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FLIGHT TEST
U. S. NAVAL AIR STATION
PATUXENT RIVER, MD.

FINAL FLIGHT REPORT

of

PRODUCTION INSPECTION TRIALS
(TED NO. BIS 2121)

on

MODEL F3A-1 AIRPLANE NO. 04691
(CONTRACT NOa(s)-172)

held

2 FEBRUARY 1944 to 20 JULY 1944

by

FLIGHT TEST

at

U. S. NAVAL AIR STATION
PATUXENT RIVER, MD.

for

BOARD OF INSPECTION AND SURVEY

Project Pilot:

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OCT 6 1944

Archives of M. Williams

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References

(a) Contract NOa(s)-172, dated 5 Mar 1943.

(b) SD-336-1, Detail Specification for Model F3A-1 Airplane, dated 1 Oct 1942.

(c) BuAer conf. ltr. Aer-E-211-RJ, C-NOa(s)-172, C13338, dated 25 Jun 1943.

(d) Power Curves for R-2800-8 engine, AEL Project No. 3911.

(e) Report No. 859, Actual Weight and Balance of Model F3A-1 for Bureau Serial Numbers 04595 thru 04624, Brewster Aeronautical Corporation, Johnsville, Pa.

(f) Recommended Changes in the Model F3A-1 Airplane Items 1 to 3, dated 9 Jun 1944 to 1 Jul 1944.

(g) NA83/44182 VF3A-1 BIS 2121 PTH/mpb (FT) Report, dated 22 Sept 1944.

(h) Report No. 5563, Pilot's Handbook for Models F4U-1, FG-1, and F3A-1, Contract No. 82811, dated 3 Nov 1942.

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BIS 2121 - F3A-1 No. 04691
3/4 Right Front View

Photo PTR 4529
3-15-44

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INTRODUCTION - On 14 January 1944, the model F3A-1 airplane, No. 04691, Royal Navy No. JS471, was delivered at the Naval Air Station, Patuxent River, Md., by air from Roosevelt Field, N. Y. The airplane, when received, had white and sky blue camouflage, non-specular finish with U. S. Navy insignia; however, on 6 April 1944, these insignia were changed to those of the Royal Navy inasmuch as the airplane was one previously allotted the United Kingdom.

The model F3A-1 airplane manufactured by the Brewster Aeronautical Corporation of Johnsville, Pa., is essentially the same as the model F4U-1 airplane manufactured by the United Aircraft Corporation (Chance Vought Aircraft Division). The airplane is a single-engine, single-place, landplane fighter for use aboard aircraft carriers and was designed and constructed in accordance with reference (b). Model F3A-1 airplane No. 04691 was the 177th airplane procured under reference (a). Photographs contained in enclosure 1 show the general condition of the airplane as flown during the trials, but a more detailed description of the external configuration is summarized below.

(a) Gun blast tube openings and shell ejection chutes were faired over with tape.

(b) The airplane was equipped with a low type tail wheel fork.

(c) A spoiler was on the right wing leading edge just outboard the gun blast tubes.

(d) A retractable mast for the ZB-1 radio equipment and an IFF stationary mast were installed on the bottom side of the fuselage. The radio aerial extended from the side of the fuselage just aft of the cockpit canopy to the mast forward of the cockpit and then to the rudder.

(e) Electrical leads for temporarily installed test instruments were securely taped to the outside of the fuselage, extending aft from the accessory compartment to a removable panel leading to the cockpit interior.

(f) An outside air temperature gauge (electrical resistance type) was installed on the underside of the right wing panel.

The Pratt and Whitney R-2800-8 engine used on the subject airplane has the following military and normal power ratings.

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Military Power

2000 BHP @ 2700 RPM - 1700 ft. altitude.
1800 BHP @ 2700 RPM - 15,700 ft.
1650 BHP @ 2700 RPM - 21,000 ft.

Normal Power

1675 BHP @ 2550 RPM - 5500 ft. altitude.
1625 BHP @ 2550 RPM - 16,500 ft.
1550 BHP @ 2550 RPM - 21,700 ft.

Take-off Power

2000 BHP @ 2700 RPM @ 54" Hg. MAP

The propeller was a three-bladed Hamilton Standard constant-speed hydromatic-control of 13'4" diameter (hub No. 23E50-495, blade design No. 6525A-21), having a pitch setting of 12° - 54° @ 72".

PURPOSE OF TEST - The purpose of the tests as conducted by Flight Test on the model F3A-1 airplane in accordance with reference (c) was to determine the following:

(a) Performance and flight characteristics.

(b) General suitability for service use as a carrier and land-based fighter.

METHOD OF TEST - Engine powers developed throughout the subject trials were based on AEL Power Curves contained in reference (d).

A temperature survey was conducted on the engine of the subject airplane by means of a specially installed Brown Recorder. Additional instrumentation was made for purposes of observing the carburetor air temperature and outside air temperature during performance evaluation flights.

