SECRET

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R.A.A.F. HEADQUARTERS

DIRECTORATE OF TECHNICAL SERVICES

SPECIAL DUTIES AND PERFORMANCE FLIGHT

REPORT

ON

BRIEF FLIGHT TRIALS OF JAPANESE

FIGHTER TYPE O

MK.II

S.S.F. HAP.

DATE OF ISSUE: 16th October, 1943.

Archives of M. Williams

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AERONAUTICAL SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Abbreviation	Unit	Abbreviation
Length	l	meter	m	foot (or mile)	ft (or mi)
Time	t	second	s	second (or hour)	sec (or hr)
Force	F	weight of 1 kilogram	kg	weight of 1 pound	lb
Power	P	horsepower (metric)		horsepower	hp
Speed	V	kilometers per hour	kph	miles per hour	mph
		meters per second	mps	feet per second	fps

2. GENERAL SYMBOLS

W Weight $= mg$

g Standard acceleration of gravity 9.80665 m/s^2 or 32.1740 ft/sec^2

m Mass $= \frac{W}{g}$

I Moment of inertia $= mk^2$. (Indicate axis of radius of gyration k by proper subscript.)

μ Coefficient of viscosity

ν Kinematic viscosity

ρ Density (mass per unit volume)

Standard density of dry air, 0.12497 kg-m^{-4}-
15° C and 760 mm; or 0.002378 lb-ft^{-4} sec^2

Specific weight of "standard" air, 1.2255 kg/
0.07651 lb/cu ft

3. AERODYNAMIC SYMBOLS

S Area

S_w Area of Wing

G Gap

b Span

c Chord

A Aspect ratio, $\frac{b^2}{S}$

V True air speed

q Dynamic pressure, $\frac{1}{2}\rho V^2$

L Lift, absolute coefficient $C_L = \frac{L}{qS}$

D Drag, absolute coefficient, $C_D = \frac{D}{qS}$

D_0 Profile drag, absolute coefficient $C_{D_0} = \frac{D_0}{qS}$

D_i Induced drag, absolute coefficient $C_{D_i} = \frac{D_i}{qS}$

D_p Parasite drag, absolute coefficient $C_{D_p} = \frac{D_p}{qS}$

C Cross-wind force, absolute coefficient $C_C = \frac{C}{qS}$

i_w Angle of setting of wings (relative to t
line)

i_t Angle of stabilizer setting (relative to t
line)

Q Resultant moment

Ω Resultant angular velocity

R Reynolds number $\rho\frac{Vl}{\mu}$ where l is a l
dimension (e.g., for an aerofoil of 1
chord, 100 mph, standard pressure at 1
the corresponding Reynolds numbe
935,400; or for an aerofoil of 1.0 m ch
100 mps, the corresponding Reynolds
ber is 6,865,000)

α Angle of attack

ϵ Angle of downwash

α_0 Angle of attack, infinite aspect ratio

α_i Angle of attack, induced

α_a Angle of attack, absolute (measured f
zero-lift position)

γ Flight-path angle

Encl 19A Refers
✓ 18A ✓

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BRIEF FLIGHT TRIALS OF JAPANESE FIGHTER TYPE 0 MK.II S.S.F. "HAP"

INTRODUCTION

The Hap is a single seater low wing all metal monoplane fighter which was captured at Buna airfield in repairable condition. The aircraft was subsequently reconstructed, and put into flying condition, by Air Technical Intelligence Unit of Allied Air Forces at Eagle Farm (see Ref. 1).

The engine which is a twin row 14 cylinder air cooled radial, was repaired in U.S. Air Corps Civilian Contract shops in Melbourne and dynamometer tested by C.S.I.R. (See Ref. 2).

This aircraft is a development of the Japanese single seater Navy fighter type 0 Mk.I S.S.F. "Zeke" from which it mainly differs in the following respects:-

AIRFRAME: The folding wing tips have been removed and replaced by short fairings, making the wing plan form square tipped and reducing the span from 39' - 4" to 36' - 4"; the ailerons have also been shortened. The firewall has been moved back 8 inches, the engine cowling lengthened and its shape improved. The position of the air intake has been changed and it is now situated in the top cowling.

ENGINE: The engine has been developed from the Nakajima model 12 used in the Zeke. The model 21 on Hap has a two speed blower, a re-designed reduction gear and a down draft carburettor. The cylinder cooling has been much improved, which permits the engine to operate on leaner full throttle mixtures compared with the earlier type engine, and the power output has thus been considerably increased. (See Ref. 2).

Hap was received at Special Duties and Performance Flight on 9/9/43 having been allotted by A.T.I.U. for brief flight trials. Combat and initial flight trials had been carried out at Eagle Farm but the weight, C.G. position and position error were unknown and the instruments were not calibrated. Automatic photo-observers were fitted for the purpose of recording performance figures and rates of roll. It is, however, emphasised that the time available for the tests was entirely inadequate for the work to be done thoroughly, and it was only due to good luck and generally satisfactory weather conditions, that the short programme originally scheduled was completed. For work of this nature, a period of two months is an absolute minimum as break-downs and unserviceability require longer to repair than with standard equipment.

In testing rates of roll, information on control and wing stiffness would have been of great interest, but it was not possible in the time available to fit the necessary equipment required for this work.

Proper engine cooling tests would also have been of much interest as the cooling of this engine is remarkably good.

The aircraft returned to Eagle Farm on 24/9/43.

1. GENERAL DETAILS (See Ref. 3)

1.1 The aircraft

Manufacturer:	Mitsubishi
Name:	Type O Mk.II S.S.F."Hap" (Carrier borne fighter)
Type:	Low wing all metal cantolever monoplane.
Overall dimensions:	Length 29' - 9" Span 36' - 4" Height 9' - 2"
Construction:	All metal semi-monocoque with fabric covered control surfaces Throughout the structure, extraordinary emphasis has been laid on lightness.
Undercarriage and Tail Support:	Inwardly retracting single oleo-pneumatic struts. Hydraulic brakes. Rearwardly retracting tail wheel with solid rubber tyre. Retractable arrestor hook for deck landing.
Armament:	2 x 20 mm. cannon in wings 2 x 77 mm. machine-guns in upper cowling.

1.2 Aerodynamic Data

Wings:	Gross Area (S)	232.4 sq.ft.
	Span (2s)	36.4 ft.
	Mean Chord	6.4 ft.
	Aspect ratio	5.7
	Dihedral on 30% chord line (measured on lower surface)	6.5°
	Taper Ratio	.44
	Wing Loading	24.3 lb./sq.ft.
Chords:	Root	9.[illegible] ft.
	tip	4.125 ft.
Section:	Root	NACA 2315
	Tip	NACA 3309
Flaps:	Type	Split
	Area	16.44 sq.ft.
	Flap span/2S	.29
	Flap chord/wing chord (mean)	.239
Longitudinal Control:		
	Tail surface area (s^1)	51.63 sq.ft.
	Elevator area/S1	.21
	Tail volume co-efficient	.522
	Type of balance -	Aerodynamic
	Percentage balance	11.35
	Trim tab area	1.19 sq.ft.

