
CAFE Challenge

BUSHBY MUSTANG II AIRCRAFT PERFORMANCE REPORT


CAFE Triaviathon

Comparative Aircraft Flight Efficiency, Inc.
A Non Profit, All Volunteer, Tax-exempt Educational Foundation
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This Lycoming O-320 powered Bushby Mustang II from Jim Lewis of Walnut Creek, CA., proved to be an excellent performer. Com antenna is forward of the canopy. The propeller was beautifully finished by Ted Hendrickson after it sustained rain damage to the leading edge.

OVERVIEW

by
Brien A. Seeley M.D., President
CAFE Foundation
EAA120126

In 1958, Bob Bushby purchased the rights for an all metal single-seat racer known as the “Midget Mustang”. This racer was a design originally built IN 1948 by Dave Long, who was at that time chief engineer at Piper Aircraft.

Bob built his prototype version of the Midget, N15J and first flew it on September 9, 1959. Its performance and capability created a demand for a two-place version and Bob designed the Mustang II between 1963 and 1965. He flew that first Bushby Mustang II to EAA’s 1966 Rockford Convention. The only parts it shared with the Midget were the wing ribs and the spar web.

Since then, Bob’s Mustang II evolved through a 125 hp Lycoming to a 160 hp O-320, fixed tri-gear, with wood as well as constant speed props, and even a folding wing design. Bob’s awards include twice winning the August Raspet Memorial Award and the Stan Dzik Memorial Award for Outstanding Design Contribution.

Over the years, builders have added retractable gear, tip tanks, wet leading edges and engines of up to 210 hp.

The aircraft in this test is a representative example of the breed, being powered by an O-320 Lycoming of 160 hp with a fixed-pitch wood prop. It belongs to Jim Lewis of Concord, California, and it is currently for sale (contact Jim at 510-938-1646).

It was built by Charles H. Chervenka of Sunnyvale, California, being completed in 1985. It was flown about

MUSTANG II APR

KIT SUPPLIER	OWNER/BUILDER N402C
Mustang Aeronautics Chris Tieman PO Box 1685 Troy, MI. 48099. (810)-589-9277 FAX 810-588-6788	Jim Lewis 7 Chester Ct. Pacheco, CA. 94553. 510-938-1646

DESIGNER'S INFORMATION

Cost of kit, less engine, instruments, lights, and interior	$10,780
Plans sold to date	1900
Number completed	300
Estimated hours to build, basic airframe	1300-2000
Prototype first flew, date	1966
Normal empty weight, with O-320	930-1100 lb
Design gross weight, with O-320	1500 lb
Recommended engine(s)	Lyc. O-320 to IO-360
Advice to builders:	fully aerobatic at 1350 lb, loops, rolls, hammerheads, spins, etc. approved only after proper instruction; inverted flight and flight with open canopy prohibited.

CAFE FOUNDATION DATA N402C

Wingspan	24 ft 4 in
Wing chord, root/root rib of wingtip	58.25 in/31.75 in‡
Wing area	97.1 sq ft
Wing loading, 1500 lb/97.1 sq ft	15.44 lb/sq ft
Power loading, 1500 lb/160 hp	9.37 lb/hp
Span loading, 1500 lb/span	61.64 lb/ft
Airfoil, main wing	64a212
Airfoil, design lift coefficient	.2
Airfoil, thickness to chord ratio	.12
Aspect ratio, span^2/97.1 sq ft	6.10
Wing incidence	-.8˚‡
Thrust line incidence, crankshaft	.4˚ Nose Down‡
Wing dihedral	4.4˚‡
Wing taper ratio, root/tip	.55‡
Wing twist or washout	2.5˚
Steering	steerable tail wheel
Landing gear	Tailwheel, spring steel, wheel pants
Horizontal stabilizer: span/area	90 in/9.8 sq ft‡
Horizontal stabilizer chord: root/tip	19.25 in/12.2 in‡
Elevator: total span/area	90 in/6.9 sq ft‡
Elevator chord: root/tip	14.5 in/7.5 in‡
Vertical stabilizer: span/area incl. rudder	49 in/14.3 sq ft‡
Vertical stabilizer chord: root/tip	38.5 in/20.75 in‡
Rudder: average span/area	47.5 in/4.2 sq ft‡
Rudder chord: top/bottom	8.25 in/17.25 in
Ailerons: span/chord, each	44.6 in/7.5 in‡
Flaps: span/chord, each	46.5 in/13 in‡
Tail incidence	-1.5˚
Total length	20 ft 6.75 in (plans = 19 ft 6 in)
Height, static with full fuel	5 ft 10 in‡
Minimum turning circle	Estimated 50 ft
Main gear track	6 ft 9 in
Wheelbase, nose gear to main gear	14 ft 9 in‡
Acceleration Limits, positive & negative	5 G yield, 7 G ultimate
AIRSPEEDS PER OWNER'S P.O.H., IAS	
Never exceed, V_{ne}	200 kt/230 mph
Maneuvering, V_a	122 kt/140 mph
Best rate of climb, V_y	83 kt/95 mph
Best angle of climb, V_x	65 kt/75 mph
Stall, clean at 1300 lb GW, V_s*	54 kt/62 mph
Stall, landing, 1300 lb GW, V_{so}*	50 kt/58 mph
Flap Speed, V_f	87 kt/100 mph

