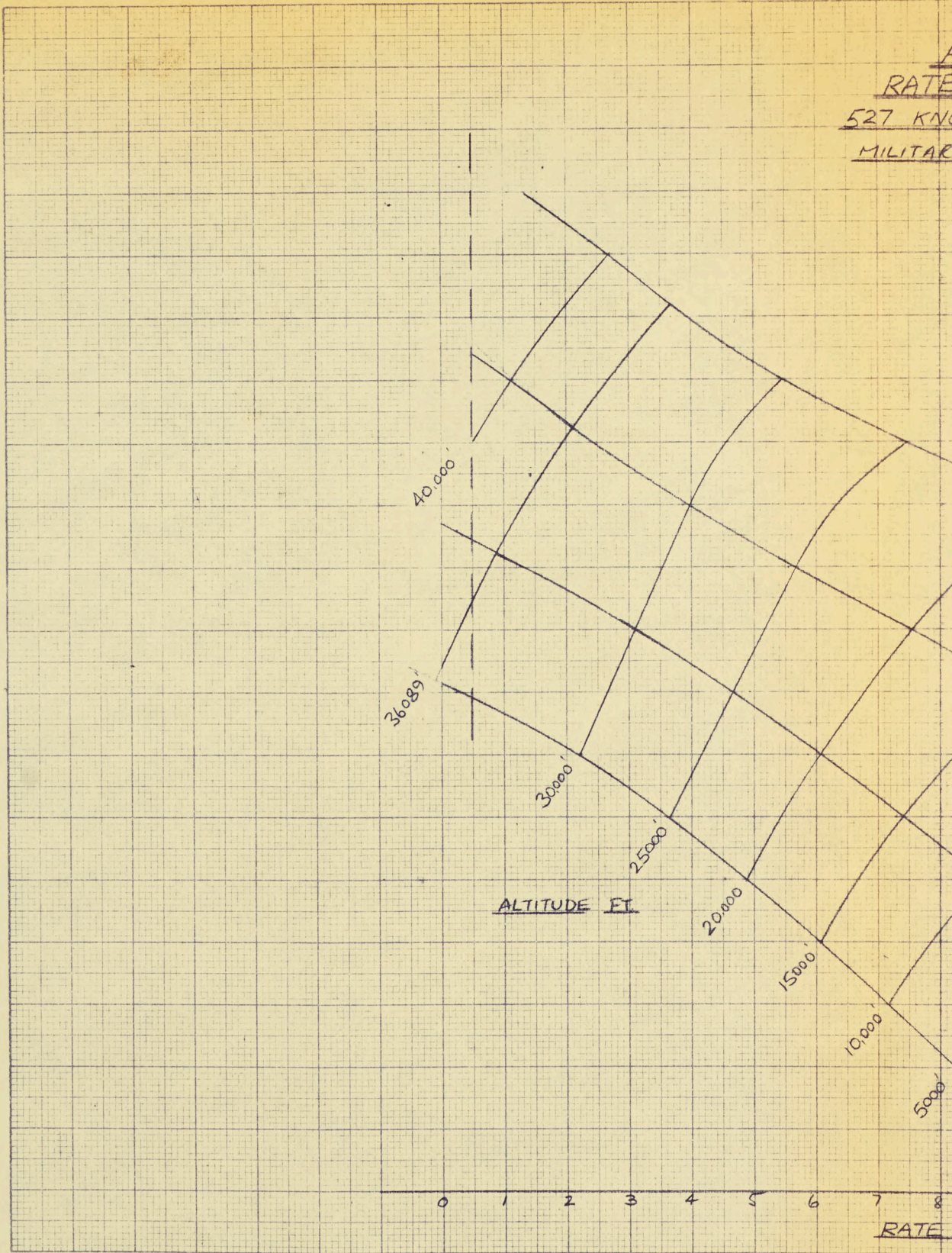


G9-12-
 10 X 10 TO THE 1/2 INCH
 MADE IN CANADA

STARTING WEIGHT LB

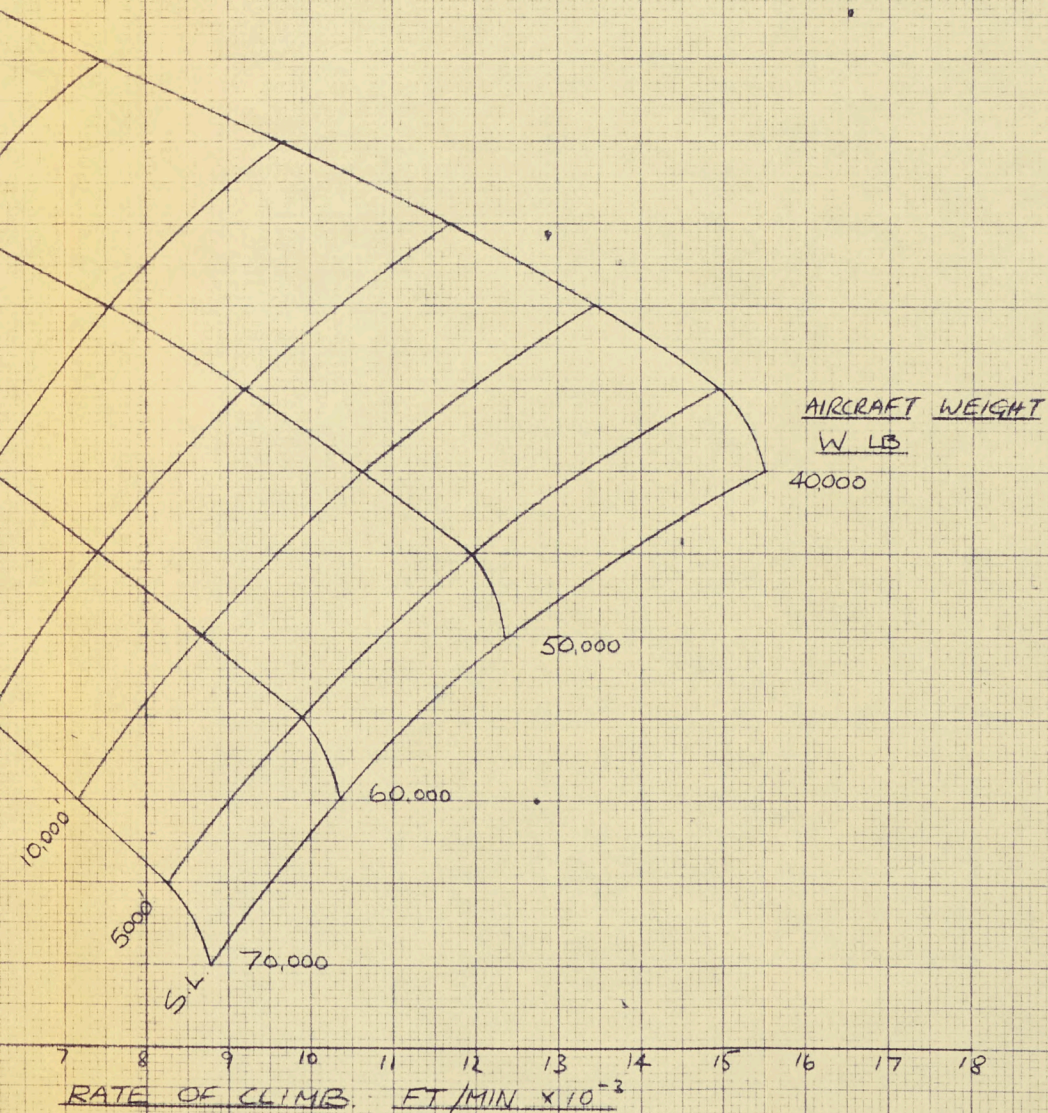
24 OCTOBER '57

KE
10 X 10 TO THE 1/2 INCH 359-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.



71/PERF/3

ARROW I
RATE OF CLIMB
527 KNOTS TAS. A/B OFF
MILITARY THRUST



P.H. OCTOBER '57

ARROW I
TIME TO HEIGHT

527 KNOTS TAS. A/B OFF
MILITARY THRUST

AIRCRAFT WEIGHT

WLB

40,000

50,000

60,000

70,000

SL.

ALTITUDE

40,000'

25,000'

20,000'

15,000'

10,000'

5,000'

0

1

2

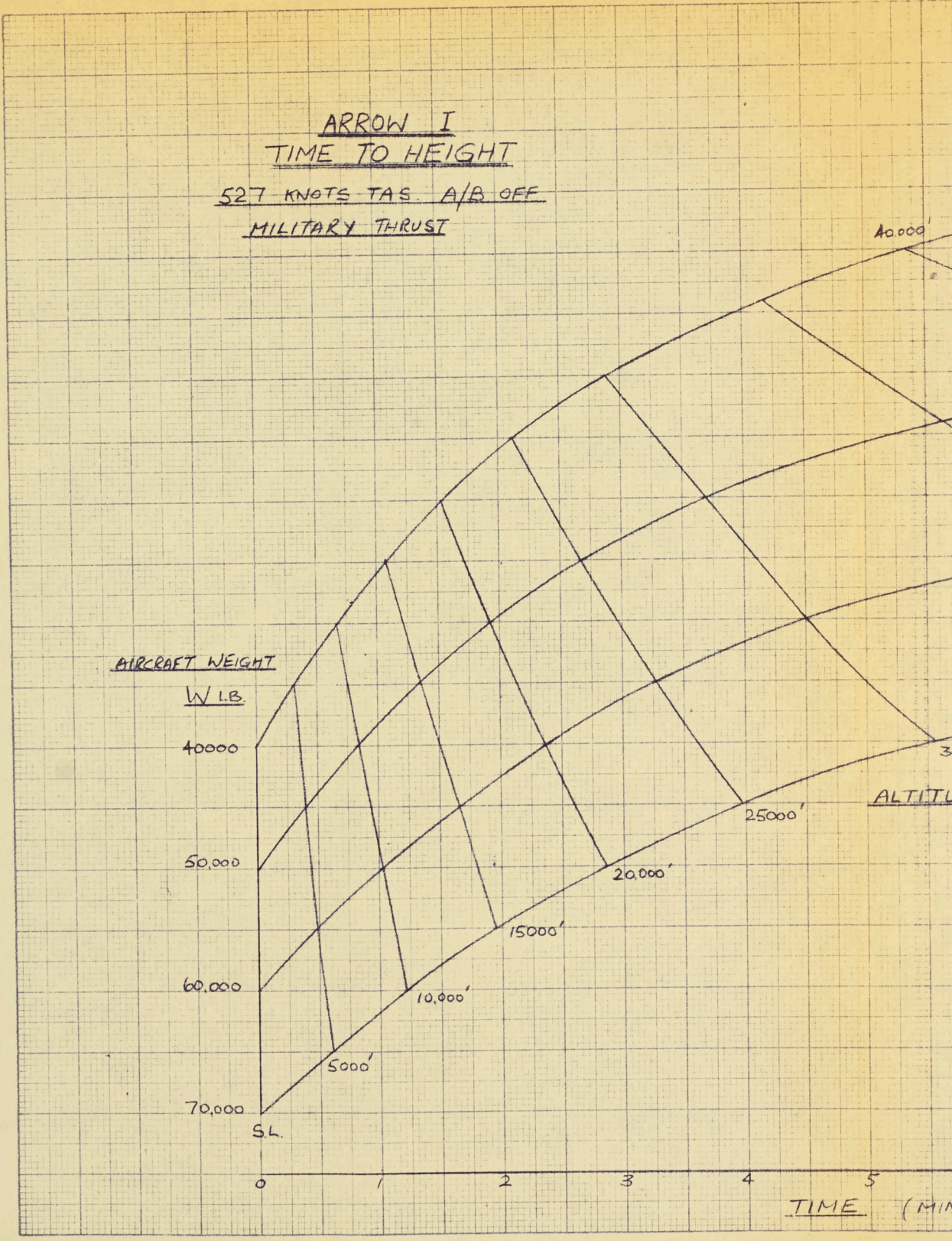
3

4

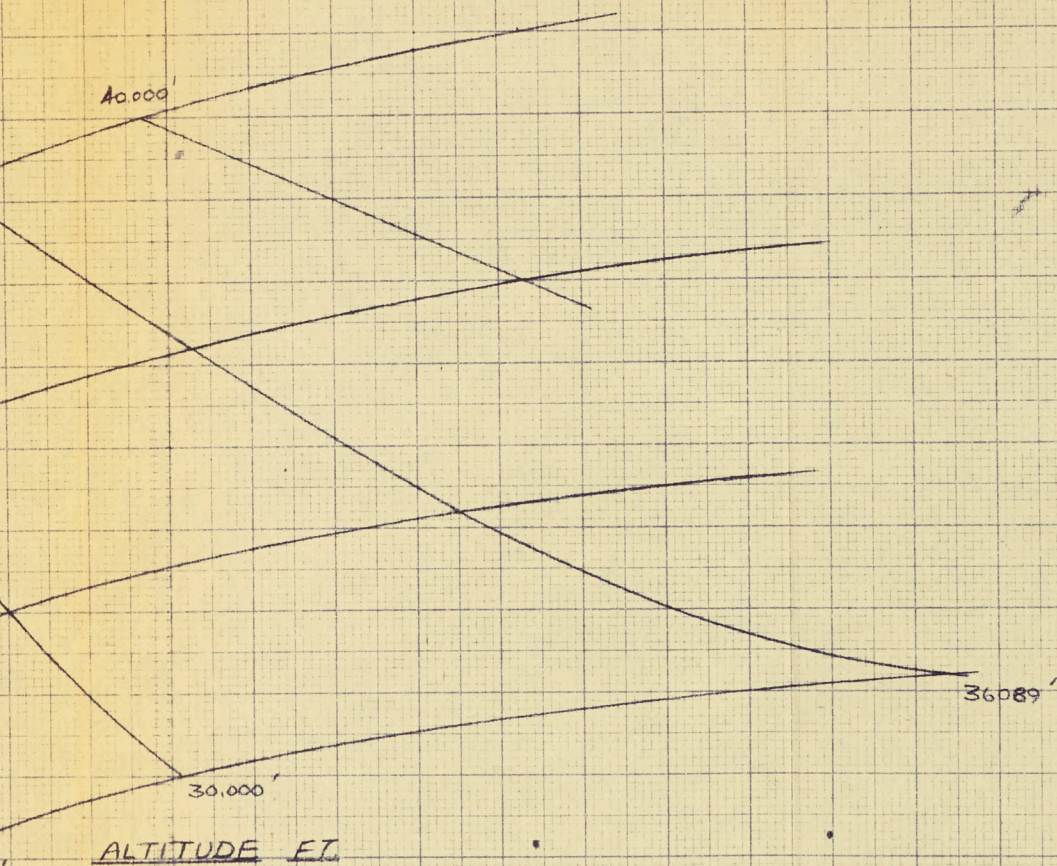
5

TIME (MIN)

10 X 10 TO THE 1/2 INCH 359-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.



71/PERE/3



TIME (MINUTES)

PH. OCTOBER '57

ARROW I
FUEL TO HEIGHT
527 KNOTS TAS. A/B OFF.
MILITARY THRUST

AIRCRAFT WEIGHT

W LB.

40,000

50,000

60,000

70,000

S-L

20,000'

15,000'

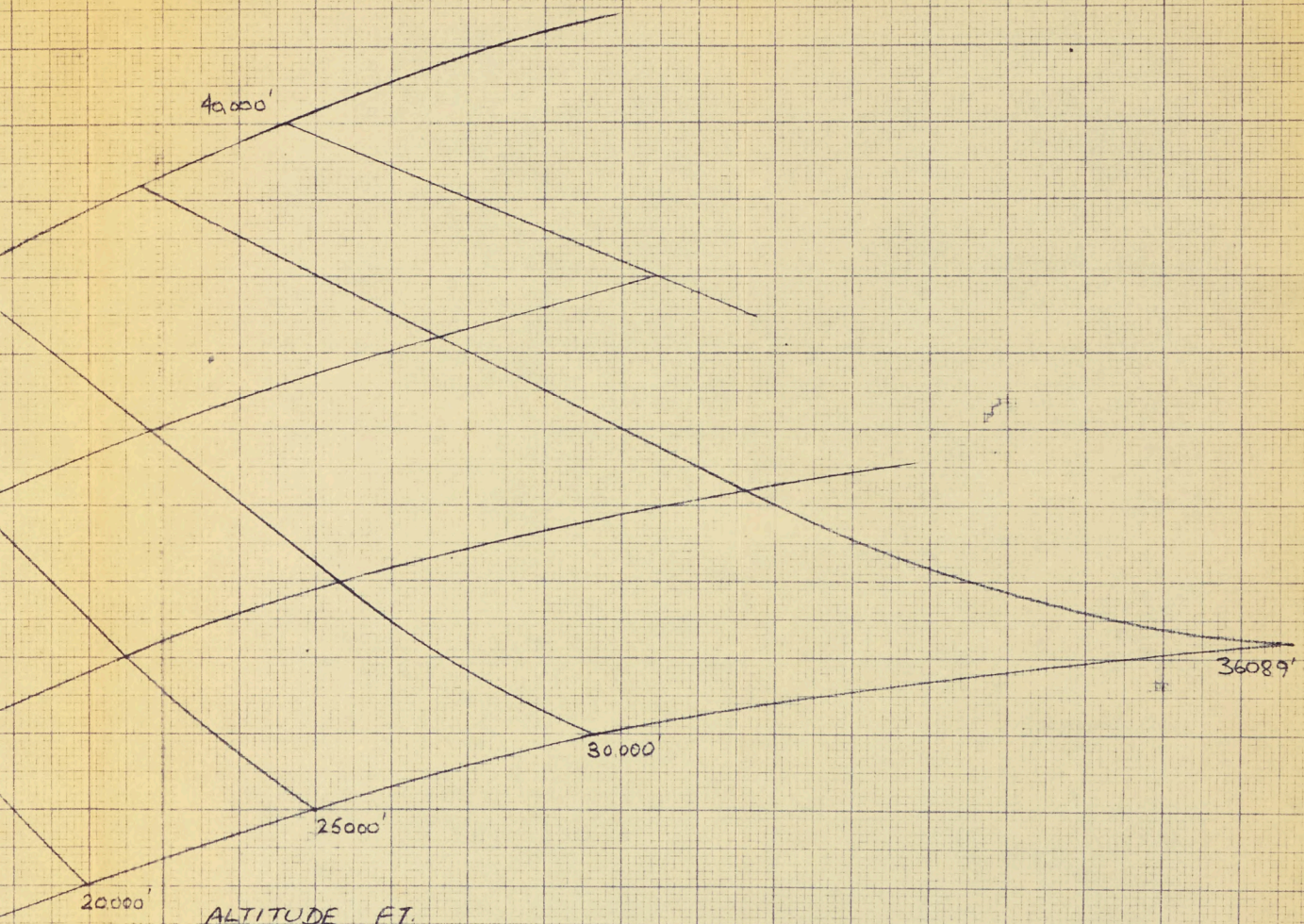
10,000'

5,000'

0 200 400 600 800 1000 1200

KE 10 X 10 TO THE 1/2 INCH 359-111L
KELUFFEL & ESSER CO. MADE IN U.S.A.

71/PERF/3



ALTITUDE FT.

FUEL (LB)

PH OCTOBER '57

ARROW I
DISTANCE TO HEIGHT
 527 KNOTS TAS. A/B OFF
MILITARY THRUST

AIRCRAFT WEIGHT

W LB.

40,000 LB

50,000 LB

60,000 LB

70,000 LB

S.L.

ALTITUDE

40,000'

30,000'

25,000'

20,000'

15,000'

10,000'

5,000'

0

10

20

30

40

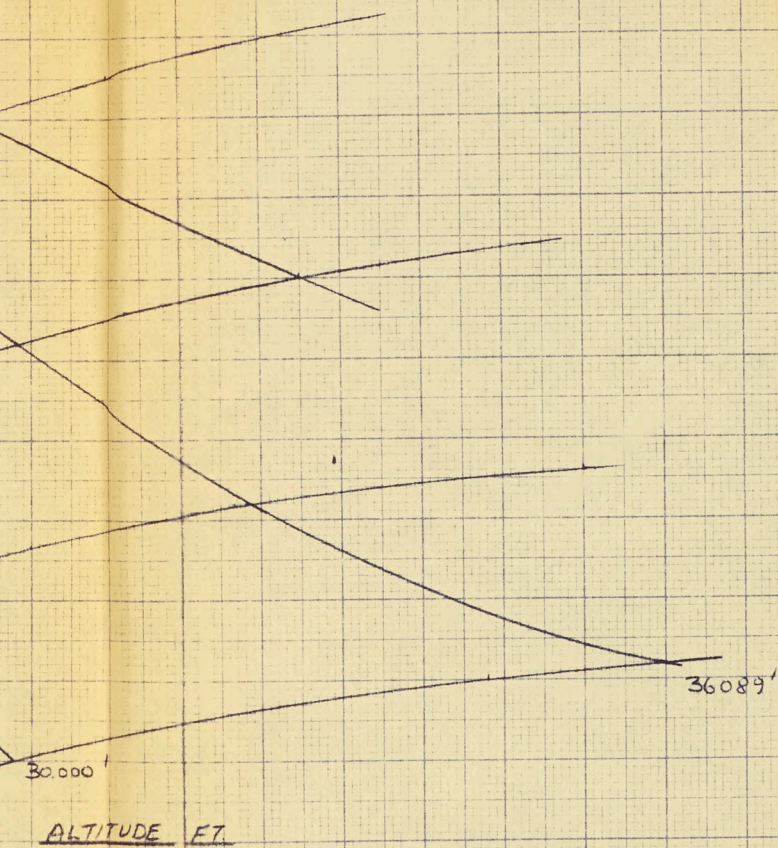
50

60

DISTANCE

K&E 10 X 10 TO THE 1/2 INCH 359-11L
 KEUFFEL & ESSER CO. MADE IN U.S.A.

