ARMY AIR FORCES
MATERIEL [redacted] COMMAND

MEMORANDUM REPORT ON
B-24E Airplane, AAF No. 42-7073

WAB/mac/4

Date 23 November 1943

SUBJECT: Comparative Propeller Performance Tests

SECTION Flight

SERIAL No. Eng-47-1672-A

Contract No.
Expenditure Order No. 627-96
Purchase Order No.

A. Purpose

1. To report comparative performance results of tests run on the B-24E airplane, AAF No. 42-7073 at Wright Field using the following propellers:

a. Hamilton Standard Hydromatic, three-bladed constant speed full feathering propellers, blade design No. 6353A-18, normal blade angle range 18 to 88 degrees at 42 inch radius.

b. Hamilton Standard Hydromatic, three-bladed, constant speed, full feathering propellers, blade design No. 6477A-0, normal blade angle range 18 to 88 degrees at 42 inch radius.

B. Factual Data

1. Airplane was equipped with four (4) Pratt and Whitney R-1830-43 engines with exhaust driven turbo-superchargers and Minneapolis Honeywell turbo regulator. Tests were conducted under two load conditions: The first at a take-off gross weight of 50,900 pounds, c.g. at 28.69 percent m.a.c., wheels up; the second at a take-off gross weight of 60,000 pounds, c.g. at 23.18 percent m.a.c., wheels up, unless otherwise noted.

Airplane was flown with landing gear retracted, wing flaps neutral, oil cooler shutters automatic, intercooler shutters wide open; astro-dome and radio antennae in place and de-icer boots installed; cowl flaps in specified position. Belly turret retracted; two fifty caliber guns each in the top fuselage turret and in the tail turret, pointed rearward; a single fifty caliber gun in the nose pointed straight ahead and depressed thirty degrees and a single fifty caliber gun in the nose pointing to the left at right angles to the line of flight and elevated approximately forty-five degrees.

Chart power data was obtained from Pratt and Whitney Aircraft R-1830-43 engine power curve No. T-731 dated 11 February 1941 and revised 11 April 1941.

Archives of M. Williams

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2. Power calibrations with propeller blade design No. 6353A-18 (narrow blades) cowl flaps closed; mixture as noted.

a. Level flight at 3000 feet.

Estimated Gross Weight Pounds	RPM	Manifold Pressure " Hg.	Automatic Mixture Setting	Average Test BHP Per Engine at Test Weight	True Speeds MPH
59,150	2690	46.8	Rich	1191	241
58,570	2700	43.1	Rich	1093	234
58,065	2550	44.9	Rich	1127	240
57,490	2550	41.1	Rich	1026	228
57,020	2400	39.1	Rich	946	223.5
56,530	2300	37.5	Rich	878	217
56,050	2250	35.5	Rich	814	211
55,610	2200	34.2	Rich	772	207
55,340	2200	33.7	Lean	761	205
55,140	2100	31.3	Lean	663	190.5
54,910	2000	29.8	Lean	597	176
48,000	2700	45.8	Rich	1158	242
47,130	2550	45.9	Rich	1146	242
46,350	2550	42.0	Rich	1050	234.5
45,880	2400	39.9	Rich	960	229
45,550	2300	37.9	Rich	888	223
45,340	2250	35.6	Rich	817	217.5
45,210	2200	34.4	Rich	775	211.5
45,020	2200	33.9	Lean	764	210.5
44,880	2100	31.5	Lean	674	197.5
44,710	2000	30.0	Lean	602	187.5
44,550	1900	25.9	Lean	477	159.5

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b. Level flight at 15,000 feet.

