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R.A.A.F. Command, R.A.A.F., BRISBANE, Q'LD.

C.S.I.R. KITTYHAWK REPORT.

Attached herewith is one copy of the subject report titled :-

"Trials with an 83 I. gallon belly tank" - Part I.

"An investigation of the effect on the top speed of polishing the aircraft". - Part II.

These extracts have been taken directly from the Flight Test Reports and have not been checked for accuracy. Consequently, the information is to be used for guidance only, as the actual speeds, fuel consumptions and resulting ranges may be misleading if used to plan an operation.

It must also be borne in mind that with regard to any figures quoted, such as those for engine operation, the correct figures, as quoted in Air Board Technical Orders, shall always be taken as the overriding authority.

DTS.509/42.

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DIVISION OF AERONAUTICS.

Report No. E.8.

KITTYHAWK AIRCRAFT.

SUMMARY.

Part I: Trials with an 83 gallon Belly Fuel Tank.

An 83 (Imperial) gallon externally carried belly fuel tank of moulded plywood has been treated as an overload item on a Kittyhawk at normal maximum load, and its effect on performance in speed and climb determined.

On rated power the initial climb is decreased from 2000 ft. per minute to 1580 feet per minute by the addition of the tank. The time to 20,000' is increased from 11.7 minutes to 15.8 minutes, while the estimated service ceiling is decreased from 32,300' to 26,800'.

The top speed on military power at full throttle height is decreased from 348 m.p.h. at 12,300' to 314 m.p.h. at 12,000' and the top speed on rated power at full throttle height is reduced from 330 m.p.h. at 11,800' to 300 m.p.h. at 11,300' by the addition of the tank.

The top speed figures have been analysed and making some broad assumptions and with the consumption figures available, a curve is given showing the probable increase in range, at constant indicated airspeed, due to the addition of the tank.

Part II: An investigation of the effect on top speed of polishing the aircraft.

The effect of polishing the aircraft in stages has been investigated -

(a) Polishing control surfaces has no detectable influence on top speed or control characteristics.

(b) Polishing the mainplanes brought about an increase in the top speed on military power at full throttle height of about 6 m.p.h.

(c) Polishing the fuselage brought about an increase in top speed on military power of about 1 m.p.h.

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PART I.

INTRODUCTION.

A moulded plywood belly fuel tank for use on Kittyhawk aircraft was developed and manufactured by the Division of Aeronautics, C.S.I.R. At the request of D.T.S., R.A.A.F., the tank was treated as an overload item, and its effect on the performance in climb and level speed, of a Kittyhawk, was determined. Some estimates of the probable effect on range of the aircraft were made.

This work was carried out in the Special Duties and Performance Flight, R.A.A.F. Station, Laverton.

THE AIRCRAFT.

Name: Curtiss Kittyhawk (P-40E) - No. A29-129.

Engine: Allison V-1710-F3R. During the trials with the belly tank on, which were made first, the thermostatic control valve on the oil cooler of the first engine, No. 10019, seized, bypassing the cooler, and the engine seized due to the oil overheating. A second engine, No. 3400, was installed, and check speeds and climb determ nations revealed no significant difference due to the engine change. The trials without tank were made with the second engine. (For details see Table I).

Airscrew: Curtiss Electric 11' diameter (for details see Table II).

Loading: For trials without the tank, the all-up weight of the aircraft was 8626 lbs., as analysed in Table III. The belly fuel tank weighing 661 lbs., installed and full of petrol, brought the weight up to 9287 lbs. for the trials with tank fitted.

Position error: That obtained from D.T.S. was accepted without check, and is given in Fig. 1.

Fuel Tank: Shape details of the tank, which was of 83 imperial gallons capacity, are given in Fig. 5. A photograph of the tank installed on the aircraft is given in Fig. 6.

CLIMBING TRIALS.

Trials were made at an indicated airspeed of 140 m.p.h. up to the full throttle height on rated power (2600 r.p.m. - 39.0 ins. Hg. manifold pressure) of 9500'. Above this height this airspeed was reduced by 3 m.p.h. per 2000' increase in altitude. These speeds were arrived at by a few check partial climbs with belly tank on, and were used also for trials without tank.

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The initial rate of climb is 2000 ft. per minute and time to 20,000' is 11.7 minutes, these figures being reduced to 1580 ft. per minute and 15.8 minutes to 20,000' with the tank on. The service ceiling of 32,300' is reduced to 26,800' by the addition of the tank.

Details of the climbing trials are given in Table IV and Fig. 3.

SPEED TRIALS.

Trials were made at both military (5 minute) power (3000 r.p.m., 44.0 ins. Hg. manifold pressure) and rated (maximum continuous) power (2600 r.p.m., 39.0 ins. Hg. manifold pressure).

The top speed at full throttle height on military power is 348 m.p.h. at 12,300' and 314 m.p.h. at 12,000' with belly tank on. On rated power, the speed at full throttle height is 330 m.p.h. at 11,800' and 300 m.p.h. at 11,300' with belly tank on. Results have been corrected to an all up weight of 8600 lbs. for the standard Kittyhawk, and 9280 lbs. with tank on. Details of the speed trials are given in Table V and Figs. 4 and 5.

RANGE ESTIMATES.

The following assumptions have been made:

(a) A mean weight equal to that with half the total fuel consumed 8500 lbs. with tank, 8150 lbs. without tank.