Directional Control:

Fin & Rudder Area (S")	15.6 sq.ft.
Rudder Area/S"	.49
Fin & Rudder Volume Co-efficient	.074
Type of balance	Aerodynamic
Percentage balance	9.64
Trim tab area	.065 sq.ft.

Lateral Control:

Type of ailerons	Frise
Aileron area	20.2 sq.ft.
Aileron area/S	.087
Aileron Span/wing span	.526
Type of balance	Aerodynamic

1.3 <u>Engine Details</u>

Manufacturer:	Nakajima
Name:	Sakae Model 21
Type:	14 cylinder two row air-cooled radial
Bore:	5.12 inches (130 mm.)
Stroke:	5.9 inches (150 mm.)
Displacement:	1700 cu.in.
Supercharger:	Single stage, two speed: Low: 6.377 High: 8.425
Carburettor:	Down draft type with manually operated mixture control
Airscrew reduction ratio:	.585 : 1 (17.1 - 10)

Power Ratings:	B.H.P.	R.P.M.	A.M.P.	Super Charger	Altitude (feet)
Military Rating (5 mins)	960	2600	40 in.	Low	0
	1020	"	" "	"	6400
	885	"	" "	High	15300
Maximum Continuous (Rated) Power	885	2400	36 in.	Low	0
	905	"	" "	"	7000
	800	"	" "	High	15200

Fuel Used:	92 Octane
Starting Gear:	Hand inertia type
Fuel Tanks:	One fuselage tank 16.5 gals. Two wing tanks 47.5 gals.ea.

One additional jettisonable tank of 75 gallons capacity can be carried under the fuselage, attached to the centre wing section.

The tanks are not self-sealing.

1.4 Airscrew Details.

Type:	Metal, 3 bladed constant speed type with counterweights.
Rotation:	Clockwise from pilot's seat
Diameter:	10' - 0"
Pitch Range:	20°
Blade Sections:	Modified Clark Y over greater part of blade, low drag sections at tips.

1.5 Aircraft Weights.

The all up weight of the aircraft during the tests was 5650 lb. This is the maximum weight of the aircraft, with full fixed tanks, but without the droppable belly tank. Full equipment was carried, the ammunition being substituted by the correct amount of lead weight in the magazines. The radio equipment was not original, but the difference in weight is not appreciable. The automatic observer which weighs 18 lb. was carried in excess of the normal equipment.

The centre of gravity location for the above condition was 26.8" behind the leading edge of the wing at the root, the auto-observer causing the C.G. to be 0.5" to the rear of the normal all up weight position.

2. PERFORMANCE

The test results have been reduced to standard atmospheric conditions by the methods of Ref.5. Only level speed and climb performances were tested and it is to be noted that the engine had not been overhauled since its initial start up. It did, however, run quite well during the trials.

Take off, fuel consumption and cooling tests could not be carried out in the available time.

The Position Error was determined by the aneroid method. A check by an alternative method especially on the low speed range, is desirable, but was not carried out in the limited time available as the level speed and climb corrections were not affected.

2.1 Level Speed

The results are shown in Table I and Fig.3. Although repeat tests could not be carried out, the results obtained show good agreement when used for calculating "extra to induced". Drag at 100 ft./sec., a value of 58 lbs. being obtained.

2.2 Climb

Results are given in Table II and Fig.4. Above 32,000 ft. the rate of climb at 2400 r.p.m. fell off noticeably and was improved by increasing the engine revolutions to 2600 r.p.m., corresponding to the military power rating. Climbs above 10,000 ft. are complicated by the mixture control being hand operated, and considerable scatter of results has occurred. In the circumstances

2.2 <u>Climb</u> (Contd)

individual climbs may show considerable variation of results and pilots technique becomes very important, particularly with such a sensitive mixture adjustment.

TABLE I

LEVEL SPEED PERFORMANCE

COWL GILLS CLOSED

WEIGHT 5,650 LBS.

	MILITARY POWER - 2600 RPM			RATED POWER - 2400 RPM		
Standard Height (ft)	Manifold In. Hg.	Blower	T.A.S. M.P.H.	Manifold In. Hg.	Blower	T.A.S. M.P.H.
0	40	Low	288	36	Low	272
1000	40	Low	292	36	Low	275
2000	40	Low	295	36	Low	278
3000	40	Low	299	36	Low	282
5000	40	Low	306	36	Low	288
7500	40	Low	314	36	Low	296
* 8600	40	Low	318			
* 9800				36	Low	304
10000	38	Low	318	35¾	Low	304
12500	34	Low	316	32¾	Low	303
12500	40	High	312	36	High	298
15000	40	High	322	36	High	306
Ø 16600	40	High	328			
Ø 16800				36	High	312
17500	38½	High	327	35	High	312
20000	35	High	324	32	High	308
25000	28¾	High	3[illegible]2	26¼	High	298
30000	23	High	285	21	High	278
35000	17	High	216			

* Full throttle heights in Low Blower
Ø Full throttle heights in High Blower

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TABLE II

CLIMB PERFORMANCE

COWL GILLS CLOSED

WEIGHT 5.650 LBS.

