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FLIGHT TEST DIVISION
U. S. NAVAL AIR TEST CENTER
PATUXENT RIVER, MARYLAND

FINAL REPORT
on
PROJECT TED NO. BIS 2157

PRODUCTION INSPECTION TRIALS
of the
MODEL F4U-4 AIRPLANE

Contract NOa(s)-2720
held
11 June 1944 to 9 January 1948

by

FLIGHT TEST DIVISION
U. S. NAVAL AIR TEST CENTER
PATUXENT RIVER, MARYLAND

for

BOARD OF INSPECTION AND SURVEY

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Total Number of Pages in Report	15
Total Number of Plates and Photographs in Report	11

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CONFIDENTIAL   Project TED No. BIS 2157

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INTRODUCTION

References:

(a) BuAer ltr Aer-E-211 JCM C17340 dated 29 June 1944.
(b) Contract NOa(s)2720 Model F4U-4 Airplane dated 12 September 1944.
(c) SD-261-4A Detail Specification for F4U-4 Airplane dated 1 May 1945.
(d) NAS Patuxent River ltr report NA83/BIS 2157, serial No. FT-1573 dated 9 October 1945, Results of Temperature Survey.
(e) CVA Report No. 6664 dated 24 February 1945, Actual Weight and Balance 25th Airplane.
(f) NAS Patuxent River ltr report NA83/VF4U-4 BIS 2157 Serial No. C-438 dated 16 June 1945, Preliminary Report on Production Inspection Trials.
(g) NAS Patuxent River Conf. ltr NA83 Serial C-402, BIS 2157.1 MAG/vba (FT) dated 18 May 1945.
(h) Fuel Consumption Report.
(i) NAS Patuxent River Conf. ltr NA83(Insurv)VF4U-4/F8-2 (29-S) Ser. 023P45 dated 9 January 1948.

Production Inspection Trials were conducted on the model F4U-4 airplane as requested by reference (a). Model F4U-4 airplanes Bu.Nos. 80762, 80763 and 80765 were assigned to this project. Reassignment of the airplanes to projects of higher priority interrupted the trials and resulted in an extended date of completion. The trials were terminated by reference (i).

SCOPE OF TRIALS

Tests were conducted on the subject airplane to determine the following:

A. Stability and control characteristics.
B. Center-of-gravity limits.
C. Performance as a normal fighter.

D. Fuel Consumption

In addition, miscellaneous tests, including a carbon monoxide and temperature survey, were conducted to evaluate the general suitability of the airplane for service us.

The configurations tested are listed in Appendix A Plate I.

RECORD OF TRIALS

(a) Project initiating letter	29 June 1944
(b) Airplane Bu.No. 80763 received for tests	29 December 1944
(c) Airplane Bu.No. 80765 received for tests	5 January 1945
(d) Airplane Bu.No. 80762 received for tests	27 February 1945
(e) New engine was installed in Airplane Bu.No. 80765	28 February 1946
(f) Project terminated (reference (i))	9 January 1948

RESULTS OBTAINED

A. Performance

Loading Configuration - Normal Fighter (reference (c) para. 104(a))
Gross Weight - 12500 lbs. C.G. 31.5% MAC (gear up)

1. Normal Rated Power

(a) Maximum speed in level flight - V_t

(1) At ACA, high blower (31900') - kts.	374
(2) At ACA, low blower (24600') - kts.	353
(3) At ACA, neutral blower (8700') - kts.	304
(4) At sea level - kts.	280

(b) Maximum rate of climb

(1) At ACA, high blower (28000') - ft/min	2115

- -

(2) At ACA, low blower (20000') - ft/min	2465
(3) At ACA, neutral blower (6500') - ft/min	2820
(4) At sea level - ft/min	2900

(c) Service ceiling - ft* 39,300

2. Military Rated Power

(a) Maximum speed in level flight - V_t

(1) At ACA, high blower (29000') - kts.	385
(2) At ACA, low blower (23100') - kts.	368
(3) At ACA, neutral blower (4600') - kts.	317
(4) At sea level - kts.	303

(b) Maximum rate of climb

(1) At ACA, high blower (25500) ft/min	2710
(2) At ACA, low blower (19000) - ft/min	3040
(3) At ACA, neutral blower (3000) ft/min	3720
(4) At sea level - ft/min	3760

(c) Service Ceiling - ft* 39800

(d) Take-off data - Flap setting: Full down

(1) Take-off speed, V_c - kts.	72.6
(2) Distance in zero wind - ft.	645.0
(3) Distance in a 25 knot wind - ft.	295.0

3. Calibrated Airspeed at Stall

(a) Clean condition, power on - kts.	84.6
(b) Clean condition, power off - kts.	89.4
(c) Landing condition, power on - kts.	64.2
(d) Landing condition, power off - kts.	77.7

B. Flight Handling Characteristics - Previously reported in reference (f).

Loading Condition - Normal Fighter

* Extrapolated values.