The following Weight and Balance summary shows the condition of the airplane as flown during the performance phase of the subject trials. The actual weight empty for model F3A-1 airplanes from Serial Nos. 04595 thru 04624 is given in reference (e).

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Weight and Balance Summary: "Overload" Fighter less wing tank fuel

Loading

Par. from Detail Spec.	104c - modified
Gross Weight - lbs.	11,939
Useful load - lbs.	3,212
Useful load - % gross wgt.	26.9
Wgt. empty - lbs.	8,727
Wing loading - lbs per. sq. ft.	38
Take-off power loading - lbs per BHP.	6
Center of gravity location - % MAC:	
Wheels retracted.	33.0
Wheels extended.	31.8
Detailed useful load:	
Pilot.	200
Fuel - main - gals.	237
Oil - gals.	15
Trapped fuel & oil - lbs.	111
Wing guns & installation - lbs. (6-50 cal.)	408
.50 cal. ammunition - rds.	2,350
Radio - lbs.	147
Navigating equipment - lbs.	4
Life raft - lbs.	14
Oxygen (double) - lbs.	44

RESULTS OF TEST:

A. Performance (As an "overload" fighter less wing tank fuel)

1. Maximum speed (high blower)

Power	Normal	Military
Brake horsepower.	1550	1650
Airplane critical altitude-ft..	24,200	23,300
Maximum speed at ACA - MPH.	393.5	390
2. Service ceiling - ft.	38,000	38,000
3. Maximum rate of climb at sea level-FPM.	2380	3080

4. Minimum speed at sea level:

	"Overload" Fighter
Clean condition-power on-MPH.	99.5
Clean condition-power off-MPH.	104.5
Landing condition-power on-MPH..	74.5
Landing condition-power off-MPH.	86.5

5. Take-off data (full flap):

*Brake horsepower.	1986
RPM.	2700
Take-off speed - MPH.	86.0

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Take-off distance - no wind -ft.....	725
Take-off distance - 25 knot wind-ft.	340

Engine Data	Airplane Configuration
RPM = 2700	Cowl flaps - 2/3 open
MAP = 54" Hg.	Intercooler - closed
CAT = 25°C	Oil cooler - full open
OAT = 21°C	Cockpit hood - full open

* On basis of AEL Power Curves - reference (d).

B. Flight Characteristics - 1. A discussion of the longitudinal stability characteristics at various gross weights and center of gravity locations is summarized below. A bungee spring installed in the elevator control system is operative only when the tail wheel is down. This spring exerts a nine pound forward force on the control stick which induces longitudinal stability in the landing condition.

(a) The most forward center of gravity location investigated on the F3A-1 airplane was 29.0% MAC (wheels retracted), 27.7% MAC (wheels extended), at a gross weight of 10,598 pounds. In order to move the center of gravity this far forward, it was necessary to drain the main fuel tank and remove the ballast equivalent of 2350 rds. of ammunition from the wing boxes; the oil tank and fuel wing tanks were filled to capacity. With this center of gravity location, the airplane, in the clean configuration, exhibited strong, positive stability when disturbed from trimmed flight during climbs, glides, and level flight at various speeds and powers. In the landing configuration, during power-off glides, using full nose-up trim tab, the indicated airspeed was approximately 112 MPH; however, sufficient stick was available to stall the airplane. Simulated carrier approaches to the field and three point landings were satisfactorily demonstrated at this loading condition. Elevator forces were normal.

(b) As a representative overload fighter, having full main fuel tank, ballast for full ammunition, 15 gals. of oil, and empty wing fuel tanks, the center of gravity location was 33% MAC (wheels retracted), 31.8% MAC (wheels extended) at a gross weight of 11,939 pounds. Static stability was satisfactory in all conditions of flight investigated except during high power climbs. When climbing at an indicated airspeed of 150 MPH, decreasing the speed to an indicated 140 MPH by an upward pitch was sufficient to produce static instability; increasing the speed from an indicated 150 MPH to 160 MPH by a downward pitch resulted in weak stability and approximately neutral dynamic stability. In high speed and cruise level flights at indicated airspeeds of 270 MPH and 235 MPH respectively, and in low power glides at 125 MPH, the airplane possesses positive static stability but little dynamic stability, having a very low degree of damping. In the landing configuration, the airplane was stable during high power climbs at indicated airspeeds of 110 MPH, and simulated carrier approaches and power-off glides at 100 MPH, with dynamic oscillations damping out promptly once the initial flight path was momentarily disturbed. Using power-off and full nose-up trim tab, the airplane glides at approximately 110 MPH indicated. Elevator effectiveness was considered adequate; control forces were normal. Elevator control movements as indicated by recorded stick positions in inches during various flight conditions are shown in the following summary:

ELEVATOR CONTROL MOVEMENT

Condition	From	To	Difference (inches)
Clean 75% Power	Level Flight 8"	Minimum V 8 3/4"	+ 3/4"
Clean Power off	Dive at Vmax Level 8"	Vstalls plus 40 knots 8 1/4"	+ 1/4"
Clean Power off	Vstall plus 40 knots 8 1/4"	Vstall 9"	+ 3/4"
Glide at 100 knots	Clean condition 9"	Landing Condition $9\frac{1}{2}$"	+ $\frac{1}{2}$"
Land Condition Power on	Vstall plus 30 knots 8 1/4"	Vstall plus 20 knots 8 1/4"	0"
Ground	Full FWD $1\frac{1}{2}$"	Full Back 19 3/4"	+ 18 1/4"

(c) The most aft center of gravity location at which investigations for stability were conducted was 34.8% MAC (wheels retracted), 33.6% MAC (wheels extended) at a gross weight of 12,257 pounds. To move the center

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of gravity this far rearward required that additional ballast be carried within the fuselage aft section, somewhat increasing the gross weight over the overload fighter gross weight of 11,939 pounds. Since the airplane has decidedly poor longitudinal stability at this loading condition and is believed unsafe except when flown by pilots with considerable experience in this type of airplane, a center of gravity position of 34.8% MAC (wheels retracted) is recommended as the most aft limit. During high power climbs at an indicated airspeed of 150 MPH, the airplane was completely unstable longitudinally and elevator stick forces were extremely light. In high speed and cruise level speed runs, the airplane possesses static stability but dynamic instability, with succeeding oscillations increasing in amplitude once the airplane is momentarily disturbed from trimmed flight. Neutral dynamic stability was evidenced during low power glides, while a slight degree of positive dynamic stability was exhibited in power-off glides in the clean condition. Dynamic stability is neutral during high power climbs and simulated carrier approaches in the landing configuration. In the clean configuration, the airplane will stall with a 2^{o} nose-down tab during a power-off glide; in the landing configuration, the airplane glides at an indicated airspeed of 88 MPH, full nose-up trim tab, power off. Elevator control movements as indicated by recorded stick positions, in inches, during various flight conditions are summarized below:

ELEVATOR CONTROL MOVEMENT

Condition	From	To	Difference (inches)
Clean 75% Power	Level Flight (knots) 8"	Minimum V 8 1/4"	+ 1/4"
Clean Power off	Dive at Vmax Level 7½"	Vstall plus 40 knots 7 3/4"	+ 1/4"
Clean Power off	Vstall plus 40 knots 8"	Landing Condition 8 1/4"	+ 1/4"
Glide at 100 knots	Clean condition 8 1/4"	Landing Condition 8 1/4"	0

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Landing condition Power on	Vstalls plus 30 knots 8 1/4"	Vstall plus 20 knots 8 1/4"	0
Landing condition Power off	Vstall plus 10 knots 8 1/4"	Vstall 8 1/4"	0
Landing condition Power off	Vstall plus 30 knots 8 1/4"	Vstall 8 3/8"	+ 1/8"
Ground	Full FWD 1½"	Full back 19 3/4"	18 1/4"

2. Directional stability characteristics were investigated with the airplane at a gross weight of 11,939 pounds, having a center of gravity at 33% MAC (wheels retracted). When gentle to sharp aileron turns were made with the rudder free during various flight maneuvers, the resulting yaw was always in the direction of bank, indicating adequate positive stability. Rudder forces, in yaw up to full rudder, were generally from normal to high except in Vmax level runs where excessive rudder forces prevented full rudder displacement. A slightly decreasing left rudder force was noticed during high power climbs, clean configuration. Recovery after level yaw, rudder free, was normal at all times.

3. Lateral stability tests were conducted at the same airplane loading and center of gravity position as used during the directional stability demonstrations, e.g., 11,939 pounds gross weight, and 33% MAC (wheels retracted). Positive stability was exhibited in all conditions investigated but was weak in the high power climbs, clean configuration, and neutral in the landing condition at an indicated airspeed of 90 MPH. Aileron forces (fixed) with yaw up to full rudder were from low to moderate. Recovery from an attitude of flight best generally described as straight yawed flight were from normal to sluggish during simulated carrier approaches and power-off glides in the landing configuration.

4. Stall characteristics were investigated under the various flight conditions as summarized below:

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Condition	Power	Stall Warning	Stall & Recovery
* Clean	2150 RPM @ 18" Hg.MAP	Controls buffeting 3-4 MPH above stall	Fell off to left-Recovers easily Loses 150-200 ft.
Clean	Throttle closed	Less warning than with power	Fell off to right Recovers easily Loses 200 ft.
** Landing Condition	2300 RPM @ 23" Hg. MAP	Controls buffeting 2-3 MPH above stall	Fell off to left with stick fallin forward Loses 300-400 ft.
Landing Condition	Throttle closed	Very little warning	Fell off to right Loses 400 ft.