(b) Excess fuel used in starting, warming up, taxying, take-off and climb to operational height - 15 minutes at rated power at sea level - 25 gallons.

(c) Available fuel is 80% of maximum capacity less allowance (b), 145 gallons with belly tank, 78 gallons at normal load.

(d) The drag of the tank installed was assumed to be 18 lbs. at 100 ft. sec., and allowance was made for the increase in weight of 661 lbs.

On these assumptions and based on the speed figures quoted above and the consumption figures given in Table I, the increased range due to the extra fuel available was computed for a series of constant indicated airspeeds and heights. It was found that within the order of accuracy of the calculations the increase in range was constant for operation at constant indicated airspeed and was independent of height. The results are shown plotted in Fig. 7 as increase in range against indicated airspeed. Thus at 250 m.p.h. true airspeed at 20,000' (182 m.p.h. I.A.S.) the increase in range is 330 miles, whereas at the same true

airspeed at 10,000' (215 m.p.h. I.A.S.) the increase is only 200 miles. The minimum speed for continuous cruising, 1.3 times the minimum power speed is 145 m.p.h. I.A.S.

Some discretion should be observed in using Fig.7. Some speeds, which without tank can be obtained on low power and lean mixture, with the belly tank fitted require higher power and consequent use of rich mixture. This results in increased consumption and deterioration in range.

MAINTENANCE ON THE BELLY FUEL TANK.

To instal the tank on the aircraft, the sway braces, designed for the standard 43 Imperial gallon belly tank, had to be lengthened. The fuel delivery pipe was incorrectly located and, in order to achieve a satisfactory pipe run, a special bent pipe from the union in the aircraft, and an increase in the size of the hole in the fuselage through which the pipe was led were necessary.

When installed, some difficulty in filling the tank was experienced, due to the poor location of the filler cap. This was installed too far under the fuselage, and too close to the aircraft to allow of easy access with the nozzle of the petrol hose.

During the trials the tank was flown for some 20 hours and was installed on the aircraft and contained petrol for just over a month. During this time no deterioration was detected and the tank remained leakproof apart from two small holes which developed, one on the top of the tank and the other around one of the screws locating the forward bulkhead in the tank. It is understood that the first hole was made by a small brad used during construction, and that the screws will be eliminated in future construction.

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TABLE I.

POWER PLANT INSTALLATION.

Engine Details.
(Extracted chiefly from U.S. Army Air Corps Technical Order No.02-SAB-1A

Manufacturer: Allison Division of General Motors' Corporation, Indianapolis, Indiana.

Engine name : Air Corps Type No. Allison V-1710-39 (Makers Type No. V-1710-F3R).

Serial Nos. : No. 1-10019, No. 2-3400.

Type : 12 cylinder liquid cooled Vee - single stage supercharger.

Weight : 1310 lbs. dry (maker's figure).

Specification:

Bore	5.50"
Stroke	6.00"
Capacity - cubic ins.	1710
Compression Ratio	6.65:1
Supercharger Ratio	8.80:1
Airscrew gear Ratio	0.50:1

Power Ratings :

	B.H.P.	R.P.M.	Man. Press. ins.Hg.	Mixture	Height Ft.	Fuel Cons. G.P.H.
Take-off	1150	2800	46.2	A.R.	S.L.	125
Military (5 min.)	1200	3000	43.9	A.R.	11,200	125
Rated (Max. cont.)	1000	2600	38.7	A.R.	10,200	103
75% Cruise	750	2280	31.6	A.R.	10,200	61
67% "	670	2280	28.9	A.R. A.L.	10,200	55 50
60% "	600	2190	27.4	A.R. A.L.	10,200	49 45
Max. Economy Cruise	375	1950	24.6	A.L.	S.L.	27.5
	430	1950	24.6	A.L.	5,000	31.6
	475	1950	24.6	A.L.	10,000	34.9
	520	1950	24.6	A.L.	15,000	38.2
	420	1950	F.T.	A.L.	20,000	31.6

Diving Rating 3120 R.P.M. (30 secs.)

Recommended Fuel : 100 octane.

Carburettor : PD-12K2 pressure type with automatic mixture control.

Lubrication System.

Desired inlet oil temperature	60-80°C.
Maximum " " "	95°C.
Desired oil pressure	70-70 lbs./in.^{2}
Maximum " "	85 " "
Minimum " "	55 " "
Idling " "	15 " "

Maximum allowable oil consumption -

At rated power	13.3 quarts/hour
" cruising power	10.0 " "

Cooling System

Desired coolant temperature	105-115°C.
Maximum " "	125°C.
Minimum " "	85°C.

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TABLE II.

AIRSCREW INSTALLATION.

Type : 3-bladed constant speed Curtiss Electric

Rotation : Clockwise from pilot's seat.

Drawing No. : 89301-3.

Diameter : 11'.

Pitch Range : 30°.

Blade Serial Nos: 24977, 24978, 24979.

Item	Calibration at 42" Radius (Maker's Ref. Station).	Calibration at 46.2" Radius (0.7 x Max.Radius).
Chord	9.45"	8.90"
Thickness	0.78"	0.68"
Thickness Ratio	0.0825	0.0765
Blade Angle Limits -		
Low	24½°	22½°
High	54½°	52½°

TABLE III.

KITTYHAWK LOADING ANALYSIS.