Gross Weight - 12,500 lbs. C.G. 31.3% MAC (gear up)
30.19% MAC (gear down)

1. Stability
(Symbols used to designate stability characteristics include: P=Positive; PW=Positive but Weak; N=Neutral; Neg.=Negative; WNeg=Weakly negative).

a. Longitudinal

	Controls	NRP Climb	NRP Vmax	CR	G	L	PA
Static -	Free	WNeg	PW	P	P	PW	WNeg
	Fixed	PW	P	P	P	PW	PW
Dynamic -	Free	Neg.	P	P	PW	Neg.	Neg.

Longitudinal stability was considered satisfactory except as noted in table above.

b. Lateral

	Controls	NRP Climb	NRP Vmax	CR	G	L	PA
Static -	Free	PW	P	P	P	P	N
	Fixed	PW	P	P	P	P	PW
Dynamic -	Free	PW	P	P	P	PW	PW

Lateral stability was considered satisfactory except as noted in table above.

c. Directional

	Controls	NRP Climb	NRP Vmax	CR	G	L	PA
Static -	Free	Neg.	P	P	P	PW	P
	Fixed	P	P	P	P	P	P
Dynamic -	Free	PW	P	P	P	PW	PW

Directional stability was considered satisfactory except as noted in table above.

A rudder force reversal was encountered in the high power climb configuration in right sideslip.

2. Controllability

a. Longitudinal

(1) Control effectiveness: Satisfactory
(2) Control forces: Satisfactory

b. Lateral

(1) Control effectiveness: Unsatisfactory (See para. (c)(1) under Lat.stability and control page 14).
(2) Control forces: Satisfactory

c. Directional

(1) Control effectiveness: Satisfactory
(2) Control forces: Satisfactory

3. Stalling Characteristics

Condition		G	CR	L	PA
RPM		2100	2100	2400	2400
MAP - in. Hg.		0	21	0	25
Tab settings:	Elevator	1°NU	2°NU	6°NU	4.5°NU
	Aileron	0°	2°LWD	0°	3°LWD
	Rudder	5°NL	8°R	3°NL	17°R
Trim Speed - V_c Kts.		120	100	104	83
Warning occurs at - Vc Kts.		93	91	81	-
Shake occurs at - Vc Kts.		91.0	87	79.8	-
Stick movement		slight aft	mod. aft	slight aft	aft
Min. flying speed - Vc Kts.		89.4	84.6	77.7	64.2
Roll		slight L or R	mod. L or R	mod. L	violent L
Pitch		Nose down	slt. nose down	nose down	nose down
Altitude lost (feet)		200 - 400	300	400	600 - 900

(The symbols used to designate control effectiveness and force include: G=Good; F=Fair; P=Poor; X=Ineffective; L=Light; M=Moderate)

Condition		G			CR			L			PA		
		A	S	R	A	S	R	A	S	R	A	S	R
Effectiveness:	Elevator	G	G	G	G	G	G	G	G	G	F	F	G
	Aileron	G	G	G	F	P	P	F	P	F	G	X	G
	Rudder	G	G	G	G	G	G	G	F	F	F	X	P
Force:	Elevator	L	L	L	L	L	M	L	L	L	L	L	L
	Aileron	L	L	L	L	M	M	L	L	M	L	L	L
	Rudder	L	L	L	L	M	M	L	L	L	M	M	M

A=Approach; S=Stall; R=Recovery

4. Trim Tab Characteristics

a. Ease of trimming:	Satisfactory
b. Tab effectiveness:	Satisfactory
c. Tab operation:	Satisfactory

5. Recommended center-of-gravity limits, previously reported in reference (f), are as follows:

Forward	25.0% MAC, gear up
Aft	33.0% MAC, gear up

6. Landing Flap Operation

a. Best flap setting for landing was full down.
b. No buffeting was induced by landing flap.

7. Take-off Characteristics

a. Flap setting for shortest take-off run and adequate control after take-off was full down.

b. Torque effect was not excessive.

c. Best rudder tab setting was 6° right for land take-off and 10° right for carrier take-off.

C. Miscellaneous Tests

1. Carbon Monoxide Survey

Carbon Monoxide survey was conducted in accordance with NavAer SR-93B and reported in reference (g). It was concluded that the carbon monoxide concentrations were not excessive except for the conditions of high power climb, and when taxiing, canopy open with a port-beam wind.

2. Temperature Survey

Temperature survey was conducted in accordance with NavAer E-59C, and reported in reference (d). It was concluded that the cooling of the power plant did not meet the requirements because of:

(a) Excessive oil-in temperatures.

(b) Excessive cylinder head and base temperatures.
(c) Excessive accessory compartment temperatures.
(d) Excessive direct carburetor air rise at critical altitude in netural blower.