* Clean - Hood, intercooler, cowl flaps closed.
** Landing condition - Engine cowl 2/3 open, intercooler closed.

C. Miscellaneous Tests - 1. Rates of roll and required stick forces using fully deflected ailerons, rudder locked, were measured under various conditions and are summarized below:

Rates of Steady Roll Through 90°

Condition	IAS MPH	Rate of Roll Degrees per Sec. Left	Right	Stick Force Pounds	*Pb/2V (radians) Left	Right
Landing	90	56.2	60.0	4	.126	.135
Clean	150	72.0	75.0	15	.098	.102
Clean	170	72.0	75.0	21	.086	.090
Clean	200	81.8	78.3	24	.083	.080
Clean	220	94.8	94.8	28	.088	.088
Clean	240	94.8	105.8	32	.081	.090
Clean	260	90.0	100.0	32	.071	.078
Clean	300	112.5	112.5	40	.077	.077

* P = radians per second
b = wing span - ft.
V = true air speed - feet per second.

2. Angles of climb and dive are plotted in the form of a curve, showing flight angle versus airspeed, and are contained in enclosure 2 as Figure 4 of Performance Characteristics.

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3. The effect of full open cowl flaps on flight stalling characteristics is shown in the following summary:

Condition	Closed Flap		Open Flap	
	IAS MPH	"Fall-off" Direction	IAS MPH	"Fall-off" Direction
Clean + Power	94	Left	91	Left
Clean - Power	96	Right	95	Right
Landing + Power	72	Left	70	Left
Landing - Power	82	Left	80	Right

4. Oil scavenger pump back pressures were observed under various operating conditions, having the following representative average values:

Condition	Back Pressure lbs/sq.in.	Engine RPM
Starting	2	-----
Warm-up	2	1000
Military Climb	4 - 5	2700
Military Level Flight	4 - 5	2700
Cruise Level Flight	4 - 5	2150

5. Carburetor air temperature rise over the outside air temperature was observed under two different operating conditions as indicated:

Condition	Altitude-ft.	RPM	MAP-"Hg.	Mixture	OAT-°C	CAT-°C
No. 1	2600	2700	52	Auto-rich	+ 26	+ 32
No. 2	1700	2700	38	Auto-lean	+ 29	+ 33

6. Evaluation of the fuel pressure system was made during a normal rated power climb. (Fuel not heated, fuel tanks not pressurized, and auxiliary fuel pump in the off position at commencement of climb.)

Fuel Pressure Data

Altitude-ft.	Fuel Pressure lbs/sq.in.	Remarks
Sea Level to 5000	16	Pressure began to drop below minimum allowable at 5000 ft.

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5,400	11.5	Emergency fuel pump turned on after fuel pressure dropped to 11.5
5,400 to 33,000	15 - 16	Climb terminated at 33,000 feet Engine "rough" from 22,000 feet up - pressurizing system off at all times.

7. Excessive carbon monoxide concentrations were found in the F3A-1 airplane during a Survey as prescribed by Navy Aeronautical Specifications SR-93A. The following test results, showing the percentage concentrations, were taken from item 1 of reference (f).

Military power climb with cockpit closed:
(a) At pilot's knees........................ .015%
(b) At diluter - demand oxygen inlet....... .097%

Military power level flight:
(a) At pilot's knees........................ .030%
(b) At diluter-demand inlet................. .082%

Cruise at 70% power:
(a) At pilot's nose......................... .010%
(b) At pilot's knees........................ .010%
(c) At diluter-demand oxygen inlet......... .016%

Military power level flight:
(a) At cockpit heater outlet, with heater on. .060%

8. Reference (g) is a complete temperature survey report on the subject airplane. Excessive temperatures were recorded during the survey as prescribed by Navy Aeronautical Specification E-59C with the following results:

(a) All temperatures were within limits during the ground runs, except the accessory compartment which averaged 17°C above the limit.

(b) Above 17,000 feet in a military climb, temperatures of cylinder head No. 2 was high, being 8°C over the limit at 28,000 feet.

(c) During the level flights in military power, the oil in temperature was high at sea level and at 19,000 feet. The head temperatures of cylinder No. 4 was 13°C over the limit at 19,000 feet and 9°C over the limit at 23,000 feet.

9. The cockpit check-off list for take-off and landing was considered adequate and satisfactory.

10. The fuel filling rate was from 30-50 gallons per minute.

DISCUSSION - With reference to the brake horsepower required curve, Figure 1 of Performance Characteristics, it will be noted that the propeller efficiency was manifestly higher at 2550 RPM than at 2700 RPM. It is for this reason that the Vmax at the airplane critical altitude, normal power, exceeds the Vmax at the airplane critical altitude, military power. Attention is invited to the fact that the propeller installed on the subject airplane is known to give inferior high-speed performance as compared to the model F6F propeller (design No. 6501A-0 of 13'1" diameter.)

