QC
Avro
C-105
MPR
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QCX
Avro
CF105
MR-3

FILE IN VAULT

CF-105

ANALYZED

MONTHLY PERFORMANCE REPORT

NO. 3

December '55

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A. V. ROE CANADA LIMITED
MALTON · ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

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AIRCRAFT: CF-105

REPORT NO. Monthly Report No.

FILE NO.

NO. OF SHEETS:

TITLE:

ANALYZED

PERFORMANCE

DRAG

ENGINE

CF-105 MONTHLY PERFORMANCE REPORT

(Issued Mid-Monthly)

National Research Council
MAR 14 1957
Aeronautical Library

This is Copy Number 7

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INTRODUCTION

This is the third of a series of monthly performance reports for internal usage, to be issued from the Aerodynamics Department. Only a minor change has occurred since the second report, and applies only to the CF-105 Performance with Pratt & Whitney JT 4A-25 (J 75) Engines. This alteration is due to a reduction in the ejector performance estimate for the JT 4A-25; and to an increase in spillage drag. The pertinent changes are noted in their appropriate sections.

Successive reports will present the latest data, with the alterations from the previous report noted. The report is divided into three major sections:-

1. CF-105 Performance
2. CF-105 Drag
3. Engine Data

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PERFORMANCE

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1. CF-105 PERFORMANCE

The performance in this issue is sub-divided into two parts:

1A. CF-105 Performance with Pratt and Whittney JT4A-25 Engines

1B. CF-105 Performance with Orenda PS 13 Engines

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1A CF-105 PERFORMANCE WITH PRATT AND WHITNEY (J-75) JT 4A-25 ENGINES

(C.G. = 29% MAC)

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The following CF-105 - (J-75) JT 4A-25 performance estimate is based on the Wind Tunnel configuration designated B_2 V_1 W_1 E_{10} N_5 D_{8-4}. The particular feature of this configuration is the extended, notched, and cambered leading edge of the wing. The drag of this configuration is summarized (extract P/Aero Data/58) and is presented in Section 2 of the CF-105 Monthly Report No. 1 issued October 1955.

The considerations for the installed engine data is summarized (extract P/Power/51) and is presented in Section 3 of the CF-105 Monthly Report No. 1. An error was made in the ejector calculations and was noted in CF-105 Montly Report No. 2. However, a further revision has been made to the thrust with full afterburning, and is given in Section 3 of this report. Only this alteration has been allowed for as changes to fuel consumption, and non-afterburing engine performance would not be significant.

A slight increase in operational weight empty has also been allowed for.

The pertinent CF-105 performance changes are listed below.

Δ Combat 'g' at 1.50 M.N. at 50,000 feet	=	- .08g
Δ Maximum speed at 50,000 feet	=	- 40 kts.
Δ Combat ceiling at 1.5 M.N.	=	- 700 ft.

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December 1955

LOADING AND PERFORMANCE

Performance Under N.A.C.A. Standard Atmospheric Conditions

To R.C.A.F. Specification AIR 7-4

(With 2 J-75 Engines)

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WEIGHT:

Take-Off Weight with 15,356 Lb. Fuel (77.1% Max.)	Lb.	59,228
Operational Weight Empty	Lb.	43,872
Combat Weight (1/2 Fuel)	Lb.	51,550
Landing Weight (With Reserve Fuel + Missiles)	Lb.	44,390
Wing Loading at Normal Take-Off Weight	Lb./Sq.Ft.	47.2
Power Loading at Normal Take-Off Weight	Lb./Lb. Thrust	1.60

SPEED

True Air Speed in Level Flight
At Sea Level at Combat Weight

Maximum Thrust	Kts.	* 755
Military Thrust	Kts.	640

True Air Speed in Level Flight
At 50,000 Ft. at Combat Weight

Maximum Thrust	Kts.	1,070

CEILING

Combat Ceiling at Combat Weight, Rate of Climb = 500 F.P.M.
Maximum Thrust at 1.5 M.N. ..... Ft. 55,500

RATE OF CLIMB

Steady Rate of Climb at Sea Level, Combat Weight

Maximum Thrust at M.N. = .92	F.P.M.	51,400
Military Thrust at 530 Kts.	F.P.M.	15,800

Steady Rate of Climb at 50,000 Ft., Combat Weight

Maximum Thrust at M.N. = 1.5	F.P.M.	5,700

TIME TO HEIGHT

Time to 50,000 Ft. M.N. = 1.5 from Engine Start at Take-Off
Weight = 59,228
Maximum Thrust ..... Mins. 4.9

MANOEUVRABILITY

Combat Load Factor at Combat Weight
Maximum Thrust at M.N. = 1.50 at 50,000 Ft. 1.39

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* Placard Speed = 720 Kts.

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TAKE-OFF DISTANCE

Take-Off Distance over 50 Ft. Obstacle at Sea Level
Take-Off Weight = 59,228 Lb.

Maximum Thrust	Ft.	3,400
Military Thrust	Ft.	6,700
Maximum Thrust, Hot Day	Ft.	4,600

LANDING DISTANCE

Landing Distance over 50 Ft. Obstacle at Sea Level at Combat Wt.	Ft.	5,300

STALLING SEPPED

True Stalling Speed in Landing Configuration at Combat Weight at Sea Level	Kts.	110

RANGE

Combat Radius of Action at 50,000 Ft., Climb at M.N. = .92, Cruise out at M.N. = 1.5, Combat for 5 Mins. at M.N. = 1.50, Cruise Back at M.N. = .92, 15 Min. Stack at 40,000 Ft., 5 Min. Fuel Reserve on Landing

High Speed Mission with 15,356 Lb. Fuel	N.M.	200
High Speed Mission with Full Internal Fuel	N.M.	309

Combat Radius of Action at 50,000 Ft., Mission as above except climb at 530 Kts. and cruise out at M.N. = .92

Maximum Range Mission with 15,298 Lb. Fuel	N.M.	406
Maximum Range Mission with Full Internal Fuel	N.M.	605

Combat Radius of Action at Sea Level, Cruise out at .6 M.N. and Combat at M.N. = .92 at Sea Level, Cruise Back at .92 M.N. at 40,000 Ft., 15 Min. Stack, 5 Min. Fuel Reserve on Landing

Sea Level Mission with 15,356 Lb. of Fuel	N.M.	325
Sea Level Mission with Full Internal Fuel	N.M.	470

Ferry Range Mission at Economical Cruise Speed (M = .92 and Height, including 15 Mins. Stacking at 40,000 Ft., 5 Min. Fuel Reserve on Landing

Range with Full Internal Fuel and 500 Gal. - External Tank	N.M.	1,859
Range with Full Internal Fuel	N.M.	1,609

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MAXIMUM G SUSTAINED IN LEVEL TURN

