

## INTRODUCTION

This report on the VariViggen is intended to serve several purposes. For the professional aerodynamist or designer it provides aerodynamic data and a qualitative flying qualities report to enable him to compare the configuration to other aircraft or to use as a base line for future design. The performance and stability data are complete enough to show the adaptability of the configuration to a specific mission.

For the amateur-built aircraft enthusiast this report includes all the information needed to compare the design to others and to see if it will fit his needs. For those who are contemplating actual construction of a VariViggen, I have prepared construction plans\* which fulfill two purposes: 1) It will serve as complete plans so one can duplicate the VariViggen prototype in every detail, 2) It will provide the amateur designer/builder with a literal 'handbook' of design ideas which can be applied to existing or new-designed aircraft.

The plans include builders handbook information, step-by-step guide, bill of materials, flight operating limitations, parts list, etc. Individual portions of the aircraft are shown in an individual chapter format to ease the "confusion" found with average construction blueprints. The aircraft can be built by an individual with few special skills and few special tools. All parts which require special shop tools (such as machined parts, fiberglass parts, brake-formed parts, heat treating, etc.) can be purchased from RAF.

This is the fourth edition of the Technical Report. Changes noted in VariViggen Newsletter #1 and #2 have been incorporated.

I've attempted to answer every question I've been asked about the VariViggen in the last pages. I may not have included yours, though, so if you do require further information please send your question, with room for my answer and a stamped, self-addressed envelope to:

Rutan Aircraft Factory  
P.O. Box 656  
Mojave, California 93501  
(805) 824-2645

### (SYMBOLS USED IN THIS REPORT)

L - Lift (lb)	$C_L$ - Lift Coefficient = $\frac{L}{qS}$
q - Dynamic Pressure (lb/ft <sup>2</sup> )	W - Weight (lb)
S - Wing Area (118.9 ft <sup>2</sup> )	V - Velocity (mph)
cg - Center of Gravity (inches)	$C_D$ - Drag Coefficient = $\frac{D}{qS}$
D - Drag (lb)	

\* Portions of several plan's pages (reduced in size) are shown on the following page.

Spruce/plywood construction is easy to jig and assemble; provides insulation and a solid, quiet structure. The outer wing panels and rudders are aluminum for ease of construction.

### CHAPTER 4 BUILDING TIPS

It is assumed that you have basic metal and wood aircraft construction knowledge. If not, get help and/or order the references checked, from EAA 1000, Box 200, Hales Corners, Wisconsin 53130.

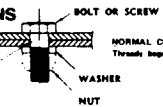
#### HOLES FOR THREADED FASTENERS (UNLESS OTHERWISE SPECIFIED)

DRILL SIZE	MINIMUM HOLE DIA.
No. 28 (.140 dia.)	1/16"
No. 24 (.1875 dia.)	3/32"
No. 18 (.188 dia.)	1/16"
No. 12 (.188 dia.)	1/16"
1/8" (.250 dia.)	3/32"
5/16" (.312 dia.)	1/4"
3/8" (.375 dia.)	1/4"
7/8" (.438 dia.)	1/2"
1" (.800 dia.)	3/4"

STEEL SHEET		ALUMINUM ALLOY SHEET	
Thickness	Hole Dia.	Thickness	Hole Dia.
1/16"	1/16"	1/16"	1/16"
1/8"	1/8"	1/8"	1/8"
3/16"	3/16"	3/16"	3/16"
1/4"	1/4"	1/4"	1/4"
5/16"	5/16"	5/16"	5/16"
3/8"	3/8"	3/8"	3/8"
1/2"	1/2"	1/2"	1/2"
5/8"	5/8"	5/8"	5/8"
3/4"	3/4"	3/4"	3/4"
7/8"	7/8"	7/8"	7/8"
1"	1"	1"	1"

NATIONAL FINE THREAD SERIES (MEDIUM FIT CLASS 3 UNF)	
Size	Lead
8-32	.015
10-32	.020
12-32	.025
14-32	.030
16-32	.035
18-32	.040
20-32	.045
22-32	.050
24-32	.055
27-32	.060
30-32	.065
36-32	.075
44-32	.090
48-32	.100
56-32	.110
64-32	.120
72-32	.130
80-32	.140
90-32	.150
100-32	.160

#### GRIP LIMITATIONS

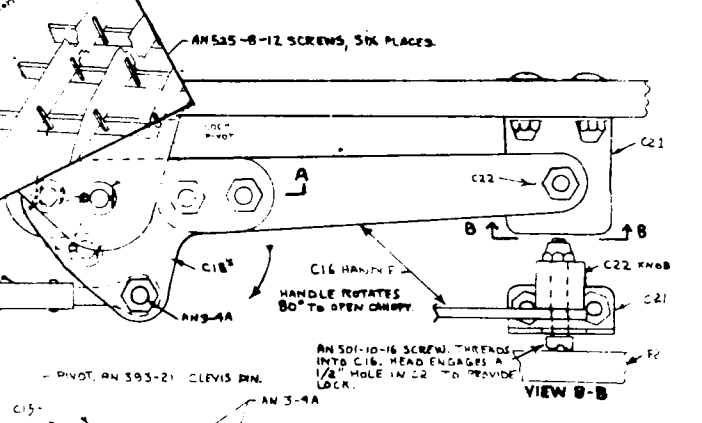
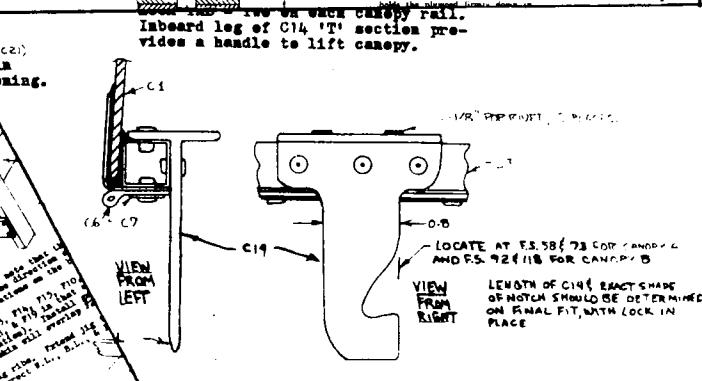


A PRECISION HAND SCARFING DEVICE. The scarfing tool is nothing more than a controlled sanding block. The sanding angle and the scarf being controlled by the rub strip, lean-in and its thickness. The advantage of this tool of course, is its portability. Its effectiveness is best realized on thin plywood as the sanding block is the tapered, triangular shape.

NOTE: Grip length is the unthreaded part of the shank.

MINIMUM ALLOWABLE GRIP LENGTH: 1 1/2 times diameter.

Use this device on each canopy rail. Inboard leg of C14 'T' section provides a handle to lift canopy.



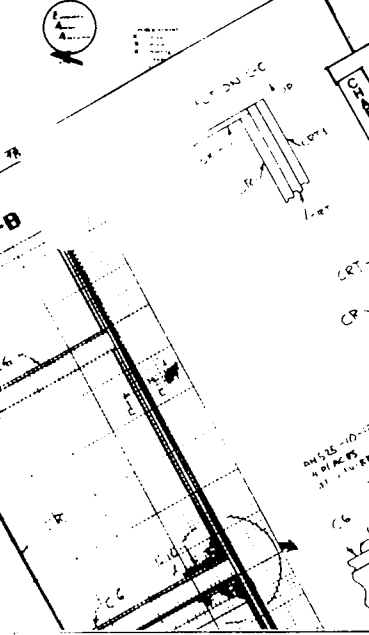
SEVERAL AN 50-10 WASHERS TO POSITION C16

SECTION A-A

RUTAN AIRCRAFT FACTORY  
VAN MOOREN BLDG. BURT RUTAN  
FULL LOCK.

DRN ENCS 95  
REVISED  
CHAPTER PAGE 35

DO NOT REPRODUCE



#### CHAPTER 2 BILL OF MATERIALS

Here is the shopping list. Items that everyone does if they're building an airplane, engine installation, are not listed. Items that are likely overlooked are listed. It's not just a good start. It's a list of what you need to get started. If you still have trouble finding something, I can help. Contact your local EAA or an airplane store at your local airport. I can give you some tips from my years of "Sport Aviation" experience.

DO NOT REPRODUCE

RUTAN AIRCRAFT FACTORY  
VAN MOOREN BLDG. BURT RUTAN  
FULL LOCK.

DRN ENCS 95  
REVISED  
CHAPTER PAGE 35

## MAJOR FEATURES

### 1. Basic Aerodynamic Design Resists Stall or Spin

The stall spin accident is the greatest killer in general aviation. The VariViggen will not stall or spin because its aerodynamic design does not permit its critical angle of attack to be exceeded for most maneuvers and flight conditions. It does not "mush in" at low speed like the common delta wing aircraft. The VariViggen has a comfortable rate of climb even while flying at full aft stick. Full aft stick can safely be used for maneuvering even at low altitude in close proximity to the ground. At high angle of attack the down wash of the canard rises above the main wing, making the main wing more effective, thus the aircraft strongly resists further angle of attack increase.

### 2. Basic Aerodynamic Design Counters Adverse Yaw

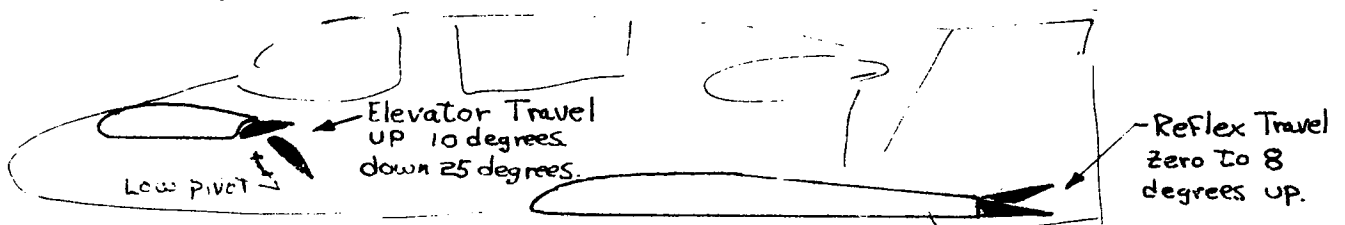
Differential ailerons cannot be used on a VariViggen because they would cause nose-up pitching with aileron deflection. However, the aircraft's design offers pro-turn yawing that is even more effective. When the aircraft is rolled right, the increased pressure on top of the right wing pushes left on the right vertical fin. Also, the decreased pressure on the left wing pulls the left fin left. This is very effective in eliminating a natural tendency to yaw away from a turn, particularly at low speed.

### 3. Basic Aerodynamic Design Improves Ground Handling

The low aspect ratio, low mounted, low dihedral wing is less affected by winds during taxiing. A VariViggen can be safely taxied when most light planes must be tied down. When taxiing in a direct crosswind, one vertical fin blanks the other, eliminating the usual, bothersome weathervaning tendency of conventional aircraft. The wing will slide under any low wing aircraft for parking; thus, VariViggen take far less hangar space.

### 4. Reflex Control Increases Performance

The VariViggen's elevator is a slotted flap-type surface on the canard wing. The ailerons on the back wing are also adjustable up and down together with an electric motor. This collective setting of the aileron is called reflex. Reflex control could also be manually controlled by a handle.

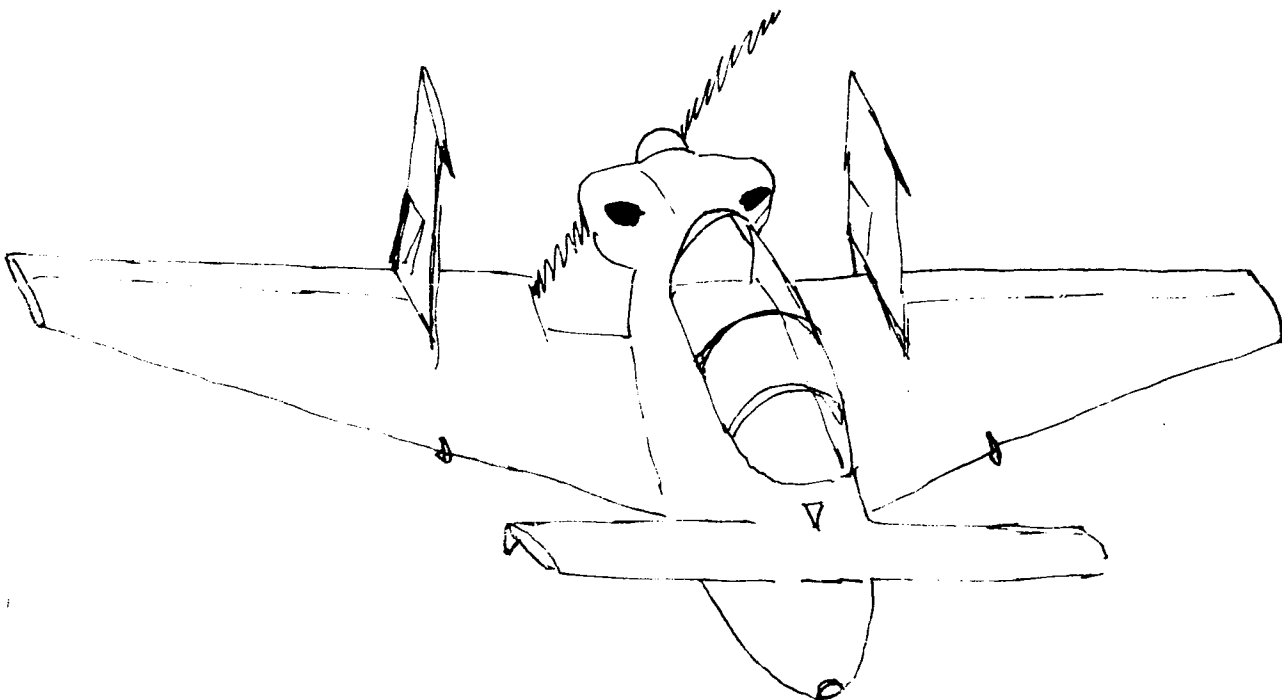


Up reflex allows the aircraft to fly at a higher maximum angle of attack for lower landing speed and allows an earlier nosewheel lift-off speed for shorter takeoff. Down reflex increases rate of climb and cruise speed. However, a fixed reflex of four degrees provides satisfactory performance for all flight conditions.

