3rd Part of Report No. A. & A.E.E./769, a.

31 JUL 1942

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT
BOSCOMBE DOWN

Liberator III. L.V.337
(4 - Twin Wasp R.1830-43)

Brief performance and tail buffet tests

A. & A.E.E. ref: 449/49-A.E.6376
M.A.P. ref: R.A.3201/DANA2/JLBS.

Progress of issue of report

Report No.	Title
1st Part of A. & A.E.E./769, a.	L.V.337 - Flame damping trials
2nd do.	L.V.337 - Carbon Monoxide contamination tests

Contents of Report

SUMMARY

The following results have been obtained on the Liberator III at a starting weight of 56,000 lb.

(a) The maximum measured speed of the aeroplane is 269 m.p.h. at 20,000 ft., but this is not the full throttle height (See end of para.1).

(b) The time to 20,000 ft. is 63 minutes, and the time to 10,000 ft. is 25 minutes.

(c) The maximum rate of climb is 430 ft/min. at ground level. The service ceiling is not known.

(d) The aeroplane takes off in 895 yards and reaches 50 feet in 1295 yards, from rest (in zero wind and standard atmosphere).

(e) From the scanty information obtained it is probable that the engine cooling is satisfactory for tropical use.

(f) In level flight at rated power, opening the cooling gills fully reduces the true air speed of the aeroplane by approximately 30 m.p.h.

(g) Tail buffeting is introduced when the inboard cooling gills are open within the range 1/3rd - 2/3rds but the degree of buffet is not dangerous at best climbing speed.

1. Introduction.

In accordance with instructions from M.A.P., brief performance tests have been completed on a Liberator IIIa, fitted with four Twin Wasp R.1830-43 engines (turbo superchargers).

The tests were carried out between April and July, 1942. Measurements of oil inlet temperature and cylinder temperatures on the climb obtained on single-point pyrometers are included in this report.

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The cylinder temperature measurements cannot be regarded as representing accurately the true temperature of the engine, nor is there any evidence to show that they are fitted to the hottest cylinder in each case.

As a result of information received from the U.S.A. that tail buffeting had been experienced on the B.24 D, brief tests were carried out at this Establishment to investigate the degree of buffet introduced when the cooling gills are opened. Results of these tests, together with speed measurements with varying gill settings, are included in this report.

The performance measurements were confined to heights up to a maximum height of 20,000 ft., this being the greatest height reached in the time allowed for operating the engines under maximum permissible power conditions. No attempt has been made to predict the performance above that height. The greatest height at which the maximum permissible boost pressure can be obtained is 25,000 ft. according to data from the U.S.A.

2. Description of aeroplane.

Manufacturer	-	Consolidated Aircraft Corporation.
Type	-	United States Army Air Corps. B.24.D.
Engines	-	4 Twin Wasp R.1830 - 43.
Propellers	-	Hamilton Hydromatic (Feathering) - 11'6" diameter.
Armament	-	Martin mid upper turret - 2 x 0.5" guns.
		Bendix under turret - 2 x 0.5" "
		Consolidated rear turret - 2 x 0.5" "
		Nose - 1 free 0.5" gun.
Duties	-	Heavy bomber.

The engines are of the Twin Wasp SC3G type, fitted with G.E.C. Type B-2 turbo superchargers.

4-view photographs of the aeroplane are given at the end of this report.

3. Results of tests.

3.1. Position error correction. The position error correction at a weight of 53,000 lb. is given in Fig.1. while Figs. 2 and 3 give the details and position of the pressure head and the correction to the altimeter when connected to the static side of the A.S.I. system. No measurements were obtained with flaps and undercarriage down. The position error correction refers to the port pressure head; this was connected to the pilot's air speed indicator.

3.2. Level speed measurements. The results are given in Table I below and in Fig.4.

TABLE I
Level speed measurements
Take-off weight - 56,000 lb.
Engine gills closed