3. Maximum rates of roll and associated aileron forces (rudder fixed):

	Vc	Rate of Roll (deg/sec)			Force -lbs. Full Deflec.		
Configuration	Kts.	Left	Right	$(\frac{pb}{2v})$ ave.	Left	Right	Altitude
Clean	205	84	89	.076	22	26	10,000
"PA"	92	35	35	.075	4	7	5,000

4. Ground Handling

a. Handling on runway was satisfactory.
b. Handling in a cross wind was satisfactory with the use of brakes.
c. Operation of brakes was satisfactory.
d. Brakes will hold the airplane at full throttle on a concrete surface having a wood-float finish.

5. The fuel tank was capable of taking fuel at a rate of 50 gallons per minute.

6. The cockpit check-off lists were considered satisfactory.

CONCLUSIONS REACHED

The conclusions reached are summarized as follows:

A. The stability, control and general handling characteristics were acceptable except for the following deficiencies:

(1) Weak negative to negative static stick-free longitudinal stability at speeds below trim was exhibited in the high power climb and power approach configurations at the normal fighter center-of-gravity position of 31.3% MAC, gear up.

(2) Neutral static stick-free lateral stability was exhibited in the power approach configuration.

(3) A rudder force reversal was encountered in the high power climb configuration in right sideslip at approximately three-quarters full left rudder deflection.

(4) Warning of the impending stall was considered inadequate in the power approach configuration. The stall in configuration "PA" was characterized by a violent uncontrollable roll to the left, accompanied by excessive loss of altitude during recovery.

B. Excessive carbon monoxide concentrations existed within the cockpit during high power climb, and when taxiing, canopy open, with a port-beam wind.

C. The cooling of the power plant installation did not meet all the requirements of NavAer E-59C.

DISCUSSION

A. Description of Airplane

1. The model F4U-4 airplane is a single engine, single-seat, low-wing monoplane designed as a carrier-based and land-based fighter. The airplane was manufactured by Chance-Vought Aircraft Corporation, Stratford, Conneticut. It is equipped with a Pratt-Whitney R-2800-18W engine and a Hamilton Hydromatic 4-blade propeller, blade design 6501A-0 and hub design 24E60, thirteen feet two inches in diameter. Photographs of the test airplane are contained in Appendix B.

The power ratings of the engine are as follows:

Take-off - 2100 BHP @ 2800 RPM for 5 minutes
Normal - 1700 BHP @ 2600 RPM at sea level
1700 BHP @ 2600 RPM and 7,000 ft. altitude
1630 BHP @ 2600 RPM and 18,000 ft. altitude
1550 BHP @ 2600 RPM and 26,000 ft. altitude
Military - 2100 BHP @ 2800 RPM and 1,000 ft. altitude
1900 BHP @ 2800 RPM and 14,000 ft. altitude
1800 BHP @ 2800 RPM and 23,000 ft. altitude
3120 RPM rated overspeed RPM for 30 second duration.

2. The airplane loading in the normal fighter configuration of reference (c) and (e) included the following:

Weight Empty (Bu.No. 80763) (lbs)			9253
Useful Load (lbs)			3170
Crew		200	
Fuel (236.3 gallons)		1418	
In internal tanks (234 gals)	1404.0		
Trapped in system (2.3 gals)	14.0		
Oil		259.75	
In tank (16 gals)	120.0		
Trapped in system (18.6 gals)	134.75		
Armament		1123.39	
Fixed gun installation	403.39		
Ammunition (50 cal.)	720.00		
Equipment		64.80	
Navigation	4.30		
Oxygen	27.80		
Miscellaneous	32.70		

B. Stalling Characteristics

Stalls from straight flight in the clean condition, power on and power off, were preceded by slight tail buffeting approximately three to six knots above the minimum flying speed, respectively. The airplane tended to pitch-down at the stall with slight left or right roll in the clean condition, power-off, and moderate left or right roll in the clean condition, power on. Recovery was readily accomplished within 400 feet of altitude by normal control manipulation.

Stalls from straight flight in the landing condition, power off exhibited, in general, the same characteristics as described for clean condition stalls.

In the landing condition, power on, there was no warning of the impending stall other than the appreciable aft stick movement. At the stall, the airplane tended to pitch nose-down and roll violently to the left. The altitude required for recovery varied from 600 to 900 feet.

C. Flight Handling Qualities

1. Longitudinal Stability and Control

(a) Dynamic Longitudinal Stability

Short period, control-free, longitudinal oscillations were initiated by abrupt deflection and release of the elevator control. The oscillation of the elevator and airplane damped completely within one cycle.

The phugoid oscillation of the airplane resulting from a displacement from its trim condition was satisfactory in configurations "P", "CR" and "G". In configuration "L" neutral dynamic stability was exhibited, and in a high power climb and in configuration "PA" a divergence resulted when the airplane was displaced from trim.

(b) Static Longitudinal Stability

Control fixed and control free stability was positive in all configurations except for the following deviations:

In configuration "PA" and high power climb, slight negative to negative stick-free stability at speeds below trim speed was exhibited at the normal fighter center-of-gravity of 31.3% MAC, gear up, and the aft limit of 33.0% MAC, gear up.