### 5. Cross-Country Utility

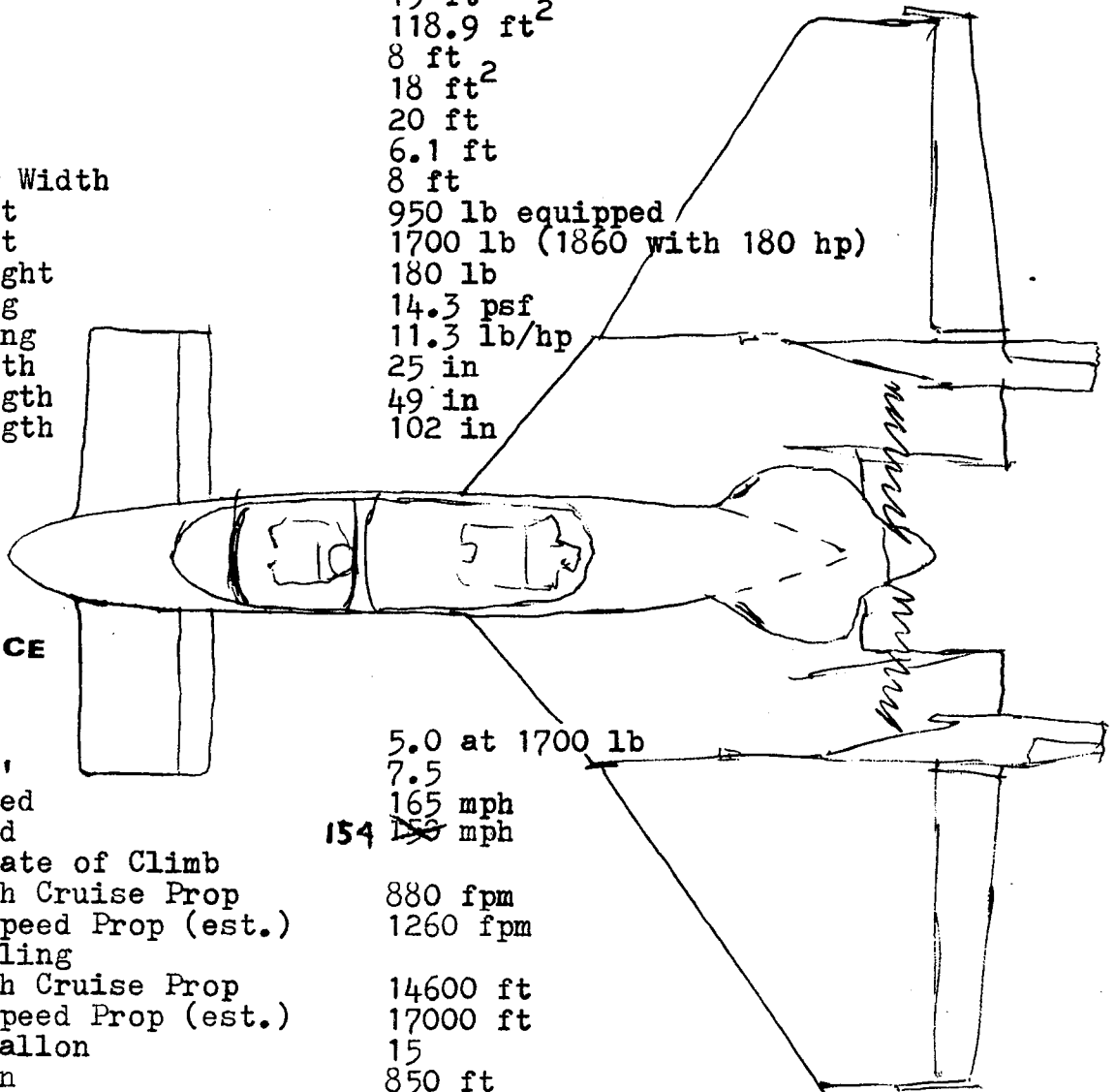
The VariViggen's cruise speed, baggage carrying capability (three-suitcase +), and miles per gallon compare favorably with other two place types. Its unusual design turns routine trips into fun-trips. Gas service and other airport services are better, too! The VariViggen will hold two 6'6" adults comfortably and can easily be made into a 2 + 2 configuration.

6. 'Modern Fighter' Cockpit Layout  
The fighter pilot will feel right at home in the front seat. The cockpit human factors are well thought out with trim, reflex and radio transmit functions on the control stick, itself. All left-hand functions (throttle, carb heat, mixture, landing gear, landing light) are in easy reach, not requiring a visual search. Radio equipment, electrical panels and engine starting controls are on the side consoles, leaving the main instrument panel for flight instruments. The canard is an excellent visual attitude reference for both pitch and roll. The back seat has minimum flight controls and instruments for checkout or copilot use.
7. Angle-of-Attack System  
Vane-type probe on the nose operates an angle-of-attack instrument for use in setting optimum maneuvering and approach conditions.
8. Road Towable  
The outer wings can be removed in about 15 minutes allowing road towing or trailering at 8-foot width.
9. Electric Retractable Landing Gear  
The landing gear is retracted by low cost, available electric motors adding very little to the weight of a fixed-gear aircraft. The gear can be operated manually if preferred.
10. Bungee Elevator Trim  
Springs provide pitch trim. No movable trim tabs are necessary.
11. Simple Fuel System  
One-tank gravity feed fuel system can be augmented by an engine-driven fuel pump if desired. No fuel management is required.
12. Flat Surfaces  
Compound curves are limited to the nosecone, visor, cowling and tank cover. This greatly simplifies construction. All compound-curved parts are available from RAF.



## SPECIFICATIONS

Wing Span	19 ft
Wing Area	118.9 ft <sup>2</sup>
Canard Span	8 ft
Canard Area	18 ft <sup>2</sup>
Length	20 ft
Height	6.1 ft
Road Towing Width	8 ft
Empty Weight	950 lb equipped
Gross Weight	1700 lb (1860 with 180 hp)
Baggage Weight	180 lb
Wing Loading	14.3 psf
Power Loading	11.3 lb/hp
Cockpit Width	25 in
Cockpit Height	49 in
Cockpit Length	102 in



## PERFORMANCE (150 hp)

Limit 'g'	5.0 at 1700 lb
Ultimate 'g'	7.5
Maximum Speed	165 mph
Cruise Speed	154 <del>158</del> mph
Sea Level Rate of Climb	
Fixed-Pitch Cruise Prop	880 fpm
Constant Speed Prop (est.)	1260 fpm
Service Ceiling	
Fixed-Pitch Cruise Prop	14600 ft
Constant Speed Prop (est.)	17000 ft
Miles Per Gallon	15
Take-off Run	850 ft
Landing Run	400 ft
Minimum Speed*	43 kts (full aft stick)
Maneuvering Speed	125 mph
Turn Radius @ 110 mph	187 ft
Pwr Off R/S Gear Up	800 fpm
Pwr Off R/S Gear Down	1400 fpm
Range	375 mi
Range with Aux. Tank	555 mi
EST. RANGE WITH SP WING	605 mi

\* Level flight, climbs, descents, and turns can be safely done under full control at 43 kts without stall or buffet.

## PILOT REPORT

### Crew Entry

Rear seat entry is via the wing walk on the left wing (the wing walk is also used for fuel service and checking oil quantity). After stepping up on the wing walk the canopy is lifted (it pivots at the right) and you step in on the seat and sit down. Baggage access is by folding the rear seat forward. The front cockpit is entered by stepping on the one-step ladder suspended from the left side of the fuselage, stepping in and sitting down. The ladder can then be stowed at the rear left of the front cockpit. Both cockpits are provided with seat belts and shoulder harnesses. (N27VV now has a kick-in step for front cockpit entry, replacing the ladder.)

### Cockpit

Both cockpits are exceptionally roomy for a homebuilt airplane with ample map storage. The rear cockpit controls are limited to stick, throttle, rudder pedals, and trim. The front cockpit controls include stick, throttle, rudder pedals, toe brakes, trim, reflex, carb heat, mixture, landing gear, landing light, position lights, and landing gear warning. The prototype has the following instruments/equipment: airspeed, altitude, rate of climb, turn and bank, compass, g-meter, cylinder head temperature, exhaust temperature, oil temperature, oil pressure, rpm, manifold pressure, ammeter, angle-of-attack indicator, outside air temp, reflex position, trim position, VHF com, nav and transponder.

The landing-gear warning system consists of a warning horn and light in each cockpit that activates when the gear is up and the throttle is retarded. The angle-of-attack indicator also serves as a gear warning. It does not work with the gear up, so when the landing approach is set up and the approach angle of attack is monitored, it "tells" the pilot the gear is up. The indicator can be overridden and turned on for gear-up maneuvering.

The human factors aspect of the cockpit have been well worked out. Buttons on the stick control the trim, reflex, and radio transmit so the pilot doesn't have to search for these when needed. The landing gear handle, landing light switch, angle-of-attack override, and warning horn defeat switches are immediately in front of the throttle quadrant and can be reached without a visual search. The engine starting controls, electrical system controls, and circuit breakers are on the right console and the radio/transponder equipment are on the left console. The entire cockpit layout and canopy are closer to a modern fighter than any light aircraft.

### Taxiing

The pilot can easily see the wing tips and rudders from the cockpit and due to its short and low wings, it can be taxied between and around other airplanes much easier than conventional aircraft. It is very maneuverable on the ground. Pivoting on one mainwheel results in a very short turn radius. The geometry of the wing is such

that the aircraft can be nosed up to within three feet of a hangar, turned and taxied away without ground assist. VariViggens are less affected by winds during taxiing than other types of similar wing loading. In fact, due to one rudder blanking the other, you can taxi in a 40-knot crosswind with no tendency to weathervane. The aircraft is as safe as a car in a crowd since it is almost impossible to taxi the prop into anyone.

### Takeoff/Landing

Due to the position of the landing gear and thrust line, the nose wheel rotation speed is about ten knots above the minimum flying speed. Thus on a full power takeoff, it is impossible to force the aircraft into the air at an unsafe speed. I generally make the takeoff roll holding full aft stick and with eight degrees reflex. At about 53 knots the nose comes up slowly and is easy to control at the desired position for initial climb. There is no tendency to "bobble" or hunt for the initial climb angle since pitch damping is high and the aircraft is not sensitive. Gear retraction results in a negligible trim change. While accelerating to best rate-of-climb speed of 80 knots, I generally run the reflex down and trim out the nose-down trim change due to reflex.

Maneuvering is a good way to slow down to the gear extension speed of 90. Landing reflex position can be set before, during, or after gear extension. Landing can be made with any reflex position but up reflex results in lower landing speed.

I generally fly a close-in pattern. Power-off glide angle is rather steep with the gear down so flaps or dive brakes are not required. I generally fly final approach at 8-degree angle of attack (about 65 knots). Correction for runway misalignment is easy and quick due to the high available roll rate and maneuverability at low speed. Airspeed bleed-off at flare is fairly rapid without a great deal of tendency to float even though there is a considerable ground effect. Braking is more effective than on a conventional aircraft because with the nose wheel down, almost all the lift disappears immediately. Full stop is easily made within 400 feet.

### Static and Dynamic Stability

As the stability plots indicate, static longitudinal stability and directional stability are very good, and dihedral effect is positive. Directional stability is weak at high speed. This is not particularly objectionable, but I have increased the height and stiffness of the vertical fins on the plans to give future VariViggens more high-speed directional stability. Longitudinal control gives the pilot a more precise feel than on conventional aircraft since the initial control input moves the aircraft in the right direction (a conventional elevator first pushes down for an up control and the aircraft must rotate to a higher angle of attack before it can go up).

Steady sideslips are conventional. The ailerons are quite effective so that only about 1/2 aileron is required to counter full opposite rudder. Full-rudder sideslips can be done with full aft stick!

