

VAM, TS

8th Part of Report No. A. & A.E.E./769, b.  
24 FEB 1944  
AIRCRAFT AND ARMAMENT EXPERTS' LABORATORY ESTABLISHMENT  
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Liberator V. BZ.791

(4 Twin Wasp - R.1830-43)

STOCK

Further fuel consumption measurements.

DATE 22/12/62

REDUCE TO

AUTHORISED

DATE

This report deals with the aircraft (in part) as far as is necessary to remedy defects, or decisions to accept items not in strict compliance with the specification, are matters for decision and action by the Ministry of Aircraft Production

A. &amp; A.E.E. ref:- CTO/AM.63/7

M.A.P. ref:- R.A.3421/11/DANA2

Period of tests:- December 1943 - January 1944

Report No.		Progress of issue of report	Title
3rd Part of	A. & A.E.E./769, b	BZ.791 - Level speed and P.E. measurements.	
4th	-do-	BZ.791 - Handling trials covering alleged elevator reversal and characteristics at forward C.G.	
5th	-do-	BZ.791 - Fuel consumption measurements and climb performance.	
6th	-do-	BZ.801 - Brief handling tests with retractable R.P. equipment fitted.	
7th	-do-	BZ.714 - Flame damping trials with two types of tapered shrouded slotted flame dampers.	

### 1. Introduction.

Further fuel consumption measurements have been made on Liberator V BZ.791 to provide information on the operational capabilities of this type of aircraft when using rich and weak mixture with the A.S.G. III is extended. Tests were also made at 20000 ft. with the A.S.G. removed and the opening faired to simulate the case of the bomber.

Fuel consumption measurements using weak mixture only made on the same aircraft fitted with A.S.G. III have been reported in the 5th Part of this Report.

### 2. Condition of aircraft relevant to test.

2.1. General. The aircraft was in a similar condition to that described in the 2nd Part of this report.

The A.S.G. III was removed and the opening faired for the tests at 20000 ft.

2.2. Propellers. The propellers fitted were Hamilton Standard Hydromatic Type 23E50/473, 11' 6" dia.

2.3. Engine numbers and limitations. The numbers of the Pratt and Whitney Twin Wasp R.1830-43 engines fitted were as follow:-

U.S. Army Air Corps No.	P.O.	P.I.	S.I.	S.O.
Makers No.	AC/42/45093	AC/42/45683	AC/42/45573	AC/42/45567
	56384	46974	56864	56858

The relevant engine limitations were as follow:-

	RPM	Boost (Inch Hg)
Take off	2700	48"
Climb	2550	43.5"
Maximum weak cruising	2230	31"
Maximum rich cruising	2230	34"

2.4. Carburetors. The carburetors fitted were Bondix Stromborg type PD-12F-4. These carburetors have no return pipe lines to the tanks from Chamber 'D' such as many Bondix carburetors have. It was unnecessary therefore to measure any return flow.

2.5. Loading. The tests were made at a take-off weight of 61950 lb. with C.G. 49" aft of the leading edge root chord.

A test was also made at a take-off weight of 57950 lb. with the C.G. 48.3" aft of the leading edge root chord.

2.6. Airspeed system. The pilots A.S.I. was connected to the port pitot-head and to common static of port and stbd heads.

### 3. Tests made.

Fuel consumption measurements were made under the following conditions:-

- (a) During a rated climb (2550 rpm 43.5" Hg boost) to 20000 ft. with A.S.G. removed and opening fairied. Take-off weight 62000 lb.
- (b) At 4000 ft. covering rich and weak mixture envelope conditions, A.S.G. extended at a take-off weight of 62,000 lb.
- (c) Covering rich and weak mixture envelope conditions at 20000 ft. at the end of test (a).
- (d) Covering weak mixture envelope conditions at 20000 ft. after taking-off at 58000 lb.

Fuel flows were measured by use of Kent flowmeters.

