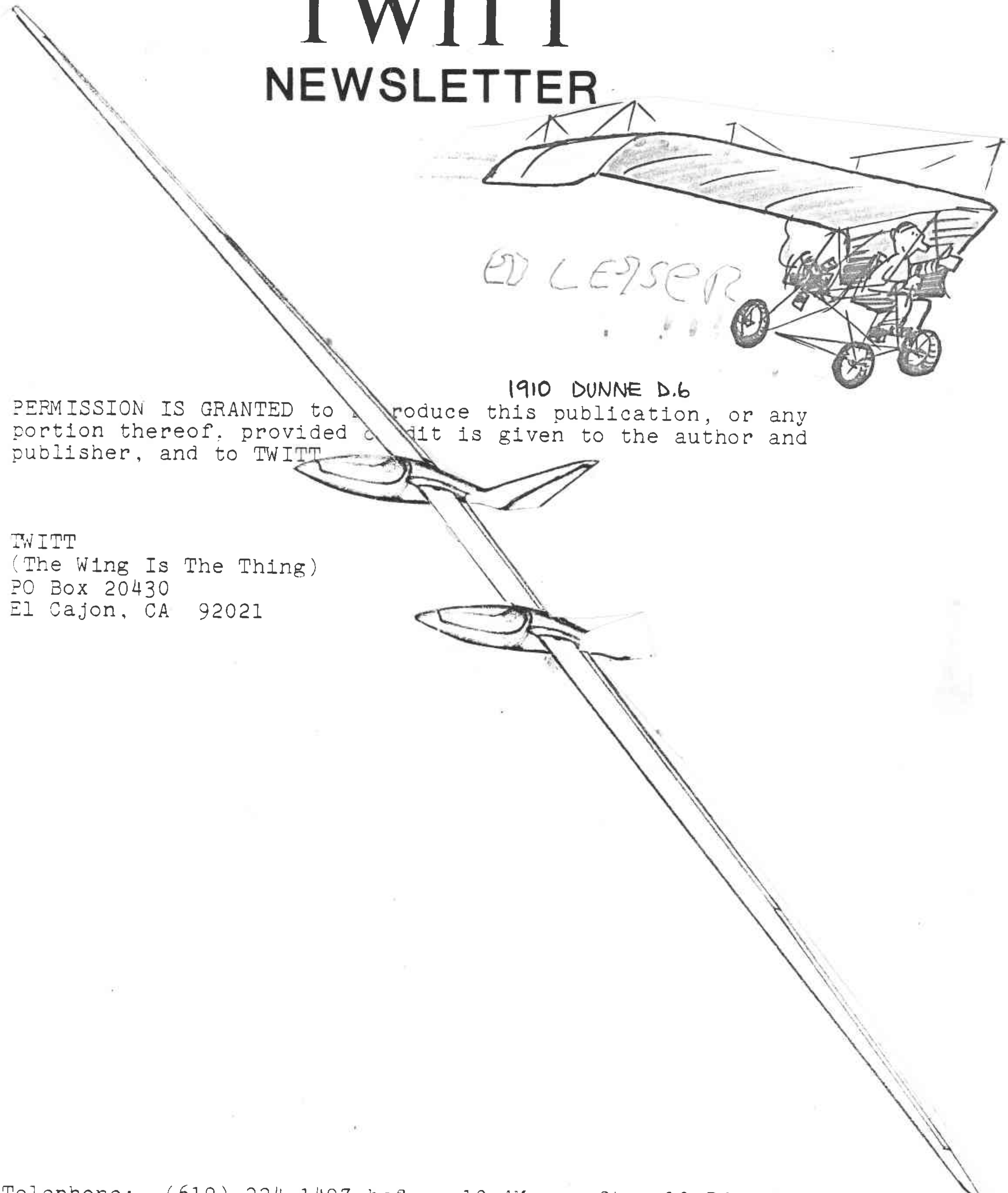
No. 7, January 1987

TWITT NEWSLETTER



1910 DUNNE D.6

TWITT
(The Wing Is The Thing)
PO Box 20430
El Cajon, CA 92021

Telephone: (619) 224-1497 before 10 AM or after 10 PM

THE ELEMENTS OF TAILLESS AIRPLANE DESIGN

By A. A. Backstrom (EAA 1162)
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Frisco, TX 75034

THERE HAS BEEN over the years a tendency to classify tailless airplane design as an area of mystique practiced by persons very adept in the manipulation of Ouija boards. The people using these guidelines seem to be able to overlook the well-engineered airplanes that have shown good flight characteristics. Several of these have been certificated by the country of origin or used operationally by their military units. After we have discussed the design problems, I will present some information on designs worthy of further development.

The first decision in tailless airplane design is WHY? To answer that question let's tabulate the primary advantages and disadvantages.

Goodies

1. Reduced drag
2. Reduced weight
3. Simpler structure (possible)

Discussion

The advantage of tailless airplanes is that for an equivalent payload, a lighter airplane requiring less power and fuel can be designed.

The CG range can be greatly extended by using low aspect ratio as in the Delta or Hoffman types. These are not normally suited to small airplanes because of the high power requirements at climb speed.

Baddies

1. Reduced CG range
2. Limited use of high lift devices

Discussion

The small CG range will kill off mid-sized airplanes. To obtain a usable design the variable weights must be very small or the airplane large so the weights can be distributed spanwise near the CG. To be blunt about it, don't try to design a Cherokee Six equivalent. The limited use of high lift devices makes achieving a large speed range difficult.

Well, if the goodies outweigh the baddies to you, let's go on and look at small tailless airplane design considerations point-by-point. (I assume that if you want a very large tailless airplane you will get your own Ouija board.)