Dynamic damping is deadbeat about all axes. however, some dutch roll is perceptable at low speeds in moderate turbulence. The ride in turbulence is more 'bumpy' in the front seat than in the back because the aircraft's translation and rotation are added.

### Reflex Control

Before I flew the VariViggen I thought I would be using negative reflex for takeoff and landing (high lift on the front and back wings at low angle of attack) and positive reflex for cruise (which would allow the elevator to be tucked in its slot for low drag). Flight test data has resulted in the reverse: positive reflex allows a lower nose wheel rotation speed for takeoff and a lower landing speed (the high angle of attack is not objectionable). I'm not sure why, but the negative reflex results in a cruise speed of about five knots faster than positive reflex. It must be that the reduced induced drag of the main wing overrides the increased drag of the canard elevator in its ten-degree (trailing edge down) position at cruise. One disadvantage with cruising with negative reflex has been that at high speed a lot of up trim on the electric bungee trim system is required to trim out the stick forces. As a result the aircraft would not hold airspeed if left "hands off" for an extended time. This was not particularly objectional but I still wanted to improve it. Recently I installed small (2-inch by 6-inch) fixed airfoils on 4-inch long booms on the trailing edge of the elevators to off-set the cruise stick force. Thus, the normal bungee trim system follows the correct trim direction (down trim for faster airspeed). The VariViggen now will hold airspeed 'hands off' at any speed and reflex setting.

### Stall/Spin

You may have read that the VariViggen will not stall or spin. This is essentially true but not entirely true. If you attempt a stall using power for level flight you will just slow up to a speed at which you reach full aft stick. The aircraft will not be stalled, the throttle will be at about 1/2 power, and you can maneuver with the ailerons or rudders making tight turns under complete control.

Holding full aft stick you can climb by adding power or descend by reducing power. The speed will hold constant and will range from 44 knots to 52 knots depending only on reflex position. This is true also for accelerated stalls; for example you can be flying at 110 knots, roll to about 80-degrees bank and slap-in full aft stick. All that will happen is the tightest turn you can imagine even if your ailerons/rudders are not coordinated! That maneuver is particularly fun at 100 feet AGL - try that with your airplane. On second thought, you better not!

Another trick (not to try on your airplane) is to line up on the runway and trim-in full aft trim (so the stick will go full aft and stay there) then make a take-off, fly the pattern and land having never touched the stick - flying the airplane with rudder pedals and throttle. These flight characteristics are why I normally say the VariViggen will not stall - but it will stall if you are at aft

cg, and set positive reflex, and pull the throttle to idle. This will force the aircraft to a very high angle of attack (19 to 20 degrees) and cause a momentary stall of the canard surface. This feels very much like a gentle stall break on a conventional airplane except that the canard quickly regains lift and then stalls again. This pitching action will continue as long as full aft stick and idle power remain. The only motion is in pitch. You can make turns with the ailerons or rudder or even cross aileron and rudder controls during this pitching motion with no unusual characteristics. Addition of power or forward stick will immediately stabilize the pitching action.

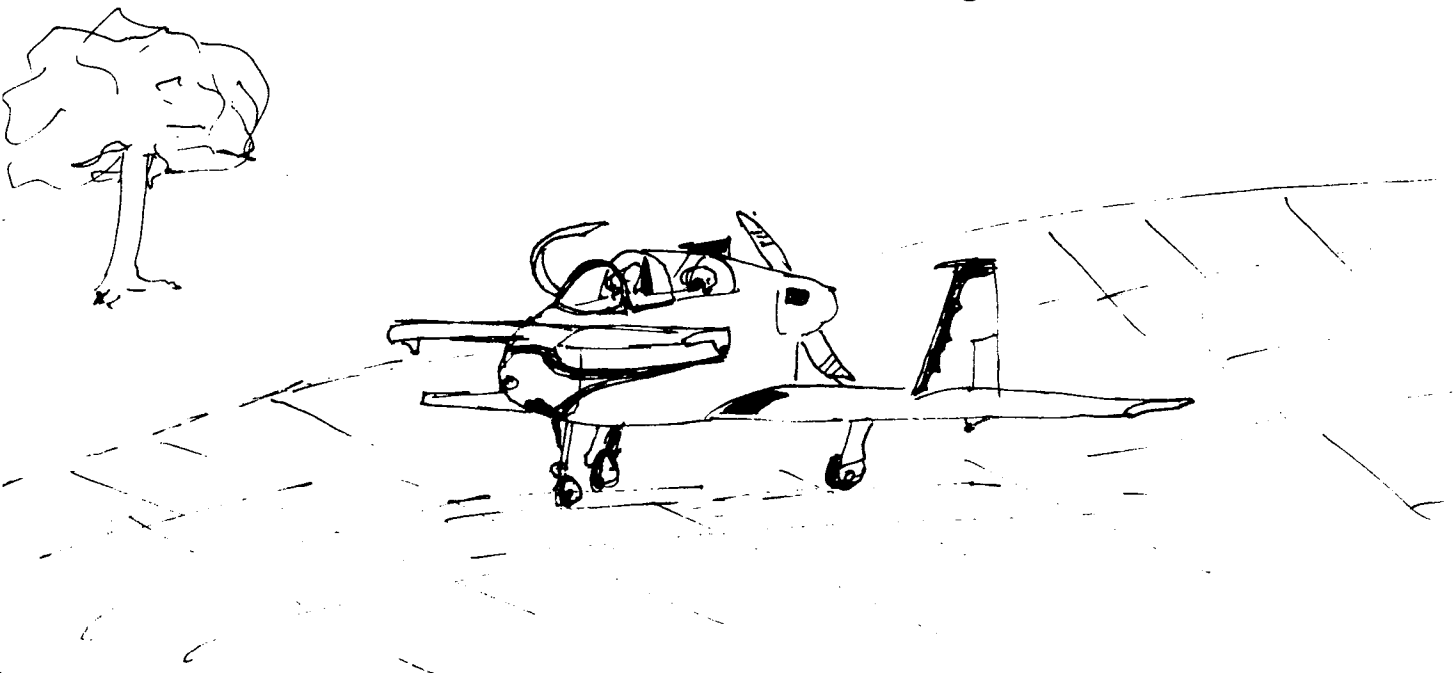
I have been unable to spin the aircraft during straight ahead stall entries or accelerated entries with all combinations of aileron and rudder controls. I haven't tried hammerhead entries (I'm chicken) but the radio-controlled model would not spin from hammerheads, so I think I can safely say it is not spinnable.

#### General Flying Qualities



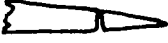
The thing I like most about the airplane is its roll qualities. Its low adverse yaw, high roll rate, ability to stop the bank right where you want, combined with the "fighter" visibility and cockpit just make it fun to fly. An F-106 pilot who flew it said it handled more like the F-106 than any type he had flown, military included. The roll rate is surprisingly high even at 50 knots. This allows you to roll 120 degrees to level at the top of a steep wing over and fly away without "dishing out".

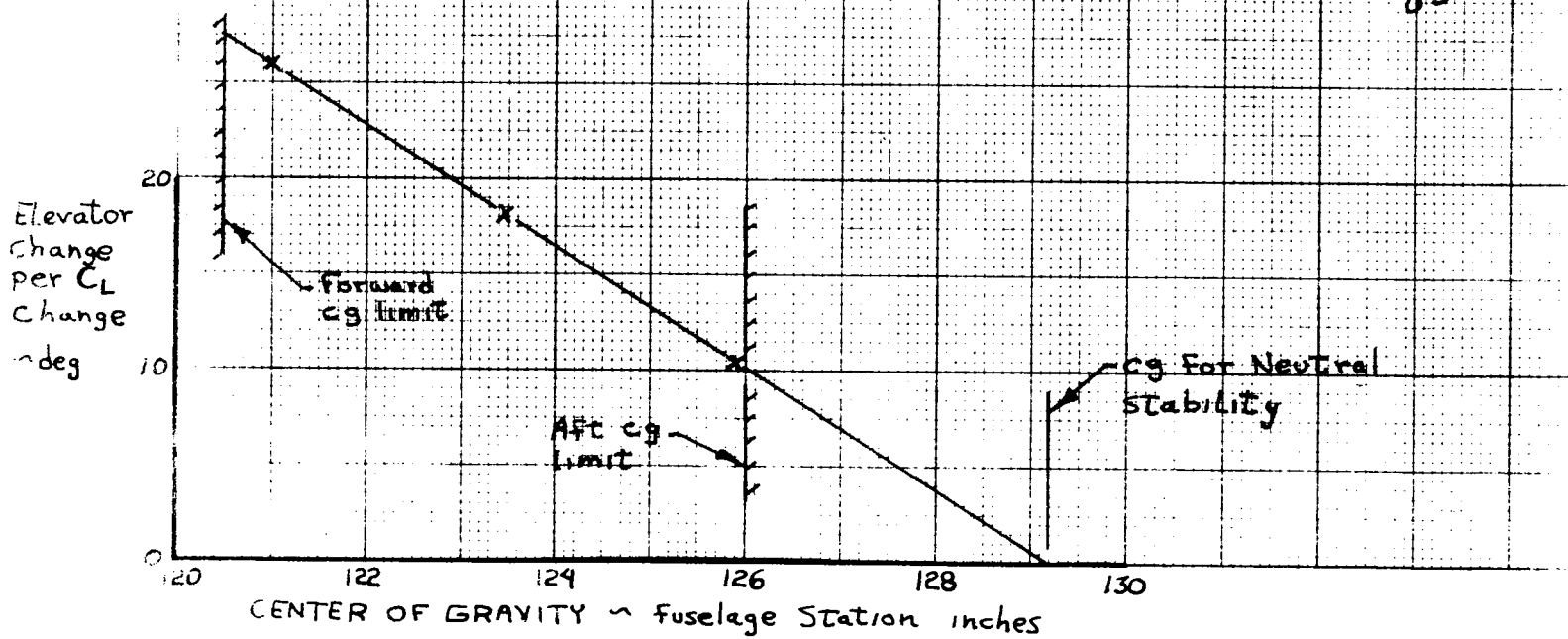
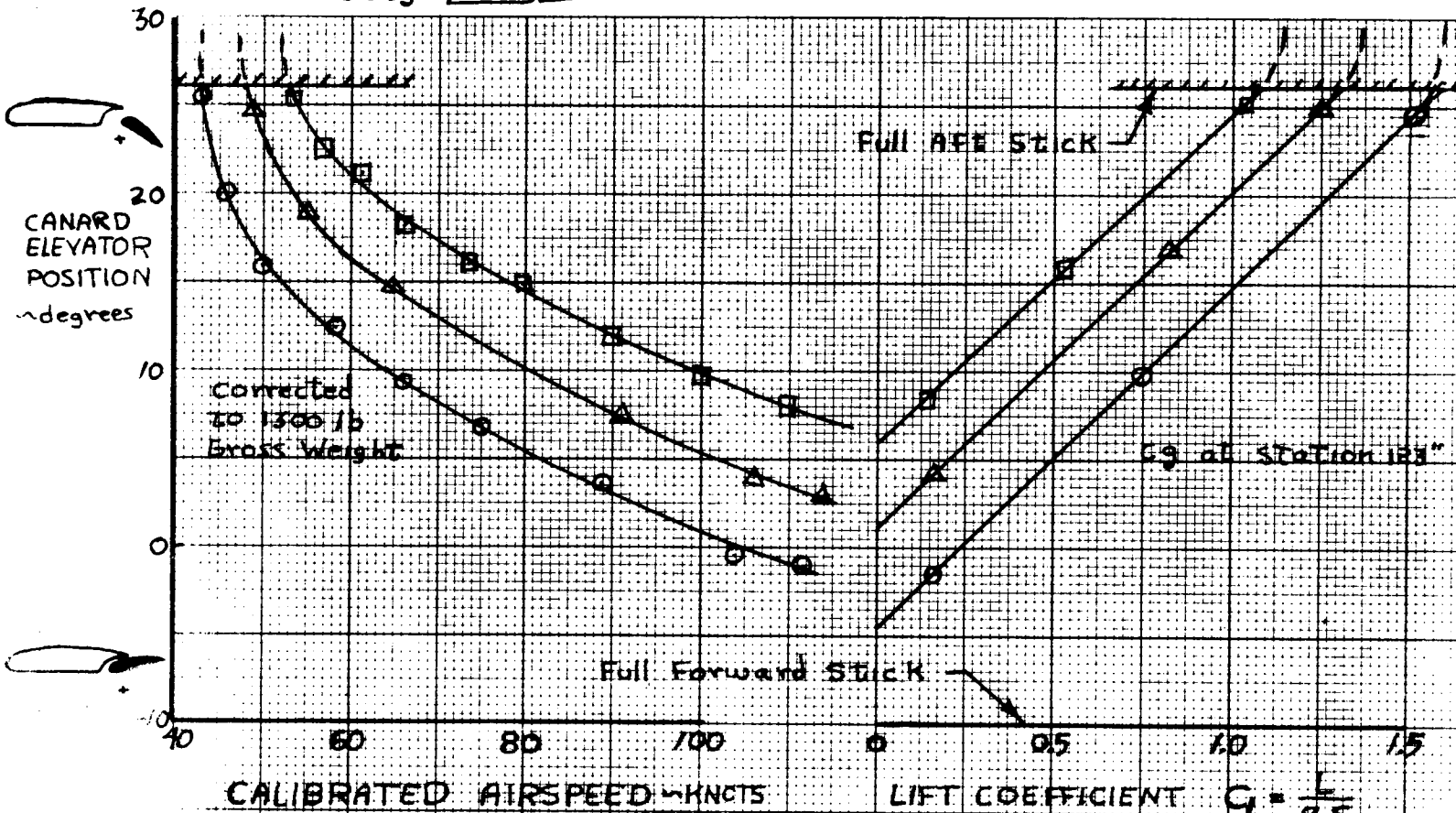
#### Aerobatics

As I mentioned, rolls are fun. You can complete a 360-degree roll without altitude loss from a level flight speed as slow as 85 knots. But, the VariViggen is not an aerobatic airplane. It is strong enough, but due to its low aspect ratio, it slows down considerably during tight maneuvering. This makes vertical maneuvers such as loops very difficult. Also, of course, true snap rolls are impossible since you can't stall the main wing.