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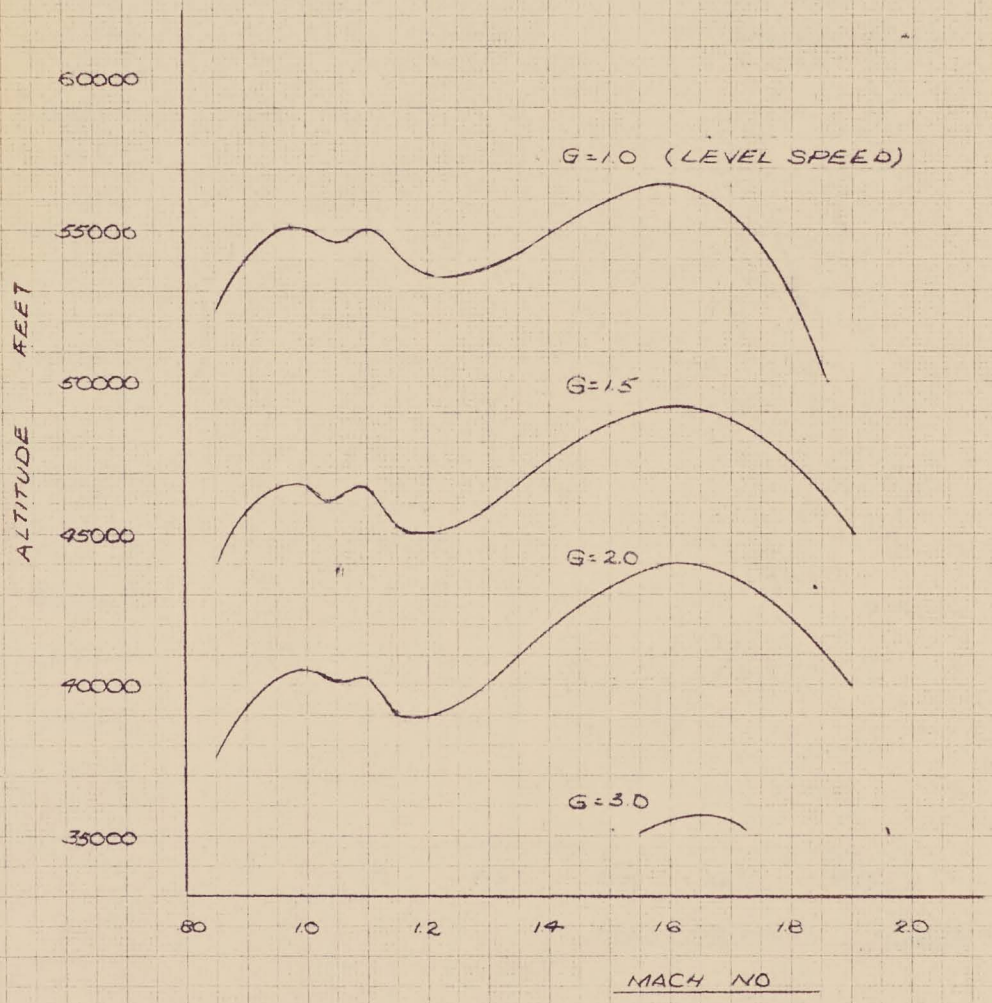

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M&E 10 X 10 TO THE CM. 359-14 KEUFFEL & ESSER CO.

LEVEL FLIGHT TRUE AIRSPEED

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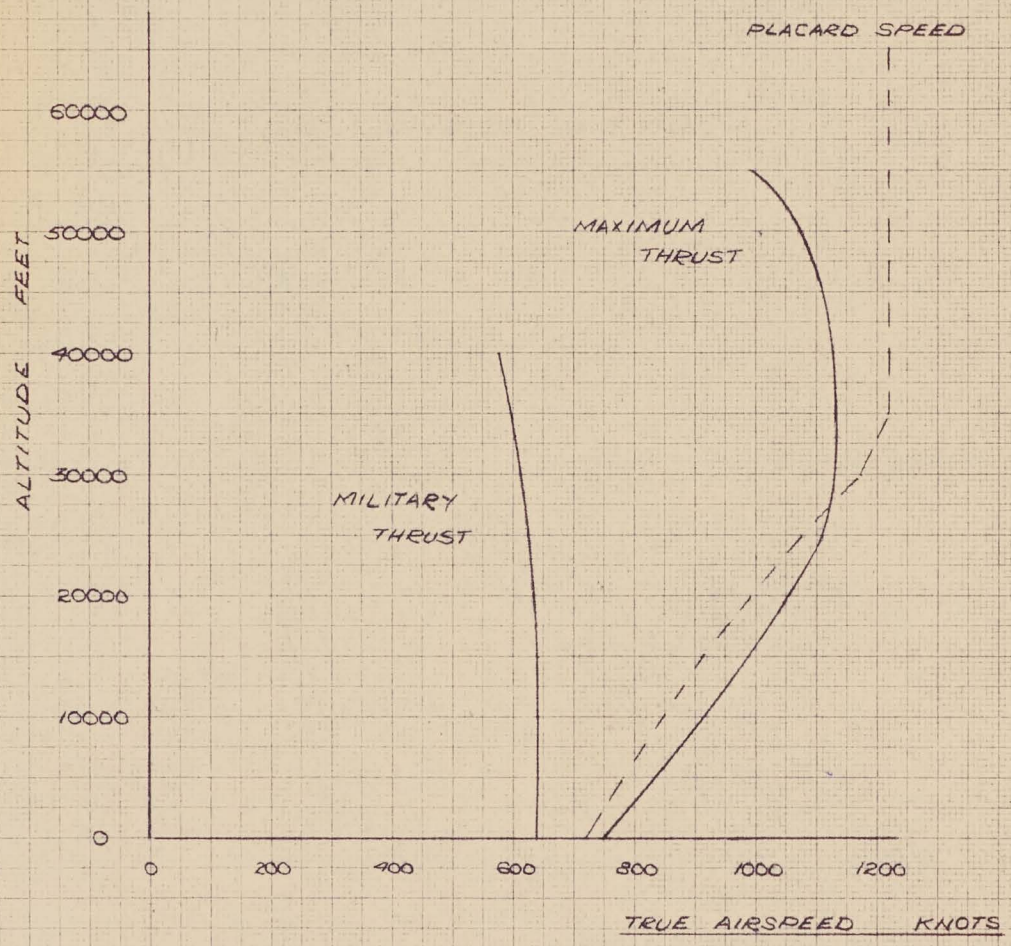