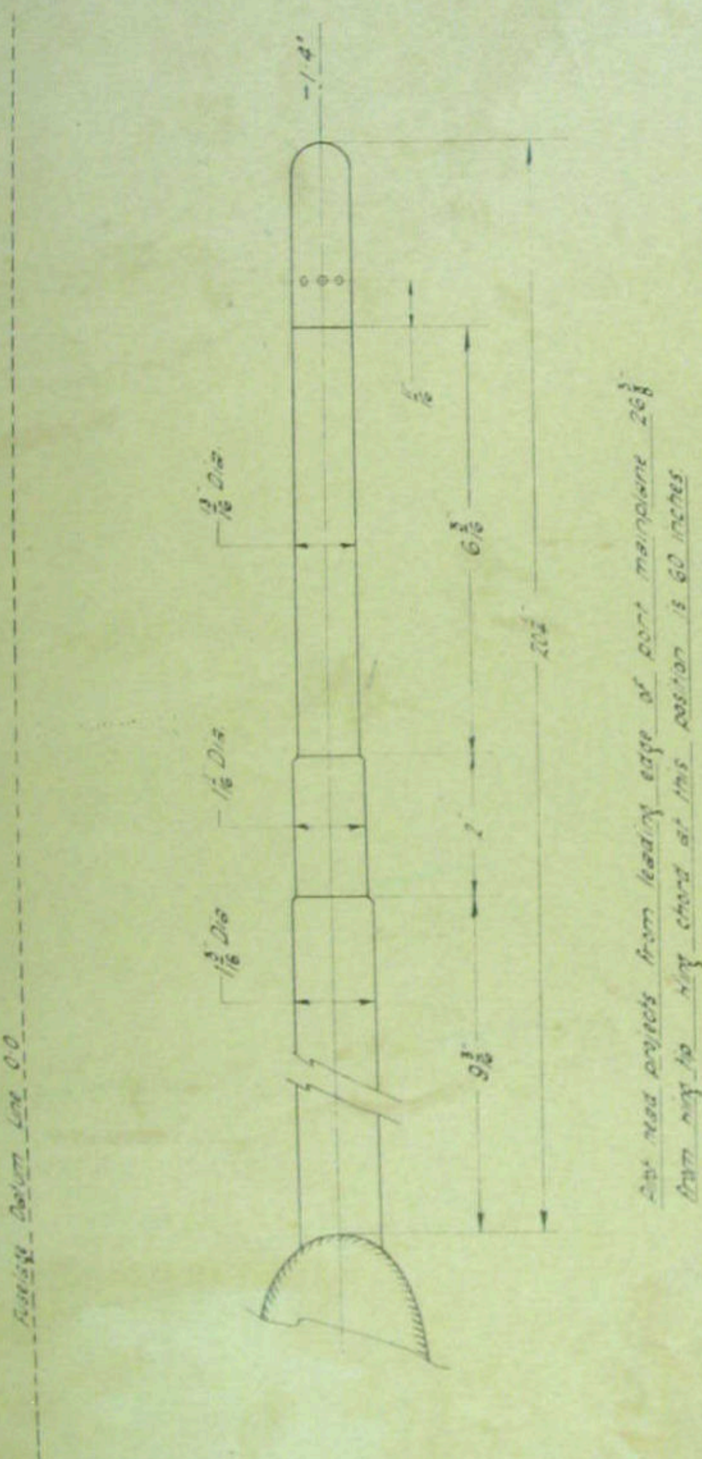
	MILITARY POWER - 2600 RPM				RATED POWER - 2400 RPM			
Standard Height (ft.)	Time from Start (min)	Rate of Climb (ft/min)	TAS MPH	Manifold (in.hg.)	Time from Start (min)	Rate of Climb (ft/min)	TAS MPH	Manifold In. Hg.
0	0	3410	146	40	0	2785	146	36
1000	.29	3410	148	40	.36	2785	148	36
2000	.58	3410	150	40	.72	2785	150	36
3000	.88	3410	153	40	1.08	2785	153	36
5000	1.46	3410	158	40	1.80	2785	158	36
x 6100	1.79	3410	160	40				
7500	2.20	3220	164	38	2.69	2785	164	36
x 7800					2,80	2785	164	36
10000	3.02	2785	170	34½	3.63	2530	170	33
12500	3.95	2775	177	40	4.64	2335	177	30¼
15000	4.85	2775	184	40	5.71	2335	184	36
ø 15500					5.93	2335	185	36
ø 15700	5.10	2775	185	40				
17500	5.78	2520	185	37	6.83	2090	185	33¼
20000	6.84	2175	186	33	8.11	1780	186	30
25000	9.60	1480	188	27	11.53	1175	188	24¼
30000	14.15	790	191	21¼	17.53	560	191	19½
32000					21.60	325	193	18
35000	29.30	100	194	17				

x Full throttle heights Low Blower

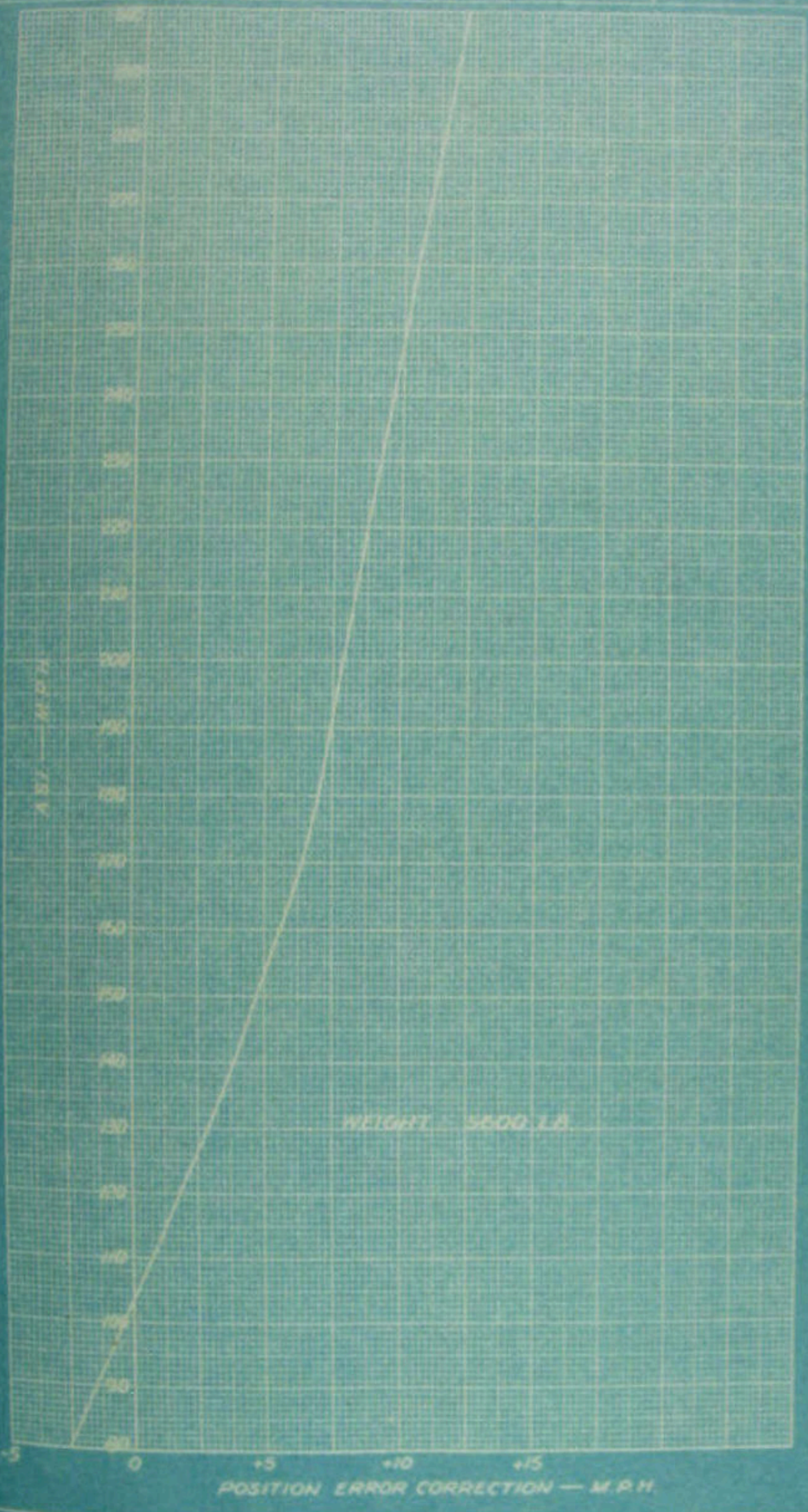
ø Full throttle heights High Blower

NOTE: The full throttle height on military power, low blower is lower than found by Dynamometer (Ref. 2). Due to the effect of ram, it should actually have been at a higher altitude, but it has not been possible to ascertain the reason for this discrepancy, which in any case is not appreciable.