Item		Weight
Aircraft at tare weight		6220
Pilot and parachute		200
N2A Gunsight		4
6 x .50 calibre guns		463
Ammunition Boxes		80
1686 rounds .50 calibre ammunition		505
Desert Equipment		27
Radio		124
Tools		20
Fuel:	Front tank 29 galls. at 7¼ lbs./gall.	210
	Rear " 42 " " 7¼ " "	304
	Fuselage " 52 " " 7¼ " "	377
Oil :	10 galls at 9 lbs/gall.	92
	Normal maximum load	8626 lbs.

Overload

Sway braces and shackles	14
Belly tank	45
83 galls. fuel at 7¼ lbs/gall.	602
Overload weight	9287 lbs.

Note: These figures were taken from information available and were accepted without check. The centre of gravity of the sway brace and tank is 25 inches aft of datum, and of the fuel is 24 inches aft of datum.

(DTS.503/42)

TABLE IV

CLIMBING TRIALS.

Kittyhawk (P-40E) A29-129.

At 9280 lbs. (take-off wt.) with 83 gallon Belly Fuel Tank
And at 8626 lbs. (take-off wt) without Belly Tank.

Standard Atmosphere

I.C.A.N. Altitude (feet)	Airspeed - (M.P.H. Indicated	Position Error	True	Engine Conditions R.P.M.	Boost (ins.Hg.)	With Belly Tank 9280 lbs. Time from start (mins)	Rate of Climb (ft. per min.)	No Belly Tank 8626 lbs. Time from start (mins)	Rate of climb (ft. per min.
Sea level	140	+3	143	2600	39.0	0	1580	0	2000
1000'	140	+3	145	2600	39.0	0.6	1580	0.5	2000
2000'	140	+3	147	2600	39.0	1.3	1580	1.0	2000
3000'	140	+3	149	2600	39.0	1.9	1580	1.5	2000
5000'	140	+3	154	2600	39.0	3.2	1580	2.5	2000
7500'	140	+3	160	2600	39.0	4.8	1580	3.8	2000
9500'#	140	+3	165	2600	39.0	6.0	1580	4.8	2000
10,000'	139	+3	165	2600	38.7	6.3	1535	5.0	1970
12,500'	136	+3	169	2600	35.2	8.1	1325	6.4	1760
15,000'	132	+3	170	2600	32.0	10.2	1110	7.9	1550
17,500'	128	+3	172	2600	29.2	12.7	895	9.6	1340
20,000'	125	+2	174	2600	26.8	15.8	680	11.7	1130
25,000'	119	+2	180	2600	22.4	27.3	255	17.2	720
26,800'ø	118	+2	185	2600	21.3	37.9	100	-	-
30,000'	112	+1	185	2600	19.8	-	-	31.8	300
32,300'ø	108	+1	186	2600	19.0	-	-	40.5	100

#Full throttle height.

øEstimated service ceiling.
Maximum Height reached during trials - 20,000' with tank, 28,000' without tank.
Radiator shutter half open during climb. Trials made in rich mixture.

TABLE V

SPEED TRIALS.

Kittyhawk (P-40E) A29-129.

At 9200 lbs. (including 83 gallon Belly Fuel Tank)

And at 8600 lbs. (without Belly Tank)

Standard Atmosphere

I.C.A.M. Altitude (feet)	Military (5 min.) Power - 3000 RPM				Rated (Max. continuous) Power - 2600 RPM			
	With Belly Tank		Without Belly Tank		With Belly Tank		Without Belly Tank	
	Man. Press. ins.Hg.	TAS (MPH)	Man. Press. ins.Hg.	TAS (MPH)	Man. Press. ins.Hg.	TAS (MPH)	Man. Press. ins.Hg.	TAS (MPH)
Sea Level	44.0	270	44.0	300	39.0	256	39.0	285
1000	"	273	"	304	"	260	"	288
2000	"	277	"	308	"	264	"	292
3000	"	281	"	311	"	267	"	296
5000	"	288	"	319	"	275	"	304
7500	"	298	"	329	"	285	"	313
10,000	"	306	"	339	"	295	"	323
11,500≡	-	-	-	-	29.0	300	-	-
11,800⁂	-	-	-	-	-	-	39.0	330
12,000≡	44.0	314	-	-	-	-	-	-
12,300⁂	-	-	44.0	348	-	-	-	-
12,500	43.0	314	43.6	348	37.6	300	38.0	329
15,000	39.3	310	39.9	346	34.4	296	34.9	327
17,500	36.1	306	36.7	343	31.6	290	32.0	322
20,000	33.0	302	33.6	339	29.0	283	29.1	317
25,000	28.0	290	28.2	325	24.0	264	24.0	301
30,000	-	-	23.2	306	-	-	19.2	281

≡Full throttle height on rated power.

⁂ Full throttle height on military power.

Speed trials made in rich mixture, radiator shutter closed.

(DTS.503/42)

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PART II.

INTRODUCTION.

Reports were received by R.A.A.F. that the top speed performance of Kittyhawk aircraft was improved by waxing and polishing the complete aircraft. At the request of D.T.S. (Ref. SAS 9761) these reports were investigated by polishing the aircraft in three stages -

(a) Control surfaces only.

(b) Control surfaces and mainplanes.

(c) The complete aircraft.

EFFECT OF POLISHING CONTROL SURFACES.

Ailerons, elevators and the rudder were cleaned down and polished with wax floor polish. This produced a somewhat glossy finish, but was in no way glass smooth. As anticipated, the effect on speed was undetectable, and pilots reported no detectable improvement in control forces or response.