Height (feet)	2700 RPM. 45" Manifold Pressure Auto-Rich Mixture				2150 RPM. 29.5" Manifold Pressure Auto-Weak Mixture			
	ASI (mph)	Position Error & Compressibility Corrections		TAS (mph)	ASI (mph)	Position Error & Compressibility Corrections		TAS (mph)
		P.E.	C.E.			P.E.	C.E.	
6000	216.5	-2.8	-0.5	233	186.5	-3.1	-0.3	200
8000	215.5	-2.8	-0.6	239	186	-3.1	-0.4	206
10000	213.5	-2.8	-0.8	244	185	-3.1	-0.5	211
12000	211.5	-2.8	-1.0	249	183.5	-3.1	-0.6	216
14000	209	-2.8	-1.2	254	182	-3.2	-0.7	221
16000	206	-2.8	-1.4	259	179.5	-3.2	-0.8	225
18000	204	-2.9	-1.6	264	176	-3.2	-1.0	227
20000	201.5	-2.9	-1.8	269	171.5	-3.2	-1.2	229

3.3. Climb. Results of climbs are given in Table II and Fig.5. As explained in para.1. the aeroplane has been climbed for a maximum of 63 minutes and the greatest height reached under the condition of test in that time was 20,000 ft. It was considered undesirable to extend the time beyond this limit in the interest of

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the engines. According to the data available from the U.S.A. the full throttle height (or, more correctly, the height up to which maximum boost can be maintained) is about 25,000 ft. The governing factor in this case is the permissible R.P.M. of the turbo-blowers. At 25,000 ft. the maximum permissible impellor R.P.M. are reached and the turbo-blowers must then be by-passed, so that the engines are then normally aspirated and the boost pressure falls off with increased height.

No attempt has been made to prodict the Service ceiling of the aeroplane above 20,000 ft. owing to the fact that the engine power and propeller efficiency are both unknown.

TABLE II
Climbing trials
Take-off weight - 56,000 lb.
Engine gills fully open

Height feet	Time mins.	Standard Rate of Climb ft/min.	ASI (mph)	RPM	Mean Manifold Pressure ins of Hg	Turbo Control Position % full travel	Engine gills	Intercooler shutters
0	0							
2000	4.5	420	145	2550	41	40%	open	open
4000	9.0	410						
6000	14.0	390						
8000	19.5	370						
10000	25.1	345						
12000	31.5	320				35%		
14000	38.0	290						
16000	45.5	255						
18000	53.5	220						
20000	63.0	180						

3.4. Take-off trials. The take-off run and distance to 50 ft. screen have been measured. The results, corrected to zero wind and standard atmosphere, are given below in Table III.

TABLE III

	All-up weight 56,000 lb.	All-up weight 47,000 lb.
Take-off run	895 yards	620 yards.
Time	28 secs.	22 secs.
Distance to 50' screen	1295 yards	860 yards.
Time	36 secs.	27 secs.
Take-off A.S.I.	110 m.p.h.	107 m.p.h.
Climbing A.S.I.	118 m.p.h.	115 m.p.h.
Manifold pressure	48 ins.	48 ins.
R.P.M.	2700	2700
Flap setting	50%	50%

For the take-off the normal technique for a tricycle undercarriage was used. If the throttles are opened up against the brakes and the nose wheel is not straight, the aeroplane will swing violently on the release of the brakes. This is avoided by opening up the throttles progressively to check any tendency to swing. When the forward speed is 10 - 15 m.p.h. the throttles are opened to full power on all four engines, and the aeroplane thereafter will keep on a straight course.

3.5. Cylinder and oil temperatures. Although cooling tests were not required on this aeroplane, temperatures recorded on the climb are given below for information. It should be noted that the oil thermometers and single point pyrometers are uncorrected for instrument error.

/Table IV

TABLE IV
Engine Temperatures on Climb

Height (ft)	A.S.I. (mph)	Air Temp. °C	Turbo blower %	Oil Press. - lb.				Oil Inlet Temp. °C				Cyl. Temp. - °C No. 5 on each engine			
				P.O.	P.I.	S.I.	S.O.	P.O.	P.I.	S.I.	S.O.	P.O.	P.I.	S.I.	S.O.
2,000	152	+13	40	90	90	91	90	53 70*	54 71*	53 70*	55 72*	200 224*	200 224*	200 224*	200 224*
4,000	153	+ 9		90	90	91	90	55 72*	55 72*	55 72*	56 73*	190 214*	210 234*	210 234*	200 224*
6,000	148	+ 6		90	90	91	90	55 71*	55 71*	55 71*	55 71*	195 218*	210 233*	215 238*	205 228*
8,000	150	+ 3		90	90	91	90	55 70*	55 70*	55 70*	55 70*	200 222*	220 242*	220 242*	210 232*
10,000	150	- ½		90	90	90	90	51 66*	55 70*	55 70*	56 71*	205 226*	225 246*	220 241*	195 216*
12,000	158	- 5	35	90	90	91	89	55 70*	57 72*	55 70*	57 72*	-	-	215 237*	205 227*
14,000	150	- 9		90	90	90	89	55 70*	57 72*	60 75*	56 71*	210 232*	230 252*	225 247*	215 237*
16,000	140	-13½		89	89	90	89	60 76*	60 76*	61 77*	57 73*	220 243*	235 258*	245 268*	240 263*
18,000	155	-18		88	90	87	88	68 84*	68 84*	68 84*	57 73*	215 238*	220 243*	220 243*	220 243*
20,000	150	-22½		89	89	89	88	68 85*	68 85*	68 85*	62 79*	215 239*	225 249*	225 249*	235 259*