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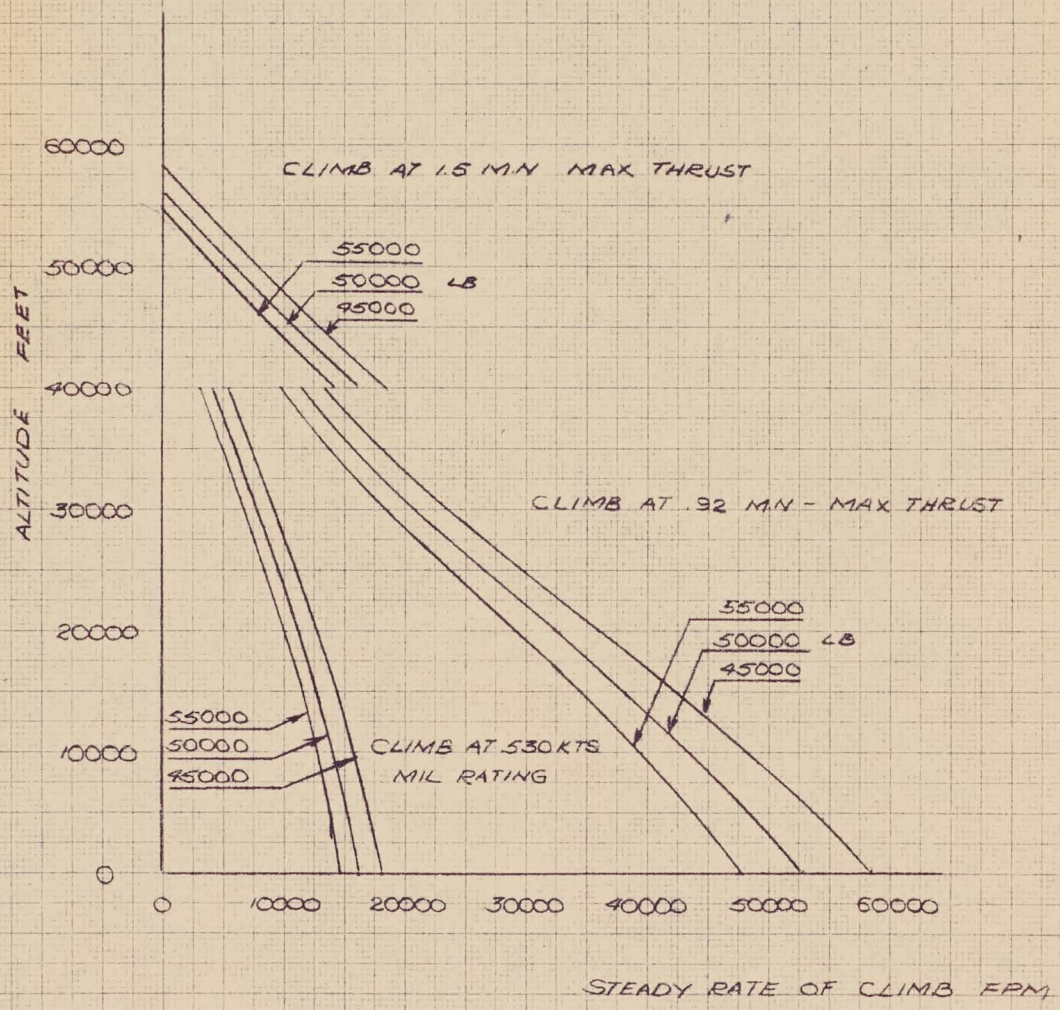
RATE OF CLIMB



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ENGINE

CF102-J75

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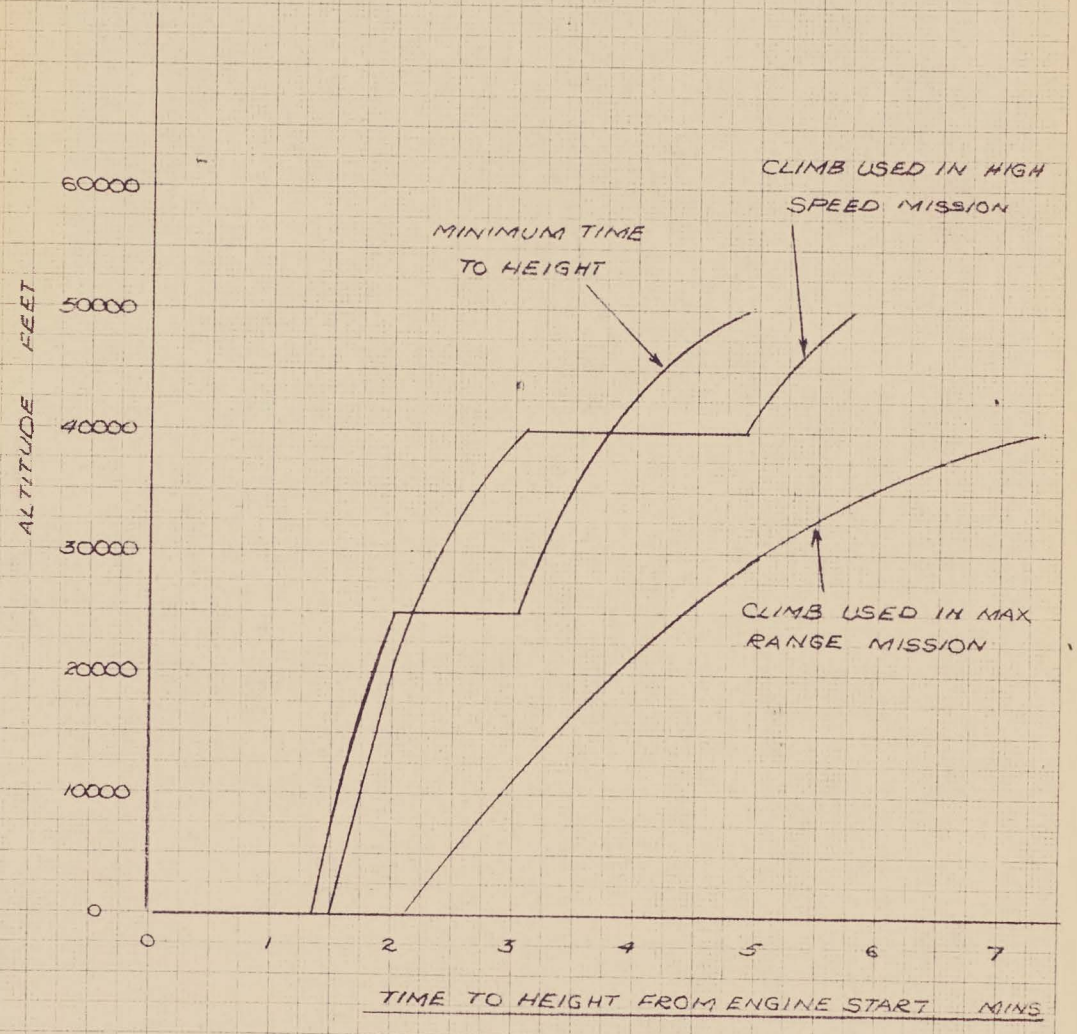
TIME TO HEIGHT

TAKEOFF WT = 59228 LB.