EFFECT OF POLISHING THE MAINPLANES.

The Kittyhawk mainplane is flush rivetted and all skin joints are reasonably flush. The aircraft as received was painted with a dull matt camouflage paint, green and brown on the upper surfaces, and blue underneath. The surface was cleaned down with petrol, and then the mainplanes and fillet given one sprayed coat of B.A.L.M. glossy paint (Manufacturer's Ref. No. S13982-3 R.A.A.F. Stores Ref. K3/229 sky blue. K3/220 brown, K3/222 green, which was cut down with B.A.L.M. No. 2 Rubbing Compound (Manufacturer's Ref. No. VZ 2006, R.A.A.F. Stores Ref. K4/339). Finally the whole surface of mainplanes and fillet were hand polished with wax floor polish, which was found to give better results than B.A.L.M. Duco Polish. The final surface, due to imperfections in the original surface, was in no way comparable with a good automobile body finish. The difference between the original and final surfaces was rather that between a fine sandpaper and a fine orange-peel or blotting paper. To obtain a glossy, glass smooth finish it would probably be necessary to fill the surface originally and apply several coats of paint machine polished or buffed.

Speed trials gave an increased top speed of about 6 m.p.h. on military power at full throttle height, i.e. 354 m.p.h. at 12,800' at 3000 r.p.m. 44.0 ins. Hg. manifold pressure.

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FIG. 1

DATE 22. 6. 42

REPORT NO F. 8.

KITTYHAWK (P40E)

ASSUMED POSITION ERROR CURVE

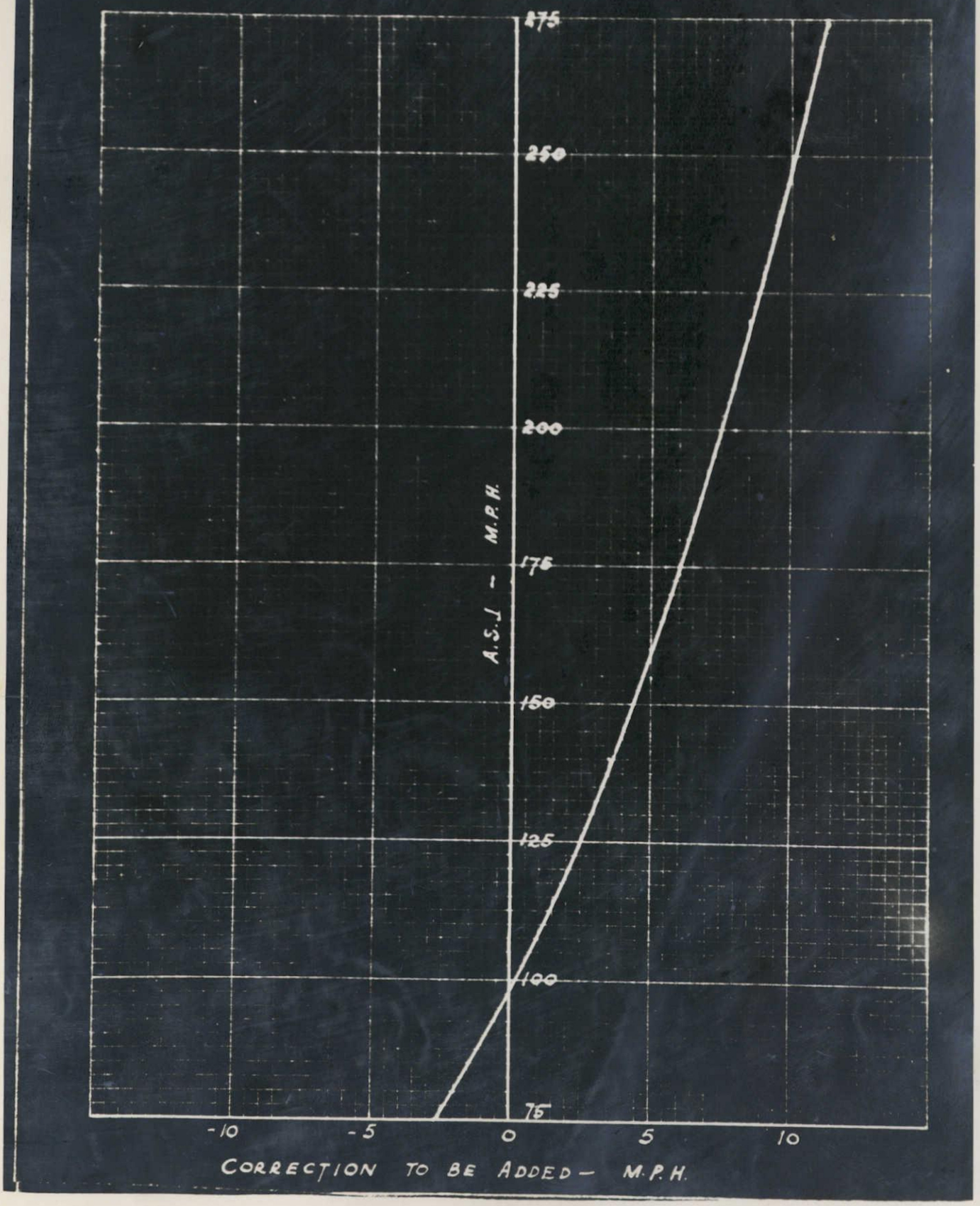

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FIG. 2

REPORT NO. F.8.