Engine gills and intercooler shutters fully open.
For details of R.P.M. and boost see Table II.

* Corrected to tropical summer in accordance with A.D.M.491.
(For temperate summer conditions, subtract 10° from oil temperatures and 14° from cylinder temperatures).

Max. permissible oil inlet temp. for climb = 100°C
" " cylinder " " " = 260°C.

3.6. Effect of gill opening on speed. As a part of the investigation into the effect of opening the gills in flight, measurements were obtained of the speed of the aeroplane under rated power conditions at two heights with various gill settings. The results are given in Table V below.

TABLE V

Height (ft)	R.P.M.	Man. Press.	Inboard engine gills	Outboard engine gills	T.A.S. (mph)
15,000	2550	41"	Closed	Closed	243
"	"	"	"	Open	225.5
"	"	"	Open	Closed	230
"	"	"	"	Open	215
10,000	"	"	Closed	Closed	231
"	"	"	"	Open	219
"	"	"	Open	Closed	223
"	"	"	"	Open	198

4. Tail buffeting with cooling gill opening. The aeroplane was climbed with gills fully open at an airspeed of 150 m.p.h. A.S.I. The gills were then partially closed and buffeting on the tail appeared when the gills reached the ¼ closed position. Although on the majority of occasions buffeting was not experienced on the climb with the gills fully open, this did occur on two occasions and it was then noticed that the buffeting increased in magnitude during a turn.

Tests were made during engine-assisted glides with the gills operated throughout their working range. It was found that tail buffeting commenced when the gills were ¼ open, then increased in magnitude until the gills were ½ open, and, finally, decreased as the gills were further opened until, with them fully open, there was no buffet. This test confirmed the previous results obtained on the climb when it was determined that, generally, tail buffeting is not to be expected when the gills are fully open.

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The effect of the position of individual engine gills was next tested. The aeroplane was climbed at 150 m.p.h. A.S.I. with all gills fully open. The outboard engine gills were gradually closed but no tail buffeting was introduced at any stage. The outboard engine gills were, therefore, fully opened again and the inboard ones slowly closed. Buffeting set in when the gills reached the 2/3rds open position and continued until they were 1/3rd open. The inboard gills were then put back 2/3 rds. open and the airspeed of the aeroplane was increased slowly. There was no apparent increase in buffet between 150 and 180 m.p.h. A.S.I., but above 180 the buffeting increased, until at 200 m.p.h. A.S.I., it became quite severe. As the airspeed was decreased back to 150 m.p.h. A.S.I., the buffeting decreased, and, when the inboard gills were fully opened, it disappeared.

The degree of tail buffeting is not considered to be dangerous to the structure but is unpleasant to the occupants of the aeroplane. It can be overcome by avoiding the range 1/3 - 2/3 rds open of the cooling gills on the inboard engines.

Table VI

Engine limitations obtaining at time of tests
Twin Wasp R.1830-43

Condition	R.P.M.	Boost (ins.Hg.)	Oil inlet Temp.- °C	Oil Pressure (lb/sq.in)	Cylinder head Temp.- °C
Max.for take-off	2700	48	-	80-105	260
" " climb (1 hr.)	2550	41	85	80-100	230
" " cruise (rich)	2230	34	85	80-100	205
" " " (weak)	2150	29½	85	75- 90	205
" " all-out level 5 minutes	2700	45	100	80-100	260

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FIG 1

LIBERATOR III LV337

POSITION ERROR CORRECTION

WEIGHT ~ 53,000 lb.