Wing Configuration

As in any other airplane, the wings may be straight, swept back, or swept forward with various combinations of taper and twist. Determine wing sweep at the .25 chord line. Figure 1 illustrates these layouts and the re-

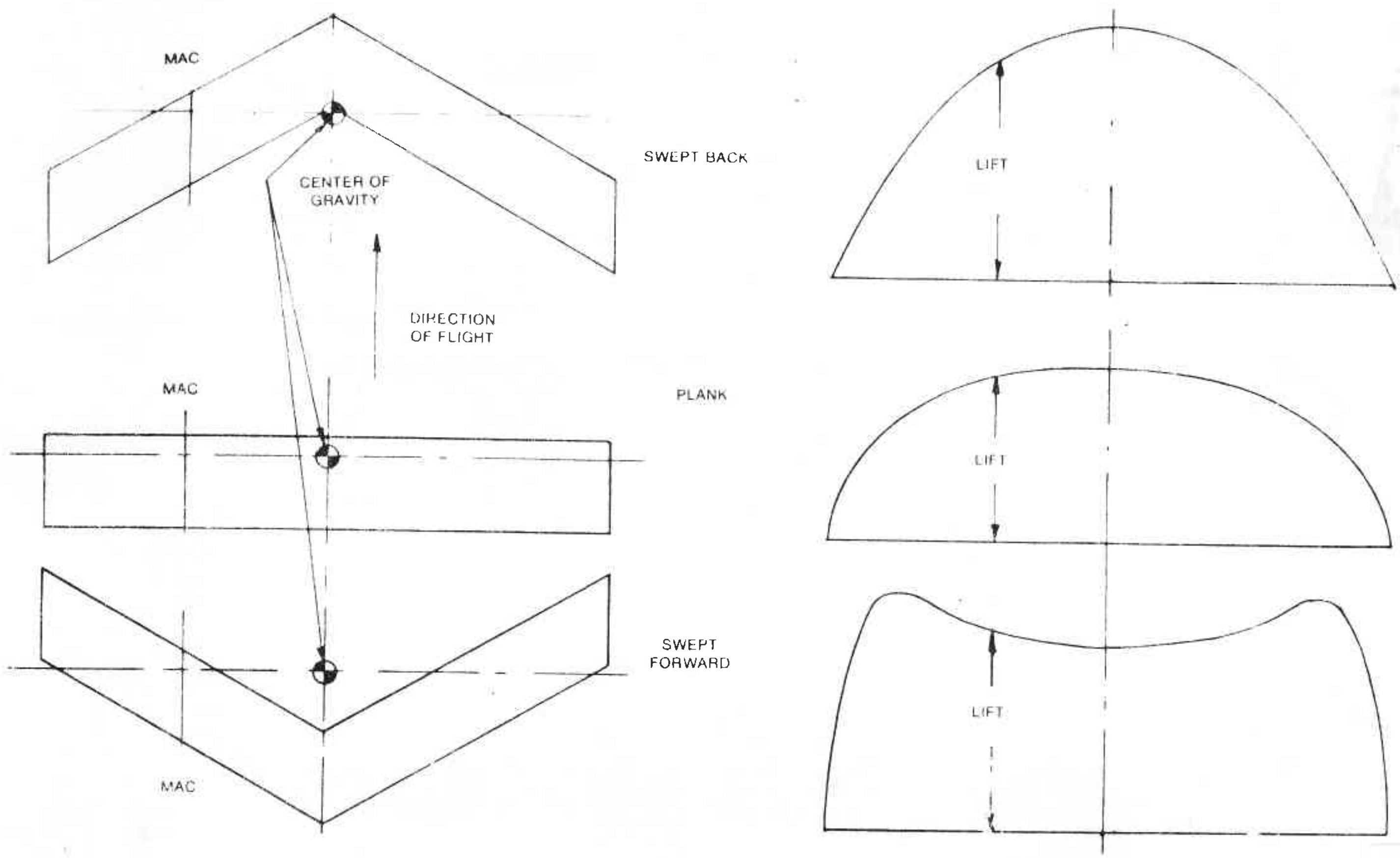


FIGURE 1
STABLE WING SYSTEMS & THEIR LIFT DISTRIBUTIONS

quired wing lift distributions. Of special interest is the swept forward configuration. I do not recommend trying the swept forward layout due to the highly loaded tips and the fact that they must either stall first or be prevented from ever stalling. Of course, for satisfactory flight characteristics the tips cannot be allowed to stall first. Some NACA Wartime Reports show the proposed Cornelius glider tanker to be about the worst of the tailless designs tested. A small amount of sweep forward to produce a straight leading edge, as used by Jim Marske, can produce good results.

So this leaves us with straight and swept back. The determination of which to use will depend on the CG travel required. Put simply, the more CG travel that must be tolerated, the more sweep required. Figure 2 shows an in-work auxillary powered plank sailplane design intended for almost zero CG travel regardless of weight changes. You may ask why work for small CG travel if it could be controlled by incorporating sweep. Well, the opposite problem is that the smaller the sweep angle the better the performance should be.

will depend on whether the airfoil (or wing system for swept types) has a nose up (+) or nose down (−) pitching moment coefficient. Also, the stability is directly tied to the CG location. Figure 6 shows the stability build up of the components of a conventional airplane and the effect of CG location. I hope you can review these figures and see that once you establish an airplane configuration, the location of the CG relative to the neutral point determines the static longitudinal stability.

Harry's numbers in Figure 6 are approximate, but they will serve to illustrate that a tailless design will have the neutral point well forward of a tailed type. On a wing alone the neutral point is approximately 25% mean aerodynamic chord (MAC). The addition of a pod as required for small machines will shift this slightly.

