

RESTRICTED

AIRCRAFT AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN  
FILE COPY

Lancaster 1 PL.435  
(4 Merlin 24)

UNCLASSIFIED

Performance at weights up to 72,000 lb.

A.&A.E.E. ref: 5710,a/15/JWM DATE 16/12/52  
M.A.P. ref: RA.711/5/RDL2(b)  
Period of tests: 22nd December, 1944 to 16th April, 1945. 52

Progress of issue of report.

This report deals with the aircraft or equipment as tested. Action to remedy defects or decisions to accept items not in strict compliance with the specification are matters for decision & action by the M.A.P.

Report No.		Title	
76th Part of A&AEE/766	W.4963	The effect on level speed of the H2S Mk.III blister and the position error of a static vent with the blister fitted.	
77th do.	PB.995	Position error trials and determination of specific air range with a 22,000 lb.bomb fitted.	
78th do.	JB.127	Modified Dowty oil-compression shock absorber in tail wheel strut.	
79th do.	W.4963	Dowty oil-compression shock absorber in tail wheel strut.	
80th do.	PB.995	Brief handling trials with a 22,000 lb. DP bomb installed in an aircraft having a dorsal turret.	

Summary.

Performance trials have been made at weights up to 72,000 lb. The results are as follows :-

Position error correction. The P.E.C. at 55,000 lb. varies from 0 mph at 120 mph ASI to -4½ mph at 280 mph ASI.

Climb. From a take-off weight of 70,000 lb.

	ICAN		Tropical Summer	
	Max.rate of climb ft/min.	At full throttle height, ft.	Max.rate of climb ft/min.	At full throttle height, ft.
MS gear	590	10,300	370	8,800
FS gear	370	16,200	170	14,700

	ICAN	Tropical Summer
Service Ceiling,ft.	20,100	15,700
Time to S.C.,mins.	51	61

Level speeds (66,500 lb.)

Maximum cruising speed in FS gear (244 mph TAS at 16,600 ft. (ICAN)  
(235 mph TAS at 15,100 ft. (tropical summer)

Cruising ceiling(based on 162 mph EAS) (19,900 ft. (ICAN)  
(17,000 ft. (tropical summer)

Specific air range. The optimum specific air range at 15,000 ft. at 66,500 lb. is as follows :-

MS gear	1.07 ampg ICAN
FS gear	1.01 ampg ICAN
	0.95 ampg Tropical summer

Take-off and landing. Under ICAN conditions the mean distances were as follows:-

Take-off at 72,000 lb., 1080 yds. (Ground run,using +18 lb/sq.in.,3000 rpm,  
20° flap)

Landing at 60,000 lb., 1070 yds. (using full flap)

/It is...



It is estimated that correction to tropical summer conditions would increase these distances by about 25%.

## 1. Introduction.

Tests have been made to assess the performance of the Lancaster I at a take-off weight of 72,000 lb. This part of the Report gives the results of the take-off, landing, climb and level speed, position error and specific air range tests. Cooling and handling tests were also made at this weight and are reported in other parts of this Report. The climb, level speeds, and specific air range tests were made from a take-off weight of 70,000 lb., as these tests had been completed before the request for these results at 72,000 lb. had been made, by RDL2(b). An estimation of the change in performance to be expected at a take-off weight of 72,000 lb. is given for the climb, level speed, and specific air range.

These results have been corrected to ICAN and tropical conditions as requested by RDL2(b).

Some of the results have been previously reported in a letter to M.A.P. (RDL2(b)), dated March 20th, 1945.

## 2. Condition of aircraft relevant to tests.

### 2.1 General.

#### Wings.

Snap head rivetting was used throughout except for the forward portion which is flush rivetted. The finish was average for the type.

Three pulsometer pump fairings were fitted under each wing

No barrage cutters

No de-icing equipment.

Cabin heating duct under each wing leading edge.

#### Fuselage

Snap head rivetting throughout, finish average for type.

Navigation blister on starboard side only.

Deepened bomb-aimer's window (Mod. 780)

Astro-dome faired into canopy

Strengthened fabric covered elevators (Mod. 1131)

Marstrand twin contact tail wheel tyre

Cabin heating duct on starboard side of fuselage at wing root.