In determining steady rates of roll using fully deflected ailerons, the rolls were started from a 60° bank opposite to the intended direction of roll; hence, the time for a 90° roll was measured from the instant the gyro horizon passed thru 30° on one side to the time it passed thru 60° on the other side. The times recorded, therefore, represent approximately the maximum steady rate of roll and do not show the effect of starting and stopping. Stick forces required to hold the controls fully deflected were obtained from a control force indicator held between the pilot's hand and stick. The expression Pb/2V is a measure of aileron effectiveness during a steady roll, where P is the rolling velocity, b the span, and V the true airspeed.

Angles of climb and glide were determined at an altitude of 9,000 feet, with the engine operated at 2700 RPM and a manifold pressure of 53.5" Hg., delivering approximately 1760 horsepower. To insure sufficient cooling at low air speeds, all climbs were made using 1/3 open cowl flap, $\frac{1}{3}$ open intercooler and oil cooler flaps; all dives were made with the airplane in the clean condition. During dives in excess of 400 MPH indicated, the controls became very heavy, the radio antenna vibrated excessively.

The effect of the full open cowl flaps on stalling speeds was to lower the indicated airspeeds approximately 2 MPH in the various conditions of flight. However, their use resulted in some undesirable features of which excessive buffeting about the tail surfaces was the most objectionable. Noticeable lessening of rudder and elevator control was apparently due to this buffeting. The use of full open flaps also impaired, somewhat, the forward visibility.

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CONCLUSIONS - 1. The model F3A-1 airplane exhibited satisfactory performance and flight characteristics. Various pilots who flew the airplane during the trials expressed the opinion that the flying qualities and control appeared identical or very similar with those of the model F4U-1 airplane.

2. The model F3A-1 airplane was found acceptable for service use as a fighter airplane except for a number of defects as covered under Recommendations. However, satisfactory completion of (a) the demonstration by the contractor pursuant to Section 6, ii, of reference (a) has not been fulfilled as of this date.

3. The engine installation does not meet the temperature limit requirements as set forth in NAVAER E-59C due to excessive oil in, accessory compartment and cylinder head temperatures.

RECOMMENDATIONS - As a result of the trials, changes in the model F3A-1 airplane have been recommended and submitted in reference (f). These and other recommendations are summarized below with responsibility for incorporation indicated as follows:

C - Contractor responsibility
G - Government responsibility

These necessary changes, considered essential to obtain a satisfactory combat airplane, should be incorporated on undelivered airplanes prior to delivery and on delivered airplanes as soon as practicable.

1. Reduce to a safe minimum the carbon monoxide concentration in the airplane cockpit. -C
2. Provide more serviceable exhaust stacks. -C
3. Improve cooling of engine and accessory compartment. -C
4. Improve oil cooling. -C

Encl: (HW)
1. Performance Curves, Photo PTR Nos. 12794, 12793, 12797, and 12796.
2. Photographs, Photo PTR Nos. 4531, 4526, 4530, 4527, 4528, 4532, 5062, 5065, 3471, 3470, 5066, 3473, 5064, 5210, 5211, 5212, 5213, 5186, 5185, 5184.