There is one other factor to be considered in design and that is protection of the rear CG limit. The tailless airplane should be designed so that in normal loading it will be very difficult to load the airplane aft of the established rear CG limit. This is because the range be-

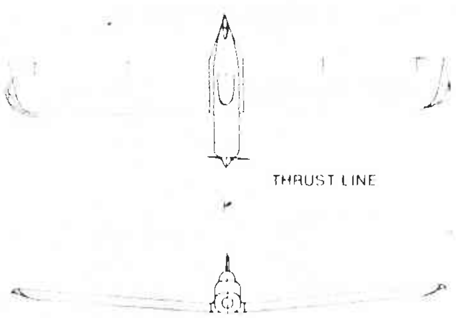
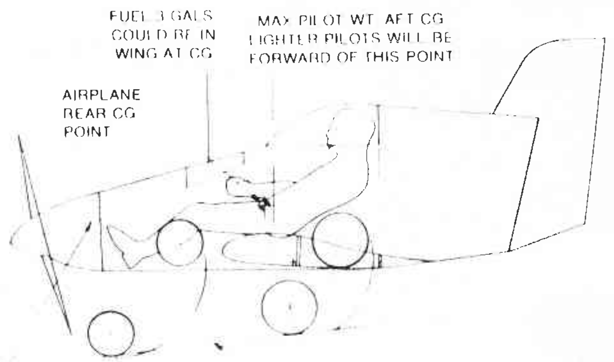


FIGURE 2
PLANK CONFIGURATION DESIGNED FOR MINIMUM CG TRAVEL



Longitudinal Stability and CG Location

Understanding longitudinal stability in airplanes provokes one of my pet peeves. I have heard the following statement thousands of times: "I know why a conventional airplane is stable, but I don't understand why yours is." Now really, if you understand one, you understand the other. To help all these people understand why airplanes are or are not longitudinally stable, let's take a quickie course on the subject using figures from Harry Hurt's excellent book, **Aerodynamics For Naval Aviators.** In these figures, Cm is pitching moment coefficient of the entire airplane, Cmac is pitching moment coefficient of the wing about the aerodynamic center, appproximately 25% chord at subsonic speeds. The sign convention is + for nose (or leading edge) up. Cl is lift coefficient, and increased Cl at fixed weight means lower speed or higher load factor.

Figure 3A shows characteristics of a Cm vs Cl curve for a typical stable airplane. Stick fixed it will trim at the point marked Cm = O and when the airplane is displaced from this Cl it will tend to return to the Cm = O point. Figure 3B shows the other possible stability conditions and that the stability is directly proportional to the slope of the curve. Ordinarily the static longitudinal stability does not change with Cl except in the range where Cl Vs angle of attack is no longer linear. Figure 3C shows a possible condition with changes due to power effect, high lift devices, wing location, etc.

Figures 4 and 5 show what a wing alone can contribute to longitudinal stability. You will note that a wing alone can be stable or unstable and that the trim point