Cabin air extractors each side of nose

H<sub>2</sub>S Mk. II blister

#### Armament.

FN.5 nose turret, with 2 x .303" guns

FN.50 dorsal turret, with 2 x .303" guns

FN.120 tail turret, with 4 x .303" guns.

#### W/T aeriels W/T from cabin to both fins

IFF aeriels from rear fuselage to fins

IFF strut aerial below rear fuselage

BA aerial, port side rear fuselage

2 whip aeriels.

2.2 Engines. Four Merlin 24 power units were fitted. The numbers of the engines were :-

Engine	Firm's No.	A.M. No.
PO	202009	508892
PI	202155	508965
SI	202203	508989
SO	201995	508885

The reduction gear was 0.42.

The relevant engine limitations for the Merlin 24 at the time of tests were :-

Condition	RPM	Boost lb/sq.in.
Take-off (5 min. or 1000 ft)	3000	+18
Climb	2850	+ 9
Cruising	2650	+ 7
Combat (5 mins.)	3000	+18

/The...



The aircraft was fitted with ice guards on the air intakes, and multi-ejector exhausts with plain shrouds.

2.3 Propellers. Hamilton constant speed fully feathering propellers, type A5/159 (paddle-blade) with a diameter of 13 ft., were fitted to all engines.

2.4 ASI system. All speeds quoted refer to the pilot's ASI, the pitot side of which was connected to the Mk.VIII head on the side of the fuselage (Mod.883) and the static side to the port static vent. The static vents were in the standard positions for the case when no H<sub>2</sub>S blister is fitted (Mod.1157 not incorporated), and details of these are shown in Fig.1., details of the pressure head are given in Fig.2.

2.5 Loading. The tests were made at the following loadings :-

Position error:	Take-off weight 55,000 lb., c.g. 49.2" aft of datum
Measured take-offs :	Weight 72,000 lb., c.g. 60.0" aft of datum
Measured landings:	Weight 60,000 lb., c.g. 53.4" aft of datum
Other tests:	Take-off weight 70,000 lb., c.g. 60.5" aft of datum

The normal c.g. range is from 41.0" to 60.6", aft of datum point.

### 3. Results.

The reduction of the climb and level speed results to ICAN and tropical summer standard conditions and the correction of the level speeds to a mean weight of 66,500 lb. (95% of 70,000 lb.), have been made by the method of Report No. A.&.A.E.E./Res/170 using supercharger constant  $C = .002$ . The tropical summer values listed in the specific air range results have been corrected by the methods recommended in A.&.A.E.E./Res/215.

3.1 Position error correction. The position error correction of the port static vent was measured by the aneroid method. The results are given in Fig.3. and show that the P.E.C. at 55,000 lb. varies from zero at 120 mph ASI to  $-4\frac{1}{2}$  mph at 280 mph ASI. The pitot position error has been assumed to be the same as that of Lancaster I W.4963, which had a similar installation fitted, and was reported in the 61st part of A.&.A.E.E./766.

3.2 Climb. Four ceiling climbs were made under maximum climbing power with radiator flaps open, at a speed of 165 mph ASI with a reduction of 2 mph per thousand feet above 16,000 ft. This speed had not been checked by partial climbs but was estimated to be the best climbing speed at the weight.

The boost control capsule failed to function correctly during the climb and the boost pressure was below the maximum permitted. The measured rates of climb have been corrected for this deficiency in boost.

The results at a take-off weight of 70,000 lb. are given in Table I and Fig.4 and are summarised below :-

	ICAN		Tropical Summer	
	Rate of climb ft/min.	At full throttle height, ft.	Rate of climb ft./min.	At full throttle height, ft.
MS gear	590	10,300	370	8,800
FS gear	370	16,200	170	14,700

	ICAN	Tropical Summer
Service Ceiling, ft.	20,100	15,700
Time to S.C., mins.	51	61

Optimum climb performance is obtained by changing to FS gear when the boost in MS gear has fallen to  $6\frac{1}{2}$  lb/sq.in.

An increase in the take-off weight from 70,000 lb. to 72,000 lb. would reduce the rates of climb by about 60 ft/min. and reduce the service ceiling by about 600 ft. in both ICAN and tropical summer conditions.