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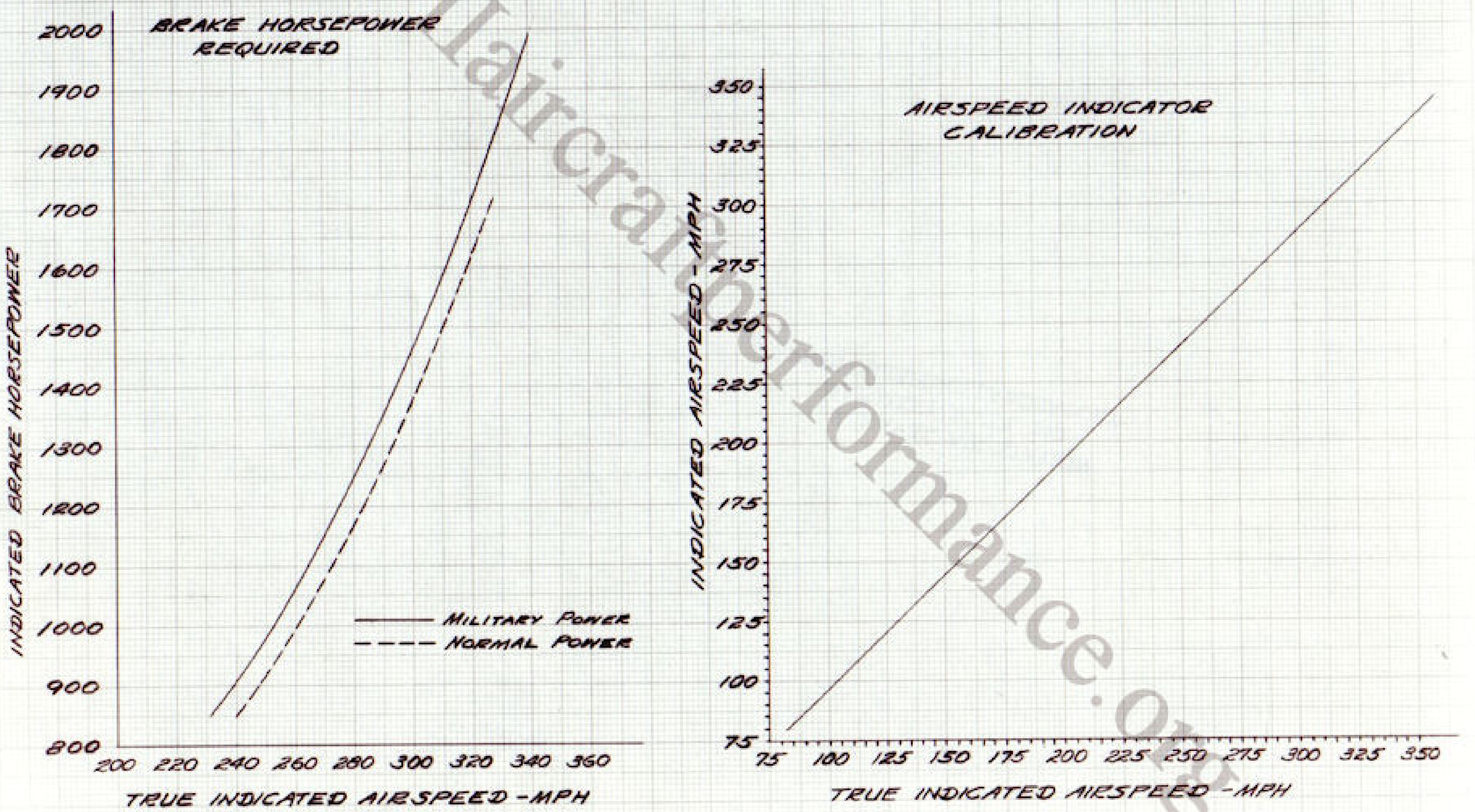
PHOTO PTR 12794

MODEL F3A-1, AIRPLANE NO. 04691
PERFORMANCE CHARACTERISTICS
OVERLOAD FIGHTER GROSS WEIGHT = 11,939 LBS.



RcB 7-29-44

FIG. 1

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MODEL F3A-1, AIRPLANE NO. 04691
PERFORMANCE CHARACTERISTICS
OVERLOAD FIGHTER GROSS WEIGHT = 11,939 LBS.