Estimated Gross Weight Pounds	RPM	Manifold Pressure " Hg.	Automatic Mixture Setting	Average Test BHP Per Engine at Test Weight	True Speed MPH
58,000	2550	44.5	Rich	1143	270
57,380	2550	40.4	Rich	1047	263.5
56,990	2400	37.7	Rich	942	254
56,605	2300	35.2	Rich	859	244.5
56,190	2200	31.7	Rich	750	232.5
55,970	2200	31.3	Lean	743	230
55,740	2150	30.0	Lean	694	222.5
55,475	2100	29.5	Lean	669	216.5
55,335	2050	27.9	Lean	617	200.5
55,295	2690	46.5	Rich	1208	278
54,850	2690	44.9	Rich	1170	274
54,450	2690	42.1	Rich	1098	270
53,735	2690	40.2	Rich	1051	263.5
53,095	2690	37.4	Rich	972	256
49,110	2550	44.8	Rich	1150	276
48,590	2550	41.1	Rich	1057	267
48,190	2400	38.6	Rich	960	258
47,780	2300	35.6	Rich	871	250
47,450	2200	32.3	Rich	767	238.5
47,120	2200	31.5	Lean	749	237.5
46,860	2150	30.2	Lean	700	228
46,550	2100	29.2	Lean	662	223
46,310	2050	28.3	Lean	631	218
46,080	2000	26.8	Lean	582	206
45,880	1900	26.3	Lean	545	202

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3. Power calibrations with propeller blade design No. 6477A-0 (wide blades); cowl flaps closed; mixture as noted.

a. Level flight at 3000 feet.

Estimated Gross Weight Pounds	RPM	Manifold Pressure "Hg.	Automatic Mixture Setting	Average Test BHP per Engine at Test Weight	True Speed MPH
59,100	2680	47.2	Rich	1208	241
58,760	2550	45.3	Rich	1137	239
58,420	2550	41.5	Rich	1034	232
58,160	2300	37.4	Rich	874	220
57,930	2200	34.5	Rich	777	209
57,790	2200	33.9	Lean	759	206
57,680	2100	31.4	Lean	656	190.5
57,180	2000	30.0	Lean	586	178
56,820	2550	41.6	Rich	1035	231
56,570	1900	27.5	Lean	503	146
55,450	2680	47.0	Rich	1215	240
55,100	2550	45.1	Rich	1131	238
52,750	2550	41.4	Rich	1040	231
52,400	2300	37.4	Rich	867	221
50,630	2680	47.1	Rich	1189	244.5
50,180	2550	45.1	Rich	1136	241
49,820	2550	41.1	Rich	1038	233.5
49,550	2300	37.7	Rich	893	223
49,320	2200	34.8	Rich	783	214
49,150	2200	34.3	Lean	774	213
48,980	2100	31.8	Lean	669	202.5
48,860	2000	30.3	Lean	601	190.5
48,780	1900	26.2	Lean	471	164
48,660	1800	28.3	Lean	493	171
48,110	2550	41.4	Rich	1039	233.5

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b. Level flight at 15,000 feet.

Estimated Gross Weight Pounds	RPM	Manifold Pressure Setting	Automatic Mixture Setting	Average Test BHP per Engine at Test Weight	True Speed MPH
58,121	2550	45.1	Rich	1169	274.5
57,688	2550	41.4	Rich	1078	264
57,320	2400	38.3	Rich	962	255.5
57,056	2300	35.8	Rich	875	244
56,773	2200	32.6	Rich	778	234
56,638	2200	32.1	Lean	764	231
56,480	2150	30.5	Lean	705	222
56,336	2100	30.0	Lean	683	217
56,221	2050	28.6	Lean	640	204.5
56,172	2690	47.2	Rich	1240	279
56,115	2000	27.2	Lean	590	193
56,014	1900	26.7	Lean	559	172
55,851	2690	44.8	Rich	1173	272.5
55,502	2690	41.8	Rich	1101	266.5
55,175	2690	39.8	Rich	1044	264.5
54,922	2690	37.7	Rich	980	258
49,180	2550	44.8	Rich	1152	274
48,260	2400	40.4	Rich	1017	260
47,670	2400	38.5	Rich	984	258
47,260	2300	35.5	Rich	868	246.5
46,780	2200	32.0	Rich	763	234
46,600	2200	31.3	Lean	747	233
46,320	2150	30.5	Lean	710	228.5
46,130	2100	29.9	Lean	682	226
45,910	2050	28.1	Lean	629	214
45,760	2000	26.5	Lean	575	203.5
45,610	1900	26.2	Lean	542	195
45,400	1810	27.4	Lean	541	196

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c. Level flight at 25,000 feet.