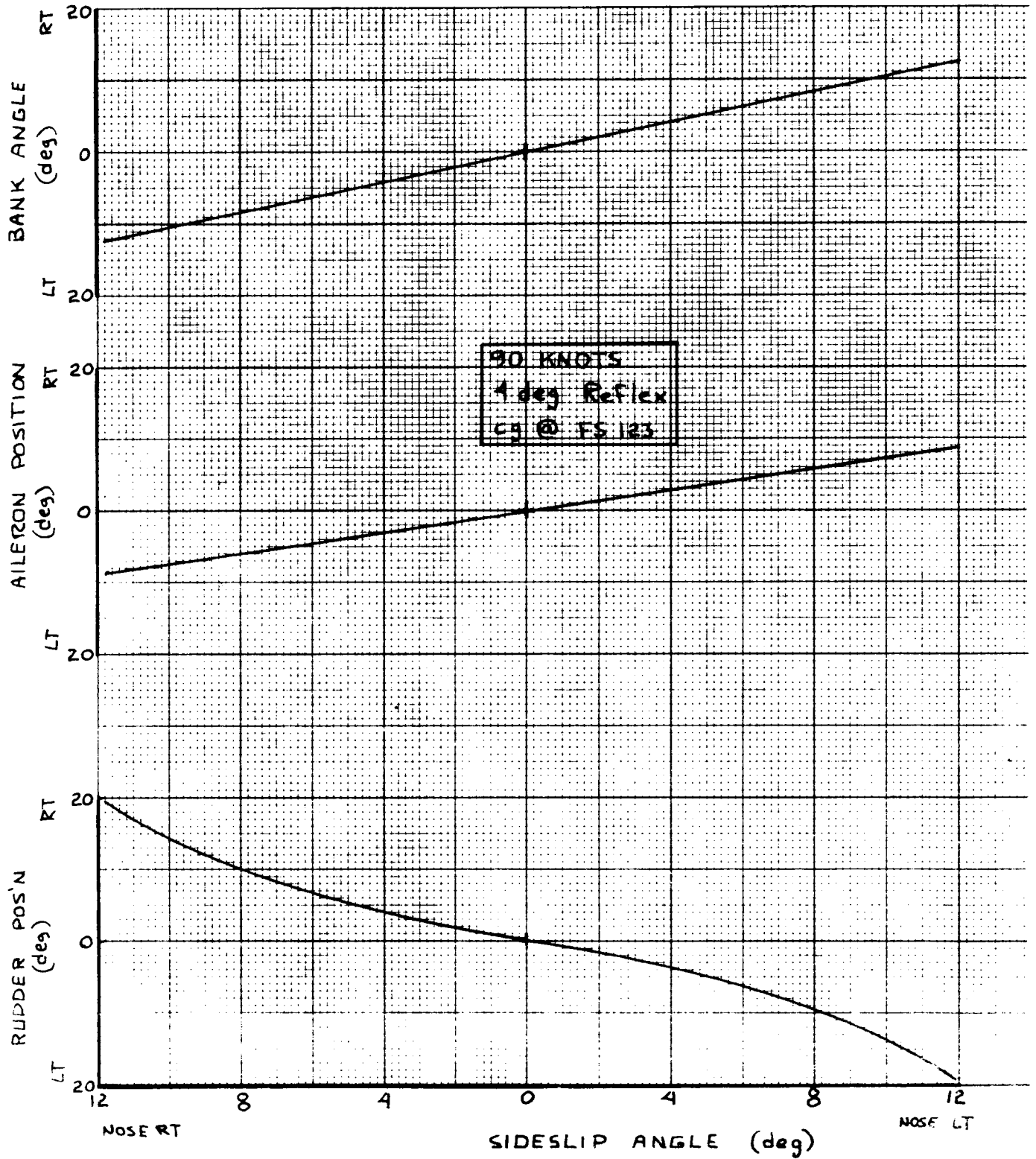


# LONGITUDINAL STABILITY




SYMBOL	REFLEX
○	8 deg 
△	4 deg 
□	0 deg 

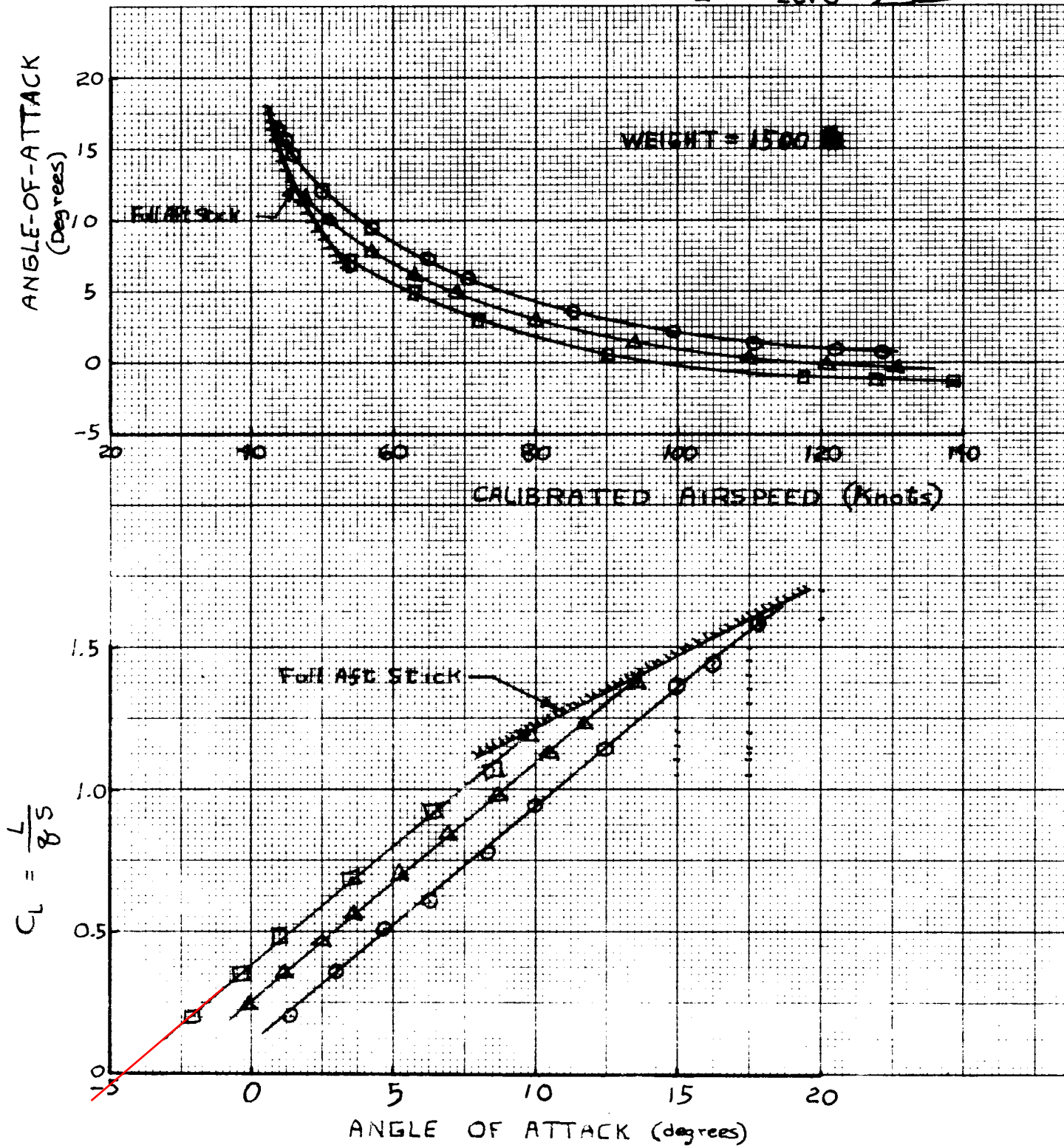


# LATERAL-DIRECTIONAL STABILITY

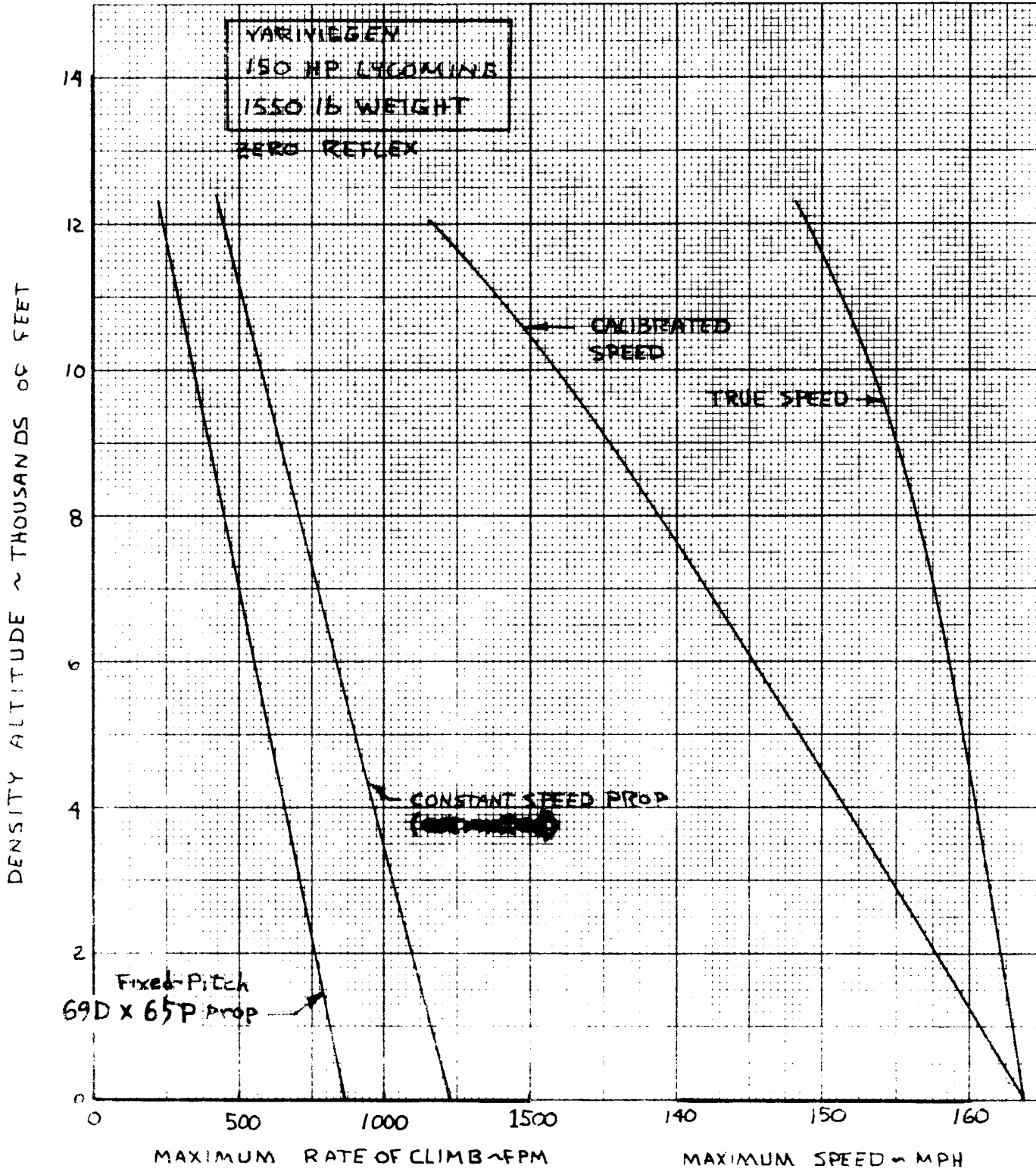


**LIFT & ANGLE-OF-ATTACK DATA**

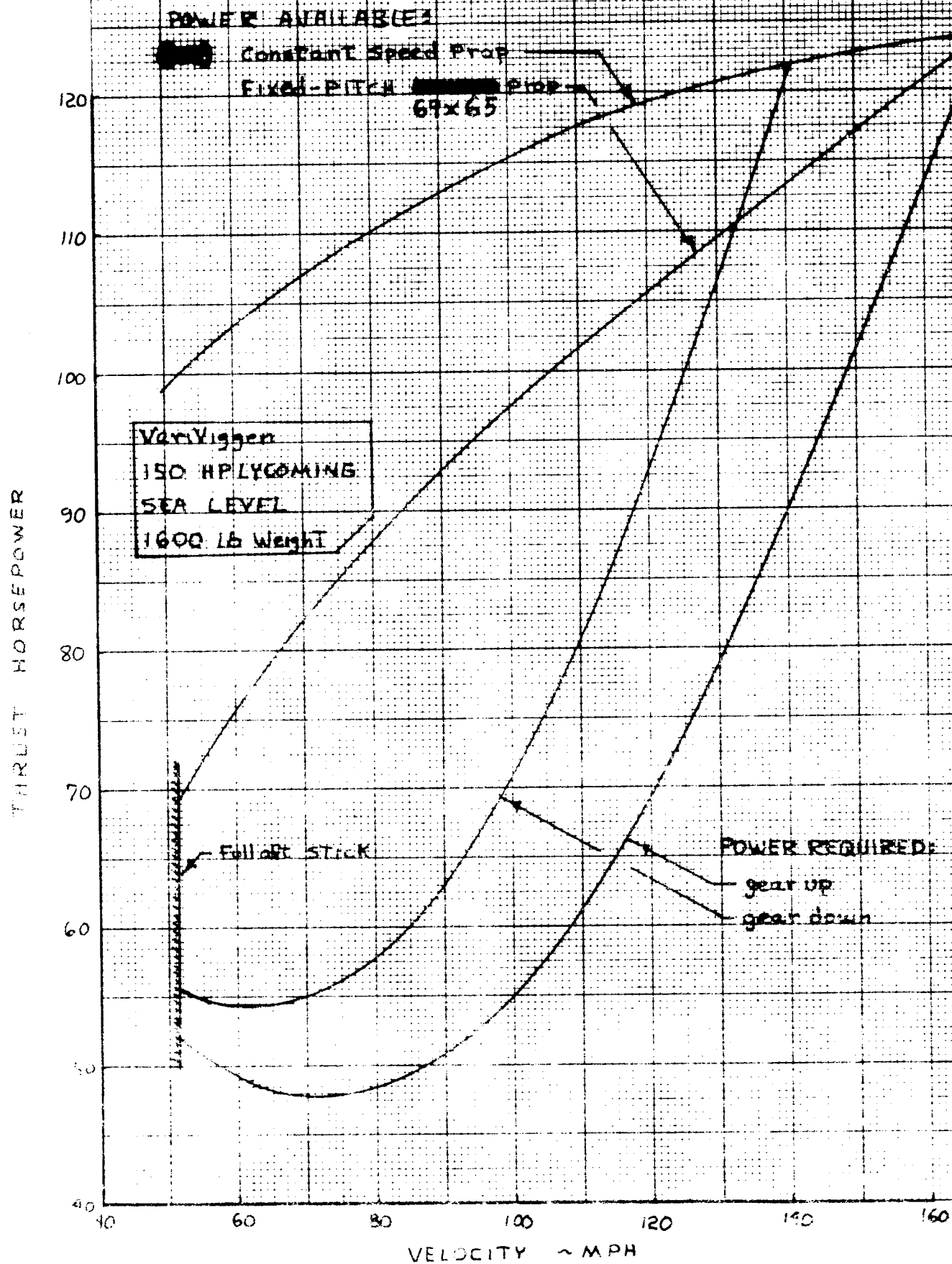
SYMBOL	TRAILING EDGE REFLEX
○	8 deg 
△	4 deg 
□	zero 



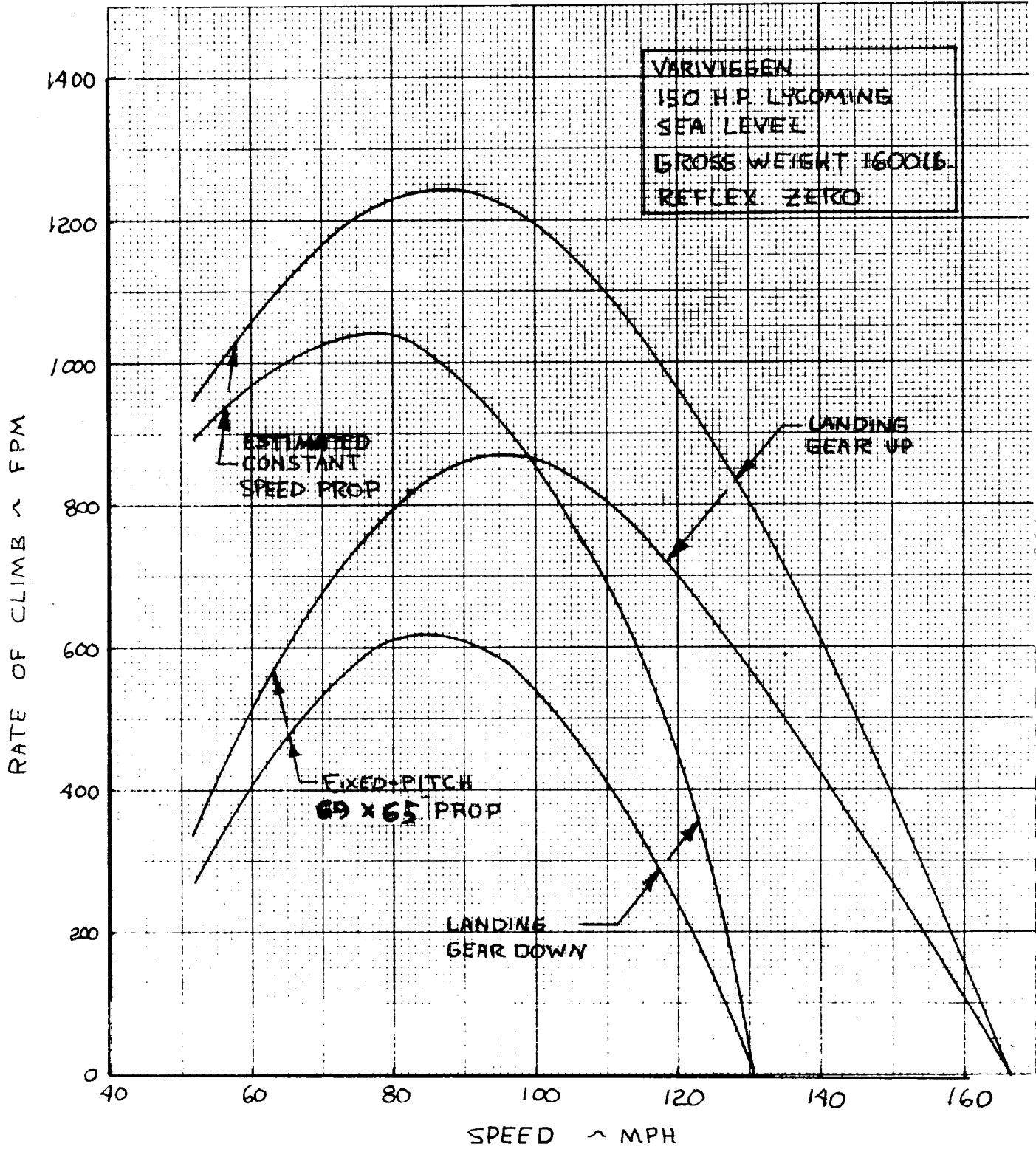
# MAXIMUM SPEED AND CLIMB



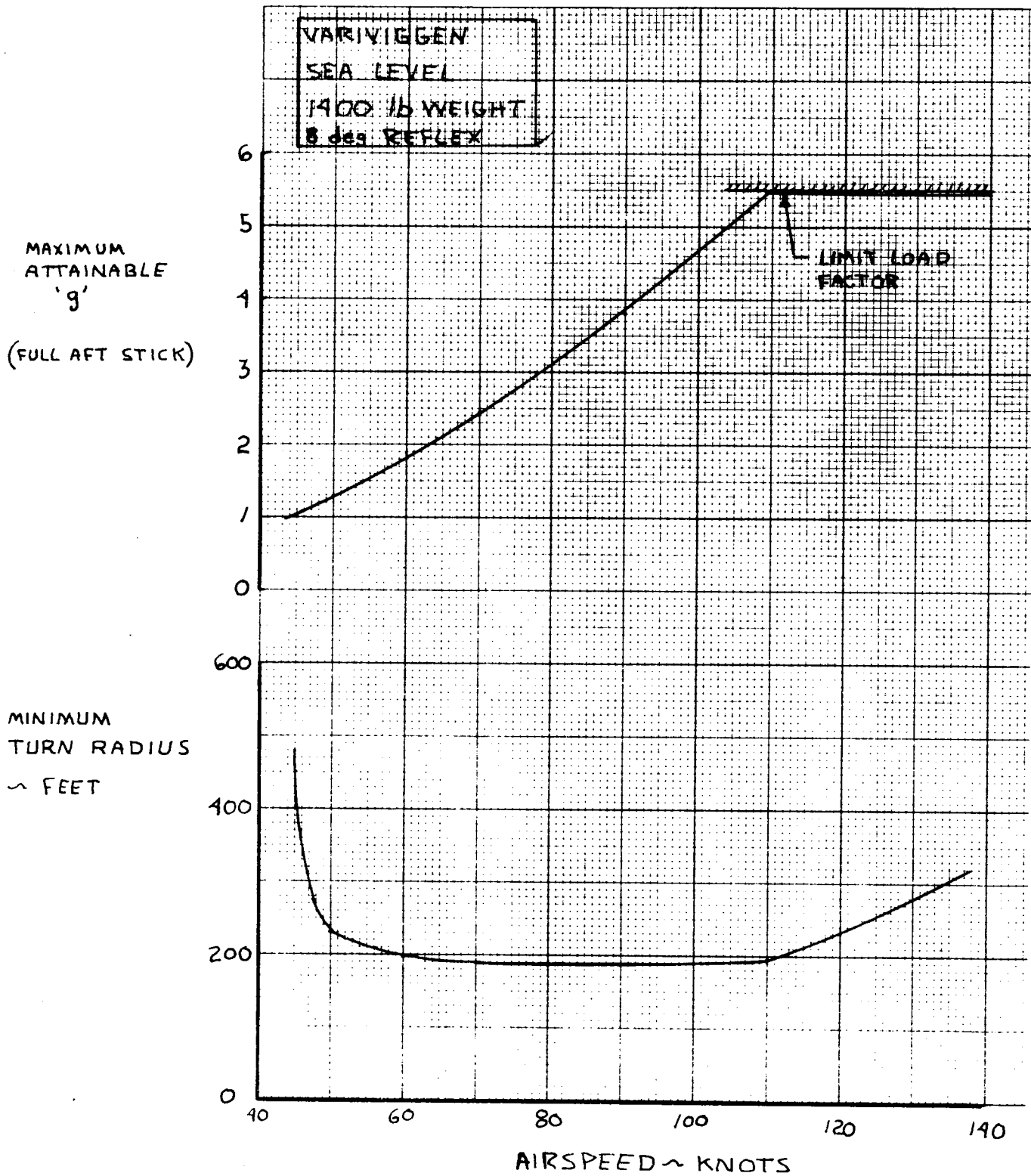
# POWER AVAILABLE AND POWER REQUIRED



# CLIMB PERFORMANCE



# MANEUVERING PERFORMANCE



## MAINTENANCE—FIRST 150 HOURS

The VariViggen prototype N27VV made its first flight on 24 May 1972. It completed its first 150 flying hours during the Spring of 1973. The following list includes all work accomplished on the aircraft under the category of routine maintenance or repair. Equipment installation, design improvements or flight test changes are not shown.

Time/Hours	Maintenance