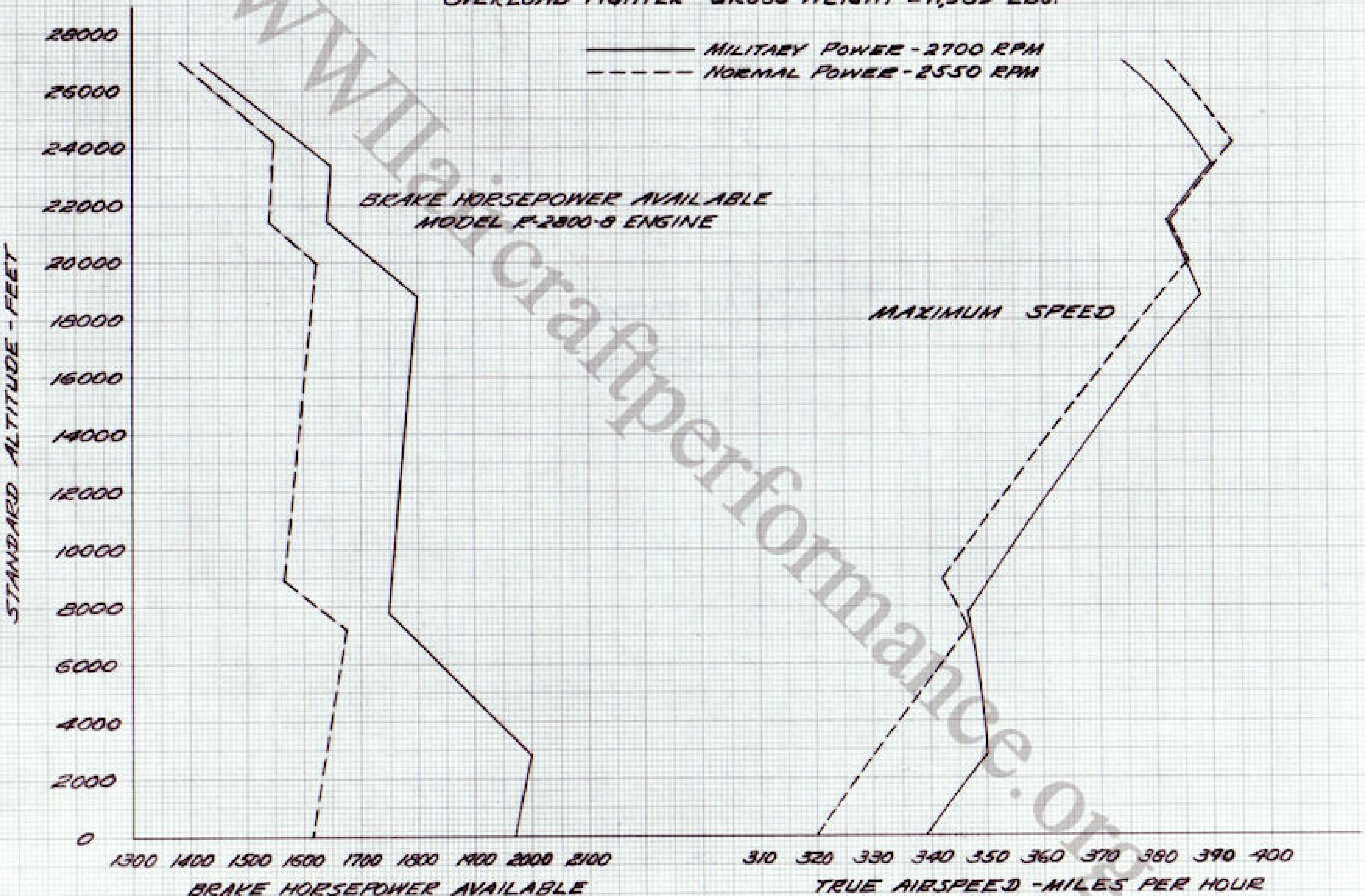

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FIG. 2

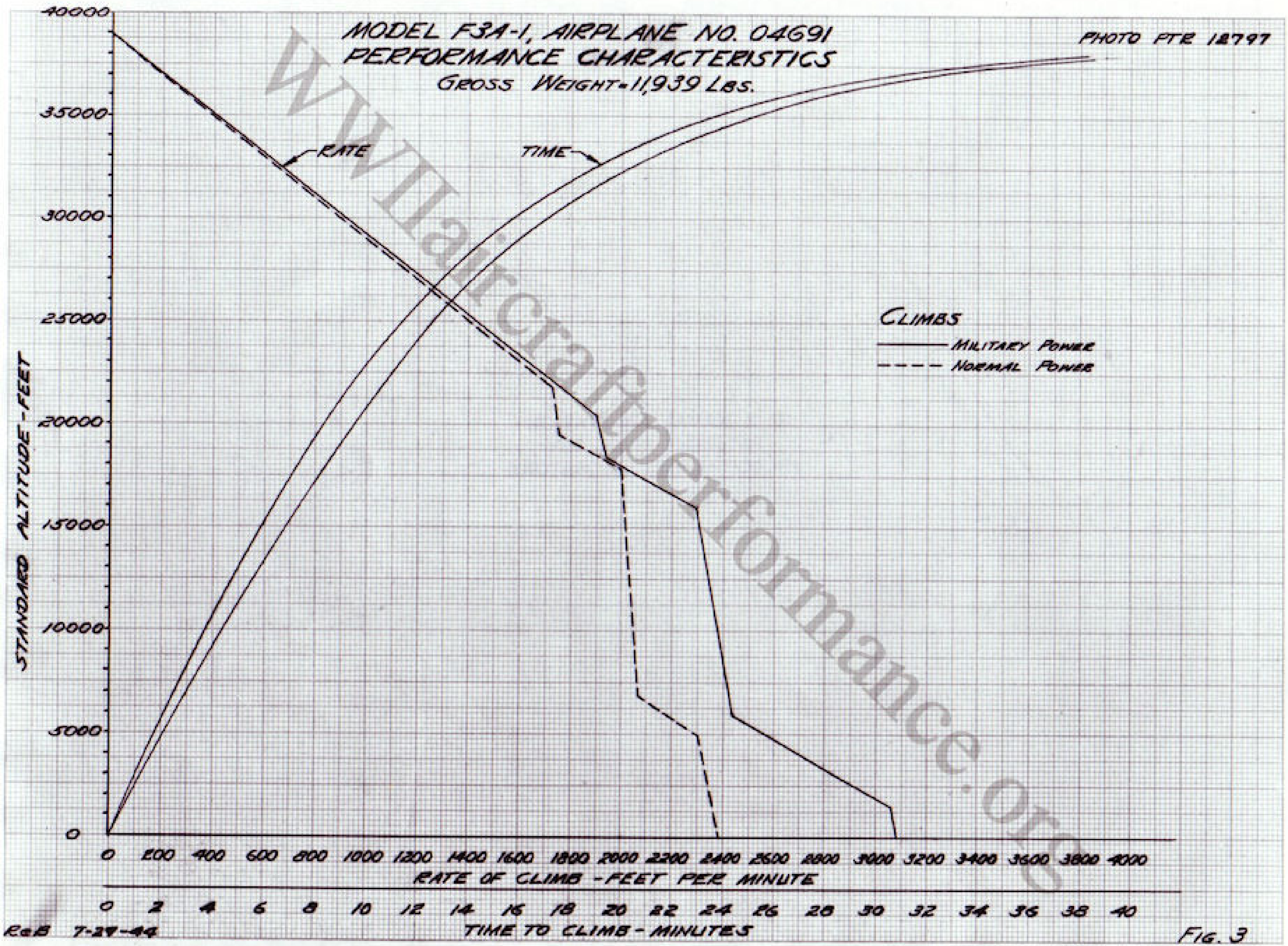

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FIG. 3

MODEL F3A-1, AIRPLANE NO. 04691
PERFORMANCE CHARACTERISTICS
OVERLOAD FIGHTER GROSS WEIGHT = 11,939 LBS.

PHOTO PTR 12796

ANGLE OF DIVE AND CLIMB VERSUS AIRSPEED
1760 BRAKE HORSEPOWER - 10,000 FT. DENSITY ALTITUDE