### 4. Results of test.

All results have been corrected to ICAN standard conditions in accordance with the methods of Report No. A & A.E.E./Res/170.

The position error correction used is that given in the 3rd Part of this Report.

4.1. Fuel consumption on climb. The fuel consumption measured during a rated climb to 20,000 ft. (2550 rpm, 43.5" boost) was found to be 441 gallons/hr., which confirms the figure used in the 5th Part of this Report.

4.2. Fuel consumption in level flight. The results are given in Tables I & II and Figs. 1-4 and are summarised below:

4.21. Fuel consumption at 4000 ft. The optimum specific air range obtainable in weak mixture at 4000 ft. with A.S.G. extended is 1.15 A.M.P.G. at a mean weight of 58,750 lb. and this is obtained by flying at 31" Hg boost and reducing rpm until an ASI of 160 mph is reached. The rpm will then be 1900 under ICAN standard conditions.

The corresponding optimum specific air range obtainable when using rich mixture and 34" Hg. boost is 0.95 A.M.P.G. at 160 mph ASI and at a mean weight of 60,500 lb.

If a flight at increased speed is necessitated by operational conditions a T.A.S. of 188 mph and specific air range of 0.67 A.M.P.G. can be obtained at a mean weight of 60500 lb. using maximum rich mixture cruising power (2230 rpm 34" Hg. boost). Using maximum weak mixture power a T.A.S. of 175 mph and specific air range of 0.93 A.M.P.G. can be obtained at a mean weight of 58,750 lb.

The minimum comfortable cruising speed at a take-off weight of 62,000 lb. is 160 mph ASI.

4.22. Fuel consumption at 20,000 ft. The tests at 20,000 ft. were carried out with the A.S.G. removed and the opening sealed in order to simulate the case of the Liberator V (Bomber).

As the rpm were reduced whilst maintaining boost constant at either 31" weak mixture or 34" rich mixture, engine fading was encountered at a little under 2000 rpm in either case. This phenomenon has been described in the 6th Part of Report No. A & A.E.E./769, a and consists of the breakdown of the turbo supercharger cycle due to the exhaust gas pressure becoming insufficient to drive the impeller fast enough to maintain the boost required. The boost then falls off resulting in a further drop in exhaust pressure. This cycle continues until eventually owing to loss of engine power the aircraft will no longer maintain height.

The rpm at which the individual engines started to fade are as follow:-

	P.O.	P.I.	S.I.	S.O.
34" Hg. boost rich mixture	1850	1975	1900	1850
31" Hg. boost weak mixture	1850	1950	1850	1850

It will be seen that the rpm at which fading commences varies from engine to engine and that runs at 1950 rpm were prevented because one engine commenced to fade at 1950 - 1975 rpm. On other aircraft it might be possible to reduce all four engines to 1850 rpm approx. and so obtain optimum conditions for a greater portion of the flight than on the aircraft tested.

The optimum specific air range obtained in weak mixture at 31" boost and a mean weight of 59,000 lb. was 1.17 A.M.P.G. at an ASI of 155 mph. The maximum specific air range obtained under weak mixture at 31" Hg. boost at a mean weight of 55,000 lb. was 1.29 A.M.P.G. at 157 mph ASI and 2000 rpm. Optimum conditions were not realised due to engine fading preventing further reduction in engine speeds.

Using rich mixture and 34" boost, a maximum specific air range of 0.88 A.M.P.G. was obtained at 2000 rpm and 168 mph ASI. Optimum conditions were again not realised due to engine fading.

The minimum comfortable cruising speed is 160 mph ASI. at 62000 lb.

#### 5. Method of operation at 20000 ft.

It was pointed out in the 5th Part of this Report that immediately after a climb to 20000 ft. at a take-off weight of 62000 lb. the maximum weak mixture cruising speed is lower than the minimum comfortable cruising speed. The first part of the flight at 20000 ft. should, therefore, be made at 34" boost in rich mixture reducing rpm till the verge of fading is reached. The flight in rich mixture should be continued until it is possible to fly comfortably under maximum weak mixture cruising power. (The weight will then be approximately 60000 lb.) The flight should then be continued at 155-160 mph ASI reducing rpm to maintain this speed until the rpm at which fading commences is reached. These engine conditions should then be maintained for the rest of the flight.