CLIMBING TRIALS

KITTYHAWK (P40E) A29-129
STANDARD ATMOSPHERE

WT = 8626 LBS
= 9280 LBS WITH BEL TANK

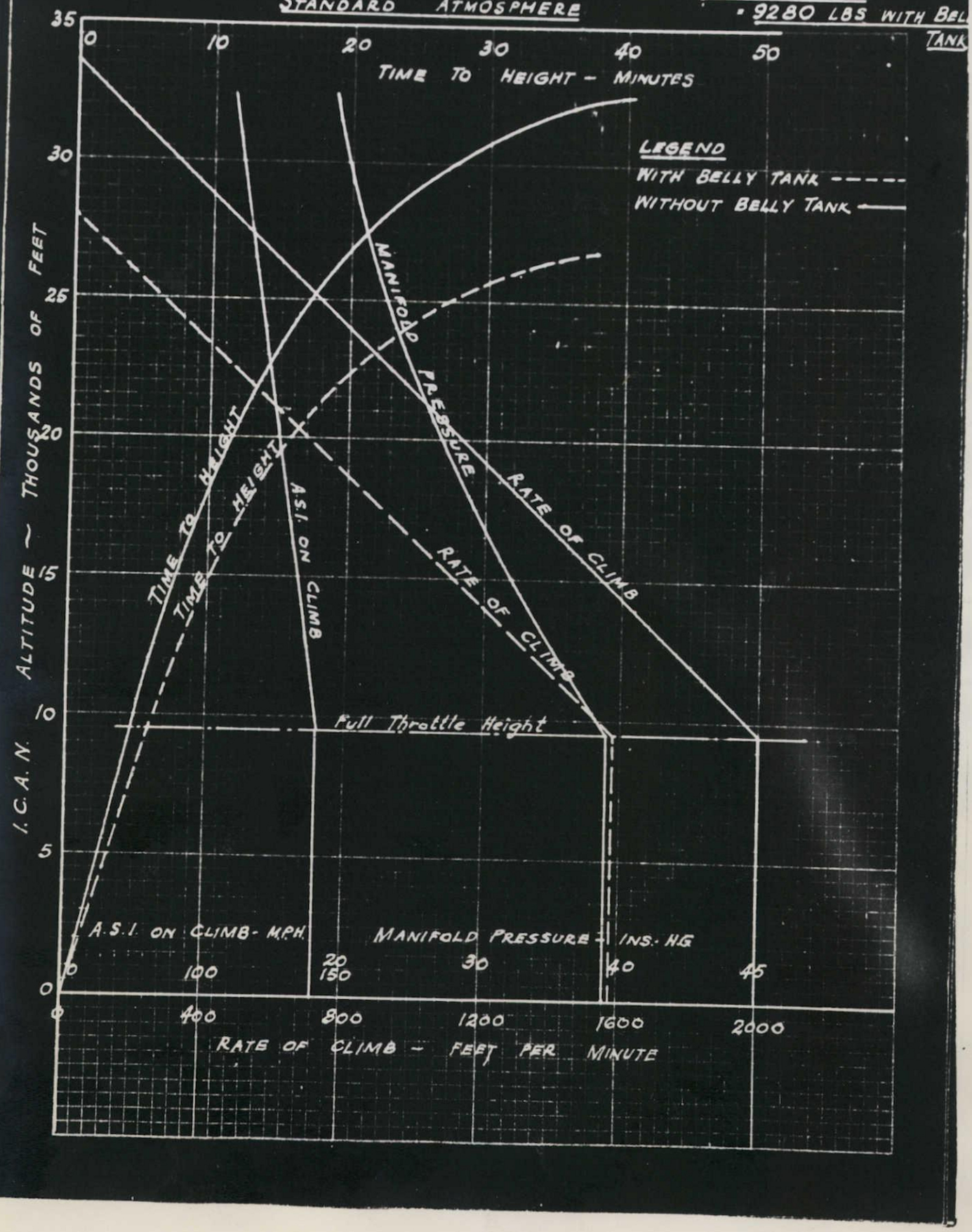

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FIG 3

REPORT NO F.8.

SPEED TRIALS (WITHOUT BELLY TANK)

KITTYHAWK (P40E) A29-129 WT 8626 LBS.