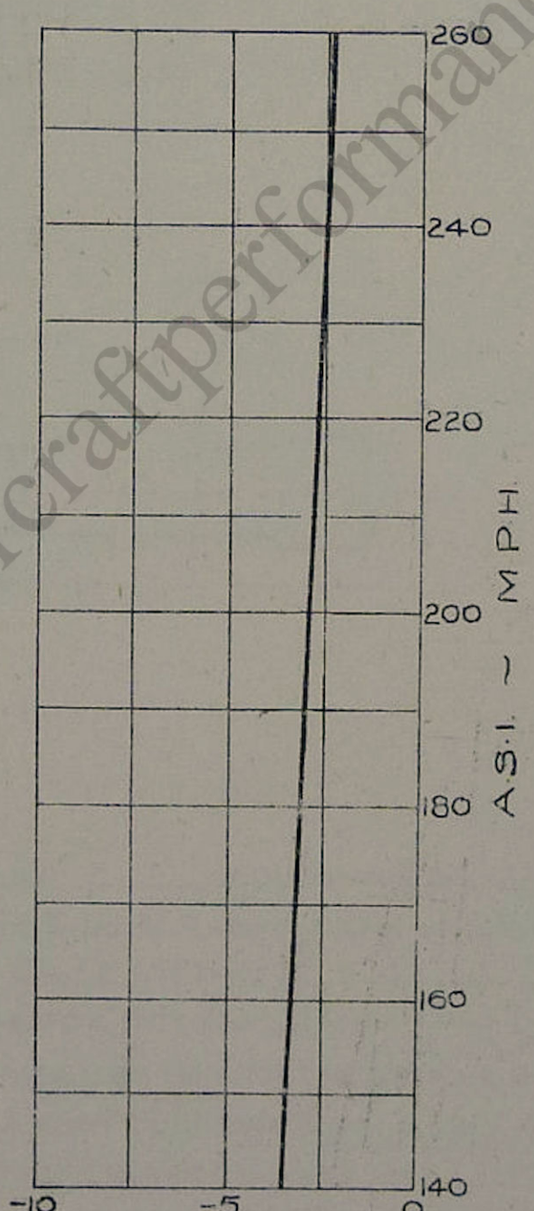
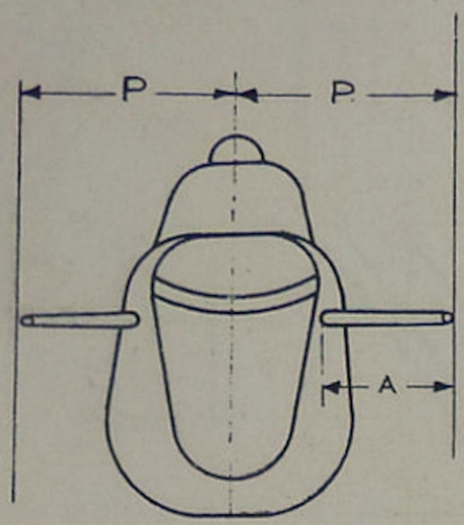
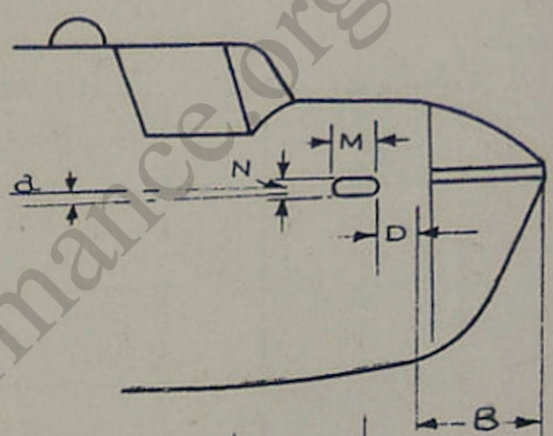