#### 6. Conclusions.

- (1) At a mean weight of 58,750 lb. the optimum specific air range is 1.15 A.M.P.G. at an ASI of 160 mph at 4000 ft. in weak mixture with the A.S.G. extended.
- (2) At a mean weight of 60,500 lb. the optimum specific air range is 0.95 A.M.P.G. at 160 mph ASI at 4000 ft. in rich mixture with the A.S.G. extended.
- (3) Under maximum rich mixture continuous cruising conditions a specific air range of 0.67 A.M.P.G. is obtained at a TAS of 188 mph at a mean weight of 60500 lb.
- (4) At 20,000 ft. the optimum specific air range at a mean weight of 59,000 lb. is 1.17 A.M.P.G. at 155 mph ASI in weak mixture. The maximum (not optimum) specific air range obtained at a mean weight of 55,000 lb. is 1.29 A.M.P.G. at 157 mph ASI.
- (5) Engine fading which occurs when the rpm are reduced below 2000 prevents optimum conditions from being realised especially at lighter weights.

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TABLE I

Fuel consumption in level flight 4,000 ft.

Gills fully closed. Intercoolers cold.

RPM	Boost	M/C	Mean weight mph	60,500 lb.			Fuel flow gallons/hr.	AMPG
				TAS mph	PEC mph	CE mph		
2230	34"	AR	188	- 7.5	-.3	185	282	0.67
2150			186	- 7.6	-.3	183	260	0.72
2100			184	- 7.8	-.3	182	246	0.75
2050			182	- 8.0	-.3	180	233	0.78
2000			180	- 8.1	-.3	178	220.5	0.82
1950			177	- 8.4	-.3	175	209	0.85
1900			174	- 8.5	-.3	173	198	0.88
1850			171	- 8.7	-.3	170	188	0.91
1800			167	- 9.0	-.2	166	180	0.93
1750			162	- 9.3	-.2	162	172	0.94
1700			157	- 9.7	-.2	158	166	0.95
1650			152	-10.0	-.2	153	161	0.94
1600			145	-10.5	-.2	147	157	0.93
Mean weight				58,750 lb.				
2230	31"	AL	175	- 8.4	-.3	174	188	0.93
2150			173	- 8.6	-.3	172	168	1.03
2100			171	- 8.8	-.3	170	159.5	1.07
2050			168	- 8.9	-.3	167	152	1.11
2000			165	- 9.1	-.2	165	146	1.13
1950			162	- 9.4	-.2	161	141	1.15
1900			159	- 9.7	-.2	158	136	1.15
1850			152	-10.0	-.2	153	132	1.15
1800			147	-10.4	-.2	148	128	1.15

TABLE IV

Fuel consumptions 20,000 ft.

Intercoolers cold. Gills fully closed.  
ASG removed and opening sealed

RPM	Mean weight mph	59,000 lb.			Fuel flow gallons/hr.	AMPG	
		TAS mph	PEC mph	CE mph			
2230	34"	225	- 8.5	-1.2	173	278	0.81
2150		223	- 8.6	-1.2	172	263	0.85
2100		220	- 8.8	-1.2	171	255	0.87
2050		218	- 8.9	-1.1	169	247.5	0.88
2000		212	- 9.2	-1.1	165	241	0.88
Mean weight				59000 lb.			
2230	31"	211	- 9.2	-1.1	164	213	0.99
2150		207	- 9.4	-1.0	162	188	1.10
2100		202	- 9.7	-0.9	158	176	1.15
2050		193	-10.2	-0.8	152	166	1.17
2000		181	-10.8	-0.7	144	156	1.16
Mean weight				55000 lb.			
2230	31"	219	- 8.0	-1.2	169	213	1.03
2150		216	- 8.1	-1.1	166	188	1.15
2100		212	- 8.4	-1.1	164	176	1.21
2050		208	- 8.6	-1.0	161	166	1.26
2000		201	- 9.0	-0.9	157	156	1.29

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FUEL CONSUMPTION ~ 4000 FT. FIG. 1  
INTERCOOLERS COLD

RICH MIXTURE 34" Hg BOOST.  
WEAK MIXTURE 31" Hg BOOST.