STANDARD ATMOSPHERE

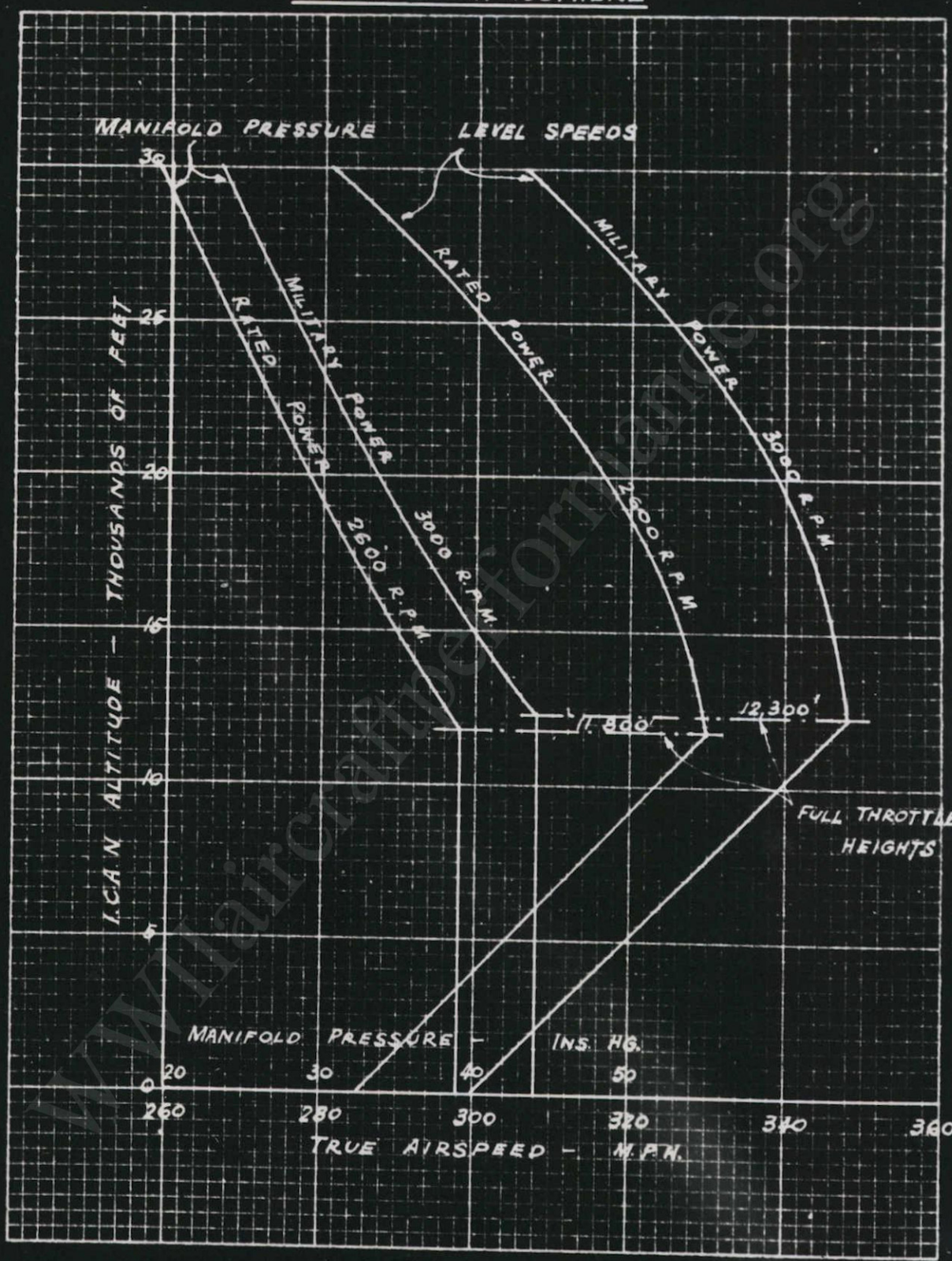

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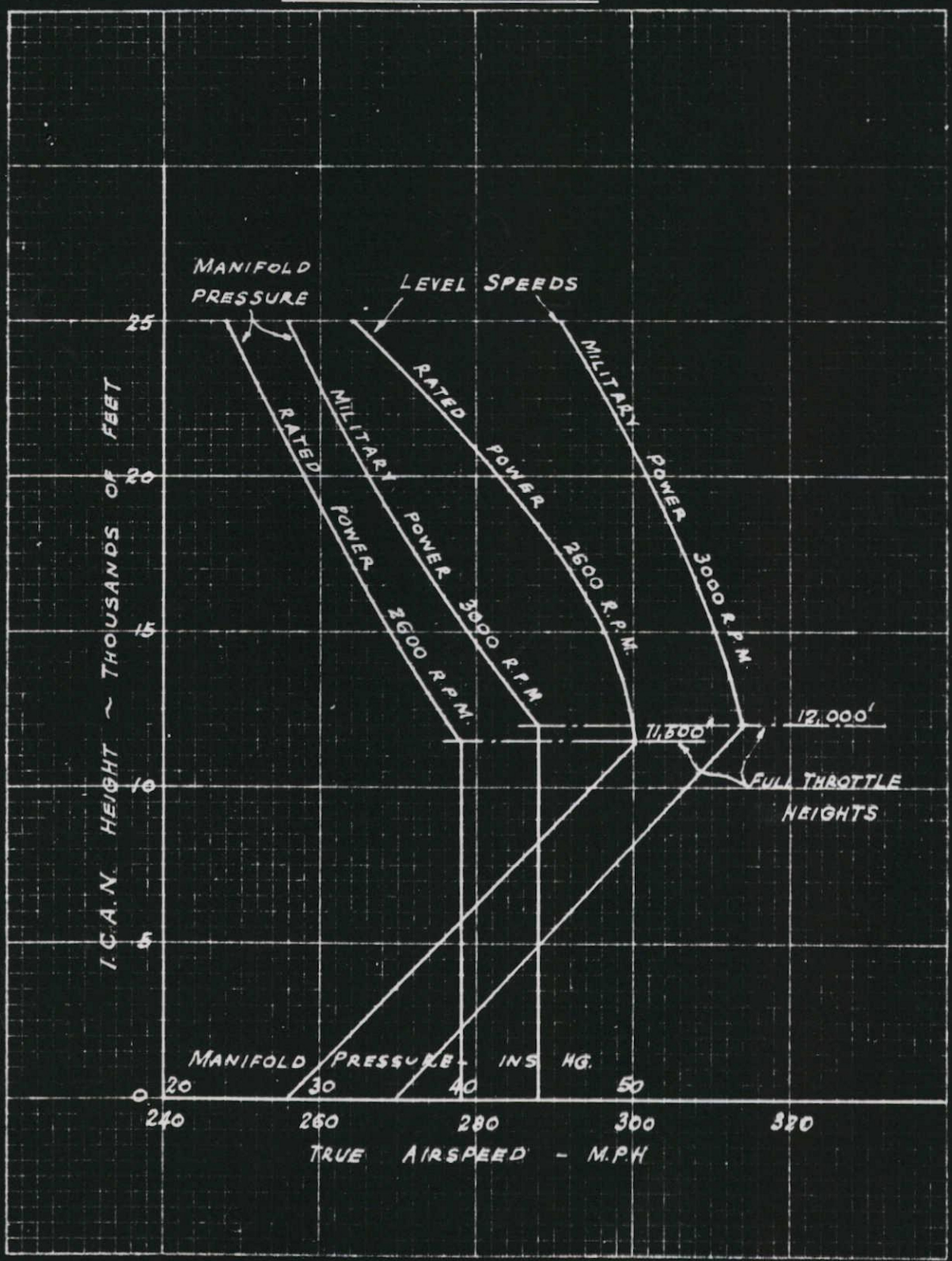
FIG 4