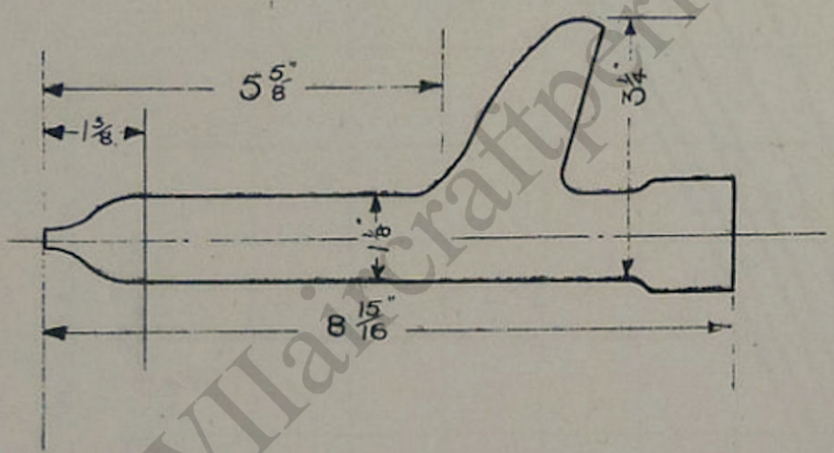
FIG 2

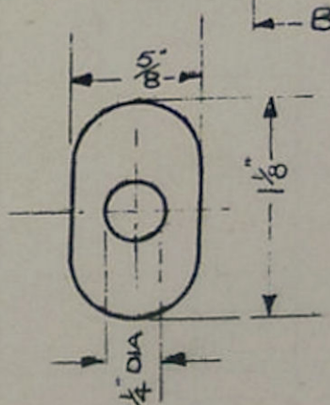
LIBERATOR III LV337

PRESSURE HEAD POSITION









DETAIL OF APERTURE.

Type of Pressure Head ..... KOLLSMAN D-1. 24V DC SPEC Nº 94-27876.

Ratio of Aperture of Tube to External Dia of Static Tube. SEE SKETCH

Incidence of Main Plane (at root) ..... 3°53'

a Angle of Static Tube to Chord of Main Plane — PORT +1°03', ST'BD. +3°29'

A Nose of Static to Fuselage (Minimum distance) — PORT 25 3/4" ST'BD. 29 7/16.

B " " " " Nose of Fuselage (parallel to datum line) ..... 2' 3 7/16"

D " " " " Strut (Minimum distance) ..... 8' 7/16" PORT & ST'BD.

M Major Axis of Strut. ..... 6" TAPERING TO 3" PORT & ST'BD.

N Minor " " " ..... 2 1/8 TAPERING TO 1 3/8" PORT & ST'BD.

P Position of Pressure Head — PORT 52 3/4", ST'BD 53 3/8" OF FUSELAGE.

3rd PART OF REPORT Nº A&AEE/769a. | SKETCH Nº 2370 | DRAWN RB. | TRACED WL | DATE 24-6-42. | CHECKED. GP. | APPROVED. A.S.C. | DO

FIG 3.

LIBERATOR III LV-337

CORRECTION TO ALTIMETER WHEN CONNECTED TO STATIC OF AIR SPEED SYSTEM.