1/2 MINUTE ALLOWED FROM ENGINE START TO MILITARY RATING



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DRAG

PROPULSION

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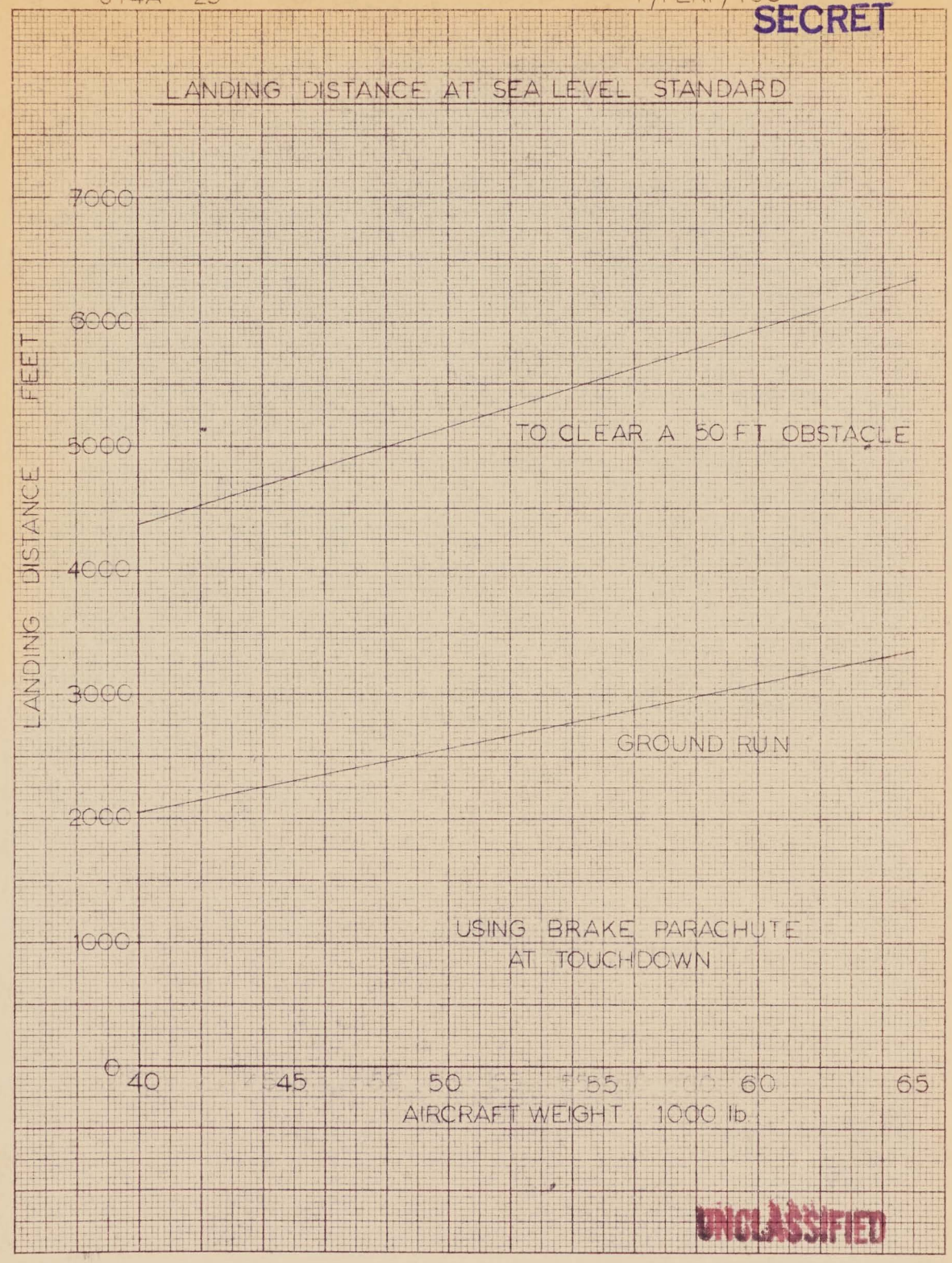

K&E 10 X 10 TO THE ½ INCH 359-12 KEUFFEL & ESSER CO. MADE IN U.S.A.

DRAG
ENGINE

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1B. CF-105 PERFORMANCE WITH ORENDA PS 13 ENGINES

(C.G. = 29% M.A.C.)

The following CF-105 - PS 13 performance estimate is based on the wind tunnel configuration designated $B_2V_1W_1E_{10}N_5D_8$-4 over the subsonic portion, and configuration W_9, N_{A5}, B_4, C_3, V_2, R_s, over the supersonic range. The particular feature of the former configuration is the extended, notched, and cambered leading edge of the wing. The drag of this configuration is summarized, (Extract P/Aero Data/58), and is presented in section 2 of this report. The latter configuration differs chiefly by not having a cambered leading edge. This drag data is given in P/Aero Data/48 but has not been summarized for this report. This constitutes little change under supersonic cruise conditions, and only decreases the supersonic drag by about 4% at maximum 'g' due to less elevator angle for trim. Thus, the performance does reasonably represent that for the one configuration, $B_2V_1W_1E_{10}N_5D_8$ - 4.

The PS 13 engine data is in a more incomplete state. The engine data above the tropopause was taken from the Dec. '54 Memo, (Ref. Orenda P11-1-1) on the PS 13, with the exception of the cruise operation at .92 M.N. and 40,000 Ft., where insufficient data was available from the Memo, and we were forced to use the original PS 13 Brochure (EMS 8) April '54. The memo of Dec. '54 assumes a 6.5 Sq. Ft. intake, and pressure recovery curve from P/Power/23 APP/A/10. It also considers the effect of a 39" ejector, as well as a bypass which opens to 118 sq. Inches. For engine performance below the tropopause the original PS 13 Brochure was used. The above mentioned pressure recovery correction were applied to this data, but no account was taken of the bypass effect. It should be noted that revised thrust estimates now being prepared indicate an increase in maximum thrust at 1.5 M.N. of approximately 4%. This offsets the slightly optimistic supersonic drags used in this report for the performance of the PS 13 engines version.