1	Replace broken link in nose gear
3	Increase spring force on main gear clutch
5	Replace shear pin on nose gear
6	Service battery
8	Patch propeller nicks
40	Oil change
51	Remove wings for inspection
59	Repair cowling crack
71	Clean and gap spark plugs
75	Replace fiberglass nose gear springs
86	Oil change
121	Remove lousy nose gear and replace with air-oleo strut
125	Oil change
132	Clean and adjust mike switch
143	Refinish propeller
149	Replace lower cowling with new design to eliminate cracking at lower holes
400	All maintenance has been routine with no major repair or failure (Fall 1974).
470	Ditto (Spring 1975).

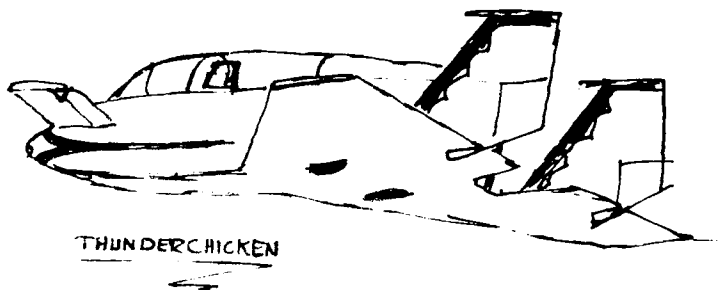
After about 500 hours, the aircraft experienced a minor component failure which prevented the main landing gear from being extended. The resulting landing, with main gear up and nose gear down, resulted in only minor damage to the underneath skids and delayed our trip by only about two hours.