3.3 Level speeds. Level speeds were measured at maximum cruising power with radiator flaps closed, in FS gear only to determine the cruising ceiling (based on 162 mph EAS).

The results are given in Table II and Fig. 5 and are summarised below :-

	ICAN	Tropical summer
Max. cruising speed at full throttle height, FS gear	244 mph TAS at 16,600 ft.	235 mph TAS at 15,100 ft.
Cruising ceiling	19,900 ft.	17,000 ft.

An increase in the weight to 68,500 lb. (95% of 72,000 lb.) would decrease the cruising speeds by about 7 mph and reduce the cruising ceilings by about 600 ft.

3.4 Specific air range at 15,000 ft. The results of speed measurements at various engine power conditions have been used in conjunction with fuel consumption results on Lancaster I JB.127 (54th part of this Report) to assess the specific air range (Table III and Fig. 6).

The optimum values at a weight of 66,500 lb. and with the radiator flap closed, are as follows :-

	S/c gear	RPM	Boost lb/in <sup>2</sup>	ASI mph	TAS mph	Total fuel flow galls/hr.	Specific air range ampg
ICAN	MS	2500	2.4	170	209	196	1.07
	FS	2350	4.6	170	214	212	1.01
Tropical Summer	FS	2400	4.1	155	201	211	0.95
	FS	2450	4.7	160	209	222	0.94

\* This speed is below the minimum for comfortable continuous cruising (160 mph ASI).

15,000 ft. is above the Service ceiling in MS gear under tropical summer standard conditions.

In each case the optimum specific air range is obtained by using the maximum boost obtainable and reducing rpm until the ASI reaches the value quoted.

An increase in the weight to 68,500 lb. (95% of 72,000 lb.) would decrease the specific air range by about 2% but would not appreciably change the optimum ASI.

3.5 Take-off and landing. The ground runs of three take-offs at a weight of 72,000 lb. from a runway, were noted by observers stationed beside the runway. The ground runs of four landings at a weight of approximately 60,000 lb., were measured in the same way. The results, which have been corrected to ICAN standard, sea level conditions with zero wind are given in Table IV and V, and are summarised below :

Mean take-off ground run (using 18 lb/sq.in. boost, 3000 rpm, 20° flap) = 1080 yds.  
Mean landing ground run (using full flap) = 1070 yds.

These distances would be increased by approximately 25% under tropical summer standard conditions.

#### Circulation List.

/Table I.

C.R.D.	A.D.R.D.E.1.
D.T.D.	A.D.R.D.E.2.
D.D.T.D.	R.D.E./T.R.
D.O.R.	A.D.R.D.D.2. 2 copies (1 for action)
D.D.R.D.A.	A.F.E.E.
D.D.R.D.T.	T.F.2.
A.D.R.D.T.1.	Chief Overseer
A.C.A.S.(T.R.)	C.I. Accidents
D.D.A.P.9.	R.D.T. Accidents
D.R.A.E. 6 copies	D.P.A.
D.Arm.D.	O.C. Handling Squadron
R.D.T.3.	R.T.P.(TIB) 6 copies + 1
D.D.E.D.	R.T.P.2.a. 50 copies
D.D.(A)R.D.E.	R.T.O. A.V. Roe 3 copies
D.D.(E)R.D.E.	R.T.O. Rolls Royce, Derby 4 copies
C.T.A./D.E.D.	R.T.O. Rolls Royce, Hucknall 2 copies



TABLE I.

Climb performance corrected to ICAN and tropical summer conditions.  
Take-off weight - 70,000 lb.  
Radiator flaps fully open.