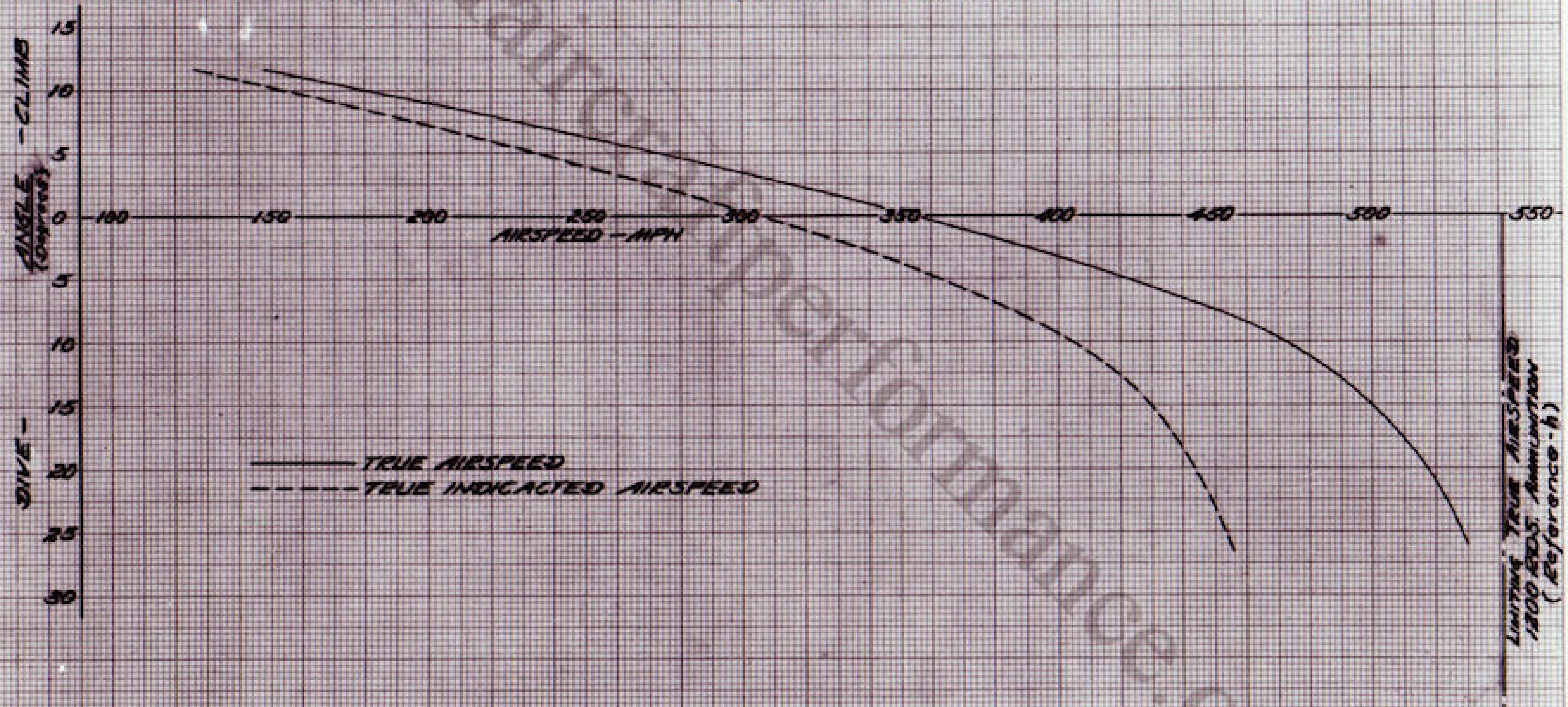

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FIG. 4


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BIS 2121 - F3A-1 No. 04691
Front View

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BIS 2121 - F3A-1 No. 04691
Left Side View

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BIS 2121 - F3A-1 No. 04691
Right Side View

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