* Compare to CAFE MEASURED PERFORMANCE.

‡ Measured by CAFE test crew.

CAFE TEST SUMMARY

VMAX CRUISE ------210.7 mph

RATE OF CLIMB----1080 fpm**

STALL SPEED--------- 63.5 mph

****2500'-3500' Std. Day, 2278 RPM, 100 IAS, 27" M.P., see text.**

12 hours before being sold to Art Beer of Santa Rosa, Californi. Art states that because this aircraft uses an engine mount which was originally intended for the 180 hp Lycoming, locates the existing O-320 engine 2" farther aft than standard, and thus makes this aircraft slightly tail heavy.

Art painted the aircraft and made several changes and refinements to it. In 1989, Art sold the aircraft to Jim Lewis. Jim had the aircraft painted with the Mustang graphic, and performed several modifications and improvements of his own, including a 70% reduction in cowl exit area, a harmonic balancer/flywheel and nozzled exhaust pipes. These changes produced about 11 mph more cruise speed, according to Jim and Art. Jim, who reports having carefully measured before and after, attributes 7 mph more speed to the harmonic balancer.

Jim owns a foreign auto repair shop in Walnut Creek, California. He was trained as an aircraft mechanic in his youth. Jim used the aircraft to practice aerobatics and has performed loops, rolls, Immelmans, Cuban eights and hammerheads in the aircraft. He has pulled 5 G's with 2 aboard and 1/2 fuel and has demonstrated the 230 mph redline IAS.

This Mustang has accumulated over 360 hours total time, and has 150 hours since top overhaul of the engine.

For these CAFE performance tests, the magneto timing was set at 27 degrees BTDC, and a "climb" Pacesetter wooden prop of 68 x 66 was used. A closed cowl outlet and nozzled exhaust pipe outlets were other modifications on this aircraft.

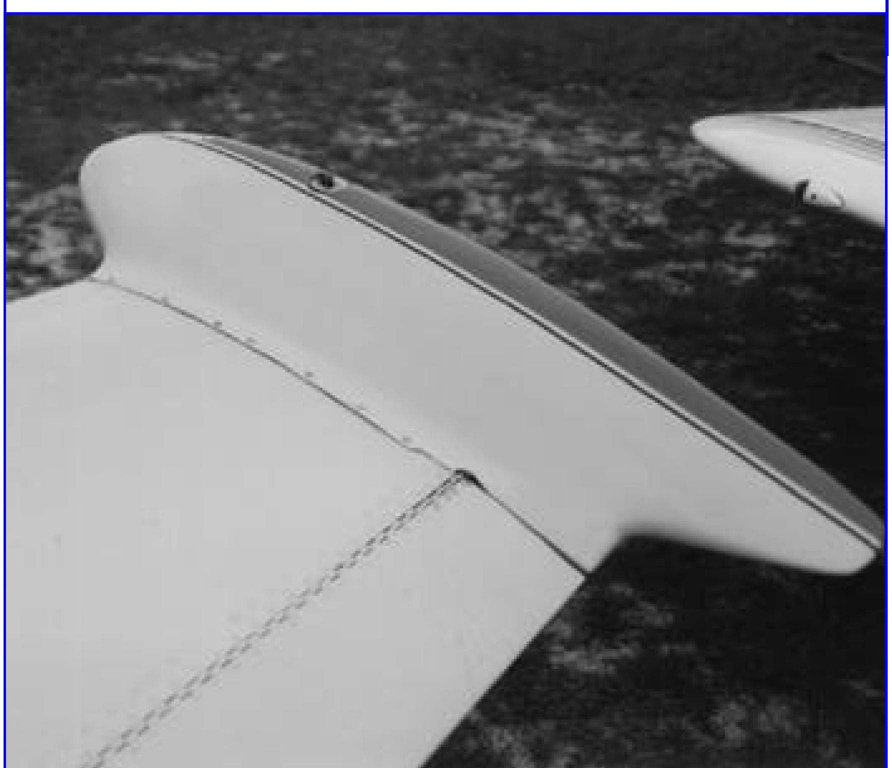
Other Mustangs have found substantial drag reductions by smoothly enclosing the main gear brake calipers inside the wheel pants, fairing the tailwheel, reducing the cowl inlet size, sealing the spinner to cowl gap, adding wing root fillets, etc. This aircraft did not have these changes, and may well have been capable of even higher speeds if they had been used. A complete discussion of modifications for