PREPARED BY	DTS R A A F HQ TS7 SPECIAL DUTIES AND PERFORMANCE FLIGHT	
CHECKED BY	FIG Nº1 HAP PITOT HEAD DETAILS	DATE 13-10-43



PREPARED BY	D.T.S. R.A.A.F. H.Q. T.S.7 SPECIAL DUTIES AND PERFORMANCE FLIGHT	FIG. Nº 2.
CHECKED	H.A.P. POSITION ERROR CURVE	DATE 14. 10. 43.



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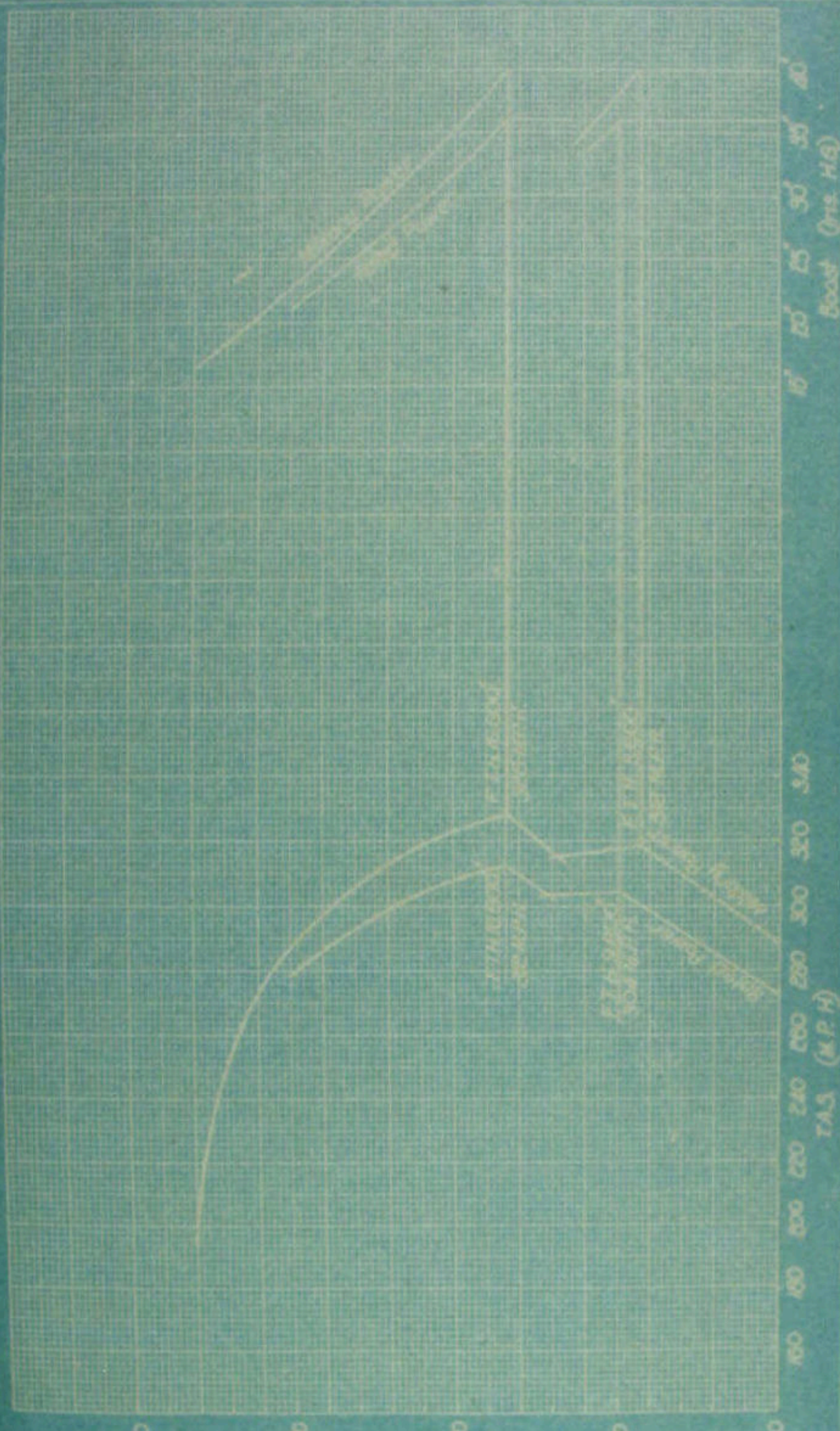
PREPARED BY J.F.M.	D.T.S. R.A.A.F. H.Q. T.S.7 SPECIAL DUTIES AND PERFORMANCE FLIGHT	FIG. No 3.
CHECKED BY	H.A.P. LEVEL SPEED TRIALS	DATE 7.10.48