71/PERF/3



ALTITUDE FT.

36,089'

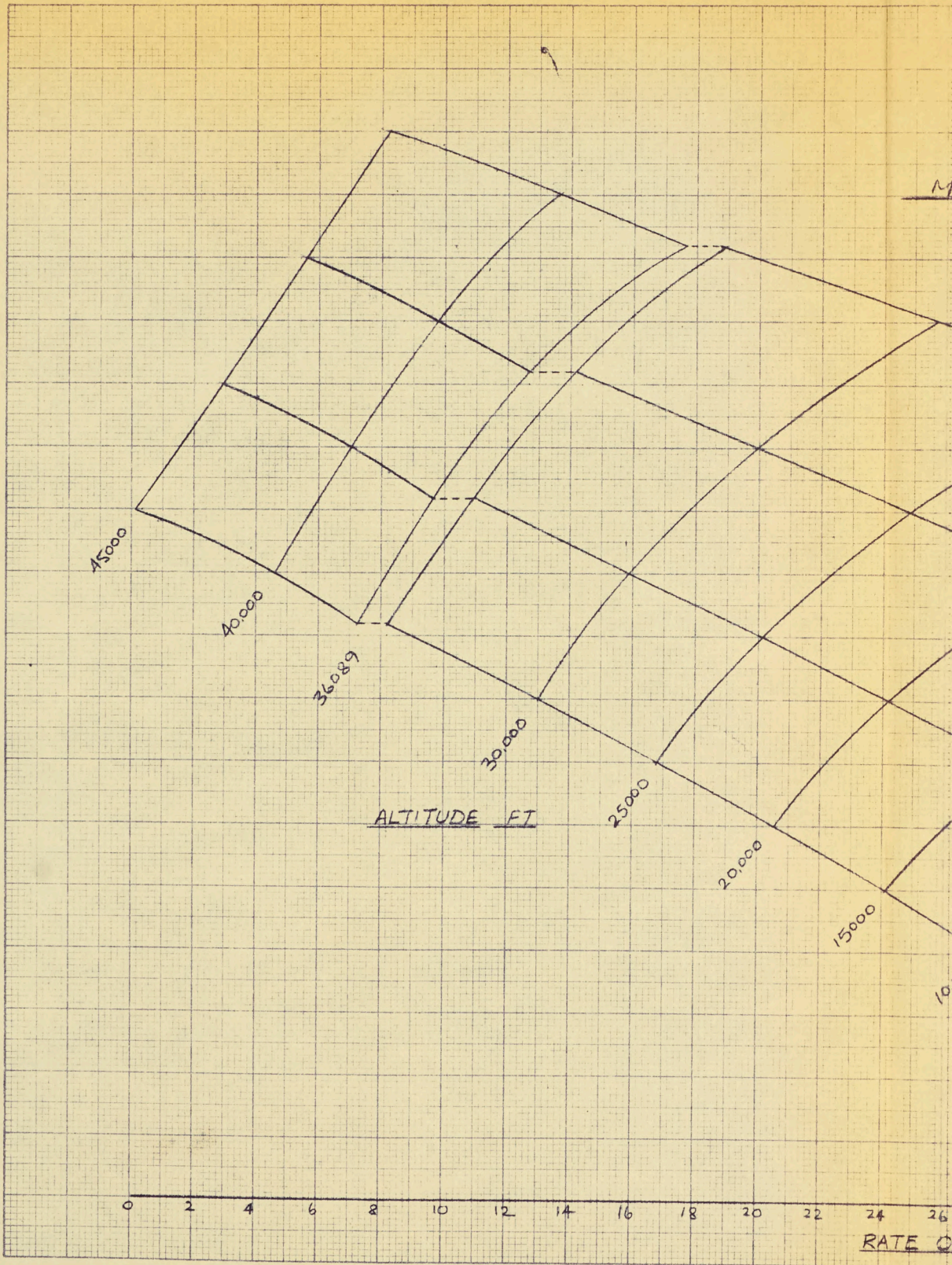
30,000'

DISTANCE

(NAUTICAL MILES)

P.H. OCTOBER '57

K+S 10 X 10 TO THE 1/2 INCH 359-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.

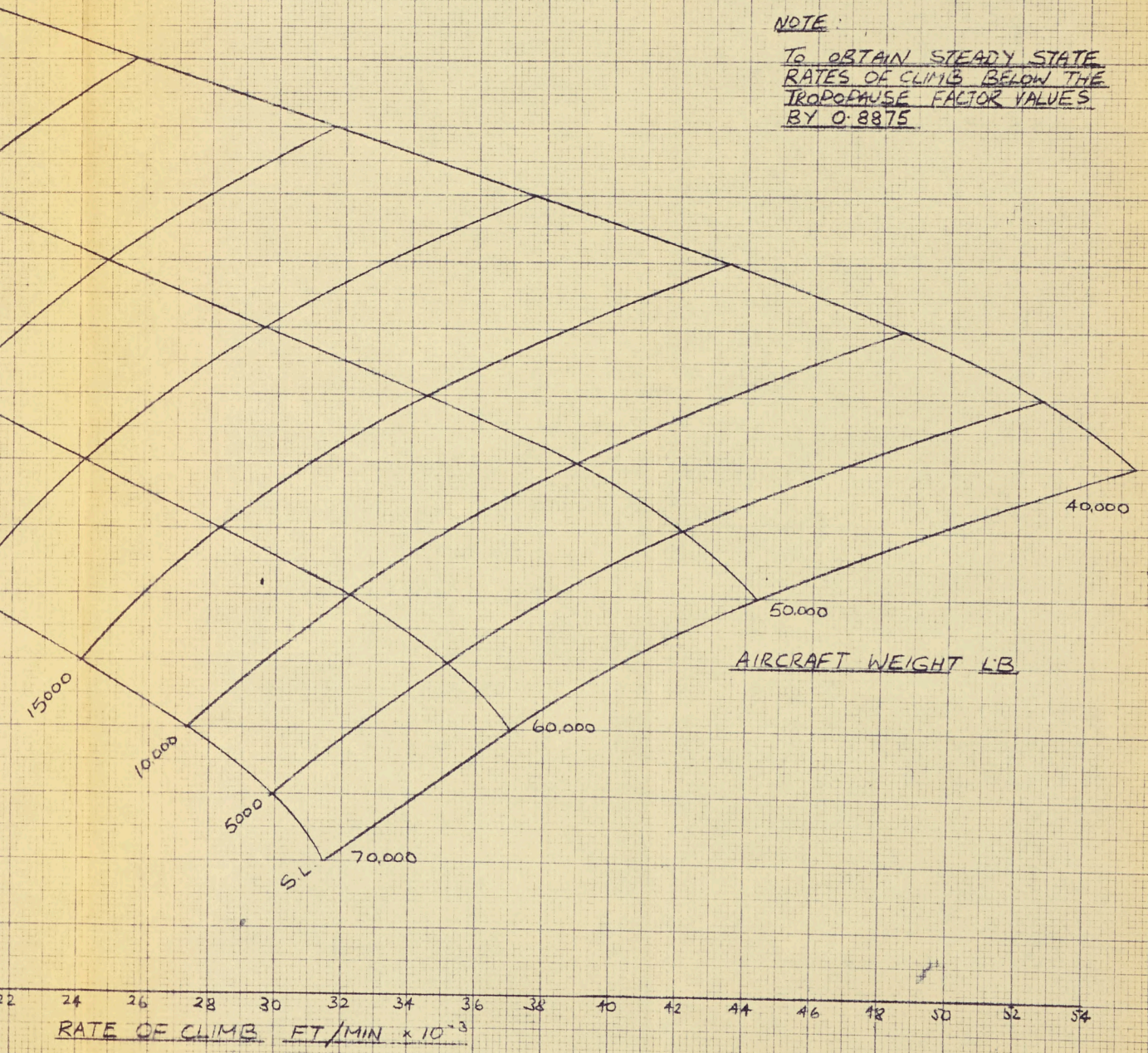


ARROW I
RATE OF CLIMB

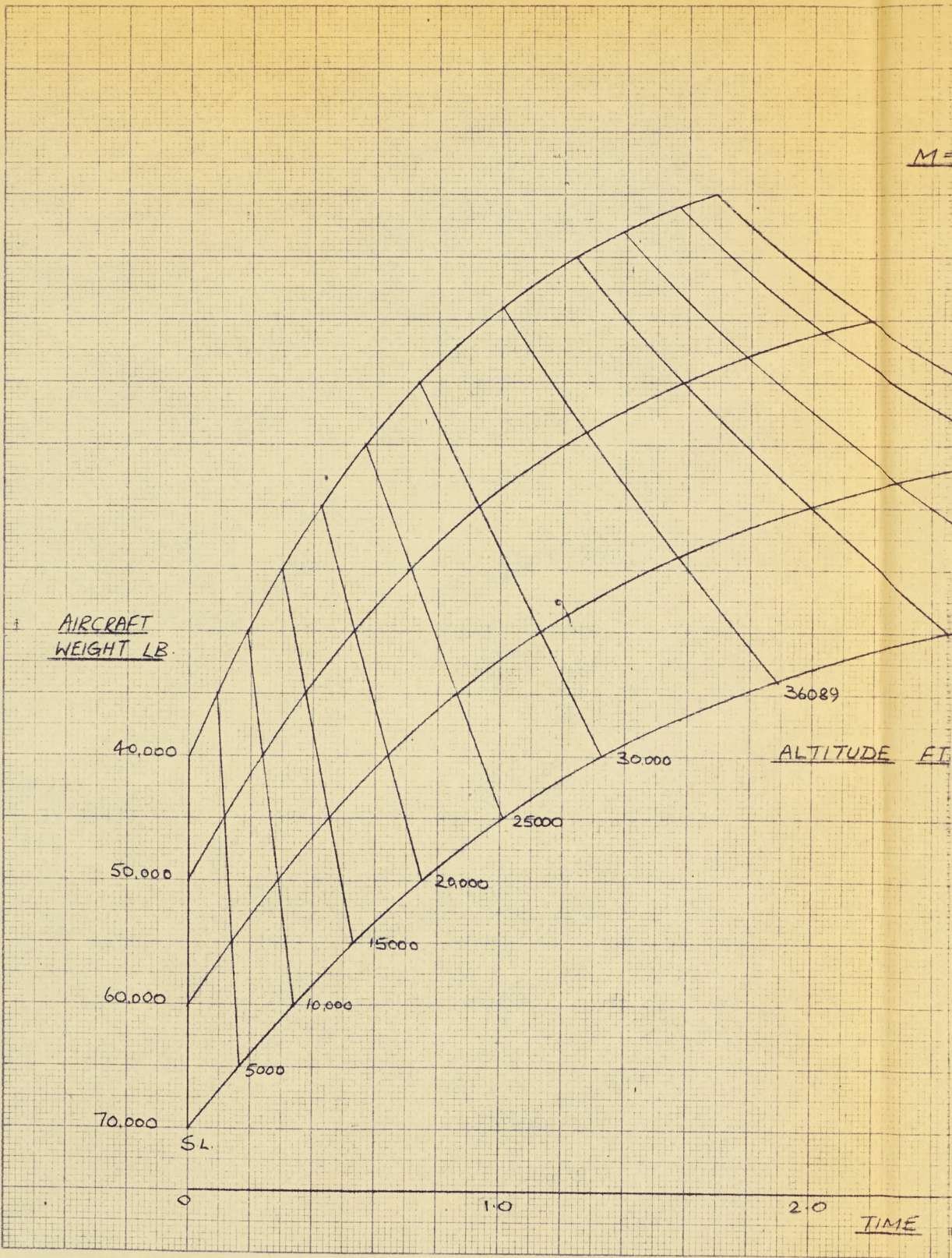
M = 0.92, A/B ON, MAXIMUM THRUST

NOTE:

TO OBTAIN STEADY STATE
RATES OF CLIMB BELOW THE
TROPOPAUSE FACTOR VALUES
BY 0.8875

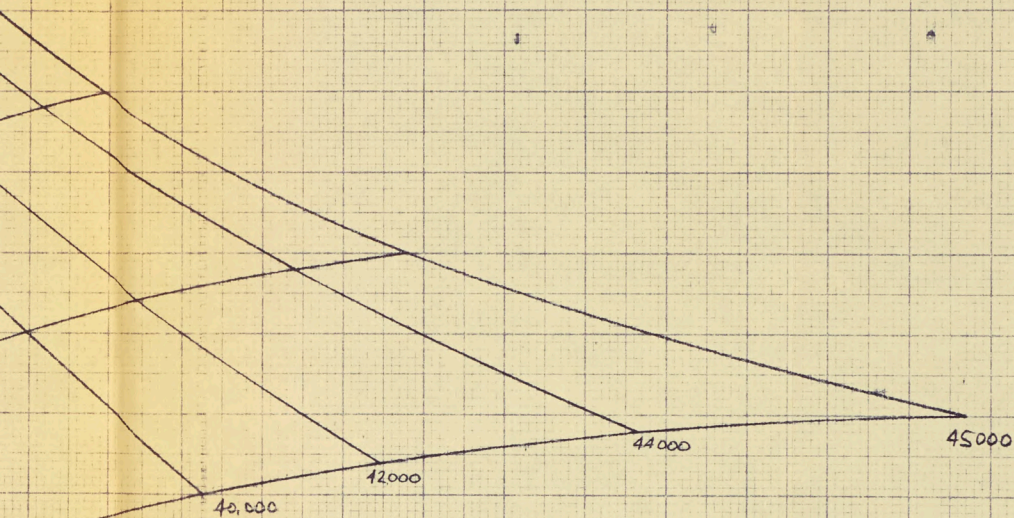


KE 10 X 10 TO THE 1/2 INCH 359-111L
KEUFFEL & ESSER CO. MADE IN U.S.A.



71/PERF/3

ARROW I
TIME TO HEIGHT
M=0.92 A/B ON, MAXIMUM THRUST



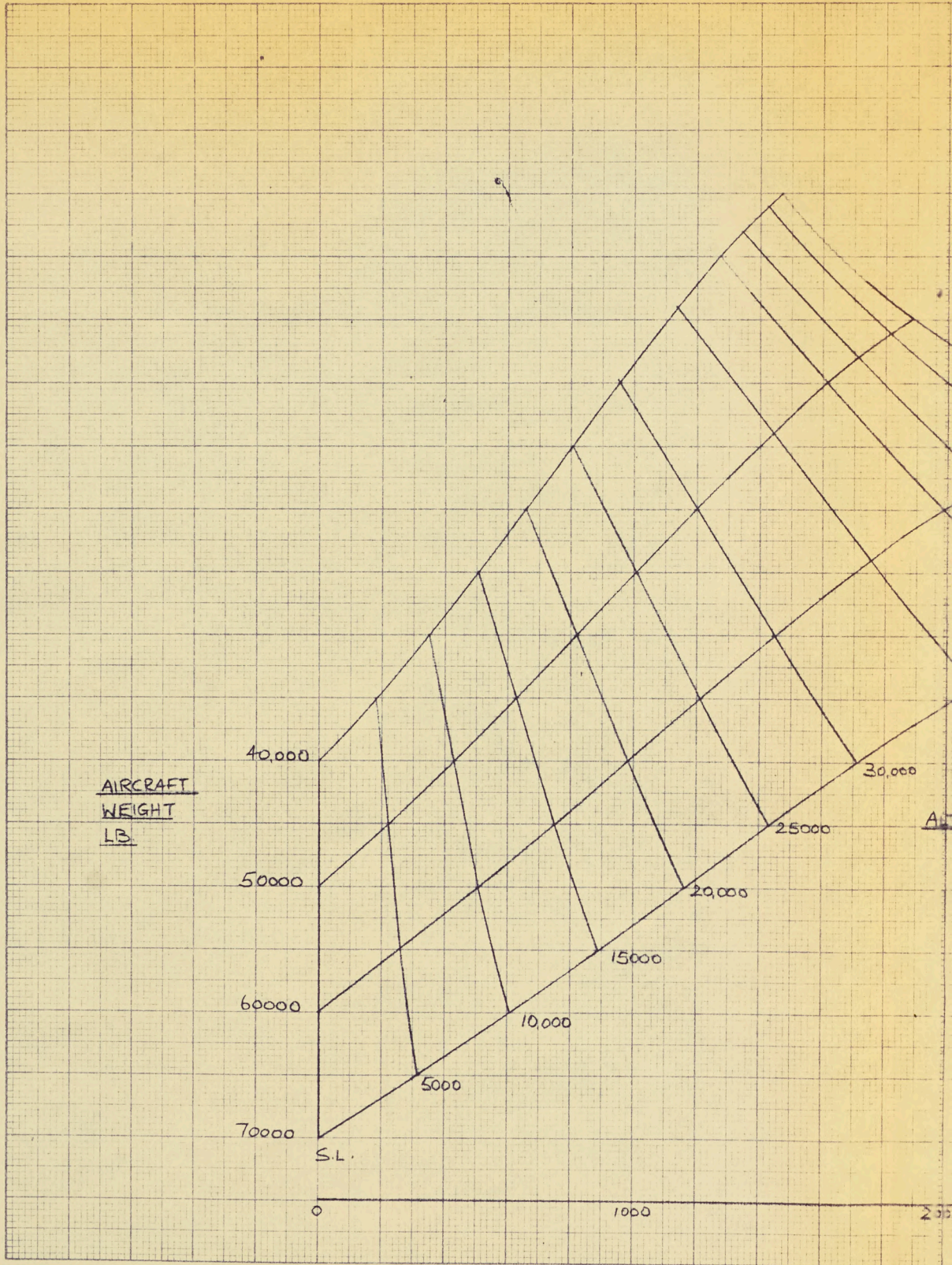
26089

ALTITUDE FT

2.0 TIME (MINUTES) 3.0 4.0

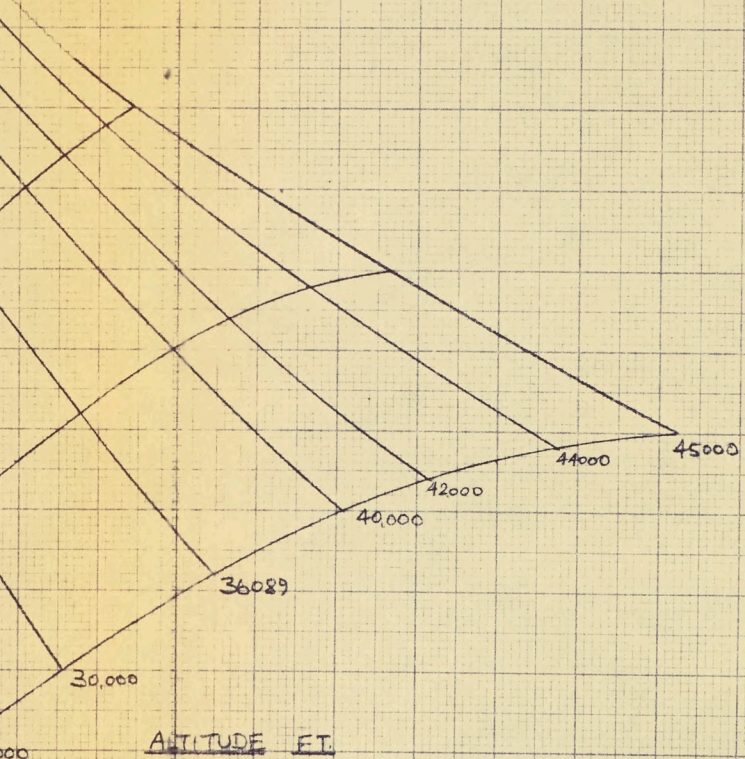
RH OCTOBER '57

KE 10 X 10 TO THE 1/2 INCH 359-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.