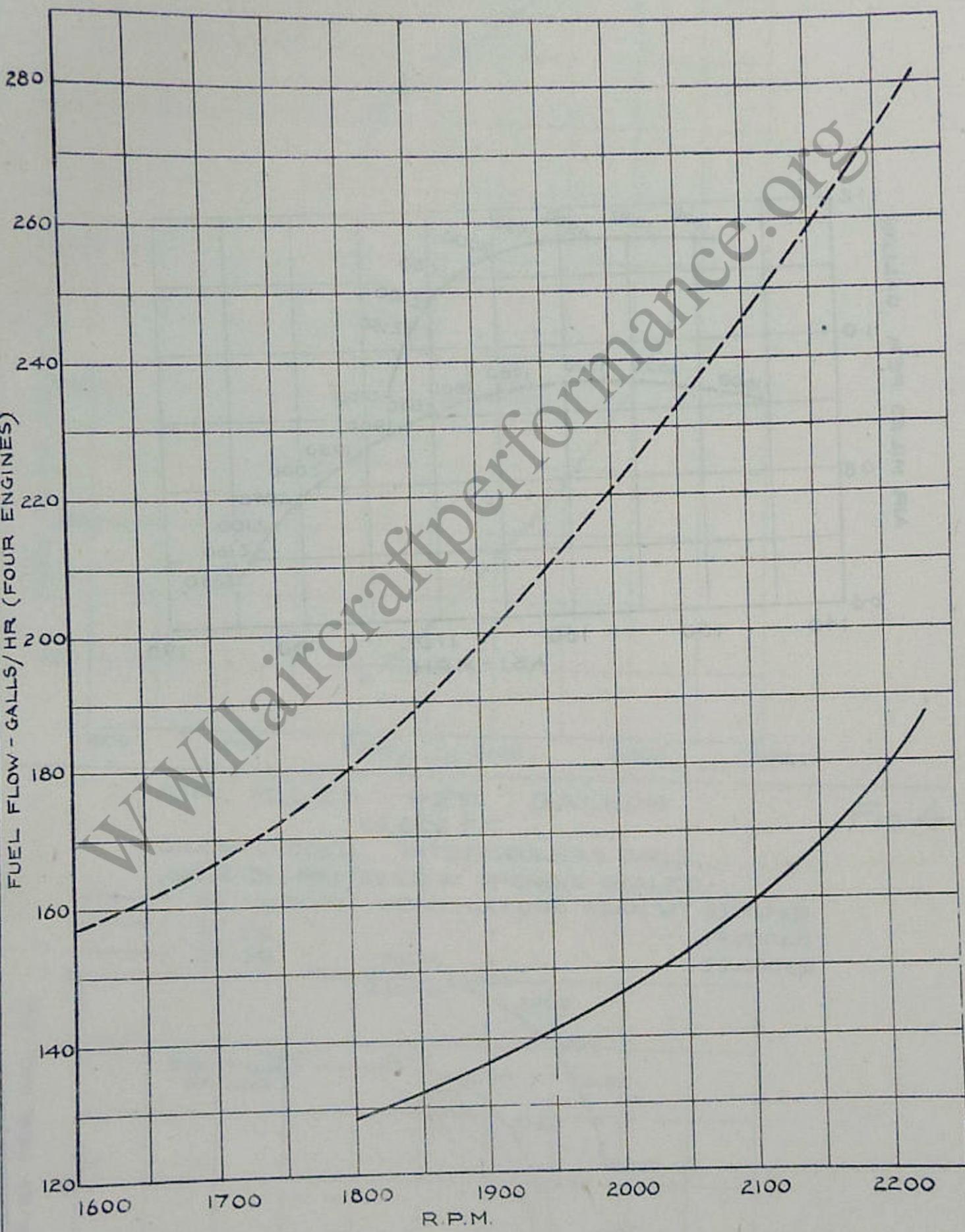