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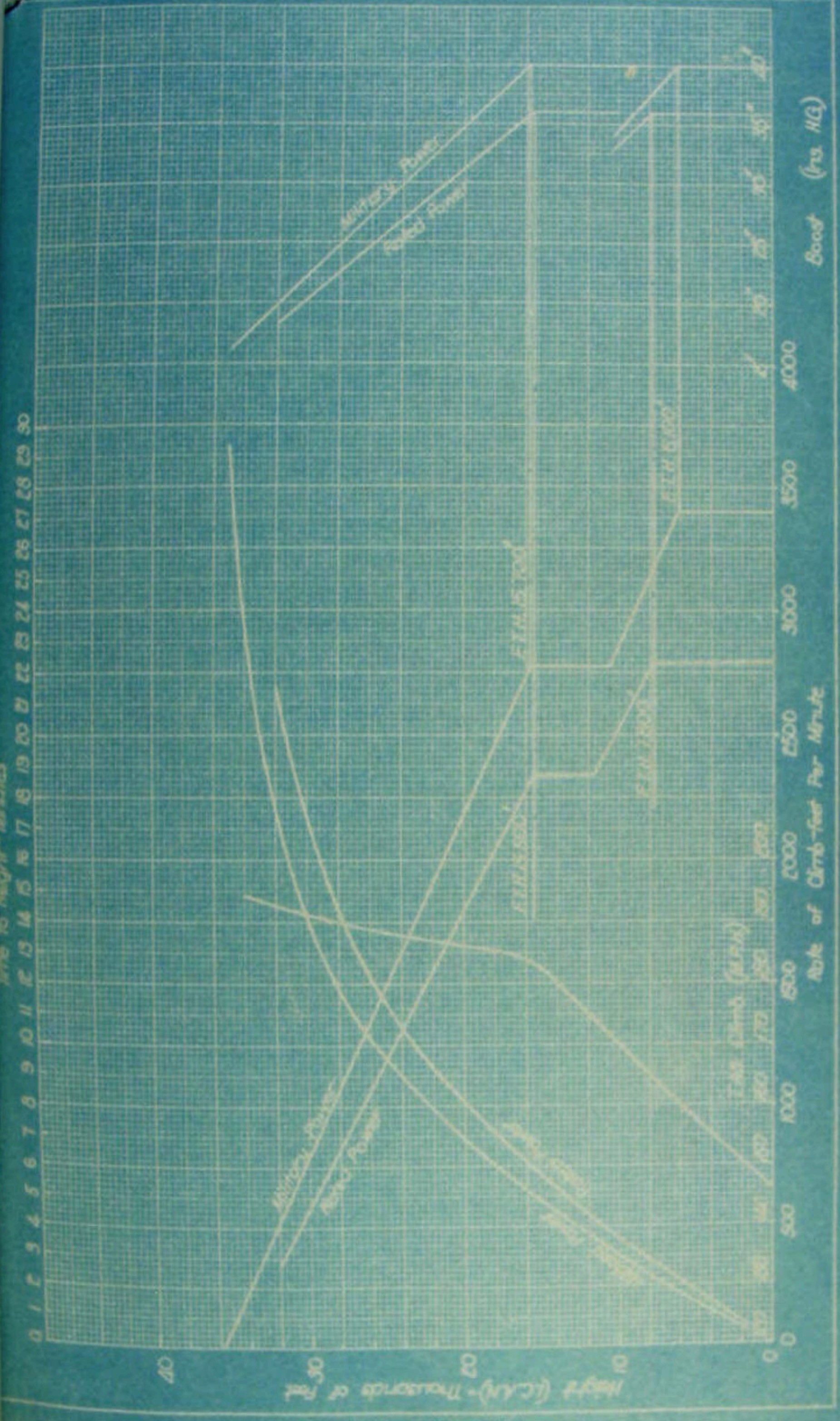
PREPARED BY JFM	D.T.S. R.A.A.F. H.Q. T.S.7 SPECIAL DUTIES AND PERFORMANCE FLIGHT	FIG. No 4.
CHECKED BY	HAP CLIMBING TRIALS	DATE 7-10-43



3. HANDLING TRIALS:

3.1 General:

(a) Starting Up:

The engine is started by means of a hand inertia system which operates quite efficiently. The airman engages the starter by cranking and the booster coil is switched on by the pilot. There is a priming pump in the cockpit but all the priming in flight was carried out by using the accelerator pump attached to the hand throttle.

(b) Stopping Engine:

If stopped immediately after landing the engine was found to oil up. The procedure was therefore adopted of running up to 2000 r.p.m., testing switches, and putting the airscrew into full coarse prior to stopping. The plugs were kept clean in this way and the engine remained serviceable for the remainder of the flying done during the tests, as well as the flight back to Brisbane.

(c) Engine Operation in Flight:

The original boost gauge was fitted in the cockpit and was used throughout the tests. It is calibrated in cms. of mercury above or below standard atmospheric pressure, its range being from -45 cms. to plus 25 cms.

The following ratings were observed:

	Boost	Engine Revs.
Maximum Military rating (5min.)	25 cm. = 39.8"	2600
Maximum continuous rating	15 cm. = 35.8"	2400

At full throttle position only plus 15 cms. of boost are available, boost control being automatic. If a control on the dash board is pulled out, a maximum of plus 25 cms. may be obtained. This is not a complete over-ride, as the boost is still automatically controlled and is limited under any condition of flight (including take-off), to plus 25 cm.

The two speed blower control is situated at the bottom of the throttle quadrant. To engage high blower the engine speed is reduced to 1500 r.p.m. and the lever smartly moved from the rear to the forward position on the quadrant.

The r.p.m. control is by means of a constant speed airscrew governor system, coarsening being carried out by counterweights. Although limited to 2600 r.p.m on the governor setting, the engine overspeeds up to 3000 r.p.m. in dives over 300 m.p.h., which indicates that the pitch range of the airscrew is insufficient.

The mixture control is by hand, one control being attached to the throttle quadrant and the other above and forward of it. Both these controls are situated on the port side of the cockpit. An exhaust gas temperature gauge is fitted, the temperatures giving an indication of the mixture strength. At high powers the engine appeared to run best at about 670 deg. C. exhaust temperature. Up to 10,000 ft. the mixture control is not sensitive. As altitude increases the mixture has to be leaned firstly by means of the control in the throttle quadrant. At 25,000 ft. this lever is at the end of its movement, and so, above this altitude, the other control is used. The mixture control then becomes very sensitive, small alterations to the control making large alterations to the mixture strength, the resultant exhaust temperatures varying from under 500 deg. C. to 700 deg. C.

The engine becomes very rough when too rich above 25,000 ft. and if the control is moved a fraction too far towards the lean position it will cut, the total range of movement being of the order of 1/4" along the quadrant. If the mixture is set correctly at 30,000 ft. the engine is liable to cut if dived down to 28,000 ft. unless the mixture control is richened up.

The cowl gills and oil cooler shutter are mechanically operated with controls and indicators as shown in the cockpit views.

(d) <u>The Operation of the Hydraulic System:</u>

The flap and undercarriage are operated by the hydraulic system. Pressure is normally maintained by an engine driven pump. The landing gear and flap selector lever have three positions - up, neutral and down - the pressure being by-passed in each case in the neutral position.

To operate the flaps, however, the landing gear lever must be in either the up or down position. When not using the hydraulic system, it is important to return both levers to the neutral position to avoid overheating of the hydraulic fluid, which takes place very quickly.

All the controls are well within the reach of the pilot, and are shown in the photograph of the starboard side of the cockpit.

The undercarriage retracting cylinders are so small that the retraction is slow, it being facilitated by skidding the aircraft. The emergency hydraulic hand pump is situated on the starboard side of the cockpit floor, its handle being stowed on the starboard side of the instrument panel. In the event of its being inoperative the wheels may be released from the up position by pulling two cables located on the cockpit floor. It is most probable that the wheels could then be shaken down by skidding the aircraft.

The indicators for the wheel position consist of green, red and amber lights - these being one each for the main wheels and tail wheel, as well as mechanical indicators protruding from the upper surface of the mainplane for the landing wheels. The green light indicates that the respective wheels are locked down, while the red shows that they are locked up. The amber comes on when the wheels are neither up nor down.

There is a horn but this only serves to warn the pilot that he has not returned the landing gear selector lever to the neutral after retraction. The flap position is determined from a mechanical indicator on the starboard side of the cockpit.

.2 Cockpit Lay-out:

Entry to the cockpit is from the port side of the fuselage.

The cockpit lay-out is quite satisfactory as regards ease of access and does not call for any undue reaching or bending. The rudder control with pedals fully extended is, however, too short even for a short allied pilot. The seat is satisfactory and may be adjusted by a lever on the starboard side.