N402C uses a 160 hp Lycoming with a tuned crossover exhaust system.

CAFE MEASURED PERFORMANCE

Propeller static RPM, Hg M.P.	**na**
Takeoff distance, ft, 120' MSL	**na**
Liftoff speed, per barograph data, CAS, typical	**73.5 IAS mph @ 1487 lb**
Touchdown speed, barograph, CAS	**84 mph**
Rate of climb,2500-3500 ft, Std Day, 100 mph CAS	**1080 fpm @ 27" and 2278 RPM**
Cabin Noise, climb/max cruise	**96/96 dBA**
Stall speed, V_{S1},clean, 1 G, CAS	**63.5 mph @ 1482 lb**
Stall speed, V_{SO}, landing, 1 G, CAS	**65.0 mph @ 1482 lb**
Vmax @ 1750' dens/2868 RPM/F.T./ 15 gph/ TAS	**210.7 mph, @ 1483 lb**

****F.T. = full throttle.**

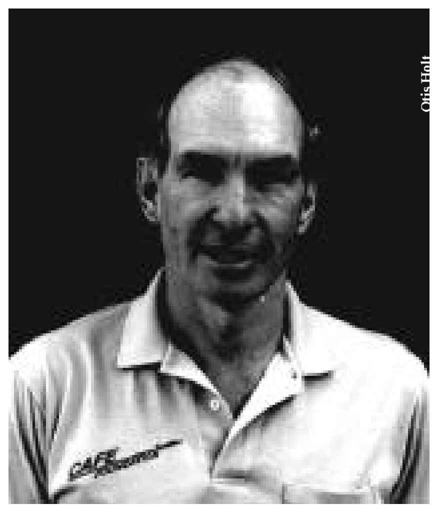

Wingtip tanks have been used to increase the range of the Mustang II.

the Mustang II is available from Kent Paser, 5672 W. Chestnut Ave., Littleton, CO 80123-6041 in his book, Speed With Economy.

The performance flight test of this aircraft was abbreviated due to the severe floods and persistent rain in Sonoma County during December and January this year. Because of this, the usual zero thrust glide drag curve measurements and resulting data are not included in this report. Some propeller leading edge rain damage occurred just prior to the rate of climb run and the climb rate may have suffered somewhat as a result.

This aircraft did not have wing leading edge stall strips which are often used to produce stick shake or buffeting as a stall warning. The lack of stall warning demonstrated in N402C could probably be corrected by such strips.

Chris Tieman at Mustang Aeronautics has upgraded the kit for the Mustang II to include new features such as pre-built wing center section, spars, engine mount, landing gear and control hardware, hydro-formed ribs, bulkheads and many other ready to in-



Chief Test Pilot, C.J. Stephens

FLYING QUALITIES EVALUATION BY C.J. STEPHENS

stall items. The completeness of the new kit offerings makes this design much more attuned to the fast-build philosophy which now pervades the homebuilt movement.

INTRODUCTION

It was a pleasure to have the opportunity to fly, as test pilot, in this tried

N402C's main gear fairing (top) and non-faired tailwheel (bottom). The center photo shows a Mustang II with stall strips and brake fairings.

and proven aircraft design. It seemed like an excellent candidate for a CAFE APR. Judging by the enthusiasm exhibited by Jim Lewis, the owner, it was obvious that he had enjoyed his association with this airplane.