Height in ft.	Time in mins. ICAN	Time in mins. Tropical	Rate of climb ft/min. ICAN	Rate of climb ft/min. Tropical	ASI mph	Boost lb/in <sup>2</sup> ICAN	Boost lb/in <sup>2</sup> Tropical	RPM	S/c gear ICAN	S/c gear Trop.
2000	3.4	5.4	590	370	165	+9	+9	2850	MS	MS
4000	6.8	10.8	↓	↓	↓	↓	↓	↓	↓	↓
6000	10.1	16.2	↓	↓	↓	↓	↓	↓	↓	↓
8000	13.5	21.6	↓	↓	↓	↓	↓	↓	↓	↓
8800*	-	24.0	↓	↓	↓	↓	↓	↓	↓	↓
10000	17.1	27.5	↓	270	↓	↓	+8.0	↓	↓	↓
10300*	17.5	-	↓	-	↓	↓	-	↓	↓	↓
11300*	-	34.0	↓	170	↓	↓	+6.8	↓	↓	FS
12000	20.9	37.8	440	↓	↓	+7.5	+9.0	↓	↓	↓
13000*	23.3	-	370	↓	↓	+6.6	↓	↓	FS	↓
14000	26.0	49.6	↓	↓	↓	+9.0	↓	↓	↓	↓
14700*	-	54.0	↓	↓	↓	↓	↓	↓	↓	↓
15700	-	61.4	↓	100	↓	↓	+8.2	↓	↓	↓
16000	31.4	64.1	↓	-	↓	↓	+8.0	↓	↓	↓
16200*	32.0	-	↓	-	↓	↓	-	↓	↓	↓
18000	37.8	-	250	-	161	+7.5	-	↓	↓	↓
20000	49.3	-	110	-	157	+6.1	-	↓	↓	↓
20100	51.0	-	100	-	-	+6.1	-	↓	↓	↓

\* Full throttle height.

∅ Supercharger gear change.

TABLE II.

Level speed performance corrected to ICAN and tropical summer conditions  
Corrected to 66,500 lb., i.e., 95% of 70,000 lb.  
Radiator flaps fully closed.  
2650 rpm, FS gear.

Std. height feet	TAS ICAN mph	TAS Trop mph	PEC (mph)	CE (mph)	ASI ICAN	ASI Trop	Boost lb/in <sup>2</sup> ICAN	Boost lb/in <sup>2</sup> Trop.
12000	236	231	-4.2	-4.0	-1.5	-1.5	191	187
14000	240	234	-4.25	-4.2	-2.0	-1.9	187	183
15000	241	235	-4.25	-4.1	-2.2	-2.1	185	180
15100*	-	235	-	-4.1	-	-2.1	-	180
16000	243	230	-4.25	-4.0	-2.5	-2.1	183	173
16700*	244	-	-4.25	-	-2.8	-	181	-
17000	243	221	-4.25	-3.8	-2.7	-2.1	180	163
18000	239	-	-4.2	-	-2.8	-	173	-
19000	231	-	-4.0	-	-2.7	-	165	-

\* Full throttle height.

TABLE III.

Fuel consumption tests

Corrected to ICAN and tropical summer conditions and mean weight of 66,500 lb.  
15,000 ft.  
Radiator flaps closed. Cold air intakes.

Corrected to ICAN conditions							Corrected to trop. summer conditions						
S/c gear	RPM	Boost lb/in <sup>2</sup>	ASI mph	TAS mph	Total fuel flow galls/hr.	Specific air range		Boost lb/in <sup>2</sup>	ASI mph	TAS mph	Total fuel flow galls/hr.	Specific air range	
MS	2350	+1.1	145	181	175	1.03							
↓	2450	+1.9	163	202	189	1.07							
	2550	+2.8	175	217	203	1.07							
	2650	+3.6	186	229	219	1.04							
FS	2250	+3.4	150	186	196	0.95	2400	+4.1	155	201	211	0.95	
	2350	+4.6	170	214	212	1.01	2450	+4.7	160	209	222	0.94	
	2450	+5.8	187	231	234	0.99	2550	+6.1	175	227	243	0.935	
	2550	+7.2	197	243	256	0.95	2650	+7.4	185	239	268	0.895	
↓	2650	+8.6	205	253	282	0.91	-	-	-	-	-	-	

\* This speed is less than the minimum speed for comfortable continuous cruising.



TABLE IV.

Take-off runs.  
3000 rpm, +18 lb/sq.in. boost.  
20° flap.

Run No.	ASI at take-off (mph)	Time in secs.	ICAN height on ground, ft.	Wind speed mph	Temp. °C	Take-off run under conditions of test, yds.	Take-off run <sup>corr<sup>d</sup></sup> to ICAN cond <sup>ns</sup> and zero wind, yds.
1	115	28	-210	11.1	+6	902	1150
2	120	30	+165	2	+16	1060	1050
3	120	30	+339	4.5	+18	1038	1040

TABLE V.

Landing runs.  
Full flap.