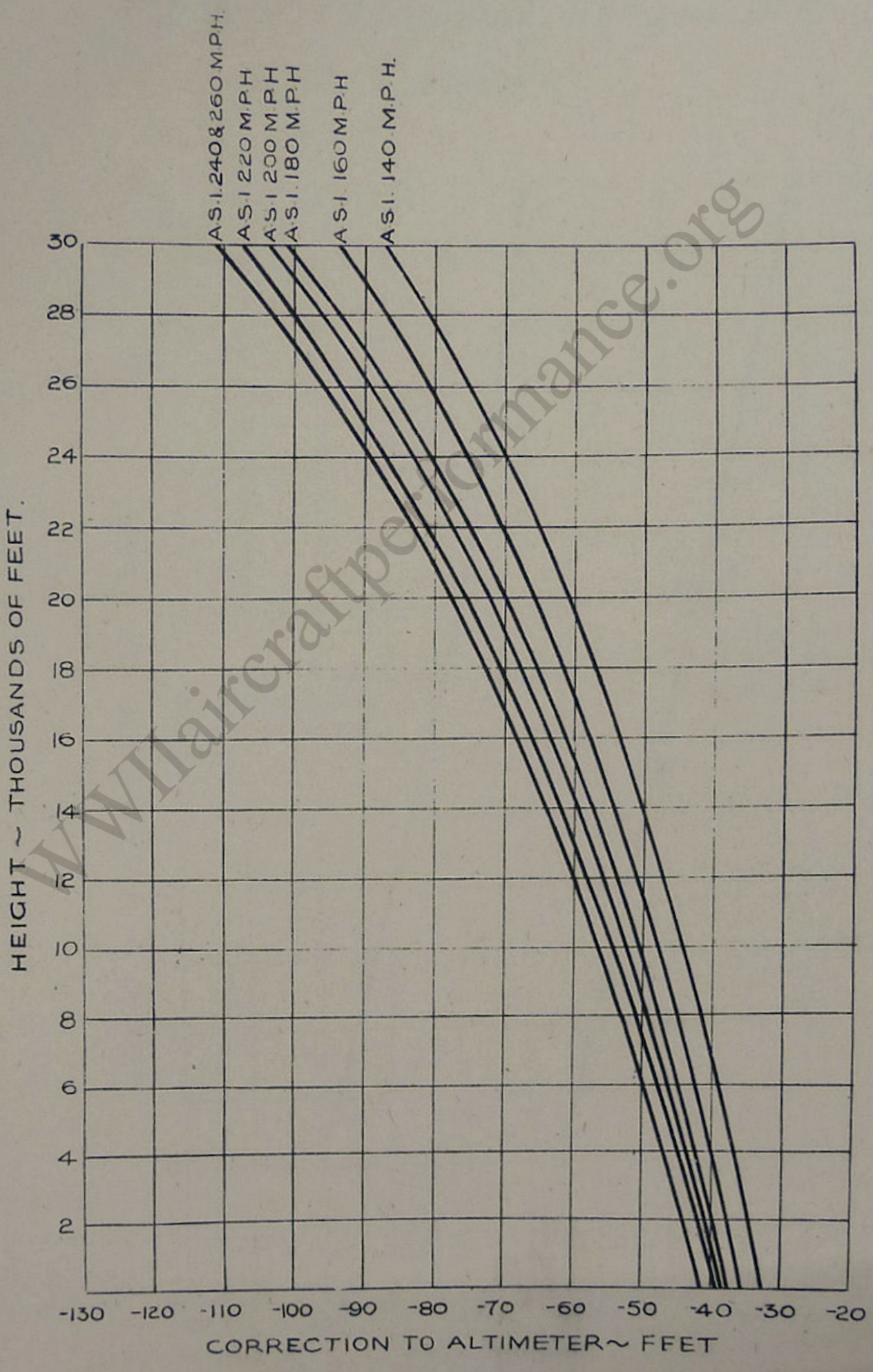


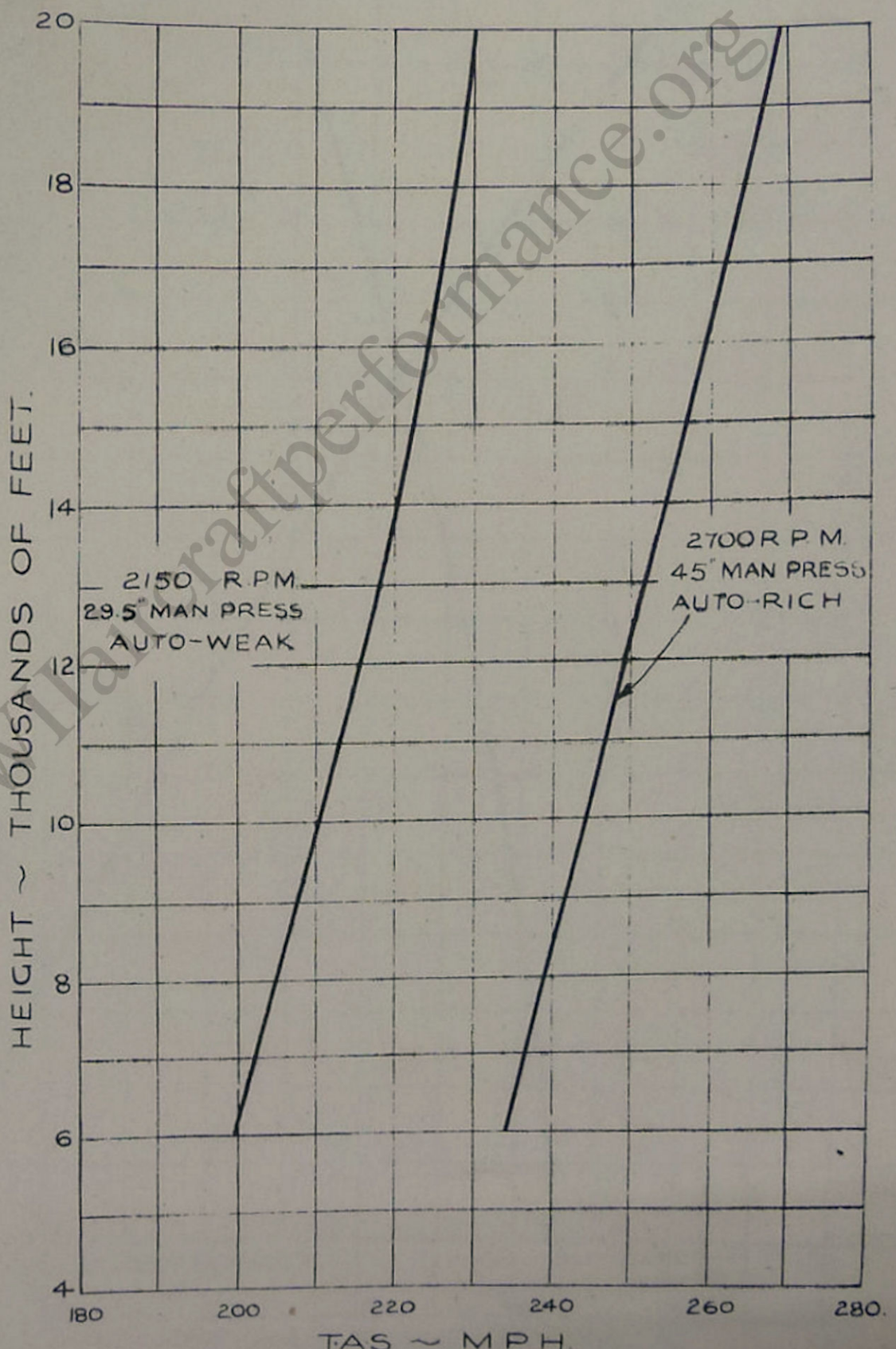
FIG 4.