The previous owner, Art Beer, was on hand to greet Jim when he arrived at the CAFE hangar. It was at that time I realized that I had flown this plane briefly several years before.

We held the standard acceptance interview with the owner regarding the various specifics about the plane's history, any modifications, restrictions or unusual characteristics.

Meanwhile, the technicians of the CAFE Foundation prepared the plane for its first flight, a subjective evaluation in which various features such as cockpit layout, ground handling, servicing, field-of-view, inflight equipment, and flying qualities are evaluated in detail.

The plane was defueled and its empty weight and c.g. were determined. A video camcorder with a link to the aircraft intercom was installed to monitor my comments and the instrument panel readouts. The CAFE Barograph was not installed on the flying qualities flight so as not to alter the plane's characteristics.

ACCOMMODATIONS

N 402C seemed to be built with a purpose in mind. It is a day/VFR fun, fast airplane. It has nothing installed that is not required to meet that mission. There is no heater, defog, or lighting system installed. Therefore, it is light, simple, and has very good performance. The rollover bar, that also serves as the windshield canopy bow, is very sturdy and would provide excellent protection to the occupants should the aircraft end upside-down.

The standard canopy locking system consisted of a twist lock at the top center of the canopy bow to keep the canopy from sliding aft on the rails. This was further modified with three overcenter canopy latch mechanisms. These latches were located at top center and one each behind the seat on either side on the canopy rail. These latches added to the security of the canopy in flight but seemed difficult to operate and, in an emergency situation, would very likely hamper egress from the cockpit.

FIRST FLIGHT IMPRESSIONS

MUSTANG II N402C

Estimated Cost: $10,780 for the basic airframe without engine/prop/instruments/paint/lights

Hours to build: 2500 hours/9 years Completed: 1985

SPECIFICATIONS N402C

Empty weight, no oil/gross weight	**983.25 lb/1500 lb**
Payload with full fuel	**314.5 lb**
Useful load	**516.75 lb**
ENGINE:	
Engine make, model	**Lycoming, O-320 E2D**
Engine horsepower	**160 BHP**
Engine TBO	**2000 hr**
Engine RPM, maximum	**2700 RPM**
Man. Pressure, maximum	**29 in Hg**
Turbine Inlet, maximum	**NA**
Cyl head temp., maximum	**500° F**
Oil pressure range	**25-100 psi**
Oil temp., maximum	**245° F**
Fuel pressure, range	**.5-8.0 psi**
Weight of prop/spinner/crank	**77.2 lb**
Induction system	**MA4-SPA carb, bottom mount**
Induction inlet	**8.75 sq in**
Exhaust system	**crossover, stainless, no muffler,exit nozzles**
Oil capacity, type	**8 qt, 15W-50**
Ignition system	**Slick 4271/4270**
Cooling system	**Pitot inlets, downdraft**
Cooling inlet	**50 sq in**
Cooling outlet	**40.5 sq in**
PROPELLER:	**Fixed pitch**
Make	**Pacesetter**
Material	**Maple, 5 laminations**
Diameter/pitch @ 75% span	**68 x 66 in**
Prop extension, length	**4 in**
Prop ground clearance, full fuel	**8 in**
Spinner diameter	**12 in**
Electrical system	**40 amp Nippondenso alternator**
Fuel system	**1 tank in forward fuselage, gravity**
Fuel type	**91 octane**
Fuel capacity	**25 US gal**
Fuel unusable	**1 oz**
Braking system	**Cleveland discs, single caliper**
Flight control system	**Dual center sticks, push-pull tubes, rudder cables**
Hydraulic system	**NA**
Tire size, main/tail	**5:00 x 5, 6 x 22 R&K tailwheel**
CABIN DIMENSIONS:	
Seats	**2**
Cabin entry	**sliding canopy**
Width at hips	**38 in**
Width at shoulders	**37.5 in**
Height, seat to headliner	**33 in**
Baggage capacity/size	**75 lb/10"L x 30"W x 27"H**
Baggage door size	**None**
Approved maneuvers:	**At 1350 lb, fully aerobatic including loops, rolls, hammerheads, spins, inverted flight with proper oil system**
CENTER OF GRAVITY:	
Range, % MAC, inches	**16% to 28% MAC, 5.88 in**
forward limit, in. from datum	**64 in**
Empty weight c.g., by *CAFE*	**69.15 in**
From datum location	**forward tip of spinner**
Main landing gear moment arm	**61.55 in**
Tailwheel moment arm	**232.05 in**
Fuel tank moment arm	**na**
Front seat occupants moment arm	**na**

I consider my first impressions of an airplane's flying qualities to be important to the evaluation. After several flights a pilot will learn to accommodate an item that is initially an irritant. By doing the subjective evaluation on my very first flight, more can be discerned.