Run No.	ASI at touch down mph	Time to stop in secs	ICAN height on ground, ft.	Wind speed mph	Temp. °C	Landing run under conditions of test, yds.	Landing run <sup>corr<sup>d</sup></sup> to ICAN cond <sup>ns</sup> and zero wind, yds.
1	100	44	-210	11	+6	811	1100
2	96	48	+520	9.5	+17	1090	1250
3	95	42	+339	8	+18	861	925
4	90	45	+339	3.5	+18	945	1000



CV NO 8171 81st PART OF REPORT NO 6546E 766 LANCASTER I PD 435 IR PD CH APP 2.1.24 for 8 of 8 1.74

FIG 1 4

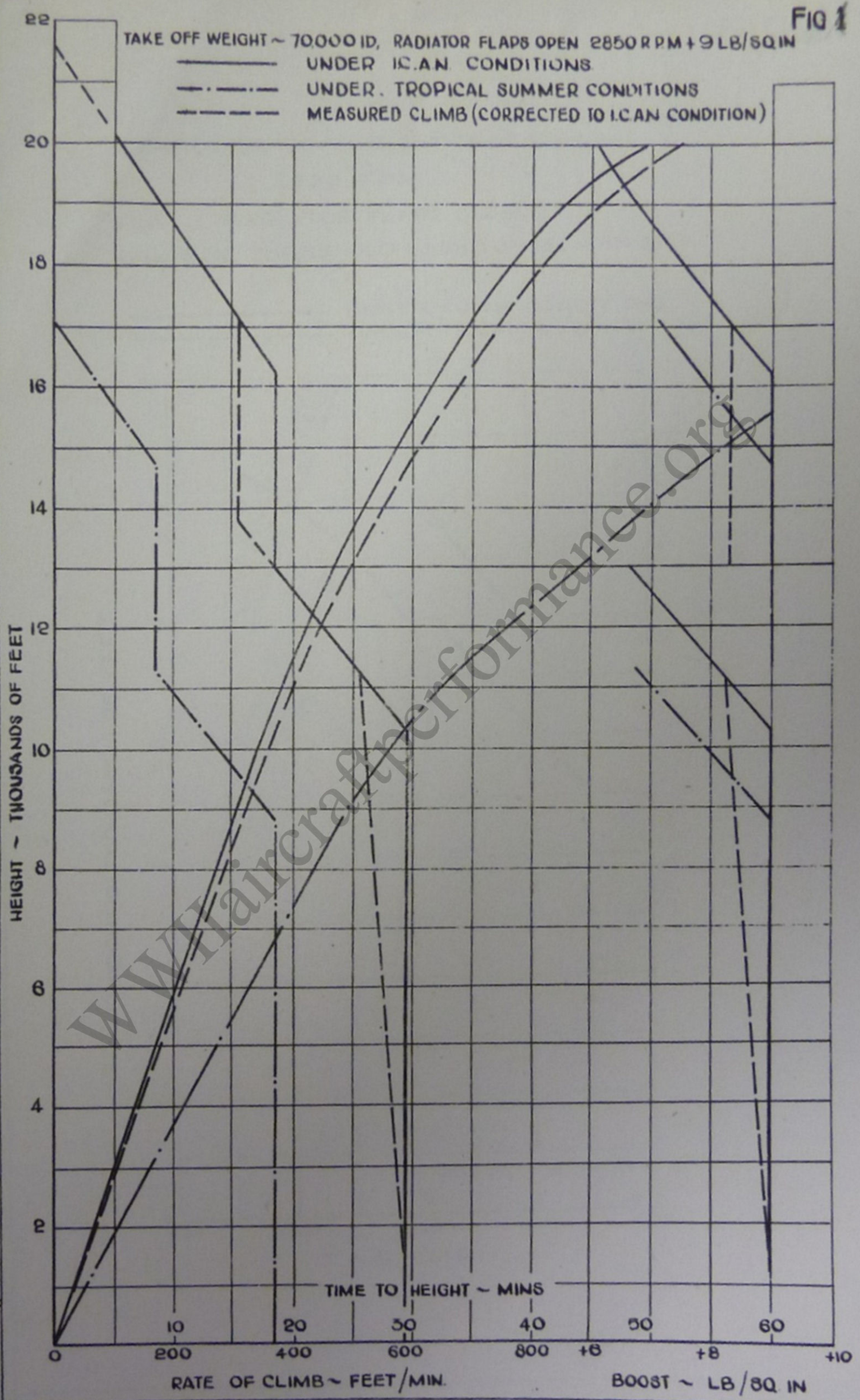




FIG. 2.