Estimated Gross Weight Pounds	RPM	Manifold Pressure "Hg.	Automatic Mixture Setting	Average Test BHP per Engine at Test Weight	True Speed MPH
47,730	2680	46.5	Rich	1226	305
47,320	2550	44.5	Rich	1158	302
47,000	2550	40.8	Rich	1062	294
46,620	2300	38.9	Rich	969	288
46,310	2300	36.0	Rich	906	281
46,010	2200	35.0	Rich	850	276
45,780	2200	33.0	Lean	803	271
45,590	2100	30.9	Lean	739	260
45,430	2100	29.8	Lean	665	248
45,280	1900	25.6	Lean	562	215
44,840	2550	40.5	Rich	1064	296

4. Climb data for propeller blade design No. 6353A-18 (narrow blades) with turbos on to give 46 inches of manifold pressure at 2550 engine RPM; mixture automatic-rich.

Altitude Feet	True Speed MPH	Average BHP per Engine	Rate of Climb Ft/Min.	Time to Climb Min.	Estimated Gross Weight Pounds
0	146.0	1145	820	0	60,200
5,000	157.5	1165	785	6.2	59,700
10,000	170.0	1170	710	12.9	59,185
15,000	184.0	1175	595	20.5	58,590
20,000	199.0	1165	450	30.1	57,850
*25,000	217.5	1150	275	44.0	56,790

*Climbs were discontinued above 25,000 feet because the turbo regulators were not functioning properly.

NOTE: Climb was not repeated at the light weight condition with propeller blade design No. 6353A-18 (narrow blades) because the airplane was taken away for another project.

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5. Climb data for propeller blade design No. 6477A-0 (wide blades) with turbos on to give 46 inches manifold pressure at 2550 engine RPM; mixture automatic-rich.

a. Take-off gross weight at 60,200 pounds.

Altitude Feet	True Speed MPH	Average BHP per Engine	Rate of Climb Ft/Min.	Time to Climb Min.	Estimated Gross Weight Pounds
0	146.0	1145	740	0	60,200
5,000	157.5	1165	740	6.8	59,865
10,000	170.0	1170	720	13.6	59,160
15,000	183.5	1175	640	20.9	58,590
20,000	198.0	1165	510	29.6	57,815
*25,000	215.0	1150	350	41.3	56,940

*Climbs were discontinued above 25,000 feet because the turbo regulators were not functioning properly.

b. Take-off gross weight at 51,670 pounds.

Altitude Feet	True Speed MPH	Average BHP per Engine	Manifold Pressure "Hg.	Rate of Climb Ft/Min.	Time to Climb Min.	Estimated Gross Weight Pounds
0	137.0	1145	46.0	1120	0	51,670
5,000	147.0	1165	46.0	1100	4.5	51,325
10,000	156.5	1170	46.0	1055	9.2	50,965
15,000	167.0	1175	46.0	980	14.2	50,580
20,000	180.0	1165	46.0	870	19.5	50,165
25,000	194.0	1150	46.0	730	25.8	49,690
**26,200	198.0	1145	46.0	690	27.5	49,560
30,000	209.0	1025	40.3	375	34.7	49,050

**Critical altitude for 2550 RPM and 46 inches of manifold pressure at limiting turbo RPM.

6. Results of comparative take-off tests obtained by the photographic method will be reported by the Aircraft Laboratory.

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7. Determination of airspeed and altimeter errors with two type D-1 airspeed heads, one on each side of the fuselage with static openings 28 inches out from the fuselage, 26 inches behind the line of intersection of the nose and fuselage and approximately level with the top of the astro-dome fairing. Static lines interconnected, and pressure line connected to left head only.