## COST TO BUILD PROTOTYPE

<u>Item</u>	<u>Cost</u>
Lycoming O-320 A2A requiring top O/H	\$ 750
Top overhaul	350
Prop and spinner	160
Engine accessories and all fittings to install engine	180
VFR instruments	310
Wheels and brakes, tires and tubes	210
Canopies - plexiglass (front canopy from HP 11 sailplane)	62
Landing gear, trim and reflex motors	59
Landing gear hardware, fittings and materials	98
Control system " " " "	78
Fuel system " " " "	67
Electrical system components	260
Construction materials for structure	435
Adhesives	40
Fiberglass for cowling, nosecone, etc.	32
Finishing and paint	180
Interior and seats	120
TOTAL	<u>\$3391</u>

Note: Does not include costs for welding, flight test instruments radios, ELT, or alimony.

These costs were during the time period from 1969 to 1972. Inflation now has made many of these values unattainable, however, I believe the cost, less engine, would be approximately \$3000.00 with today's prices.



## CAR-TOP "WIND TUNNEL"

The VariViggen was designed in the wind tunnel rather than by calculation. I started out with a canard configuration quite a bit different and kept changing it until it flew in the wind tunnel the way I wanted the real thing to fly. Many changes were made (27 in all) to the configuration during the tests to optimize the low speed handling and stall resistance and to determine cg limits.

The wind tunnel was considerably different than the conventional wind tunnel. Basically, the setup involves an automobile with a mount on top sufficiently high enough to get the model out of the car's wake and an instrumentation system by which the parameters can be read from a panel in the car. A disc mounted near the model reads dynamic pressure (or calibrated airspeed) so the car driver can drive a given  $q$ , or speed. The guy in the right seat can control the model's control surfaces, and since the model is on a free pivot at its cg, it assumes its trimmed flight attitude. This attitude and the aerodynamic forces are displayed on the panel.

The following parameters are read from the panel meters on the panel:

- dynamic pressure -  $q$  (on the driver's side)
- elevator position
- angle of attack
- lift
- drag
- rudder position
- aileron position
- sideslip angle
- roll moment

For the pitch stability, lift, and drag data the model is set with full down elevator and the elevator is moved up in small increments while recording lift, drag, elevator position and angle of attack. For the roll/yaw stability tests the model is set at the desired angle of attack, and the rudder is moved while recording sideslip and roll moment. This gives directional stability and dihedral effect. The ailerons can be evaluated at any sideslip angle by deflecting them and recording roll moment. The test are done at several cg positions, set by moving the model's pivot back and forth in the model. The following basic plots thus obtained will evaluate the acceptability of the configuration:

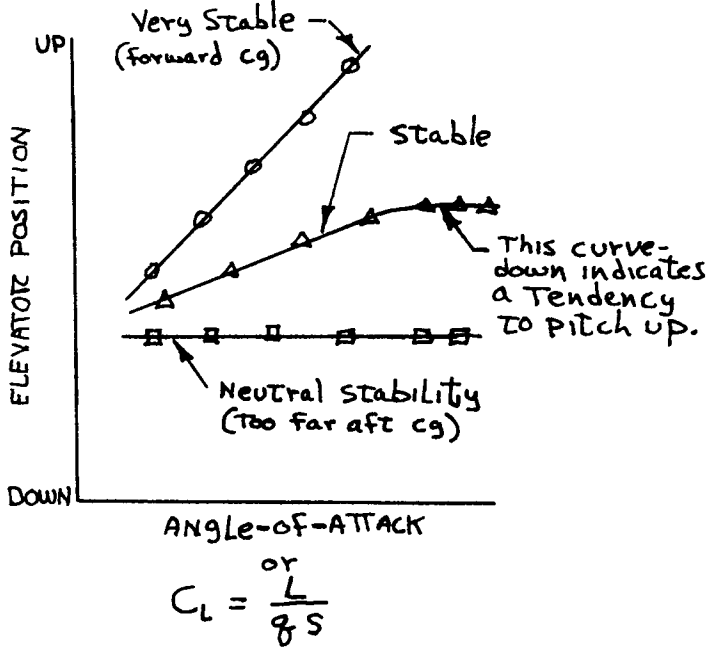
Determination of Dynamic Pressure. -  $q$  (lb/ft<sup>2</sup>)

$$q = 5.91 \times F$$

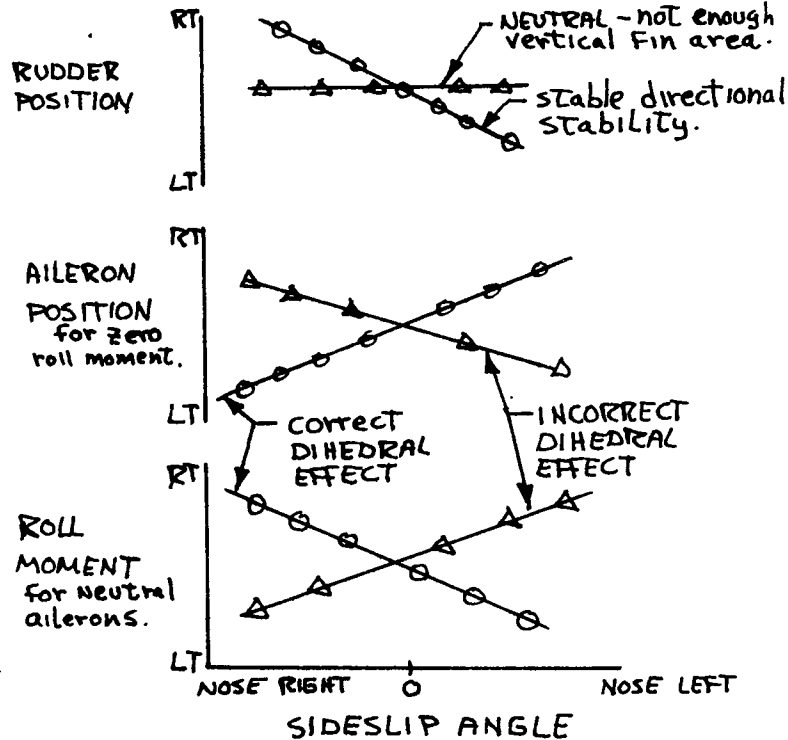
where  $F$  = force on a 5 inch diameter Disc faced into the wind.



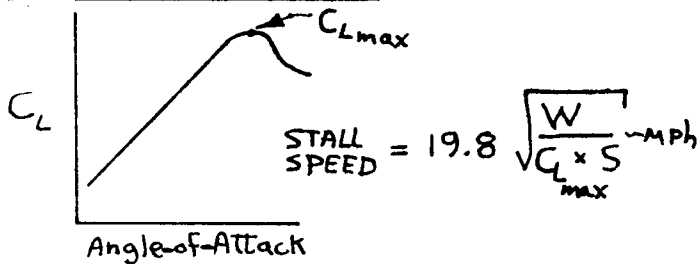
**LONGITUDINAL STABILITY**



**ROLL & YAW STABILITY**



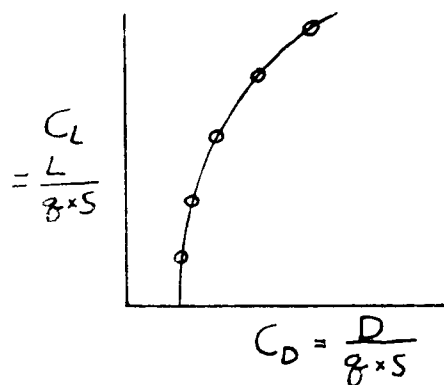
**STALL SPEED**



**POWER REQUIRED TO FLY LEVEL**

**VARIYIGGEN PILOTS HAVE MORE FUN!**

First, PLOT  $C_L$  VS  $C_D$



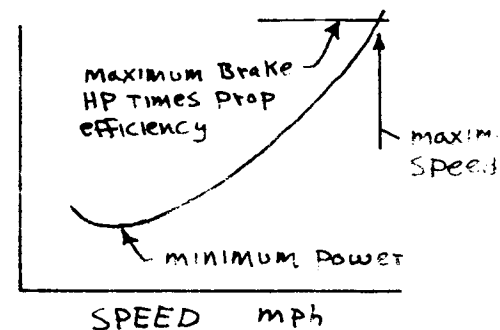
Then, select several values of  $C_L$  and  $C_D$  from the curve and calculate speed and Horsepower:

$$\text{Speed} = 19.8 \sqrt{\frac{W}{C_L \times S}} \sim \text{mph}$$

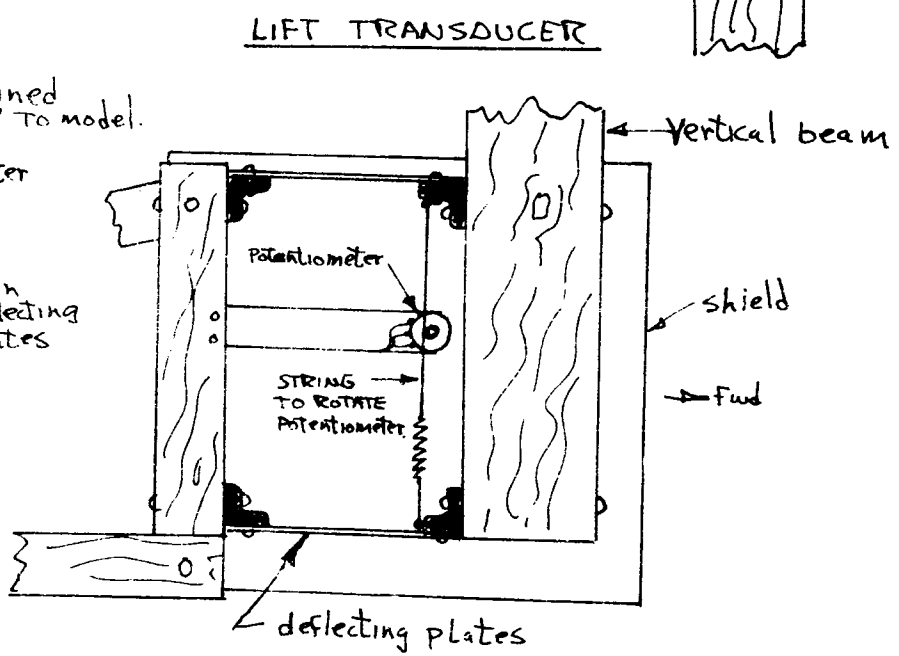
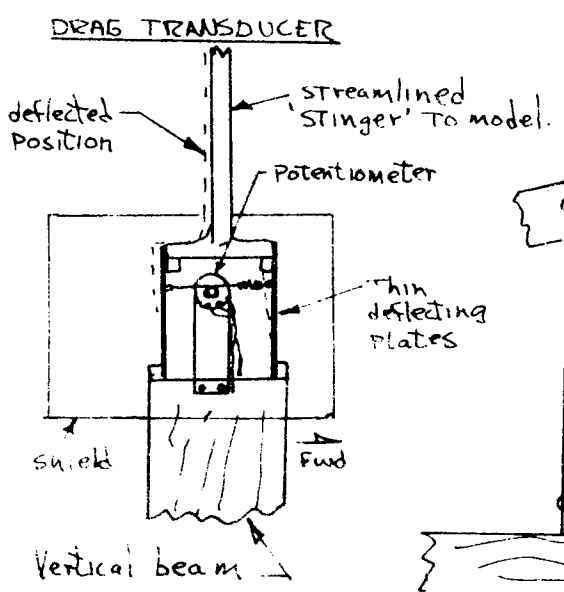
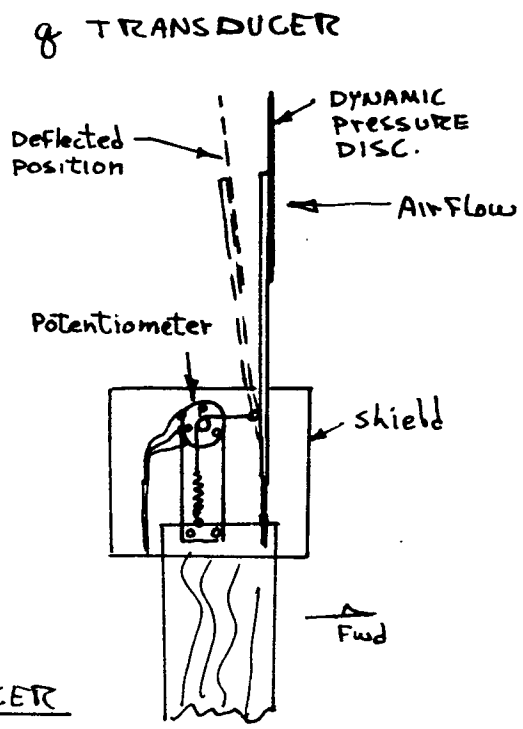
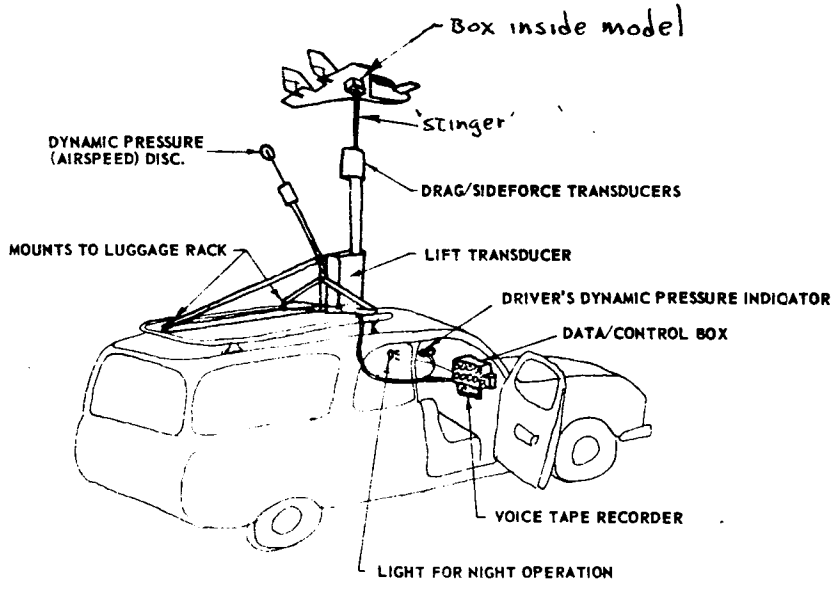
$$\text{Horsepower Required} = 0.0527 \sqrt{\frac{W^3 \times C_D^2}{S \times C_L^3}}$$