GROUND OPERATIONS

Ground handling of the plane was very nice. Its light weight allowed for easy pushing and the tail could easily be picked up for maneuvering in tight spots. Moving the plane backwards on the ground required the picking up of the tail, which was not difficult, since it weighed about 40 pounds.

Start up was quick and easy, requiring only a few pumps of the throttle. The warmup and ground operations were routine.

All pre-takeoff checks were accomplished routinely although no organized written checklist was provided. The light weight of the wooden propeller was evident by the quick acceleration following throttle movement.

Braking was effective for slowing and turning sharply in parking spots. The non-swivel tail wheel was positive and very sensitive while taxiing. I felt it was too sensitive, causing quick movement, and required constant attention to taxiing direction.

Tail-wheeled airplanes traditionally have field of view restrictions on the ground, however this one showed a good wide field of view over the nose while taxiing.

TAKEOFF AND CLIMB

Once cleared for take-off the power responded quickly and acceleration was swift. Directional control on takeoff was positive except that some oversensitivity of the tailwheel was evident. Once the tailwheel lifted off, the directional control settled down to being very nice. Pitch and roll controls were positive and precise, making it easy to attain and hold the desired climb attitude.

Climbing at full throttle while indicating 120mph showed an initial rate of climb of 2000 fpm indicated on the panel's VSI. The view over the nose during the climb was adequate to see any obstacles. A transparent green plastic sun block had been installed over the pilot's head for greater comfort on sunny days. With a little practice, the view through this was sufficient to see other traffic.

In this Mustang II the oil temp consistently ran below 180 degrees. Even after sustained periods of slow flight the temperature only came up to 185 degrees. No cowl flaps are available, nor do they seem necessary. No climb cooling test was performed.

STATIC LONGITUDINAL STABILITY

Upon leveling off at 7,000' and 120 mph IAS the first task was to explore the static longitudinal stability. With the airplane trimmed to 120 mph a hand-held stick force gauge was used to measure the elevator force required to hold level flight. Each airspeed, in 10 mph increments throughout the entire speed range, was evaluated by adding or reducing power as necessary to alter the airspeed. The elevator trim remained unchanged throughout this test. The greater the incremental force at each successive airspeed the greater the static stability. Having flown a variety of other similar airplanes and previously submitted reports on the RV-6A and the Tailwind it is my opinion that the Mustang II has one of the best stick force gradients for all-around flying. See Figure 1.

DYNAMIC STABILITY

Dynamic stability, short period, in both stick-fixed and stick-free modes were explored. A sampling of all airspeeds across the entire operating range were tested in both modes. The results were completely 'deadbeat', in that when pitch doublets were induced and the stick was then let free, no pitch oscillations or overshoots resulted. This is evidence of the ideal dynamic stability qualities with this design.

I was unable to fully trim the elevator to airspeeds below 110 mph IAS due to the limited travel of the electric elevator trim system.

SPIRAL STABILITY

Normally my evaluation of spiral stability would be done at both 90 & 120 mph IAS, however, due to the inability to fully trim the elevator to 90 mph I could only evaluate its performance at 120 mph. After carefully trimming and stabilizing in a 30 degree bank turn, the controls were released at which time I observed the banking tendencies. After more than 40 seconds of continued turn with no change in the bank attitude, the test was terminated. The Mustang II thus exhibited neutral spiral stability in both directions. A feature such as this would be beneficial to a pilot during moments of inattention. The Mustang II gives the feel of lightness on the controls, yet is not an airplane that you have to watch constantly to keep it under control in bank. The airplane tends to stay in the existing attitude unless control inputs cause it to change.

ROLL DUE TO YAW

Roll due to yaw, at Va and 1.5Vso, was examined by inducing steady state yaw with the rudder and observing the bank required to hold the airplane on a constant heading. The results were similar at both airspeeds examined (90 & 120 mph). half rudder deflection required 8-10 degrees of bank to hold a constant heading. Full rudder deflection required 15 degrees of bank. The 90 mph test was repeated with full flaps extended. Here, only 5 degrees of bank with half rudder, and 10 degrees with full rudder deflection were needed.