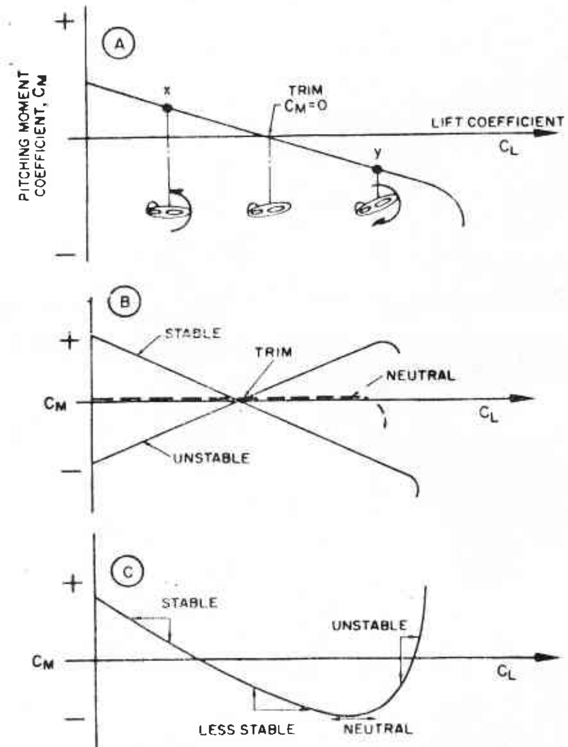


FIGURE 3
AIRPLANE STATIC LONGITUDINAL STABILITY

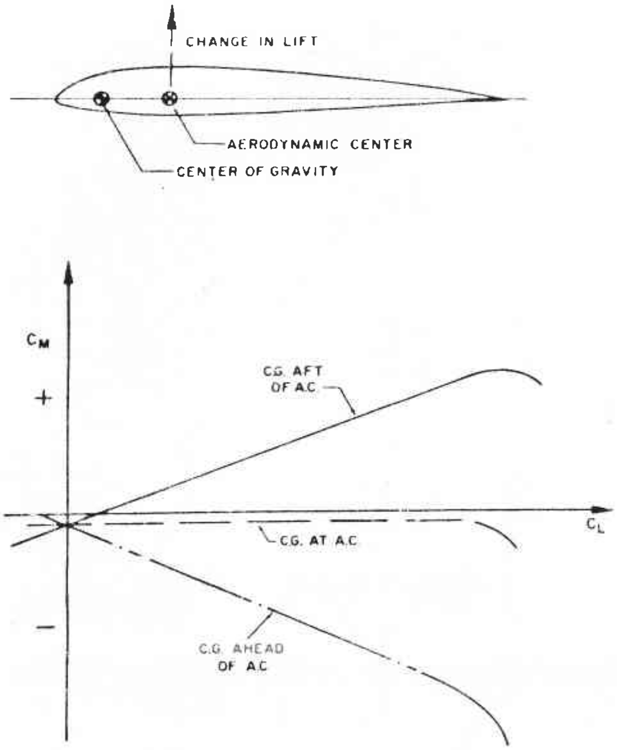


FIGURE 4
WING CONTRIBUTION

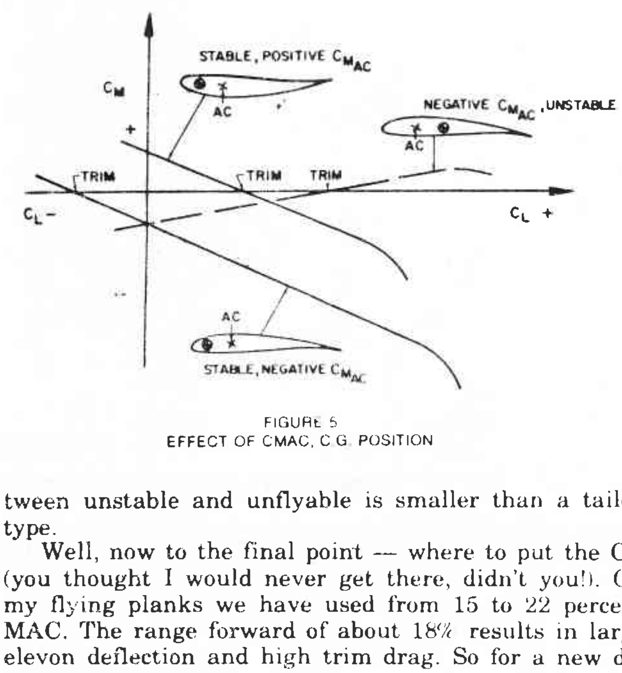


FIGURE 5
EFFECT OF CMAC, C.G. POSITION

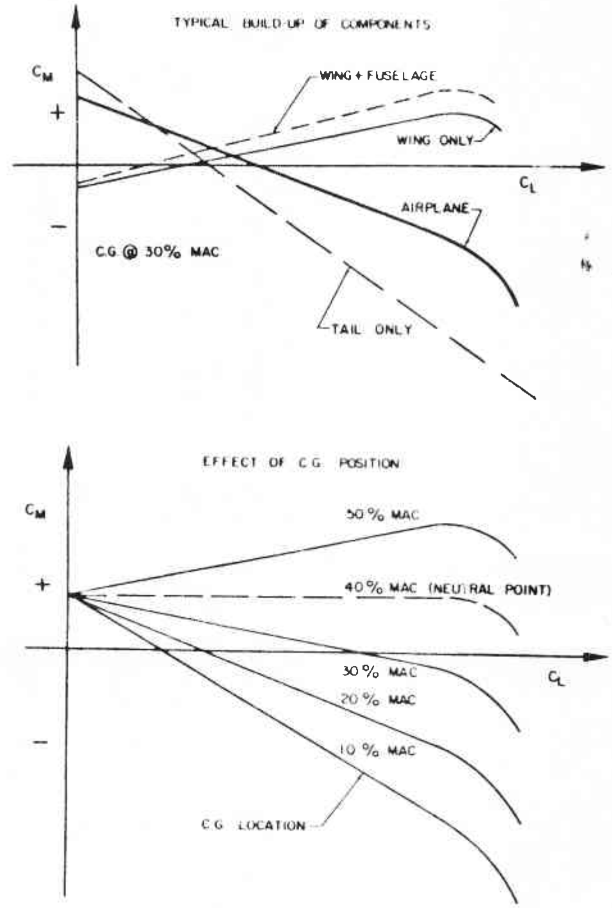


FIGURE 6
STABILITY BUILD-UP AND EFFECT OF C.G. POSITION

tween unstable and unflyable is smaller than a tailed type.

Well, now to the final point — where to put the CG (you thought I would never get there, didn't you!). On my flying planks we have used from 15 to 22 percent MAC. The range forward of about 18% results in large elevon deflection and high trim drag. So for a new design, use about 20% MAC to start with and work forward and back slowly to determine what the design can handle. You can refer to most aerodynamics text books for ways to determine MAC.

This was more discussion than I intended, but I hope it has helped you understand the basic principles of static longitudinal stability.

Directional Stability

Most of the reports of poor flight characteristics I have heard of in tailless airplanes are the result of poor directional stability. It seems that some designers, aiming at drag reduction, lose sight of the fact that it won't fly right if it doesn't go in a straight line. The solution to the problem is simply to have enough vertical surface far enough aft to accomplish this. On a swept wing you might use a diffuser tip as shown in Figure 7 rather than tip fins. You should note that both the bend down and the canting of the break line are required for a diffuser tip.

The roll your own section will provide you with information on how to find out how much area, etc.

Aerodynamic Controls

In selection of design for aerodynamic controls, you should try and select types that will produce a minimum of adverse secondary effects. You may refer to the drawings of successful designs for some information on proportion.

I personally favor wing tip elevons for pitch and roll control because they will build in additional wash out in the tip area at low speed which will help prevent tip stalling and increase spin resistance. On straight wing designs with pusher engines tip fins and drag rudders should be used. With a straight wing tractor a single fin on the aft pod can be used if it is far enough aft. Don't copy the EPB-1c in the EAA Museum because the arm is too short; it was done that way to keep the sailplane trailerable. If you have a similar design problem you should use a fixed fin and drag rudders at the wing tip. The drag rudders may be like Jim Marske's XM-1D or a flap on the upper surface only with the lower surface fixed (similar to that shown in Figure 7 or the plank modification shown in **Soaring**, July 1972). On a swept wing design the diffuser tip with a drag flap rudder (see Figure 7) or a small vertical surface and outward moving rudder can be used. Drag flaps of this type on diffuser tips, in addition to providing the yaw forces, will produce a roll force in the desired direction and some desired up pitch force during a turn.

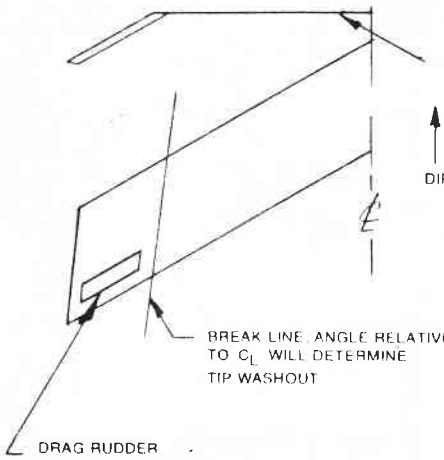


FIGURE 7
DIFUSER WING TIPS

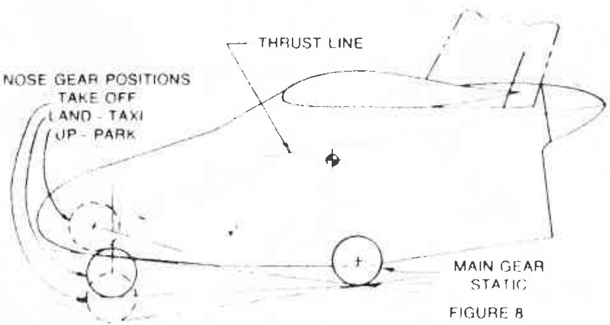


FIGURE 8

Power Effects

For our small airplane discussion only propeller types will be covered. As a tractor propeller will generally reduce the stability of an airplane, it is desirable to arrange for a minimum of adverse forces to be counteracted. Ideally, you would want power changes to be made with no control corrections being required. To accomplish or approach this, it is necessary to use an offset thrust line. Vertically the thrust line should be slightly above the CG and should be canted (left or right depending on propeller rotation) to counteract the combination of things generally referred to as torque. The offset thrust lines are illustrated in Figure 2. If possible, the thrust line should be adjustable in a prototype to allow a best setting to be found, just like a free flight model airplane.