Then, PLOT:

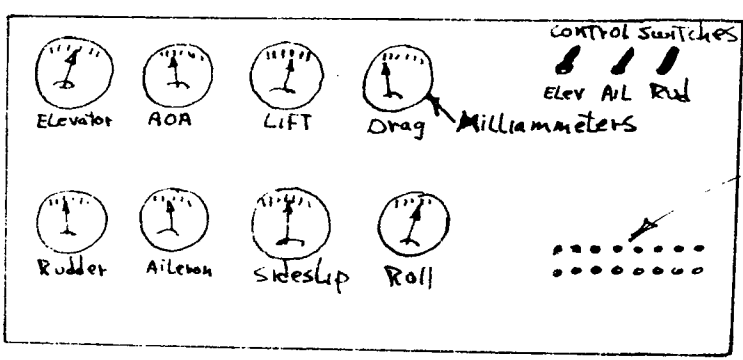
Thrust Horsepower Required for Level Flight



The following sketches illustrate the basic construction of the wind tunnel setup:



### DATA/CONTROL BOX



Calibration performed by applying loads with a spring scale

## QUESTIONS WE'VE BEEN ASKED

Q. Why name it VariViggen?

A. Viggen is the name of a mach-2 canard fighter aircraft built in Sweden that uses the same high-lift vortex interaction principle. Vari refers to the variable flying qualities by changing reflex position.

Q. Can the Viggen be built all aluminum, fiberglass or steel tube?

A. Sure, however, only the external dimensions of the plans could be used. You or an engineer helper would have to dream up the internal structure and size all the parts. The airplane should fly the same, but would not be as quiet and fatigue-free as the current wood prototype. A wood airplane, particularly one hangared, would last indefinitely when properly cared for.

Q. Building skills required?

A. The VariViggen is a relatively good "first builders" project because no special skills are required and few special tools are needed. Difficult parts such as steel wing attach. fittings, fiberglass parts, and machined parts can be purchased. VariViggen plans have been approved by NASAD in the "AA" category.

Q. Will prop be shrouded?

A. I have no plans to do this. It would improve takeoff and climb but probably reduce cruise speed.

Q. Could rockets or jets be mounted on the fins and wingtips?

A. Anything you could dream of is possible to build and work, but I suggest a more conservative, lower-cost project than a rocket VariViggen!

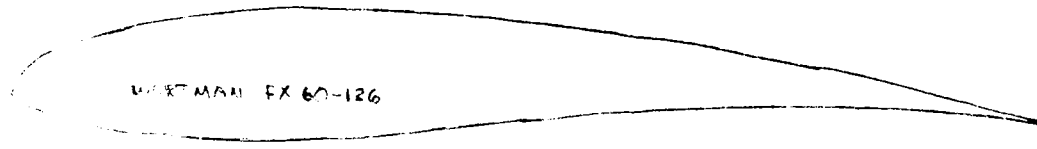
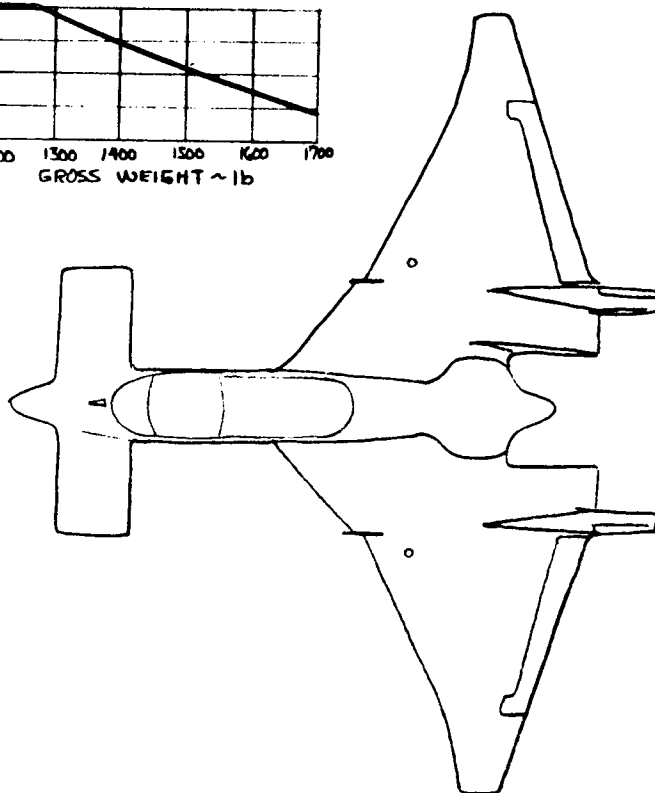
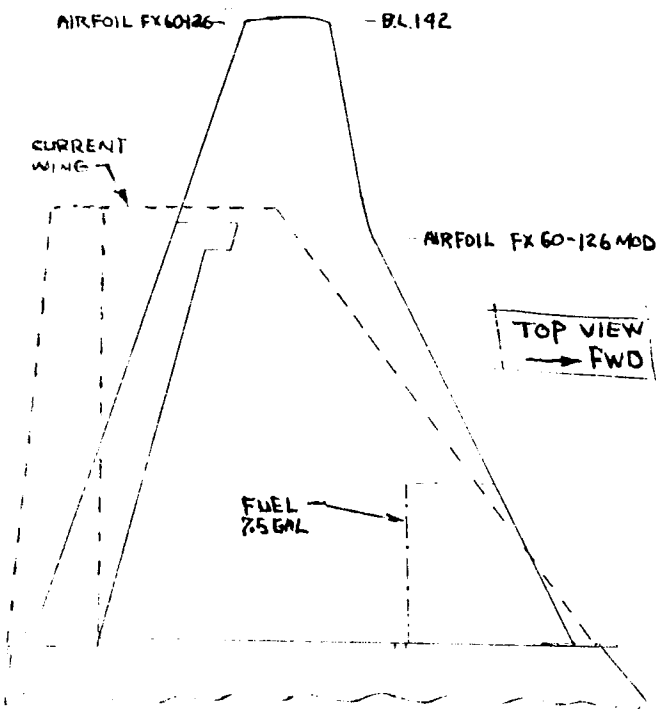
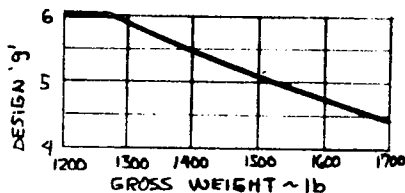
- Q. Would a radio control model of the VariViggen fly?
- A. Yes, I flew one to test the spin characteristics. It was a 1/5 scale model with Kraft radio and a Veco 61 - it flew well. VariViggen model plans are available from RAF.
- Q. Time to build?
- A. Better count on around 2 years of your spare time, or about 1200-1500 man hours for the average worker with little experience.
- Q. How can I have it licensed?
- A. This is easy. Your local FAA General Aviation District Office (GADO) looks at your aircraft before covering and before first flight and writes your airworthiness certificate. See your GADO with further questions. A complete procedure for licensing in the amateur builder category is shown with the plans.
- Q. Would other engines be okay?
- A. With modification any 125 to 200 hp powerplant would be adequate, provided the weight is between 200 and 320 pounds. However, since the installation has been well proven with the Lycoming I strongly recommend the O320, IO320 or O-360 Lycoming. I think the 200 hp Lycoming is too heavy. *IO320-200-112 is a good choice for this plane. I think the 200 hp Lycoming is too heavy.*
- Q. Can it be built fixed gear and without reflex control to make it simpler to build?
- A. Yes, an intermediate reflex setting (4 deg) is satisfactory for all flight conditions. A 'basic' fixed gear airplane with no 'extras', no electrical system, etc., could be built with an empty weight of around 750 to 800 pounds and with 125 hp could still cruise at about 125 mph.
- Q. Can it be flown open cockpit?
- A. I've flown it with the aft canopy off for photo work and for bombing contests.
- Q. Can it be flown solo from back seat?
- A. No, it's too tailheavy. In fact the controls in the back don't even allow engine starting or taxi.
- Q. Where are the antennae?
- A. Since it's a wood fuselage the antennae work well inside. The VOR is inside the canard, the COM and transponder antennae are behind the pilot.

**Special Performance Wing**

We have started construction on an entirely new outboard wing panel design for testing on N27VV. First, a little background: we have done extensive testing on a new construction method using urethane foam and hand layup unidirectional fiberglass. I do not mean the Rand formulae of wood construction with foam and Dynel surface development. We actually make a tapered spar very easily by laying up layers of unidirectional glass, carve a wing using only three rib/templates, and cover with two crossed layers of thin unidirectional cloth. This method is light, strong, requires no particular skills or tools, and best of all, can be done in about 1/4 of the man-hours required to build the metal wing. If this system meets test expectations, we will supply plans for outboard wings and rudders, thus taking the aluminum construction totally out of the design. A small cost savings is also possible. Since the unidirectional glass with the epoxy surface treatment is somewhat difficult to obtain in partial rolls, we are importing a large quantity from Europe and will make available kits for the outboard wings and rudders. No aircraft-quality wood is required.

Now, for the really big news - the aerodynamic design of the wing panel. The original panel is a very, very conservative design from the stall standpoint, and retains the flat bottom out to the tip for ease of metal construction. Now that I have actual flight test data, I can design out some of the unnecessary stall margin, and reflex and twist the wing for optimum performance. I wouldn't recommend this for a new design, but it can be done with low risk, using actual flight test data. Considering the trim requirements, and designing for best climb and cruise performance without excessively reducing the g-capability, I have arrived at the following design and have started construction:

	Original VariViggen	VariViggen SP	Increase
Span ft	19	23.7	25%
Area ft <sup>2</sup>	119	125	5%
Aspect Ratio	3.03	4.47	47% !
Span Loading	89.5	71.83	-20%

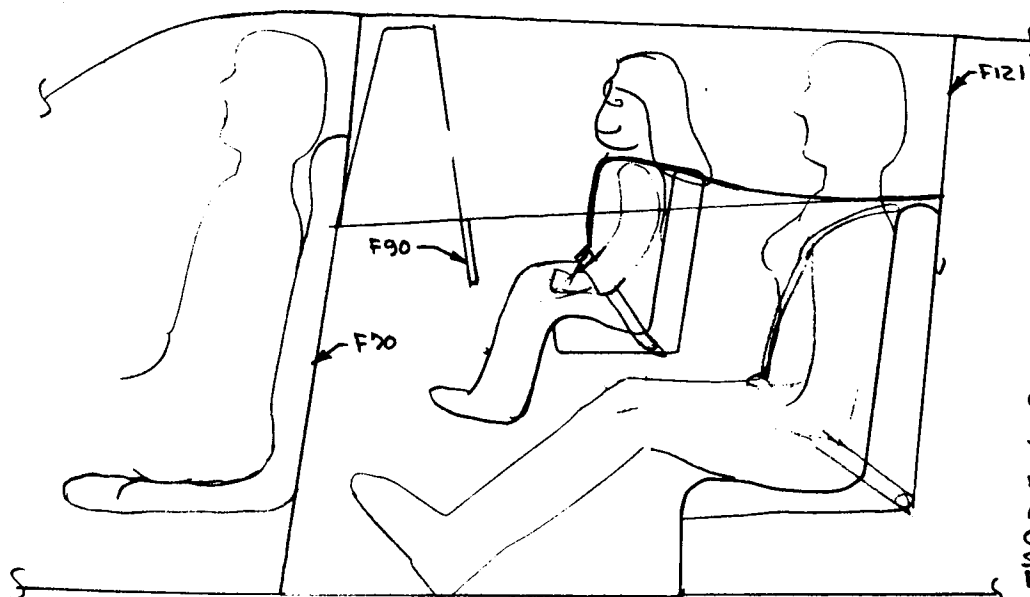


Conservatively, we estimate a 25% increase in rate of climb at gross weight and a five to seven mph increase in cruise speed. That's almost 180 hp performance on the 150 hp engine! As you can see from the sketch, the new wing has a 15 gallon aux. fuel capacity. It will fit the inboard wing built to your plans and uses the same V-WAA (WA2 and WA3) wing atch. assembly as is used on the original outboard wing. It will also tie in directly with the current design AB10 aileron pushrod and should require no other changes.