Another way to look at the roll due to yaw or dihedral merits of an airplane is to observe the bank while inducing yaw with the rudder (hands off the ailerons). This plane shows a strong and positive tendency for the bank to follow the yaw input. With rudder alone the bank could be controlled from 30 degrees of bank in one direction to 30 degrees bank in the opposite direction. It was during these checks that I noticed that the airplane exhibited a stronger than normal tendency to oscillate in yaw. I decided to further investigate this during the Dutch roll check later in the flight.

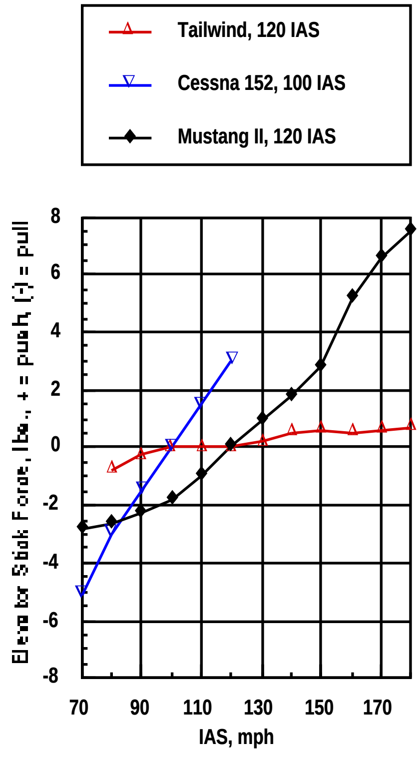
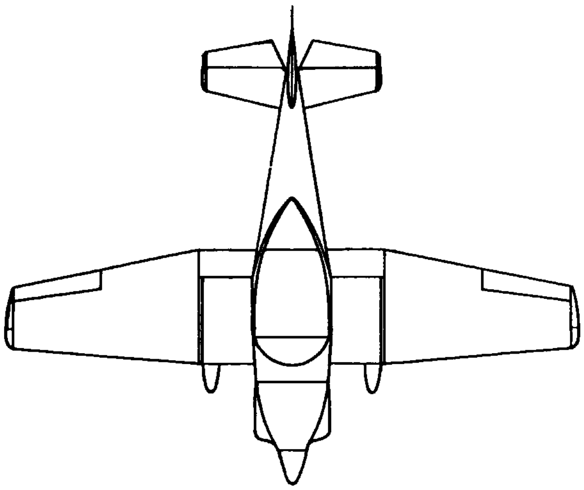


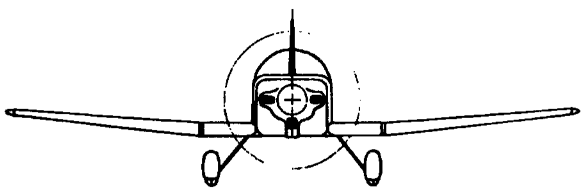
Figure 1.
Static Longitudinal Stability
Trimmed hands-off at Va

ADVERSE YAW

An adverse yaw estimation was made by slowing to 80 mph and, using full aileron, observing the hesitation

The cowl exit area was reduced by 70% to cut cooling drag.





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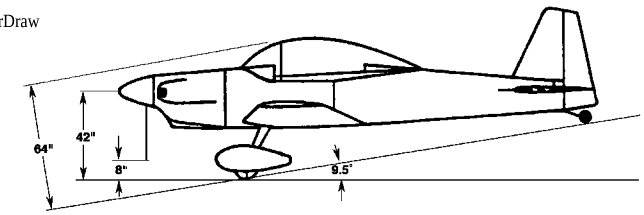

of the heading at the onset of the turn. With the short wingspan and quick roll it responded as anticipated with very little adverse yaw. Even the most dramatic aileron inputs yielded only 5 degrees of heading change opposite to the roll input.

ROLL PERFORMANCE

Roll rates were also measured at 120 mph through the use of a wire grid attached to the instrument panel and a stop watch. The right to left roll rate was 72 degrees per second, while the left to right rate was 66 degrees per second. Figure 2 compares the roll performance of other aircraft we have tested.