For a pusher design, the problem is somewhat simpler since no left or right offset is necessary. The thrust line should pass slightly above the vertical CG location. You can see this shown in Figure 8.

The vertical location of the thrust line for a tractor should not be more than 20% MAC above the CG and not more than 10% for a pusher.

Spins

There was at one time the belief that tailless airplanes could not be made to spin. Sorry, but this is just an old pilot's tale. In fact, during the thirties the Hill Pterodactyls were spin tested and I remember Dr. Lippisch telling of the German authorities requiring him to do extensive rework on one of his Delta series so that he could show that it would spin and recover. Tailless airplanes can, and should, be designed to be unspinnable but it must be done in the basic design rather than hoping it will fall out naturally.

Basically, to prevent spins it is necessary to maintain a large amount of damping in roll at minimum flying speed. To accomplish this, most of the outer section of the wing must not be stalled. This can be obtained by wing twist, slots, elevons (which provide effective wash out in the up range), or a combination of these. Also, tailless airplanes need to have the same stability power on as power off. Offset thrust lines, as discussed in the section on power effects, can provide this.

Landing Gear

Most tailless airplanes of today use a tricycle type landing gear. If you design one around a tail wheel, you can use the geometry Pazmany calls out in his book on lightplane design. Paz's information on tricycle gear is also satisfactory except in many cases it will have too much load on the nose wheel. Due to the limited elevator power on many tailless designs, they cannot raise the nose wheel early enough in the take off roll without help from wing lift. This requires that the airplane sit at a high deck angle which will reduce nose wheel load. The resultant will be poor nose wheel steering authority if this is used for ground control. In some cases also the empty airplane will sit with the tail on the ground which makes it easy to blow away. Figure 2 shows an arrangement with a single position nose gear that will have more weight on it empty than loaded. Figure 8 shows a multi-position nose wheel arrangement inspired by Burt Rutan's VariEze. This allows a lightly loaded nose wheel for take off, moderate load for landing and taxiing, and a negative ground angle for parking.

High Lift Devices

Although the use of high lift devices is limited, there are some things that can be done to reduce minimum speeds. Slots can be used full span to increase Cl max but the increased angle of attack required will lead to landing gear design problems. This was the reason for the extreme gear design on the Vought F7U-3 airplanes. Conventional trailing edge flaps can be used on some swept back designs. A split flap would be the preferred type.

There have been several proposals to use a centrally mounted flap on swept wing tailless designs as an elevator. This is an intriguing idea as the elevator would be deflected downward and increase Cl at low speed. An elevon type control system reduces Cl at low speed. With proper aspect ratio and sweep angles it will work in small models and Figure 9 shows such a planform layout.