LIBERATOR III LV337.

LEVEL SPEEDS AT HEIGHT

WEIGHT ~ 56,000lb AT TAKE-OFF.

GILLS CLOSED.



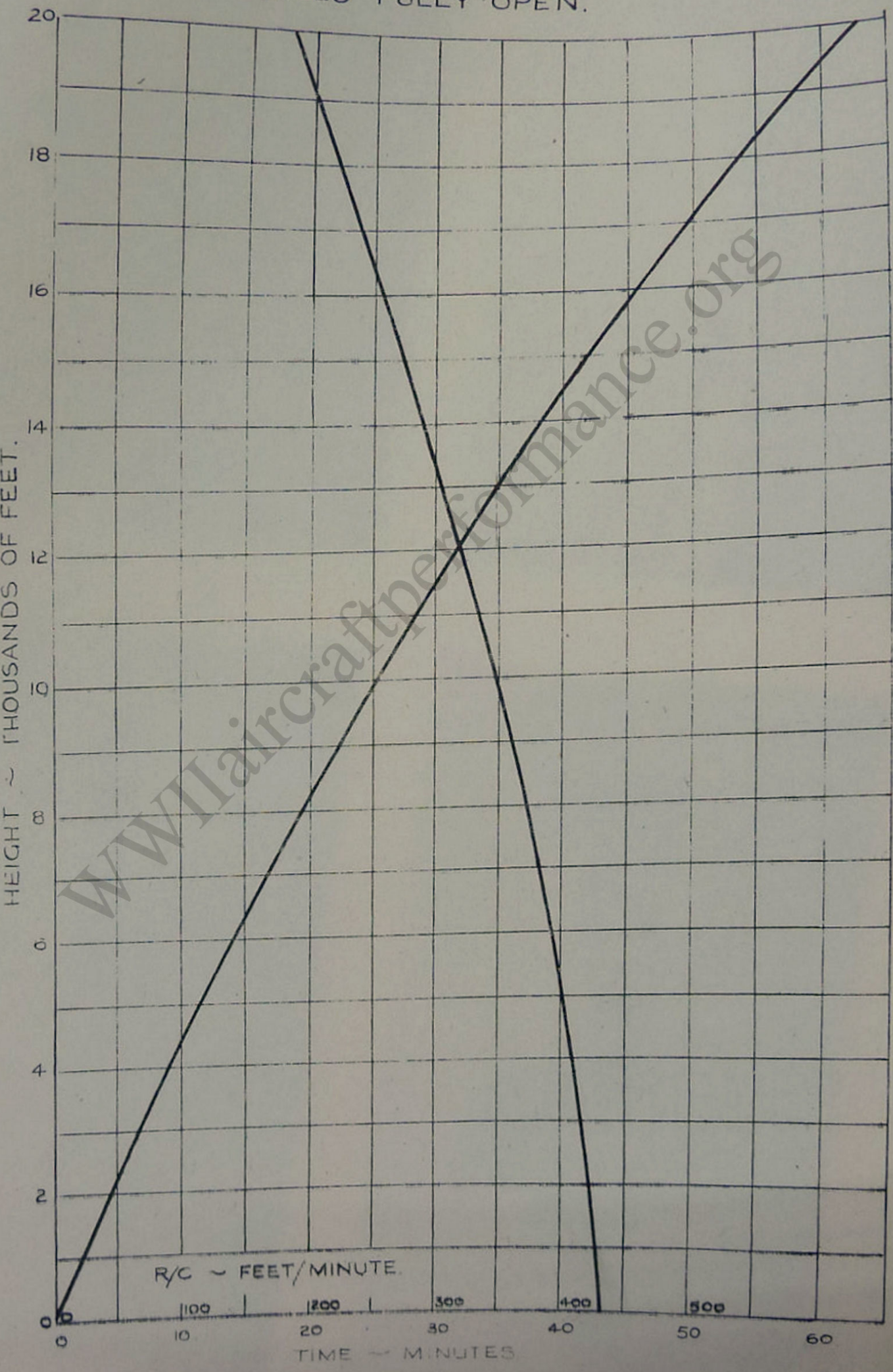
LIBERATOR III LV 337 FIG 5.