DUTCH ROLL

Dutch roll was examined by inducing doublets in yaw, pitch, and roll. Upon release of the controls the oscillation continued much longer than normal for an airplane that had just exhibited such otherwise strong stability characteristics. Upon further exploration I found that with rudder alone I could excite yaw oscillations that would continue for as many as 15 overshoots. At no time was it severe enough to present any danger. It was just that the directional stability was not as strong as it was in roll and pitch. The oscillation could be easily controlled with the use of the rudder as a yaw damper. It exhibited no Dutch roll tendencies.

STALLS

The stall sequence was very interesting to evaluate. At 1300 rpm, to approach the stall slowly, the airspeed was reduced while looking for any signal of an impending stall. There was no electronic stall warning system installed. In flaps up configuration, the stall occurred abruptly with virtually no aerodynamic buffeting or warning. The nose just crisply and abruptly pitched down with mild left wing drop. The recovery was instantaneous with the release of the stick back-pressure. Several stalls were made with exactly the same results each time. The 60 mph panel indication of stall was consistent but will be checked for accuracy on later CAFE flights.

ROLL RATE, degrees/second		
Speed, IAS	Va	1.3 Vso
RV-6A	80	36
Tailwind W10	47	45
Cessna 152	47	34
Mustang II	72	na

Figure 2. Roll rates include the aileron input time.

Flaps were extended for comparison of the landing stall characteristics with those of the clean stall. It was difficult to fully extend the flaps to the third notch until the airspeed was below 85 mph. The handle could be moved to the proper position but it would not lock into the notch and stay extended. The stall with full flaps occurred at a panel indication of 63 mph, 3 mph higher than with no flaps. The abrupt pitch down and left wing drop were very similar to that of no flaps.

Since the higher airspeed puzzled me, I checked the stall speeds at all flap settings. With two notches the stall was 61 mph and with one notch it was 60 mph. The quick recovery and very predictable nature of the stall characteristics are pleasant and not a worrisome thing at all. However, if one desired the buffeting stall warning of some of the production aircraft, this plane would need some added devices to create such warning.

Without the barograph and other instrumentation installed, a maximum speed run was made at 7,500' for later comparison with the instrumented flights. The maximum IAS was 178 mph @ 2750 rpm.

MANEUVERING STABILITY

Figure 3 shows a graph of the maneuvering stability or stick force per G obtained. This is a measure of how much tacttile feedback is provided to the pilot relative to the wing loadings being produced by the pilot's force on

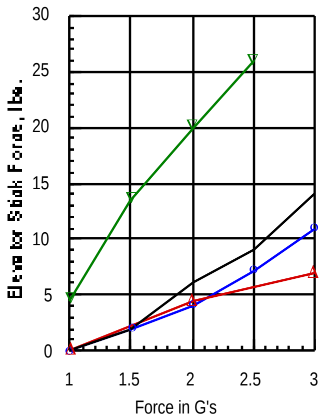

Figure 3. Maneuvering Stability
@Va with mid to forward c.g.

the stick. Comparison is made to the other aircraft tested thus far and reveals that the Mustang II has a good level of stick feedback relative to the others.

APPROACH AND LANDING

After more than an hour of very pleasant flying in an enjoyable airplane it was time to return to see its landing qualities. With the nose down the speed would build quickly due primarily to the clean aerodynamic exterior. With the excellent visibility and fine maneuverability it was easy to manage the flight path in the traffic pattern. Downwind was flown at 100 mph slowing to 90 mph on final, further reducing to 80 mph in the flare. Keeping in mind the small value the flaps had in reducing the stall speed my first landing was planned to use only the first notch of flaps; however, with the low drag that this setting produced it was difficult to maintain the desired glideslope. Therefore, flaps were reset to the third notch. The touchdown and landing were straightforward and comfortable. A three point landing was made with only a small crosswind evident from the wind sock. The still too-sensitive tailwheel gave plenty of authority to control the direction during the roll out.

CONCLUSION

My final subjective flight is to determine the suitability of the plane for the continuation of the CAFE APR. This seems like an excellent choice. One interesting note is that this is our first test aircraft that was not "new". This airplane has been owned by three EAA members, each adding their own touches, and it has been in continuous use facing the rigors of life on the flight line. It is in excellent condition and has been obviously well cared-for by its owner, Jim Lewis.

ACKNOWLEDGEMENTS

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