(c) Maneuvering Longitudinal Stability

The maneuvering longitudinal stability data as measured in steady turning flight is presented in Appendix A Plates V and VI.

(d) Elevator Control Effectiveness

The elevator control was effective for all speeds and center-of-gravity positions tested. In configuration "L" at the recommended forward center-of-gravity position of 25% MAC, gear up, there was sufficient elevator control to hold the airplane off the ground at 1.05 V_{S_L} . However, at this center-of-gravity position the maneuvering stick forces are excessive.

(e) Longitudinal Trimming Device

The elevator trim tab maintained a given setting indefinitely unless changed manually and was of sufficient effectiveness to meet the requirements in all configurations tested.

2. Lateral Stability and Control

(a) Dynamic Lateral Stability

(1) When the ailerons were deflected and released quickly, oscillations of the ailerons disappeared within two cycles and they returned to their trim positions.

(2) "Dutch Roll" was damped to one-half amplitude within one and one-half cycles in all configurations tested.

(b) Static Lateral Stability

Lateral stability was positive in all configurations except "PA". In configuration "PA" the aileron control force did not change appreciably with increasing sideslip angle, indicating neutral stick-free stability.

(c) Aileron Control Power and Forces

(1) The ailerons were not sufficiently effective to give a wing-tip helix angle $\frac{pb}{2V}$ of .09 with the rudder locked in its trim position, in configuration "G" with power for level flight not exceeding normal rated power. Under the conditions above, a maximum $\frac{pb}{2V}$ equal to .076 was obtained.

(2) Aileron control forces were not considered excessive.

(d) Lateral Trimming Device

The aileron trim tab maintained a given setting unless changed manually and the aileron force could be reduced to zero in all configurations tested.

3. Directional Stability and Control

(a) Dynamic Directional Stability

When the rudder was deflected and released quickly, it returned to its trim position but the oscillation of the rudder did not disappear completely within one cycle.

(b) Static Directional Stability

(1) The rudder-fixed static stability was such that rudder deflections from its trim position at zero bank produced sideslip in the correct direction when performing sideslip in all configurations. The amount of rudder-fixed static stability was sufficient to restrict the angle of sideslip due to sudden application of aileron deflection to not more than one degree of sideslip per five percent of full aileron deflection when rolling out of steady 45 degrees banked turns.

(2) The rudder-free static stability was positive in all configurations except "PA". When steady side-slips were performed in configuration "PA", right rudder forces were in the correct direction to approximately one-half full rudder deflection, and were approximately zero at full deflection. Left rudder forces were in the correct direction to approximately three-fourths full deflection, but then suddenly reversed. The rudder could be returned to neutral with moderate pedal force.

(c) Rudder Control Power

(1) The rudder control gave sufficient directional control to trim the airplane in steady flight with wings level in all configurations tested.

(2) The rudder control, in conjunction with other means of control was adequate to maintain straight ground paths during normal take-offs and landings.

(d) Directional Trimming Device

The rudder tab maintained a given setting unless changed manually, and was capable of reducing the rudder pedal force to zero as specified.

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CONFIGURATIONS TESTED
Model F4U-4 Airplane