RATE OF CLIMB & TIME TO HEIGHT.

TAKE-OFF WEIGHT ~ 56,000 lb.

2550 R.P.M. 41" MAN PRESS.

GILLS FULLY OPEN.



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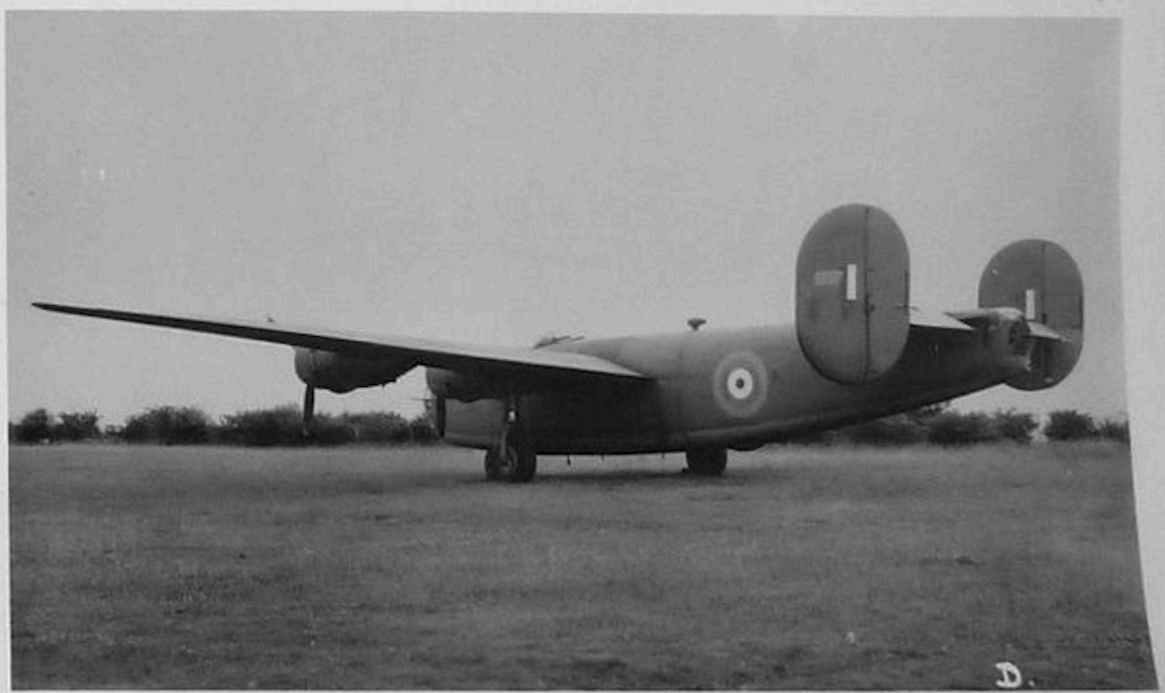
AM.11052 A.


B.


C.


D.