Indicated Airspeed MPH	Indicator vs Water column MPH	Calibrated Airspeed MPH	Airspeed Installation Error MPH	Altimeter Error Feet
240	239	242	-3.0	-20
225	224	225.5	-1.5	-10
210	209	209.5	-0.5	0
190	188	186.5	+1.5	+15
170	168	165.5	+2.5	+30
150	148.5	144.5	+4.0	+45
130	129.0	123.5	+5.5	+60

C. Conclusions.

1. In level flight at 3,000 feet at both gross weights, the wide blade propeller (design No. 6477A-0) is very slightly faster (approximately one MPH) at high speed and from 3 to 10 MPH faster through the cruising range; at 15,000 feet at both gross weights the narrow blade (design No. 6353A-18) is approximately 3 MPH faster at high speed and 2 to 3 MPH faster through the operating range with approximately the same performance at the very low powers. Only the wide blade (design No. 6477A-0) was run at 25,000 feet so no comparison can be given at this altitude. The comparative performance results of the speed vs power data corrected to gross weights of 49,000 pounds and 60,000 pounds are shown on the attached summary curves on pages A-1 and A-2, respectively.

2. The above results are contrary to all expectations; speeds were accurately determined but since torquemeters were not available for this test, horsepower figures were obtained from engine power charts. This method of determining powers is never entirely accurate and may be considerably in error depending on the carburetor settings and the general overall efficiency of the engines on test airplane.

3. In the climbs at the heavy gross weight, the narrow blade propeller (design No. 6353A-18) has approximately 60 feet per minute higher rate of climb at sea level and approximately 75 feet per minute lower rate of climb at 25,000 feet than the wide blade propeller (design No. 6477A-0). Climb computations are accurate to ± 3%. Either propeller may be used with nearly equal effectiveness for all normal operations below 20,000 feet. Above this altitude the wide blade propeller (design No. 6477A-0) gives a decidedly better rate of climb.

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C. Conclusions

4. Flight Tests of this nature require accurate measurement of power as well as speed and should not be attempted without the use of torquemeters on all engines which can be so equipped.

D. Recommendations

None.