REPORT NO F8

SPEED TRIALS (WITH BELLY TANK)

KITTYHAWK (P40-E) A29-129 — WT 9280 LBS (INC. BELLY TANK)

STANDARD ATMOSPHERE



Drawn [redacted] 1-8-42 Fig No 5 Report No F6

C.S.I.R. PLYWOOD BELLY TANK

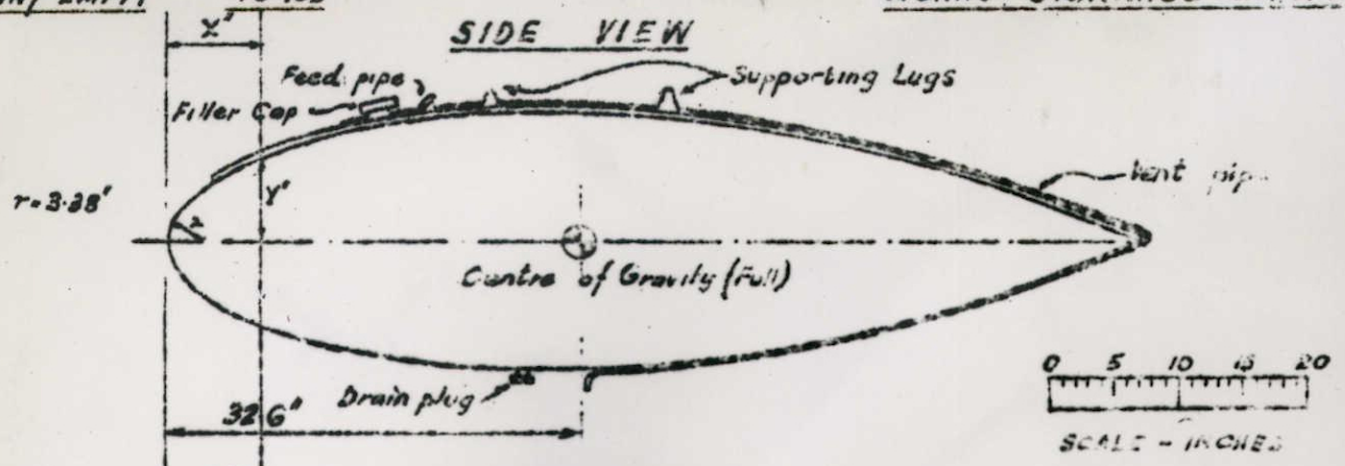
CAPACITY 83 IMP. GALLS. (100 U.S.) FITTED TO KITTYHAWK A29-129