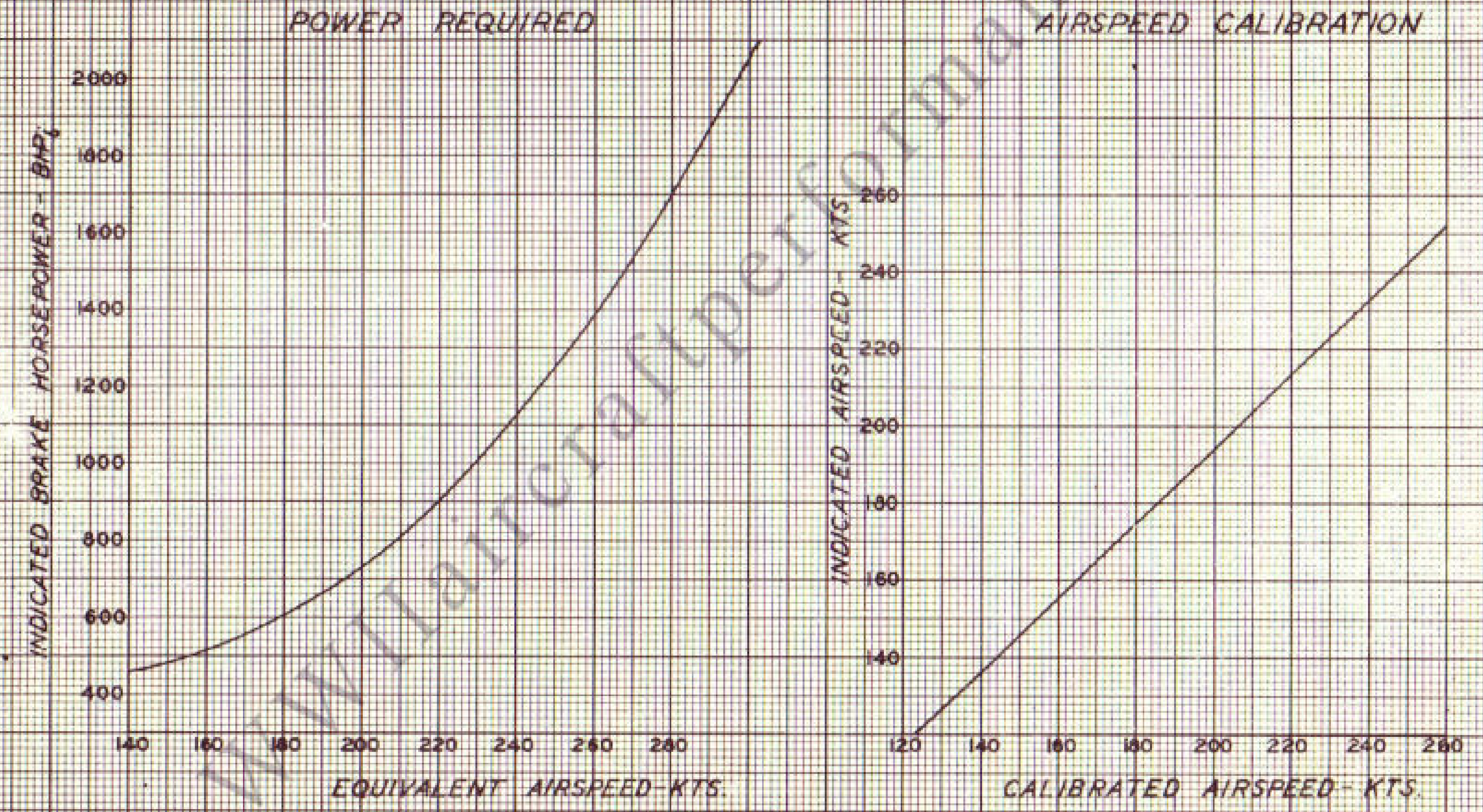
Configuration	Symbol	Flaps	Landing Gear	Cowl Flaps	Canopy	RPM	MAP In.Hg.
Cruise	"CR"	Up	Up	Closed	Closed	2100	20
Power on Clean	"P"	Up	Up	Closed	Closed	2400	37
Glide	"G"	Up	Up	Closed	Closed	Power	off