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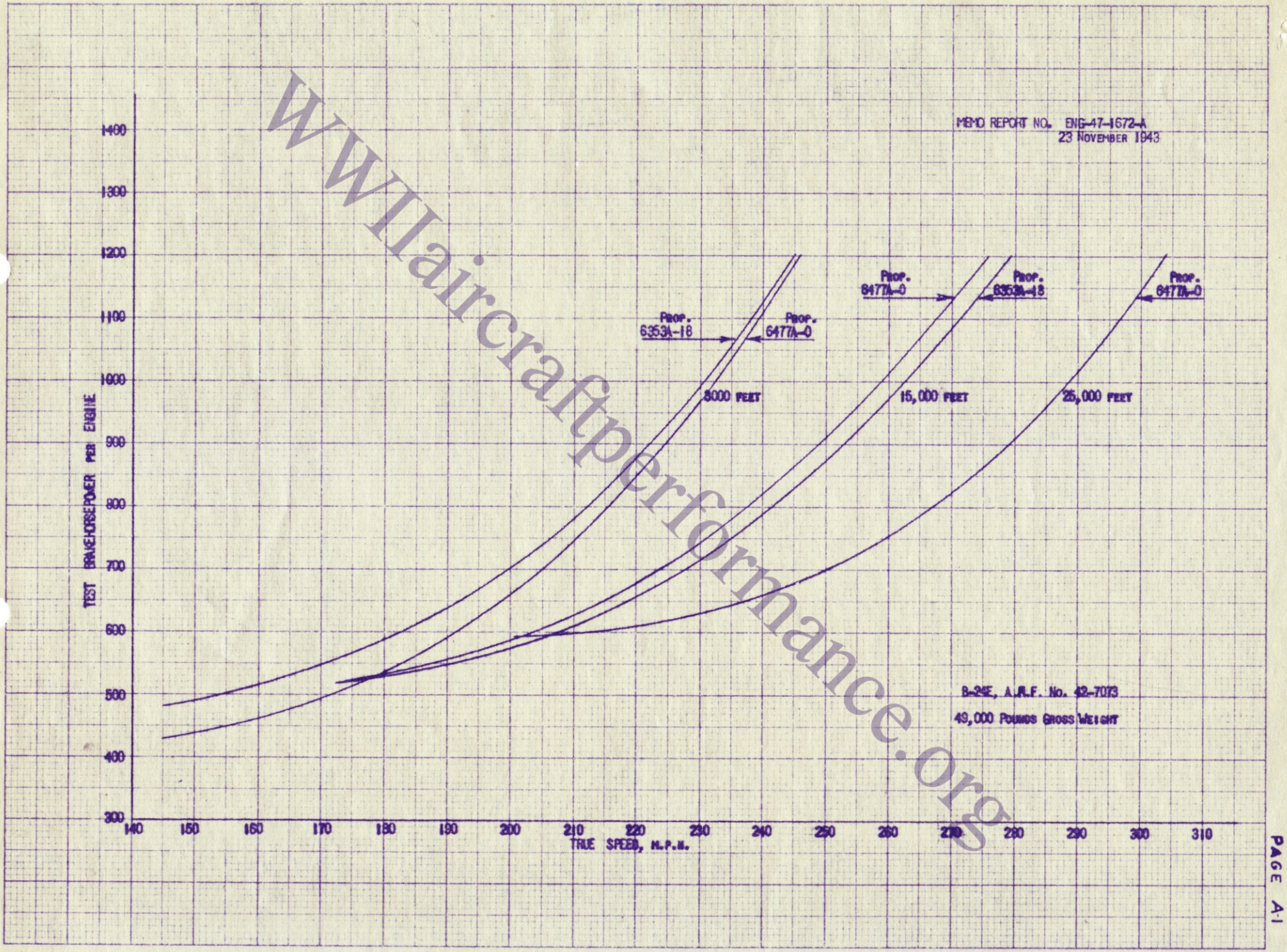