71/PERF/3

ARROW I
FUEL TO HEIGHT
M = 0.92, A/B ON, MAXIMUM THRUST



2000

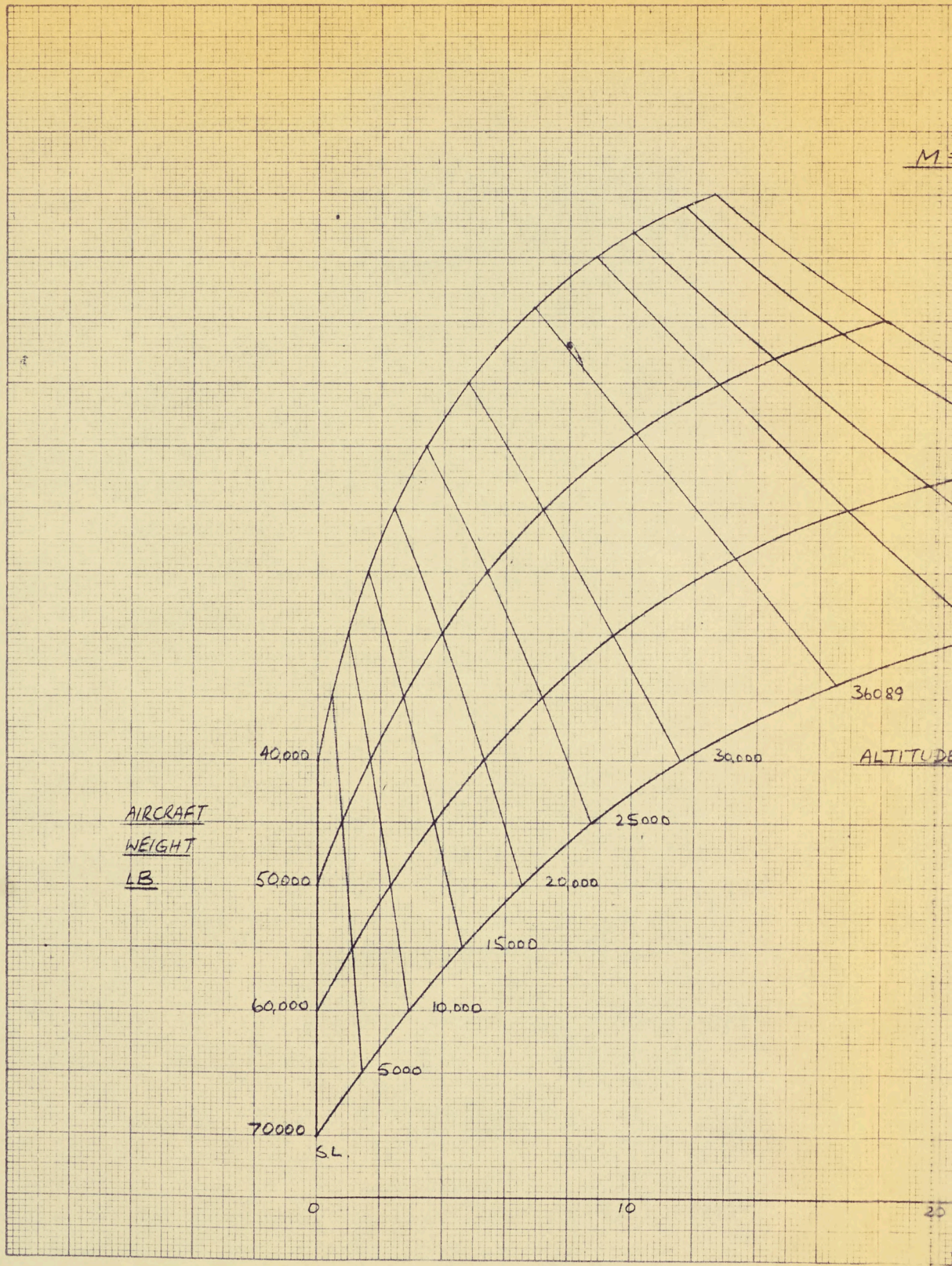
FUEL (LB)

3000

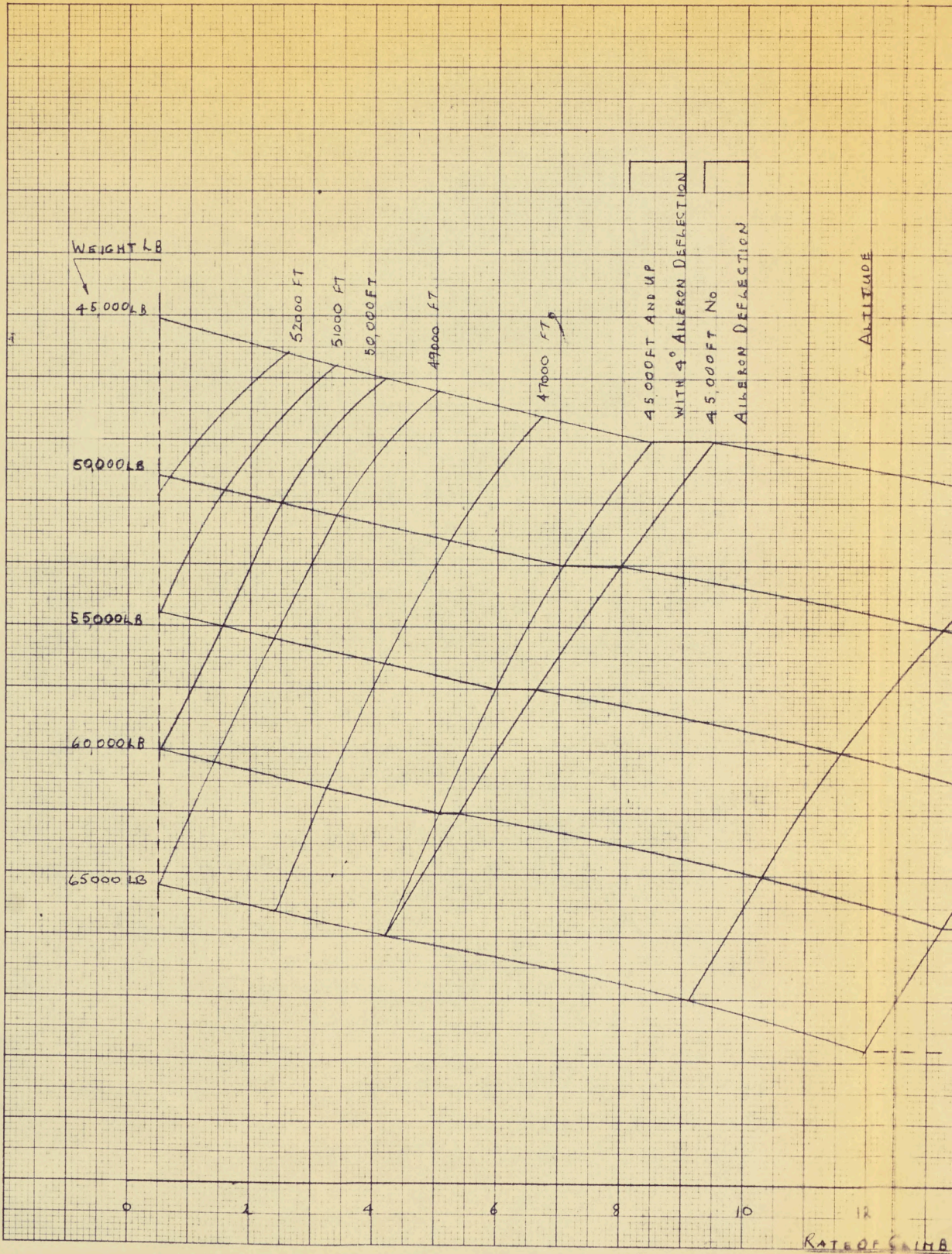
4000

PH OCTOBER '56

10 X 10 TO THE 1/2 INCH 359-111L
KEUFFEL & ESSER CO. MADE IN U.S.A.



G9-11L
10 X 10 to the 1/2 inch, 5th lines accented
MADE IN CANADA



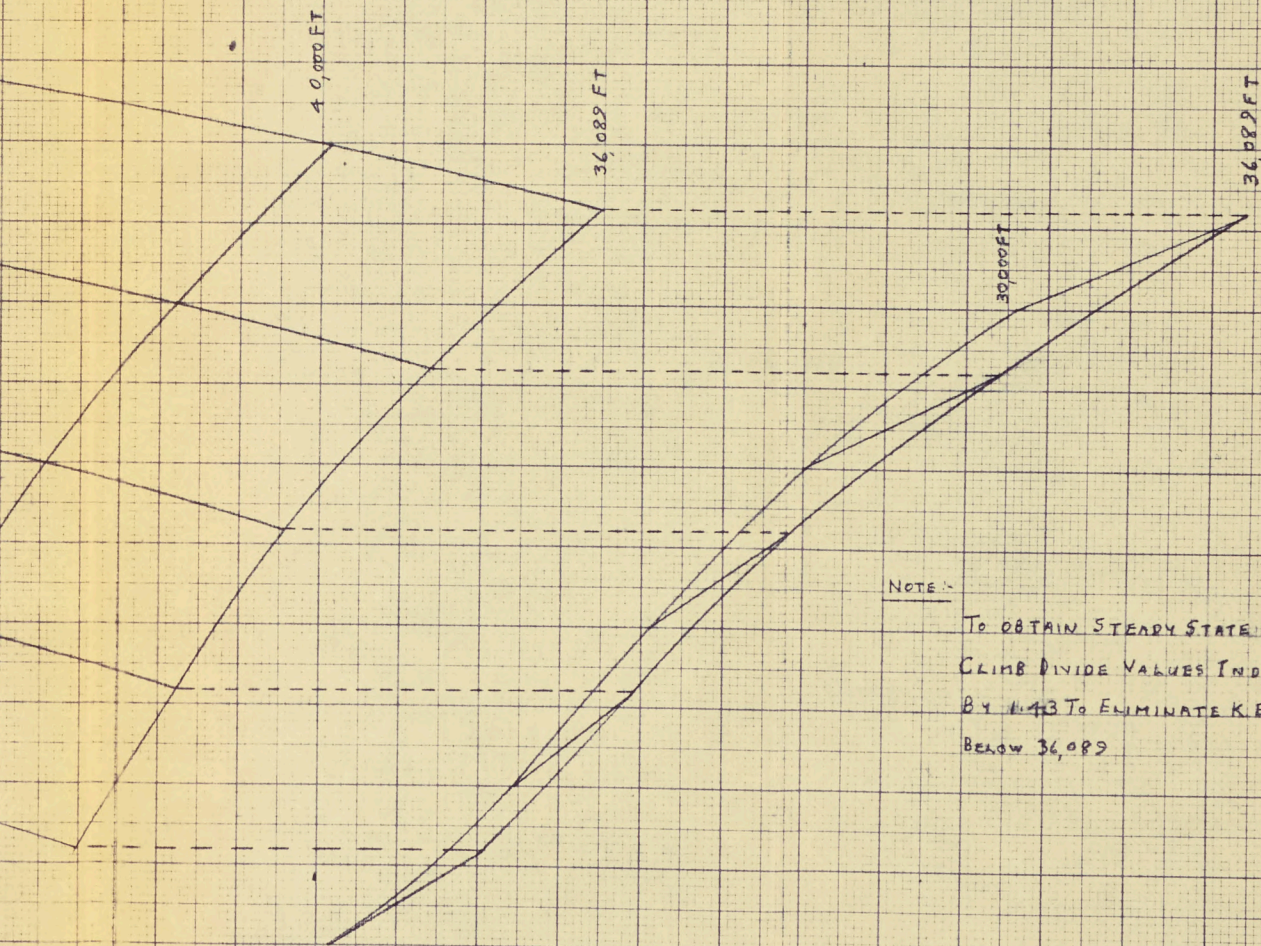
ARROW I

RATE OF CLIMB

MACH NUMBER = 1.5

MAXIMUM THRUST

ALTITUDE



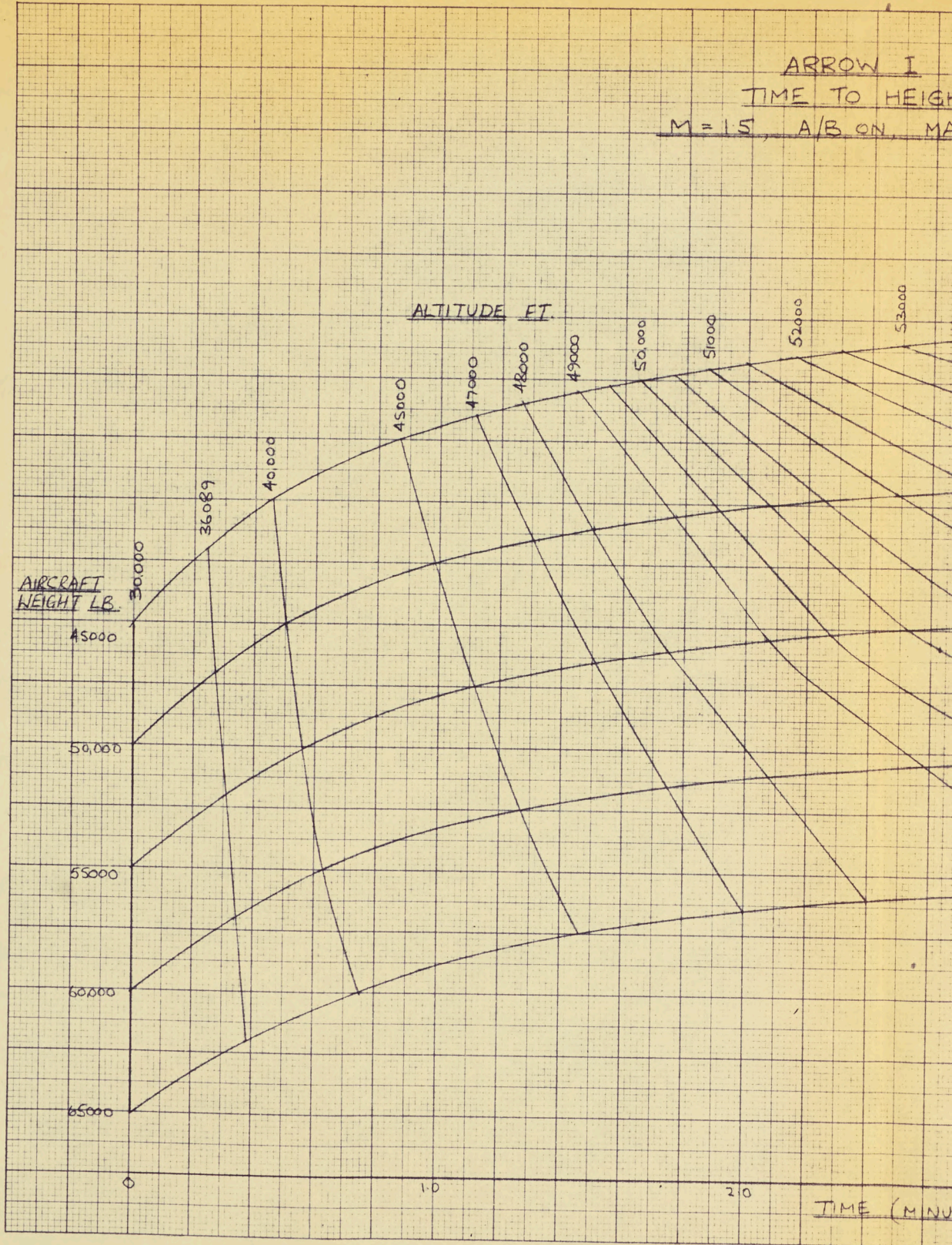
NOTE:-

TO OBTAIN STEADY STATE RATE OF CLIMB DIVIDE VALUES INDICATED BY 1.43 TO ELIMINATE K.E. EFFECT BELOW 36,089

12 14 16 18 20 22 24 26
RATE OF CLIMB - FT/MIN X 10^3

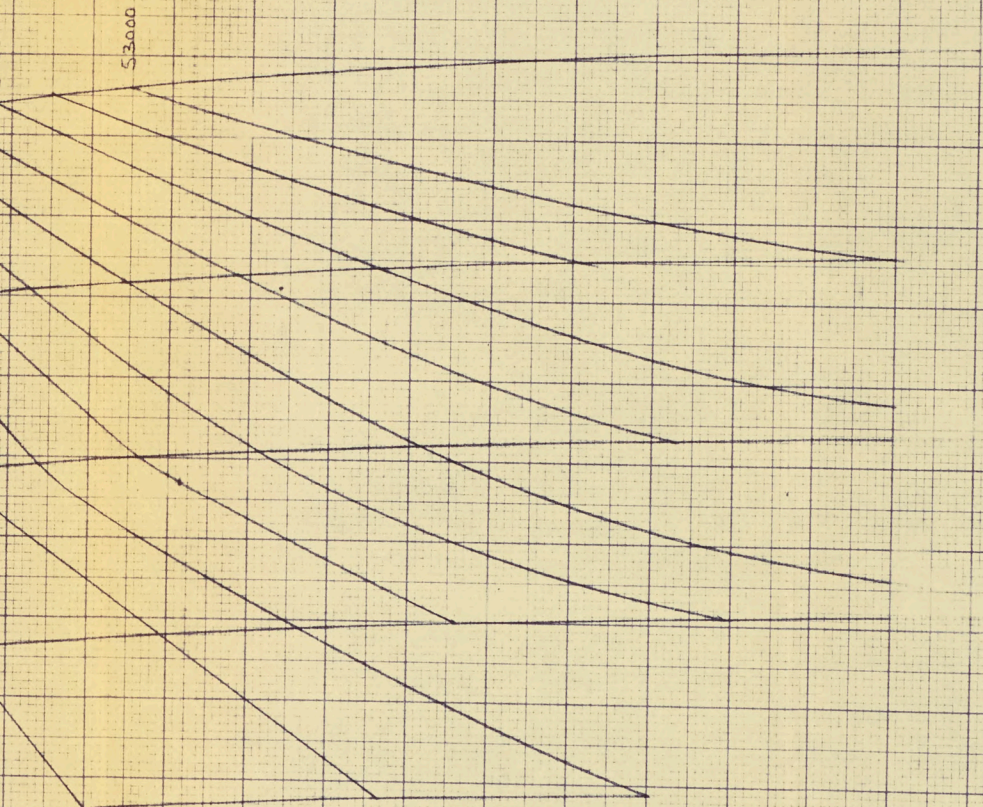
G9-11L
10 X 10 to the 1/2 inch, 5th lines accented
MADE IN CANADA

ARROW I
TIME TO HEIGHT
M=15, A/B ON, MA



71/PERF/3

ROW I
TO HEIGHT
A/B ON, MAXIMUM THRUST



TIME (MINUTES) 30

40

50

PH NOV 57

G 9-11 L
10 X 10 to the 1/2 inch, 5th lines accented
MADE IN CANADA

ARROW I
FUEL TO HEIGHT
M=1.5, A/B ON, M

AIRCRAFT
WEIGHT LB.

ALTITUDE FT.