In addition, we are going to incorporate the recent NASA-developed "winglets" developed by Dr. Whitcomb in an attempt to further increase rate of climb. In summary, if the SP works as I think it will and retains the stall safety, we will have a very competitive performance aircraft to go along with our already superior handling characteristics. But that's an if, so please don't bother us alot with further questions now; we should have test data and a decision whether to make plans available by Newsletter #4. I do suggest that you hold off on purchasing materials and building the outboard wing if you have not already done so.

SAMPLE PAGE FROM NEWSLETTER #3

**OTHER** Modifications - True, the VariViggen is not a 4-place airplane, but it can easily be made into a 2 + 2 configuration with plenty of room and visibility for a 140-lb wife and one or two children, combined weight up to 110 lb. The sketch is self-explanatory. This is the best way to add some family utility without compromising cruise performance. Scaling up the outside dimensions to add more people will result in either slower speeds or higher fuel flow, depending on engine selection.



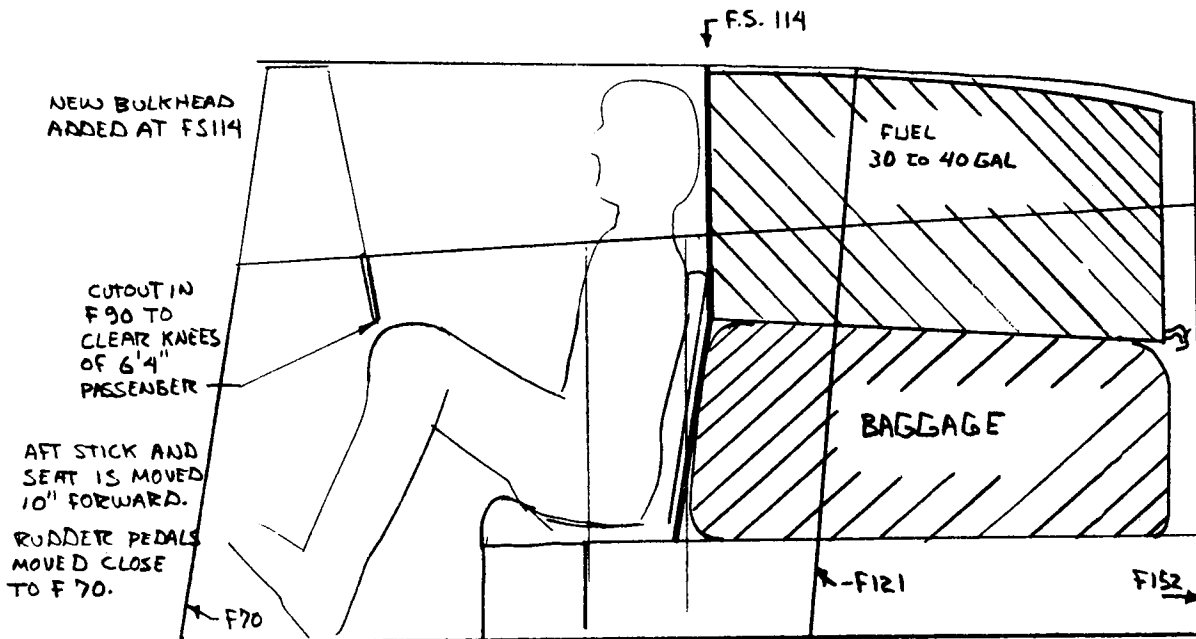
JUMP SEAT CAPACITY -  
2 CHILDREN SIDE-BY-  
SIDE, TOTAL WEIGHT  
110 lb.

CHILDS JUMP SEAT  
CAN FOLD FORWARD  
OR BE REMOVED TO  
ALLOW EASY BACK  
SEAT ENTRY AND  
ACCESS TO BAGGAGE  
COMPARTMENT

CHILDS SEAT BELT  
ATTACHES TO F103.  
CHILDS SHOULDER  
HARNES ATTACHES  
TO F8 OR F5.

F90 IS CUTOUT TO  
ALLOW CHILDS LEG  
CLEARANCE. REAR  
STICK IS MADE  
REMOVABLE.

As a two-place, the rear seat area is much larger than is usually needed, and a relatively minor modification can be made to increase fuel capacity, baggage capacity, and still hold a 6' 4" back seater in relative comfort. Again, the sketch is self-explanatory. This is probably the best way to increase range, since it does not add any complexity to the simple gravity-feed fuel system.



NEW BULKHEAD  
ADDED AT F.S.114

CUTOUT IN  
F90 TO  
CLEAR KNEES  
OF 6'4"  
PASSENGER

AFT STICK AND  
SEAT IS MOVED  
10" FORWARD.

RUDDER PEDALS  
MOVED CLOSE  
TO F70.

FUEL  
30 to 40 GAL

BAGGAGE

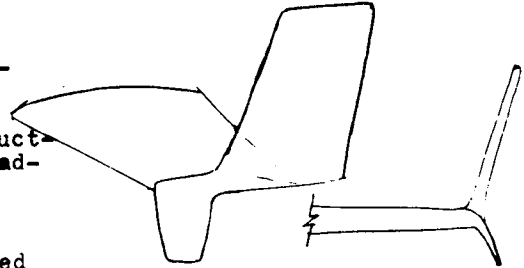
**ADHESIVES**

I am still hearing about some builders using obsolete wood adhesives and varnish. That was S O P years ago, but inexcusable now that modern epoxies are available. With modern epoxies, the wood structure should last indefinitely. Here are two more very good adhesives: 1. FPL glue 16-A, available from Aircraft Spruce, Bx 424, Fullerton, Ca. 92632, at \$11/qt or \$29.90/gal; 2. West System Epoxy, available from Gougoen Brothers, Bay City, Mi. at \$19.95/gal plus \$5 for hardner (specify 206 hardner for 40 minute pot life). This latter one sounds excellent as it has a relatively fast cure of six hours and can be used as low as 40° F temperature. It's a 5 to 1 mix, has a relatively low viscosity, and can be used directly for painting structure. It provides a 100% molecular bond between coats without surface preparation. For gaps over 1/32", it can be thickened with "401 fibers" (\$1.90 for a bag - enough for the entire aircraft) to fill even large gaps without decreasing strength. Send Gougoen Brothers an extra \$ for their manual on this epoxy system. Pastor Jenkins, S/N 177, is using it on his VariViggen. He completed his fuselage structure and canard in only 12 days!

## VARIVIGGEN SPECIAL PERFORMANCE WINGS

The new all-glass special performance wings for the VariViggen (see Newsletter #3) were flown for the first time on July 16. The performance improvement has been as expected: rate of climb at sea level, 1600-lb weight, is just over 1000 fpm! For rate of climb at altitude, add about 150 fpm to the curve shown in the VariViggen Technical Report. Cruise performance is higher, also. With the new wings and the new RAF-supplied cowling, the cruise speed at 8000 feet is 159 mph using the O-320 engine at 75% power. The SP wings were flown both clean and with winglets. The winglets add directional stability, help the rate of climb at low speeds, and have no effect on the cruise speed.

What are winglets? Winglets are two vertical fins on each wing tip. They were designed by Dr. Whitcomb from NASA who previously developed the transonic area rule principle and the supercritical and GA(W) airfoils. VariEze, N7EZ, was the first aircraft to fly with winglets although hundreds of hours of windtunnel tests were previously conducted by NASA. The lower surface winglet extends from the leading edge back to 33% of the tip chord. This surface is cambered inward and is inclined 30° out from vertical. The upper surface winglet extends from 33% of the tip chord aft. This surface is cambered outward and is inclined 15° out from vertical. Winglets are optimized to unwind the tip vortex to the greatest extent possible. This reduces induced drag, resulting in a 6% fuel saving. In addition, the local incidence of the surfaces are inclined to produce forward thrust which offsets the parasite drag of the vertical fins. This is possible due to the high amount of lateral flow near a wing tip.



The SP wings hold 18 gal of aux fuel, which increases max range to near 600 miles. This fuel is pumped into the normal fuselage tank by an electric pump. The tanks have flush caps and are filled individually. The weight of the new wings are about the same as the old, metal wings. The tiedown points have been moved to near the tip to allow more convenient attachment of the most common tiedown systems.

The SP wings use the same WA3 straps which are used on the metal wings. These bolt to a stub wood spar which is only two ft long. The rest of the spar is unidirectional fiberglass. The entire skin, trailing edge spar, and ailerons are glass/foam composite. No ribs are used. The SP wings were built in about 110 man-hours which is only 1/3 the time needed for the aluminum wings. Finishing time to obtain a first-class surface contour added about 30 man-hours.

A large number of photos were taken during the new wing construction for use in the SP wing plans. The plans will also show many details to educate the builder in the methods of structural fiberglass application. The plans will also include drawings of a foam/glass rudder. Thus, all the sheet-metal structure will be removed from the aircraft.

Flight tests have shown only a one-mph cruise speed change with reflex position, thus reflex control probably will not be required for a VariViggen with SP wings. I need to do more flight testing with the new wings before I decide on this for sure, but it looks as though we may recommend a fixed reflex and lengthening the nose gear about 2" to allow a slower nosewheel lift-off speed without the aid of up reflex. Rate of climb does not seem to change with reflex position when using the SP wing. All modifications required and details will be included with the plans. The wings will be "service tested" on the Oshkosh trip. We will start work on the construction drawings when we return. I expect plans availability by October.



ADDENDUM TO VARIVIGGEN TECHNICAL REPORT  
MARCH 1978

Page 2 and 5 - The items referenced as "available from RAF" are no longer marketed by RAF. See the VariViggen flyer or "Canard Pusher" newsletter for current vendor for prefab parts.

The performance and flying qualities data in this report are for the VariViggen with the standard wing. This is a metal, low-aspect ratio wing with a large tip chord (see cover). In 1975 a new outboard wing was developed. It was designated the "SP" (special performance) wing because it increases range, rate of climb and cruise speed. It uses all composite (foam and glass) construction and includes wing fuel tanks to further increase range. The SP wing increases the overall span from 19 to ~~22~~<sup>23</sup>.7 feet, and area from 119 to 125 ft<sup>2</sup> (see sketch). The SP wings incorporate Whitcomb winglets. Winglets are two vertical fins on each wing tip. They were designed by Dr. Whitcomb from NASA who previously developed the transonic area rule principle and the supercritical and GA(W) airfoils. VariEze, N7EZ, was the first aircraft to fly with winglets although hundreds of hours of wind tunnel tests were previously conducted by NASA. The lower surface winglet extends from the leading edge back to 33% of the tip chord. This surface is cambered inward and is inclined 30° out from vertical. The upper surface winglet extends from 33% of the tip chord aft. This surface is cambered outward and is inclined 15° out from vertical. Winglets are optimized to unwind the tip vortex to the greatest extent possible. This reduces induced drag, resulting in a 6% fuel saving. In addition, the local incidence of the surfaces are inclined to produce forward thrust which offsets the parasite drag of the vertical fins. This is possible due to the high amount of lateral flow near a wing tip.

The SP wings hold 16 gal of aux fuel, which increases max range to near 600 miles. This fuel is pumped into the normal fuselage tank by an electric pump. The tanks have flush caps and are filled individually. The weight of the new wings are about the same as the old, metal wings. The tiedown points have been moved to near the tip to allow more convenient attachment of the most common tiedown systems.

The SP wings increase climb by about 150 fpm and cruise by about 4 knots. The stall characteristics are degraded with the SP wing, in that the airplane will roll off, if unco-ordinated while near full aft stick. Complete details on performance and flying qualities of the SP wing can be found in the "VariViggen Owners Manual."

Several builders have elected to use the standard wing because of its better flying qualities, but to use the composite construction materials designed for the SP wing. This is done by following the construction information in the SP plans, supplemented by additional details in the "Canard Pusher" newsletter 14.

The March 1978 issue of "Sport Aviation" (magazine published by EAA, Box 424, Hales Corners, Wis. 53130) contains an excellent article on Mike and Sally Melvills' excellent 180-hp VariViggen. Mike won the runner-up grand championship trophy at the 1978 Florida Sun-N-Fun flyin.