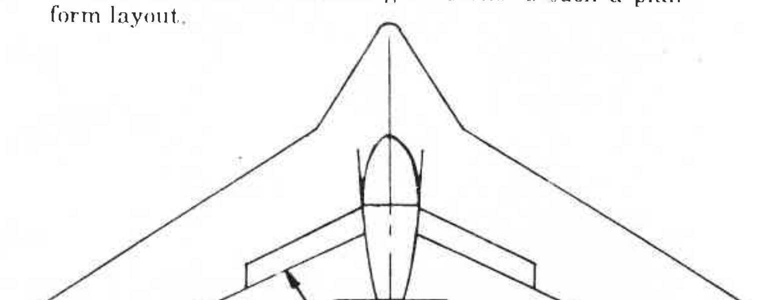


FIGURE 9
PLANFORM LAYOUT FOR
DESIGN INTENDED FOR INBOARD
ELEVATOR

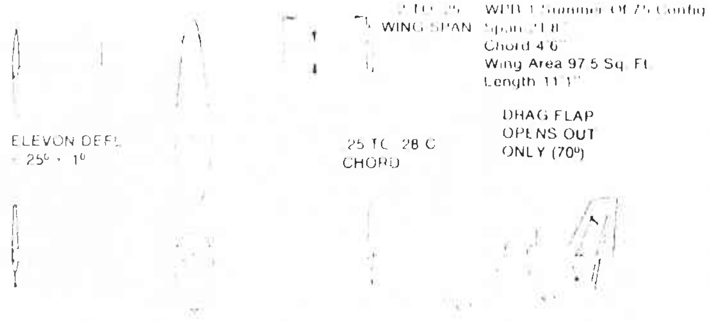


FIGURE 10

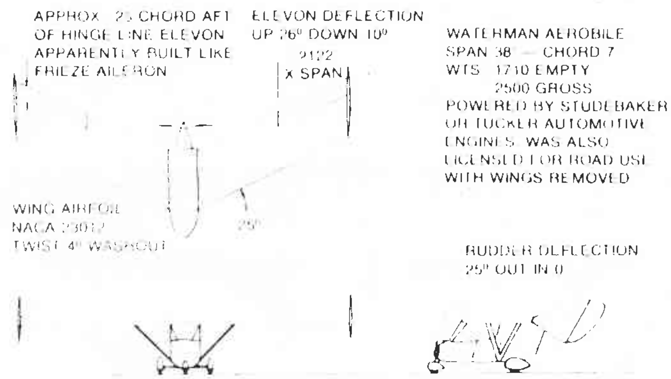
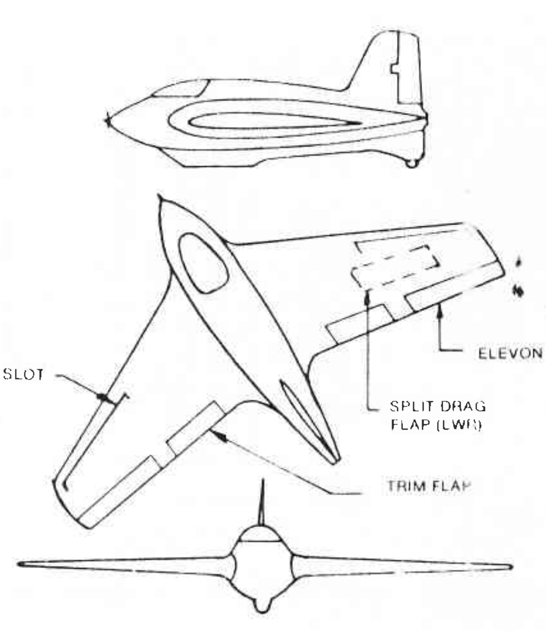


FIGURE 11



ME 163 ROCKET
INTERCEPTOR
FIGURE 12

Designs For Further Development

I started to call this section "Designs Worth Copying", but I thought better of it. For a long time I have considered a good designer to be one who only copies good ideas. There are two people who have good designs that are not covered here. This is because they are both still active and selling drawings. They are Jim Marske, 130 Crestwood Drive, Michigan City, IN 46360 and Charles Fauvel, 72 Boulevard Cornot, 06400 Cannes AM, France. Jim has a line of sailplane designs and Fauvel has both sailplanes and small airplanes. Largely forgotten these days is the fact that the Fauvel AV10 was certificated in France in the thirties and at one time held its class altitude record. (Also, a two-place plank sailplane has been certificated in Australia.)

Figures 10, 11 and 12 show a Flying Plank, Waterman Aerobile, and the Messerschmitt Me.163. Very good detailed drawings of Waterman's Aerobile are available from Paul R. Matt, Box 33, Temple City, CA 91780. I have presented the Me.163 because I do not have any detailed information on Dr. Lippisch's Delta series airplanes. If anyone has detailed information on these I would like to get a copy or, better yet, they should write them up for publication.

I would not recommend copying the true flying wing types unless you are willing to make revisions to increase directional stability.

Where To Find More Information

I have had many inquiries for material on tailless airplane theory and practice, etc. so I will pass along my normal reply. The best general study of tailless airplane history, stability, etc., was written by A. R. Weyl and published in **Aircraft Engineering** magazine during 1944 and 1945. This is a British publication, but there are copies in several engineering libraries in the U. S. During World War II, NACA did a lot of tailless airplane studies that are covered in Wartime Reports. These reports cover one study each, but they are worth reading to find out what did or did not work in the wind tunnels. WR-L-199 was the report that convinced me to proceed with the plank design.

Roll Your Own?

The rest of this discussion is primarily intended for those people interested in true experimental design development.

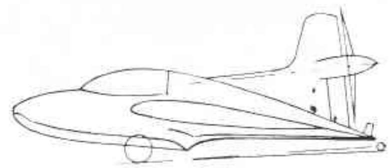
As in any design work, the first step is to set your objectives, performance parameters, etc. When this is done you can start sketching out a design that you feel might meet them. For now, we will only consider development of a stable and flyable airplane; performance is a separate problem. From your sketches, develop a scale layout to see if you can fit everything into your envelope. Looks pretty, doesn't it? Will it work? Well, let's use an example to find out. Figure 13 shows a small amphibian design I started a few years back. Note the drawing description, "Concept Layout." The finished machine may be a lot different. So build a scale profile glider model (about 1/20 scale) as shown in Figure 14. You must be able to make this fly stably across the room. Any changes required must be shown back on your layout. You can experiment with drastic changes easily at this stage so see what you can do to make it better.

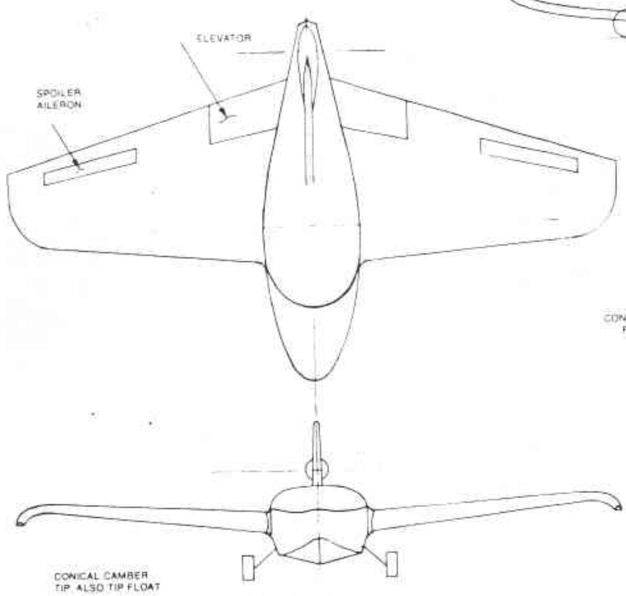
The next step is to go three dimensional at about 1/10 scale, glider or powered free flight. This will let you look at your lines, etc. and further check stability. Again carry any changes necessary back to your layout.

Now, depending on your faith, guts or whatever, you can go to a R/C model or full scale. A 1/5 or larger scale R/C model can check many static stability and control effectiveness items. For instance, we would have found that the WPB-1 layout would have a landing gear geometry problem if this step had been taken. If you go to dynamic scaling, a lot of additional items can be checked, but for small airplanes it is almost as easy to go full scale.

Epilogue

The tailless airplane offers the most potential for the ultralight field. Also it seems that we should have reached a point in airplane design where we must consider ways of improving performance that do not rely entirely on a bigger engine. It seems that current economics (initial and operating costs) are changing the situation to where the bigger engine is not necessarily the cheapest overall solution to obtaining increased performance.