The canopy is easy to operate and can be locked in full open, closed, and several intermediate positions. It cannot be jettisoned.

The visibility is good with the canopy open and shut, both on the ground and in the air, and is not obstructed by cowl gills if opened.

Photographs of the cockpit are given in Figures 5, 6 and 7, and a key to the instruments is attached.

During the trials such instruments as were required for the performance tests were calibrated and fitted by R.A.A.F. The original Japanese instruments are calibrated in the metric system. Elevator trim is the only trim control fitted. A noteworthy feature is also the air inlet for cooling the fuel tanks, operating by means of shutters on the under side of the wing (the tanks are not self-sealing).

Oxygen and wireless equipment fitted were American. The Japanese controls are, however, still fitted.

HAP COCKPIT

Key to Photograph Item Numbers

Port Side:

0 Air valves for cocking 20 m.m. cannon
0a Gun selector switch on throttle
1 Fire extinguisher control
2 Elevator trim
3 Belly tank release
4 Elevator trim indicator
5 Throttle control
6 Mixture control
7 Pitch control
8 Blower control
9 Main switch panel
9a Undercarriage warning lights
10 Cockpit lights
11 Voltmeter - ammeter
12 Air temperature gauge
13 Fuselage fuel gauge
14 Generator switch
15 Main wing tanks gauge
16 Wobble pump
17 Fuel tank selector for gauge No.15
18a Wing fuel tanks selector
18b Fuselage and belly tank selector
19 Bomb release (used for tail wheel lock during trials).

Starboard Side:

20 Cockpit cool air vent
21 Wireless tuning (American)
22 Cockpit light
23 Japanese wireless control (not operating)
24 Flap indicator
25 Arrestor hook lowering control
26 Arrestor hook indicator
27 D/F loop control
28 Wireless control box (American)
29 Arrestor hook release
30 Pilot seat adjustment
31 Flap control
32 Undercarriage control
33 Emergency hydraulic pump
34 Emergency Undercarriage release
35 " " "
36 Wing tank cooler indicator
37 Wing tank cooler control
38 Cockpit fresh air control
39 Cowl gill control

Cockpit Front:

40 7.7 Machine Gun
41 7.7 Machine Gun cocking handle
42 Accelerometer (not standard fitting)
43 Ring and bead sight
44 Reflector Sight
45 Rheostat for reflector sight
46 Artificial Horizon
46a Locking Device for Artificial Horizon
47 Turn and Bank indicator
48 Magnetic Compass
49 Rate of Climb Indicator
50 Oil Pressure Gauge
51 Fuel Pressure Gauge
52 Revolution Counter
53 Cylinder temperature Gauge
54 Oil temperature Gauge
55b Boost Gauge
56 Oil Shutter Indicator
57 Oil Shutter Control
58 Booster Coil Switch
59 Oxygen Regulator
60 Control Column
61 Brake Pedal
62 Fore and aft Level
63 Priming Pump
64 Radio Compass Indicator
65 Ignition Switches
66 Altimeter
67 Exhaust temperature gauge
68 Clock
69 Airspeed Indicator
70 Mixture Control and Idle Cut Off

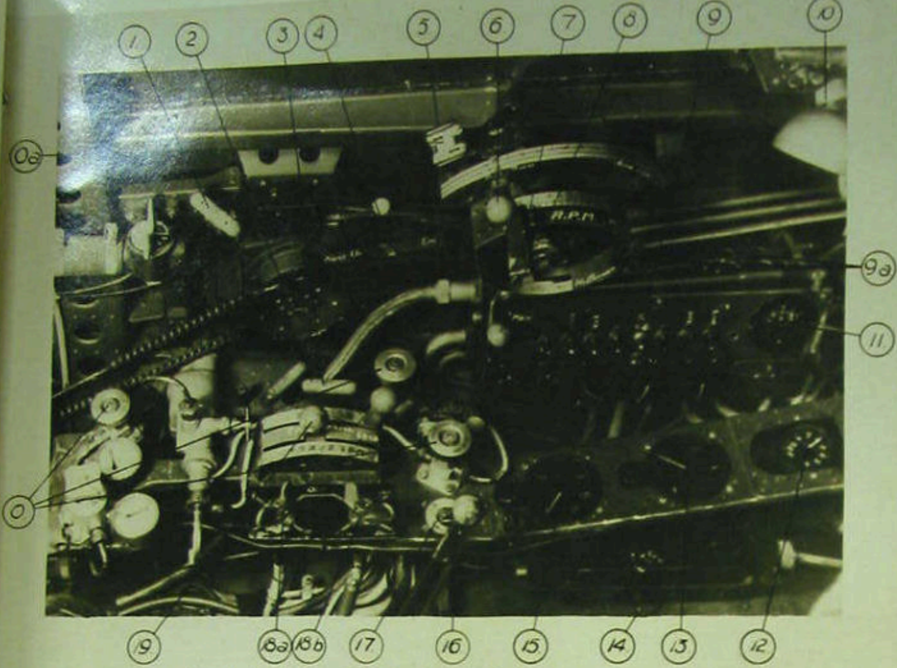


Fig. N° 5. Port Side of Cockpit

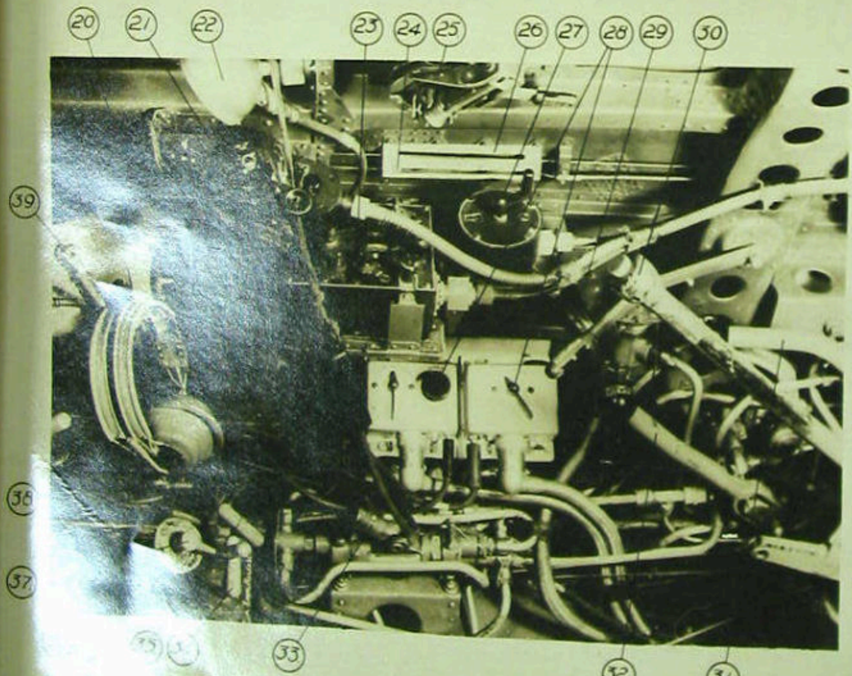


Fig. N° 6 Starboard Side of Cockpit.