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LOADING AND PERFORMANCE

Performance Under N.A.C.A. Standard Atmospheric Conditions

To R.C.A.F. Specification AIR 7-4

With Two PS 13 Engines

WEIGHT:

Take-Off Weight with 15,510 Lb. Fuel (78.2% Max.)	Lb.	55,889
Operational Weight Empty	Lb.	40,379
Combat Weight (1/2 Fuel)	Lb.	48,130
Landing Weight (With Reserve Fuel + Missiles)	Lb.	42,200
Wing Loading at Normal Take-Off Weight	Lb./Sq.Ft.	44.5
Power Loading at Normal Take-Off Weight	Lb./Lb. Thrust	1.19

SPEED

True Air Speed in Level Flight At Sea Level at Combat Weight		
Maximum Thrust	Kts.	* 720
Military Thrust	Kts.	650
True Air Speed in Level Flight At 50,000 Ft. at Combat Weight		
Maximum Thrust	Kts.	1,110

CEILING

Combat Ceiling at Combat Weight, Rate of Climb = 500 F.P.M. Maximum Thrust at 1.5 M.N.	Ft.	62,200

RATE OF CLIMB

Steady Rate of Climb at Sea Level, Combat Weight		
Maximum Thrust at M.N. = .92	F.P.M.	50,000
Military Thrust at 530 Kts.	F.P.M.	25,200
Steady Rate of Climb at 50,000 Ft., Combat Weight		
Maximum Thrust at M.N. = 1.5	F.P.M.	11,500

TIME TO HEIGHT

Time to 50,000 Ft. M.N. = 1.5 from Engine Start at Take-Off Weight = 55,889 Lb. Maximum Thrust	Mins.	4.1

MANOEUVRABILITY

Combat Load Factor at Combat Weight Maximum Thrust at M.N. = 1.50 at 50,000 Ft.		1.84

* Placard Speed = 720 Kts.

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ENGINE

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TAKE-OFF DISTANCE

Take-Off Distance over 50 Ft. Obstacle at Sea Level .....
Take-Off Weight = 55,889 Lb.

Maximum Thrust	Ft.	2,500
Military Thrust	Ft.	3,800
Maximum Thrust Hot Day	Ft.	3,300

LANDING DISTANCE

Landing Distance over 50 Ft. Obstacle at Sea Level at Combat Weight Ft. 5,000

STALLING SPEED

True Stalling Speed in Landing Configuration at Combat Weight at Sea Level ..... Kts. 105

RANGE

Combat Radius of Action at 50,000 Ft., Climb at M.N. = .92, Cruise out at M.N. = 1.5, Combat for 5 mins. at M.N. = 1.50, Cruise Back at M.N. = .92, 15 Min. Stack at 40,000 Ft., 5Min. Fuel Reserve on Landing

High Speed Mission with 15,510 Lb. Fuel	N.M.	200
High Speed Mission with Full Internal Fuel	N.M.	318

Combat Radius of Action at 50,000 Ft., Mission as above except Cruise Out at M.N. = .92

Maximum Range Mission with 15,510 Lb. Fuel	N.M.	315
Maximum Range Mission with Full Internal Fuel	N.M.	491

Combat Radius of Action at Sea Level, Cruise Out at .6 M.N. and Combat at M.N. = .92 at Sea Level, Cruise Back at .92 M.N. at 40,000 Ft., 15 Min. Stack, 5 Min. Fuel Reserve on Landing

Sea Level Mission with 15,510 Lb. of Fuel	N.M.	217
Sea Level Mission with Full Internal Fuel	N.M.	318

Ferry Range Mission at Economical Cruise Speed (M = .92 and Height, including 15 Mins. Stacking at 40,000 Ft., 5 Min. Fuel Reserve on Landing

Range with Full Internal Fuel and 500 Gal. - External Tank . N.M. 1,675

DRAG

ENGINE

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PS 13 ENGINES

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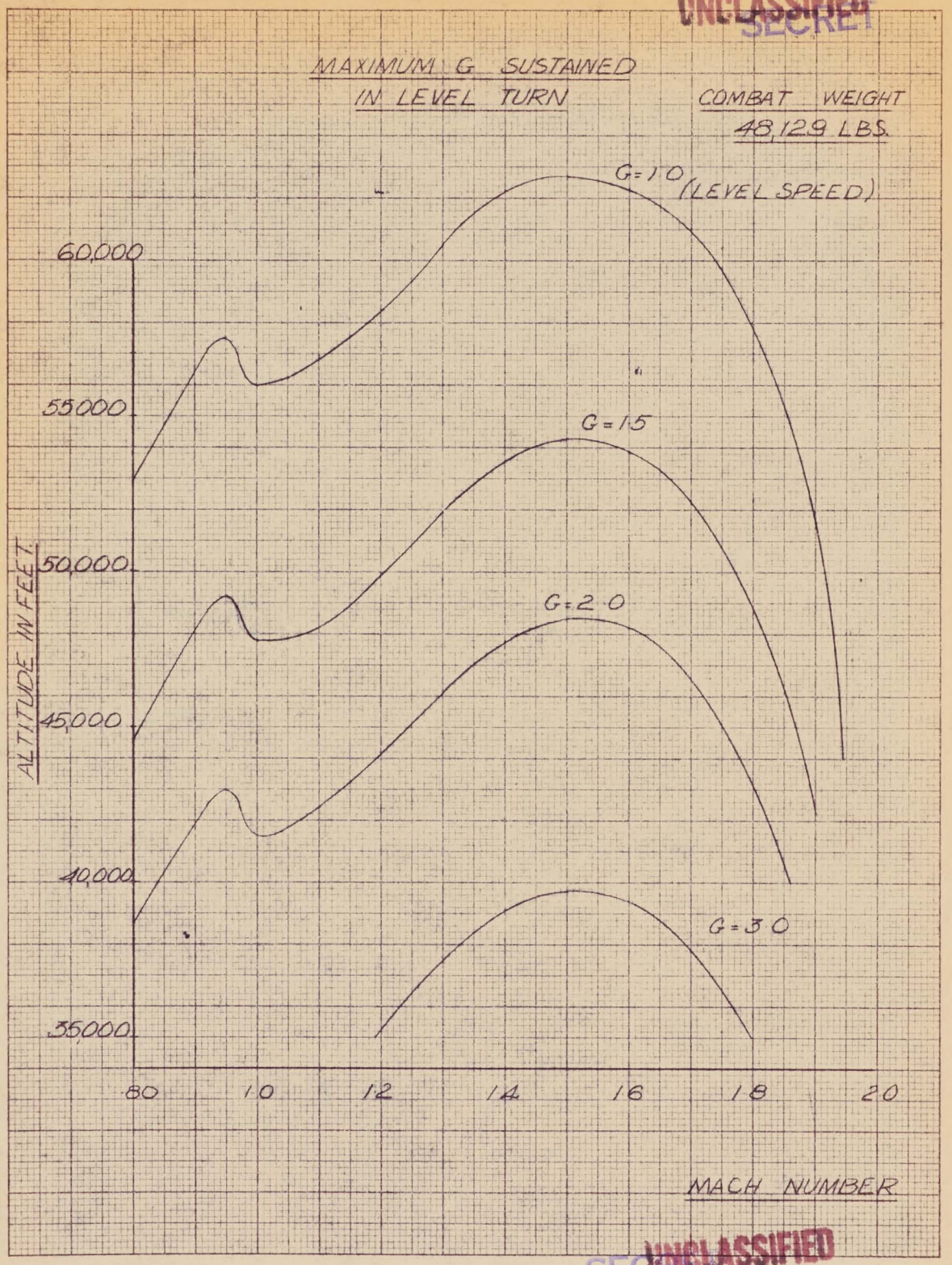