WEIGHT FULL 647 lbs

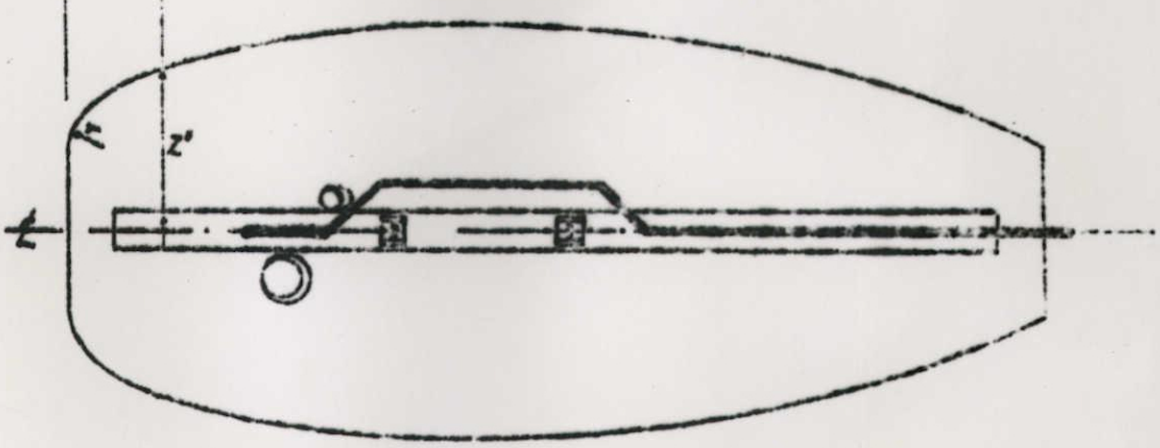
WEIGHT EMPTY 46 lbs

FOR CONSTRUCTIONAL DETAILS SEE ORIGINAL C.S.I.R. DRAWINGS S.M. Sheets

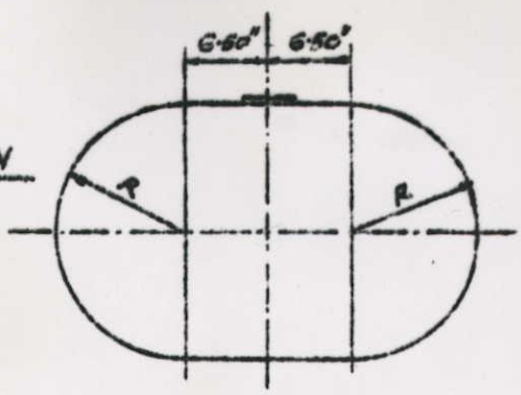
SIDE VIEW



PLAN VIEW



TYPICAL CROSS-SECTION



NOTE
R = (Z-6.5)"

EXTERNAL ORDINATES OF TANK - INCHES

X	0	2.09	3.94	7.69	15.19	22.69	30.19	37.69	45.19	52.69	60.19	67.69	69.19	75.65
Y	0	3.64	4.85	6.55	8.53	9.49	9.82	9.59	8.89	7.71	5.96	3.53	2.39	0
Z	6.50	10.04	11.35	13.05	16.03	15.99	16.32	16.08	15.39	14.21	12.46	10.03	9.39	6.50

FIG. 6.

Belly Tank installed on Kittyhawk aircraft.

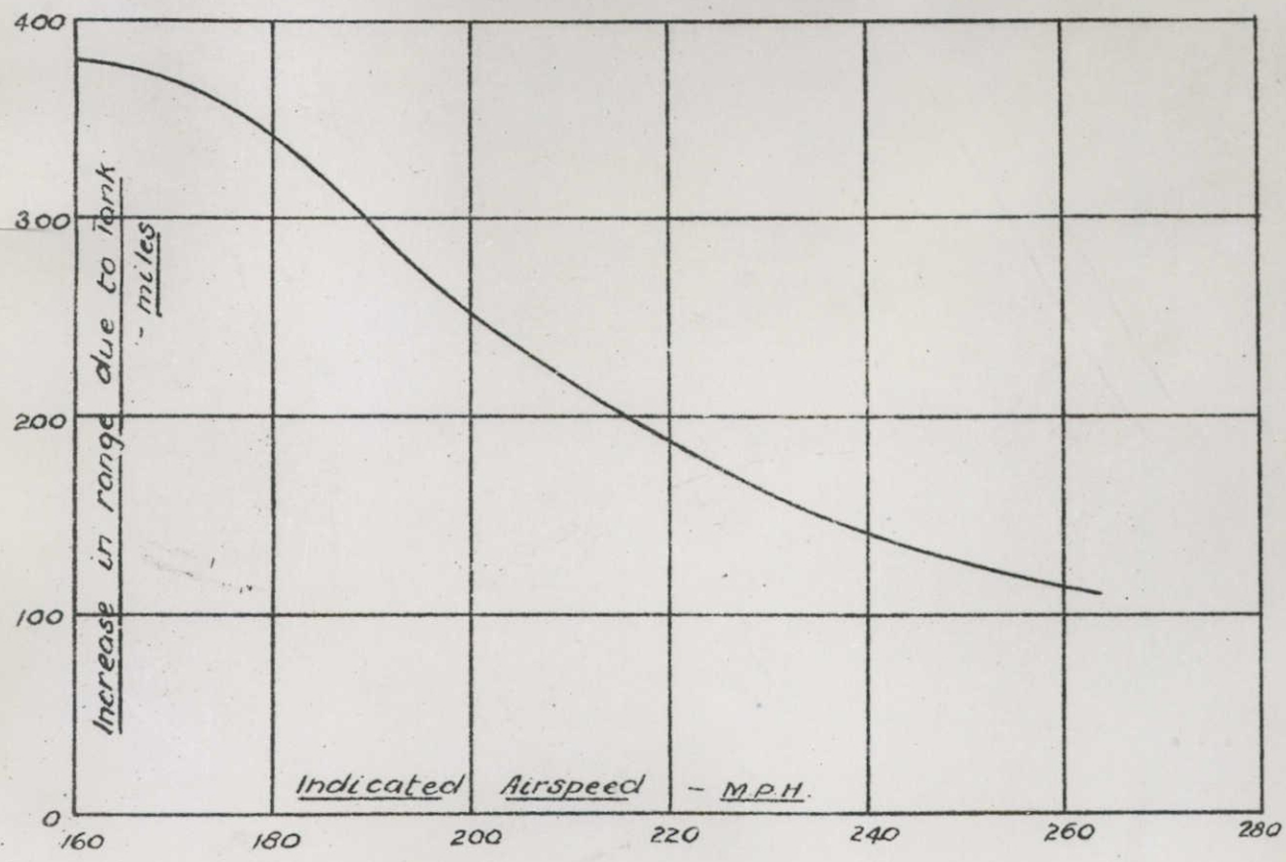


FIG. 7.

Variation of increase in range with indicated airspeed, due to fitting 83 gallon Belly Fuel Tank.