Landing	"L"	Down	Down	Open	Open	Power	off
Power Approach	"PA"	Down	Down	Open	Open	2100	25

Appendix A Plate I

MODEL F4U-4 AIRPLANE NO. 80765

PERFORMANCE CHARACTERISTICS

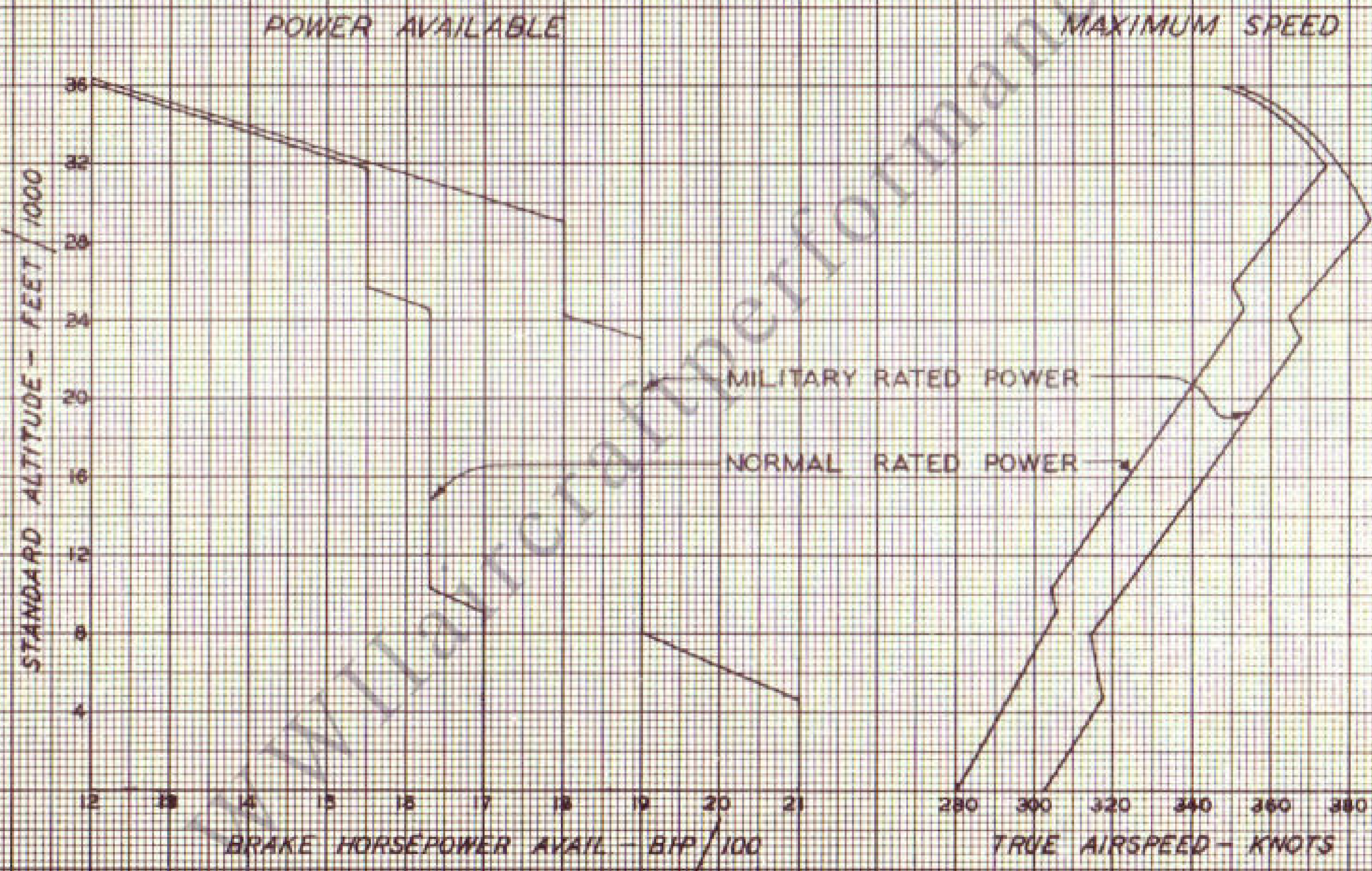
GROSS WEIGHT — 12,500 LBS.
CLEAN NORMAL FIGHTER