CONCEPT LAYOUT
FIGURE 13

EARLY IN MY TRAINING as a pilot at Reese Air Force Base, Texas, I tried to impress an instructor with my knowledge of aerodynamics. He interrupted me with a seasoned pilot's explanation: "Push forward on the stick, and the houses get bigger. Pull back, and the houses get smaller. Keep pulling back, and the houses get big again."

—Contributed by Jere J. Matty

All you have to do is quadruple the span, halve the weight, find a smaller chap who can pedal twice as hard, and it still won't fly

TWITT
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PO Box 20430
El Cajon, Ca. 92021
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Peter Selinger
Landschreiberstrasse 21
D- 7000 Stuttgart-75

HAPPY NEW YEAR, PETER....!!!

and thank you for the letter and card.

Regarding the newsletters, don't worry, we will send them gladly(and at no cost, of course) and regularly to you. As you can notice while reading them, we are getting into the technical side of the project and the whole idea is getting really exciting and challenging!

Answering your question about Mr. David Myhra; he is actually writing several books. One of them is about the Horten 9, and is one of the reasons he went t o Germany, to obtain information from Mr. Walter Horten. Afterwards, he went to Argentina to see Mr. Reimer Horten and together revise a Horten biography manuscript. Another subject of his interest is the Pulqui 2 Projected Jet fighter designed in Argentina by Kurt Tank and his design team in the fifties.

We hope you will enjoy these newsletters and are anxious to read the information you are preparing for us on the S-B-13,and once again, we wish you a great year with lots of accomplishments.

SINCERELY....

Phillip

MEETING DATE---- January 17 at Gillespie Field----hangar A-5

In the next TWITT meeting,the first in 1987,we will have Mr Karl Sanders speaking to us. Mr Sanders is an aeronautical engineer, and his experience goes back to Messerschmitt in Germany. His aeronautical activities continued in Argentina, working together with Dr Reimar Horten. He came to the United States in 1956. After working for three years in Dallas ,Texas ,he came to San Diego in 1959 and worked at Teledyne Ryan Aeronautical. His actual residence is in Los Angeles and works as a designer specialist in Advanced Systems,at Northrop.

Dear June,

A crisis in aviation is with us at the present time. Multi-million dollar court awards, the resulting liability insurance escalation and skyrocketing prices have just about ended production of small general aviation aircraft. Recent 70 to 100% increases for spare parts by the big three should drive the final nails into the factory-built airplane coffin. The same forces are drastically reducing aircraft engine sales while prices surge upward. The resulting drop in new pilot training is already creating a problem for airlines which face a lack of pilots to replace their rapidly aging cockpit crews.

The high cost of lessons and flying in new airplanes and sailplanes is discouraging many interested people from getting into our sport. SHA and Soaring Society Membership has reached a plateau with a current slow downward trend.

SHA has a golden opportunity to solve the current dilemna in the following way:

Develop a low cost 2-place, easy to build, reasonable to operate, self-launching sailplane that can be used to introduce the huge reservoir of persons from all walks of life who are now barred by excessive prices. This aircraft should be capable of good cross-country powered flying so that it is a reliable means of transportation. Eliminating the need and cost of a tow plane and offering quiet fun flying to boot is an added attraction.

The HP-22 is my effort to provide such a ship with a couple of added attractions such as water, snow and ice operations with a cheap jet power plant.

The flying version engine should make its first test runs within a week and hopefully, the HP-22 will be completed by spring. I will bring the engine to Colorado Springs in February if it works OK.

Sincerely Yours,

R.E. Schreder

EDITORIAL

A primary purpose of the F.A.A. administration is to respond to requests for aircraft inspection and sign-offs that they alone can perform.

To turn this routine operation into a horrendous ordeal for those who must comply with it, and are stopped dead by lack of reasonable response, is an intolerable F.A.A. performance.

cc: Barb Weber

PHONE 419/636-1340

September 8, 1986

BRYAN AIRCRAFT, INC.

WILLIAMS COUNTY AIRPORT
BRYAN, OHIO 43506

NEW PULSE JET PROP ENGINE

PRINCIPLES OF OPERATION

The Pulse-Jet Prop is a very low-cost, zero weight aircraft engine incorporated in a hollow, stainless steel propeller, which performs all necessary functions of an engine. Air is drawn into the hub, mixed with fuel boiled inside the prop shaft and is fired by small igniter plugs.

Successive pulsing explosions are trapped by a disc valve in the hub which forces high pressure gases to exhaust through propeller tip nozzles.

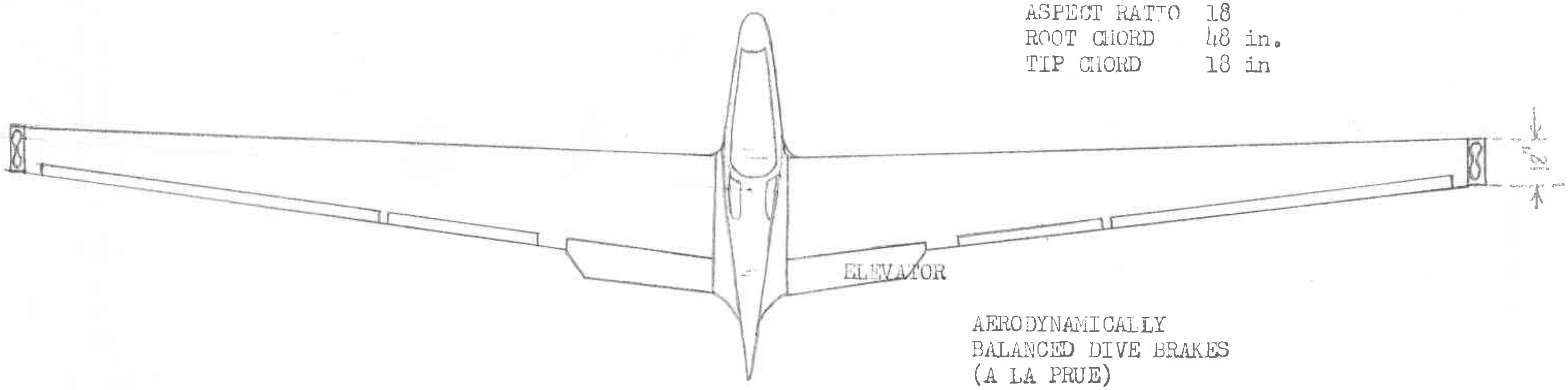
The throttle controls fuel injection pressure which governs RPM to match the speed which will provide a combustable fuel-air ratio.