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JULY 55 T. GRAYSON

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DRAG

ENGINE

PS 12 ENGINES

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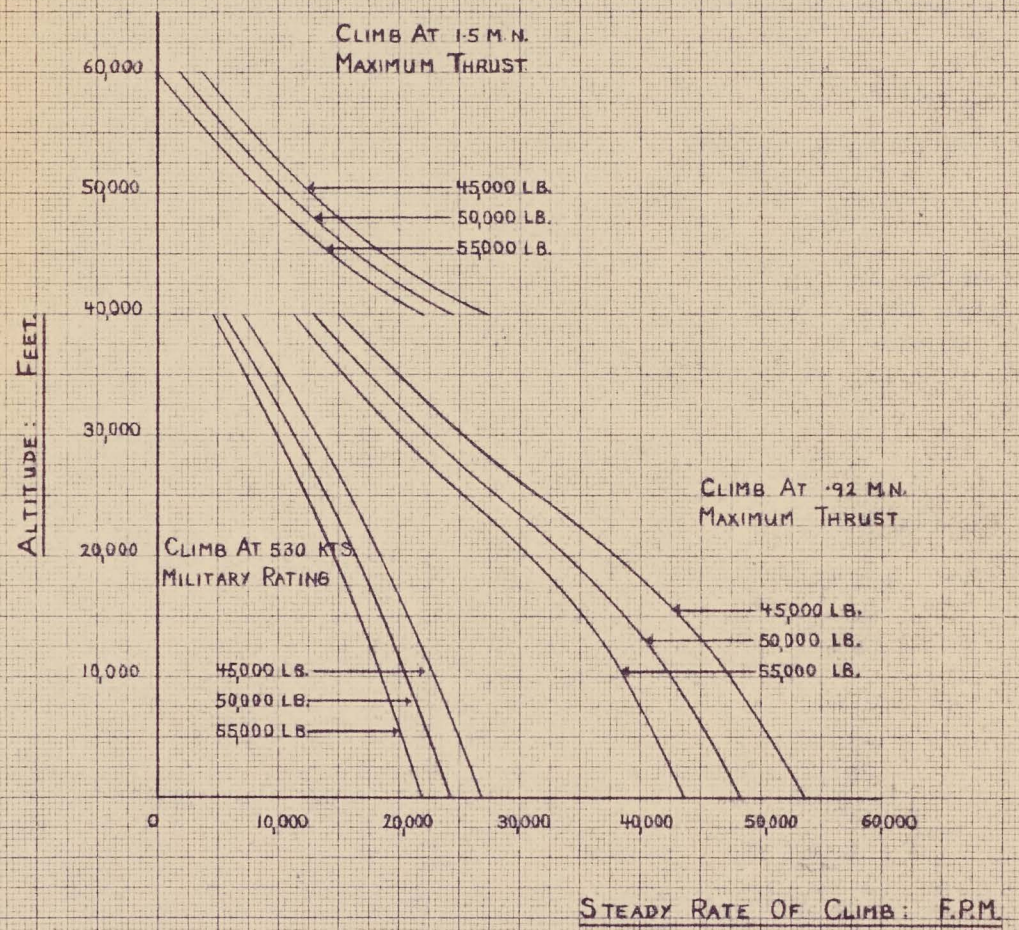
RATE OF CLIMB



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PS 13 ENGINES

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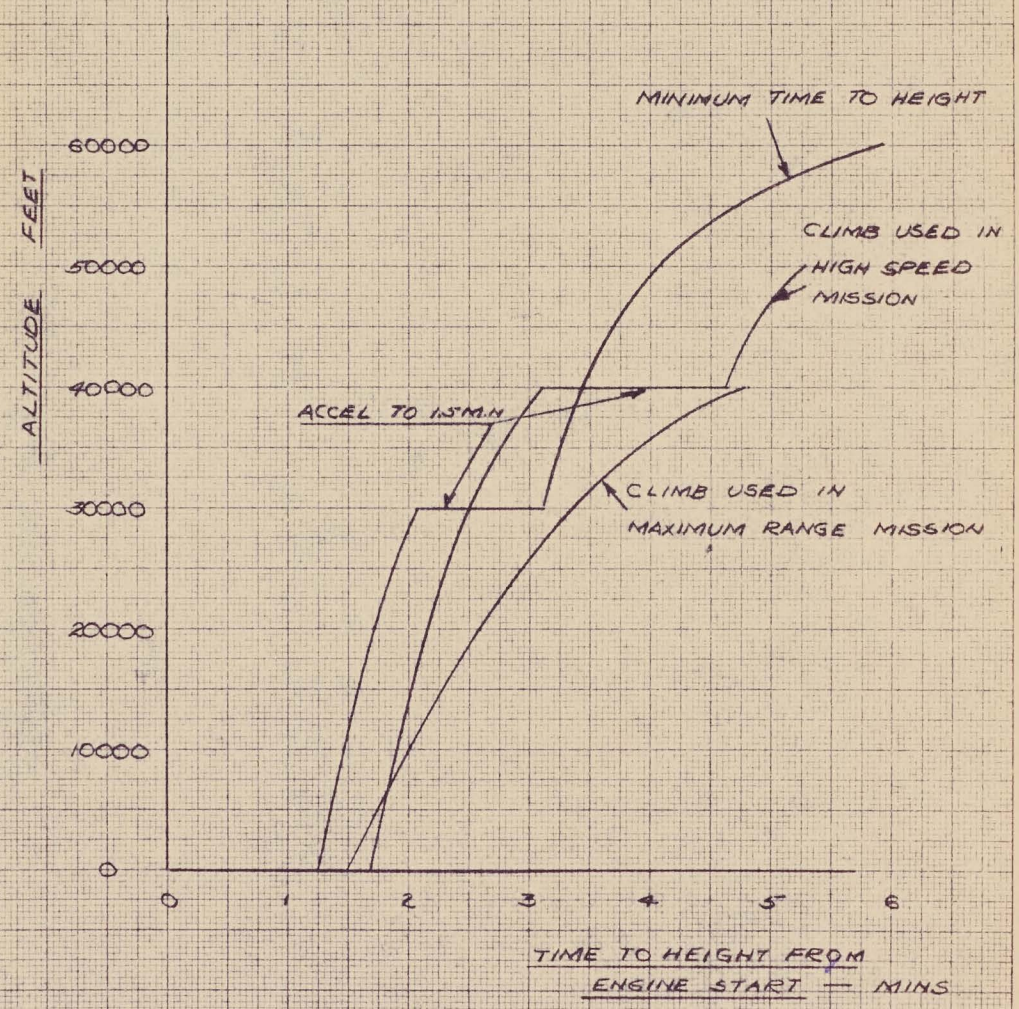
TIME TO HEIGHT