45000

50000

55000

60,000

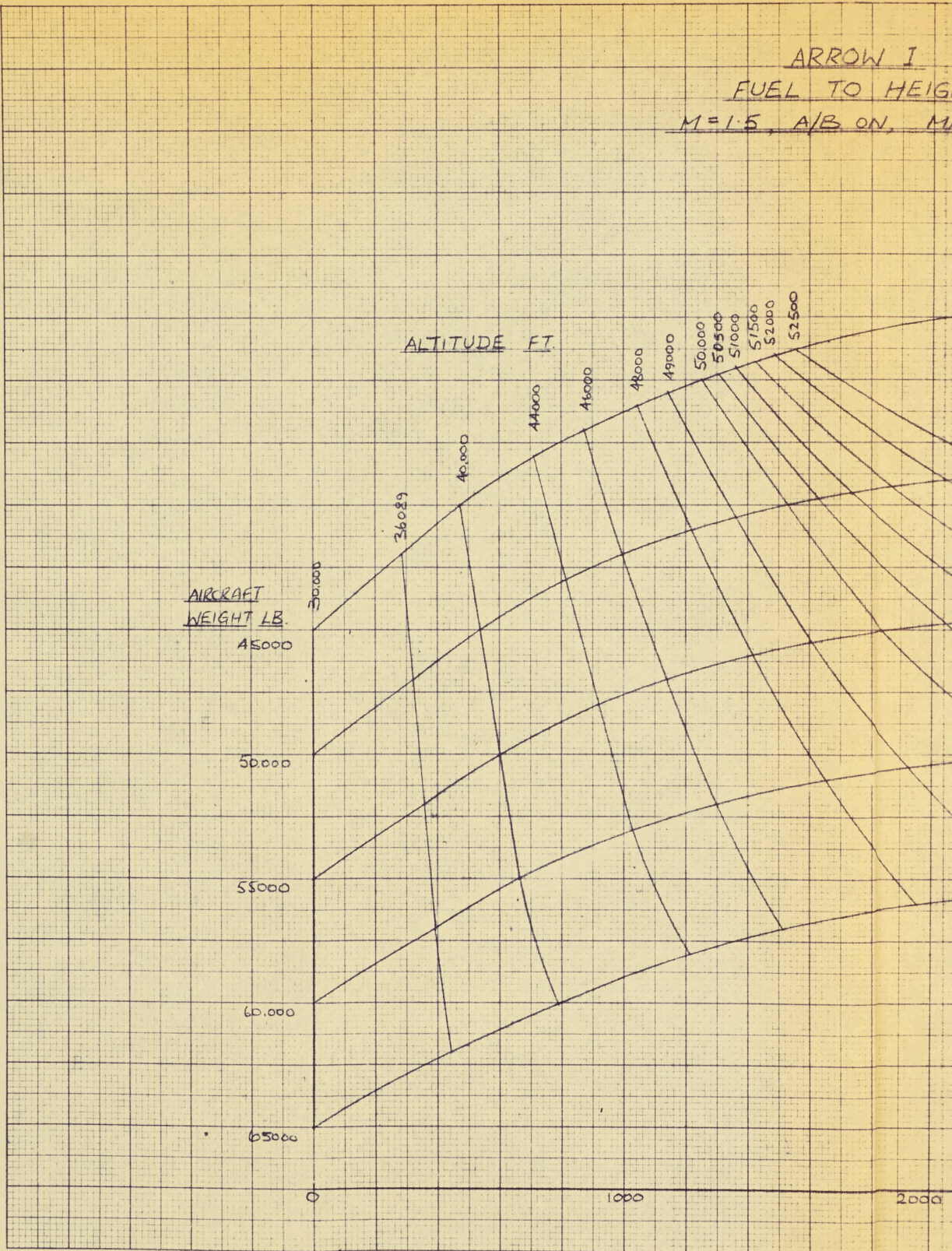
65000

0

1000

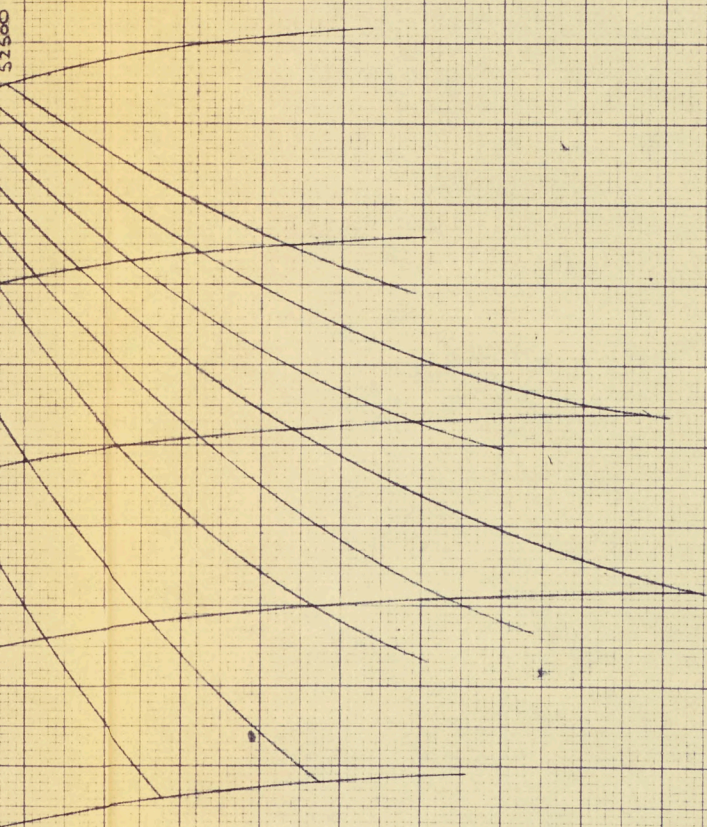
2000

36000
40,000
44000
48000
49000
50,000
50500
51000
51500
52000
52500



ARROW I
TO HEIGHT
A/B ON. MAXIMUM THRUST

71/PERF/3



2000

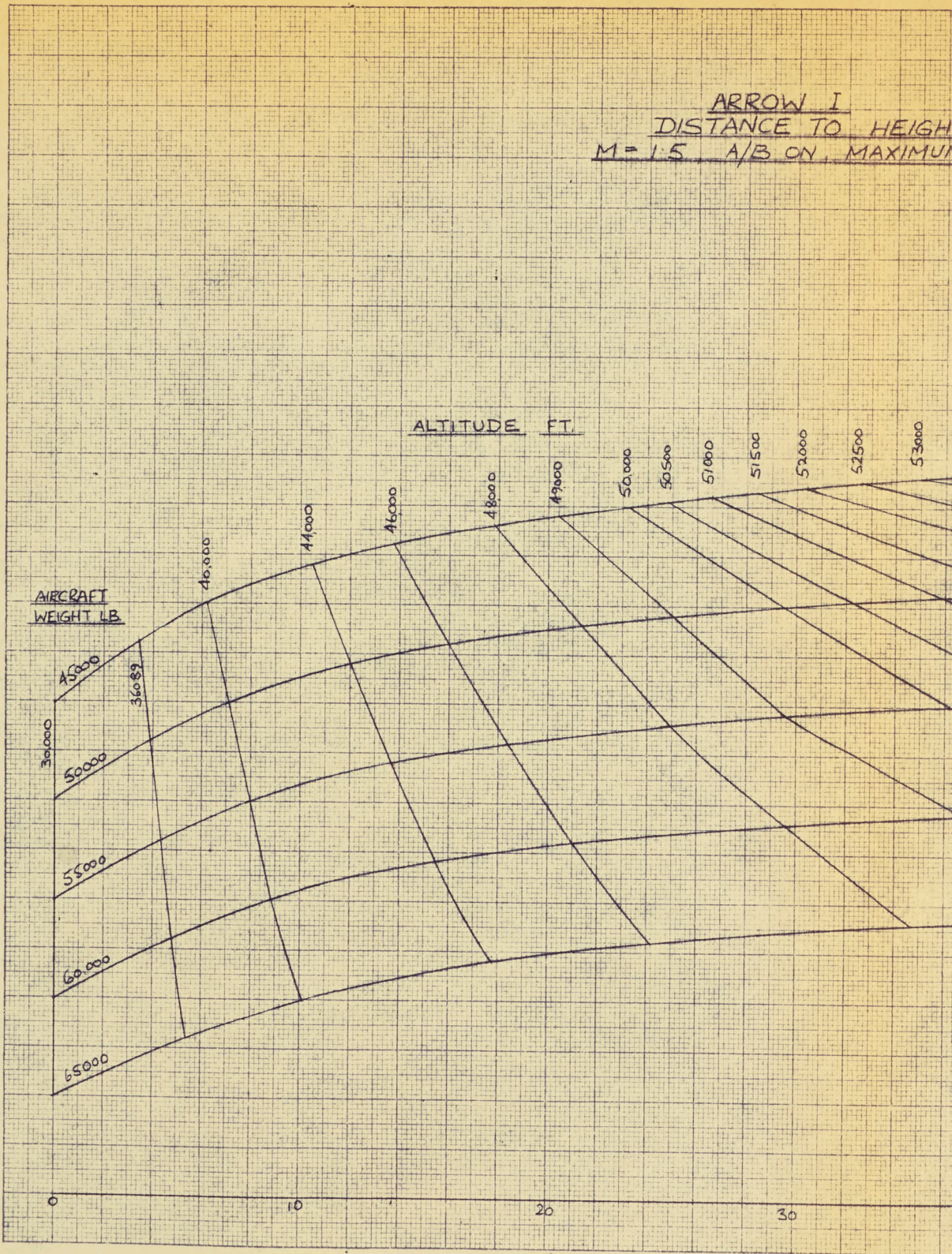
FUEL (LB)

3000

4000

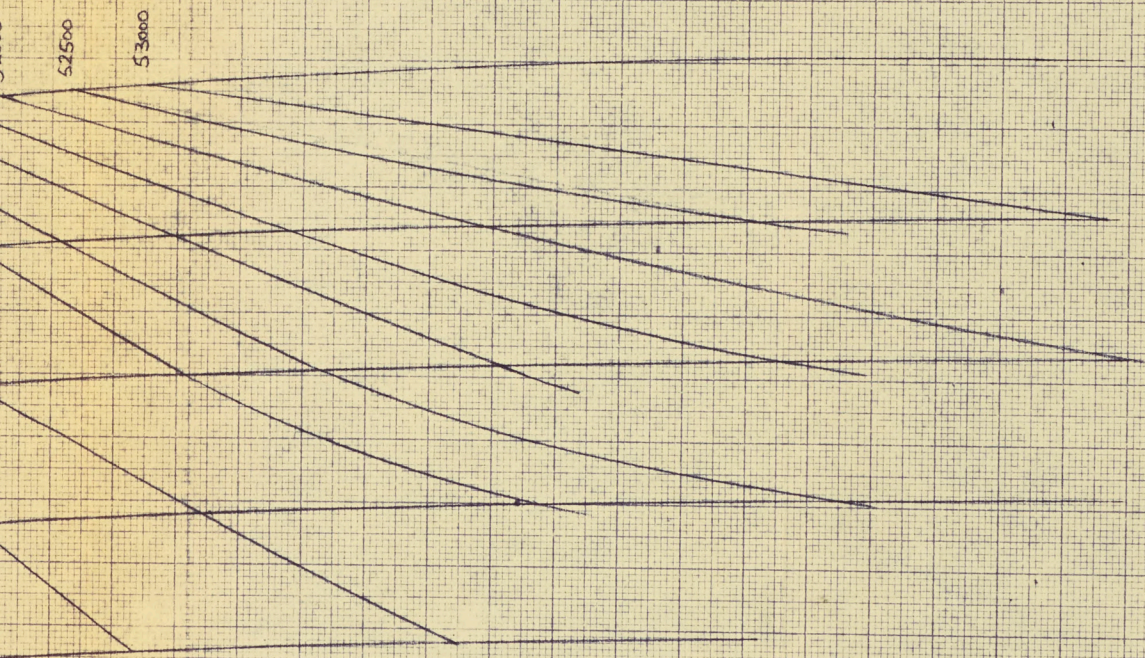
PH NOV 57

K&E 10 X 10 TO THE CM. 359-14L
KEUFFEL & ESSER CO. MADE IN U.S.A.



TI/PERF/3

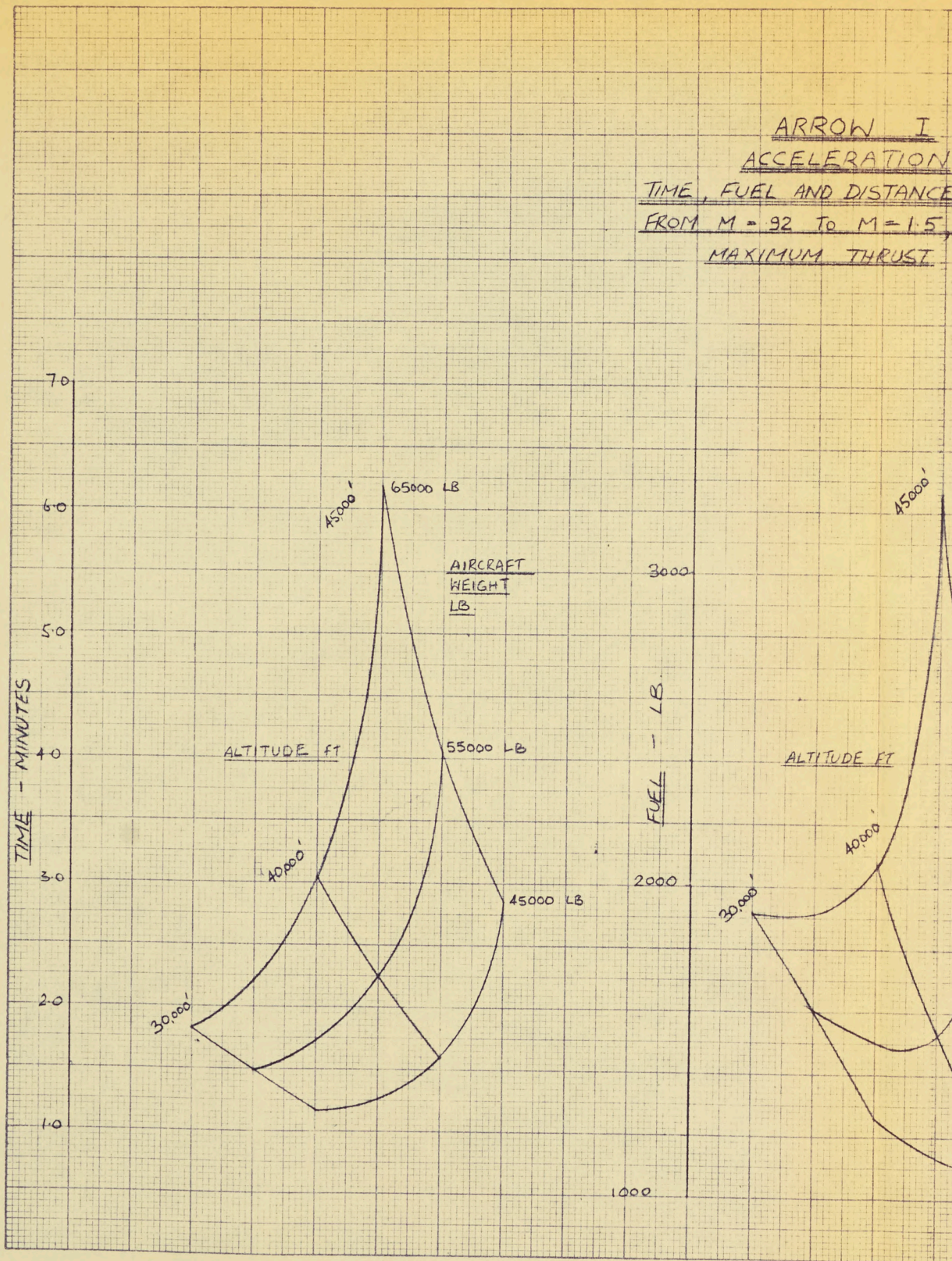
I
TO HEIGHT
Y, MAXIMUM THRUST



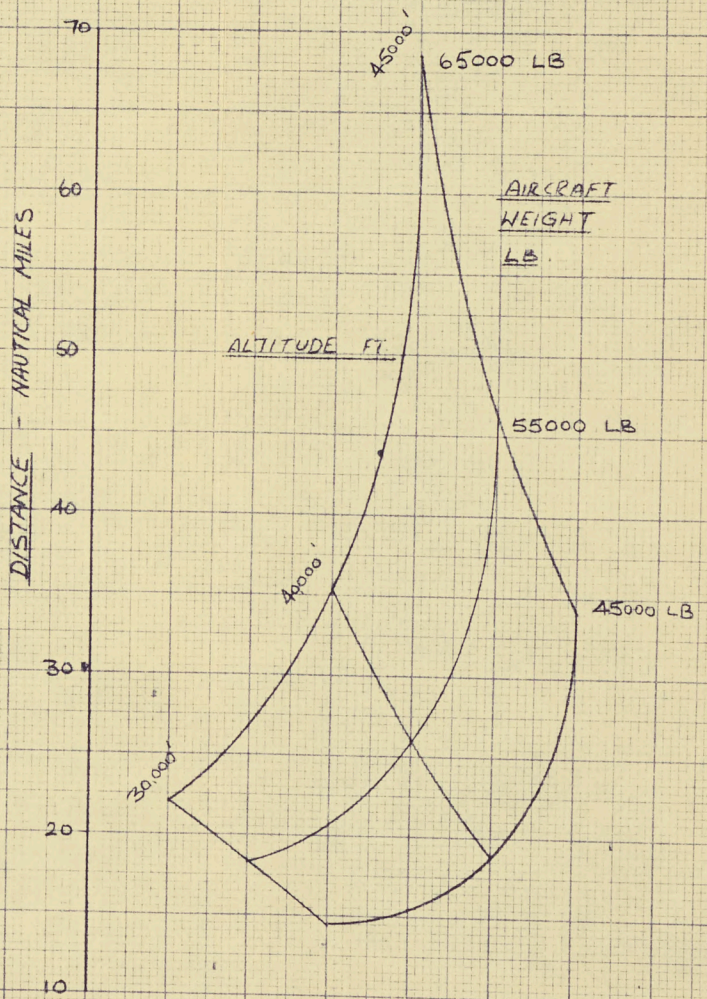
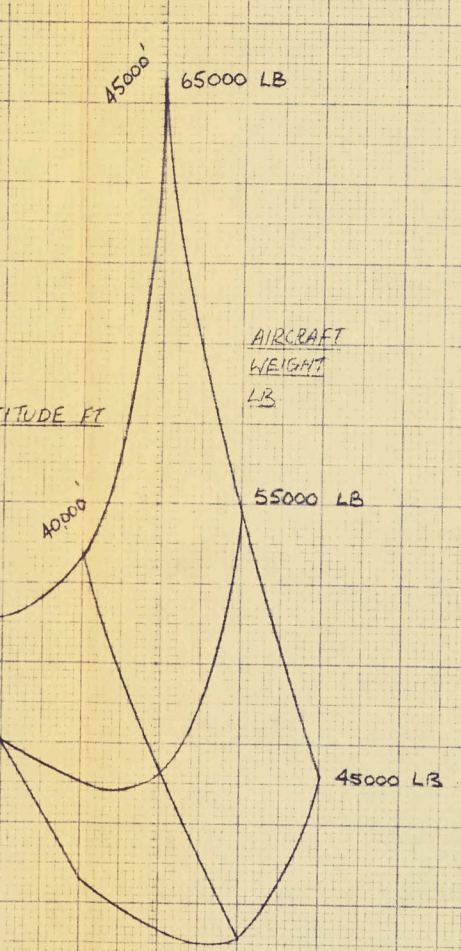
40 DISTANCE — 50 (NAUTICAL MILES) 60

70
P.H. NOV 57

ARROW I
ACCELERATION
TIME, FUEL AND DISTANCE
FROM M = .92 TO M = 1.5
MAXIMUM THRUST



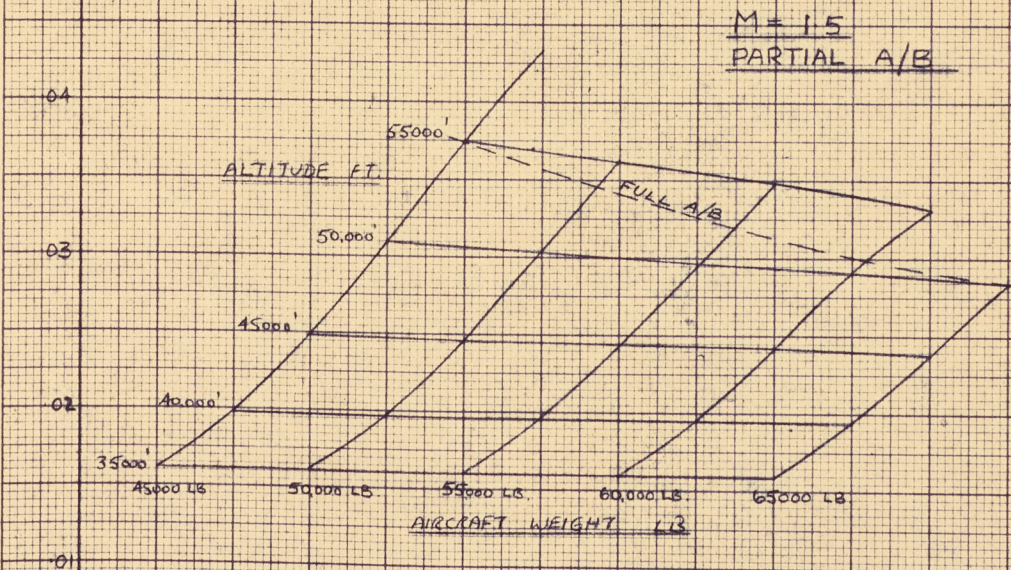
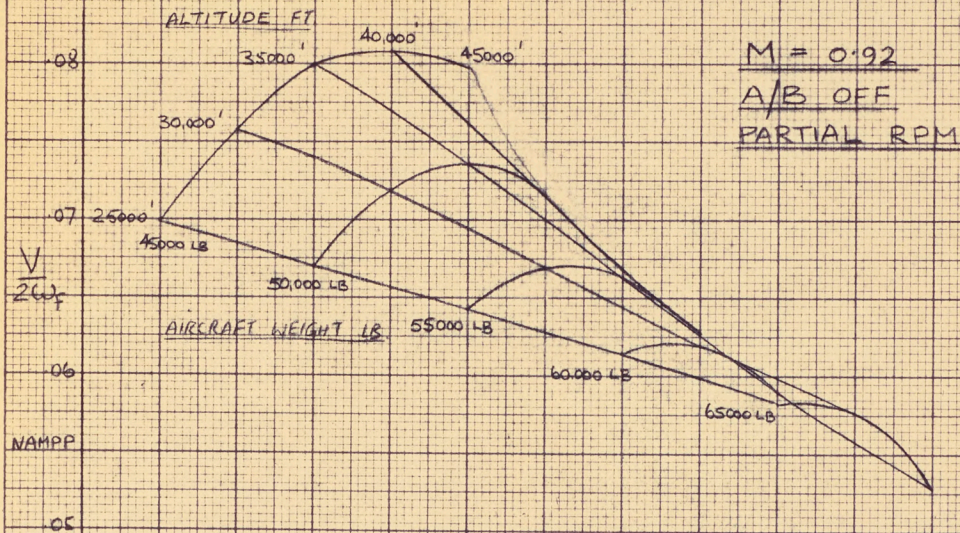
ROW I
ACCELERATION
AND DISTANCE TO ACCELERATE
TO M=1.5, A/B ON
MAX THRUST



71/PERE/3

ARROW I
CRUISE NAMPP

NOTE: 4° UP AILERON USED ABOVE 45000'



P.H. OCTOBER 57

G9-12
10 X 10 TO THE 1/2 INCH
MADE IN CANADA

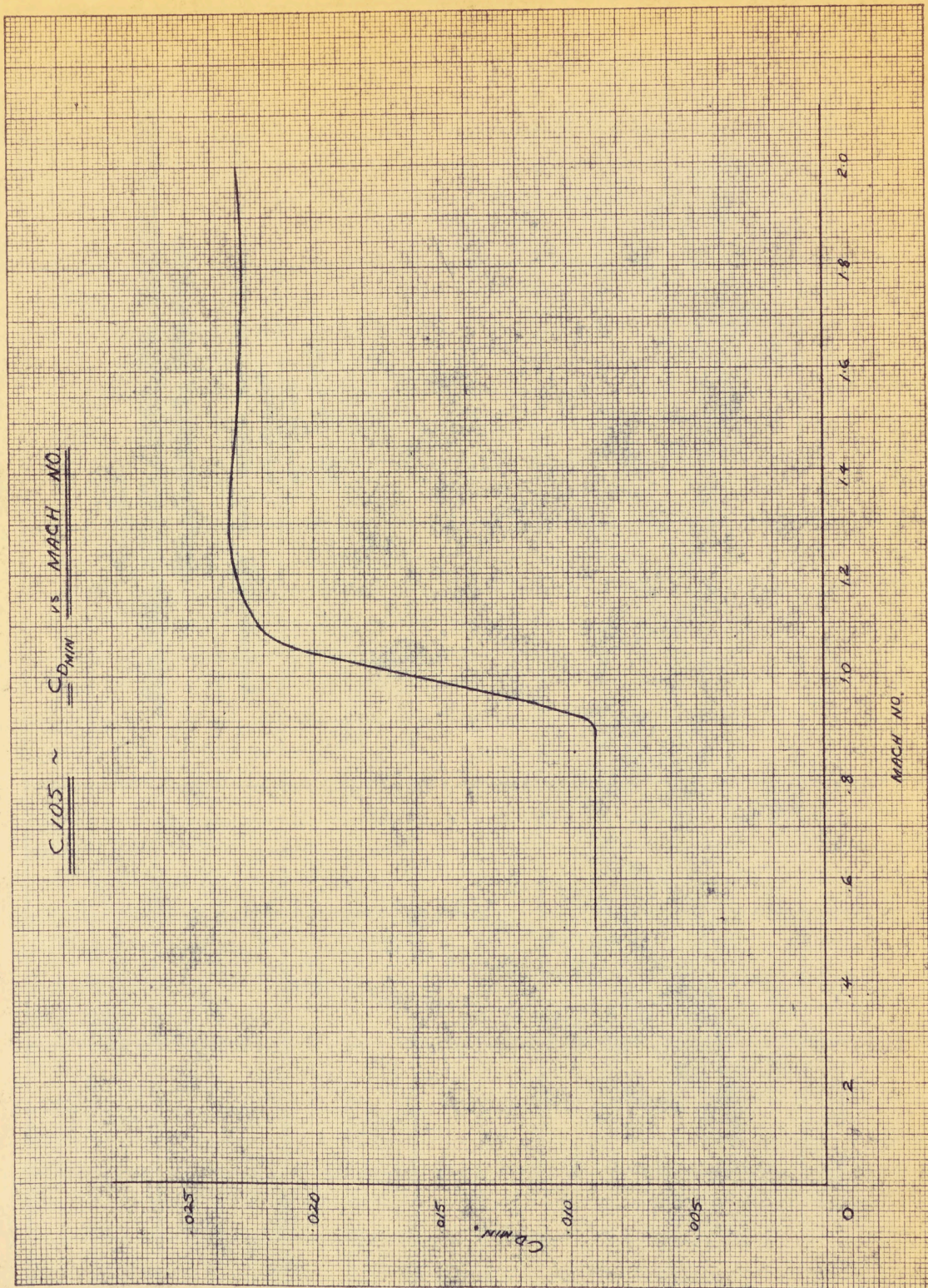
DRAG

2 : ARROW DRAG DATA

No drag revision has been made since periodic performance report No. 9. For the user's convenience this data has been reproduced in this report.