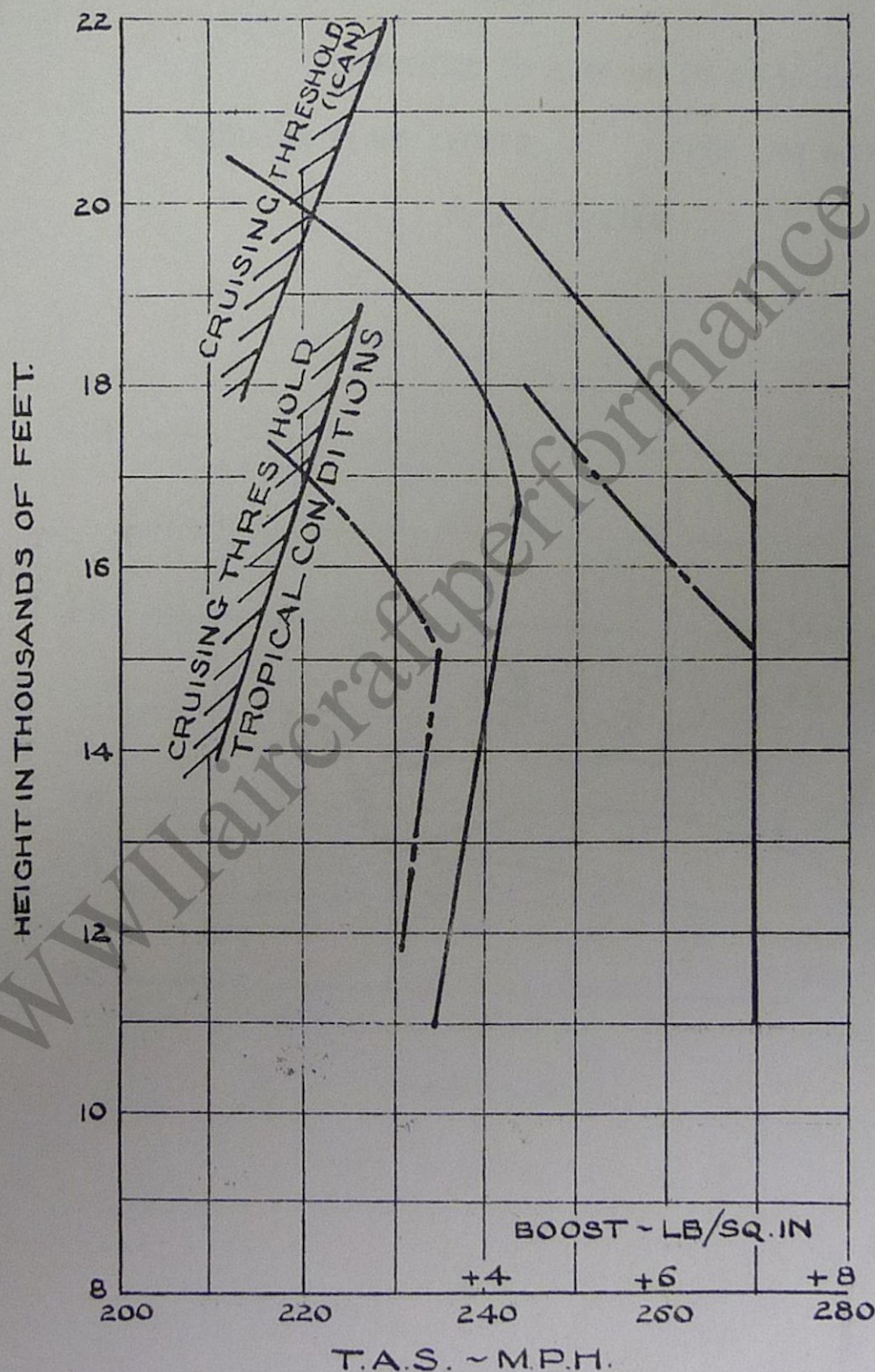
CORRECTED TO A WEIGHT OF 66,500 LB

2650 R.P.M.

RADIATOR FLAPS CLOSED

CRUISING THRESHOLD BASED ON 162 MPH-EAS.