TAKEOFF WEIGHT = 55889 LB

NOTE: ONE HALF MINUTE ALLOWED FROM ENGINE START TO MILITARY RATING



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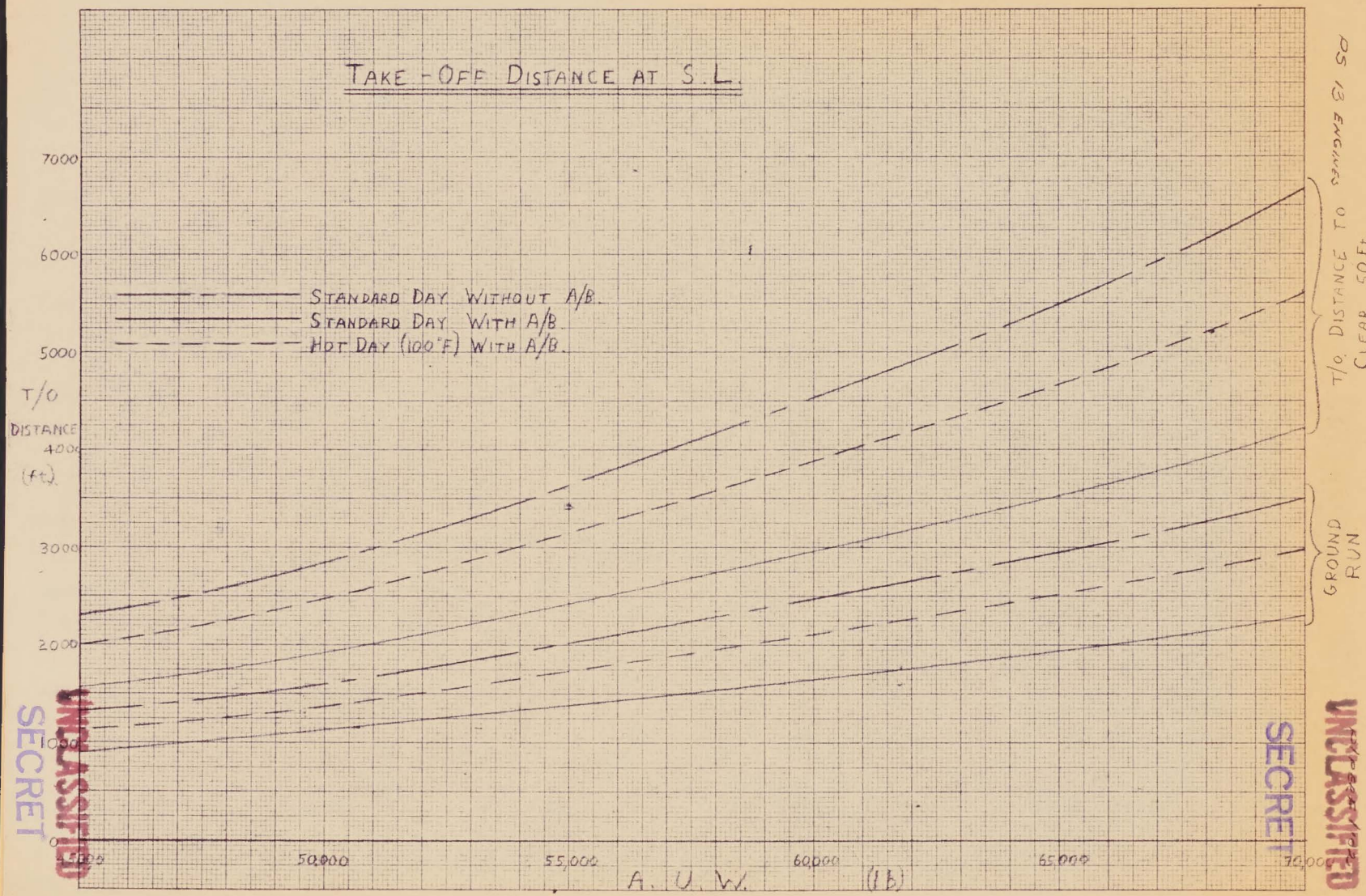

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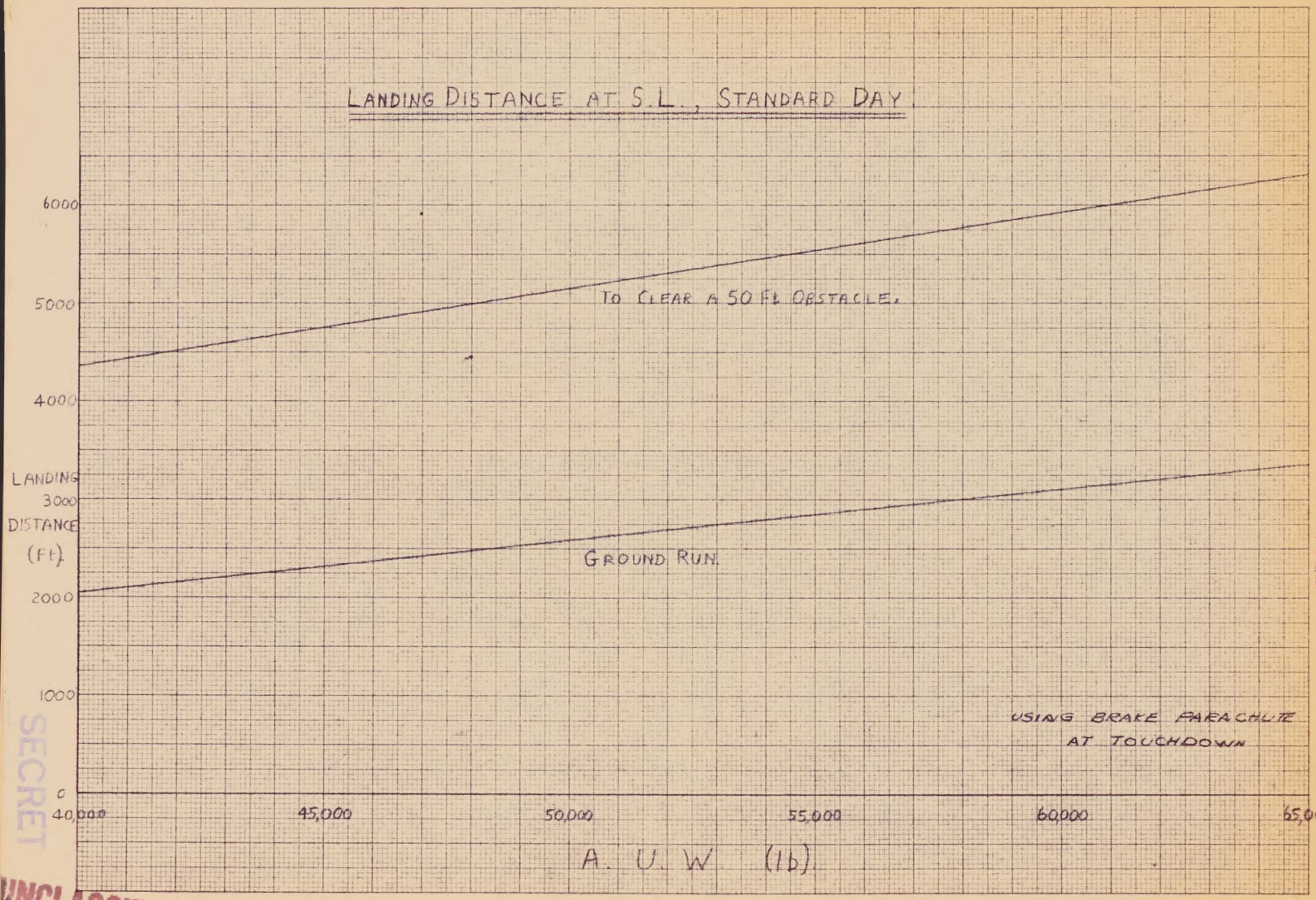