MODEL F4U-4 AIRPLANE NO. 80765

LEVEL FLIGHT PERFORMANCE CHARACTERISTICS

CLEAN NORMAL FIGHTER AT 12,500 LBS. GROSS WT.



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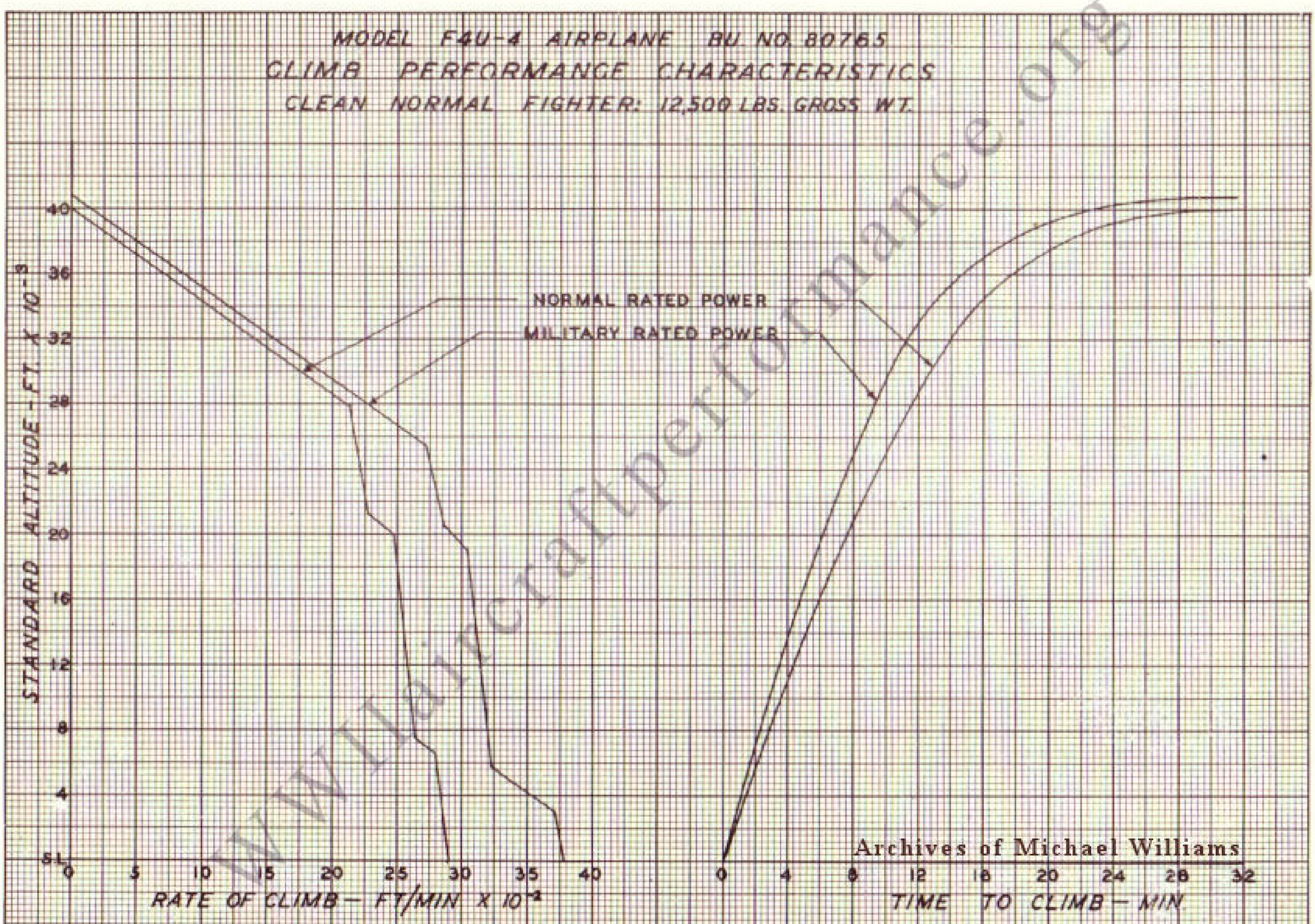
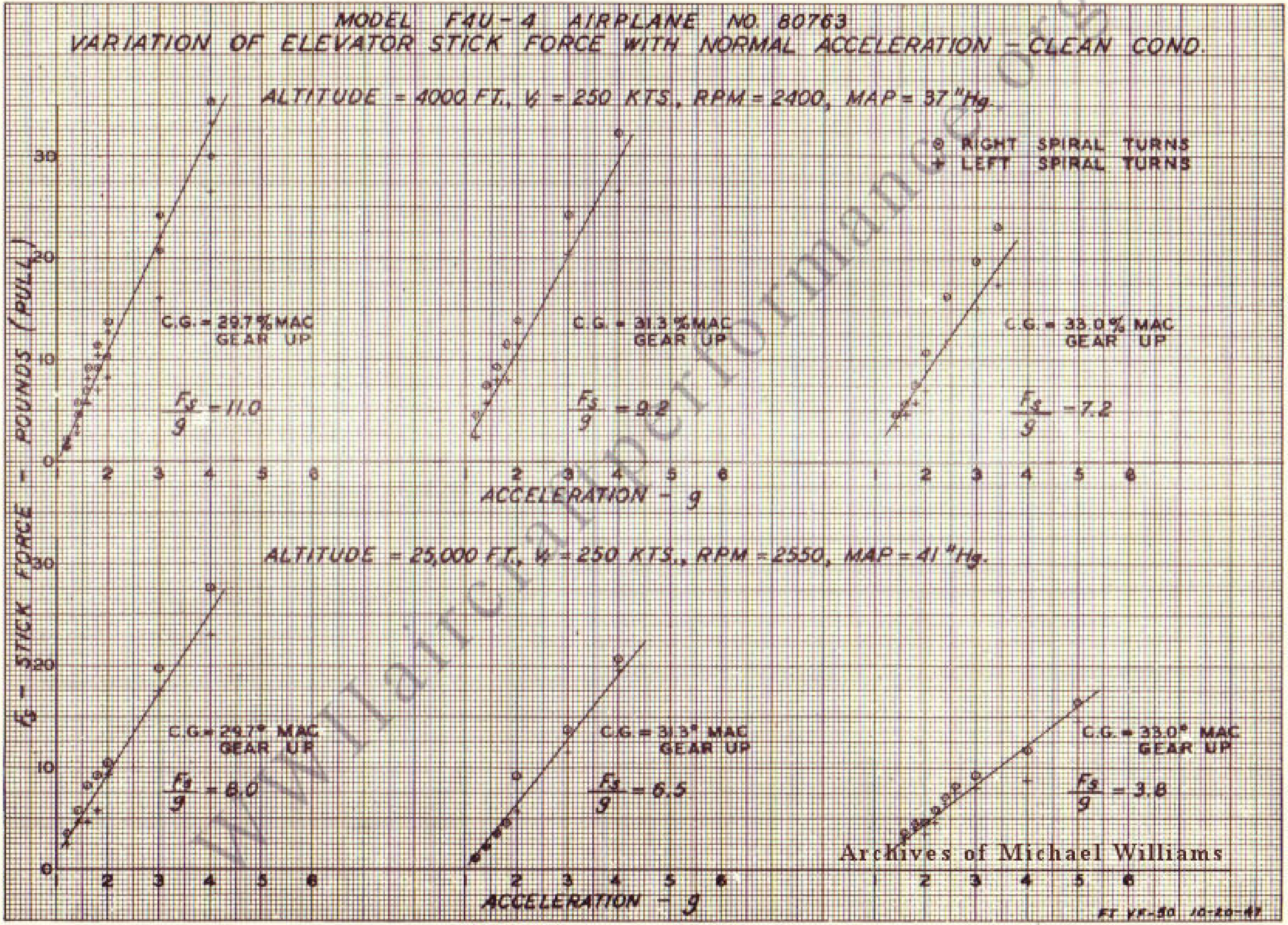
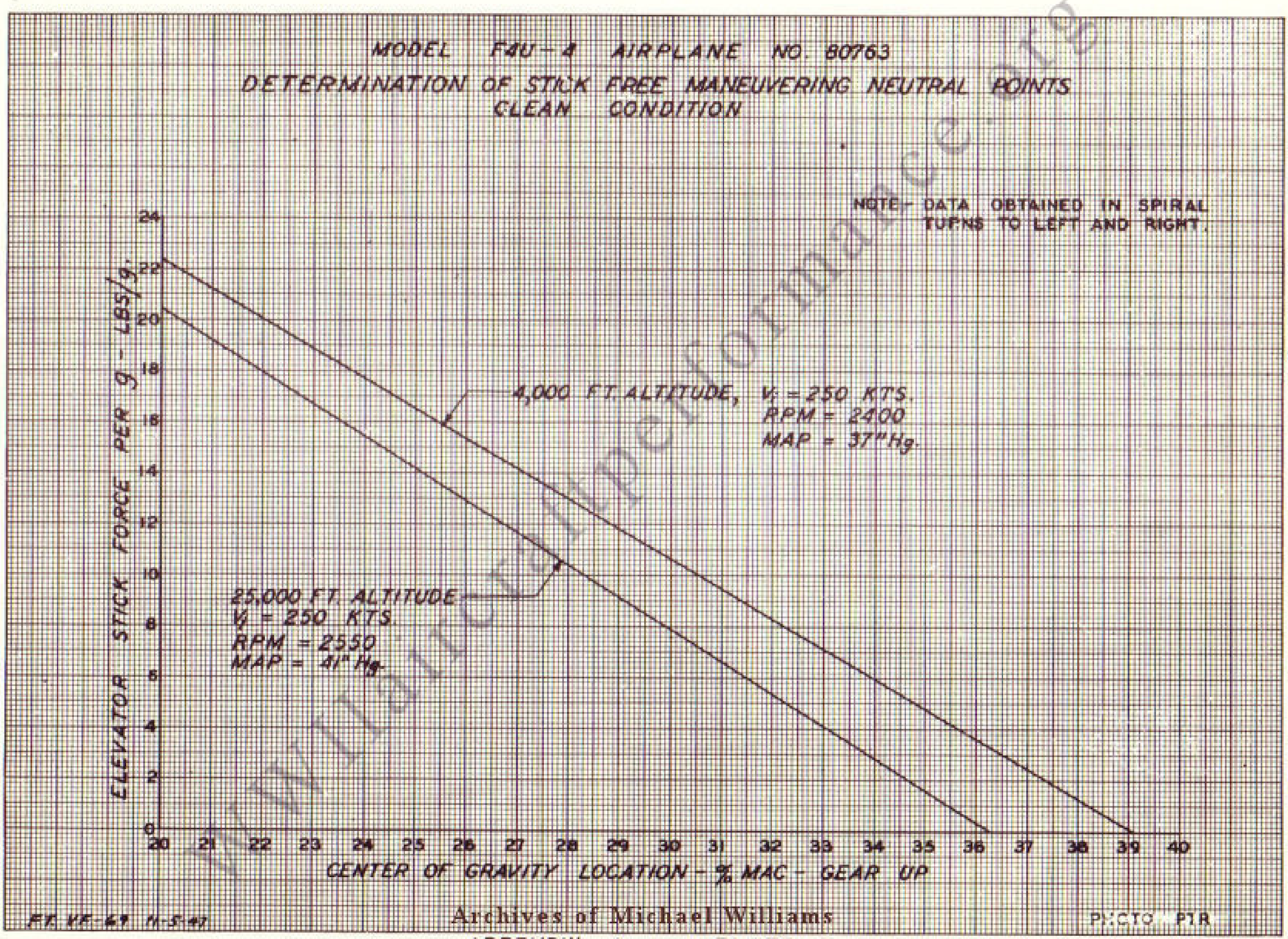


APPENDIX A PLATE 4

FT. VF-96 2-10-48



APPENDIX A - PLATE 5


MODEL F4U-4 AIRPLANE NO. 80763
DETERMINATION OF STICK FREE MANEUVERING NEUTRAL POINTS
CLEAN CONDITION
NOTE- DATA OBTAINED IN SPIRAL TURNS TO LEFT AND RIGHT.
ELEVATOR STICK FORCE PER g - LBS/g.
24
22
20
18
16
14
12
10
8
6
4
2
0
4,000 FT. ALTITUDE, Vi = 250 KTS.
RPM = 2400
MAP = 37" Hg.
25,000 FT. ALTITUDE
Vi = 250 KTS.
RPM = 2550
MAP = 41" Hg.
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
CENTER OF GRAVITY LOCATION - % MAC - GEAR UP
FT. VF-49 11-5-47
PHOTO PTR

Model F4U-4 Airplane #81563 Photo PTR 28029
Left Side View 7-25-45
BIS 2157

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