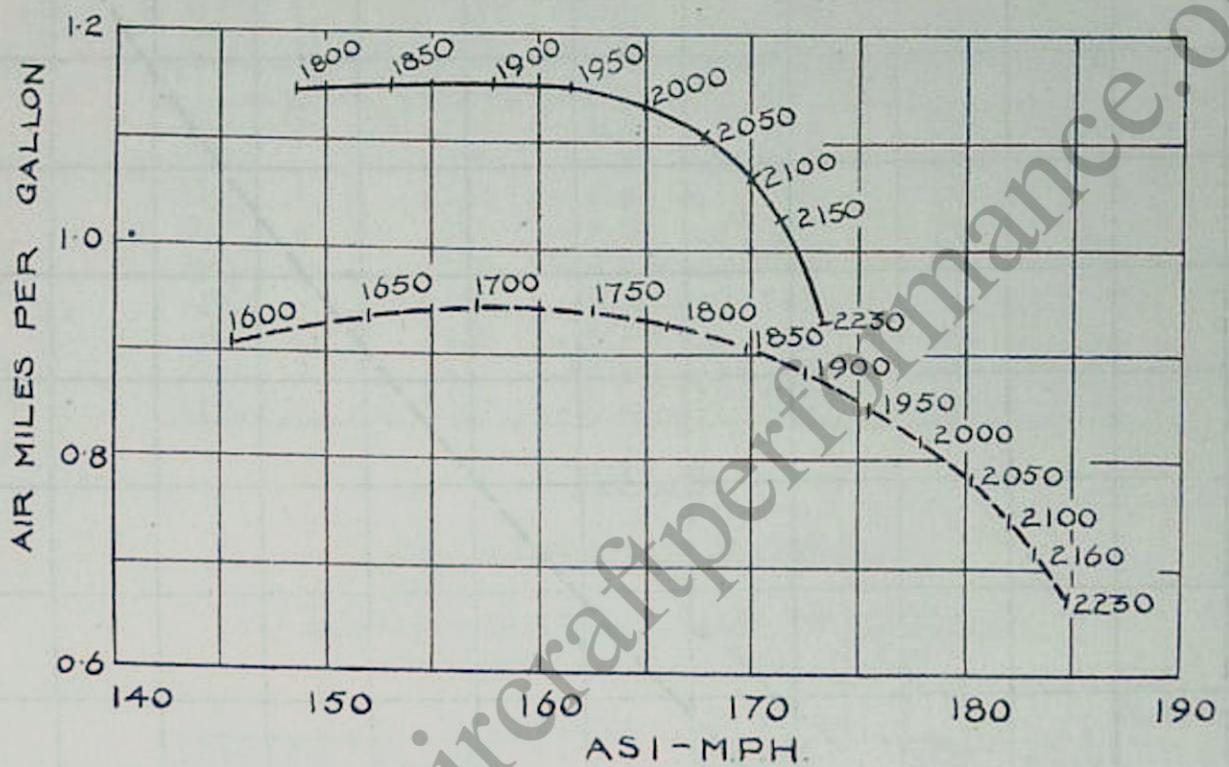