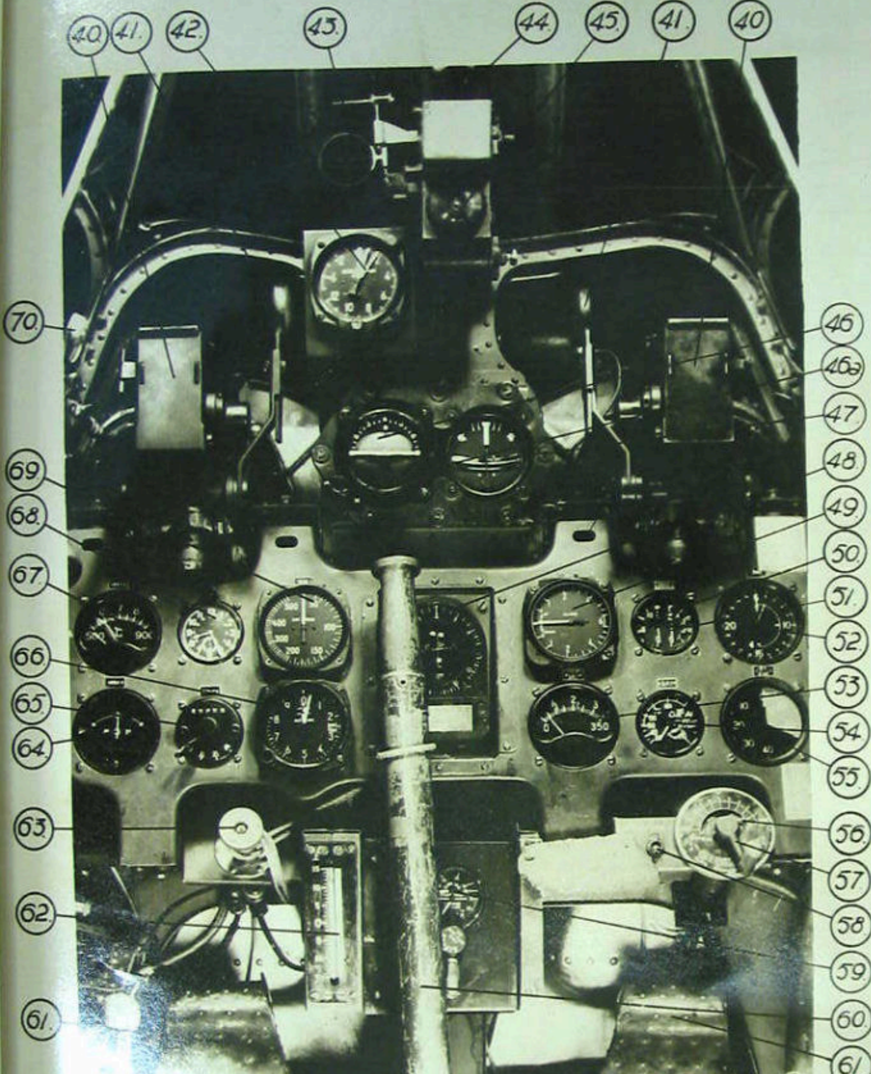


Fig. No. 7. Cockpit Front with Instrument Panel.

.3 Ground Handling:

Repeated efforts were made in the early stages of flight tests to obtain satisfactory brake operation. All attempts failed, and from the experience gained it is felt that the brakes on this type of aircraft are normally most ineffective. In view of this, ground handling tests were not carried out. Taxying was only done with the aid of ground staff at the tail of the aircraft, as the rudder gives insufficient control for taxying without brakes.

There is no tail wheel lock, but one was fitted in view of the unserviceability of the wheel brakes, in order to aid the pilot to keep straight in take off and landing.

The cowl gills are opened for ground running, but may be kept closed under all flying conditions, and in take off.

.4 Behaviour During Take-Off:

The take off is carried out without flaps. There is a tendency, during the first three or four seconds, to swing to port against full right rudder if full military power is applied rapidly. This swing is only small, and is not sufficient to swing the aircraft off a normal runway. At lower powers there is ample rudder control. The tail rises early in the run and the aircraft unsticks at 80-85 m.p.h. A.S.I. After raising the undercarriage, which retracts very slowly, the best climbing speed of 140 m.p.h. A.S.I. is quickly obtained and right rudder is required to keep the aircraft properly trimmed, as there is no rudder trim adjustment in the cockpit. For extended climbs at high powers this is slightly tiring.

Take-offs and climbs were carried out with cowl gills closed, the cooling of the engine being excellent.

.5 Behaviour During Approach and Landing:

The undercarriage is lowered at speeds not exceeding 130 m.p.h. A.S.I. and makes the aircraft slightly nose heavy. This can be trimmed out, but is not necessary as lowering the flaps makes the aircraft tail heavy. These two effects balance each other. The most comfortable approach speed is 95-100 m.p.h. A.S.I., with very little power on.

All landings in this aircraft have been tail up in order to maintain good rudder control after touching down, but three point landings should be quite simple to carry out. After touch-down the aircraft rides hard during the remainder of the landing run.

.6 Longitudinal Control:

The elevator control is fairly responsive and light above 95-100 m.p.h. A.S.I. At lower speeds the elevator control becomes less satisfactory and near the stall has little power. As the speed increases the elevators become progressively heavier.

At 200 m.p.h. A.S.I. it is estimated that 75-100 lb. stick force is required to obtain 4G., with a considerable increase in elevator heaviness as the speed approaches 300 m.p.h. A.S.I. Use of the trimming tab is of some assistance, but it is stiff and not particularly convenient to use. Above 16,000 ft. in general, but depending on temperature conditions, the trim became frozen solid and could not be used for manoeuvring.

In cruising flight the aircraft may be trimmed hands off and appears quite stable.

3.7 Directional Control:

The rudder control is ample for all normal flying conditions as already mentioned under take off. On high power slow speed climbs, right rudder pressure is required, there being no rudder trim adjusting device in the cockpit. In dives up to 350 m.p.h. A.S.I. slight left rudder pressure was required, but if flown feet off at this speed only slight skidding resulted.