— UNDER I.C.A.N. CONDITIONS  
 - - - UNDER TROPICAL CONDITIONS



LEVEL SPEED PERFORMANCE.



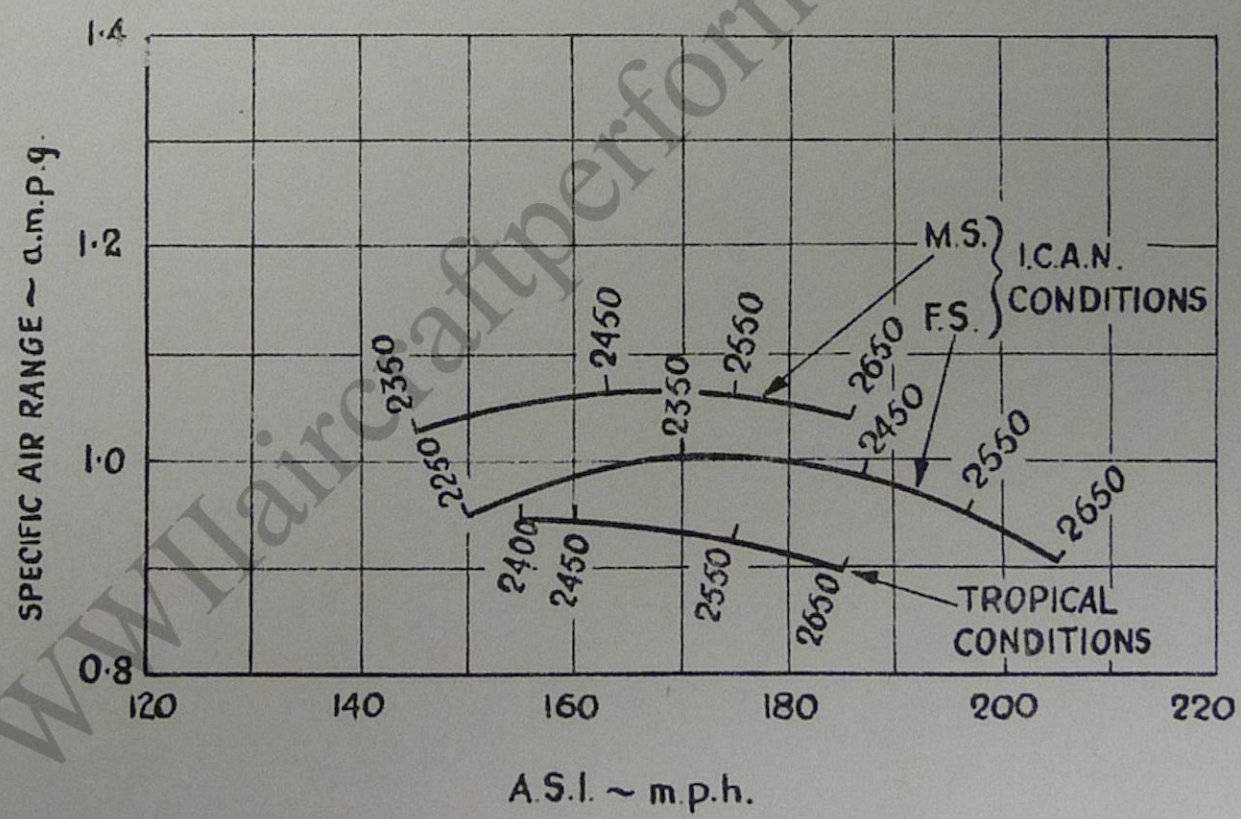
Fig. 76

M.S. AND F.S. GEAR, UNDER I.C.A.N. CONDITIONS,  
AND F.S. GEAR UNDER TROPICAL CONDITIONS.

15,000 FT.

CORRECTED TO A WEIGHT OF 66,500 lb.

RADIATOR FLAPS CLOSED, COLD AIR INTAKES.  
FULL THROTTLE.



SPECIFIC AIR RANGE.