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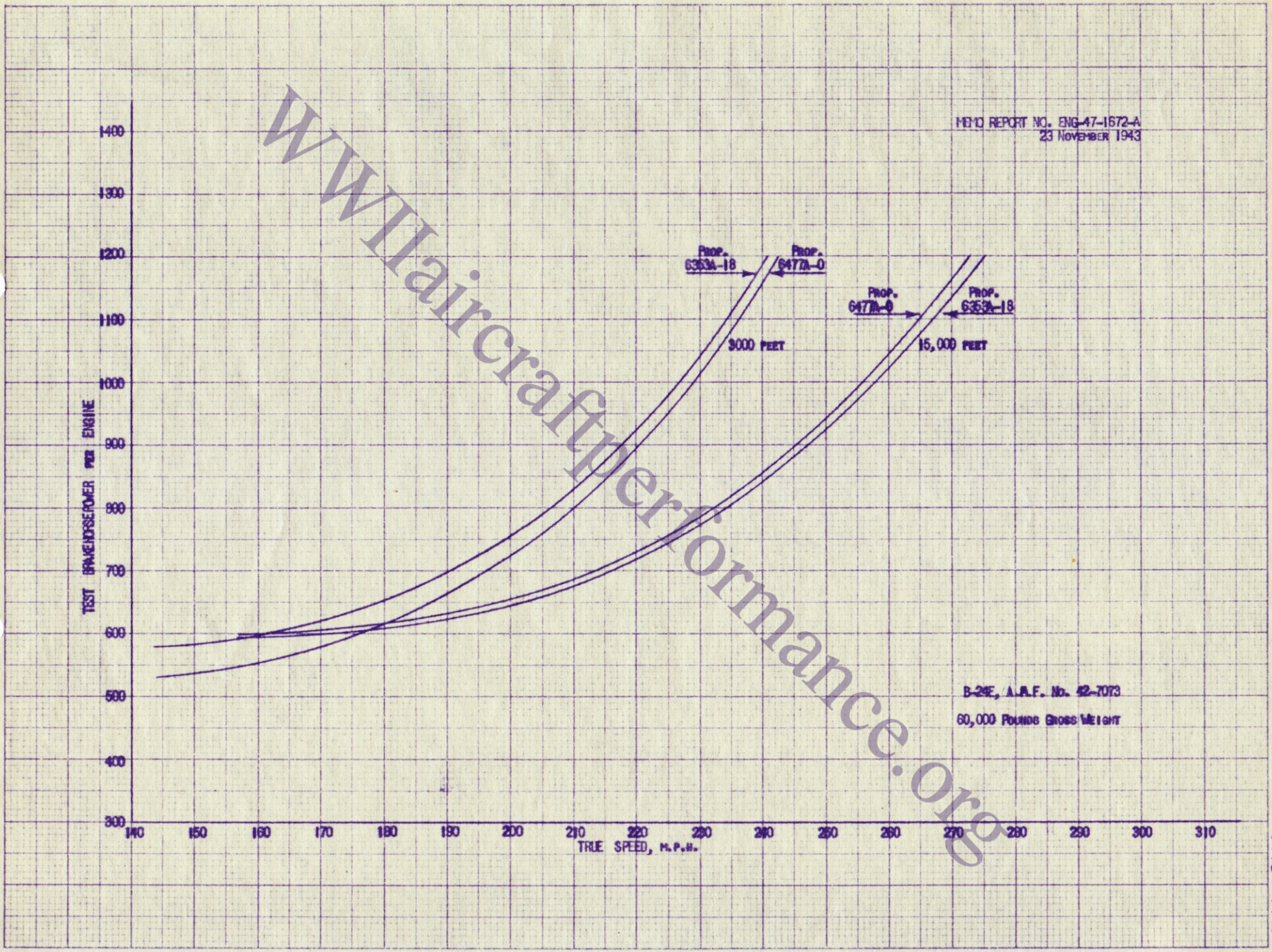