Fig. 2 AIR MILES PER GALLON - ASI 4000F  
INTERCOOLER COLD. GILLS FULLY CLOSED  
ASG EXTENDED.

— 31" Hg BOOST WEAK MIXTURE MEAN WT 58,750 LB  
---- 34" Hg " RICH " " " 60,500 LB



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100  
1 JUEL CONSUMPTION ~ 20,000 FT. FIG 3 & 4.  
INTERCOOLERS COLD

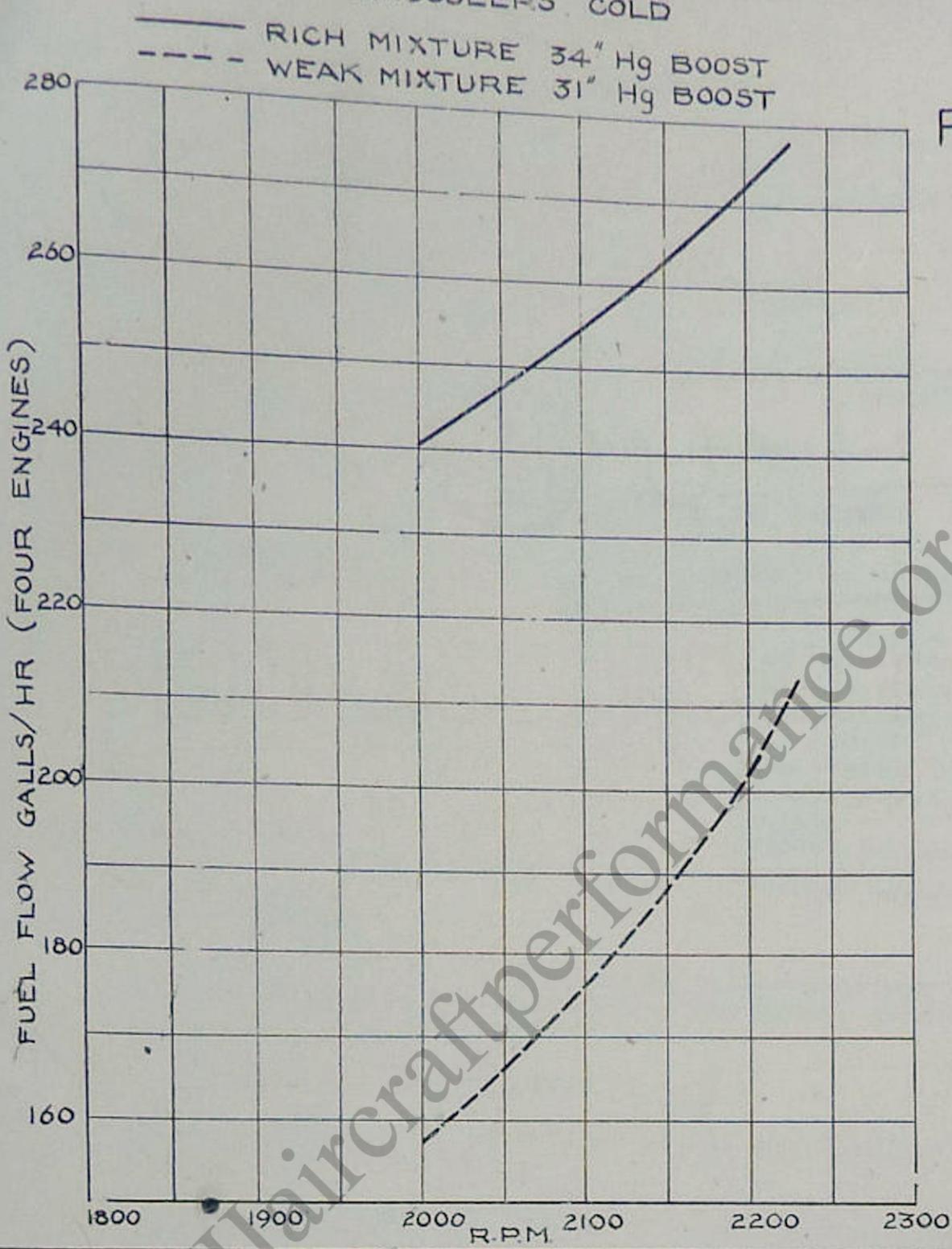


FIG. 3.