RS 13 ENGINES

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ENGINE

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CF-105 (CONFIGURATION B_2 V_1 W_1 E_{10} N_5 D_{3-4}) DRAG NOTE

"The drag of this configuration is summarized (Extract P/Aero Data/58) and is presented in section 2 of the CF-105 Monthly Performance Report No, 1 issued October 1955."

No Revisions have been made.

ENGINE

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3. CF-105 INSTALLED ENGINE DATA

(J-75) JT 4A-25 ENGINES)

The methods of estimating installed engine data and the subsequent installed engine data estimates (extract P/Power/51), has been presented in Section 3 of CF-105 Monthly Report No. 1. Since then the net thrust equation was found to be in error and was corrected in CF-105 Monthly Report No. 2.

In this issue the thrust has been changed further for two reasons.

(1) The estimation of the gross thrust with ejector has been based on an analytical method in place of the experimental data given in NACA RM E52L24.* The equation for gross thrust with ejector is -

$$F_{ej} = P_a A_p \left[\left\{ \frac{P_p}{P_a} \frac{2^{\frac{\gamma}{\gamma-1}}}{(1+\gamma)^{1/\gamma-1}} - 1 \right\}_{\gamma\,hot} + \left(\frac{A_e}{A_p} - 1 \right) \left\{ \frac{P_s}{P_a} \frac{1+\gamma M_s^2}{\left(1+\frac{\gamma-1}{2} M_s^2\right)^{\frac{\gamma}{\gamma-1}}} \right\} \right]$$

(2) The spillage drag has been revised. This is deducted from the thrust instead of added to drag because of its dependence on engine mass flow.

* This change was on the advice of NACA as they have since found the experimental data to be optimistic.

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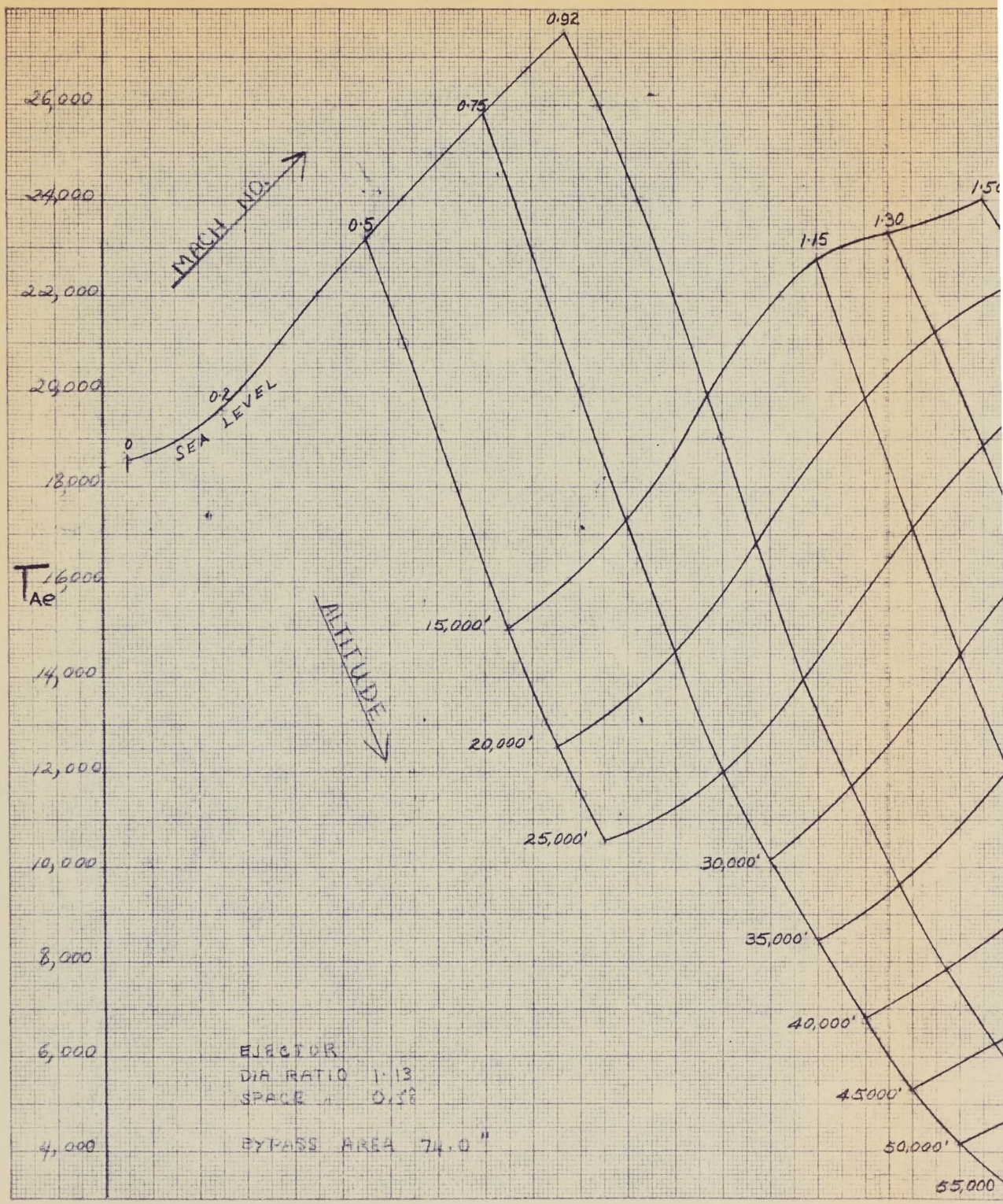

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