K&E
10 X 10 TO THE CM. 359-14
NEUFFEL & ESSER CO. MADE IN U.S.A.

P/AERO DATA/74



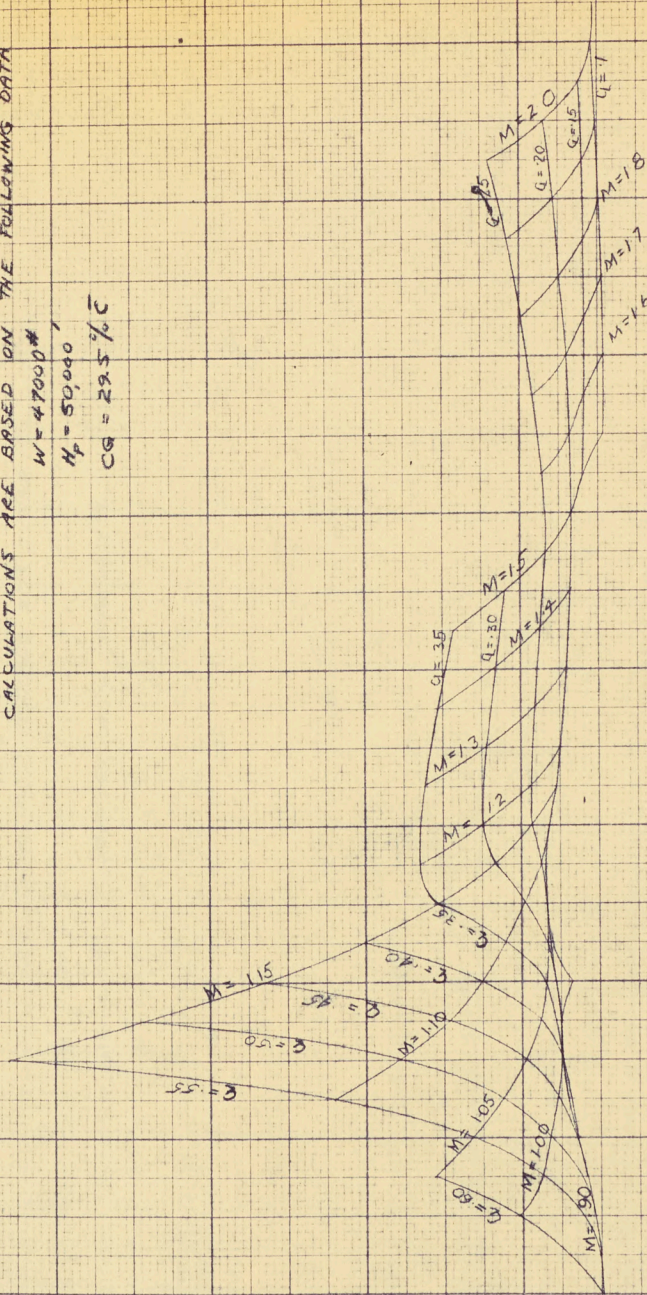
C-105
Δ δ_e TRIM DUE TO POWER AND ELASTIC EFFECTS
AND -4° AILERON DEFLECTION

CALCULATIONS ARE BASED ON THE FOLLOWING DATA

$W = 47000 \#$
 $H_f = 50,000$
 $CG = 29.5 \% \bar{C}$

Δ δ_e TRIM

8
7
6
5
4
3
2
1
0

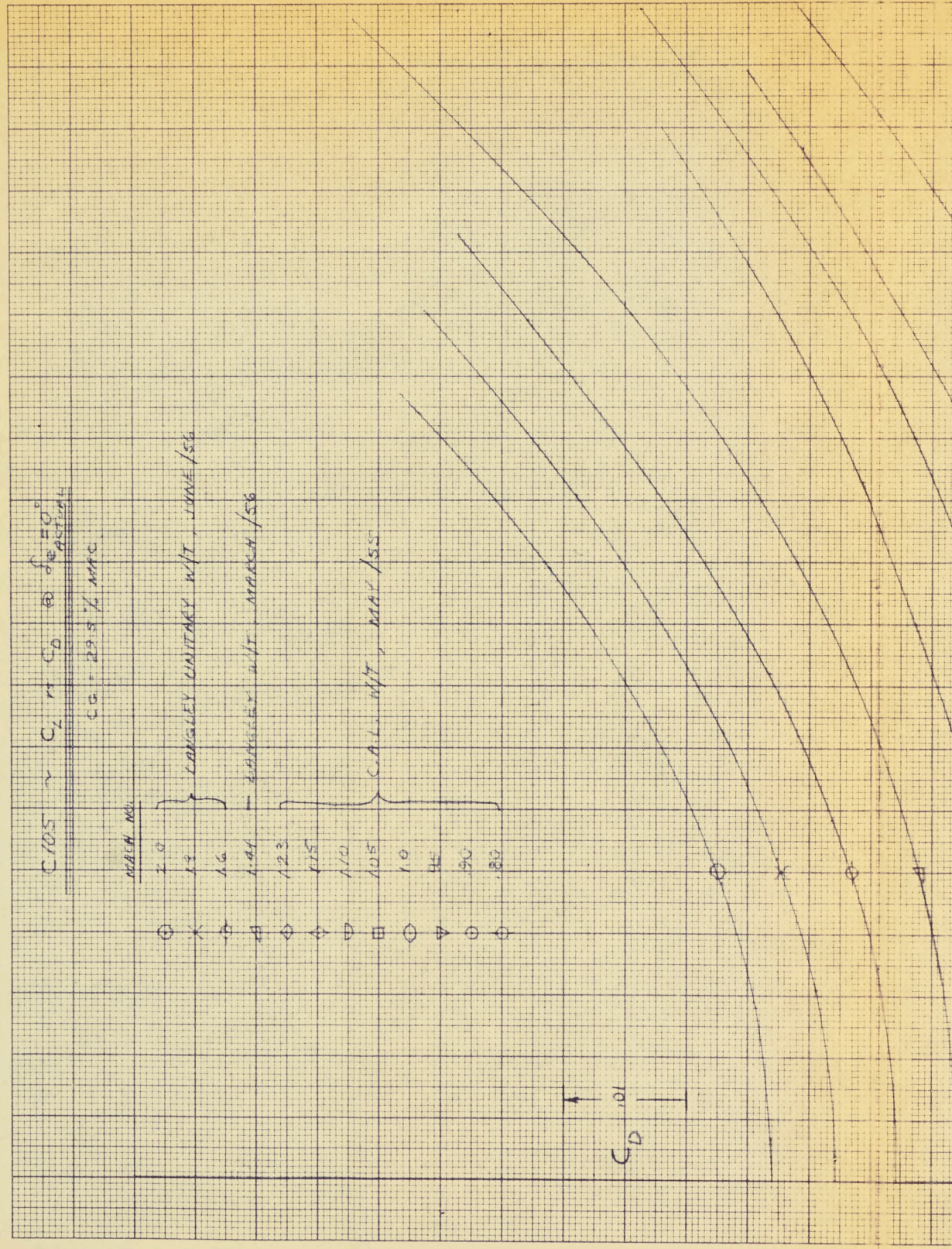


$C_L \sim C_D$ $\int_{0.05}^{0.10} \frac{dC_D}{C_D}$
 ACTUAL
 $C_D = 29.5\% \text{ MAC}$

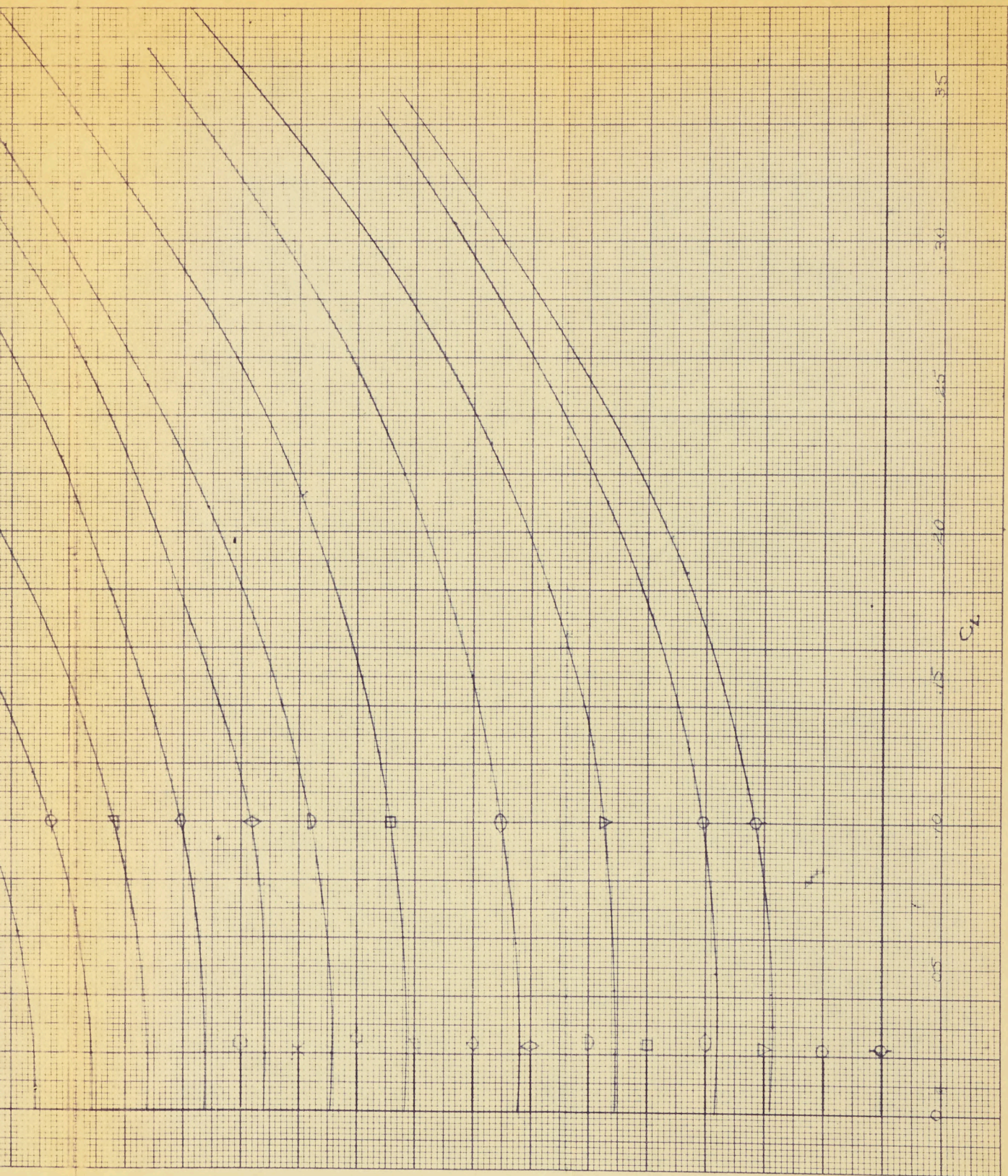
MARCH 1956 }
 1.0 } CONLEY UNITARY W/T, JUNE /56
 1.5 }
 1.6 }
 1.41 }
 1.23 }
 1.15 }
 1.10 }
 1.05 }
 1.0 }
 .95 }
 .90 }
 .80 }

APRIL /56 }
 C.A.L. W/T, MAY /55

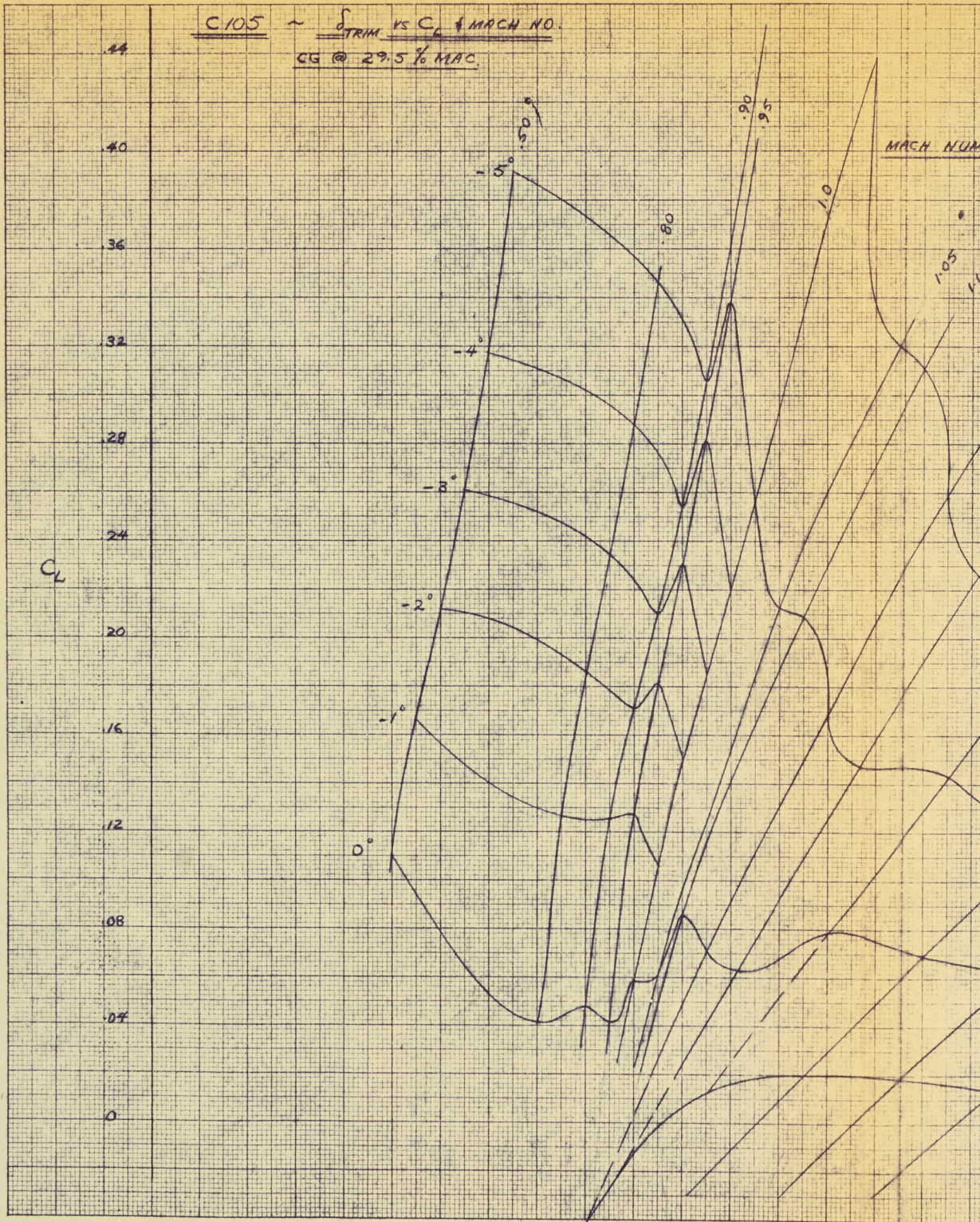
C_D
 1.01



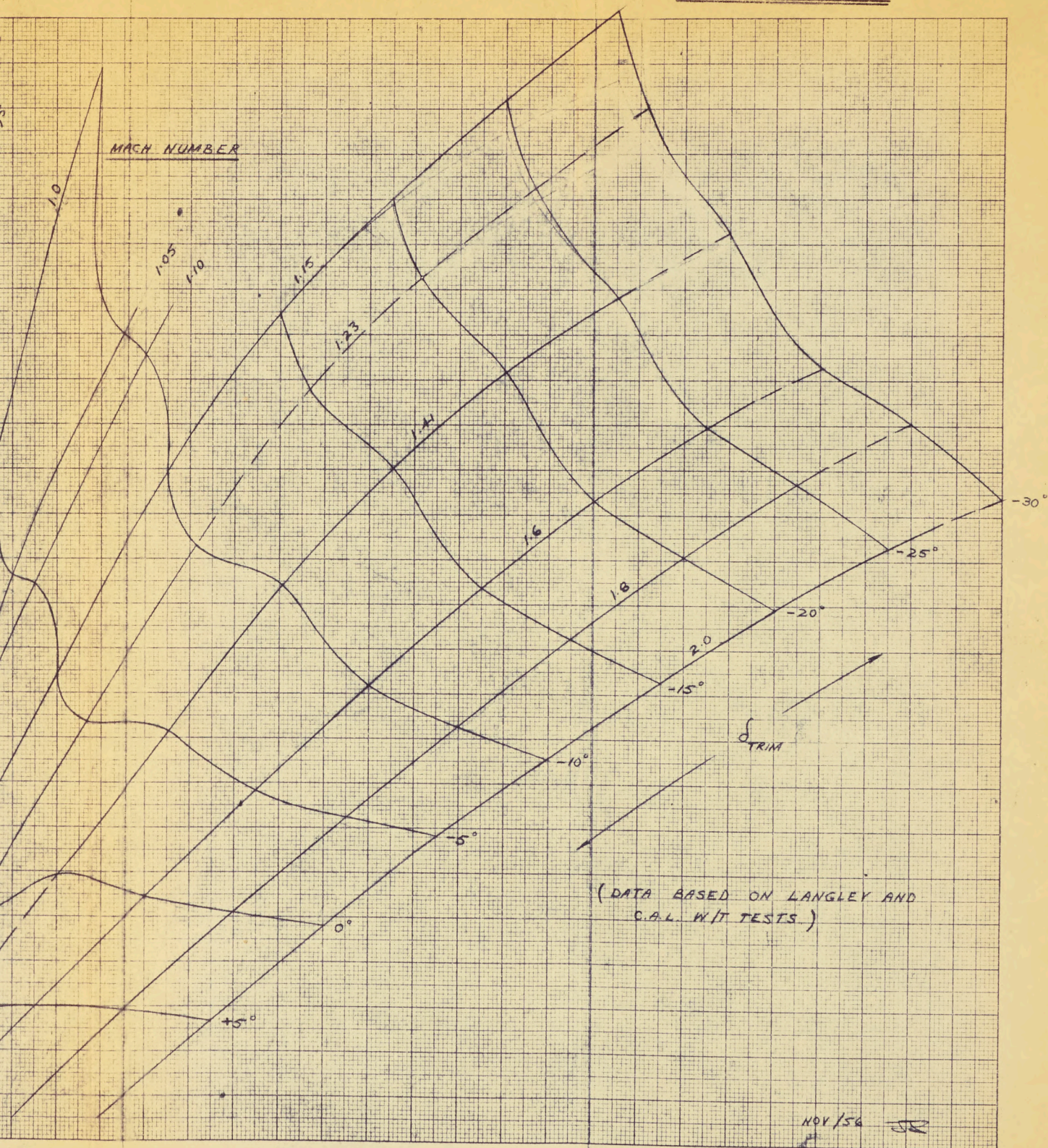
P/NER DATA 174

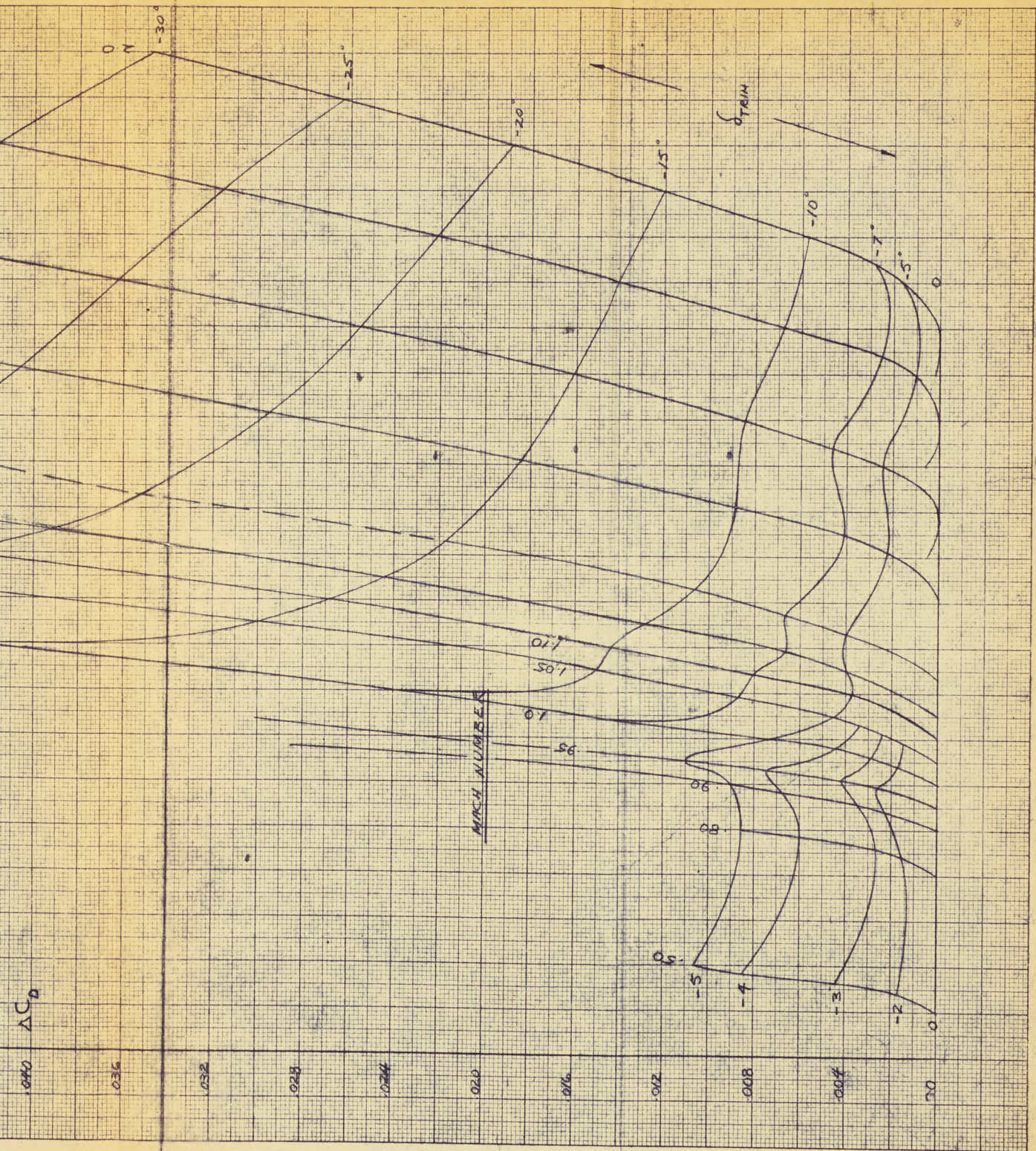


K&L
10 X 10 TO THE CM.
KRUEFFEL & ESSER CO.
MADE IN U.S.A.