8<sup>th</sup> PART OF REPORT N° A&AEE /7696 LIBERATOR V BZ 791 CURVE N° 605/ TRACED B.M. DATE 7.2.44 CHECKED 2/64

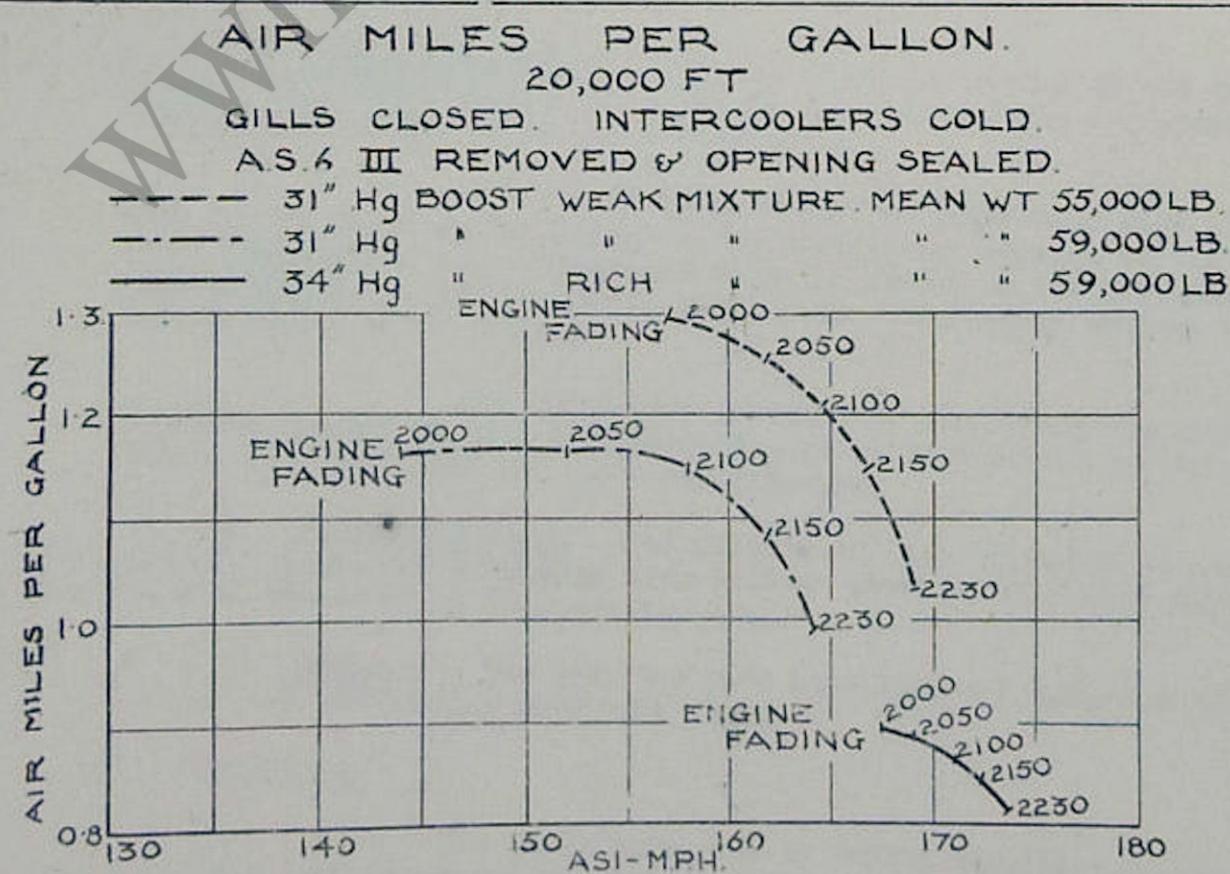


FIG. 4