FEATURES

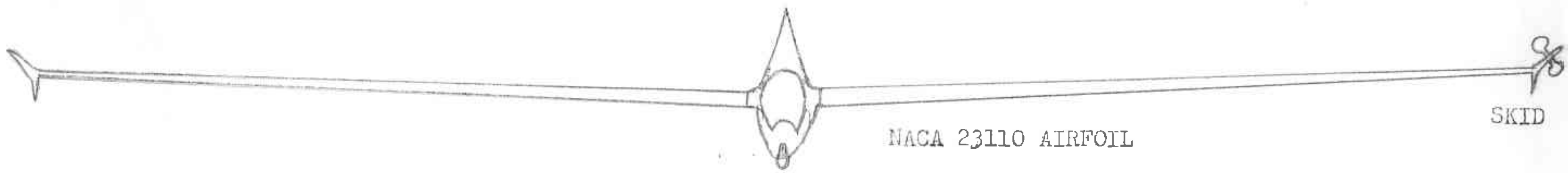
1. No starter (First explosion spins prop).
2. No oil pump.
3. No oil cooler.
4. No cooling fins.
5. No air pump.
6. No cooling fan.
7. No timing system.
8. No valve actuating mechanism.
9. No gearing.
10. No complicated machining.
11. No carburetor icing.
12. No blade icing.
13. No exhaust stacks.
14. No muffler.
15. No engine mounts, mast and installation.
16. No vibration.
17. No torque exerted on aircraft.
18. One moving part.
19. Fuel cools bearings and shaft.
20. Automatic fuel-Air mixing.
21. Automatic extending and retracting prop.
22. Economical to operate -- 0 to 4 gal./hr.
23. Good propulsive efficiency.
24. 0 to 3000 rpm range.
25. 3000 RPM = 58 HP.
26. Propeller blades serve as tuned exhaust stacks & mufflers.
27. Two 20 pound thrust nozzles.
28. Unlimited operating life.
29. Five minute overhaul. (replace plugs & valve disc).
30. Will run on any fuel from propane to light oil.
31. Prop & Engine weight 13 lbs.
32. Self retracting & extending mast 10 lbs.
33. Throttle controls fuel flow.
34. Rotating prop pumps air into hub.

STAN'ARD CLASS SAILPLANE BY W. J. ADAMS WATERLOO ONTARIO

ASPECT RATIO 18
ROOT CHORD 48 in.
TIP CHORD 18 in



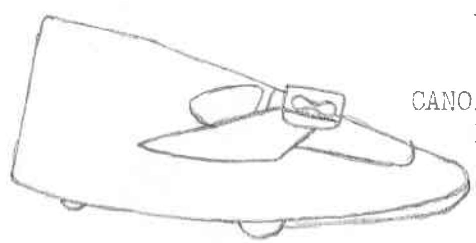
AERODYNAMICALLY
BALANCED DIVE BRAKES
(A LA PRUE)



NACA 23110 AIRFOIL

AERODYNAMICALLY BALANCED
WING TIP SPOILERS

TIP SPOILER HOUSING MOUNTED
AT 45 degree ANGLE TO WING



CANOPY OF TWO STRAIGHT
BENT THIN PLEXI SHEETS
WITH AIRSPACE BETWEEN

POEMS by WALT MOONEY

Approximation

The areas of ◎ are implied,
By Π and r^2 multiplied.

Circumference is given by,
Twice r multiplied by Π.

And Π is somewhat >3,
With decimals to ∞.

3.141 etc., forever
The final digit beyond all endeavor.

Therefore when we calculate
Our circles we approximate,
Using more, or less, than Pi
The radius to multiply.
Knowing that our figures lie
Using what we know of Pi,
And until we are more wise,
We'll be forced to compromise.

"One of Those Days!"

Woke up one morning in a hurry
Eyes, from sleep, a little blurry.
Stubbed his toe upon the bed,
Bent up double, bumped his head.

Shaving whiskers, cut his face,
Tieing shoes, he broke a lace.
Looked in his mirror, head was balding,
Toast was burned, and coffee scalding.

Forgot his lunch, and car had flat,
Got a ticket, lost his hat.
Late to work, caught heck from Boss,
Flipped for coffee, lost the toss.

Opened up the seventh floor window,
Leaped and yelled, "look out below!"
People gathered where he died,
And wondered at his suicide.

The Banning Santa Ana

Chorus: *The wind blew and the dust flew*
And Dave Labelle was white,
With the prop stopped and the brakes locked
That Cub almost took flight.

Dave was a carefree pilot
Who really loved the air
But the Banning Santa Ana
Almost greyed his hair.

Chorus →

The air was calm at Skylark
The sky an azure blue
As this intrepid pilot
Took the 85 and flew.

He took off in the morning
The air was cool and clear
And headed out for Banning
Without a thought, or fear.

Chorus →

Banning's in a valley
A pass both long and low,
Between San Jacinto Mountain
And high Gorgonio.

There's desert to the east of it,
To the west there is L.A.
And through the Banning Pass
The Santa Ana plays.

Chorus →

He landed in an East wind
With gusts to thirty-five
And Dave was stuck with sitting in
The good old eighty-five.

He sat there in that Piper Cub
His feet held on the brake
But as the Santa Ana hit
The Cub began to shake.

Chorus →

It skittered back across the field,
He held the tail up high,
But in the Santa Ana
That Cub wanted to fly.

To get out was to lose it,
Besides he didn't dare
For if he let go of the stick
The Cub would take the air.

Chorus →

The airport crew came out at last,
Tied down that 85,
And Dave was grateful as could be
To just get out alive.

Chorus →