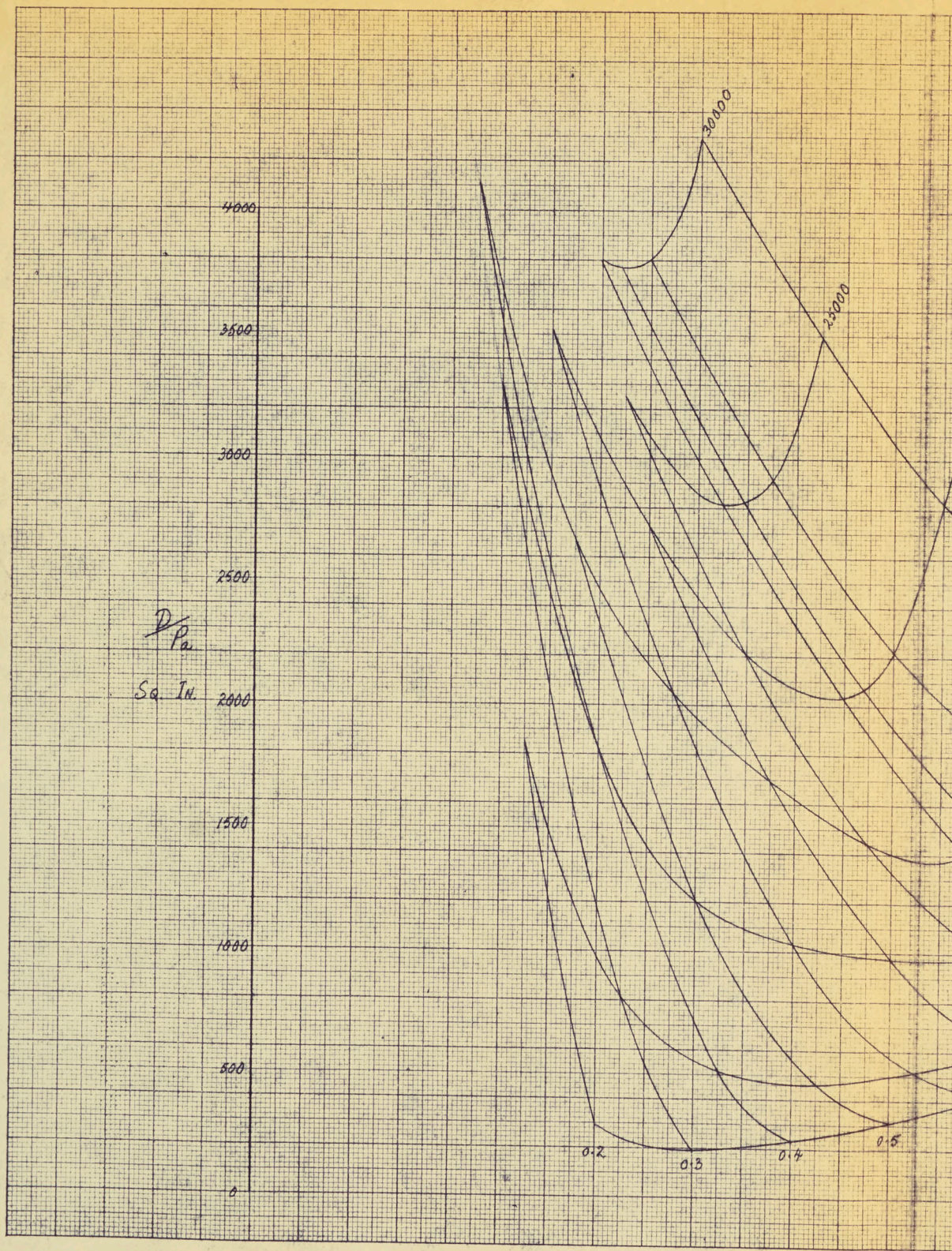


PIAERO DATA 174



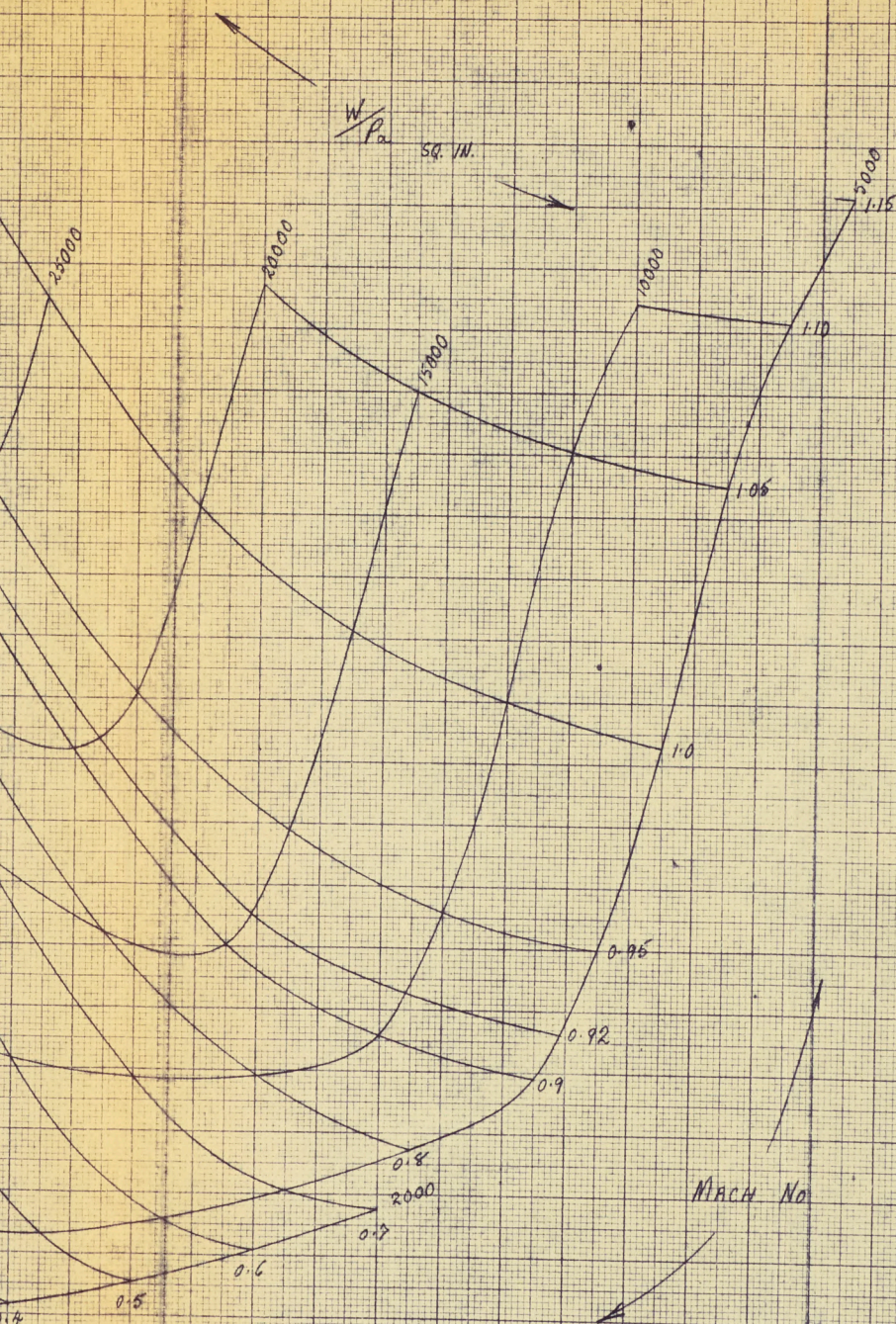


10 X 10 TO THE CM.
KEUFFEL & ESSER CO.
MADE IN U.S.A.



Oct. 1956

CF105 $\frac{D}{P_a} \sim \frac{W}{P_a} & M$

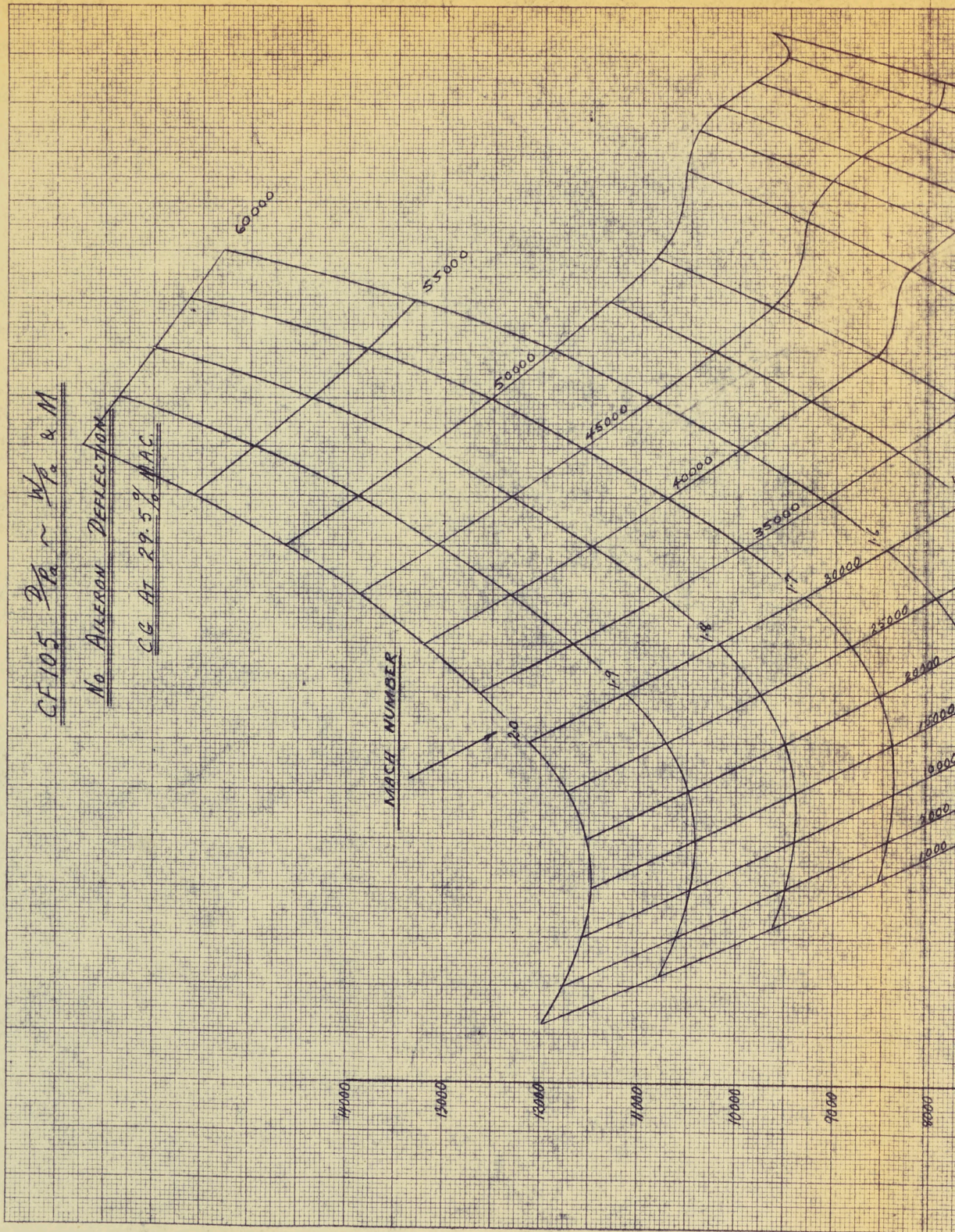


K&E 10 X TO THE CM. 359-14L
KEUFFEL & ESSER CO. MADE IN U.S.A.

CF105 $P_{1/2} \sim W_{1/2} & M$

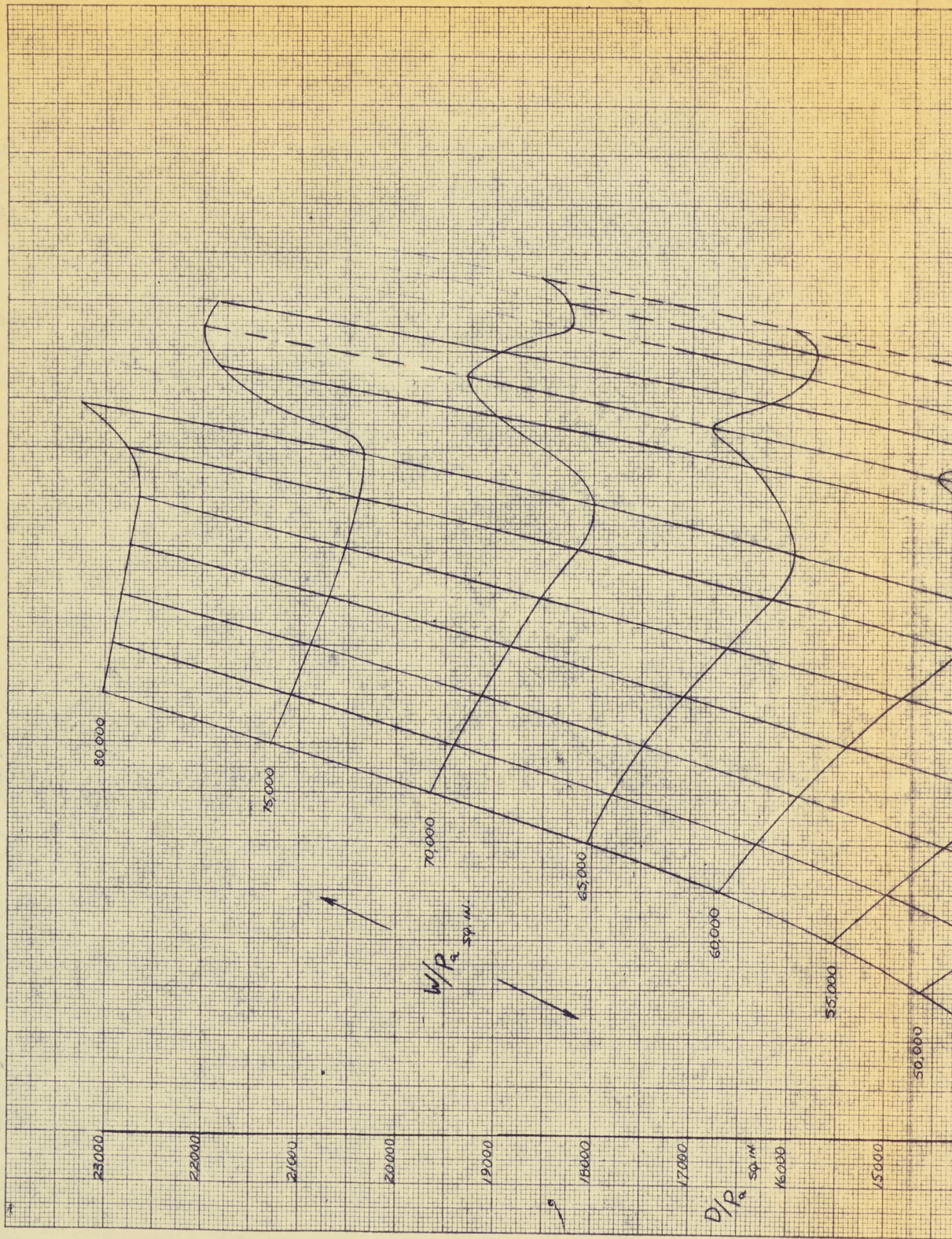
NO AILERON DEFLECTION

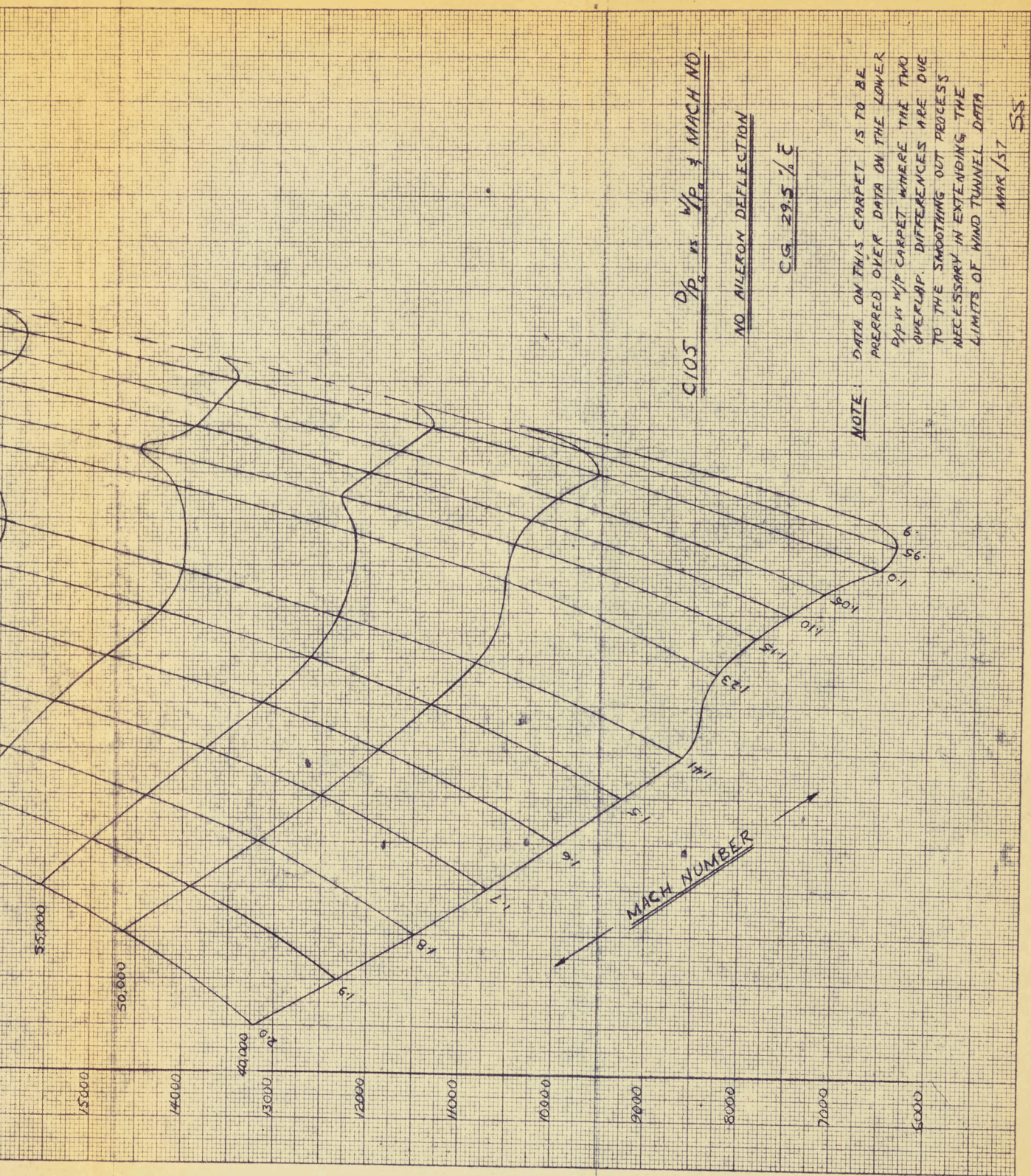
CG AT 29.5% MAC



Nov 1956

K&E 10 X 10 TO THE CM. 359-14L
KEUFFEL & ESSER CO. MADE IN U.S.A.





C105 q/p_0 vs. W/P_0 & MACH NO.