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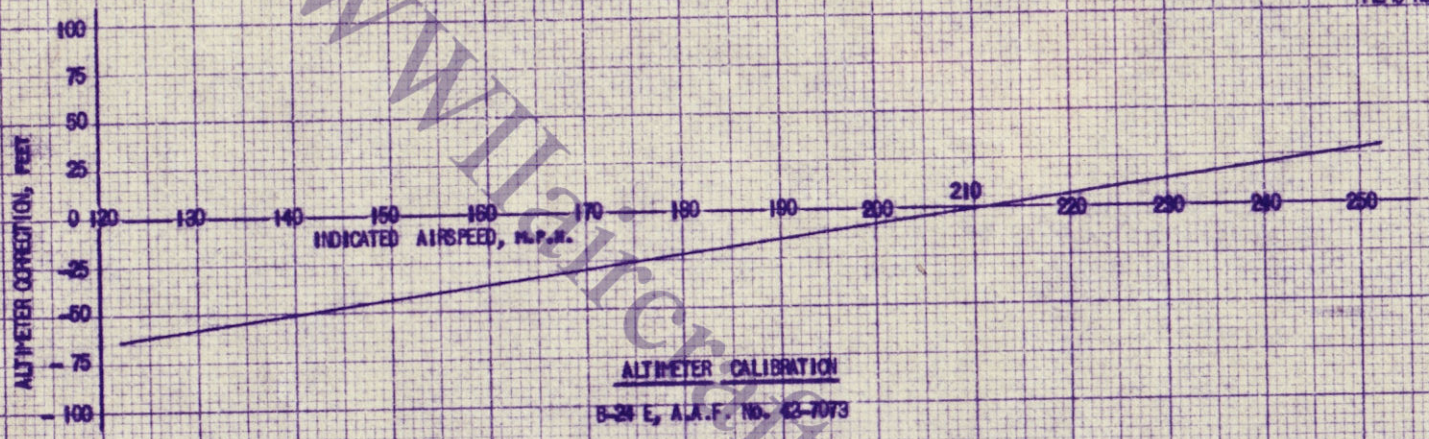
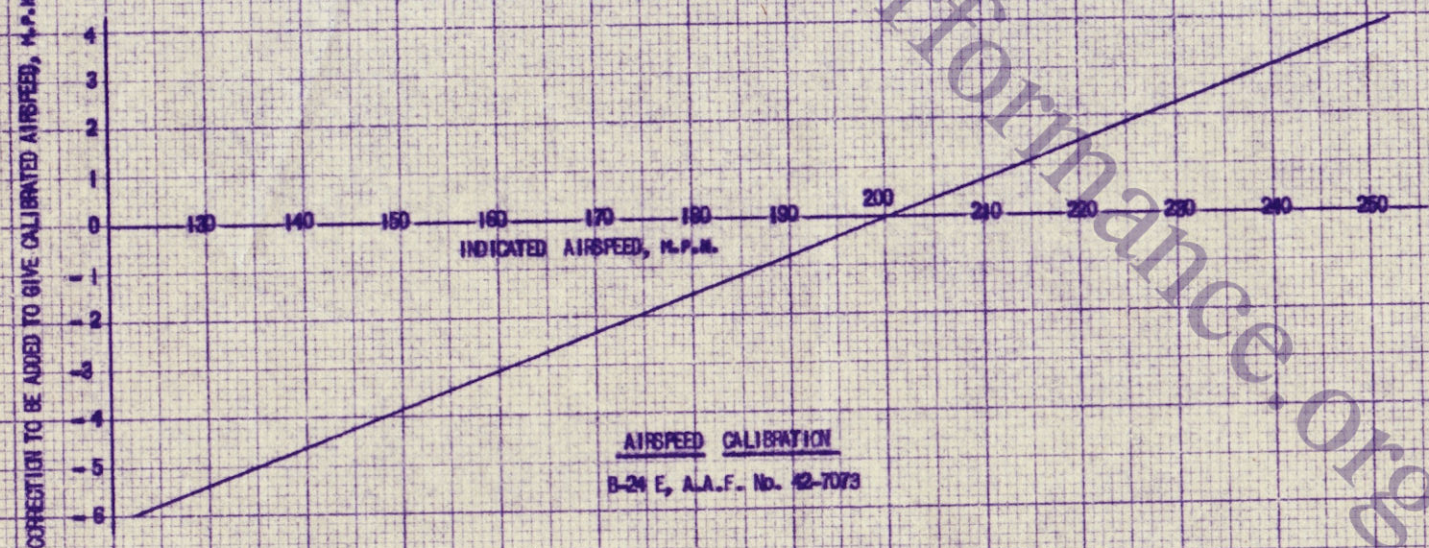


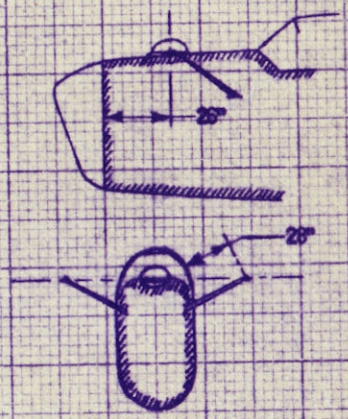
ALTIMETER CALIBRATION

B-24 E, A.A.F. No. 42-7073



AIRSPEED CALIBRATION

B-24 E, A.A.F. No. 42-7073



LOCATION OF PITOT HEAD
NOTE: AIRSPEED PRESSURE LINE CONNECTED TO LEFT HAND PITOT HEAD ONLY; STATIC LINES CONNECTED TO BOTH SIDES.
TYPE D-1 AIRSPEED HEADS

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