3.8 Aileron Control:

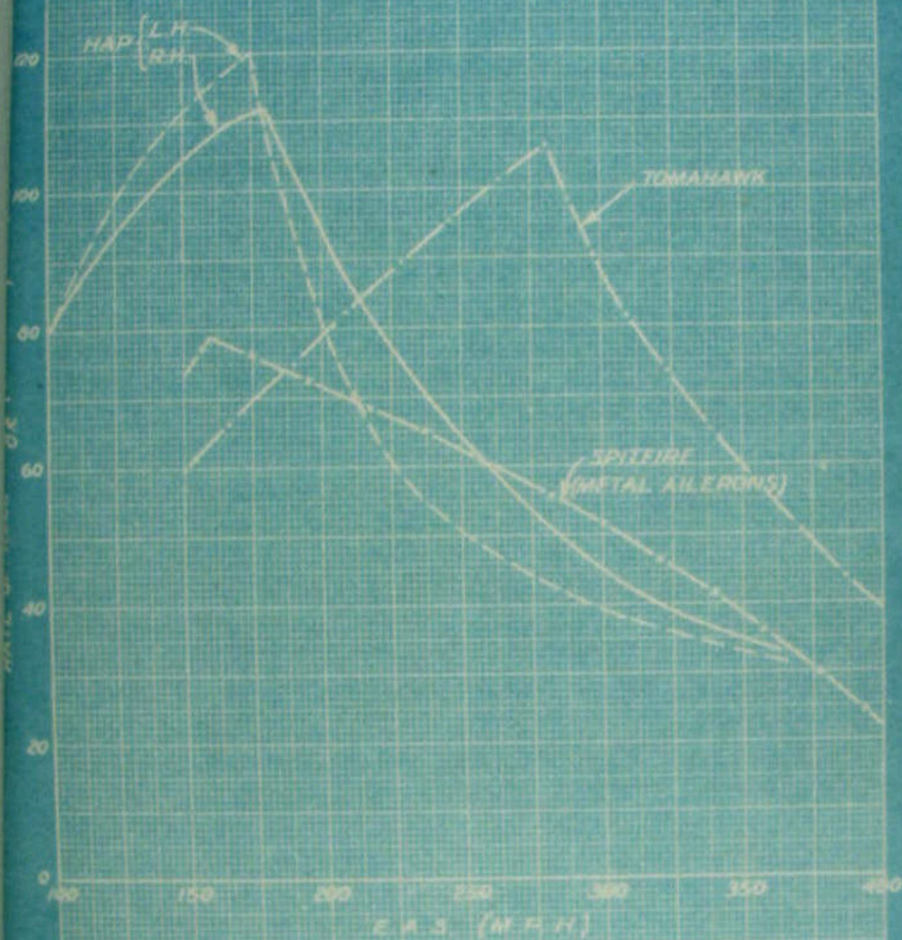
THE aileron control at speeds from the stall to about 140 m.p.h. A.S.I. is light and responsive and good rolls can be executed at 140 m.p.h. At speeds above 140 m.p.h. the ailerons become rapidly heavier until at 300 m.p.h., the stick forces are very great and only very slow rolls can be executed. At high speeds only small stick displacements are possible. There is not much difference in the stick force or rate of roll to the right or left, although rolls to the left at low speeds appear slightly better. There is no aileron trimming mechanism.

A peculiarity was noted on climbs or flying above 27,000 ft. The ailerons started to stiffen up even at slow speeds, and at 35,000 ft. they were virtually frozen solid. On a subsequent climb the controls were, however, kept fairly free up to 33,000 ft. by continually moving the control, but even then the ailerons became quite stiff to operate. The reason for these low temperature effects is not known.

An automatic photo-observer was fitted which measured degrees of roll and time. Stick movement, stick forces and aileron deflections were not recorded, as there was insufficient time to instal the necessary equipment. The rates of roll are presented graphically on Figure No.8.

[...]ARED BY | D.T.S. R.A.A.F. H.Q. T.S.7 SPECIAL DUTIES AND PERFORMANCE FLIGHT | FIG Nº 8

[...]KED BY | RATES OF ROLL | DATE 14.10.43.



Note – H.A.P. Rates of Roll (full aileron below 150 M.P.H. otherwise 50 lb. Stick Force)

Tomahawk & Spitfire Rates of Roll for 30 lb. Stick Force or full aileron.

Archives of M. Williams

Control at the Stall:

Test No.	1	2	3
Engine	off	off	On 18" Boost, 2200 r.p.m.
Flaps & U'carriage	up	Down	Down
	The aircraft was trimmed to fly "hands off" at 175 m.p.h. A.S.I. and the stick pulled slowly back, keeping the aircraft on an even keel until the stall occurred.		
Stall Warning	In all cases buffetting commences 6-10 m.p.h. above stalling speed, and as the speed decreases there is a noticeable falling off of effectiveness of the elevator control.		
Stalling Speed mph. ASI.	83	78	65-70
Stick Position	Hard back	Hard back	Hard back
Stick Force lbs.	10-15	10-15	10-15
Altitude at Stall	Nose slightly above horizon	Nose initially slightly above horizon	Nose slightly higher
Aileron effectiveness at stall	The ailerons become sloppy at the stall, but remain positive throughout.		
Behaviour at Stall	With stick hard back the aircraft remains stalled without any tendency for either nose or wing to drop, airspeed remaining at 83 mph A.S.I. There is considerable buffetting over the elevator in this condition.	As in the previous case, there is no tendency to drop a wing, but the nose drops and with stick hard back the aircraft see-saws, the speed alternating from 80 to 78 m.p.h. A.S.I.	As the stall occurs left wing and nose drop, but there is no tendency for the aircraft to spin or to go on to its back.
Recovery	Recovery is very easy and is effected with a height loss of not more than 200-ft. by pushing the stick slightly forward.		Recovery is effected easily in less than 600 ft., stick forward.
Spinning tendency:	There is no spinning tendency at any time during the stall.		

3.10 Aerobatics:

All aerobatics can be carried out and are quite normal. They can be performed at much lower speeds than on comparable allied aircraft. Upward rolls at 160 m.p.h. A.S.I., loops 200 m.p.h. A.S.I., and rolls off the top at 210 m.p.h. A.S.I.; loops at 200 m.p.h. can be performed quite easily with 26" manifold pressure and 2300 r.p.m. Throughout these comparatively low speed aerobatics the controls are noticeably positive in their effect.

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1. (Headquarters Allied Air Forces, D. of I.
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3. R.A.A.F. H.Q., D.T.S., T.S.7 "Examination of Type "O" SSF Mk.II.
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APPENDIX

DRAG ANALYSIS OF 'HAP'

ITEM	DRAG DETAILS	DRAG LBS. @ 100ft/Sec.	
Wing	Profile (L.E. transition)	21.2	
	Surface Roughness	1.5	
	Gaps, etc.	.8	
			23.5
Fuselage	Profile (L.E. transition)	7.5	
	Surface Roughness	1.0	
	Cabin	1.5	
			10.0
Empennage	Profile	5.8	
	Control Gaps	1.2	
			7.0
Miscell-aneous	Interference	1.5	
	Pilot, Lights, Antenna	2.0	
	Guns	2.0	
	Leak Drag	2.5	
			8.0
Power Plant	Cooling and Leak Drag	7.5	
	Cooler	2.0	
			9.5
Total D_{100} (extra to induced drag at 100 ft. per sec.)			58

Engine assumed to develop 1020 HP at 16,600 ft; measured speed 328 m.p.h., weight 5,650-lb., airscrew efficiency = 83%. (assumed)

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