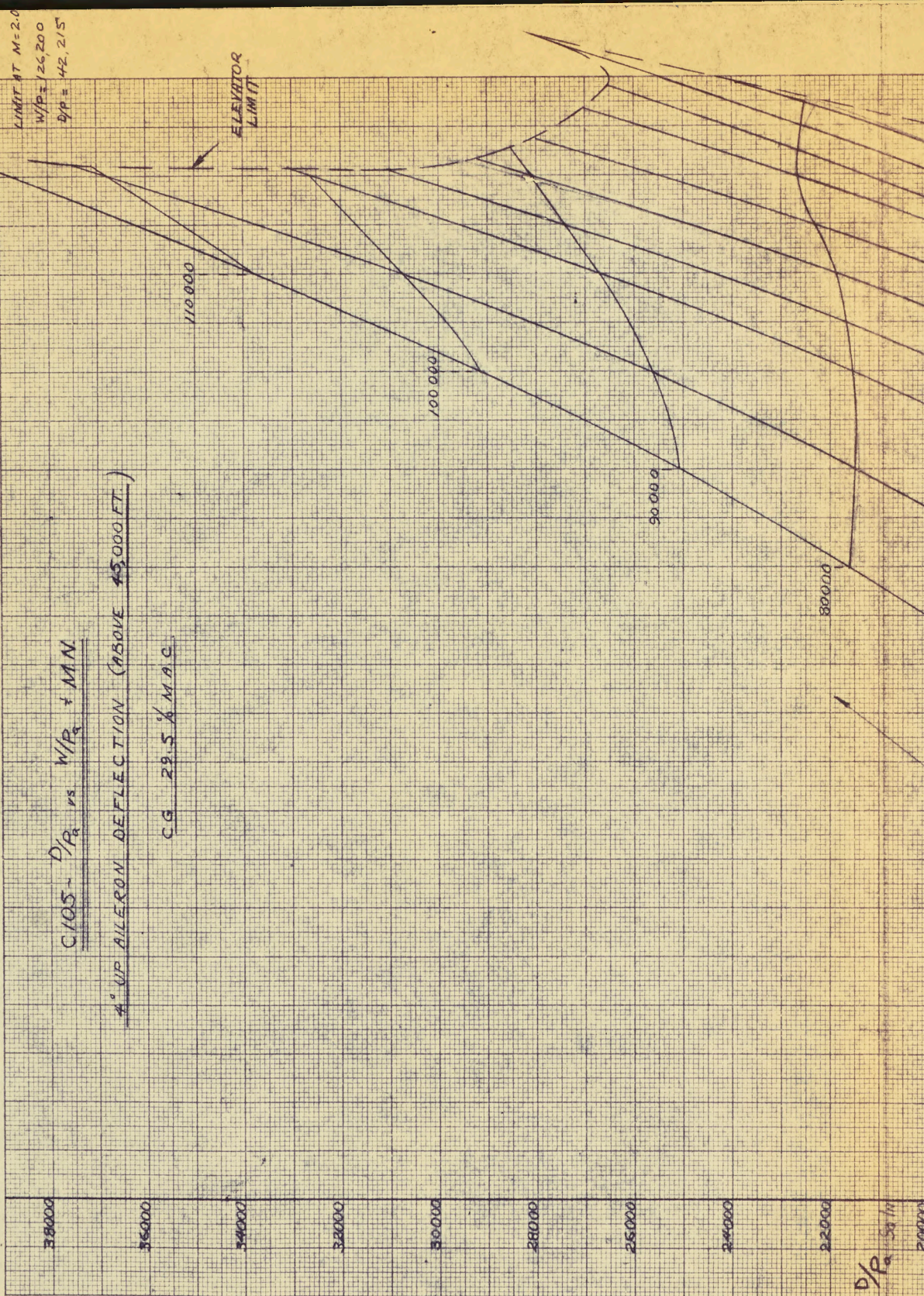
NO ALLERON DEFLECTION

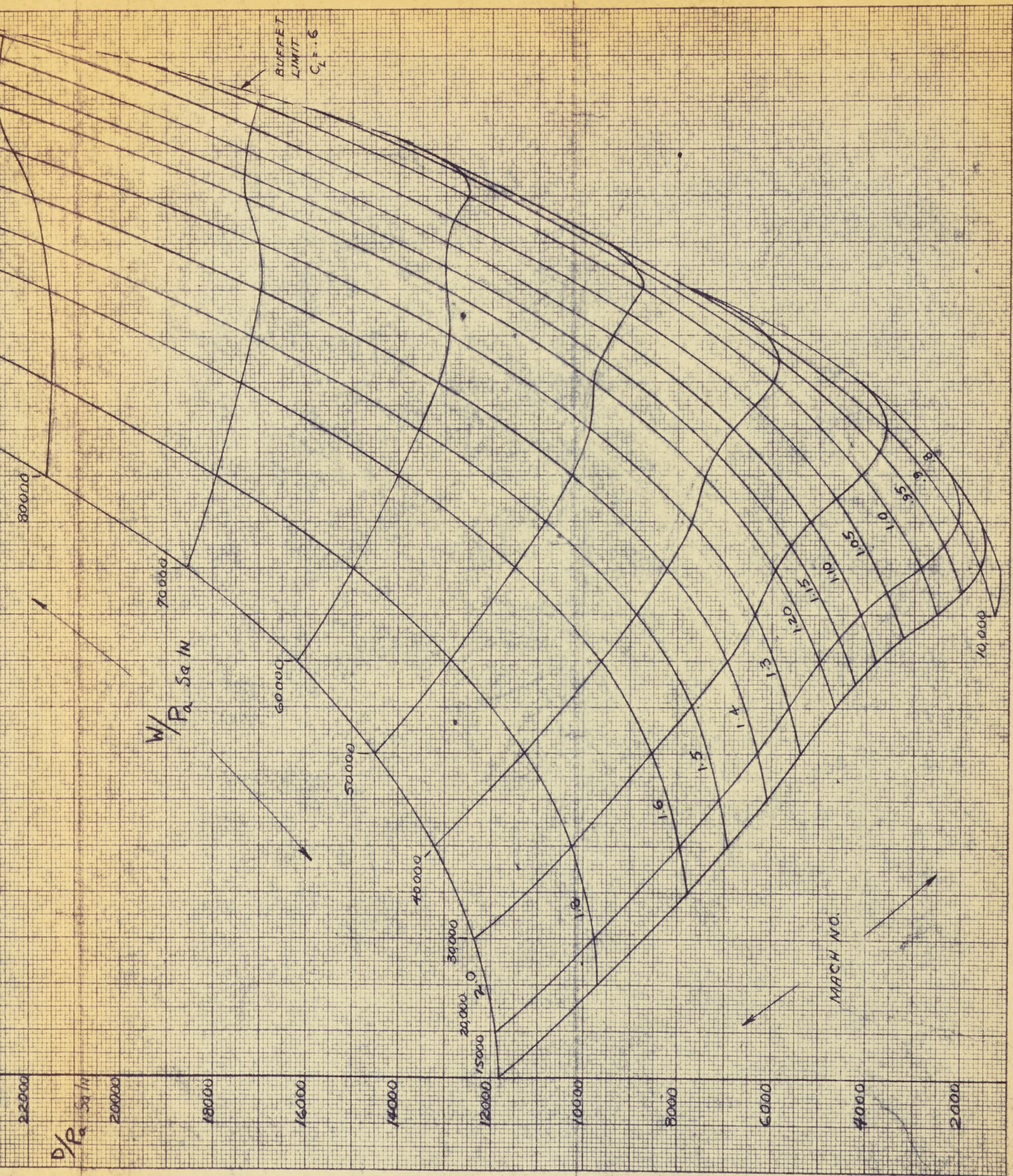
CS 29.5 $\frac{1}{2}$ E

NOTE: DATA ON THIS CARPET IS TO BE
 PREFERRED OVER DATA ON THE LOWER
 q/p_0 vs W/P_0 CARPET WHERE THE TWO
 OVERLAP. DIFFERENCES ARE DUE
 TO THE SMOOTHING OUT PROCESS
 NECESSARY IN EXTENDING THE
 LIMITS OF WIND TUNNEL DATA

MAR/57 SS

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





BUFFET
LIMIT
 $C_L = 0.6$

$W/P_a S_a W$

MACH NO.

$D/P_a S_a W$

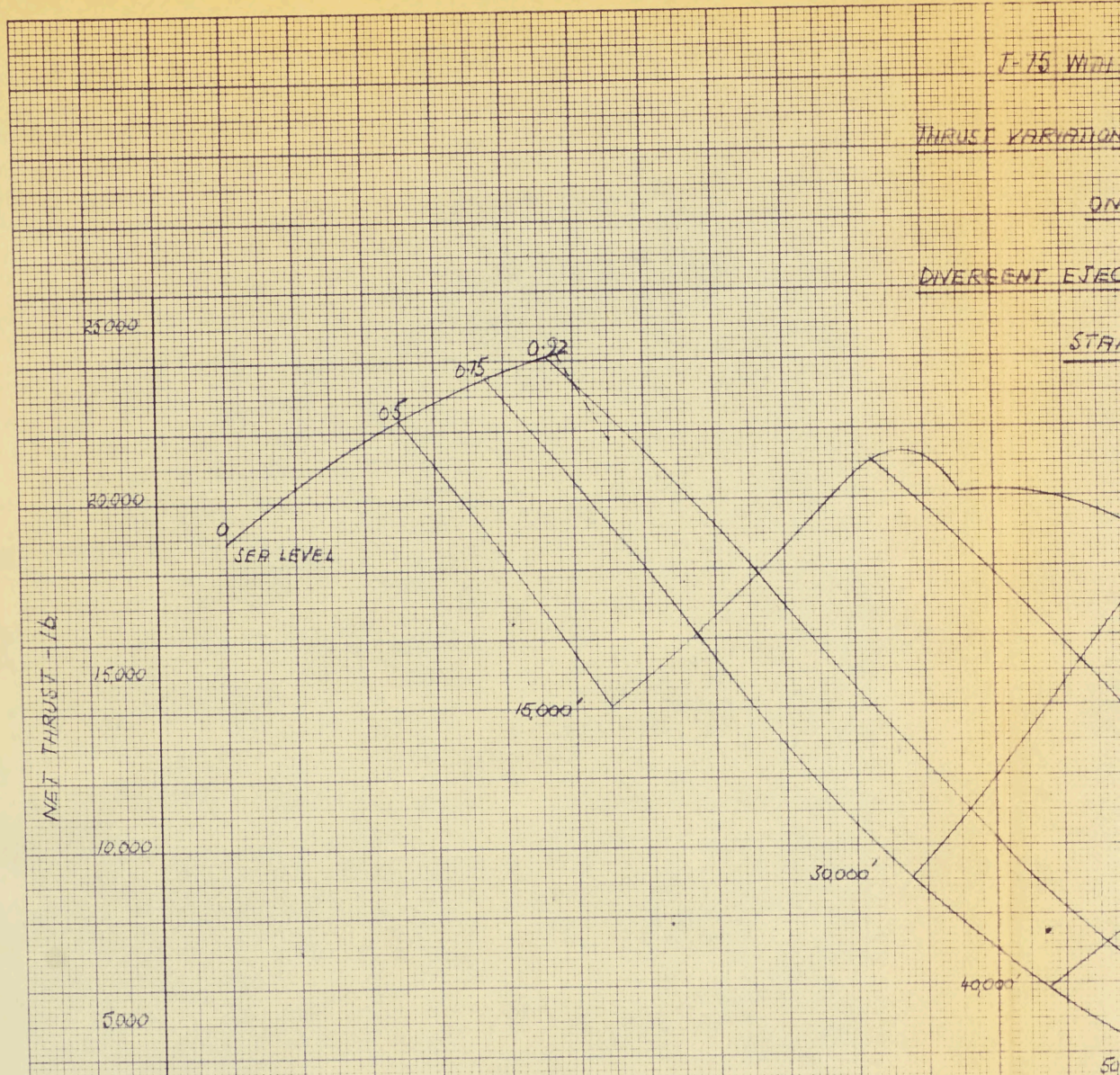
PROVISION

3 : ARROW 1 PROPULSION DATA

The installed J 75 engine data has been revised. Essentially the change is to a 45" divergent ejector instead of a 39" cylindrical ejector.

This revised estimate utilizes experimental ejector pumping and thrust characteristics from Nobel, with the exception of afterburner unit thrust characteristics which have been obtained from N.A.C.A. experimental data, as the Nobel showed too much scatter to correlate. The geometry of the tests differs slightly from the actual installation particularly in the afterburner unit cases

This leads to some doubt as to whether the discharge flow is attached or unattached, notably at $M = .92$ at 40,000 ft. In the present estimate the more conservative value obtained with attached flow has been used.



NOTE - THIS THRUST INCLUDES ALLOWANCES FOR -

1. CONSTANT ENGINE AIRSPEED OF 138 1/2/SEC
2. POWER EXTRACTION OF SOHP FROM HIGH PRESSURE RO
3. POWER EXTRACTION OF SRHP FROM LOW PRESSURE RO

SEPT/57

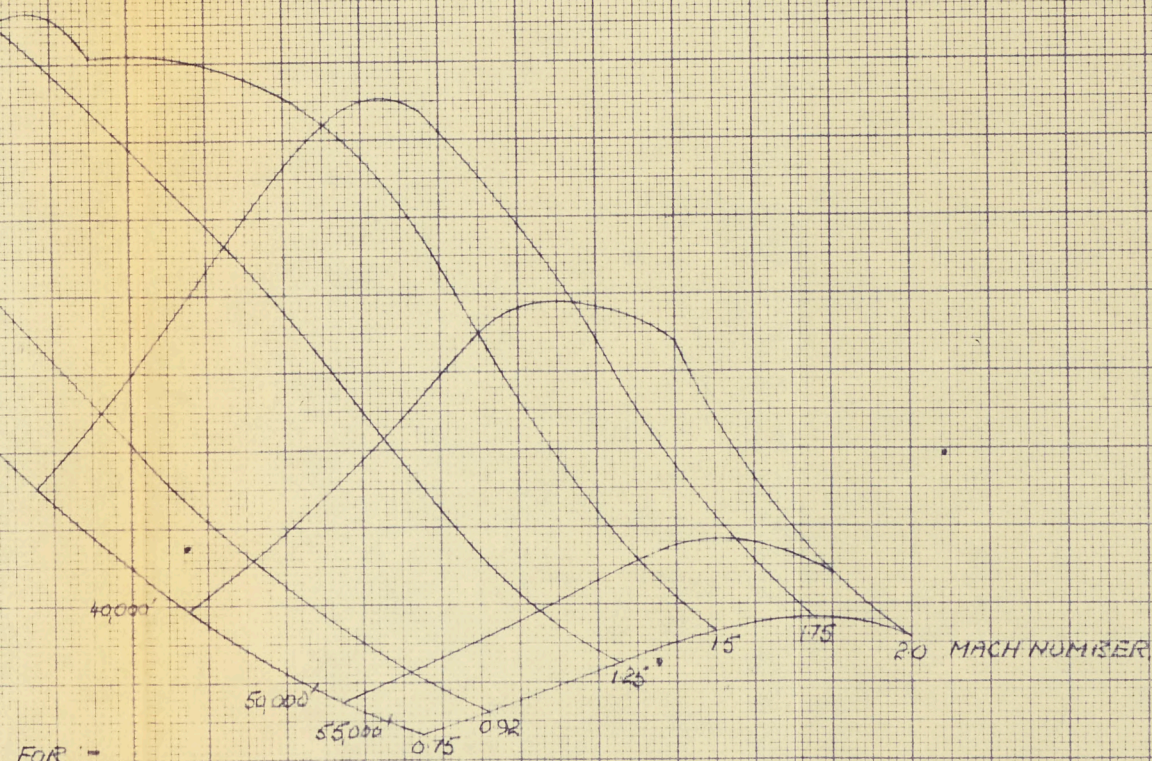
F-15 WITH FULL AFTER BURNER MAX THRUST

THRUST VARIATION WITH MACH NUMBER AND ALTITUDE

ONE ENGINE

DIVERGENT EJECTOR WHERE $D_e/D_f = 34.2$ AND $D_e/D_f = 13.12$

STANDARD DAY



3 10/SEC

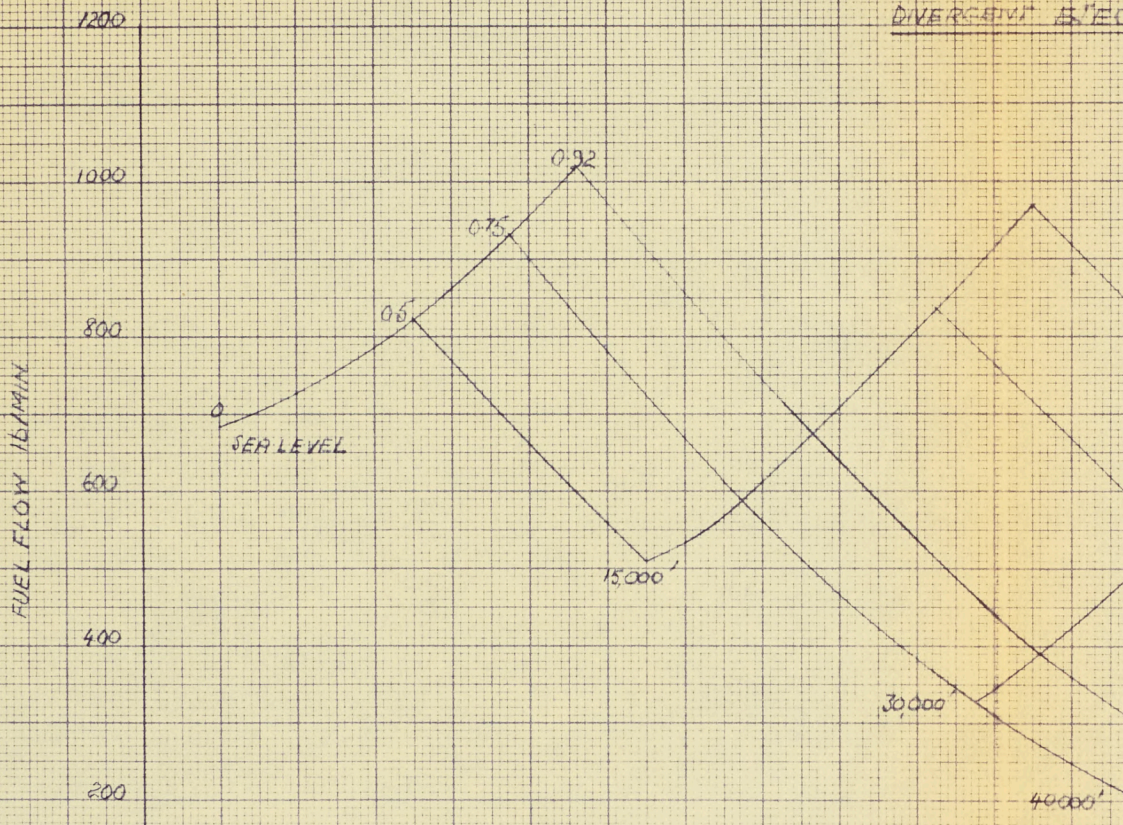
HIGH PRESSURE ROTOR FOR HYDRAULIC SERVICES

LOW PRESSURE ROTOR FOR ELECTRICAL SERVICES

F-76 WII

FUEL FLOW VARIATION

DIVERGENT B/E/C



NOTE - THIS FUEL FLOW INCLUDES ALLOWANCES FOR -

- 1 CONSTANT ENGINE AIR BLEED OF 133 LB/SEC
- 2 POWER EXTRACTION OF 50 HP FROM HIGH PRESS
- 3 POWER EXTRACTION OF 32 HP FROM LOW PRESS

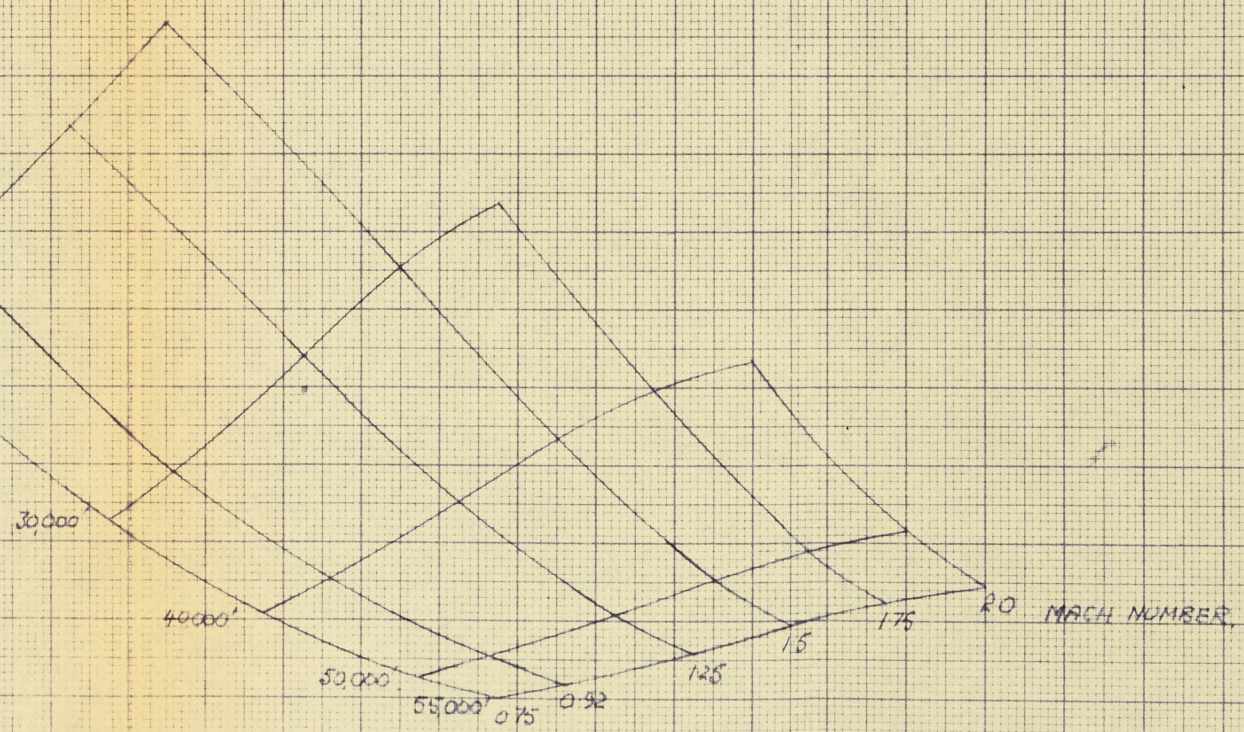
F-75 WITH FULL AFTERBURNER MAX THRUST

MASS FLOW VARIATION WITH MACH NUMBER AND ALTITUDE

ONE ENGINE

DIVERGENT SECTION WHERE $D_2 = 34.2"$ AND $A_2/A_1 = 1.512$

STANDARD DAY



QUANTITIES FOR -

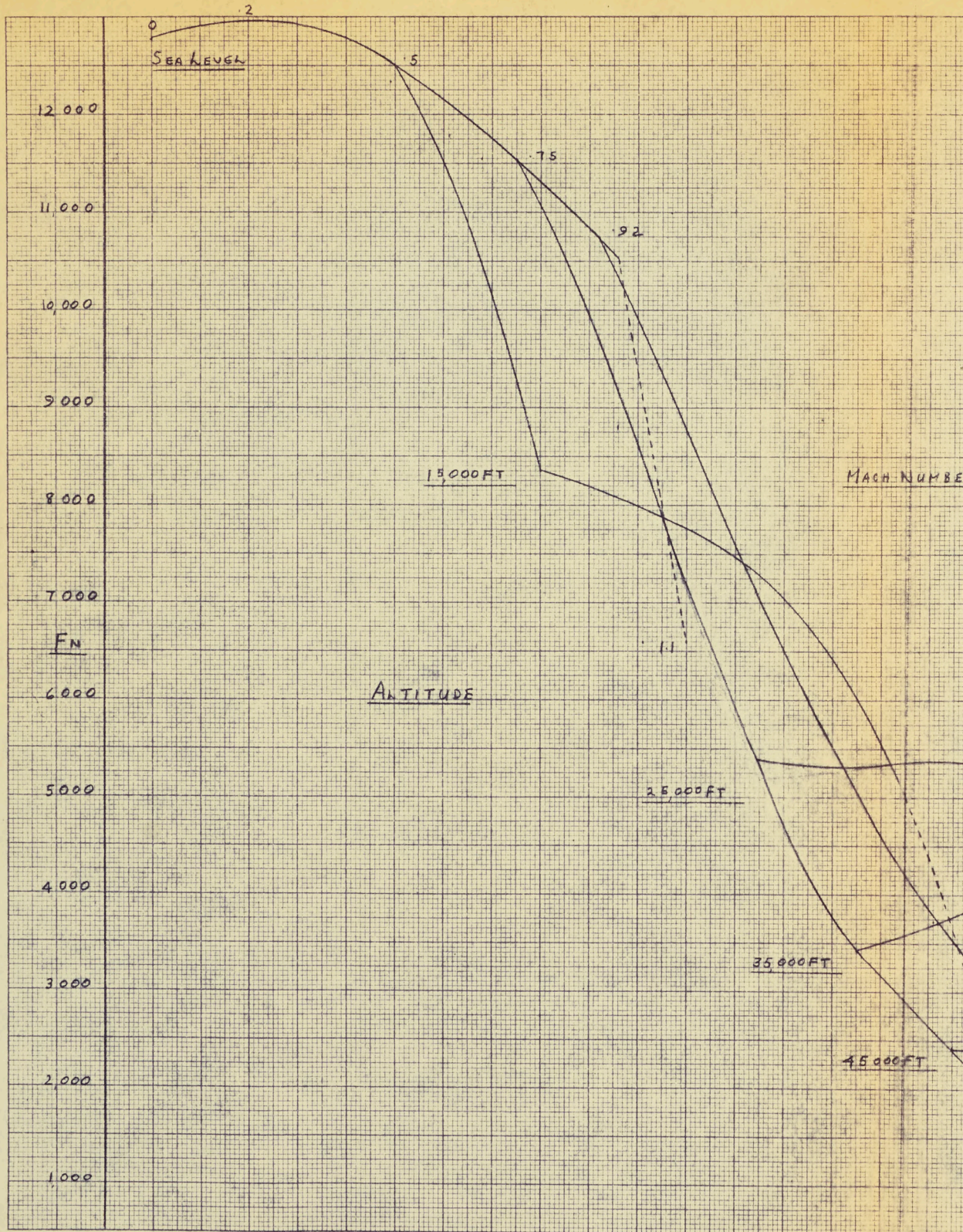
D OF 188 lb/SEC

P FROM HIGH PRESSURE ROTOR FOR HYDRAULIC SERVICES

P FROM LOW PRESSURE ROTOR FOR ELECTRICAL SERVICES,

359-14L
MADE IN U.S.A.

10 X 10 TO THE CM.
KEUFFEL & ESSER CO.

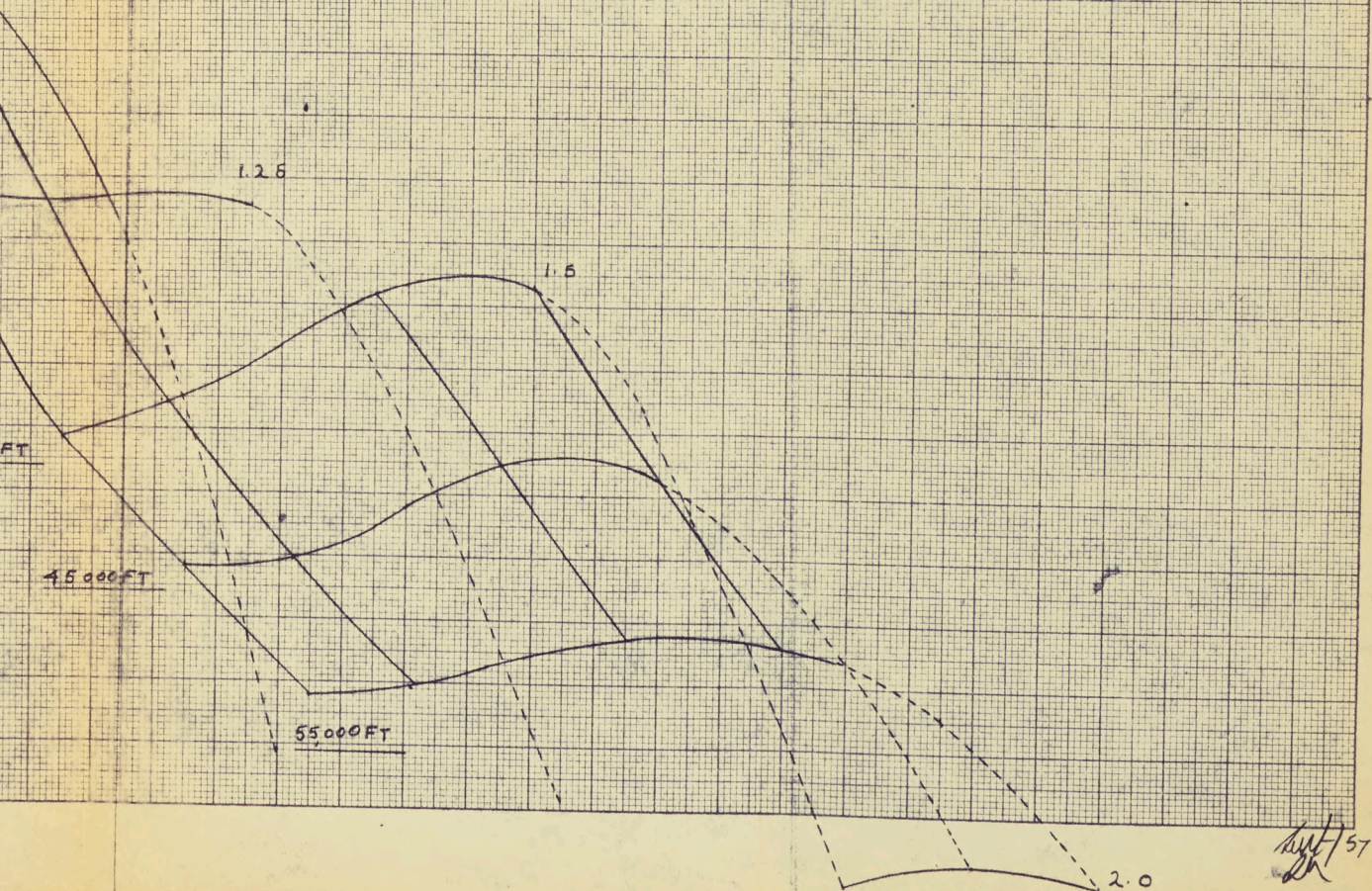


J 75 WITHOUT AFTERBURNER MILITARY THRUST

THRUST VARIATION WITH MACH NUMBER AND ALTITUDEONE ENGINEDIVERGENT EJECTOR WHERE $D_e = 25.6''$ AND $D_e/D_p = 1.756$ STANDARD DAYNOTE:- THIS THRUST INCLUDES ALLOWANCE FOR

- (1) CONSTANT ENGINE AIR BLEED OF 1.33 LB/SEC
- (2) POWER EXTRACTION OF 50 H.P. FROM HIGH PRESSURE ROTOR FOR HYDRAULIC SERVICES
- (3) POWER EXTRACTION OF 32 H.P. FROM LOW PRESSURE ROTOR FOR ELECTRICAL SERVICES

MACH NUMBER



JT5 WITHOUT AFTERBURNER MILITARY THRUST

FUEL FLOW VARIATION WITH MACH NUMBER AND ALTITUDE

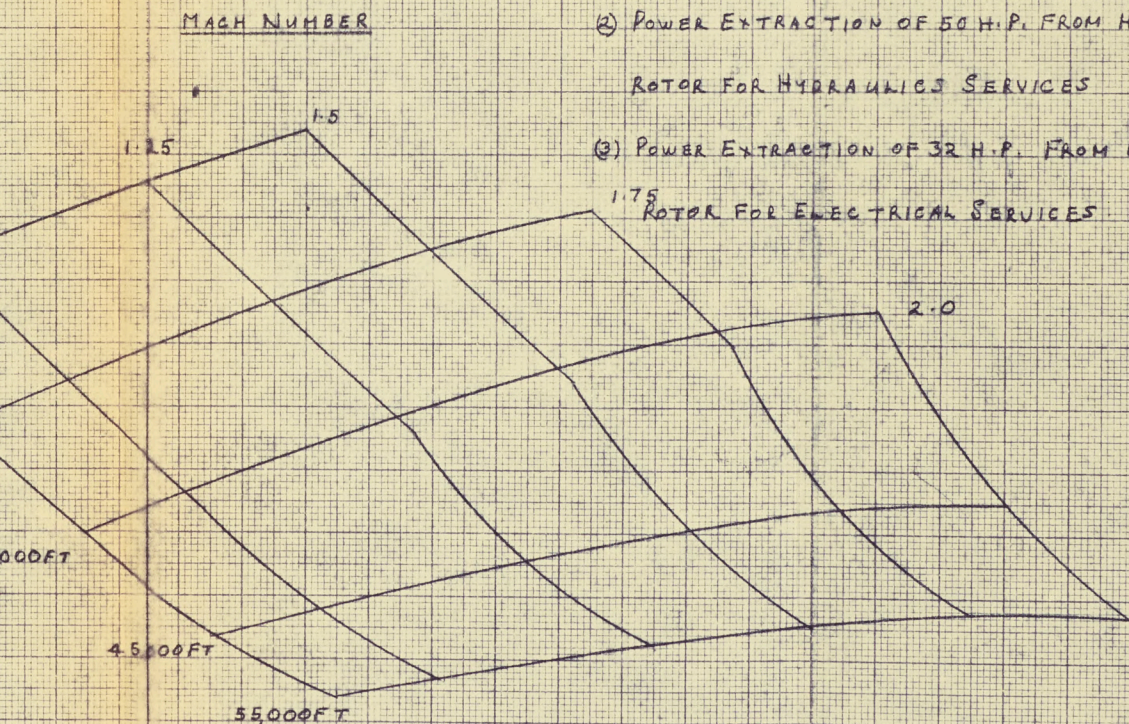
ONE ENGINE

DIVERGENT EJECTOR WHERE $DP = 25.6''$ AND $D_2/D_1 = 1.756$

STANDARD DAY

NOTE:- THIS FUEL FLOW INCLUDES ALLOWANCES FOR:-

- (1) CONSTANT AIR BLEED OF 1.39 LB/SEC
- (2) POWER EXTRACTION OF 50 H.P. FROM HIGH PRESSURE ROTOR FOR HYDRAULICS SERVICES
- (3) POWER EXTRACTION OF 32 H.P. FROM LOW PRESSURE ROTOR FOR ELECTRICAL SERVICES



2/16/57
JW

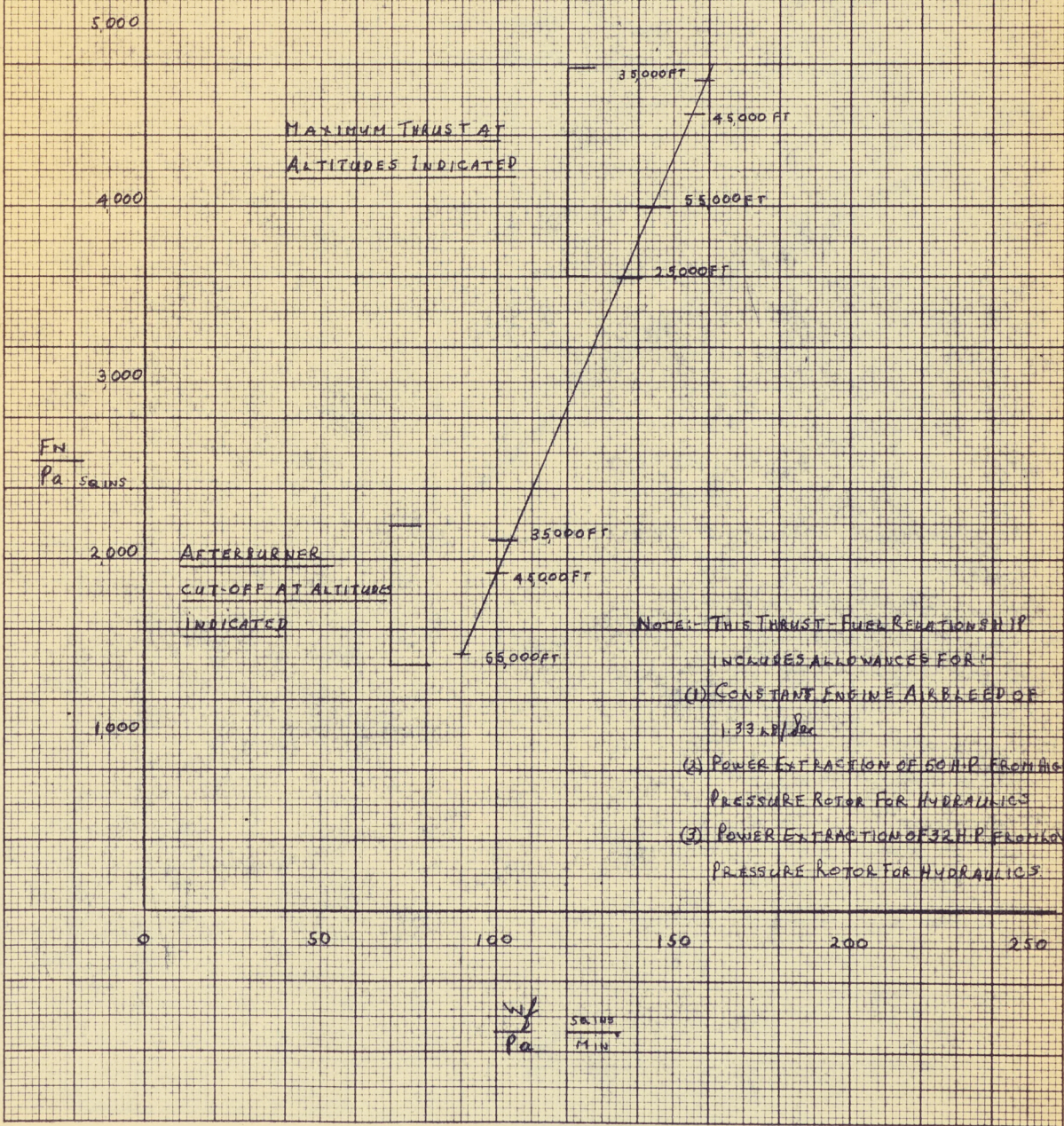
71/POWER/1

J 75 INSTALLED THRUST V. FUEL FLOW

PARTIAL RPM AFTERBURNER 1.97

MACH NUMBER 1.5

STANDARD DAY AT ALTITUDES 25,000FT - 55,000FT



MAXIMUM THRUST AT ALTITUDES INDICATED

AFTERBURNER CUT-OFF AT ALTITUDES INDICATED

NOTE: THIS THRUST-FUEL RELATIONSHIP INCLUDES ALLOWANCES FOR
 (1) CONSTANT ENGINE AIR BLEED OF 1.33 LB/SEC
 (2) POWER EXTRACTION OF 50 HP FROM HIGH PRESSURE ROTOR FOR HYDRAULICS
 (3) POWER EXTRACTION OF 32 HP FROM LOW PRESSURE ROTOR FOR HYDRAULICS

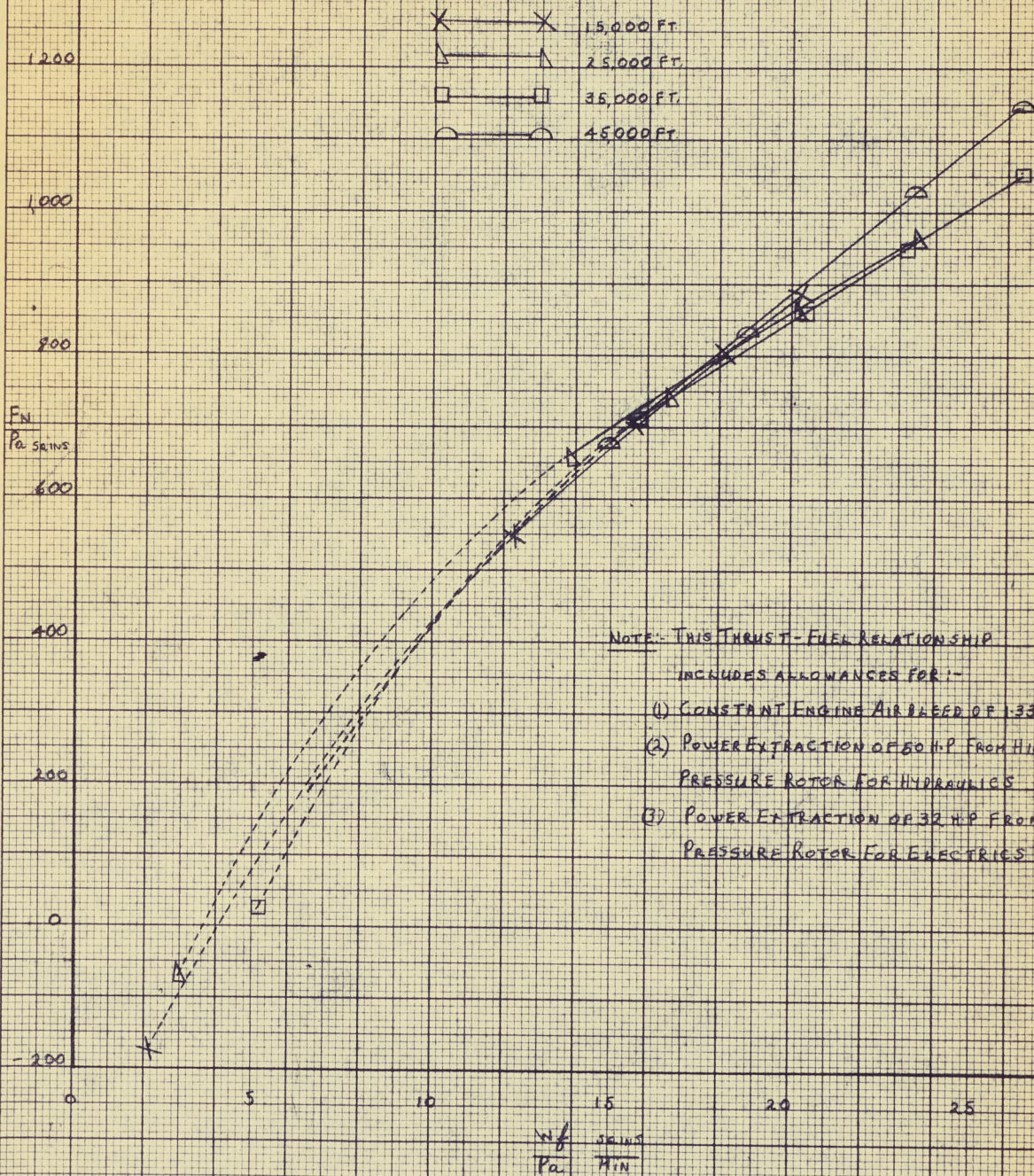
G9-12
 10 X 10 TO THE 1/2 INCH
 MADE IN CANADA

Oct/57

J75 INSTALLED THRUST V FUEL FLOW

PARTIAL RPM AFTERBURNER UNLIT

MACH NUMBER .92



NOTE: THIS THRUST-FUEL RELATIONSHIP INCLUDES ALLOWANCES FOR:-

- (1) CONSTANT ENGINE AIR BLEED OF 1.33 LBS/HR
- (2) POWER EXTRACTION OF 80 H.P FROM HIGH PRESSURE ROTOR FOR HYDRAULICS
- (3) POWER EXTRACTION OF 32 H.P FROM LOW PRESSURE ROTOR FOR ELECTRICS

G9-12
10 X 10 TO THE 1/2 INCH
MADE IN CANADA

out/52

BUO-TANG
3558
MADE IN U.S.A.